STUDIES IN THE FUNCTIONS AND DESIGN OF HOSPITALS

NUFFIELD PROVINCIAL HOSPITALS TRUST

The Report of an Investigation sponsored by the Nuffield Provincial Hospitals Trust and the University of Bristol

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ABBREVIATIONS

B.R.S.	Building Research Station
H.M.C.	Hospital Management Committee
H.M.S.O.	Her Majesty's Stationery Office
M.R.C.	Medical Research Council
U.S.P.H.S.	United States Public Health Service

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INTRODUCTION

IN 1949 the Nuffield Provincial Hospitals Trust enlisted the co-operation of the University of Bristol in sponsoring the Investigation to which this report relates. A small committee representative of the University and the Trust was set up, with Mr. Farrer-Brown as Chairman, to control the Investigation, and Mr. John Madge was seconded from the Department of Economics at Bristol to be Director of the research team. A panel of advisers expert in various disciplines concerning the Investigation was also appointed. In 1950 Mr. Madge resigned and Mr. R. Llewelyn Davies became Director, the University of Bristol continuing to be joint sponsor.

The terms of reference of the Investigation—to study the functions and design of hospitals—were purposely left wide, though it was recognized that in practice research would have to be focused on a limited range of subjects.

Hospital problems may be approached from two directions. One way is from the accumulated knowledge and experience of those whose daily work has been within the hospital or in hospital design; the other is by bringing to bear fresh minds and fresh methods from outside because people working in hospitals are often too close to their problems to view them dispassionately. These two approaches are complementary, and the Investigation has aimed, in its organization and staffing, at a balanced relation between them. The Controlling Committee and the panel of experts, who acted as advisers to the research team, helped to ensure that critical, fundamental study was focused on practical issues, and that conclusions were related to practical possibilities.

The Investigation has always been well aware that the quality of hospital service depends on the standard of medical and nursing care, and on the humanity with which that care is given to the patients. Work of the highest quality is often done under difficulty in inefficient and palpably ill-designed buildings. Yet in the complex environment of the hospital the influence of design upon function may be very great, although hospital planners have generally wished to believe that function has dictated design.

The Investigation's studies fell into three principal groups:

(i) studies of individual departments;
(ii) studies in physical environment—concerned with questions such as lighting, heating and ventilation, colour, the control of noise, and the prevention of fire; and
(iii) study of hospital case-load, i.e. the demand for hospital services arising from the surrounding area.

Studies of individual departments covered the wards, the consultative and treatment services for outpatients, and the operating theatres. Studies in physical environment were made in conjunction with the Building Research Station of the Department of Scientific and Industrial Research.

The study of the case-load involved a pilot survey of the demand for hospital facilities from a population of approximately 400,000 and a detailed study of the demand from a population of 500,000. This study was undertaken because no satisfactory data were then available as to the relationship between hospital services and the needs of a population.

The first six months of the Investigation were devoted to general reading, discussion, and visits to hospitals in the United Kingdom, France, Switzerland, and Scandinavia. During this period the research programme was gradually developed. The first detailed study undertaken concerned the ward, and the pattern of work which evolved was followed, with slight modifications, in subsequent researches. It is divisible into three fairly distinct stages: (i) an appraisal of current problems, together with a historical survey designed to show what had led up to the current situation; (ii) research on selected and specific aspects; (iii) design and construction of experimental buildings, in which the results of the research could be tested and demonstrated. Work on the first stage was usually undertaken by the whole team working together, so that each member could gain an insight into aspects beyond his own main contribution. During the second stage specialized studies were undertaken by the various members of the team. These studies aimed at the collection of objective data rather than of opinion. It had already been found that, on many key problems, opinion, even authoritative opinion, was often sharply divided and that there was little factual information available. The third stage was a synthesis of the various detailed studies.

The Investigation sought the co-operation of a number of hospital authorities in the United Kingdom. The Department of Health for Scotland invited the Investigation to prepare designs for a 64-bedded medical ward unit to be added to Larkfield Hospital, Greenock; a little later the Northern Ireland Hospitals Authority invited the Investigation to design an 80-bedded surgical unit for Musgrave Park Hospital, Belfast. This latter unit will have attached to it a block housing two operating theatres, X-ray facilities, and a central sterile supply department serving the entire hospital of 600 beds. In both cases the cost is being met by the authority concerned and the buildings form part of their current programme. Designs have been

prepared by the Investigation, working with officers of the authorities, and the execution of the work and control of the contract are in the hands of local architects.

At the conclusion of the studies in the outpatient department it was not possible to proceed to the stage of experimental building. During the course of these studies, however, the architectural staff of the Investigation were responsible for the design of the Nuffield Diagnostic Centre at Corby which provides accommodation for a number of hospital outpatient clinics. The Centre embodies some, but by no means all, of the results of the Investigation's researches in the outpatient field.

At the outset the Investigation was limited to the study of the acute general hospital, because the team considered it to be the most important single component of the hospital service. Specialized institutions such as mental hospitals and sanatoria were excluded, as were hospitals devoted to a particular specialty, such as eyes or children, though all these need study. Departments of the acute general hospital not so far studied in detail are: radiology, pathology, physiotherapy, administration (including records), and the various service departments (for example, the kitchen, laundry, and boiler-house).

Neither the time nor the resources were available for the limitless task of assessing the impact of the hospital service upon the community. Nor could other parts of the Health Service—the work of the general practitioners and of the local authorities—be examined except in so far as was necessary to throw light upon specific problems of the functions and design of hospitals. Another important study which could not be attempted was the extent of the contribution which voluntary organizations continue to make in the hospital field.

Much of the work of the Investigation has broken new ground. This report therefore contains a full account of the method and conduct of the studies, since conclusions and recommendations are of little value unless the arguments from which they are derived are available. Indeed, wherever ideas are changing and developing as rapidly as they are in hospitals, a new method of approach to a problem may be a more useful contribution than any particular solution. Many of the Investigation's conclusions take the form of proposals for new methods and new approaches to the problems of hospital functions and design. The report puts forward no standard or ideal solutions; instead its aim is to provide those who have to deal with these problems in practice—hospital authorities and administrators and architects—with means and techniques which may help them. The experimental buildings illustrated in this report are simply individual solutions inspired by the results of the team's research. Each represents one possible way in which considerations arising from the research may be applied. They are not in any sense to be regarded as type-plans.

To make an effective contribution research must be so directed as to assist those on whom practical responsibility rests. The Investigation hopes that by making its principal aim the provision of data designed to illuminate some of the many complex problems facing hospital authorities, staffs, and architects, it may stimulate fresh thinking which, through the skill and imagination of those responsible for the provision, design, and operation of hospitals, may suggest new solutions.

1 THE WARD

I. HISTORICAL INTRODUCTION

Eighteenth-century Opinion on the Ward

IN the last quarter of the eighteenth century Dr. John Aikin wrote in his book, *Thoughts on Hospitals*:

> The architect considers it is his business to manage his room and materials in such a manner as to accommodate the greatest number of people in the least possible space. The physician on the contrary would leave as much vacant space, occupied by the fresh air alone circulating freely, as was in any degree compatible with use and convenience. It is to the prevalence of the former above the latter that all our complaints are owing.

Aikin himself advocated 'a range of cells or small rooms opening into a wide airy gallery, having a brisk circulation of air through it', and drew attention to the fact that 'many hospitals, however faulty in general construction, are provided with small rooms for the reception of those who have undergone operations'.[1]

John Howard, who was an authority upon hospitals as well as upon prisons, believed that no ward should contain more than eight beds, and on his visits to hospitals was indefatigable in distinguishing good conditions from bad. At Guy's Hospital, for example, he contrasted the old, low, wards, each containing about thirty bug-infested wooden beds, with the new wards which were clean and fresh, and where the bedsteads were of iron and the mattresses filled with hair. He approved also of the construction of the new W.C.s, 'for by opening the door, water is turned into them'.

Howard was less pleased with the London Hospital, where the wards, though not dirty, badly needed white-washing. Of London hospitals generally, he complained that 'there are no convalescent wards or sitting rooms, so that patients are often turned out very unfit for work, or the common mode of living'.[2]

In 1801 the Newcastle Infirmary was being extended, and the planning committee arranged that the new wards should incorporate the most up-to-date notions on hospital construction and organization. Each story was to contain a row of 6-bedded wards, opening on to a wide gallery where the patients could take exercise. 'Every floor in the new house' was to include a 'nurse's room, scullery, and water-closet, conveniently situated'. The fourth story of the building was to contain the operating room, and five 2-bedded rooms, measuring 25 feet by 12 feet, reserved for patients who were dangerously ill or had recently undergone a major operation. Each room was to contain only one patient in a serious condition, the other bed being occupied at night by a nurse or a convalescent patient acting as nurse.[3]

Ward Organization in the Early Nineteenth Century

A fairly detailed picture of the day-to-day running of the wards at St. Bartholomew's, St. Thomas's, and Guy's, as they were at about the time when Queen Victoria came to the throne, may be pieced together from surveys made at those hospitals for the Charity Commissioners. The surveys show quite clearly the growing importance of the sisters of the wards, who were 'responsible for everything which occurs therein that does not fall within the department of the medical attendants'. Under the direction of the medical officers, the sisters were sometimes allowed 'to exercise a discretion in the administration of medicines during the night', and 'they attend at the operations performed on their respective patients'. They were 'usually selected from a higher class of females than the nurses' (who were described as being the servants of the sisters). Often they were widows from the respectable ranks of the lower middle class.

In the wards at St. Bartholomew's—many of which were divided into two parts by a wall down the middle—there were between 22 and 36 beds, and each sister of a ward had two or three nurses working under her. Fifty of the seventy-five nurses employed by the hospital 'also discharge, in rotation, the duty of night nurses'. At St. Thomas's, however, the night nurses seem to have been a separate staff, 'who come to their duty at eight o'clock in the evening, and remain there till ten the next morning'.

The night nurses, besides keeping an eye on the patients —in any emergency they roused the sisters, all of whom slept in rooms adjoining their wards—apparently did the heaviest cleaning jobs. It was noted at Guy's that 'the wards are scoured at five o'clock on Tuesday in each week, and scrubbed on Friday, at the same early hour, before the patients rise'.

In the absence of the principal physicians and surgeons, the resident apothecary and surgical officers were responsible for the medical care of all patients in the wards, and had the duty of visiting them regularly and frequently. Nevertheless a large share in the routine work was taken by the consultants' pupils, the medical clerks, and the surgical dressers—particularly the latter. The Charity Commissioners stated that although the dressers did not 'properly speaking, form any part of the Hospital Establishment . . . they are highly instrumental in . . . contributing to the comfort of the in-patients, whose symptoms they observe and report to their respective principals'. Their duties at St. Bartholomew's, prescribed in a list of rules drawn up in 1823, included receiving instructions from the surgeons about the treatment of patients, and

either giving the treatment themselves or superintending the giving of it. They were also responsible for entering the details of each patient's case on a board hung by the bed, with particulars of medicines and diet. They were expected 'to dress all cases of fracture, wounds, ulcers, and all affections that require local applications and to see that poultices are properly made and applied'.

The patients' day seems to have been arranged on tolerably comfortable lines. At Guy's, the Charity Commissioners noted, 'no regular hour is fixed for the rising of the patients; those who are well enough being permitted to get up when they please. They are required to wash themselves in the scullery of the ward, where warm water is furnished for them. Those who are too ill to rise are washed by the nurses in their beds.' Breakfast was usually between 8 and 9 o'clock, and the patients dined between 1 and 2 o'clock. 'Their remaining meal is at no fixed hour, but when the wards are quiet, and the convenience of the nurses permits.'

Provisions were prepared in the main kitchen of the hospital by the cook, who delivered them to the nurses of each ward. Patients, according to their medical condition, were usually put on one of four different types of diet—the full, the milk, the dry, and the fever diet—which could be supplemented if the doctors thought it necessary. Beer was included in the full diet; if patients wanted tea they had to provide it at their own expense. Tea drinking, the Charity Commissioners thought, was 'an indulgence which might perhaps be advantageously afforded to all at the cost of the hospital, and more particularly to the medical and female patients'. Visitors were allowed into the wards for an hour in the morning on three days a week and on Sunday afternoons.

Patients who were well enough were expected to help the nurses by doing light household tasks. But at St. Bartholomew's, 'the assistance received by the hospital servants from the patients in the discharge of their ordinary duties is but little, and the latter appear on the whole to spend more time in bed than is the case in some other London hospitals, and more attendance is consequently here required'.[4]

The Mid-Victorian Period

In the course of the first twenty-five years of Queen Victoria's reign hospital wards lost most of the domestic and leisurely atmosphere which they seem previously to have had. The general use of anaesthesia increased the amount and complexity of the surgery undertaken, and the already established tendency in English hospitals to admit more surgical than medical cases was accentuated. Owing to the prevalence of sepsis, and the fear that operation-wounds might break down, more patients were confined to bed, and the need for skilled and constant nursing care was imperative. During the terrible fever epidemics in the large cities, it was good nursing almost alone which kept patients alive.

In the eighteen-sixties the most authoritative voice defining what hospital wards should be like and how they should be run was Florence Nightingale's. In *Notes on Hospitals* she wrote:

> It is singular how little, even in civil hospitals, attention has been directed to the comparative cost of nursing in larger and smaller wards. In two civil hospitals in London, I found the annual cost of nursing each bed about one-third *more* in the one than in the other. . . .
>
> In civil hospitals the proportion is 1 to every 7, generally, of attendants to patients, but is mainly determined by the size of the ward.

She declared that a sister and two nurses were commonly given the charge of 20 patients (because the ward held that number), whereas in fact they could look after 32, 'provided there be lifts and a supply of hot and cold water all over the building'. Conveniently placed lifts and water-supply 'make, on an average, the difference of 1 attendant to every ward of 32 patients', she said. 'And, other things being equal it is certain that a ward with the appliances and without the extra attendant, will be better served than a ward without the appliances and with the extra attendant.'

The maximum number of 32 patients which Miss Nightingale advocated seems to have been based primarily upon an allowance of 1,500 cu. ft. of space per patient and 100 sq. ft. per bed. She recommended a ceiling height of 15 feet. 'Wards larger than of 32 beds are undesirable', she said, 'because they require a greater height of ceiling, and are hence more costly in construction and difficult to ventilate.' That number of patients and size of ward also met her other requirements, the most important of which were *ease of supervision* and *economy of attendance*.[5]

A size of ward which appeared so happily to combine economy in construction with hygienic and nursing requirements was evidently desirable, and Florence Nightingale's recommendations were accepted. The 30-bedded ward became common also on the Continent and in the United States.

Nursing in the Late Victorian Period

Specialization in the field of medicine, and the advances in surgery which quickly followed the antiseptic methods introduced by Lister in the late eighteen-sixties, put fresh burdens upon the nurses. 'A good nurse of twenty years ago had not to do the twentieth part of what she is required by her physician or surgeon to do now', wrote Miss Nightingale in 1882.[6] Indeed at about that time medical men, in the course of resisting the efforts of women to enter their profession, were perturbed to find that 'subjects of purely medical and surgical concern are beginning to be included in the "studies" of the *nurse*, while other matters, on which mainly the success of treatment must always depend, are regarded as menial, and relegated to the care of servants'. Much discussion followed, on what the proper work of nurses should include; but though the *Lancet* might deplore the fact that minor surgical procedures in the ward were no longer done by the medical students, the change proved to be irreversible.[7]

In 1890 a Select Committee of the House of Lords was inquiring into the organization of the metropolitan hospitals. In hearing witnesses, the chairman asked Mrs. Bedford Fenwick—who had been the matron of St. Bartholomew's Hospital and was then the leader of the newly formed British Nurses Association—what was the proper staffing for a ward. She replied that it 'depends on the construction of the ward, and the number of beds which it contains, as well as the severity of the cases in them. . . .'

> I have worked the matter out very carefully, and in practice [she said], and am convinced that no woman can thoroughly superintend the nursing of more than 30 patients in a general hospital; but for each ward of 30 beds there should be, on day duty, one sister and one fully certified staff nurse, one staff probationer, who has passed through her first year's work and examinations; and under the staff nurse and staff probationer there should be three junior probationers . . . passing through their first year of training.

Mrs. Fenwick thought that at night, in addition to the nursing superintendent who supervised the whole hospital, there should be for each 30-bedded ward 'one certified staff nurse, one staff probationer who has passed her first examination, one probationer in her first year,

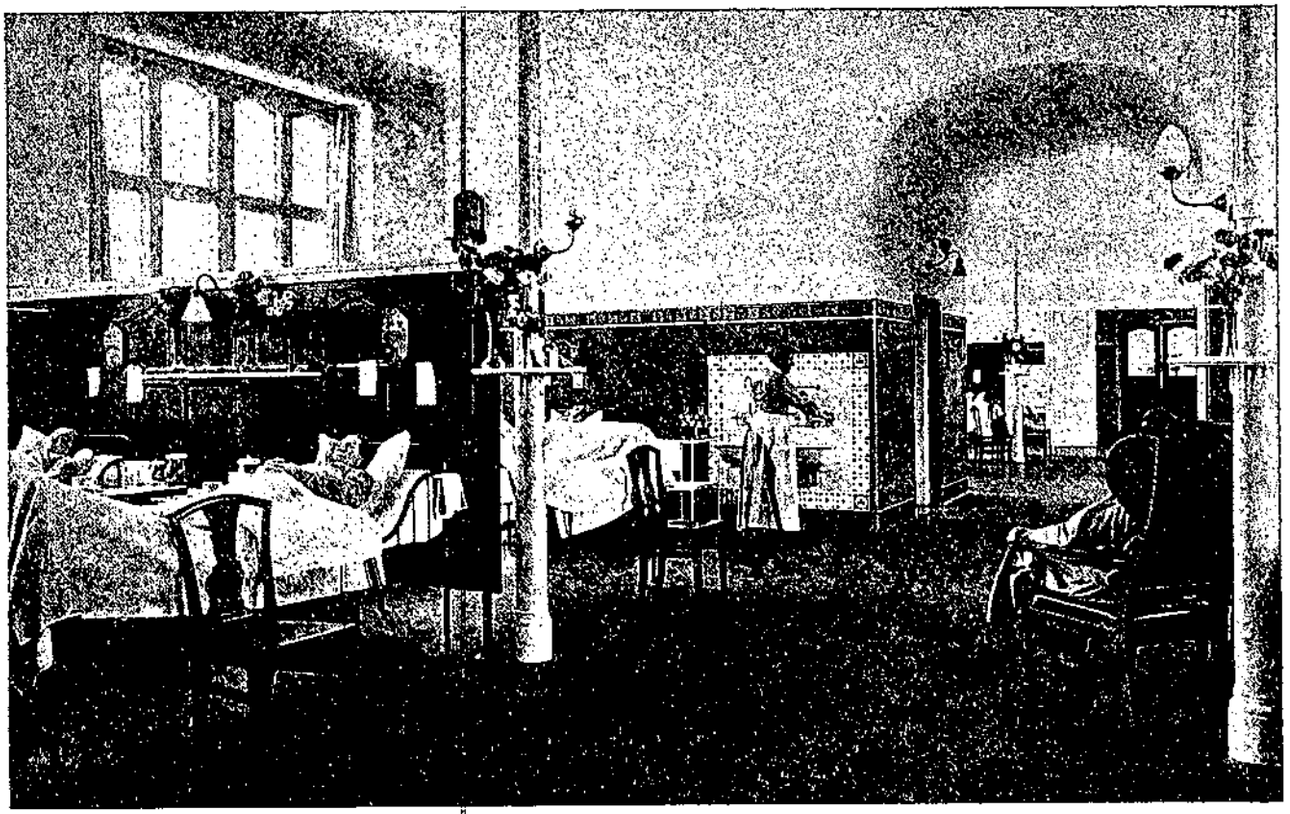

Fig. 1. A medical ward in the Rigs Hospital, Copenhagen, 1910

and such special nurses as may be required'—the special nurses having the sole charge of very ill patients. She added that in her opinion no nurse should 'have more than six patients in the daytime to nurse', and that the bulk of the nursing should fall on the trained nurse, the junior probationers merely carrying out the directions given them by the seniors.

Speaking of the heavier cleaning work, Mrs. Fenwick said:

> A ward of 30 beds would require one ward-maid entirely for that ward. . . . A great deal of the superficial cleaning . . . is in the hands of the nurses, and should remain so in my opinion. . . . It is very desirable that it should be impressed upon the nurse in her training, that cleanliness is the basis of all good nursing. . . . Attention to the inside of lockers, and drawers, and cupboards, and the cleanliness of the beds and bedsteads . . . and all those things should belong to the nurse.[8]

Single Rooms, Small Wards, and Partitioned Wards

In many hospitals on the Continent and in the United States, while 'charity' patients were accommodated in large open wards, it had long been customary also to accept paying patients, and they—since it was clearly not proper to give them different medical care—were allowed to buy greater privacy. According to their means they might elect to go into a single room or into a small ward.

In the United States of America this was carried very much farther. As early as 1908, at the King's Daughters' Hospital, at Temple, Texas, it was decided that all patients, charity or otherwise, should be put into single rooms. 'So far as I know', wrote a member of the hospital staff in 1920, 'this is the only hospital that gives charity patients private rooms.'[9] In the early nineteen-twenties, however, the idea that being an inpatient in a hospital should be as much as possible like being a guest in a hotel was beginning to have a strong appeal for the Americans. 'Labor conditions have so changed that the average working man does not want charity', wrote the superintendent of the Presbyterian Hospital, Chicago. 'The private room for each patient, with its complete utility equipment, not only provides comfort, but . . . allows the occupancy of *all the beds all of the time*.'

> In working out this plan, certain fundamental principles of construction and organization have been found to be imperative—the elimination of special duty rooms and general lavatories, and the substitution of a toilet and lavatory in each patient's room, the abandonment of floor diet kitchens and serving rooms . . . the abandonment of floor linen rooms, and the substitution of one central linen supply room.[10]

The superintendent of the Beth Israel Hospital, in New York, pointed out that 'without an individual utility room, the private room system may not be feasible economically', because 'from a practical point of view the great advantages of a room for every patient might be counterbalanced by the inadequate service arrangements, and by the great work thrown upon doctors, nurses, and other hospital employees'.*[11]

Although the single room with toilet facilities of its own (or shared with one adjacent room) was fully accepted for paying patients, the practicability of providing on that scale for all patients was soon questioned. The American architect, E. F. Stevens, wrote in 1922:

> The old twenty- to thirty-bed . . . wards have gone, let us hope for ever. But how, in the much desired private room hospital, are we going to meet the economic conditions of nursing, feeding, and general administration which obtain in the open ward? It is evident that we must find some middle ground.

Stevens advised the use of small wards in which the beds were separated into groups of three or four by partitions. Water-supply, and facilities for emptying bedpans, and for sterilizing, would be provided in a 'sub-sink room' serving two adjacent wards, and W.C.s would also be provided between pairs of wards, so that 'the patient as well as the attendant has the utmost facility with the minimum of travel'. The ward unit, as a whole, would contain 'one bathroom, a general sink room'; and 'the quiet room or private ward essential for every ward unit could be provided with a common toilet with special bedpan-hopper water closet'.[12]

These ideas stemmed directly from the ward arrangement adopted at the Rigs Hospital, in Copenhagen, opened in 1910 (*Fig. 1*), which Stevens had visited just before the 1914–18 War. He wrote at the time:

* Americans had been made very conscious of such aspects of work in wards, through studies carried out by Professor W. Gilman

The ward itself, containing twenty-six beds, is divided into 8 sections, each section containing three or four beds. The dividing screen affords privacy to the patients and still allows free access to all parts of the room for the attendants. An isolation room and nurses' room are placed in the center. . . . These screens only 6 feet high and 1 foot from the floor, afford the same ventilation as an open ward.

Stevens noted that the staircase, lift, and 'noisy parts' are kept at the extreme ends of the ward unit. 'The serving kitchen, bath-room and sink-room are on a cross corridor and the surgical dressing-room and water-closet are removed to the opposite end.'[14]

The Rigs Hospital arrangement had been used at the Bridgeport Maternity and Children's Hospital, in America, as early as 1914. By 1923 it was said to be becoming quite common in the States.[15]

In England it seems first to have been used in the Hertford County Hospital (1929), in the new wing of the Sussex Hospital for Women and Children (1930), and in the Southend Hospital (1932).

When in 1937 the London County Council proposed to standardize the dimensions of 'normal' types of ward—'that is to say, those in which the beds are placed on either side of the ward and project at right angles from the side walls'—the *Lancet* commented that the chairman of the Council had not made it clear whether he 'accepts the view that the type of ward which he described as "normal" is also the best'. The *Lancet* supposed that the partitioned wards 'common in other countries, but rarely seen in our general hospitals, are still at too experimental a stage to permit of standardized dimensions'.[16] In the same year the Departmental Committee on the Cost of Hospitals, also referring to partitioned wards, wrote:

We doubt whether, at present, the difficulty of supervision can be assessed in terms of the additional staff that it would necessitate.[17]

The new Westminster Hospital, opened in 1939, contains some partitioned wards, and all the wards at the Kent and Canterbury Hospital (1937), and in the new wing of the National Hospital for Nervous Diseases, Queen Square (1938), are partitioned, with beds placed parallel to the window-wall. Recently big wards in many older hospital buildings have been rearranged in that way.

While the idea of associating patients in small groups within a large open ward-space has slowly gained favour in England, in the United States, and on the Continent—notably in Scandinavia and Switzerland—a preference has been shown for ordinary rooms, shared by small numbers of patients, opening off a corridor running the whole length of the ward block. Sometimes the ancillary rooms are interspersed with the wards, sometimes they are all situated on one side of the corridor while the wards are situated on the other. A fundamental difference between American small wards and those on the Continent is that the former do not usually contain more than 4 beds (arranged 2 and 2 on opposite sides of the room) whereas the latter often contain 6 (arranged 3-deep on opposite sides of the room).

Recent Trends in Ward Planning

When delegates from the Charing Cross Hospital visited new hospitals in France, Switzerland, and Sweden in 1947 they reported that 'the number of beds in a ward unit is still clearly in the experimental stage and so also is the division of the beds into sickrooms within the unit'.[18] When the same delegates visited American hospitals, in 1949, they reported that the number of beds in the ward unit varied from 40 to 58 beds divided into two equal nursing units. Each unit might, for example, be arranged as three single rooms, one 2-bedded room, and six 4-bedded rooms. They noted that 'the maximum of four beds in a sick-room arises indirectly through the semi-private patients who are usually those insured under the Blue Cross or similar schemes. These bodies stipulate that their beneficiaries shall not be in rooms containing more than 4 beds and in all recent hospitals this figure is not exceeded because it was considered best to plan the non-paying accommodation on the same principle so as to retain sufficient flexibility of the nursing units.'[19]

II. STUDIES BY THE INVESTIGATION

1. Comparative Studies in the Use of Space and Provision of Facilities

IN planning accommodation for inpatients, the problem is to reconcile maximum economy in provision with proper conditions for medical care and adequate amenity for the patient—including sufficient privacy. At the outset of researches into ward design the Investigation examined the use of space in various modifications of the two principal ways of accommodating inpatients now being used—that is, the 'English traditional' type of ward unit, in which the ancillary rooms open off a short passage at the entrance to a large ward; and the 'corridor' type of ward unit, in which smaller wards and ancillary rooms face each other across a longer passage. Six examples were chosen for comparison:

(1) a traditional, open ward unit, in the Bradford Royal Infirmary;
(2) a variant of the traditional type, in the Westminster Hospital;
(3) a corridor ward unit, in the National Hospital for Nervous Diseases, Queen Square;
(4) a corridor ward unit, taken from the type-plans of the Hospital Facilities Section of the U.S. Public Health Service;
(5) a corridor ward unit deriving from the U.S. Public Health Service type-plans, in the St. Lô Hospital, in Normandy;
(6) a corridor ward unit with beds arranged 3-deep, in the Sandvikens Hospital, in Sweden.

Large plans of these ward units, drawn to the same scale, were used in making the comparison; and since the total number of beds differed in each case, comparison was made by calculating the space in terms of *square feet per bed.*

Considerable diversity was found in the kinds of ancillary rooms provided, and it was decided to ignore any not exclusively serving the beds in the ward unit under consideration—such rooms, for example, as doctors' rooms and rooms used for teaching. Circulation spaces serving areas other than the ward, such as staircase landings and bed-lifts, were also ignored.

The use of space was classified under three main headings: (i) the bed-area (including open wards for two or more beds, and single rooms); (ii) ancillary rooms (including clean- and dirty-utility rooms* and the ward kitchen, the treatment-room, the day-space, sister's and nurses' rooms and stations, and patients' w.c.s and bathrooms); and (iii) corridor space.

Table 1 and *Fig. 2* give the areas, in square feet per bed,

Thompson (of Cornell). By attaching pedometers to nurses he had recorded the miles walked on duty, and had weighed the objects which had, unnecessarily, to be lifted and carried, because insufficient thought had been given to arranging things more conveniently.[13]

* The Investigation has adopted the terms *clean-utility room* in place of the traditional English terms *duty room* or *sterilizing room*,

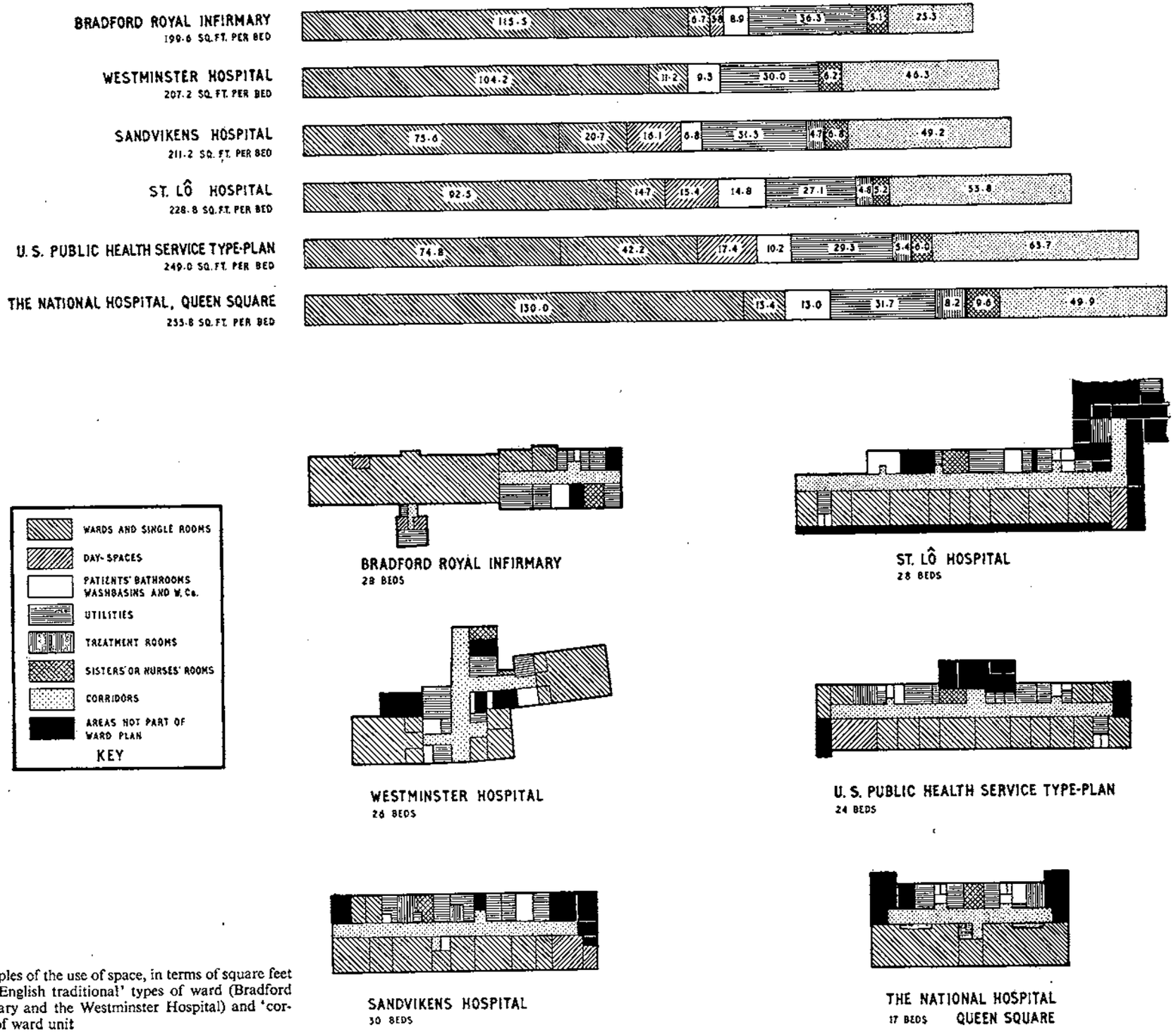

Fig. 2. Examples of the use of space, in terms of square feet per bed, in 'English traditional' types of ward (Bradford Royal Infirmary and the Westminster Hospital) and 'corridor' types of ward unit

for each of the three groups, group (ii), the ancillary rooms, being subdivided as shown in the key.

Table 1. Comparative use of space in two open-ward and four corridor-type ward plans: *Area in square feet per bed occupied by the beds, the ancillary rooms, and corridors*

Hospital	*Ward and single rooms*	*Ancillary rooms*	*Corridors*	*Total area*
Bradford Royal Infirmary (*a*)	122·2 (61%)	54·1 (27%)	23·3 (12%)	199·6
Bradford Royal Infirmary (*b*) with circulation space in centre of ward counted as corridor	94·5 (47%)	54·1 (27%)	51·0 (26%)	199·6
Westminster Hospital	115·4 (56%)	45·5 (22%)	46·3 (22%)	207·2
Sandvikens Hospital	96·3 (46%)	65·7 (31%)	49·2 (23%)	211·2
St. Lô Hospital	107·2 (47%)	67·3 (29%)	53·8 (24%)	228·8
U.S. Public Health Service Type-Plan	117·0 (47%)	68·3 (27%)	63·7 (26%)	249·0
The National Hospital, Queen Square	143·4 (56%)	62·5 (24%)	49·9 (20%)	255·8

The total floor area per bed was found to vary from just under 200 sq. ft. to over 250 sq. ft. As might be expected the older, open wards use the least space, and the corridor wards the most. Within the group of corridor wards there is considerable difference, from 211 sq. ft. per bed in the Sandvikens Hospital to 256 sq. ft. per bed at the National Hospital, Queen Square.

Fig. 2 shows that the relative amount of space occupied by the beds differs in the various examples, but does not primarily account for the differences in total area.

In the two open-ward units the central part of the ward serves also as a corrridor, and the bed-area is thus comparatively large. But even if the central space is counted as corridor (see *Table 1*, analysis *b* for Bradford) the two open-ward units still have a smaller total area than any of the four corridor types. These open wards are pre-war designs and do not contain some of the ancillary rooms which would nowadays be considered necessary; open wards built at the present time would certainly require a greater total area. Nevertheless, where the centre of a ward is used as a corridor the total area will always be relatively small—at the cost of some disturbance to patients.

and *dirty-utility room* in place of *sluice room*. The team had found that the English usage was not generally understood abroad, whereas clean-utility room and dirty-utility room readily gave an idea of the kind of work which went on in each.

It may be concluded that, whatever the size and arrangement of wards, the amount of space allowed round each bed is likely to remain fairly constant because it is determined by nursing considerations and the medical requirement that beds must be sufficiently far apart to reduce the risk of direct cross-infection from patient to patient. One hundred square feet per bed has been recommended (see pp. 12–13), and most of the examples analysed here are close to this standard.

The relative amounts of space occupied by ancillary rooms and corridors (which together equal or exceed the bed-area) are considerably affected by the number and placing of beds in the unit.

In comparing the four corridor-type plans, which all provide a full range of ancillary rooms, it is notable that the larger the number of beds in the unit, the less, generally, is the total area per bed, ancillary-room area per bed, and corridor area per bed. *Table 2* shows the four corridor wards compared in terms of the number of beds in the unit. The highly economical use of space in the Sandvikens Hospital is worthy of special note. This plan uses little more total area than the older, open types, while giving a full range of ancillary rooms, and making no use of ward space for circulation. The area per bed, as is usual in Sweden, is a little less than in England. Even if it were increased from 96 to 100 sq. ft. per bed, the plan would remain very economical in total area. The special features of this plan are the large number of beds in the unit (30) and the use of an arrangement of beds 3-deep. By these means a compact bed-area has been achieved, and corridors and ancillary rooms are enabled to serve more beds than is the case in the other plans.

Table 2. Comparative use of space in two open-ward and four corridor-type ward plans: *Corridor-type wards compared, showing area per bed in terms of the number of beds in the unit*

	No. of beds	*Area per bed in sq. ft.*
Sandvikens Hospital	30	211
St. Lô Hospital	28	228
U.S. Public Health Service Type-Plan	24	249
The National Hospital, Queen Square	17	255

Compactness in Ward Planning

In the ward there are a number of points—the patients' beds—to which service is provided from the ancillary rooms. Clearly the more compact the arrangement of beds, the shorter will be the service distances. *Table 3* shows, for the wards previously discussed, the numbers of beds, the total lengths (measured down the centre-line of the corridors), and the linear density in beds per 10-foot run of ward building. The most compact plan is the Sandvikens Hospital with 1·9 beds per 10-foot run, and the least compact are the wards at St. Lô and in the United States Public Health Service type-plan, with 1·4 beds per 10-foot run. Taking, for the sake of example, the dirty-utility room in the least compact unit and the dirty-utility room in the most compact unit, then for a given pattern of traffic between that room and the beds, walking distances would be about 30 per cent. greater in the least compact unit than in the most compact unit.

Table 3. Comparative use of space in two open-ward and four corridor-type ward plans: *Linear density of beds per 10-foot run of ward building*

	Total length of corridor in feet	*No. of beds in unit*	*No. of beds per 10-foot run*
Bradford Royal Infirmary	182	28	1·6
Westminster Hospital	177	26	1·5
Sandvikens Hospital	157	30	1·9
St. Lô Hospital	197	28	1·4
U.S. Public Health Service Type-Plan	173	24	1·4
The National Hospital, Queen Square	112	17	1·5

Hence from the point of view of economic provision of services, the high linear density achieved in the Sandvikens Hospital is very desirable. It also has the effect of reducing walking distances generally within the ward.

2. Cross-infection in Relation to Ward Planning and Organization

In deciding how space in wards is to be used, the need to guard against the spread of infection must inform every aspect of the plan. 'There cannot surely be a greater contradiction in the nature of things than a disease produced by a hospital', Dr. John Aikin said in 1771.[20] Without precise knowledge about cross-infection, he and his contemporaries empirically did what they could to protect patients, by advocating thorough ventilation, not overcrowding the wards, providing single rooms for

isolation, and trying to promote general cleanliness (cf. p. 12). In the course of the last hundred years the need for these measures has been endorsed by constantly advancing bacteriological knowledge. At the present time infecting organisms are usually identifiable, and their sources in the ward unit are very often known or at least suspected. What cannot always be discovered beyond doubt is which of a number of possible vectors—animate and inanimate—is primarily responsible for transmitting the infecting organism from source to fresh host.

Observed Conditions in Ward Units

The Investigation approached the problem of cross-infection in two ways: by enlisting the help of hospital staffs in keeping records of infections in their wards over varying periods; and by examining the wards where records were being kept, in order to understand the circumstances of cross-infection, and the methods employed to prevent it.

The results of this work were published in the *Lancet*, in April 1952, and the clinical aspects of the survey were summarized as follows:

Information about cross-infection was collected from 13 wards in 8 hospitals, covering periods up to ten months. Of 5095 patients 9·9 per cent developed an illness defined as cross-infection. The commonest troubles were colds and upper respiratory infections, wound infections, urinary infections, and minor septic conditions. The organism most frequently isolated was *Staph. aureus*.[21]

Cases of cross-infection were identified in all the wards, and the proportion of patients developing an infection believed to be due to organisms which they did not harbour on admission was in no ward less than 3 per cent. of all the patients treated in that ward during the period of the survey. In one ward (for children) the proportion was as high as 21 per cent.

The medical member of the team, Dr. J. W. D. Goodall, himself studied 24 ward units, including the 13 wards in which records of the incidence of cross-infection were being kept. They were: 10 general surgical wards, 4 medical wards, 3 maternity wards, 2 children's wards, and single examples of wards for each of the following specialties—ear, nose, and throat cases; neurosurgery; thoracic surgery; plastic surgery; and neurological cases.

Most of the wards were of the large, open type, containing between 18 and 25 beds arranged with the heads to the wall, and although some of the newer wards—which were generally more nearly square than the older wards—had been partitioned, most had not. The average distance between bedcentres was 7 feet, but there was considerable variation in the distance in different wards.

Goodall was impressed by the high standard in nursing procedure at the bedside. The Medical Research Council's recommendations were generally followed; for example, in doing surgical dressings the 'no-touch' technique was everywhere regularly used.[22]

Conditions in Ancillary Rooms

Over and over again lapses and shortcomings in approved hygienic routine were noted which were due principally to a lack of proper equipment and to poor organization of space—particularly storage space.

Often no sharp distinction was made between the kind of jobs which were done in the clean-utility room and those which were done in the dirty-utility room. 'Clean and dirty work went on side by side', wrote Dr. Goodall; 'sterilization, the storage of dirty linen and dressings, and the disposal of excreta were sometimes carried out in the same room. Bathrooms and W.C.s were commonly partitioned off in the same area.' That made it necessary for patients to pass to and fro there.

In ward kitchens he generally found only one sink; and only one ward had a modern sink-unit for washing up, with arrangements for sterilizing china and cutlery in boiling water, and for leaving them in racks to dry by evaporation.

In refrigerators, besides butter and milk, penicillin, blood, skin, and cartilage might sometimes be found, together with pathological specimens waiting to be transferred to the laboratory.

Bathrooms were scarce; the most generous allowance was 1 to 12 patients, the most meagre 1 to 33. All the ward bathrooms, with one exception, were used for many purposes other than bathing patients. For example, bed mackintoshes were often carbolized in the bath and hung up to dry. A surgical ward had no suitable means of sterilizing bedpans, and each evening they were filled with disinfectant fluid and left in the bath for some hours. 'I saw a number of bathrooms in which pillows, oxygen cylinders, dirty-linen bins, urine-testing apparatus, wet bandages, and the outdoor clothes of the domestic staff were occupying a great deal of space', Goodall reported. The bathroom was a common 'dumping ground' for trolleys or other odd articles, such as a dispensary basket or ultraviolet lamp, for which no other convenient place could be found.

The most generous provision of W.C.s was 1 to 9 patients, the most meagre 1 to 24.

Nurses were not always provided with adequate means for washing their hands; in one ward the nurses had to go into the sister's office to wash. In another ward the nurses washed their hands in enamel basins which were subsequently emptied in the sink in the ward kitchen.

The lack of cloakrooms for domestic staff was very evident. Their hats and coats were to be found in passages, bathrooms, kitchens, and linen cupboards. And the nurses were seldom better off. In one unit nurses' cloaks hung over the soiled-linen bins in the dirty-utility room.

The way in which used dressings and dirty linen were disposed of was noteworthy.

A fairly uniform system of disposal of dirty dressings was in operation in most wards. Usually there were at least two bins with lids in the sluice-room or bathroom. One bin was kept for dry dressings and the other for wet dressings; the wet-dressing bin usually contained an antiseptic solution. These bins and the dirty-linen container had often to be carried the length of the ward to be emptied. Porters usually called once or twice a day with a larger bin on wheels into which the contents of the ward bins were emptied. In a few wards a nurse carried the bin down to the basement where she emptied it into a larger bin whose contents were then incinerated. The final disposal was always incineration.

Almost half the wards still counted their soiled linen. The linen was usually changed in the morning when beds were made. The soiled linen was then taken to the sluice-room or bathroom and stuffed into either a bin with a lid or a soiled linen bag of the type recommended by the Medical Research Council. Later in the day a junior nurse pulled all the soiled linen out of the bin or bag, arranged the various articles in piles on the floor, and counted them. She then stuffed them back into the container to await removal by a porter. Sometimes there was so much soiled linen that it was impossible to close the lid or the top of the bag. Most wards rinsed grossly contaminated articles in the sluice-room sink before sending them to the laundry, which would not accept them otherwise. Some wards not only counted linen 'out' but 'in' as well, and in one instance, after a ward count, a nurse took the linen to the supervisor where it was checked and counted again.[21]

Little was done in the wards to suppress dust. In spite of the strong and frequent recommendations of the Medical Research Council and the British Paediatric Association, none of the twenty-four wards oiled either bedclothes

or floors, and the usual way of cleaning was to dry-sweep the floor with a broom two or three times a day. Floors were scrubbed with soap and water every three months, and polished daily with a 'dummy'; sometimes an electric polisher was used, but very few wards had the use of a vacuum cleaner.

Which of these various undesirable practices led directly or indirectly to cross-infection is not known: possibly none of them. But the practices showed unmistakably the demoralizing effect of inadequate accommodation and facilities, even on people working to a discipline as carefully prescribed as is nursing procedure.

3. The Treatment-Room

Two principal reasons have been advanced for providing a treatment-room. The first is that the risk of cross-infection will be reduced if most treatment procedures are done, not in the open ward where the danger of scattering bacteria is unavoidable, but in the more strictly controllable conditions of a special room. The second is that the patient, and whoever treats him, will benefit from the more convenient facilities and the privacy, and other patients in the ward need not be disturbed or distressed.

The Investigation advances a third reason. It has long been a rule in hospitals that after the early morning sequence of bed-making and cleaning in the ward, the dust in the air must be given 'at least one hour' to settle before any treatment is begun.[23] This régime (in conjunction with the time of the doctors' round) is one of the chief causes why it is usually found necessary to wake patients so early. The Nuffield Job-Analysis team noted that, in most of the hospitals they studied, these tidying and cleaning tasks were done between 6 and 7 a.m., so that breakfast could be served between 7 and 8 a.m. and the subsequent bedpan round be finished in time for treatment to start at 9 a.m., at which time also the ward must be 'open' for medical rounds.[24] If patients are taken out of the ward into a treatment-room for dressings to be done there is no longer any need to allow one hour for dust to settle after bedmaking and cleaning.

Record of the Use made of a Treatment-Room

The Nuffield Job-Analysis data showed that the provision of treatment-rooms was desirable; but information as to their use was needed in order to determine how many beds each room could be expected to serve. In this country they are not very commonly found, outside specialized units, but the Investigation was able to collect information about the use of a treatment-room in a men's general surgical ward of 30 beds in a hospital in the north of England. The male nurse in charge of the treatment-room (under the ward sister) was asked to record daily for a month the time taken by various cases. All treatment was done in the treatment-room, the patients (usually six or seven a day—or between 20 and 23 per cent. of the number in the ward) were wheeled there on their beds if they were too ill to walk or be taken on a trolley. Blankets going into the treatment-room were contained in a sheet to reduce the danger of scattering bacteria from them.

During the month's recording the room was used each morning for about 2½ hours between 9.15 a.m. and 12 noon for routine surgical dressings. There was no morning on which it was used for less than 1¼ hours, and on five occasions it was used for over 3 hours at a stretch. It was also frequently used for treatment more specialized than routine dressings, during periods of various duration, in the afternoon and early evening.

Table 4 shows a typical morning's list of cases.

Table 4. Use of a treatment-room: *Record of cases treated between 9.13 a.m. and 12 noon on one day*

Nature of treatment	*Time patient entered treatment room (a.m.)*	*Time patient left treatment room (a.m.)*
1. Removal of alternate sutures	9.13	9.23
2. Removal of alternate sutures	9.27	9.36
3. Inspection of dressing	10.15	10.17
4. Wound toilet and dressing	10.20	10.25
5. Removal of drain from appendicectomy wound	10.50	11.05
6. Insertion of corrugated drain to abdominal wound	11.19	11.34
7. Wound toilet and dressing	11.54	12 noon

Cases treated in the afternoon included some attended to by a surgeon, e.g. a cystoscopy, a sigmoidoscopy, and the injection of varicose veins. It appeared that one treatment-room was sufficient for the needs of the 30-bedded ward, and that it could perhaps carry the work arising from a slightly larger number of beds.

4. Pattern of Movement in Ward Units

After Gilman Thompson's studies (see p. 3 fn.) no similar studies appear to have been made until in January 1949 the Job-Analysis team, sponsored by the Nuffield Provincial Hospitals Trust, began to record the work of nurses in hospital wards. But the purpose of the Job-Analysis was for the most part concerned with answering the question left unresolved by the Working Party on nursing recruitment and training—'What is the proper task of a nurse?'; and the effects of ward design and of facilities available were only incidentally treated.[25]

The Investigation therefore decided to make studies of the actual point-to-point sequence of nurses' movement in ward units at three of the hospitals already considered from the point of view of the use of space and provision of ancillary rooms and services (see pp. 4–6).

At the Westminster Hospital a medical unit and a surgical unit, as nearly as possible identical in design, were chosen for study. Each ward unit was staffed during the day by 1 sister, 2 trained nurses, 6 nurses in training, and 2 orderlies; and at night by 1 trained nurse and 3 nurses in training. At the Bradford Royal Infirmary two identical ward units—one medical, the other surgical—were chosen. Each was staffed during the day by 1 sister, 1 trained nurse, 4 nurses in training, and 2 orderlies; and at night by 1 third-year nurse and 1 first-year nurse in training. Since work at the National Hospital is wholly specialized it was considered that one example of a neurosurgical ward would suffice for study. This ward was staffed during the day by 1 sister, 6 trained nurses, 2 nurses taking additional training after State Registration, 1 full-time and 1 part-time assistant nurse, and 1 full-time and 1 part-time orderly; and at night by 1 staff nurse and 1 post-registration nurse in training. Thus the staff complements were: at the Westminster Hospital, 15 staff to 28 beds; at the Bradford Royal Infirmary, 10 staff to 32 beds; and at the National Hospital, 13 staff (plus 2 part-timers) to 17 beds.

Pilot Studies

Each observer was given a large-scale plan of the ward fixed to a stout piece of cork, with small nails marking

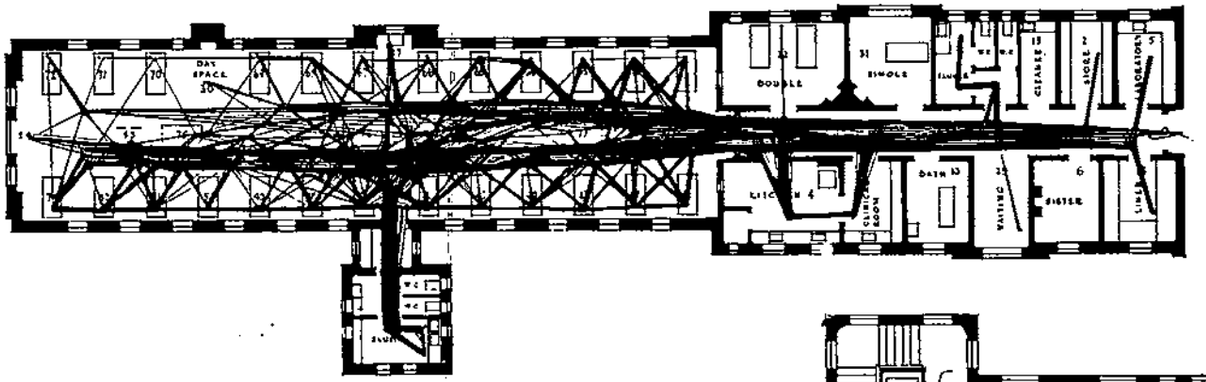

Fig. 3. The pattern of movement of a first-year student nurse during a complete tour of duty in a ward unit in the Bradford Royal Infirmary

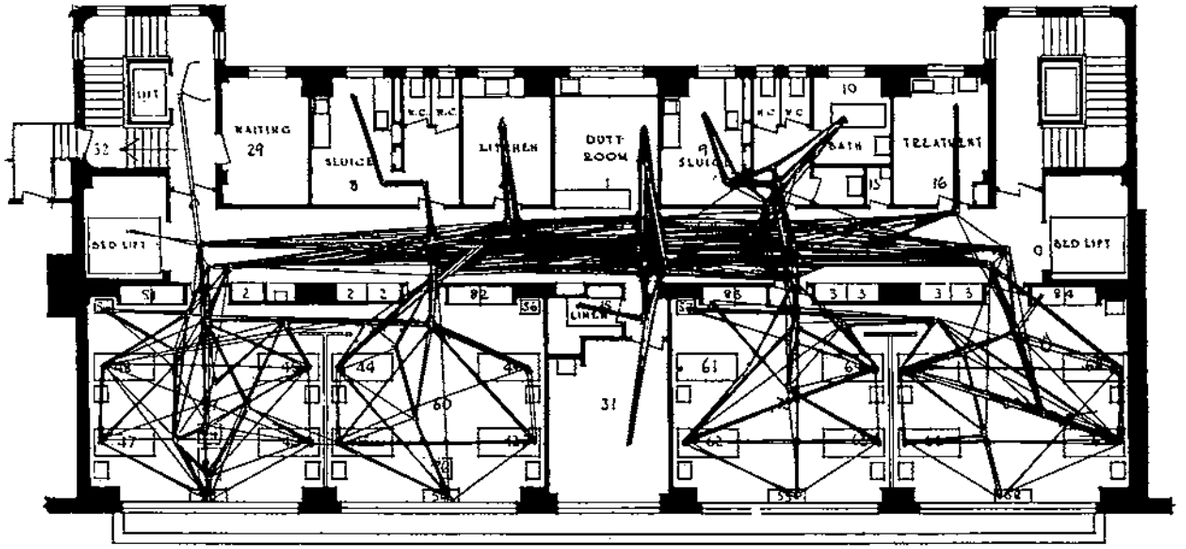

Fig. 5. The pattern of movement of a nurse in training, during a complete tour of duty in a ward unit in the National Hospital, Queen Square

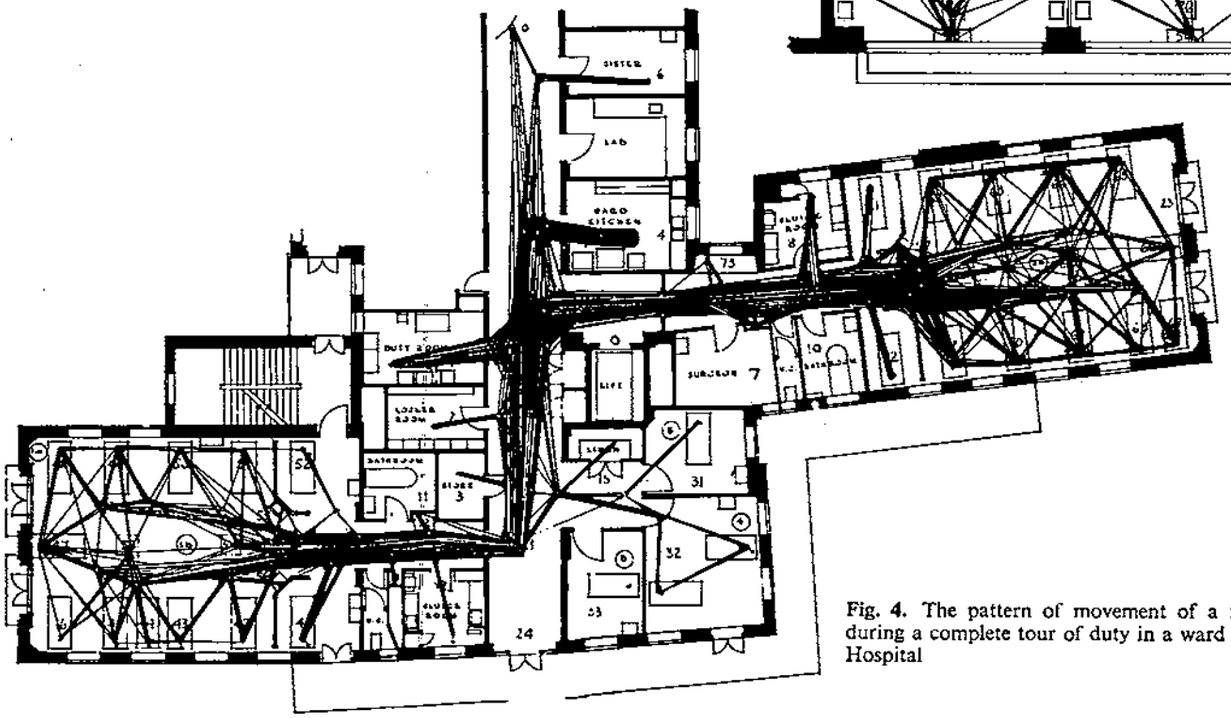

Fig. 4. The pattern of movement of a first-year student nurse during a complete tour of duty in a ward unit in the Westminster Hospital

each key point to which the nurses might have occasion to go. Each observer followed a particular nurse and recorded her excursions by laying a trail of cotton from one relevant nail to another.

Though somewhat cumbersome, the method showed graphically how frequently journeys were made from bed to bed, and from the beds to the various ancillary rooms, and between ancillary rooms; and it served to underline the fact that there was much walking in corridors from which patients could not be seen.

Figs. 3 and 4 show the pattern of movement of two first-year student nurses during a complete tour of duty, one at the Bradford Royal Infirmary, the other at the Westminster Hospital. The density of the strands of cotton laid down in the corridors shows how substantial was the distance walked in those areas, and how often the student nurses had to go out of the bed-area. *Fig. 5* shows the results of a similar study made at the National Hospital, Queen Square.

Final Studies

In the final studies all the key points were given code numbers, for example, from 1 to 20 for ancillary rooms and service points such as cupboards; 21–30 for less important points visited. The observer following a nurse had only to record the appropriate code numbers on a standard form. Every member of the nursing staff, on day or night shift, was followed during one complete tour of duty. The records were subsequently transcribed on to cards and analysed by machine.

In all, 27,327 journeys were recorded and analysed, and it was found that these journeys—each simple excursion from one point to another—made by a nurse in the course of her tour of duty, usually amounted to between 300 and 400, and accounted for between 2 and 2½ miles of walking. These calculations exclude journeys made outside the ward unit itself, and movement around or within the places numbered—for example, round a bed or inside the ward kitchen.

In analysing the journeys, the ward unit was thought of as comprising two elements: (i) the beds, and (ii) the ancillary rooms and services (called *supply points*), of which the three most important (the *main ancillaries*) were the kitchen and the dirty-utility and clean-utility rooms.

The journeys were divided into three groups: (1) journeys within the bed-area—for example from one bed to another, or to trolleys, tables, and wash-basins; (2) journeys to the supply points; and (3) journeys between one supply point and another (called *cross-journeys*). An analysis of these three kinds of journey is given in *Table 5*, each kind of journey being shown as a percentage of the total number of journeys made.

Table 5. Analysis of nurses' journeys in medical and surgical wards in three hospitals: *Percentage of journeys between beds, between beds and supply points, and cross-journeys*

	WESTMINSTER HOSPITAL % of all journeys		BRADFORD ROYAL INFIRMARY % of all journeys		NATIONAL HOSPITAL % of all journeys
	Surgical Ward	*Medical Ward*	*Surgical Ward*	*Medical Ward*	*Neuro-surgical Ward*
Journeys within the bed-area	48·6	45·9	53·8	58·0	41·1
Journeys between bed-area and supply points:					
(*a*) 3 main ancillaries .	26·0	30·0	26·8	26·6	31·4
(*b*) All other supply points* . .	7·1	5·7	4·0	3·3	7·8
Cross-journeys. . .	18·3	18·4	15·4	12·1	19·7
TOTALS . . .	100·0	100·0	100·0	100·0	100·0

* Store cupboard, linen cupboard, medicine cupboard, 'laboratory' (at Bradford, used chiefly for testing urine and arranging flowers), treatment room (at the National Hospital), sister's room, bathrooms, day-space, visitors' space, cleaners' cupboard, doctors' room, telephone, patients' cupboards.

In *Table 5* the preponderance of journeys recorded within the bed-area in comparison with the number of journeys made to the three main ancillary rooms, and between one supply point and another, reflects the established nursing practice of organizing as much as possible of the routine work as rounds from bed to bed—toilet rounds, for example, and rounds for bed-making and bed-tidying, attending to pressure areas, and distributing food and drinks. The first stage of most rounds takes the nurse from the bed-area into the ancillary-room area, where she collects together everything which may subsequently be needed. Only in this way can she hope to save steps, where beds and ancillaries are arranged in line down the long sides of a rectangle.

Table 6 shows a detailed analysis of the proportion of journeys made from the beds to each of the three principal ancillary rooms: the ward kitchen, the dirty-utility room, and the clean-utility room.

Table 6. Analysis of nurses' journeys in medical and surgical wards in three hospitals: *Percentage of journeys from the beds to the kitchen and dirty- and clean-utility rooms*

	WESTMINSTER HOSPITAL		BRADFORD ROYAL INFIRMARY		NATIONAL HOSPITAL
	Surgical Ward	*Medical Ward*	*Surgical Ward*	*Medical Ward*	*Neuro-surgical Ward*
	%	%	%	%	%
From beds to ward kitchen	37	45	31	39	29
From beds to dirty-utility room	35	34	37	37	45
From beds to clean-utility room	28	21	32	24	26
TOTALS . . .	100	100	100	100	100

Despite differences in the layout of the ward units at each of the three hospitals, the proportion of all journeys made in them, both those shown in *Table 5* and those shown in *Table 6*, are similar. In particular it may be seen that, in the number of journeys made, each of the three main ancillaries is of almost equal importance, though journeys connected with food and with the patients' toilet slightly out-number journeys to the clean-utility room.

In all three hospitals it was difficult for the nurses to supervise the patients in the single and 2-bedded rooms while attending to patients in the ordinary wards. As it is obviously unsatisfactory for the nurses merely to glance into these rooms while on the way to ancillary rooms, the small rooms, particularly in surgical units, were not much used for very ill cases. These patients were commonly placed in beds nearest the door of the ward where they could be under the eye of one or other of the nurses. Therefore fewer journeys were made to single and 2-bedded rooms than to more readily accessible beds in open wards.

5. The Use of Clean- and Dirty-Utility Rooms

The records of the number of journeys made to the ward kitchen, the dirty-utility room, and the clean-utility room showed the preponderant and very nearly equal importance of each of those rooms in the ward unit, whether medical or surgical (cf. *Table 6*).

In considering the three rooms in turn, the Investigation came to the conclusion that, although the planning and organization of the ward kitchen evidently needed careful study, the work done is not different in kind from

much of the work done in a household kitchen. The uses to which dirty- and clean-utility rooms are put are peculiar to hospital wards, so that particular studies of work in progress in them were needed before attempting to design and equip them.

The Ward Units chosen for Study

Five surgical units were chosen for study, in three hospitals:

Ward unit A, in *Hospital 1*—a London teaching hospital—consisted of two 14-bedded wards, one for men, the other for women, with ancillary rooms in common. The unit was staffed during the day by: 1 sister, 2 trained nurses, 6 nurses in training, 2 ward orderlies, and 2 domestic workers; at night it was staffed by: 1 trained nurse and 2 nurses in training—a total complement of 16 staff to 28 beds.

Ward unit B, a 24-bedded ward for men, and *Ward unit C*, a 32-bedded ward for women, were both in *Hospital 2*—a large general hospital in Greater London. *Ward unit B* was staffed during the day by: 1 sister, 1 trained nurse, 2 nurses in training, 2 part-time nurses, 2 ward orderlies, and 2 domestic workers; at night it was staffed by: 1 nurse in training, a second nurse in training shared by two wards, and one orderly shared by four wards. *Ward unit C* was similarly staffed except that during the day there were 3 nurses in training and only 1 part-time nurse. Each ward unit therefore had a complement of 11 staff (to 24 and 32 beds, respectively) plus the shared services of a nurse in training and an orderly, at night.

Ward unit D, a 20-bedded ward for women, and *Ward unit E*, a 22-bedded ward also for women, were both in *Hospital 3*—a medium-sized hospital built during the nineteen-thirties in a town in the Home Counties. *Ward units D* and *E* were each staffed during the day by: 1 sister, 2 trained nurses, and 5 nurses in training; at night they were staffed by 2 nurses in training. In addition, during the day, *D* had the services of 1 orderly, and *E* of 1 domestic worker—a total complement of 11 for each ward unit.

Clean-Utility Rooms

Clean-utility rooms are chiefly used in preparing to give treatment: for example, for sterilizing bowls and instruments, laying up dressings trolleys, and packing surgical-dressing drums.

At *Hospital 1* the area of the clean-utility room was 131 sq. ft.; at *Hospital 2* the area of each clean-utility room was 117 sq. ft.; and at *Hospital 3* the area of one was 81 sq. ft., and of the other 73 sq. ft. Equipment included: a combined sterilizer for bowls and instruments; a sink with draining-board, and/or a wash-basin; storage space for drums of sterile dressings; dressings trolleys; storage cupboards; a workbench or table.

In all three hospitals such pieces of equipment as were suitable were mounted on the wall to make cleaning the floor easier.

In each unit in turn recordings were made during a 5-day period, from Monday to Friday. It was found that the clean-utility rooms were most continuously in use between 9.30 a.m. and 12 noon daily. Detailed studies were then made during that peak period, to find the actual number of minutes which the nurses spent, between 9.30 a.m. and midday, in various preparatory activities connected with the treatment of patients, excluding the time spent in incidentals such as hand-washing, pausing to speak to each other, and tidying the workbench.

Table 7 shows, for the daily 2½-hour peak period of work, the proportion of time during which the clean-utility rooms were unoccupied or occupied by one, two, or more than two, nurses. It may be seen that there were rarely more than three nurses together for longer than a very short space of time.

Table 7. Daily peak period of occupancy in the clean-utility room in three hospitals: *Percentage of time during which different numbers of nurses were together in the room*

HOSPITAL 1

WARD UNIT A. *No. of nurses occupying room together*

9.30 a.m.–12 noon (% time (in min.))	*0*	*1*	*2*	*3*	*4*	*5*
Monday	52·7	27·0	15·2	4·6	0·3	—
Tuesday	60·2	21·3	13·3	4·8	0·3	—
Wednesday	36·5	37·3	19·2	5·7	1·0	0·3
Thursday	37·1	34·6	18·6	8·0	1·5	—
Friday	43·8	38·0	13·5	3·6	1·0	—

HOSPITAL 2

WARD UNIT B

9.30 a.m.–12 noon (% time (in min.))	*0*	*1*	*2*	*3*	*4*	*5*
Monday	70·1	19·5	9·0	1·2	—	—
Tuesday	59·9	27·5	11·3	1·2	—	—
Wednesday	61·1	30·3	8·0	0·5	—	—
Thursday	72·9	21·6	5·3	—	—	—
Friday	76·6	21·5	1·8	—	—	—

WARD UNIT C

0	*1*	*2*	*3*	*4*	*5*
73·8	22·5	2·2	1·5	—	—
74·6	18·3	4·3	2·7	—	—
79·4	18·2	2·0	0·2	0·2	—
77·1	21·8	1·0	—	—	—
66·6	25·8	6·5	0·8	0·2	—

HOSPITAL 3

WARD UNIT D

9.30 a.m.–12 noon (% time (in min.))	*0*	*1*	*2*	*3*	*4*	*5*
Monday	48·5	41·0	10·2	0·3	—	—
Tuesday	52·6	29·3	16·3	1·7	—	—
Wednesday	43·6	36·0	18·0	2·2	0·2	—
Thursday	61·0	31·8	6·8	0·3	—	—
Friday	27·6	25·1	29·0	12·3	5·7	0·2

WARD UNIT E

0	*1*	*2*	*3*	*4*	*5*
57·3	26·5	14·2	2·0	—	—
70·4	25·6	3·0	0·8	—	—
52·1	34·6	11·7	1·5	—	—
77·1	18·5	3·7	0·7	—	—
52·3	32·8	9·5	5·3	—	—

Dirty-Utility Rooms

The main jobs done in dirty-utility rooms are emptying and cleaning such utensils as bedpans, urine-bottles, and sputum-mugs, disposing of used dressings and similar material, testing specimens of urine, and cleaning, and where necessary disinfecting, all grossly soiled or contaminated objects not to be thrown away. It was observed that the rooms were also used for arranging flowers brought for the patients.

At *Hospital 1* the dirty-utility room was 192 sq. ft. in area; at *Hospital 2* each dirty-utility room was 157 sq. ft. in area; at *Hospital 3* one was 88 sq. ft. and the other 90 sq. ft. in area. The equipment included: a bedpan washer; a slop-sink with flushing cistern; a sink with porcelain draining-slab; a bedpan storage rack, and in the men's wards a rack for urine-bottles; cupboards for storing mackintosh sheets, bowls, mugs, &c.; a ventilated cupboard for storing, and a cupboard for testing, urine specimens; bins for the disposal of used dressings; soiled-linen bins, and the dirty-linen 'rounder'.

To discover the peak periods of use in the dirty-utility rooms in the same ward units in which the use of the clean-utility rooms had been observed, continuous time-studies were made between 6 a.m., when activity in the ward began to assume its daily rhythm, and 8 p.m., when patients had been prepared for the night. The most important factor in the use of the clean-utility rooms appeared to be the lengths of time during which it might be occupied by more than one person working there. So far as the dirty-utility room was concerned, the most important factor (implicit in the nature of the work done there) appeared to be the number of brief visits made to the room to fetch, empty, and clean utensils during various kinds of toilet rounds. *Fig. 6* shows the number of visits made to the dirty-utility room during each successive half-hour between 6 o'clock in the morning and 8 o'clock at night in each of the five ward units. The times of meals, which were the same at all three hospitals, are indicated by heavy parallel lines.

The team found that the busiest periods were:

6.30 to 9.00 a.m.
1.10 to 1.40 p.m.
4.00 to 5.00 p.m.
6.00 to 6.30 p.m.
7.00 to 7.30 p.m.

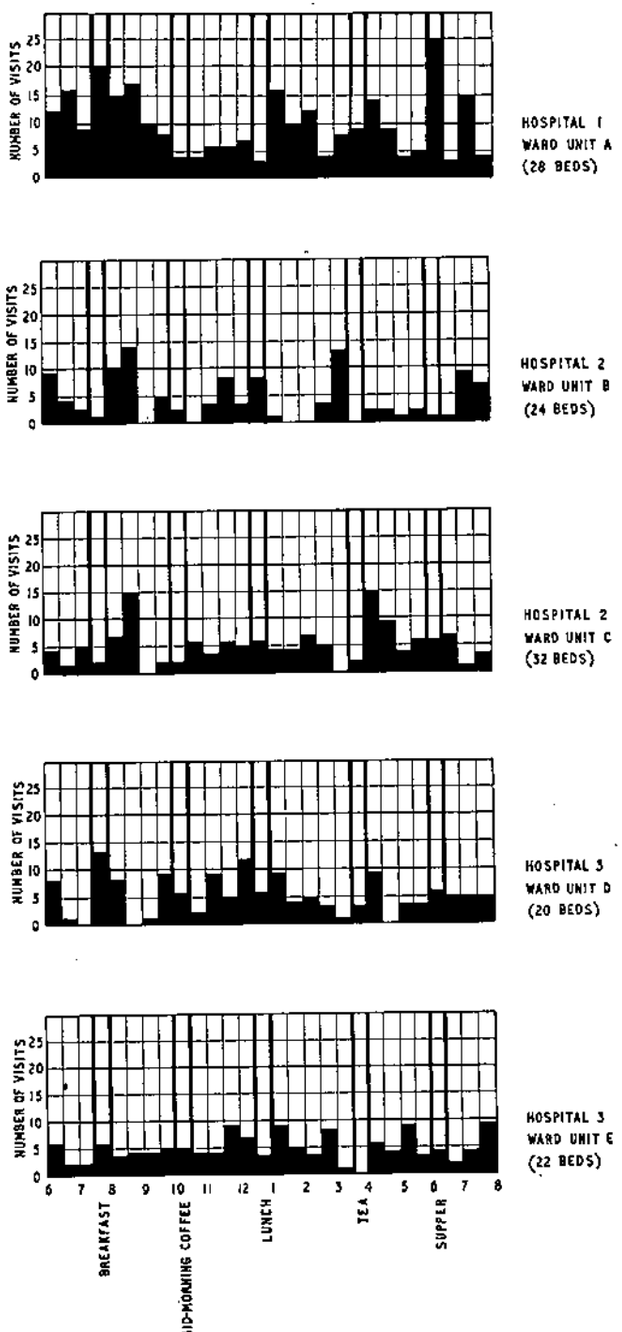

Fig. 6. Number of visits to the dirty-utility rooms made by nurses and orderlies during successive half-hours between 6 a.m. and 8 p.m.

Table 8 shows the different jobs done during the peak periods of activity and the time spent on each.

Table 8. Time spent in the dirty-utility room in three hospitals: *Jobs done by nurses and orderlies during peak periods between 6 a.m. and 8 p.m.*

	HOSPITAL 1 *Ward unit*	HOSPITAL 2 *Ward units*		HOSPITAL 3 *Ward units*	
	A	*B*	*C*	*D*	*E*
Occupation	*Total time (min.)*	*Total time (min.)*	*Total time (min.)*	*Total time (min.)*	*Total time (min.)*
Dealing with:					
Bedpans	22	17½	20½	36¼	45
Urine-bottles	32¼	25	—	—	—
Used dressings	7½	2	2½	1¾	6¼
Soiled linen	7¾	2¼	1¾	19½	¼
Rubber sheets, Bowls, &c.	23¾	14¼	7¾	9½	8¾
Cleaning and tidying room	50½	25¼	47¼	61¼	26¼

6. The Space required round Each Bed in the Ward

About the middle of the eighteenth century Sir John Pringle expressed the opinion that, to keep the air in hospitals fresh and to reduce the risk of contagion, the number of patients admitted to the ward should be such 'that a person unacquainted with the danger of bad air, might imagine there was room to take in double or triple the number'.[26] His belief in the efficacy of sufficient space round each sick-bed was shared by his contemporaries, and indeed persisted in this country.

A century after Sir John Pringle's pronouncement Florence Nightingale gave exact measurements for what she considered to be proper bed-spacing in wards.

Let us inquire what is the smallest amount of superficial area we can do with. Hospital beds are generally from 3 feet to 3 feet 6 inches wide, and 6 feet 3 inches long, the bed space being increased to 7 feet by the bed being a little removed from the wall. The mere surface required to hold the bed is hence from 21 square feet to 24½ square feet. . . . There should be space sufficient between the sides of adjacent beds to avoid stagnation of air altogether. There should also be room for free movement of three or four persons, for the use of a night-chair, without annoyance to the next patient, and also for a portable bath, when required. . . . In round numbers, the superficial area per bed should be not less than 100 square feet.[27]

Florence Nightingale's opinion was as usual accepted in principle and often acted upon in the voluntary hospitals, but a distinguished *ad hoc* committee (which included the President of the Royal College of Physicians and the Regius Professor of Medicine in the University of Oxford) reported to the Poor Law Board in 1866–7 that in their view 6 feet between bed centres was sufficient spacing for the ordinary sick.[28]

In 1937 the Departmental Committee appointed by the Minister of Health to consider the cost of building and running various kinds of institutions, particularly hospitals, provided by Local Authorities, reported that they had decided to adopt a distance of 8 feet between bed centres as their standard—as recommended by the Voluntary Hospitals Commission (1928). They noted, however, that in voluntary hospitals it seemed to be generally accepted that a *minimum* of 100 sq. ft. and 1,200 cu. ft. per bed should be allowed, even when beds were arranged as in the Rigs Hospital.

On the question of cubic space per bed, the Departmental Committee commented:

> We are of opinion that sufficiently exact data do not exist on which to base a confident opinion in respect of the space desirable on hygienic grounds. Moreover, there is very general agreement, in which the witnesses who gave evidence concurred, in regarding height as relatively unimportant in comparison with floor area and distance between bed centres, and we are of opinion that if adequate area per bed and, more especially, sufficient distance between adjacent beds are provided the demands of hygiene will be satisfied leaving the height to be determined mainly by considerations of proportion and amenity. Accordingly, the standards we have adopted have been based upon the amount of space required for convenient working. In adopting this criterion, however, we believe that the resulting dimensions are adequate also from the hygienic point of view.[29]

Although the General Nursing Council of England and Wales advocated, in a memorandum on hospital planning issued in 1946, that 'the distance between the bed centres should not be less than 10 ft. as an absolute minimum', the revised edition of the Medical Research Council's memorandum on *The Control of Cross Infection in Hospitals* (1951) required only a minimum of 8 feet between bed centres.[30]

In the United States the Hospital Facilities Section of the Public Health Service allows 88·5 sq. ft. per bed in 4-bedded rooms, 95 sq. ft. in 2-bedded rooms, and 115 sq. ft. in single rooms, with bed centres 7 ft. apart. On the Continent new hospitals have a distance of 6 ft. or 6 ft. 6 in. between bed centres; and the area per bed in 4-bedded and 6-bedded rooms is about 88 sq. ft. or rather less, and in 2-bedded rooms, about 95 sq. ft.

Cinematograph Record of Nursing Procedures at the Bedside

Medical requirements for controlling cross-infection remain the principal considerations in the spacing of beds; and patients must not feel that they are being crowded. But the Investigation decided that it would be useful to see how much space is taken up by the furniture usually provided for the patient's use while he is in bed, and how much room is needed for various bedside nursing procedures.

Of the furniture, only the bed and the patient's locker have a more or less fixed location within the bed-space; in wards where over-bed tables are used, these can very readily be moved out of the way.

A cinematograph recording of work in progress against a clearly visible scale seemed to be the most telling way of deciding how much space nurses, with their equipment, would take up at the bedside. A film was made with the assistance of the Building Research Station film unit and a London teaching hospital which allowed the actual shooting to be done in one of its wards. Later a second film was made of precisely similar procedures in a small general hospital near London; the results in the two hospitals were nearly identical.

The nurses invited to take part in the filming were not the very slimmest, and they were asked to carry out various procedures as nearly as possible as usual—which might or might not be strictly according to orthodox teaching.

An electric clock, wired so that it could be used like a stopwatch, was placed conspicuously at the foot of the bed, so that the time spent at various distances from the bed could be analysed. The patient's locker was left in place, either on the right- or on the left-hand side of the bed, during filming. The floor was marked out in 1-foot squares, to enable the space occupied in nursing to be measured. The procedures to be filmed were chosen because they were known to be frequently necessary, and because more than one person, often using fairly bulky equipment, would be involved. The procedures were:

(1) making a bed with the patient in it;
(2) attending to the usual physical pressure-points for a bedfast patient;
(3) assisting a patient getting out of bed and into a wheel-chair;
(4) lifting a patient out of bed and on to a trolley;
(5) giving an intravenous infusion;
(6) arranging an oxygen tent over a patient in bed;
(7) taking an X-ray photograph of a patient's chest (*a*) from the front, and (*b*) from the side.

In addition to nurses, a house-surgeon, a radiographer, and orderlies took part in some of the procedures.

It may be seen from *Table 9* that the only procedures which encroached on space beyond 4 feet on either side of the bed (and then only briefly) were: lifting the patient on to a trolley, which needed two orderlies as well as a nurse; arranging an oxygen tent over the patient in bed, which was done by 2 orderlies and 2 nurses; and taking an X-ray photograph of the patient's chest from the front, the radiographer being assisted by 2 nurses.

In making the bed the nurses remained well within the 4-foot mark, and during most of the time were within 2 feet of the bed-edge (see *Fig. 7*). Helping a patient into a wheel-chair was also accomplished within the 4-foot mark, and so was giving an intravenous infusion. *Fig. 8* shows the grouping for the latter procedure—one corner of the dressings trolley is just on the 4-foot line. In attending to pressure-points, one of the two nurses was stationed within 18 inches of the bed-edge, and the other made only one brief excursion over the 3-foot line.

Apart from procedures which involve more than one person in addition to the patient, and the use of sizable pieces of equipment, such as dressings trolleys, wheel-chairs, and so on, most nursing procedures are done close to the bed. Hence it may be concluded that to satisfy the needs of nursing a 4-foot space between beds (that is, bed centres at 7 feet) is adequate.

7. Accommodation to be provided in Single Rooms

Both the Investigation (see p. 10) and the Nuffield Job-Analysis[31] observed that the single rooms in a ward unit were not always occupied by the patients for whom they are primarily intended—those whose medical condition makes them particularly in need of a room to themselves, in their own interests or those of other patients. There is usually a good reason why convalescent patients, sick (but

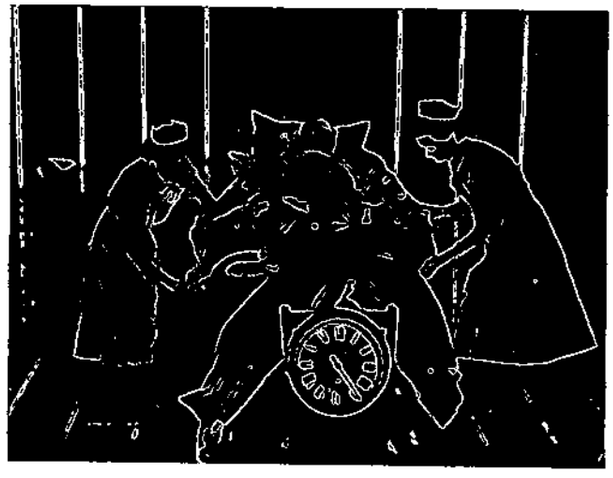

Fig. 7. The space needed to make a bed with the patient in it

Fig. 8. The space needed to set up an intravenous transfusion at the bedside

Table 9. Space round the bed needed for some common nursing procedures: *Time in seconds spent at various distances from the bed in a general medical and a general surgical ward*

Function	*Operator*	*Distance from bed on left-hand side*								*Time spent in front of bed*	*Distance from bed on right-hand side*							
		Over 4 ft.	*3½–4 ft.*	*3–3½ ft.*	*2½–3 ft.*	*2–2½ ft.*	*1½–2 ft.*	*1–1½ ft.*	*0–1 ft.*		*0–1 ft.*	*1–1½ ft.*	*1½–2 ft.*	*2–2½ ft.*	*2½–3 ft.*	*3–3½ ft.*	*3½–4 ft.*	*Over 4 ft.*
Making bed with patient in it	Nurse	—	4	7	2	65	177	168	69	—	—	—	—	—	—	—	—	—
	,,	—	—	—	—	—	—	—	—	—	1	185	249	54	—	3	—	—
Attending to patient's pressure points	,,	—	—	14	23	4	17	64	—	—	—	—	—	—	—	—	—	—
	,,	—	—	—	—	—	—	—	—	—	—	125	—	—	—	—	—	—
Assisting patient from bed to wheel-chair	,,	—	1	5	30	13	27	72	—	—	—	—	—	—	—	—	—	—
	,,	—	5	15	17	3	14	24	—	2	—	70	3	—	—	—	—	—
Lifting patient from bed to trolley	Orderly	—	—	—	—	36	—	4	54	31	—	—	—	—	—	—	—	—
	,,	—	—	12	20	44	4	41	—	9	—	—	—	—	—	—	—	—
	Nurse	20	29	44	—	3	25	3	—	—	—	—	—	—	—	—	—	—
Intravenous infusion	Surgeon	—	—	—	—	—	—	—	—	—	—	173	55	45	45	—	—	—
	Nurse	—	—	—	—	—	—	—	—	—	—	81	32	30	48	87	40	—
Arranging an oxygen tent over patient in bed	,,	—	1	—	1	—	16	31	25	—	—	—	—	—	—	—	—	—
	,,	—	—	—	—	—	—	—	—	—	27	13	30	6	—	—	—	4
	Orderly	—	—	—	—	—	—	—	—	—	—	3	22	—	5	—	23	34
	,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	18
Chest X-ray (front)	Radiographer	20	—	6	8	14	5	46	37	61	—	—	11	6	12	15	—	—
	Nurse	—	—	—	—	—	—	—	246	—	—	—	—	—	—	—	—	—
	,,	—	—	—	—	—	—	—	—	—	246	—	—	—	—	—	—	—
Chest X-ray (side)	Radiographer	—	9	51	12	8	1	2	—	22	—	—	4	14	48	9	—	—
	Nurse	—	—	—	—	—	—	—	180	—	—	—	—	—	—	—	—	—
	,,	—	—	—	—	—	—	—	—	—	180	—	—	—	—	—	—	—
TOTAL time in seconds		40	49	154	113	190	286	455	611	125	454	650	406	155	158	114	74	56

Time in seconds

not very sick) members of the hospital staff, amenity-bed patients, and others who cannot lay claim to privacy by medical right are often placed in single rooms although there are gravely ill patients in the open ward. It is because in most English open-ward plans the only place where the single rooms can be fitted in is among the ancillary rooms outside the ward itself. This location means that during the recurrent peak periods of work the nurses have to withdraw attention from patients in the open ward more completely than is at all desirable, in order to attend to patients in the single rooms, and vice versa. Faced with this dilemma, the ward sister tends to put the illest patients into whichever beds in the open ward are most easily visited and kept within view by the nurses.

The Investigation formed the opinion that if single rooms were situated so that the nurses could conveniently divide their attention between the patients in them and the rest of the patients, more might justifiably be provided than are generally provided now. But insufficient information was available to show either how many more rooms would be appropriate in different kinds of ward or which patients could most suitably be placed in them.

Since *Sections 4* and *5* of the National Health Service Act, 1946, lay it down that beds in single rooms may only be allotted to paying patients if they are not 'for the time being needed by any patient on medical grounds', it is evident that medical need remains the only basic criterion for determining the number to be provided; and it was from that point of view alone that a study of the matter was made.[32]

Study of the Use to be made of Single Rooms

Twenty-four senior specialists, representing every clinical speciality, were asked on what medical grounds they would place patients in single rooms. The reasons they gave showed that patients could be classified under five headings:

(1) patients liable to infect others;
(2) patients particularly susceptible to infection;
(3) seriously ill patients and those who are dying;
(4) patients likely to disturb others;
(5) patients requiring special attention.

Asked what proportion of the beds in their wards they would wish to have in single rooms, and how long,

approximately, they would expect patients (in the various categories listed above) to occupy them, most of them replied that they could not hazard an opinion on either point with any confidence.

It was therefore decided that an attempt should be made to establish data by using a schedule to assess the eligibility of patients (in open wards) to occupy single rooms had such been available. The schedule of 'conditions warranting single-room accommodation' were those suggested by the twenty-four specialists. The original five categories were rearranged into two main groups: (A) patients who have to be kept under close observation, and (B) patients who do not need frequent supervision by the nursing staff. Examples of the former, type A, are patients dying or seriously ill, and cardiac patients needing peace and quiet; examples of the latter, type B, are patients who may be infectious or who are otherwise socially unacceptable. The distinction is important for ward planning, since type A single rooms must be situated for easy observation, and therefore near the centre of the ward, whereas type B single rooms can if necessary be placed at the periphery of the ward.

Method of Study

Resident medical and surgical officers, in eight hospitals, were invited to take part in a survey of patients to determine which of them would have been placed in a single room had one been available. Twenty-nine resident officers (in 24 wards with a total of 1,010 beds between them) agreed to record, on their daily rounds, which of their patients qualified according to the prepared schedule. The daily recording was to last not less than one month. The wards chosen were of the following kinds:

medical (10 examples)
surgical (10 examples)
gynaecological (4 examples)

Analysis of the Survey Recordings

The records showed that in addition to patients who needed isolating, primarily for medical reasons, a large number of patients would have been put into single rooms because their illnesses made them unacceptable to their fellow patients. Although the kind of 'demand' for single rooms was fairly similar in different wards allocated to the same specialty, the day-to-day demand fluctuated widely in all wards. These fluctuations made it useless to try to estimate the number of single rooms needed, on the basis of *average* requirement.

It was found possible to use a simple mathematical model to evaluate (1) the extent to which the demand for single rooms could be met with varying degrees of separate accommodation—the 'efficiency of provision', and (2) the extent to which the single rooms actually provided would be occupied for the proper purpose—the 'efficiency of use'.

If enough single rooms are provided to accommodate all the patients requiring them at the peak of demand, there will be many occasions between peaks when too few patients will qualify for the number of rooms available. If a satisfactory balance is to be struck between these conflicting factors, namely the purely medical needs and the necessity for economizing space and finance, hospital planners must try to choose an optimum number of single rooms, giving as high an efficiency of provision as possible without allowing the efficiency of use to drop too low. Tables giving these standards of efficiency for varying amounts of separate accommodation are needed in order to make an adequate decision in the matter. It will in general be necessary to have such tables constructed for the particular specialty and ward size under consideration.

Table 10 shows how the data from the ten medical wards surveyed were analysed to yield recommendations for providing single rooms for a hypothetical 16-bedded medical ward. Because of the importance of type A rooms—those intended for patients needing constant supervision—they have been given separate columns in *Table 10*.

Table 10. Predicted use of single rooms for patients needing them on medical or social grounds: *Medical ward (16 beds), based on data from ten wards*

Number of single rooms	Both types of single room		Type A rooms only	
	Efficiency of provision (%)	Efficiency of use (%)	Efficiency of provision (%)	Efficiency of use (%)
2	47	97	65	86
3	67	92	84	74
4	82	84	94	62
5	92	75	98	52
6	97	66	—	—

It may be seen that in a 16-bedded medical ward, if four single rooms are provided (three of them being of type A), then they will meet 82 per cent. of the total demand for single rooms (and 84 per cent. of the demand for type A rooms) and will be occupied by fully eligible patients for 84 per cent. of the time—though the type A rooms would be so occupied for only 74 per cent. of the time.

Table 11 similarly shows the single-room requirement in a 16-bedded surgical ward. This table is based on data relating to only eight of the ten surgical wards included in the survey. The data relating to the remaining two wards (both in the same hospital) differed markedly from the rest for various special reasons and they were therefore rejected as being atypical.

Table 11. Predicted use of single rooms for patients needing them on medical or social grounds: *Surgical ward (16 beds), based on data from eight wards*

Number of single rooms	Both types of single room		Type A rooms only	
	Efficiency of provision (%)	Efficiency of use (%)	Efficiency of provision (%)	Efficiency of use (%)
1	36	95	45	87
2	65	86	76	73
3	84	74	92	59
4	94	62	98	47
5	98	52	—	—

It may be seen that if three single rooms are provided (two of them being of type A) 84 per cent. of the total demand for single rooms (and 76 per cent. of the demand for type A rooms) will be met, though they will be occupied by fully eligible patients for only 74 per cent. of the time (and type A rooms will be so occupied for only 73 per cent. of the time).

The data on the four gynaecological wards included in the survey suggested a total of three single rooms in a ward of 16 beds (two being of type A). Such a provision would satisfy 75 per cent. of the total demand (and 80 per cent. of the demand for type A rooms) and the rooms would be occupied by fully eligible patients during 86 per cent. of the time (type A rooms being so occupied for only 67 per cent. of the time). If the number of type A rooms was reduced from two to one, that one room would be occupied by fully eligible patients for 83 per cent. of the

time, but less than half the demand for type A rooms would be met.

8. Early Ambulation and the Planning of Ward Units

In ward planning, an important medical development of recent years which must be taken into account is the principle of *early ambulation.*

According to this principle patients, with some exceptions, should be encouraged to get out of bed and move about, and in particular should go to a w.c., either walking or in a wheel-chair, instead of being made to use a bedpan.

Some patients have always been allowed to get up during their stay in the ward; but the mid-nineteenth-century belief that complete rest was an essential part of treatment for the majority of cases has had a lasting influence on ward design and nursing organization. On the assumption that the greater proportion of patients in the ward would be bedfast, it was not thought necessary, even ten years ago, to provide enough bathrooms, lavatory-basins, and w.c.s for the use of all or even most of the patients at any given time. Nor was it thought necessary to give each patient a cupboard for his day-clothes, or to arrange for any comfortable place a little removed from the bed-area where he could sit, and perhaps eat some of his meals.

In 1950, when the members of the Investigation were thinking about this problem, it was evident that there were no firm data on which to estimate how many bathrooms, lavatory-basins, and w.c.s ought to be provided for any particular ward unit, or how many patients might daily be expected to occupy a day-space. A small survey was therefore made, and the results were published in January 1951.[34]

Survey on Early Ambulation Policy in Wards

The medical member of the team examined patients in a number of hospital wards to assess their capacity to get up and look after themselves. He decided upon two different approaches to assessment—one from the standpoint of a doctor practising early ambulation, and the other from the standpoint of a doctor of the traditional school. After a little experience Dr. Goodall found it not unduly difficult to act as an advocate of each of the two schools of thought. He went round each of the chosen wards in eight different hospitals (five of them teaching hospitals) accompanied by the ward sisters concerned and the appropriate medical officers—usually senior registrars. With their help Dr. Goodall, in the dual role of advocate for early ambulation and for traditional methods, classified each patient as being I, bedfast, or II, partially ambulant (i.e. able to get out of bed, with or without assistance, to wash and use the w.c.), or III, fully ambulant. In category III a judgement had often to be made on how many patients might already have been discharged under a stricter régime of early ambulation.

The wards in which patients were classified included: six general surgical wards (155 patients); six general medical wards (167 patients), and four gynaecological wards (109 patients). *Table 12* shows the results.

Table 12. Early ambulation: *Actual and hypothetical classification of patients in general surgical, general medical, and gynaecological wards.*

A: *General surgical ward (155 patients)*

Category	I *Bedfast* (%)	II *Partly ambulant* (%)	III *Fully ambulant* (%)
Actual régime	50·3	20·0	29·7
Early ambulation	16·4	35·0	48·6
Traditional	66·7	17·3	16·0

B: *General medical ward (167 patients)*

Category	I (%)	II (%)	III (%)
Actual régime	53·3	24·6	22·2
Early ambulation	25·7	28·3	46·1
Traditional	61·1	13·9	25·0

C: *Gynaecological ward (109 patients)*

Category	I (%)	II (%)	III (%)
Actual régime	46·8	33·0	20·2
Early ambulation	16·2	45·5	38·4
Traditional	55·7	31·0	13·3

From *Table 12* it appears that a visitor to a general surgical ward, a general medical ward, and a gynaecological ward, in 1950, might have expected to find about half the patients bedfast, while a quarter of them, more or less, could get up to use the w.c. and wash, and the rest would be fully independent so far as their own toilet was concerned. Under a rather more advanced régime of early ambulation, the proportions of fully ambulant and bedfast patients might have been reversed, so that only about a quarter or less of them would have been confined to bed.

The percentages given in *Table 12* are average values only, and in reality there will be considerable day-to-day fluctuations in the numbers of patients who are bedfast, or fully or partly ambulant—the variation being greater, proportionately, in small than in large wards. It can be inferred from the figures that, if the practice of early ambulation prevailed, 70–90 per cent. of patients in the types of ward covered would require the use of wash-basins and w.c.s and 40–55 per cent. would require day-space. These percentages may be contrasted with the present 45–55 per cent. requiring the former and 15–30 per cent. requiring the latter facilities.

Very few hospitals are equipped to provide for even the current percentages, and it appears that many more patients would be permitted to get up if the necessary facilities were provided.

III. NURSING ORGANIZATION IN WARDS

The Traditional Pattern

Nursing in hospital wards in this country still follows a traditional pattern. Under the matron, and with day-to-day instructions from the medical staff, the ward sister bears the responsibility for nursing the patients; for the management of her ward; and—if the hospital is a training school for nurses—for arranging the practical instruction of the students. Even in the acute general hospital she may still have 32 or more beds in her charge.[35] She, like the rest of the nursing staff, will work a 96-hour fortnight, and will probably have 1½ days off duty each week.

On day duty the sister will have under her one trained nurse who will deputize for her in her absence. There may be a second trained nurse, but there are unlikely to be more. If the hospital is a training school, there may be student nurses on the ward strength, though the actual number will vary according to the number available in the hospital, the kind of ward, and the system of training.

In recent years it has become quite common to employ part-time nurses when they are to be had, and also assistant nurses,* and orderlies. The number of part-time nurses, assistant nurses, and orderlies to be included on the strength of any particular ward will depend on such factors as their availability to the hospital as a whole, on the availability of student nurses, and the nature of the work being done in that ward.

At night it is usual to have one night superintendent of nursing, with an adequate number of night sisters to help her, to supervise throughout the hospital. They are not attached to the wards and are directly answerable to the matron. The ward itself is commonly left in the immediate charge either of a staff nurse or, more often, of a second- or third-year nurse in training, with not less than one other nurse in training to assist her. Where there are few or no student nurses a trained nurse (full-time or part-time), with, for example, a nursing auxiliary, may be in immediate charge of the ward. It is a General Nursing Council recommendation that no nurse shall be left alone in a ward on night duty.

The purely domestic work of the ward and the heavy cleaning will be undertaken by the full-time ward maid, sometimes assisted by an orderly, and usually getting supplementary help from cleaners, who sometimes serve more than one ward.

A comprehensive picture of the routine organization in wards by day and night is given in the report of the Job-Analysis team, published by the Nuffield Provincial Hospitals Trust, in 1953. One of the points brought out by the Job-Analysis was that variations in staffing, and particularly in the number of student nurses working in different wards, 'was not entirely, or even mainly, due to differences in the size of wards'. Another point emphasized in the report was that 'the pattern of work in all wards is basically the same' (cf. pp. 9, 10). 'In each ward the same tasks occupied most of the time of a particular grade of staff.' A considerable variation was found in the method of deciding how work was to be allocated to the student nurses. 'In some cases hospital policy determines the allocation of duties according to seniority and in others it is left to the discretion of the ward sister. In practice there is a considerable measure of agreement: thus, in well over half the wards third-year nurses were mainly responsible for medicines, injections, and other technical procedures, and first-year nurses were responsible for toilet rounds, bed baths, bedpans, and giving out food.' The student nurses were 'an indispensable part of the labour force of the wards. Three-quarters of the nursing was contributed by them.' The ward sister and the staff nurse, or nurses, 'were mainly engaged on ward management rather than bedside nursing duties', and were not able to find much time for teaching student nurses.

As the Nuffield Job-Analysis team pointed out, all the patient's nursing requirements 'originate in human needs which inevitably react upon one another'. Physical discomfort and worry, they said, can slow down the patient's recovery, 'and the best way to ensure that the effectiveness of the treatment is not discounted by these factors is surely to allow the patient's medical, emotional, and physical needs in relation to nursing to be met by the same individual. . . . Nurses themselves have often emphasized the fact that it is not possible to treat any of these needs adequately in isolation. Thus a junior student nurse (or auxiliary) may be capable of making a patient's bed, but not of noticing facts about his condition of which the trained nurse would immediately have seen the significance had she been doing the job.'[36]

The Job-Analysis produced verified information to support the belief held by many that changes in the organization of nursing in hospital wards are necessary if good standards of care are to be maintained throughout the country. Among the effects of the 'traditional' system which have come in for some sharp criticism are: (i) the strain imposed on the sister by her triple role of ward manager, nurse, and teacher, under present-day conditions; (ii) the want of a proper distinction between the work and responsibilities of the fully trained nurse and the nurse nearing the end of her training, who necessarily lacks experience; (iii) the fact that nurses in training bear so large and important a share of the actual nursing to be done in the ward that their particular needs as students are sometimes passed over; and (iv) the custom of organizing the work as a series of jobs, or parts of jobs, each to be done by a different nurse proceeding from patient to patient round the ward. This gives the patient a service which is to some extent both unsatisfactory and unsatisfying—unsatisfactory because responsibility for the attention given him is arbitrarily divided between several people, unsatisfying because the attention itself is apt to be impersonal. In making a study of work in wards, for the Royal College of Nursing, Miss Eileen Skellern found that 'out of 57 wards, 55 used the job-assignment method of organizing the work'. She particularly mentioned the number of different people who, within a short space of time, might visit one patient to do things for him; it was, she thought, very nearly impossible for the nurses to see the care of any individual patient as a whole.[37]

Patient-Assignment to Nurses in Training

A few hospitals, having accepted that the job-assignment system does not encourage nurses in training to think of the patients as individuals, have adopted a system of placing particular patients under the care of student nurses—always under the supervision of an experienced nurse. One London teaching hospital, for example, has taken advantage of the fact that each of its 25-bedded wards is physically separated into two intercommunicating parts and has put each part into the care of two nurses; in one part a trained nurse (who is also the ward sister's deputy) and a first- or second-year nurse in training, and in the other a third-year nurse and a first-year nurse in training. Two more students act as reliefs and also give extra attention to patients who need it, especially to those patients in side-rooms attached to the ward.

As far as possible the pair of nurses collaborate in looking after their half of the ward. The patients may indeed be apportioned so that each regards certain of them as being under her particular care, although they share all tasks needing two pairs of hands, and although one or other of them may sometimes do a particular task for the whole group of patients.

In another hospital each student nurse, from the beginning of her training, is responsible, under supervision, for the nursing of a particular group of patients. For example, in a 23-bedded surgical ward, a staff nurse, and a third-year and a second-year nurse in training, each has seven patients in her care, under the supervision of the ward sister, and a first-year nurse in training similarly looks after two patients. An additional student nurse, usually in her second year, acts as relief so that other nurses may take their day off duty. The day shift runs from 8 a.m. to 8 p.m. At present relief for the day-nurses' evenings off is

* The Nurses Act, 1943 (6 & 7 Geo. 6, c. 17) first provided for a State Roll of Assistant Nurses. Until 1948 the Roll was open to anyone who could show adequate practical nursing experience; but after 1948 it was open only to those who had been trained in an approved training school and had passed the tests prescribed by the General Nursing Council.

provided by two student nurses working an evening shift from 4 p.m. to 12.30 a.m., during the last 4 hours of which they are in charge of the ward. At 12.30 a.m. the night staff, one senior and one junior nurse in training, come on duty, and they are then in immediate charge of the ward; a relief nurse serves three wards. At this particular hospital it is intended to revert to a two-shift system, and the nurses now on evening duty will be added to the day shift. This, it is expected, will allow patient-assignment methods of nursing to work more smoothly.

Several other systems of patient-assignment to student nurses are in operation; one of them was described in the *Nursing Mirror* in December 1953.[38]

An important variation in such systems of patient-assignment lies in the method of supervising the nurse in training. Sometimes the staff nurse superintends the students while working with them in attending to a group of patients; sometimes the staff nurse has patients separately assigned to her—very often the more difficult cases—and supervises and assists the students only when she is deputizing for the ward sister. In the latter circumstances the sister has to spend more time helping the students with the bedside care of patients than she does if the staff nurse is working with them as the leader of a nursing team.

The Concept of the Nursing Team

The apparent advantages of developing appropriate forms of team nursing in Britain have recently been arousing interest. When the Nuffield Job-Analysis team had completed their field studies and prepared their report, the Panel of Advisers appointed to assist them made, among other observations, the following points. That 'nursing should be done by trained nurses and not merely supervised by them'; that 'each trained nurse should be responsible for total nursing care to a specified group of patients'—a *nursing unit*—and that 'the trained nurse in carrying out the many duties that require a "second pair of hands" should be assisted by nursing auxiliaries who may be either student nurses, assistant nurses, pupil assistant nurses, or orderlies'.

The Panel went on to suggest that 'the ward should be a large administrative unit subdivided into a number of nursing units, each of which should be the direct responsibility of a trained nurse'; and that 'the ward sister should be responsible for the management of the administrative unit'. They added that 'the ward sister, though necessarily in the first instance an administrator, should have an overall responsibility for the care of patients'.[39]

A small working-party appointed by the Royal College of Nursing to consider the report concluded 'that the care of the present hospital patient must be the responsibility of a team; that what is required is not a greatly increased number of State registered nurses to carry out the nursing care at present largely given to student nurses, but a sufficiency of well-balanced nursing units, each with a State registered nurse at its head'. Until practical experiments had been undertaken, the working-party did not feel able to suggest any particular form of team organization, though they endorsed the view expressed by the Horder Committee, in 1942, that the assistant nurse should 'become one of the most stable elements in our national nursing service—an integral part of the profession'.

As a result of a conference held by the Royal College of Nursing, at which the working-party's findings were discussed, several ward sisters are now experimenting with team organization in their own wards. In one such experiment, in a 23-bedded ward, two teams under the general supervision of the sister, each consisting of one trained nurse and three nurses in training, divide the care of the patients between them, one team looking after a group of eleven patients and the other team looking after a group of twelve patients.*

As an outcome of the Nuffield Job-Analysis inquiry, the Ministry of Health's Standing Nursing Advisory Committee have sponsored some studies in team nursing in medical and surgical wards in four hospitals. A feature of these studies is that a job-analysis is made in the selected wards before the work of the ward is reorganized on the basis of team nursing and again after the organization has become well established. Factual information will thus be forthcoming on the two systems of nursing.

* In the United States, where most patients pay directly towards their care in hospital, nursing by trained nurses on a case-assignment basis has generally been aimed at. Nevertheless in the States, as elsewhere, there is a shortage of trained nurses, and this has sometimes led them to concentrate too exclusively upon the technical nursing needs of their patients while delegating the simpler bedside care to less skilled assistants. This tendency is generally considered regrettable, and efforts to reorganize nursing on a team basis have recently been made, largely through the initiative of the Division of Nursing Education, at Teacher's College, in the University of Columbia. During 1949 and 1950 the *American Journal of Nursing* contained several detailed accounts of team nursing experiments,[40] and a book has been written on the subject by Miss E. C. Lambertsen, of Teacher's College.[41]

One of the four hospitals is conducting several experiments, of which the following are examples. Two teams work under one sister in a 24-bedded medical ward. Each consists of a staff nurse and one nurse in training, and has the care of twelve patients. A part-time staff nurse and an additional nurse in training act as reliefs for both teams, and a part-time assistant nurse helps whichever team happens to need her services the more. In a 32-bedded surgical ward in the same hospital, fourteen patients (including four in side-rooms) are in the charge of one staff nurse and two nurses in training; ten patients are in the charge of a staff nurse and one nurse in training; and the 8-bedded annex to the ward (to which ambulant patients are transferred) is in the charge of a part-time staff nurse. Another part-time staff nurse and an additional student nurse act as reliefs.

In a 24-bedded surgical ward in another of these hospitals the sister divides the patients equally between two teams, and each team is composed of one staff nurse and two nurses in training. A part-time staff nurse and two additional nurses in training act as reliefs—each student adhering to one or other team.

It is understood that Scottish nursing bodies have similar developments under consideration.

The Unit of Ward Management

It is implicit in any method of organizing nursing on the basis of small numbers of patients in the care of a team, that several such nursing units should be grouped to form a larger unit for purposes of ward management. In Great Britain, in the hospitals where team nursing is established or on trial, the unit of management has so far remained the ward itself, under the sister.

At an early stage in studying ward planning the Investigation came to the conclusion, on the evidence then available, that much of the purely administrative day-to-day management for which the sister is responsible might be done with greater efficiency and economy for a larger number of patients than the traditional types of ward usually contain. From an architectural point of view other advantages could be expected to follow a concentration in the number of patients accommodated as a group (see p. 21). These views were supported by the findings of the Nuffield Job-Analysis team, who wrote as follows:

> If the ward sister's position as manager of the ward under the hospital matron is to remain, her administrative functions cannot be delegated, although substantial assistance . . . can be

given in carrying them out. . . . One of the facts revealed by the analysis of the time spent on organizational duties was that the number of beds in the ward has no appreciable effect upon it. The time spent on some duties such as clerical work and miscellaneous contacts with other hospital departments seems to be fairly constant from ward to ward whether there are 10 beds or 30. . . . This being so, it would seem economical to make the area of ward organization as large as is consistent with its efficient running.[4a]

Exactly how large the area of efficient ward organization may be is a matter for further study and experiment. If the sister can delegate nursing responsibility directly to trained nurses, and if she is provided with a deputy and with clerical assistance, so that she has some possibility of planning her day, it seems likely that she can give overall care to more patients than is now customary and still supervise the nursing care which each receives.

Observations of the Work of a Departmental Sister in Denmark

In collecting background information for the Investigation's nursing studies to be done in the experimental wards at Larkfield and Musgrave Park Hospitals, the nurse member of the team spent several days, in January 1954, observing in the Kommune Hospital in Copenhagen, one of the four municipal hospitals in the city, where nursing is organized on a basis of small units (generally 12 beds) grouped to form a larger administrative unit (a *department* of 78 beds) under one sister.

In a surgical department, for example, the nurses worked on a 3-shift system, and on day duty each 12-bedded unit was in the charge of one trained nurse with one student nurse and one relief nurse (either trained or a student) under her. It was part of the sister's daily routine to attend all ward rounds made by senior members of the medical staff, and to discuss cases with them and the nurse responsible for each group of patients. The sister herself made a twice-daily round to discuss nursing care. In addition to her supervisory and advisory duties each sister was responsible for all the staff organization and household management in her department. She was also responsible for superintending the practical training of her student nurses.

At the Kommune Hospital no sister had regular clerical assistance; each was relieved only for weekly days off duty (by a senior nurse in charge of a 12-bedded group). Each sister received some help daily from student nurses who, one at a time, spent a month as her assistant, learning the general running of the department. In those circumstances it was essential that all the nurses in charge of 12-bedded units should be experienced (as in fact they were), for the sister could not have found time to give the amount of detailed supervision which less experienced nurses would have required.

An important advantage of the large administrative unit was the freedom which it gave the sister to use relief nursing staff and domestic staff when and where they were most needed. This led to an economy in the number employed.

A sister responsible for the overall nursing care of seventy to eighty patients, without a full-time deputy with whom to share nursing supervision and without trained clerical help, might (like some of the sisters at the Kommune Hospital) feel herself without sufficient direct contact with her patients because of the amount of administrative work to be done on their behalf. In the new wards at Larkfield and Musgrave Park it should be possible to establish both the optimum number of patients for whom one sister can efficiently take full responsibility, and the extent of the help which she will need in doing so. In each nursing experiment the sister and her deputy will study how best to share the clinical, administrative, and bedside teaching duties arising in one case from two groups of thirty-two patients, and in the other from two groups of forty.

IV. THE INVESTIGATION'S EXPERIMENTAL WARD BLOCKS AT LARKFIELD HOSPITAL, GREENOCK, AND MUSGRAVE PARK HOSPITAL, BELFAST

THE purely architectural aspects of the two experimental ward blocks designed by the Investigation—ventilating and heating, lighting by day and at night, control of noise, and colour schemes—are discussed under the various subheadings in *Chapter 4*. The descriptions which follow are from the standpoint of the principal users—the patients, the doctors, and the nurses and their assistants.

Step by step with the architectural and environmental studies, the Investigation tried to consider the detailed needs of the users. Compromises had sometimes to be made between economy in building and convenience in use, but the team believe that on the whole the adjustments were equitable; and in many instances the advantages gained on the one side were benefits also on the other.

Although at the outset of planning the experimental blocks the Nuffield Job-Analysis of the work of nurses in wards was only newly begun, the team, as the result of discussions with various people working in the hospital field, were nevertheless thinking in terms of a larger administrative nursing unit than the traditional one, containing smaller clinical nursing units.

1. Larkfield Hospital Experimental Ward Block (*Fig. 9*)

Larkfield Hospital houses the medical beds of the Greenock Royal Infirmary, and in the experimental ward block added to it—the first of the two which the Investigation was commissioned to design—the basic clinical unit was set at eight patients.

The nurse member of the Investigation, at that time Miss C. M. Grant Glass, had already gone some way in attempting to assess how many patients could, at peak periods, be looked after by one trained nurse, with suitable assistance. In the absence of any positive information (the Nuffield Job-Analysis data being not yet available) she had tentatively concluded that the *minimum* would be eight patients. During non-peak periods it was thought that the trained nurse would be able to supervise two units of eight patients. Eight and multiples of eight were therefore accepted as the basis for planning, because this would be the starting-point for the nursing experiments which the team proposed to make in the Larkfield wards when they were completed.

From an architectural point of view, eight was a convenient multiple. It is now considered proper, in the interests of tranquillity, to make each ward unit a cul-de-sac (with only a fire-escape exit in the farther end), but in the interests of economy the main staircase and bed-lift must serve as many beds as possible on each floor (cf. p. 144). On an 8-bed basis, the main vertical circulation route can economically serve 64 beds on each floor, by being placed between two 32-bedded units, each a self-contained cul-de-sac. The Investigation's studies on the use of ancillary rooms (see pp. 8–12) had led to the conclusion that one set of ancillary rooms could serve 32 or more beds, if they

were compactly planned and near the bed-area—distance rather than capacity being the controlling factor.

To cut down walking distance in the ward unit, the team early in their researches decided to place the principal ancillary rooms, all of which are of nearly equal importance to the work of the ward (cf. p. 10), in a central block within the actual bed-area, so that journeys to and from them would be radial. The 32-bedded unit neatly divided into a group of 16 beds on either side of the ancillaries (*Fig. 9*). For each group a nurses' station is placed at the end of the row of ancillary rooms, where it commands a view into the bed-area.

In considering how to arrange the beds themselves in each group of 16, the team accepted four single rooms as being the optimum number for medical cases, but designated only two, instead of Goodall's three, as type A rooms (for patients needing close observation) to ensure a slightly greater amount of use (cf. *Tables 10, 11*, p. 15). These rooms are placed opposite the nurses' station. The two type B rooms (for patients not needing constant supervision) are placed together at the farther end of the unit.

The remaining 12 beds are arranged in fours, in open bays, two bays being adjacent, the third immediately opposite, on the other side of the ward, next to the type B single rooms. Each 4-bedded bay, and one room in each pair of single rooms, has a W.C. beside it—in one type B room the W.C. actually opens out of it, making a self-contained unit which can be used for isolating a patient. This arrangement of the W.C.s means that they are within easy reach of all patients, who, if they are not confined to bed, can either walk there or be taken on a lavatory-chair. Inside each W.C. is a small wash-basin for rinsing hands. In this way the use of bedpans will be reduced to a minimum. The methods of ventilating and warming the W.C.s and of controlling noise from them, are discussed on pp. 118, 127, 128.

Each group of 16 beds has the use of one bathroom and of two individually screened wash-basins. The other main ancillary rooms—the clean- and dirty-utility rooms, the treatment-room, and the ward kitchen—are shared by both groups, and so is the day-space. The day-space is opposite the ancillary rooms and near the ward kitchen, so as to make it convenient to serve meals in the day-space to patients who can remain up for some time.

The ancillary rooms are served by two hoists. One opens into the dirty-utility room and is used for the disposal of soiled objects—dressings, linen, and so on. The other hoist is immediately outside the door into the kitchen and is used for receiving clean stores and food trolleys. The 'dirty' hoist has been designed to accommodate two disposal bins adequate in size for the needs of the 32-bedded unit; it is rubber-lined to reduce noise, and the door shuts quietly. The 'clean' hoist is big enough to contain a heated food trolley bringing the meals from the

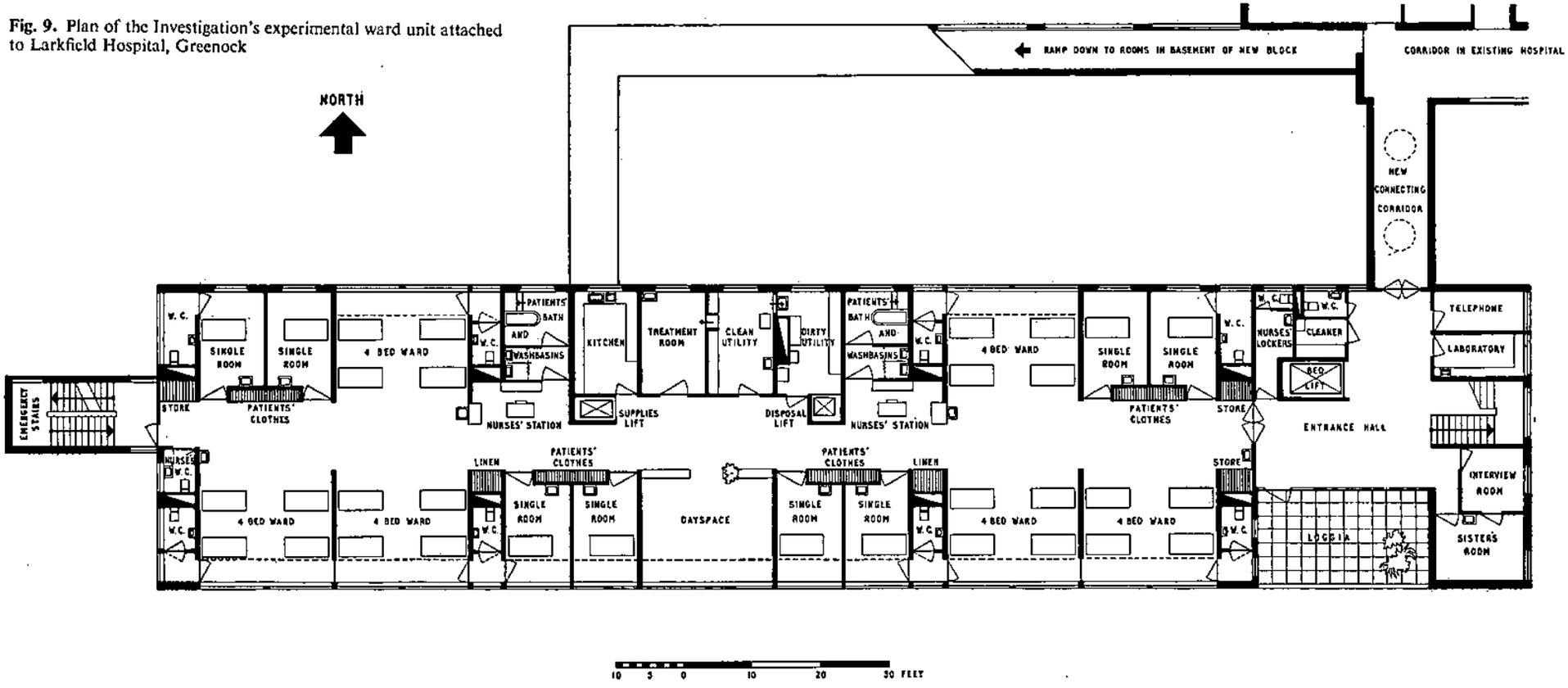

Fig. 9. Plan of the Investigation's experimental ward unit attached to Larkfield Hospital, Greenock

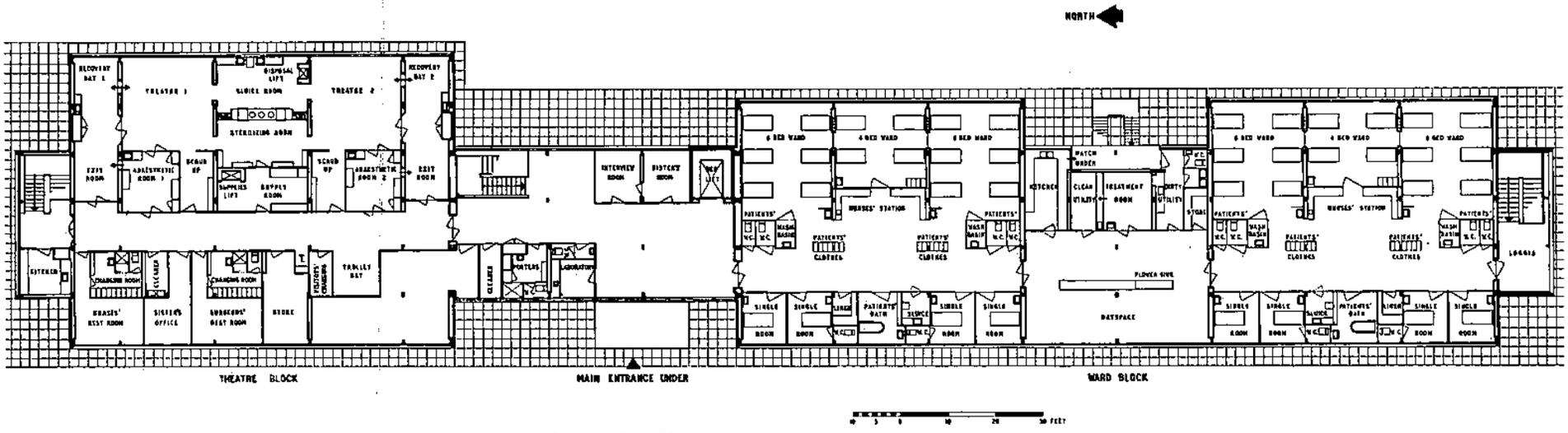

Fig. 10. Plan of the Investigation's experimental ward unit attached to Musgrave Park Hospital, Belfast

main kitchen—two trolleys are supplied for the 32-bedded unit, each serving a group of 16.

In grouping the patients (other than those needing single rooms) in open, 4-bedded bays, the Investigation intended that they should gain a sense of being part of a small, friendly community in fairly spacious surroundings—easily accessible W.C.s and washing facilities affording the customary domestic privacies, and the treatment-room removing distressing medical procedures from their notice. Each bed has curtains which can be drawn round it on silent runners.

Every patient, in addition to his bedside locker, has been provided with locking wardrobe space for his day clothes in banks of lockers in the bed-area. Patients in single rooms have a small wardrobe in the room with them.

2. Rooms and Services provided on a 'Floor' Basis

In addition to the main staircase and bed-lift, there are certain other items of provision which can serve all the beds on a floor of the ward block, and therefore may conveniently be placed between two cul-de-sac units. These will vary according to the particular needs at different hospitals. At Larkfield they include: rooms for the sister and her deputy; an interview room for talking privately with relations, patients, and colleagues; a room for the use of doctors, and a small laboratory for minor investigations arising out of the clinical work of the wards; a cloakroom, with lockers and toilet facilities, for the nurses; a small room containing the telephone control-panel for the ward block, attended by a reception clerk; a room for the use of the cleaners; a W.C. with a wash-basin in it; and some extra storage space for bulky objects not conveniently storable within the bed-area. The end of the entrance hall off which these various rooms open gives on to a loggia, which was specially requested by the hospital authorities.

At Larkfield Hospital the size and situation of the site available for the experimental block made it impossible to place both 32-bedded units on the same floor. They had to be built one over the other, with the main staircase and bed-lift together with the rooms and services common to all 64 beds, at one end of the block instead of in the middle—the rooms being divided as conveniently as possible between the two stories. The experimental block very conveniently simulates conditions in a multi-story ward block divided vertically to include the central circulation area in one half. To meet local requirements one of the floors will house men, the other women.

3. Musgrave Park Hospital Experimental Wards (*Fig. 10*)

By the time the team were ready to begin designing the surgical wards they had come to the fairly firm conclusion that ten patients was the number likely to prove the most economical nursing unit. The architectural members of the Investigation welcomed that conclusion, because it enabled a more economical building to be designed.

A nursing unit of ten patients makes it possible to increase the number of beds served by one block of ancillary rooms from 32 to 40—20 beds instead of 16 being placed on either side of the main ancillary rooms serving both groups—and to increase the number of beds in two cul-de-sac units forming a floor, from 64 to 80, thus intensifying the use made of the rooms and services provided on a 'floor' basis.

Application of the results of studies made jointly with the Building Research Station on daylight conditions in wide buildings (see pp. 96, 97) showed that it was feasible to accommodate the eight additional beds in each cul-de-sac unit by increasing the width of the building at certain points, from the Larkfield measurement of 43 ft. 4 in., to 50 feet without altering the overall length of the unit (160 feet, as at Larkfield). This plan has the great advantage of keeping walking distances between beds and ancillary rooms short and radial, but it has led to one major change in the arrangement of the beds themselves. At Musgrave Park 12 beds in each group of 20 will be placed 3-deep instead of 2-deep, parallel to the window-wall, in two semi-open wards each containing 6 beds. Bed centres will be 7 feet apart.

In continental hospitals built within the last fifteen or

so years it is common to find wards containing 6 beds placed 3-deep on opposite sides of the room, parallel to the window-wall. With bed centres 6 feet or 6 ft. 6 in. apart (cf. p. 13) this arrangement achieves great compactness. It is sometimes rightly said, however, that the rooms can become stuffy, that the patient in the middle of each row has no chance of turning away from his neighbours, and that the two patients farthest from the window may get insufficient daylight. In considering the arrangement of beds for the experimental wards at Musgrave Park Hospital, the Investigation concluded that none of these disadvantages of beds three in a row was inevitable. Stuffiness could be avoided by proper ventilation and by not completely enclosing the room; bed curtains, privacy for toilet and treatment, and bed centres 7 feet apart should avoid any sense of being crowded; and the daylighting studies tended to show that all the beds could receive adequate natural light. These considerations, together with the strong architectural reasons for attempting to establish whether wards with beds arranged 3-deep could prove acceptable in Great Britain, seemed to justify the Investigation in taking advantage of an apparently favourable opportunity to test the reactions of patients and staff.

The two 6-bedded wards are separated by a 4-bedded ward—all three intercommunicating. The 4-bedded ward opens on to a nurses' station, and the nurses' station faces the four single rooms on the opposite side of the ward block. All the beds are thus contained in a compact rectangle in which the nurses' station is the central point. Within the rectangular bed-area there are also a bathroom, a small sluice-room, and a linen store.

As at Larkfield, the single rooms are in pairs, and one room in each pair has its own W.C.; but all four rooms are in direct view from the nurses' station, instead of being differentiated into type A and type B rooms. The twelve patients in the semi-open wards have the use of four W.C.s and two washing cubicles. As described on p. 131, these W.C.s have been placed in pairs in the interior of the building. Each pair has one of the two washing cubicles beside it, and this triad forms the barrier which partly closes each 6-bedded ward—the washing cubicle opening directly into the ward, the two W.C.s backing on to it and opening into the circulation space outside. The 6-bedded wards are further shielded from the circulation space by free-standing banks of wardrobe lockers for the patients' clothes.

The rectangle which contains the block of ancillary rooms between the two groups of 20 beds, and shared by them, is narrower than the rectangles containing the beds themselves, and is divided from them by swing-doors. One side of it is wholly occupied by the day-space, the other by the ward kitchen, a storeroom, the cleaners' cupboard, a W.C. for the nurses, and by three rooms which together form a technical-nursing unit—the clean-utility room, the treatment-room, and the dirty-utility room. The latter, which does not incorporate sluice-room facilities—these have been decentralized to the immediate bed-area—is used for washing instruments and utensils handed through a hatch from the treatment-room. The room also serves as a general reception and dispatch point for soiled articles, such, for example, as the dirty linen in canvas bags, and articles being sent to the Central Sterile Supply Department for sterilizing.

At Musgrave Park Hospital, as at Larkfield, the two experimental wards have had to be placed one above the other, but arrangements for supply and disposal do not simulate conditions in a multi-story building. On the ground floor disposal from the dirty-utility room and the ward kitchen is direct to the outside of the building; on the first floor disposal is on to an external gallery, so that the porter collecting refuse, soiled-dressing bins, and dirty linen, need not enter the ward unit. Food trolleys will be wheeled from the entrance hall to the ward kitchen, and all clean goods for immediate use or storage will similarly pass through to the appropriate point. While these simple arrangements are adequate to buildings one or two stories in height, hoists delivering to the ancillary rooms, as at Larkfield, would be used if a multi-story ward block were designed on the Musgrave Park Hospital plan.

The experimental block at Musgrave Park Hospital includes, besides the ward block, another two-story building housing operating theatres, an X-ray unit, and a central sterilizing department, cf. p. 81. An entrance hall on each floor separates the two blocks, and as at Larkfield these halls contain the rooms and services which would be shared by two cul-de-sac units on one floor of a complete ward block. On the ground floor they include the sister's room, with an interview-room beside it, the doctors' room, the nurses' cloakroom, and a W.C. On the upper floor they include the deputy sister's room, with an interview-room beside it, a small laboratory, a W.C., a waiting-space for patients' visitors and others, and the stairs and bed-lift. The telephone control-panel will be in the lower entrance hall, and the clerk attending it will act also as receptionist.

4. The Design and Equipment of Ancillary Rooms

The Nurses' Station

Although the 'corridor' type of building, with small wards facing the ancillary rooms across a passage, brings beds and ancillaries nearer together, it does little to meet the fundamental need—that the nurse should be able to keep a continually watchful eye on the patients as she goes about other work. Because many nursing tasks have to be done in enclosed rooms away from the beds, this need cannot be wholly satisfied; but in planning the experimental wards the Investigation regarded ease of supervision as a crucial factor in the design.

The nurses' stations in the experimental wards are not, except during night-duty, places where the nurses sit in order to supervise the patients. They have been designed as places where some jobs, such as preparing doses of medicine, using the telephone, writing reports and charting details of the patients' condition, which are disturbing if they are done among the beds, can still be done with the patients in sight. Each nurses' station is simply a small unenclosed area of the ward, near the ancillary rooms and near the patients, where there are the following things: built-in locking cupboards for internal medicines, in particular the cupboards required under the Dangerous Drugs Act for certain drugs and scheduled poisons, a work-bench including a small sink, a telephone in a recess lined with acoustic tiles, and next to it a notice-board, a desk and a desk-lamp, a chair, and a bank of cupboards and drawers for articles such as stationery. Each dangerous-drug and poison cupboard locks separately and has a light automatically switched on and off by the opening and closing of the door.

As described on p. 20, there are two nurses' stations to the 32 beds on a floor at Larkfield Hospital, each serving and overlooking a group of sixteen patients, and separated one from the other by a row of ancillary rooms. Similarly at Musgrave Park there are two nurses' stations to the 40 beds on a floor, each serving a group of twenty patients, and each at the centre of its group (*Fig. 10*). During the nursing experiments to be sponsored by the Investigation the trained nurse responsible for the group

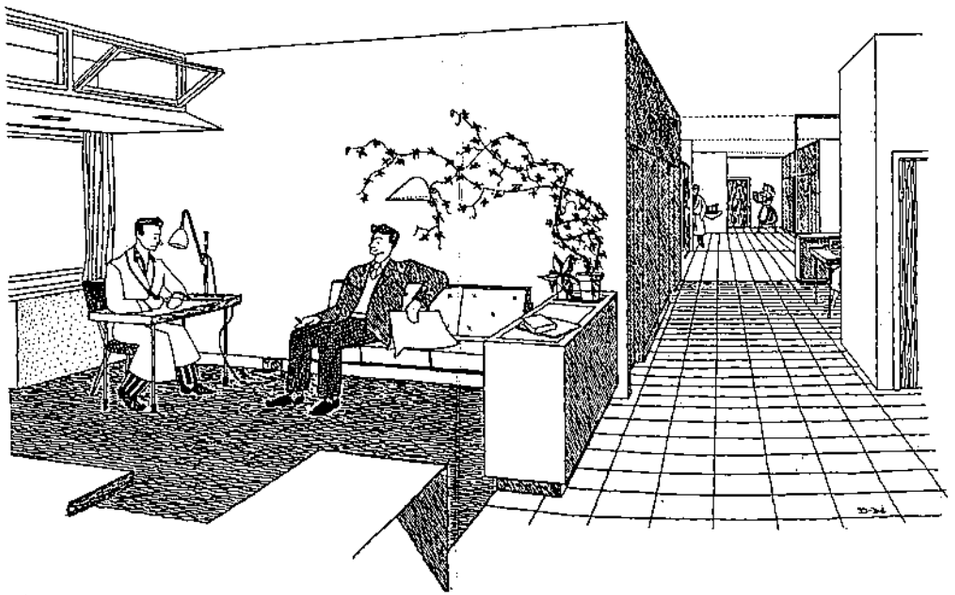

Fig. 11. Day-space in the Investigation's experimental ward unit at Larkfield Hospital, Greenock viewed from the central circulation space

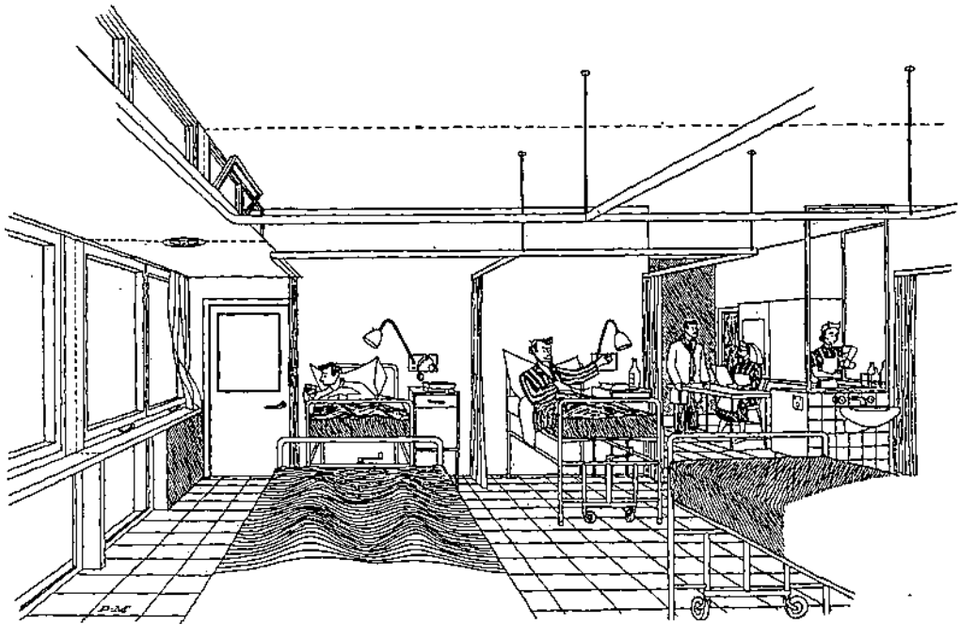

Fig. 12. A ward in the Investigation's experimental ward unit at Larkfield Hospital, Greenock: the patient's view

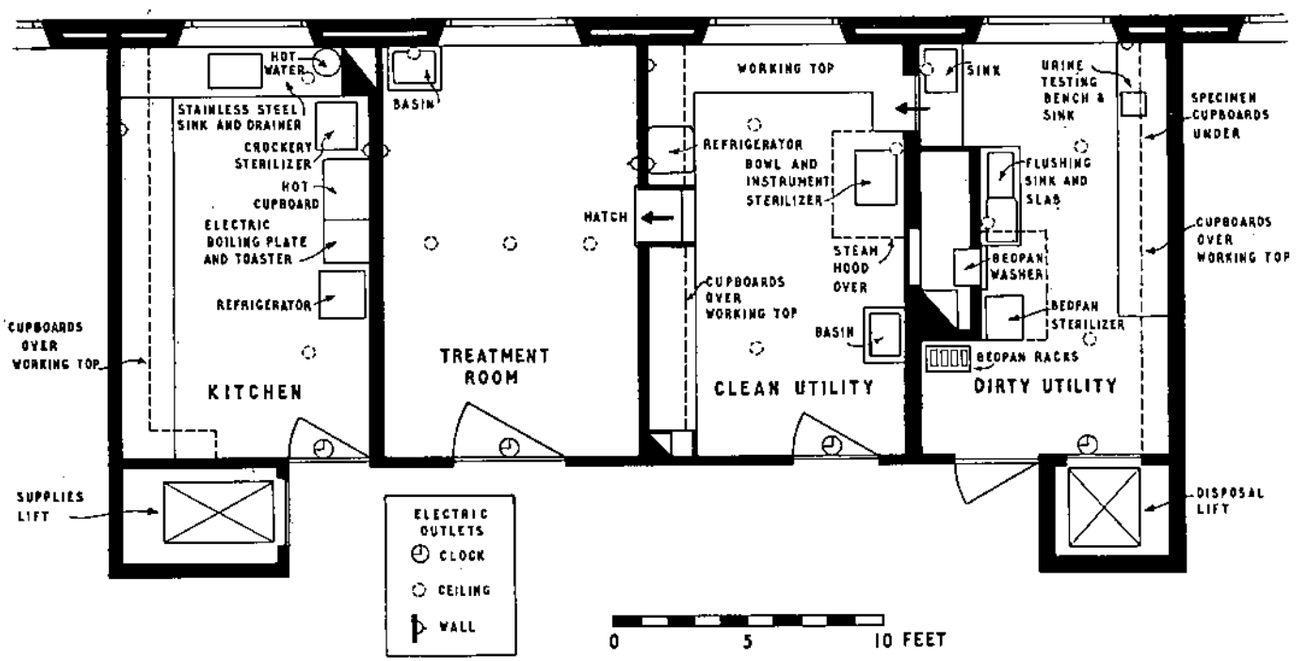

Fig. 13. Plan of ancilliary rooms in the experimental ward unit at Larkfield Hospital, Greenock

will be responsible also for their medicines—which is the reason why each has been given her own D.D.A. cupboard.

The Investigation favours the idea of dispensing medicines from a trolley specially designed to hold all the bottles and other containers and utensils—the trolley itself possibly acting as a mobile locking cabinet in which are stocked the medicines, other than the dangerous drugs. The Chief Pharmacist in a large teaching-hospital group is trying such a trolley in the wards. If he and the Investigation are satisfied with its performance, its use may be adopted at Musgrave Park, and space for it has been allowed under the work-bench in each nurses' station.

At both Larkfield and Musgrave Park space has also been allowed for a mobile chart-rack in which the patients' case-papers are filed while they are in the ward, and which can be wheeled from bed to bed during medical rounds. The type chosen for the experimental wards has a lower shelf for small diagnostic instruments and equipment, and the flat top can be used for writing.

The Treatment-Room

For the reasons stated (p. 8) a treatment-room is considered to be of great importance in the ward unit. No special explanation is needed for its use in the surgical wards at Musgrave Park Hospital for all but the simplest pre- and post-operative treatment. In the medical wards at Larkfield the physician in charge proposes to use it for such procedures as full physical examination (including, for example, sigmoidoscopy and proctoscopy), electrocardiography, sternal and lumbar punctures, catheterization, setting up intravenous infusions, and physiotherapy. The method of air-conditioning the treatment-room to guard against cross-infection is described on p. 130.

To make it easier to maintain a high standard of cleanliness in the treatment-room, it will contain only two fixtures—a wash-basin, with a small shelf beside it, and an inspection lamp suspended from the ceiling. Bedfast patients will be wheeled into the room and treated on their beds. A special trolley will be provided which can be used either for transport or as an examination couch. The other furniture will be: two stainless-steel dressings trolleys—one remaining in the treatment-room, the other being used also in the clean-utility room and in the wards—two bins for soiled dressings (with pedal-operated lids), and two adjustable stools with plastic-covered sponge-rubber seats. There is a 15-amp. outlet in each treatment-room so that various pieces of electrical equipment may be used.

The Clean-Utility Room

At both Larkfield and Musgrave Park the chief purpose of the clean-utility room is to ensure that the treatment-room itself need not be used for the preparation of equipment. At both hospitals there is a hatch between the clean-utility room and the treatment-room through which sterilized instruments and utensils can be passed. But whereas at Larkfield all the sterilizing needed can be done in the clean-utility room, at Musgrave Park, where the experimental wards will use the Central Sterile Supply Department (see p. 81), the clean-utility room will be used mainly as an assembly and laying-up place, though a portable sterilizer can be used when necessary.

The clean-utility rooms will contain the following items: storage cupboards for equipment, instruments, lotions, &c. (less cupboard space will be needed at Musgrave Park because the resources of the Central Sterile Supply Department can be drawn on for all stocks other than those sufficient for immediate use), work-benches, adjustable stools, a mobile stand for drums with pedal-operated lids, and a refrigerator (capacity 1 cu. ft.) kept exclusively for medical supplies needing cold storage.

The Dirty-Utility Room

At Larkfield Hospital the dirty-utility room has two main functions: (i) it is the sluice-room for 32 beds, where wash-bowls, bedpans, urine-bottles, sputum-mugs, &c., are emptied, cleaned, and stored, and where certain urine specimens can be kept and tested; and (ii) it is the receiving and washing-up room for equipment and instruments which have been used in the treatment-room. It is also the point from which soiled-dressing bins and soiled linen* are dispatched in the dirty-hoist.

For these various activities it will contain: a bedpan-washer recessed into the wall, with automatic valves delivering either hot or cold water for a set period; a boiling-water bedpan sterilizer; a teak rack for storing 12 bedpans—the warmed metal racks are considered to be somewhat noisy, and not uniformly effective in taking the chill off the pans; a ventilated storage cupboard for 24-hour urine and other specimens; a cupboard containing reagents for testing urine, placed above a work-bench with a small sink and goose-neck tap, and a Bunsen burner; a cupboard for storing flower vases on the upper shelves, and enema trays, &c., on the lower shelves; a slop-sink; and a sink and draining slab for cleaning the equipment used in the treatment-room.

At Musgrave Park the sluice-room functions on each floor have been concentrated in two small rooms containing the necessary facilities and each directly serving a group of twenty patients. In these sluice-rooms the equipment is similar to that provided at Larkfield, except that the bedpan-washer and bedpan-sterilizer have been combined. The Investigation collaborated with an engineer in designing this piece of apparatus. The idea for it was taken from the automatic combined bedpan washing and sterilizing machines in use at St. Bartholomew's Hospital, which give results consistently satisfactory to the hospital's bacteriologists. The Musgrave Park machine, also, has been tested at St. Bartholomew's, and found satisfactory. When the bedpan is placed inside and the door closed, the machine automatically washes the pan in the first phase of its operation, and steam-sterilizes it in the second phase. The whole process takes 87 seconds. The machine costs slightly less than would a bedpan-washing machine and a separate bedpan-sterilizer, and it takes up considerably less room. Moreover, the sterilizing process needs no timing by a nurse.

The dirty-utility room at Musgrave Park is used almost exclusively as the washing-up and disposal room for instruments and utensils and soiled dressing-bins used in the treatment-room, though the dirty-linen sacks from the 'rounders' in the ward are also received there to await collection.

The difference, at Musgrave Park and at Larkfield Hospitals, in the cycles through which instruments and utensils used in the treatment-room pass, from being sterile, to being soiled, washed, and sterilized again, is due to the provision at Musgrave Park of a Central Sterile Supply Department, while at Larkfield there is no such department.

At Musgrave Park the treatment-room is between the clean- and the dirty-utility rooms. Sterilized equipment is brought from the C.S.S.D. to the clean-utility room, where it is assembled as it is needed, and passed through a hatch into the treatment-room. When it has been used

* Because the hospital has no laundry facilities of its own and so has to use an outside laundry, the soiled linen will be sent down to a room in the basement under the ward block, where it will be sorted by an orderly, wearing protective clothing. She will also clean the bed mackintoshes there, and hang them up to dry.

it is passed, again through a hatch, directly into the dirty-utility room, and after it has been washed there it is sent down to the C.S.S.D. to be resterilized. Thence it comes back as required to the clean-utility room, and so the cycle is completed.

At Larkfield the clean-utility room is between the treatment-room and the dirty-utility room, because it is both the beginning and the end of the cycle. The instruments and utensils are sterilized in the clean-utility room and passed into the treatment-room through a hatch, and after use are taken straight to the dirty-utility room (without passing through the clean-utility room) to be washed. Having been washed they are passed, through a hatch, directly into the clean-utility room, where they are resterilized, and so the cycle is completed.

W.C.s and Washing Cubicles

As stated on pp. 127, 128 all the rooms provided for the patients' toilet are at the same temperature as the rest of the ward unit, and technical precautions have been taken so that no disagreeable noises or smells will reach the patients in bed.

It is assumed that most patients will be able to go to the W.C.s and washing cubicles, either walking or on a lavatory-chair, and the low-level cistern, W.C. pan, wash-basin, and the basins in the washing cubicles, have all been chosen and placed to accommodate a patient either sitting on a wheel-chair or moving in the normal way. Inside each W.C. there is a small wash-basin, with liquid-soap and paper-towel dispensers, and a mirror. A grab-rail is fixed to the wall beside the W.C. pan, and there is an easily reached bell-push. In each washing cubicle, in addition to the basin, there is a mirror, and a shelf on which the patient can put down his belongings.

The wheel-chair chosen for the experimental wards may be propelled by a nurse or by the patient sitting in it. The metal frame of the chair has a lavatory-seat built into it, and can be placed over the W.C. pan. It may also be used as a commode, by slipping a bedpan on to a rack beneath the seat. The chair has a separate, leather-upholstered seat which fits over the built-in lavatory-seat, making it then quite suitable for general use. The chair remains steady as the patient gets in or out.

Bathrooms

It is part of early ambulation policy to encourage patients to bath in the bathroom when possible; but getting a helpless or feeble patient safely in and out of a bath is often difficult and hazardous. All the baths in the experimental wards are free-standing, so that if necessary two nurses at once can assist or lift the patient. The bath is raised on a concrete plinth, and the rim is 2 ft. 6 in. from the floor, which saves some bending for the nurse. For the convenience of the feeble patient there is at one end of the bath a small, cork-covered platform up two steps from the floor, with a grab-rail on the wall beside it. This platform is at the same level as the bottom of the bath, and the patient therefore has only to step over the 15½-inch side of the bath itself. There is a bell-pull suspended within reach over the bath.

The Ward Kitchen

In the experimental units the general layout of the kitchen does not differ greatly from that of an up-to-date kitchen in a private house; the equipment and cupboards are ranged round the walls, leaving a clear space in the middle of the room.

Only the very simplest cookery will be undertaken in the ward kitchen. The main hot and cold dishes for breakfast, lunch, and supper are all received ready to be served, in heated food trolleys (having a cold compartment). The trolleys are plugged in to an electrical outlet on arrival in the wards. Each group of sixteen patients at Larkfield, and twenty at Musgrave Park, will have a separate food trolley.

To make meals seem as individually arranged as is possible when sixteen or twenty people are in fact all sharing the same food at the same time, a tray will be laid at each patient's bedside (from a trolley carrying the stock of trays, crockery, cutlery, and condiments). When serving begins, each patient will be consulted about his helping of food; for tea, each will have a stainless-steel tea-set.

The cookery and preparation to be done in the ward kitchen will include: preparing bread and butter, making toast in an automatic toaster, boiling eggs, and making various kinds of hot and cold drinks. Each kitchen has a rapid hot-water boiler, two thermostatically controlled quick-heating electric hotplates, and a refrigerator (capacity 3 cu. ft.).

After meals the crockery and cutlery will be washed up in the ward kitchen, and then stacked in wire baskets and boiled in a sterilizer. All the articles will dry by evaporation and will then be put away in cupboards and drawers. The plates are stored separately, in a cupboard which is also an electrically heated warmer. This warming cupboard stands at the level of the work-bench, so that it will not be necessary to stoop when moving piles of plates. Kitchen stores—edible and inedible—are kept in locking cupboards. The work-benches are surfaced with heat- and scratch-resisting plastic.

The Day-Space

At both Larkfield and Musgrave Park the day-space has been placed away from the bed-area and opposite the ancillary rooms—to increase the patients' sense of being convalescent and once more among active people—and near the kitchen, so that food and drinks can be conveniently served. The day-space is not shut away behind doors, but is screened from comings and goings to and from the ancillary rooms by banks of cupboards. Some of these cupboards open into the day-space, and some into the circulation area on the other side.

At Musgrave Park one bank of cupboards has been modified so that it can be used for arranging flowers for the ward. A work-bench with a small sink has been provided, with parking space for a trolley underneath, and storage shelves for vases. The want of such a place is keenly felt in many English hospitals, where planners have not felt justified in setting aside a whole room for the purpose.

The day-space is close-carpeted to make it both pleasant and quiet. There are stacking, birchwood chairs (used generally in the experimental wards), and upholstered arm-chairs which adequately support the body and allow the occupant to move freely. There are tables for dining and writing, with mahogany tops, and birchwood legs which can be removed when the table is stored.* Bookshelves and cupboards for magazines, games, and so on are built-in round the day-space.

The Interview-Room

The interview-room adjoins the sister's room, and serves the whole unit. In addition to its primary use for private talks, the interview-room is also designed to accommodate the relatives of dangerously ill patients who wish to spend the night near at hand. Besides stacking chairs and a desk, the room therefore contains a com-

* These tables were designed by the Investigation. Drawers can be attached to turn them into desks; they are used throughout the experimental units.

fortable couch, which by day divides into three easy chairs.

Other Rooms

There are no very special or unusual features about the rest of the rooms in either of the experimental ward blocks—for example, the sisters' rooms, the doctors' rooms, and nurses' cloakrooms, the cleaners' rooms, and the laboratories.

All the storage cupboards in the units have either adjustable or movable shelves; and in the utility rooms some cupboards have extra shelves for small objects on the inside of the doors, so that as many as possible of the articles in daily use are within easy reach of the nurses. Only things not in constant use are stored on high shelves. Linen cupboards are warmed. At Larkfield Hospital, because there is no central linen service, a room in the basement below the ward block will be used to simulate such a service. The linen for the whole experimental unit will be stored in this room, coming directly to it from the laundry and being issued from it daily, by staff from the linen-room, as needed by the nursing units.

Furniture and Fittings in the Wards

Beds and Mattresses. Formerly hospital beds were designed to save the nurses from having to stoop when attending to bedfast patients, but more modern policies of early ambulation made it necessary for the Investigation to collaborate with a firm of hospital bed makers in designing a bed to suit both the nurse and the early ambulant or elderly patient. This bed has two positions for the mattress frame: the first, for nursing patients in bed, is about 28 inches above the floor; the alternative, for the patient's convenience and safety, lowers the frame to about 18 inches above the floor. The bed can be adjusted with ease by two nurses.

A proportion of the beds will have removable side-rails for patients in danger of rolling out of bed. A few adult cot-beds will also be provided, the cot sides sliding under the bed when not required. All the beds have telescopic back-rests, and lifting-poles; and the bed-heads themselves can be removed to allow access to the patient from that end of the bed. The beds move easily on castors, with a simply operated braking-pedal on one of the back wheels and on the front wheel at the opposite side of the bed. These when depressed hold the bed immobile.

Half the beds will be provided with interior-sprung mattresses, the other half with foam-rubber mattresses in ticking covers (with both types of mattress ordinary bed-mackintoshes will be used when necessary), so that the Investigation can compare the two types.

Bedside Locker and Overbed Table. The overbed table has been designed to be readily adjustable to the two heights at which the bed itself may stand. The table is covered with heat- and scratch-resisting plastic, and the centre section can be raised at an angle to form a book-rest.

A prototype bedside locker designed by members of the Investigation will be tested in the wards at Larkfield. The chief aim in designing the locker has been to make it as convenient as possible for the patient in bed.

Wash-basins. The wash-basins are very simple in design, to make cleaning easy, and they are cantilevered from the wall so that no supports obstruct the floor beneath. Taps are, in general, elbow-operated, and there are standing-wastes instead of overflow slots which can become foul. Either a soap tray or a liquid-soap dispenser is mounted on the tiled splashback. In washing cubicles towel rails are provided and patients will use their own towels; but elsewhere there are paper-towel dispensers beside the basins.

Vacuum Cleaners. A large cylinder-type vacuum cleaner will be used in each ward unit.

Heights of Equipment and Furniture

In deciding upon the correct heights for equipment and furniture, the Investigation had the advice of Dr. E. M. B. Clements, of the Department of Anatomy in the University of Birmingham. This collaboration was not begun sufficiently early to affect all pieces of furniture and equipment in the experimental wards at Larkfield, but it has influenced the heights of most of the furniture and equipment for Musgrave Park Hospital.

Sterilizers. The height of crockery- and bedpan-sterilizers is 2 ft. 6 in. to the top of the container, to facilitate the removal of loaded wire baskets. The height of bowl- and instrument-sterilizers is 2 ft. 9 in.

Sinks and Wash-basins for the use of staff at Larkfield have their rims 3 feet above the floor; at Musgrave Park Hospital the rims are 2 ft. 9 in. above the floor. The rims of wash-basins for patients at Larkfield are 2 ft. 7 in. from the floor, and at Musgrave Park, 2 ft. 9 in. Both heights allow a patient sitting in a wheel-chair to use the basin.

Working Surfaces and Stools. All work-bench tops at Larkfield are 3 feet from the floor; at Musgrave Park they are 2 ft. 9 in. or 3 feet from the floor. Stools to be used at the work-bench are 2 ft. 3 in. high.

The laboratory work-bench at Larkfield has a working surface of teak and is 3 ft. 6 in. from the floor—the height requested by the medical staff.

5. Comparison of Space per Bed in the Experimental Units at Larkfield and Musgrave Park Hospitals

The plans for the experimental ward units at Larkfield and Musgrave Park Hospitals were analysed in terms of total area per bed, and the areas in square feet per bed occupied by the beds (in ward-bays and single rooms), the ancillary rooms, and corridors. This enabled the two units to be compared with each other, and with the six previously studied by the same method (*Fig. 14*, cf. *Fig. 2*, p. 5).

In total space requirements, Musgrave Park Unit (total space 194 sq. ft. per bed) is more economical even than those at the Bradford Royal Infirmary or the Westminster Hospital, although it has a full range of ancillary rooms, which neither of those two 'traditional' wards has.

Among the corridor-type wards, the next most economical is the Sandvikens Hospital (total space 211 sq. ft. per bed), which, like Musgrave Park, has beds arranged 3-deep. The Larkfield plan is very close in total area to the Sandvikens plan, needing 218 sq. ft. per bed, as compared with the Sandvikens Hospital's 211 sq. ft. per bed.

Table 13. Use of space in six ward plans (cf. *Table 1*) compared with the experimental ward units at Larkfield and Musgrave Park Hospitals: *Linear density of beds per 10-foot run of ward building*

	Total length of corridor in feet	*No. of beds in unit*	*No. of beds per 10-foot run*
Experimental Unit, Musgrave Park	160	40	2·5
Bradford Royal Infirmary	182	28	1·6
Westminster Hospital	177	26	1·5
Sandvikens Hospital	157	30	1·9
Experimental Unit, Larkfield Hospital	160	32	2·0
St. Lô Hospital	197	28	1·4
U.S. Public Health Service Type-Plan	173	24	1·4
The National Hospital, Queen Square	112	17	1·5

Table 13 shows the linear density in beds per 10-foot run for Larkfield and Musgrave Park, compared with those in the six plans previously analysed. The experimental wards are more compact than the others, Larkfield having 2 beds per 10-foot run and Musgrave Park 2·5 beds per 10-foot run. These compare with 1·9 beds per 10-foot run at the Sandvikens Hospital (the most compact ward previously considered) and about 1·5 beds per 10-foot run in most of the other plans.

Capital Cost of the Experimental Wards

The cost of the experimental ward block at Larkfield was £89,000, including the connecting ways to the main hospital, entrance hall, stairs and lifts, basement, site works, and fixed equipment. The cost per cubic foot was 5*s*. 3*d*., and the cost per square foot of usable space was £4. 10*s*. The cost per bed was £1,400, including the cost of the basement, connecting ways, &c.

The cost of the experimental ward at Musgrave Park is estimated at £80,000, excluding connecting ways, but including entrance hall, stairs and lifts, site work, and fixed equipment. The cost per cubic foot is estimated at 4*s*. 8*d*. and the cost per bed at £1,000.

6. Proposals for Nursing Experiments in the Ward Units designed by the Investigation

From the outset one of the chief aims of the Investigation has been to provide surroundings which will assist

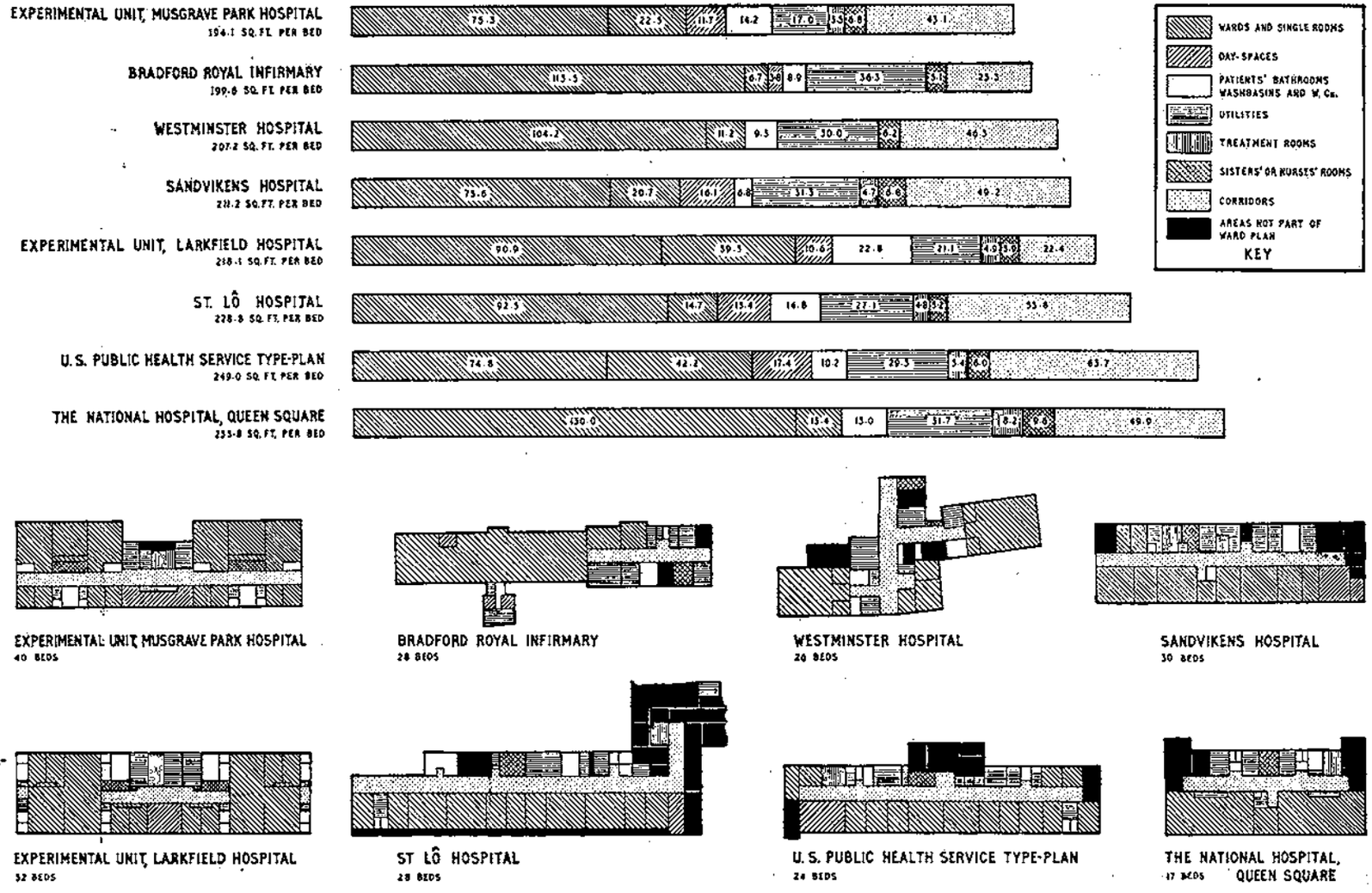

Fig. 14. The use of space in terms of square feet per bed, in the Investigation's experimental ward units at Larkfield and Musgrave Park Hospitals, compared with examples of the use of space in 'English traditional' and 'corridor' types of ward unit

positively the work of nurses. It is intended that, when the experimental ward blocks at Larkfield and Musgrave Park Hospitals are completed, observations shall be made of work in progress in them, to see which features of each experimental unit as a whole have so assisted, and how the details of planning and design can be improved.

The Investigation envisaged a large administrative nursing unit within which smaller clinical nursing units could give a more personal service to each patient than has sometimes been possible of late years in wards dating from a time when medical and nursing procedures had not reached their present complexity. The completion of the Nuffield Job-Analysis of the work of nurses in hospital wards, the important discussions on the job-analysis findings, promoted among its members by the Royal College of Nursing, and the subsequent trials of team nursing on a patient-assignment basis now being made both under the auspices of the Ministry of Health and independently, have enabled the Investigation to work out staffing proposals for the experimental wards. These proposals, which have been discussed with the Chief Nursing Officers of the Ministry of Health and the Department of Health for Scotland, have been put forward in some detail for the Larkfield block; those for the Musgrave Park block are only tentative.

Nursing Proposals for Larkfield Hospital

Two sisters will be in charge of the unit of 64 beds at Larkfield Hospital. One sister will be responsible for administrative duties connected with ward management which can most efficiently be done for the 64-bedded unit as a whole, and the other sister will act as her deputy. In addition to their management duties, they will share the overall nursing supervision of 32 beds on one floor, guiding the trained nursing staff in giving day-to-day care to groups of patients, teaching the student nurses at the bedside and, in particular, developing the senior students' ability (while they are deputizing for a trained nurse) to bear responsibility for all the nursing care needed by a group of patients. The sisters may also instruct any nursing auxiliaries,* who may be members of the nursing team, receiving their training on the job.

In the initial trials of team nursing for groups of patients each nursing unit of 16 beds will be in the care of three nurses, the one in charge being a trained nurse. Each pair of teams on a floor will have the assistance of three relief nurses—one to cover the daily off-duty periods of both junior members of the nursing teams, and two to relieve during weekly days off.

At night a similar team of three nurses will take charge of both groups of sixteen patients on a floor, a relief nurse being provided when each in turn has her nights off duty. The night sister for the whole of Larkfield Hospital will give overall supervision in the experimental block.

The complement of nursing staff provisionally suggested for the Larkfield experimental ward block is therefore:

1 senior sister
1 deputy sister
7 trained nurses
6 senior nurses in training
13 junior nurses in training or nursing auxiliaries*
28 Total.

The ward domestic staff proposed for the experimental block is:

4 ward orderlies (1 per floor, on an 8-hour shift morning and afternoon).
3 ward maids.

The ward orderlies are chiefly concerned with the cleanliness and general good order of furniture, fittings, and equipment used exclusively by the nurses or provided for the patients' particular use. They will sort soiled linen for dispatch to the laundry, in a room outside the ward units (see p. 24 fn.), and will put away in the linen cupboards the daily clean supplies sent up for the nursing units (see p. 26).

As suggested in the Nuffield Job-Analysis report,[43] clerical assistance will be provided for the sister. One clerk from the Larkfield Hospital pool of clerical staff will do desk-work under the direction of the sister. How long she will be needed daily for this work has yet to be determined by experience.

Team Nursing and the Patient

When a patient is admitted to a bed on the appropriate floor (for men or women) in the experimental block at Larkfield, the sister—trying as far as possible to keep the nursing load evenly distributed—will put the patient in the care of one or other of the teams on that floor. The patient will remain in the care of that team until the time comes to leave the hospital. This arrangement is not, of course, intended to be so rigid that aid can never be given by members of one team to another.

The trained nurse in charge of each nursing team will have the responsibility for considering and planning all the various aspects of the nursing care needed by each patient in the group of sixteen. From day to day she herself will decide which patients particularly need her personal skill and experience; this she will give them while superintending her assistants and working closely with them in nursing the whole group.

To free the nurses as much as possible from work which might distract them from giving direct and personal attention to their patients, or which might properly be done by others, certain nursing procedures are likely to be reviewed by the medical staff at Larkfield. The lightening of the load on the nurses to be achieved by employing orderlies (and in some small respects, ward clerks) has already been mentioned.

It is hoped that by simplifications and rearrangements of the timetable for day and night duty in the units, the hour for waking patients can be made later.

Musgrave Park Hospital

The nursing proposal for the experimental ward units to be built at Musgrave Park Hospital are likely to follow the Larkfield proposals in principle. They have not been planned in detail at present because it is expected that some practical experience can be gained at Larkfield in time to benefit Musgrave Park.

In outline, the proposals for Musgrave Park are as follows. Allowing a ratio of nurses to patients similar to that proposed for Larkfield, there would be 4 nurses in each team, and one team would look after a group of 20 patients. Because the experimental wards at Musgrave Park were designed on the assumption that the basic nursing unit might be 10 patients, it is proposed that during certain phases of the daily routine in the ward units, each group of 20 patients should be divided, 10 patients being looked after by one pair of nurses and 10 by another pair. It is possible that the nursing teams at Musgrave Park Hospital may include assistant nurses.

* Nursing auxiliaries are men or women neither in training for nursing qualifications nor on trial before taking them, who assist qualified nurses in nursing work.

* With the addition of one junior nurse in training, or a nursing auxiliary, part-time on night relief.

The larger administrative units to be managed by the sisters at Musgrave Park will need careful study; and the use of the Central Sterile Supply Department may be expected to affect the way the nurses spend their time, possibly entailing adjustments in staffing.

Proposed Studies of Work in Progress in the Experimental Units

The Investigation hopes to make detailed observations of various aspects of work in progress, first in the experimental block at Larkfield, and later in the Musgrave Park block. The subjects of these studies, each one of which will have a bearing upon all the rest, will probably include: nursing (variously subdivided); the extent to which the design of the buildings makes it easier to practise early ambulation; the use to which the single rooms are put, and the effect on staffing; the use of the treatment room; circulation routes of people and objects within the ward block; the effect of withdrawing certain jobs from the ward units at Larkfield, by simulating central services, for example, a central linen service; and the actual use of the Central Sterile Supply Department at Musgrave Park Hospital.

Some studies will be done in collaboration with the Building Research Station, others will require the co-operation of various different experts and independent assessors.

SUMMARY

I. Historical Introduction. Small wards advocated in the eighteenth century were replaced in the mid-nineteenth by large open wards designed for adequate cross-ventilation and easy supervision. In the twentieth century a higher standard of living led to a demand for greater privacy and so to partitioning open wards and building smaller wards.

II. Studies by the Investigation. 1. In a comparison of the use of space in open-ward and corridor-type units, the latter, being more recent, showed an increase in the ancillary rooms. A decrease in the size of the corridor-type unit was achieved by placing beds 3-deep. 2. The incidence of cross-infection was recorded in wards in eight hospitals. Inadequacies in ward design and equipment were observed. These may have led directly or indirectly to infections which lengthened patients' stay in hospital. 3. It is argued that a treatment-room in every ward unit would improve conditions for patients treated and for their neighbours, and would help to make possible a later waking hour. Records of the daily use of a treatment-room showed that it could serve at least 30 beds. 4. Records of journeys between beds and to ancillary rooms indicate that in 'traditional' wards nursing was organized as a series of rounds to reduce walking. The kitchen and clean- and dirty-utility rooms were shown to be visited with almost equal frequency. Where single rooms were not easily supervised very ill patients were not put into them. 5. Only exceptionally were more than three nurses together in the clean-utility room; brief visits to the dirty-utility room during peak periods, and time spent there on various jobs were recorded. Its use for arranging flowers showed the need for a more suitable place for this job. 6. English and foreign views on bed-spacing are stated. A film of ordinary bedside nursing jobs showed that only a few procedures, involving sizeable equipment (e.g. a trolley), encroached on space 4 feet beyond the bed. 7. Information gained from assessing the need for single rooms in different kinds of ward enabled appropriate scales of provision and the probable amount of use to be calculated. 8. From assessments made in eight hospitals it was estimated that under an early ambulation régime 70–90 per cent. of patients in any unit would get up to use toilet facilities, and 40–55 per cent. could sit in a day-space.

III. Nursing Organization in Wards. The traditional English system which places the whole responsibility for nursing and ward management upon the sister leaves too little distinction between the trained nurses under her and the student nurses. Patients may suffer, since much of their bedside care is left to students, among whom nursing tasks are arbitrarily divided and are frequently done as rounds from bed to bed.

To overcome these defects some hospitals give students, under the supervision of a more senior nurse, responsibility for the care of groups of patients. Recently this way of nursing has been further developed experimentally, and all the trained nurses and students attached to a ward unit have been organized as teams. This relieves the sister of some direct responsibility for patients' care, and it should be possible for her to assume overall responsibility for many more patients —a change likely to result in greater efficiency in ward management. But so far, in Britain, the scope of the sister's work has not been much enlarged.

As the Investigation wishes to conduct team nursing experiments in the 64-bedded experimental ward unit at Larkfield and the 80-bedded ward unit at Musgrave Park, observations were made by the nurse member in a hospital in Denmark where team nursing is long-established and where the sister has responsibility for a large administrative unit.

IV. The Investigation's Experimental Ward Blocks at Larkfield Hospital, Greenock, and Musgrave Park Hospital, Belfast. The Investigation was invited to design two experimental ward blocks, one a medical unit attached to Larkfield Hospital, Greenock, the other a surgical unit to be attached to Musgrave Park Hospital, Belfast.

At an early stage in planning, the Investigation decided that the ward blocks should be so designed that a larger unit of nursing administration could be tested. At Larkfield there are 64 beds in the block. From an architectural point of view this unit is a satisfactory size for a floor in a multi-story building—giving two cul-de-sac units of 32 beds on either side of a common circulation area. From the nursing point of view the administrative unit of 64 beds is conveniently divisible into two units of 32 beds, for which the sister in charge and her deputy will be responsible. The units are again divisible into two groups of 16 beds sharing one set of ancillary rooms. The basic nursing unit is 8 beds.

In each group of 16 beds, 12 are arranged in open bays and 4 are in single rooms. The beds are arranged 2-deep parallel to the window-wall.

As a result of the joint researches of the Investigation and the Building Research Station into daylighting in wide buildings, it was possible in the Musgrave Park Hospital plan to increase the total number of beds in the unit from 64 to 80 without increasing the length of the building. As at Larkfield this

number of beds is conveniently divisible between the sister and her deputy, and one set of ancillary rooms can serve 20 beds. The basic nursing unit is 10 beds.

In each unit of 20 beds, 12 will be arranged 3-deep in two 6-bedded wards, 4 will be arranged 2-deep in a small ward, and 4 will be in single rooms.

The arrangement of beds 3-deep parallel to the window-wall is common on the Continent, and architecturally is valuable because it allows greater compactness in the building. This arrangement has yet to be fully accepted in Britain, but the Musgrave Park experimental ward units offer propitious conditions for testing the reactions of patients and staff to it.

In deciding how many beds the ancillary rooms could serve and how each room should be designed, the Investigation drew upon the information produced by its field studies—for example, the studies on the use of clean- and dirty-utility rooms and the treatment-room, the proper provision of single rooms, and the proportion of patients who, under an early ambulation régime, would be likely to need the use of washing cubicles, W.C.s, and a day-space.

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2 THE OUTPATIENT SERVICE

I. HISTORICAL INTRODUCTION

Origins of the Outpatient Service

THOUGH 'out patients' are briefly mentioned in the early *Journals* of St. Bartholomew's Hospital—in 1664, for example, and again in 1678, in which latter year the number was said to have become burdensome, and it was laid down that not more than eight were to be admitted in a week[1]—they do not seem to have been accepted at St. Thomas's Hospital until about 1760.[2] But the outpatient department was always an integral part of the English voluntary hospital system which came into being in the first quarter of the eighteenth century. When the Charitable Society for Relieving the Sick and Needy proposed to establish an infirmary at Westminster in 1719, they could not at once find a suitable house, and many people were therefore attended in their own homes; 'and even after a house was hired and furnished, and the Infirmary set up, they continued, and do still continue, to assist considerable numbers of poor people upon the foot of outpatients'.[3] The first provincial voluntary hospital, at Winchester, was modelled upon the Westminster Hospital and likewise received outpatients; and so in turn did the other voluntary hospitals as they were founded.

In the beginning the number of outpatients was automatically limited, for every outpatient—like every inpatient—had to be recommended personally by a subscriber to the hospital, and the number of recommendations which each might make was itself limited according to the subscription paid.

Many people were accepted as outpatients while they waited for beds to become vacant; others continued to attend the hospital for treatment after their discharge from the wards. But there were some outpatients whose cases were considered wholly unsuitable for inpatient treatment—asthmatics, for example, and others with chest complaints—and inpatient treatment was usually reserved for those likely to obtain the greater benefit from it. At the Newcastle upon Tyne Infirmary, for instance, at the beginning of the nineteenth century, the revised rules of the hospital allowed the medical staff complete freedom to decide in all cases whether inpatient or outpatient treatment was the more appropriate.[4]

Growth of the Outpatient Service

One effect of the discipline of the new Poor Law, after 1834, was to increase the work of outpatient departments; for the poor turned to them when they could no longer freely turn to the parish doctor for treatment, as they had done before. At about the same time many hospitals began to look on the outpatient department as a valuable source of teaching material from which to fill their beds, and some no longer insisted on patients coming provided with a subscriber's letter. During the decade 1828 to 1838 the number of outpatients and casualties attending St. Bartholomew's Hospital grew more than six times, and other hospitals could show similar increases. This pressure upon the outpatient department continued not only in London but in country towns also, in many of which the hospital officers visited the patient in his home.[5] In London, in particular, general practitioners were chagrined by the deflexion of potential patients; and many people complained of the abuse of charity and the degradation of the poor who chose to obtain free what they might possibly have been able to pay for.

The *Lancet* took a broader view. It did not think that there could be so very much abuse, for conditions in the outpatient department were scarcely such as to encourage patients to go there unless they really had to seek such medical aid. The *Lancet* undertook its own 'Investigation into the administration of the out-patient department of the London hospitals', in 1869. The investigators reported delay, gross overcrowding, rapid and perfunctory examination and prescribing, and a general lack of privacy and proper consideration for the comfort and feelings of patients. The doors of the outpatient department were usually thrown open at a certain hour each morning and after the assembled throng had crammed into the waiting rooms were closed again. During the next three hours or so the patients were examined, questioned, and prescribed for until all, or at any rate most of them, had been seen. 'Nothing can be worse', said the *Lancet*, 'than the necessity of despatching patients at railroad speed.'[6]

The investigation brought to light the fact that specialist consultant services were already beginning to develop. At both Guy's and the Great Northern Hospital the 'diseases of women' was an established outpatient as well as inpatient specialty. St. Bartholomew's had then recently begun to hold eye clinics and clinics for diseases of the ear and of the skin. Guy's also held eye clinics and had been holding ear and skin clinics since 1863. Of Guy's Hospital, the investigators remarked that

> In every department many cases are sent to the hospital by medical men; sometimes for advice, sometimes for medicine also. It is a question worthy of deep consideration whether such consultations might not be facilitated with benefit to the medical practitioners, their patients, and the hospital itself. It

would often be a great relief to the general practitioner or parish doctor if he could command the gratuitous advice of some eminent consultee for a patient who, though perhaps able to pay himself, is quite unable to afford a fee.

Attempts at reform in the outpatient department were complicated by the fact that hospitals continued to be charities while becoming increasingly specialized medical institutions. During the last thirty years of the nineteenth century efforts were made to relieve outpatient departments of their enormous load of trivial cases by encouraging the poor to make use of dispensaries. Many charitable and provident dispensaries had been established in the course of the century, and after 1867 the Poor Law authorities had powers to provide their own. An important factor in reducing the load was the system, introduced in 1895 by C. S. Loch of the Charity Organization Society, of employing lady-almoners to make searching inquiries into each intending outpatient's ability to pay for treatment elsewhere. Moreover, the consultants themselves came to set a limit upon the number of patients they would, and indeed could, properly see, during an outpatient session.

From 1905 onwards the British Medical Association campaigned steadily to have outpatient care restricted to patients whose general practitioners had directly sent them to the department for consultation. Although most hospitals could not see their way to adopting this referee system exclusively, they nevertheless approved it and encouraged its use. Consultative cases and cases requiring special treatment thus formed an increasingly large part of the outpatient load. And this tendency to confine outpatient care to the more intricate cases had a rather important effect. It raised the proportion of outpatients who became inpatients—particularly on the surgical side. The sequence: outpatient consultation, inpatient admission, outpatient follow-up, though not originally the principal feature of voluntary hospitals, gradually came to be looked upon as normal for the majority of patients.

The Beginnings of Appointment Systems

Over twenty years ago, in 1932, a committee appointed by King Edward's Hospital Fund for London to investigate outpatient arrangements* reported conditions which are still by no means unfamiliar:

During the wait before seeing the consultants, the patients usually sit on benches in that part of the out-patients' waiting hall which is nearest to the consulting room of the doctor who will see them. . . . Where the building is large enough and modern enough, there may be ante-rooms attached to each consulting room suite and the patients may be moved forward into these several at a time. Some doctors prefer that the interview with a patient should not be in the presence of other patients. . . .

With patients who have to be undressed either before their examination begins or before it can be completed, much depends on the number of dressing rooms or cubicles available, and on their planning. When the doctor has finished with one patient the next must be ready. . . . At one teaching hospital . . . with a large and fairly modern out-patient department, each examination room attached to a consulting room has four dressing cubicles. . . . One special hospital reports that it has saved much time by having two dressing rooms instead of one; they are used alternately, so that no patient has to wait for a room.

The committee recognized the fact that 'patients have no ready means of making grievances known', and therefore they gave special attention to evidence bearing upon the patient's attitude, submitted to them by such bodies as the Charity Organization Society and the Hospital Saving Association. Much of this evidence related to the length of time patients had to spend waiting for medical attention in the outpatient department, and to the complaints of employers about working-time lost in that way.

Three teaching hospitals had kept records of the time taken by individual patients at different stages of their visits, and the committee drew attention to this useful method of finding out where procedure could be improved.

Among other suggestions, the committee recommended that if there was a fixed time for the arrival of patients then it should be as near as possible to the time when the visiting staff began work; and furthermore that separate times should be fixed for the arrival of old and new patients.

They believed that any comprehensive system of appointments, giving each outpatient a separate time, was an 'impossible ideal'; but they thought nevertheless that in some of the special departments an appointment system for individual patients or groups of patients might be possible. And even for the main outpatient department they suggested that a system might well be adopted 'whereby some of the patients would come at the beginning of the session and the rest at half time'.[7]

In fact Dr. A. R. Friel, in 1930, had described an individual appointment system which he had been using at a school E.N.T. clinic in Tottenham since 1926; and the *Lancet* at the time commended 'this sensible idea' to the notice of its readers.[8] Moreover, the Fund's committee had found some evidence that several hospitals were already using rudimentary appointment systems.

In 1931 the *Lancet* drew attention to the appointment systems then being used in all clinics, for both old and new patients, by the Victoria Memorial Jewish Hospital, Manchester, and the King George Hospital, Ilford.[9] At Ilford the clinics were purely consultative, and, since the number of patients was very small, there was little practical difficulty in giving individual appointments. At Manchester there was a considerable problem of organization. The queue of patients waiting outside the hospital for admission to a limited waiting-space had made the need for reform urgent. So at the entrance to the outpatient department the authorities set up an 'appointments bureau'. This bureau was also the registration, records, and almoner's office, dealing with inpatients as well as outpatients. It was staffed by the almoner herself, with one senior and one junior assistant. An account of the system, written some years after its inauguration, stated that

the first thing the hospital had to do was to get an approximate idea of the speed at which the different Honoraries were accustomed to work when dealing with new and old patients respectively. . . . The rate is found to vary from 2 to 15 patients in 15 minutes, and the Honorary's weekly chart is divided into 15 minute sections. . . . Patients tend to come in good time for their appointments and advantage can be taken of this factor. A patient may have to wait anything up to half an hour, and the Honorary is kept busy even if he does happen to get through several patients in as many minutes. In fact occasions when the Honorary has to wait for the next patient are so rare as to be quite negligible. . . . It is found in practice that forecasts that patients would not keep their appointments were mistaken.[10]

It was not, however, until the late nineteen-thirties that appointment systems were by any means generally adopted.

In May 1939 Mr. W. Howarth described in the *British Medical Journal* the appointment system newly introduced in his ear, nose, and throat clinics at St. Thomas's Hospital. Arrangements were complicated by teaching. For the first hour of each session all the new patients were examined, and cases suitable for teaching purposes

* A similar committee reported in 1912,[14] but its findings had been largely outdated by the National Insurance Act of 1911.

identified; for the rest of the session the chief assistant, the house surgeon, and two more clinical assistants each saw old patients by appointment at the rate of four in every quarter of an hour, and Mr. Howarth himself taught. The lady-almoner undertook the clerical duties, and she arranged 'an early or a late appointment to suit the convenience of the patient'. Mr. Howarth remarked that 'the successful working of the scheme depends on the punctuality and regularity of attendance of the visiting surgeon and other officers concerned'.[11] This appointment system was so successful that a few months later the hospital authorities were considering extending it to new patients, and the almoner herself looked forward to a time when 'the mere idea that patients, except in an emergency, should come up to a hospital without an appointment will be regarded as fantastic'.[12]

Mr. Howarth's article was followed by some letters to the *British Medical Journal*. Dr. W. Arklay Steel, the Medical Superintendent of the Hillingdon Hospital, described an appointment system which he had recently introduced in all clinics in his hospital. He pointed out that an efficient appointment system 'removes the necessity for providing large halls as has been the custom in the past'. Other letters about recently introduced appointment systems came from the Secretary of the Hospital for Women, Soho Square, and University College Hospital.

In spite of the outbreak of war, the Elizabeth Garrett Anderson Hospital adopted an appointment system at the end of September 1939.

In some places the war temporarily hindered the spread of the use of outpatient appointment systems, though at one hospital at least—the Royal Hospital, Wolverhampton—it was the direct cause of a system being adopted in 1940, when the impossibility of providing air-raid shelters for all the occupants of a full waiting-hall made a reduction in numbers imperative.[13] When the war ended, and hospitals employed full-time records officers, the devising and running of appointment systems was usually among their duties.

The General Practitioner and the Consultant Service

From the time when the outpatient department first began to do much consultative work there had been a risk that a proper interchange of information between the general practitioner and the consultant would not prove feasible. The first outpatient committee appointed by the King's Fund, in 1911, had recognized this, and the British Medical Association's witnesses, in giving their evidence before that committee, had urged that 'shorthand clerks and typewriters should be provided to deal with the correspondence' in consultative outpatient clinics.[14] But it was not until 1929 that the matter again received much attention. Then a general practitioner, writing to the *British Medical Journal* from Southborough in Kent, complained that while some hospitals were punctilious in sending information to the general practitioner who had asked for a second opinion, others 'simply absorb the patient, of whom one hears no more. . . . The whole trouble is that the hospitals have no organization for acting in a consultant capacity. Unless individual members of the staff answer letters privately it is not done.'[15] Another practitioner described a more satisfactory state of affairs obtaining in the Ear, Nose, and Throat Department of the Bristol Royal Infirmary.

> In all cases, whether in-patient or out-patient, one receives a letter with full notes under appropriate printed headings—'diagnosis', 'clinical findings', 'suggested treatment', 'prognosis', &c. In addition to this, and added underneath the address of the department, are days and hours of attendance, details which are apt to escape the memory of the busy practitioner.[16]

While many general practitioners received no information from the outpatient department, the hospitals complained that general practitioners often sent patients 'with only a visiting card or a scrap of paper which gives no information about the case'. The King's Fund committee on outpatients recommended the use of printed forms, in 1932,[7] and when, soon afterwards, the British Medical Association and the London Panel Committee each prepared model forms for the use of general practitioners, the Fund circulated both within the London area, advocating the use of one or the other. For the further convenience of general practitioners in London, the Fund also began regularly to circulate time-tables of all hospital outpatient clinics.

As time went on more hospitals made determined efforts to supply clerical help to consultants, and to take some responsibility for seeing that information was received from, and passed to, general practitioners.

Later Concepts of the Functions and Design of Outpatient Departments

The Local Government Act of 1929, which transferred the poor-law infirmaries to the Local Authorities, gave the impetus to an official attempt to define precisely the functions of an outpatient department and, indirectly, to a consideration of its proper physical layout. The poor-law infirmaries had had no outpatient departments (this service was supposed to be provided either by the parish doctor or, after 1867, by the poor-law dispensaries). But after 1929 the intention to improve the quality of work done in all municipal hospitals implied the need for outpatient consultative, diagnostic, and treatment facilities, modelled on those supplied by the voluntary hospitals, both for hospital patients and as a supplement to the work of the Local Authority clinics. In his report for 1932 the Chief Medical Officer of the Ministry of Health outlined the functions of the outpatient department in a municipal hospital. It was to be:

> (*a*) The reception department, where patients for admission to the hospital can be examined.
> (*b*) The casualty department, where emergency treatment is rendered.
> (*c*) The centre at which continuation treatment is provided for patients who had been discharged from hospital.
> (*d*) The consultative centre for specialist investigation and treatment which cannot be efficiently given in the home but does not necessitate the admission of the patient to hospital, and to which patients from the Local Authority's clinics, &c., may be referred.[17]

Official interest in municipal hospitals led to the setting up of a Departmental Committee on the Cost of Hospitals, which unsuccessfully attempted to lay down standards in terms of design. The committee simply concluded that the outpatient department 'is a developing service in municipal hospitals, and it does not appear that the outpatient practice of Local Authorities has yet become sufficiently standardised to enable us to suggest standards for the Department'.[18]

When the new Westminster Hospital was being planned a fresh approach was made to the outpatient service. It was decided to disperse all the consultative clinics throughout the ward block so that each medical and surgical service (whether general or special) consisted of adjacent inpatient and outpatient units each occupying one floor of the hospital. Until that time it had been customary at the Westminster Hospital to appoint some physicians and surgeons solely to have care of outpatients. The new plan was designed to ensure that in future when an outpatient became an inpatient, and when eventually he attended for a follow-up examination, he remained in

the care not only of the same 'firm' of doctors but also of one sister, who presided both in the ward and in the appropriate outpatient clinic—a dual responsibility which imposed a heavy load upon her.

The assumption implicit in this way of planning was that most outpatients were either about to be, or had recently been, inpatients. But it was already becoming clear that an efficient outpatient service could in many cases prevent the need for outpatients to become inpatients, and the war-time sequestering of civilian beds under the Emergency Medical Service tended to enforce this idea of the role of the outpatient service. 'Some general hospitals have come to undertake such a large proportion of their medical work for outpatients without admission that they may almost be regarded as medical consultative centres supported by beds, rather than as hostels or hotels providing treatment', wrote the Chief Medical Officer of the Ministry of Health in his report for the year ending 31 March 1948.

II. THE OUTPATIENT SERVICE SINCE 1946

General Background

THE National Health Service Act (1946), in July 1948, caused two immediate alterations in the scope of hospital outpatient services. By making it possible for everyone to obtain general-practitioner care on equal terms, it finally did away with any necessity for outpatient departments to undertake non-specialist work; and at the same time it imposed upon hospitals full responsibility for the specialist care of all sections of the community. Neither of these changes produced any very unexpected effects upon the outpatient case-load, for they merely confirmed long-established tendencies. Developments in diagnostic and curative medicine have continually led to increases in the demand for outpatient care—a demand which preventive medicine and improved social conditions have so far not been able greatly to diminish—and to this was simply added something of the 'hidden demand' for medical attention which usually becomes evident whenever any new facility is provided. Because of this persistent upward trend in the outpatient load any lightening of the burden through the universal provision of general-practitioner care is hard to gauge.

Reporting on the first nine months of the Health Service in operation, the Chief Medical Officer of the Ministry of Health said:

> Out-patient attendances began immediately to rise. This was a real increase in the number of patients, for the number of attendances per patient did not rise. The increase has been particularly noticeable in gynaecology, radiology, pathology and ophthalmology but it has affected other specialities as well. It was not unexpected and indeed marked only an accentuation of change already apparent before the appointed day—a change which is steadily increasing the emphasis on hospitals as centres for diagnosis rather than mainly institutions providing beds for the treatment of the sick.[19]

The national figures show that very nearly two new outpatients attended for every inpatient discharged from hospitals in England and Wales during 1952;[20] and the ratio of outpatients to inpatients is probably much above the average in the many hospitals which have concentrated upon developing outpatient care in order to reduce the number of patients who may need admission. The Chief Medical Officer gave a warning that 'the policy of saving beds through extending the range of diagnostic and treatment procedures in the outpatient department should only be adopted in so far as the hospital has senior staff and facilities in that department such that the patient is not prejudiced by being treated without admission to a ward'.[21] A number of minor operations are now done without admitting patients to beds.

The existence of a large and growing class of outpatients who have not been and may never be inpatients, and the idea expressed by Professor H. W. C. Vines that 'the chief function of the outpatient department should be to keep patients out of the beds of the inpatient departments',[22] together with the merging of the individual hospital into the hospital group, have in recent years led many in Britain to think of the outpatient department simply as a *centre* for diagnosis and treatment by consultant and other specialists: a *polyclinic*.

Methods of Organization

The idea of the polyclinic, and the name, originated late in 1871 in the medical faculty of the University of Vienna, when a group of professors formed themselves into an independent association, took rooms in a house and there held consultative clinics for the poor, at which they also taught students. The various clinical sessions, each of which lasted an hour, included general medicine and surgery, diseases of the chest and throat, urinary system, skin, eyes, ears, nervous system, and diseases of women and children. What at the time was new about the Vienna polyclinic was not that it provided an outpatient service (for the various hospitals of the city did that), or even that it was a separate institution (though separateness afterwards came to be considered an important characteristic), but that each session was conducted by a specialist of professorial rank.[23]

Since 1871 the term *polyclinic* has been adopted elsewhere on the Continent and in the United States of America. In some countries, however, notably in Denmark and Sweden, the most essential feature—that each clinic should be directly in the charge of a specialist of consultant status—seems not to be fulfilled. In Denmark polyclinics are virtually confined to Copenhagen itself and are attached to the larger hospitals as separate outpatient departments, each in the charge of a director with a staff of assistants; in Sweden some polyclinics are attached to hospitals and are staffed by juniors, others are small independent units to which specialists give part-time service.[24] In England and Wales the consultative outpatient department of the larger acute general hospital would certainly qualify for the name 'polyclinic', though it has not commonly been so called.

Some advantages of the polyclinic method of organizing the outpatient service, by contrast with the Westminster Hospital's method of locating outpatient consultative clinics beside the appropriate ward or wards, were referred to in the Report of the Ministry of Health for the year 1949–50:

> A strong argument in favour of the single department is that out-patients can enter and leave it without penetrating into the rest of the hospital. True, [at the Westminster Hospital] . . . all out-patients, on arrival, go to the same point, from which they are conveyed by lift direct to the appropriate out-patient suite. . . . In a hospital on a different plan, however, out-patients might be streaming along the corridors to out-patients suites in various parts of the hospital.
>
> A weighty reason in favour of concentrating out-patient work in one department is that it can be in a separate building which can be expanded or altered at need. It is impossible to see how out-patient work, which is certainly gaining in importance will develop and, therefore, the plan should facilitate expansion and alteration of the accommodation to meet changing needs. This is easy if there is a separate out-patient building but might not be possible if the out-patient accommodation is broken up into a number of small sections each attached to the corresponding wards.[25]

It must be admitted, however, that the arguments for rejecting the Westminster system because of its inflexibility are less valid in the case of parent teaching hospitals than they are for other acute general hospitals. The work-load in teaching hospitals is easier to predict, because of the need to select patients for teaching purposes,[26] and the proportion of outpatients who subsequently become inpatients is likely to be larger and more constant.

A combination of the polyclinic and a modified version of the Westminster Hospital outpatient system was proposed in 1948 by the committee planning the Medical Teaching Centre projected by the Royal Liverpool United Hospital.

The committee proposed to establish (i) a *Consultative Outpatient Service*, on an orthodox polyclinic pattern; and (ii) a *Departmental Outpatient Service*, to be used by 'the patient who has to have "hospital" treatment but not in bed'. The latter patients, the committee thought, would at that stage usually be 'the exclusive concern of a particular branch of medical care'; and since many inpatients under the same care would need the use of the same facilities for special investigation and treatment, it was suggested that the departmental outpatient service would 'best be obtained in accommodation which was part of the appropriate ward block', for such an arrangement would be economical of both staff and equipment. The committee added that it was difficult to interpret these recommendations in terms of space, and that in any case the relative needs would vary in the different branches of medicine; but 'generally speaking', they said, 'the total of accommodation required in the ward blocks would appear to be almost as large as the total accommodation in the Polyclinic'.[27]

In some acute general hospitals it is established practice to send certain classes of outpatients needing treatment to the treatment-room of the appropriate ward. Provided that the ward is adequately staffed to deal with outpatients as well as inpatients, the system has the advantages suggested by the Liverpool planning committee; it has also the disadvantages pointed out by the Ministry of Health in connexion with the Westminster Hospital system.

Since January 1949 the Ministry of Health and the Department of Health for Scotland have repeatedly urged hospital authorities to review outpatient arrangements, in order to improve the service given, and in particular to make conditions in the department more agreeable and to reduce time spent waiting.

A memorandum issued by the Ministry of Health in August 1953 opened the way to further improving organization in the hospital generally. It gave guidance on the constitution and functions of fully representative medical staff committees—at both hospital group and hospital levels—and accorded them (and executive subcommittees appointed by them) an official prestige which they previously lacked.

> The object of the committee is to advise the hospital authority on all matters of medical policy and all medico-administrative problems. Its primary medico-administrative function is to maintain a continuous review of all hospital facilities in the group to ensure their most effective employment. . . . In addition to advising on matters referred to it by the hospital authority, it should initiate advice as occasion requires when no reference has been made.[28]

The Patients' Point of View

Despite official recommendations and other authoritative suggestions for the bettering of outpatient services, and despite the efforts of individual hospitals and hospital groups to put them into practice, patients continue to have well-founded grounds for complaint and from time to time they voice them publicly. As a rule their chief grievances are that they are kept waiting inordinately long and in discomfort. A vigorous correspondence was conducted in the winter of 1952–3 in the *Manchester Guardian*, in the course of which it was said that 'the conditions to which out-patients have to submit are sometimes beyond endurance'.[29] In June 1953, at their annual meeting, members of the National Federation of Women's Institutes discussed difficulties and hardships experienced in outpatient departments, and passed a resolution requesting hospital management committees to review outpatient arrangements—in particular the appointment system—'bearing in mind the special difficulties of country people who have to travel long distances by public transport'. The *Lancet* published a report of the conference and supported the resolution.[30] In September 1953 the National Association of Women's Clubs, at their annual conference, passed a similar resolution.[31]

In June 1954 the Ministry of Health addressed a memorandum to Regional Hospital Boards and Boards of Governors asking them to review the arrangements in outpatient departments, and again stressing the importance of efficiently run appointment systems.[32]

III. STUDIES BY THE INVESTIGATION

WHEN the National Health Service came into force broad agreement had been reached as to how the outpatient service should function, but there is evidence of widespread dissatisfaction among patients about the day-to-day organization—a dissatisfaction not paralleled in the inpatient service. Attempts to get at the causes of this dissatisfaction raise a host of questions: for example, why, since most hospitals purport to use appointment systems, do outpatients have to wait so long? how long in fact, do they wait? is their waiting done mainly before consultation begins, or afterwards, in the course of receiving further examination or treatment? how far are the conditions complained of the result of inadequate buildings, too few medical and other staff, inadequate administrative methods? how far is the waiting-time affected by the unpunctuality of outpatients themselves or of the hospital staff attending to them?

In the course of administering or discussing outpatient departments many people have tried to answer these questions, but the Investigation found that there were few precise facts. Proposals for new departments showed enormous variations both in the design of the buildings and in their equipment.

The Investigation determined to make a series of studies into the functioning of outpatient clinics with the object of collecting as much quantitative information as possible. The principal studies are described in the present section. As they broke new ground, and as other people may wish to pursue similar lines of inquiry, the methods used, as well as the results, are described in some detail.

1. The Preliminary Survey

The first study was a general survey aimed at establishing methods for recording the common pattern of outpatient organization and, particularly, for finding out how patients' time was spent during visits to different kinds of clinics.

A northern industrial town with a population of just over 500,000 was selected for the survey, and observation was made, during two consecutive weeks, in the following places: (1) a teaching hospital; (2) and (3) two acute general hospitals (formerly under the local authority), at which observations were confined to obstetric clinics; (4) a hospital for women; (5) a maternity hospital; (6) a former public dispensary, now mainly engaged upon outpatient work; and (7) a chest clinic.

Information was collected about patients attending nearly all kinds of consultative clinic, including general medicine, diabetes, general surgery, ear, nose, and throat, ophthalmology, gynaecology, thoracic surgery, and obstetrical care. As it would scarcely have been possible to record the time spent by every patient in each of these clinics in the course of a fortnight, a sampling method was used: of some 12,000 attending the clinics in one fortnight, just under 3,500 were observed, the sample being taken as nearly equally as possible from the various clinics.

In carrying out the survey the Investigation enlisted thirty undergraduates as additional observers under the direction of the Investigation's team.

The following information was recorded:

(*a*) the actual time of each patient's arrival at the hospital;

(*b*) the time at which each patient had been asked to attend at the hospital;

(*c*) the time elapsing between (*b*) above and time at which the patient first began to receive medical attention;

(*d*) the total time spent in receiving medical attention of all kinds;

(*e*) any time spent waiting in the course of (*d*) above.

The information was recorded on cards with standard headings, which could afterwards be sorted by machine.

Method of Study

The procedure was as follows: observers with synchronized watches were stationed at all the entrances to the outpatient department and outside every consulting-, examination-, and treatment-room. As each patient entered the department he was handed a card on which an observer recorded his time of arrival and the time of the appointment which he was keeping. The patient retained the card while waiting, but whenever he entered a consulting-, examination-, or treatment-room the observer on duty there took it, recording the time; as he left that room the time was once more recorded and the card returned to him. When the patient left the hospital the time was finally recorded and the card collected.

Results

In addition to establishing working methods, the preliminary survey gave a general picture of the standard of punctuality of outpatients attending the various clinics observed at the different hospitals, and of the proportion of time taken up by medical attention during a visit to the outpatient department as compared with the total length of the visit. In this survey no attempt was made to distinguish between new and old patients.

Fig. 15 shows that although at most clinics the patients were on average early—by about 10 minutes—there was considerable variation in the average time of arrival at different clinics, and the punctuality of the patients also varied. The standard deviation measuring this variability was on average about 20 minutes. Thus at a clinic where patients were on average 10 minutes early, about one in six would be more than 30 minutes early and about one in six would be more than 10 minutes late. It was noticed that many of the clinical sessions did not begin at the scheduled time because the medical staff arrived late—sometimes very late.

Table 14 shows the average duration of a visit to the various clinics at the different hospitals and the time taken up by medical attention in the course of that visit. Because the observers were stationed *outside* the consulting-, examination-, and treatment-rooms, it was not always possible for them to see when patients inside were having to wait, and some of the times set down under the heading 'medical attention' in *Table 14* include waiting time and time taken to undress and dress. This only emphasizes the comparative briefness of the time spent in receiving medical attention. It may be seen, for example, that in the general medical clinics 231 patients averaged an hour's stay in the outpatient department for 9 minutes' medical attention, and similarly in the general surgical clinics 240 patients averaged 52 minutes' stay for 5 minutes' medical attention.

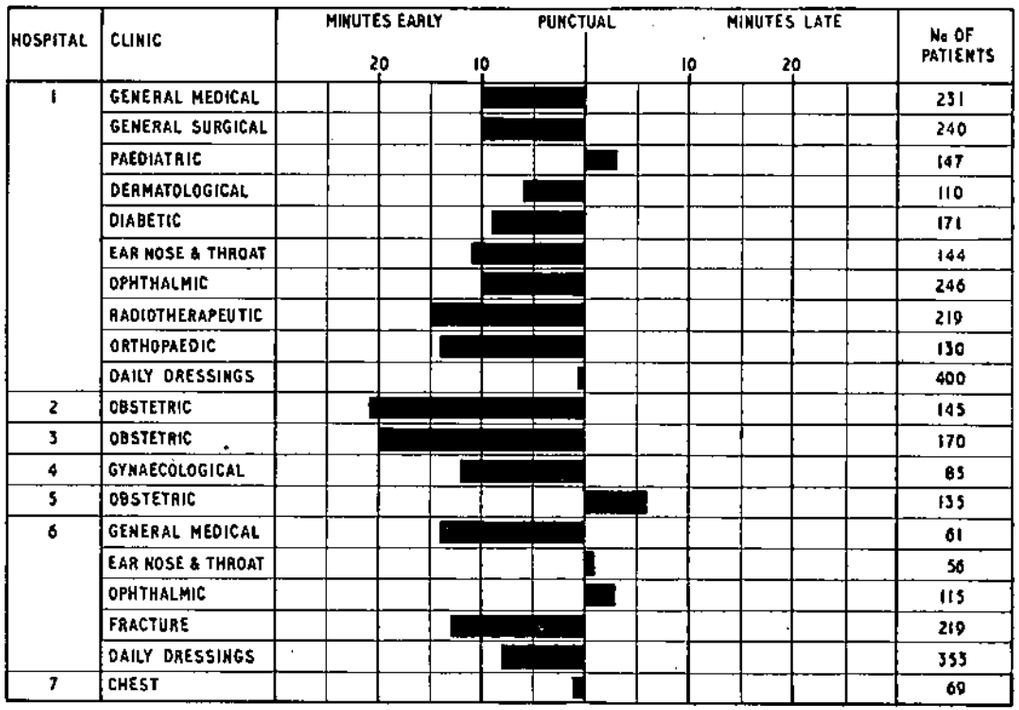


Fig. 15. Average difference between appointment time and arrival time of patients attending various outpatient clinics at seven hospitals in Northampton

Table 14. Preliminary survey in various clinics at seven hospitals in a northern city: *Average duration of outpatient visit and time taken up by medical attention*

Clinic	*No. of patients observed*	*Average duration of visit (from time at which patient was asked to arrive)*	*Average time taken up by medical attention*
Hospital (1):			
General medical	231	1 hr.	9 min.
General surgical	240	52 min.	5 min.
Paediatric	147	1 hr. 21 min.	16 min.
Dermatological	110	1 hr. 10 min.	16 min.
Diabetic	171	1 hr. 1 min.	5 min.
Ear, nose, and throat	144	1 hr. 13 min.	7 min.
Ophthalmic	246	57 min.	8 min.
Radiotherapeutic	219	38 min.	3 min.
Orthopaedic	130	58 min.	3 min.
Daily dressings	400	57 min.	5 min.
Hospital (2):			
Obstetric	145	1 hr. 8 min.	5 min.
Hospital (3):			
Obstetric	170	1 hr. 36 min.	5 min.
Hospital (4):			
Gynaecological	85	1 hr. 5 min.	5 min.
Hospital (5):			
Obstetric	135	1 hr. 40 min.	8 min.
Hospital (6):			
General medical	61	1 hr. 7 min.	11 min.
Ear, nose, and throat	56	56 min.	2 min.
Ophthalmic	115	1 hr. 16 min.	8 min.
Fracture	219	41 min.	7 min.
Daily dressings	353	54 min.	4 min.
Hospital (7):			
Chest	69	59 min.	15 min.

2. Studies in Surgical and Skin Clinics

In analysing the information collected during the preliminary survey it was found that for some phases of patients' visits to the various outpatient clinics the recorded timings were lacking in detail. In particular the observers had noticed that patients often appeared to spend a considerable amount of time waiting in the course of consultation, being examined, and receiving treatment, yet it had been impossible in the circumstances to record exactly what happened. As this kind of waiting evidently was an important aspect of outpatients' progress through the clinics, a new series of studies was planned in which observers were to be posted within the consulting-, examination-, and treatment-rooms whenever it was suitable, and when they could not actually be present, in key positions from which they could judge when patients

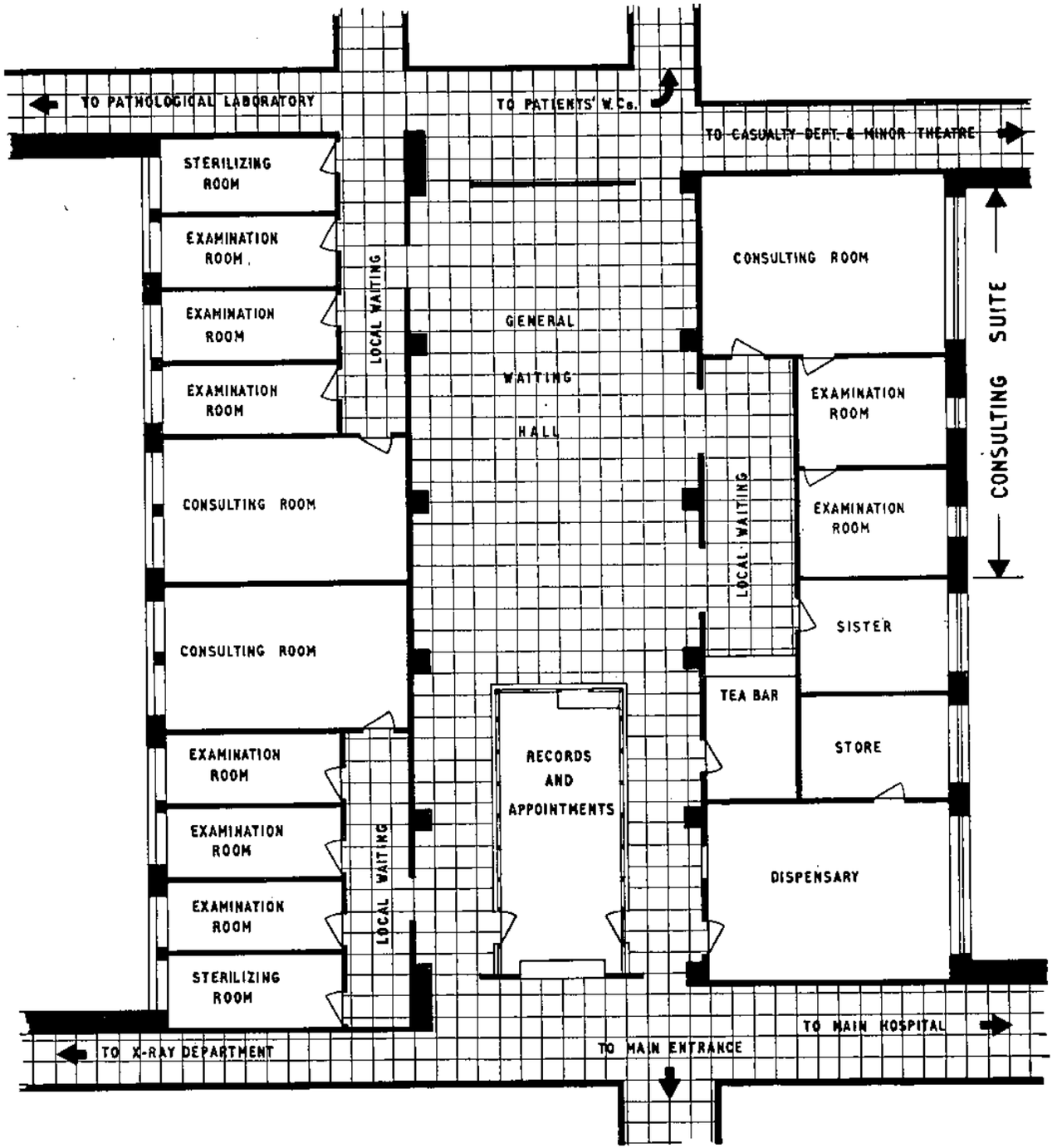


Fig. 16. The Outpatient Department—a 'traditional' type of layout

were receiving medical or nursing attention or were merely waiting to do so. It was decided also that further information should be collected about the general pattern of a visit to the outpatient department—about punctuality, for example, and the time taken to undress and to dress again, and about the use made of examination-rooms.

Facilities for observing outpatient work in surgical and skin clinics were offered to the Investigation by a London teaching hospital with large daily attendances at its clinics. At this hospital only about 10 per cent. of patients were used for teaching purposes at the general surgical and skin clinics, and no formal teaching was done at other surgical clinics.

Method of Study

The outpatient department at that hospital had been little altered since it was first erected in the nineteenth century. There was a large central waiting-hall surrounded by consultation suites, treatment-rooms, and so on. The only major innovation was a records office improvised in the middle of the hall. There was access to the dispensary from the central waiting-hall.

Fig. 16 shows diagrammatically the arrangement of such a department.

The various rooms had clearly been designed for a specific sequence of work in the clinics, but were not being used in the manner originally intended. They were, in fact, not very well suited to modern outpatient work, and in particular the consulting-rooms, which were very large, had to be used also as waiting-rooms and patients had no privacy during consultation.

The following clinics were observed:

(1) general-surgical clinics, held daily by different firms;
(2) surgical follow-up clinics, held three times a week;
(3) a neurosurgical clinic;
(4) a rectal clinic—including treatment given by the medical team;
(5) a varicose-vein clinic—including treatment given by nurses;
(6) daily-dressings clinics;
(7) infected-hand clinics, held three times a week; and
(8) skin clinics, held three times a week.

The study included a general survey of patients' progress through teaching as well as non-teaching clinics, but detailed time-studies of consultation and treatment procedure were made only in non-teaching clinics. The general survey was carried out, as in the preliminary survey, by undergraduates supervised by members of the Investigation's team; the time-studies, however, were made by members of the team only. The progress of 2,652 patients (94 per cent. of all attendances at the clinics) was recorded on cards by thirty-eight observers during two weeks. As before, the actual times at which patients arrived in the outpatient department and the times at which they had been asked to arrive were recorded separately so that standards of punctuality could be assessed. The period which elapsed between the 'appointment' and the time when the patient first began to receive any medical attention was called the 'first-waiting time'.

Table 15. Observations in surgical and skin clinics in a London teaching hospital: *Average first-waiting times*

Clinic	*No. of patients observed*	*Average time waited*
General surgical	894	1 hr. 12 min.
Neurosurgical	91	1 hr. 26 min.
Follow-up	126	49 min.
Rectal	105	1 hr. 20 min.
Varicose veins	137	1 hr. 14 min.
Daily dressings	357	1 hr. 10 min.
Infected hand	73	32 min.
Dermatological	869	1 hr. 7 min.

Punctuality

In theory the hospital used an outpatient appointment system, but in practice large blocks of patients—between 25 and 50—were called to attend at the time the clinical sessions were due to begin, i.e. 9 o'clock in the morning and 1 o'clock for the afternoon sessions. It was found that on average patients came a little in advance of the time at which they had been told to arrive, although individual standards of punctuality varied very greatly at most of the clinics. *Figs. 17* and *18* show the distribution of arrivals of a random sample of 451 patients attending surgical clinics and 444 patients attending skin clinics. At the surgical clinics some 20 per cent. of patients were either half an hour early or half an hour late. At the skin clinics 26 per cent. of patients were more than half an hour early or more than half an hour late.

Fig. 19 shows the standard of punctuality of the medical staff at all clinics observed.

First-Waiting Time

Table 15 shows the average periods which patients were observed to wait in the various clinics between their 'appointment times' and the times when they first began to receive medical attention. *Figs. 20* and *21* show the distribution of first-waiting times for a sample of 129 new patients and 109 old patients attending the general surgical clinics. A few patients were seen before the 'appointment time' given them by the hospital, but the majority waited for a long time after 'appointment time' before their consultation with the surgeon began.

The average first-waiting time for this sample of new patients was 1 hour 40 minutes. Thirty-five per cent. waited more than 2 hours, and 17 per cent. for more than 2½ hours; two patients waited for about 3 hours 25 minutes.

The average first-waiting time for the sample of old patients was 61 minutes. Thirteen per cent. of these old patients waited for more than 2 hours, and 7 per cent. for more than 2½ hours, before consultation.

Consultative Procedure

The average times which surgeons spent in consulting with and examining patients at the various clinics studied is shown in *Table 16*.

Table 16. Observations in surgical and skin clinics in a London teaching hospital: *Average times for consultation and examination*

Clinic	*New patients*		*Old patients*		*New and old patients*	
	No. receiving consultation	*Time to nearest min.*	*No. receiving consultation*	*Time to nearest min.*	*No. receiving consultation*	*Time to nearest min.*
General surgical	287	7	607	4	894	5
Neurosurgical	13	9	78	8	91	8
Follow-up	—	—	125	4	—	—
Rectal	26	5	79	4	105	4
Varicose veins	17	5	111	3	128	3
Dermatological	212	6	640	3	852	4
Daily dressings	44	2	279	3	323	3
Infected hand	—	—	72	3	—	—

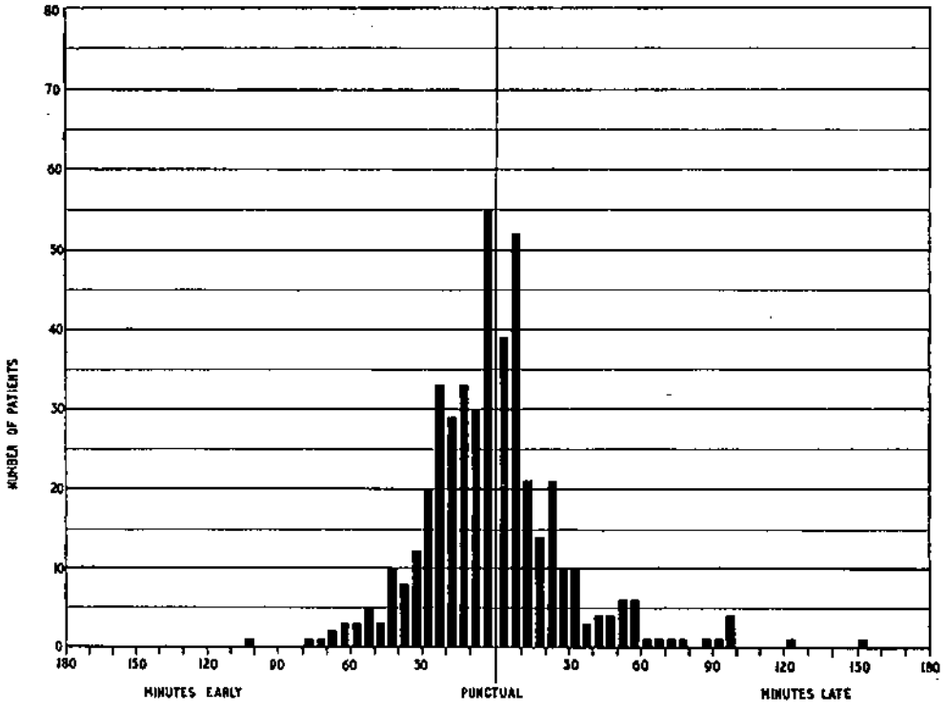


Fig. 17. Distribution of difference between appointment time and arrival time of 451 patients during 5-minute periods at general surgical clinics at a London teaching hospital

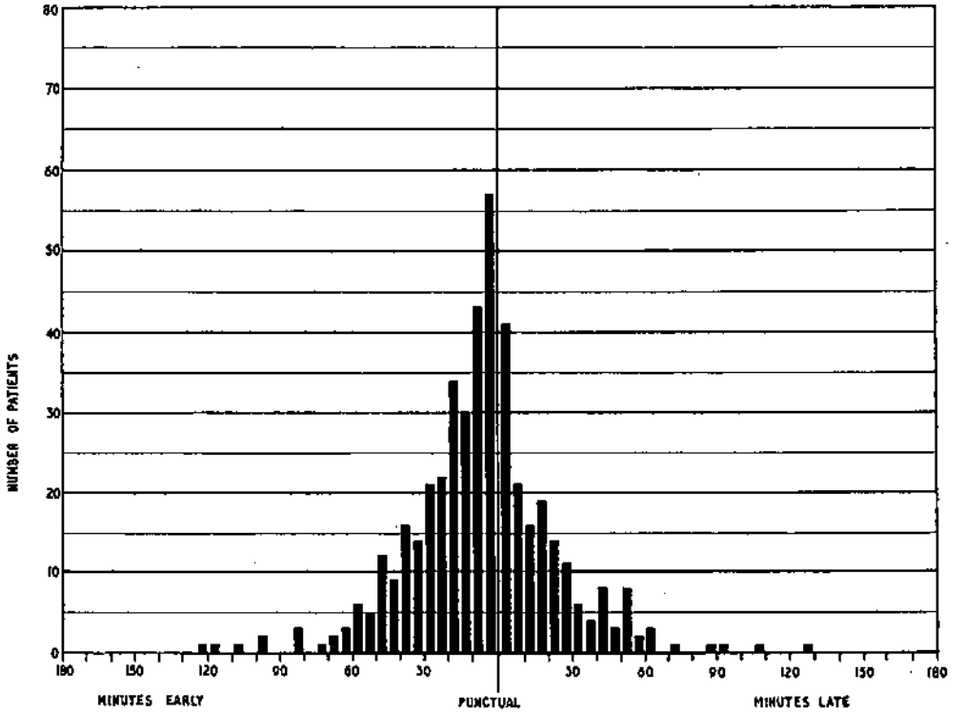


Fig. 18. Distribution of difference between appointment time and arrival time of 444 patients during 5-minute periods at skin clinics in a London teaching hospital

Any patient who needed a physical examination in the course of consultation was taken by a nurse or an orderly from the consulting-room to one of the two or three examination-rooms at the surgeon's disposal and asked to undress. Meanwhile the doctor occupied himself with the next one or more patients waiting to consult him, and some of them, in turn, might be sent to prepare for examination. In this way it often happened that patients waited a considerable time in a state of undress between consultation and examination. In the general-surgical clinics, for example, of the 894 patients observed, 428 of them waited, on average, 19 minutes in consulting-rooms, and 431 waited, on average, 8 minutes in examination-rooms.

Undressing and Dressing Times

Table 17 shows what proportion of all the patients observed had to remove garments at each kind of clinic, the average time taken to do so, and the average time taken to dress.

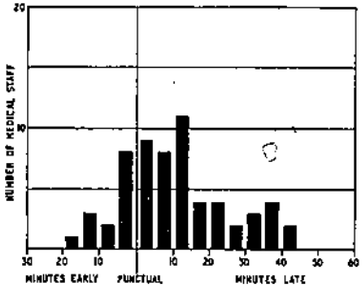


Fig. 19. Difference between the appointed time for the session and the arrival time of medical staff conducting general surgical and skin clinics at a London teaching hospital

Fig. 20

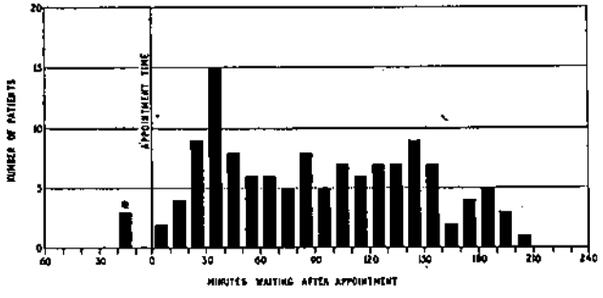


Fig. 21

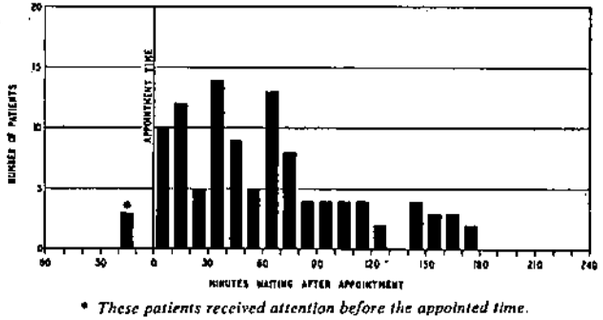


Fig. 20. Distribution of first-waiting time of 129 new patients attending general surgical clinics at a London teaching hospital

Fig. 21. Distribution of first-waiting time of 109 old patients attending general surgical clinics at a London teaching hospital

* *These patients received attention before the appointed time.*

Table 17. Observations in surgical and skin clinics in a London teaching hospital: *Average undressing and dressing times*

Clinic	*Total no. of patients receiving consultation*	*Percentage of patients who undressed*	*Average time taken to undress (min.)*	*Average time taken to dress (min.)*
General surgical	894	62	2	3
Neurosurgical	91	23	1½	3
Follow-up	125	63	2	3¼
Rectal	105	71	2	3
Varicose veins	128	47	1	2¼
Dermatological	852	20	1½	2¼
Daily dressings	323	50	1½	2½

It may be seen that neither undressing nor dressing took very long, though the latter always took a little longer than the former.

Use of Undressing-Rooms

Observations recorded in examination-rooms were analysed to discover how long, during a session, they were actually being used for examining and for undressing and dressing, how long patients spent in them simply waiting to receive medical attention, and how long they stood empty. It was found that for the greater part of the time they were either occupied by waiting patients or were empty, and that the time they stood empty was by far the longer.

Table 18 illustrates how two pairs of examination-rooms were used by two surgeons, A and B (picked at random from the time-study records), in the course of one outpatient session. The patterns of use were remarkably similar.

Table 18. Observations in surgical and skin clinics in a London teaching hospital: *Use of examination-rooms*

	Percentage of total time covered by study	
	Surgeon A's rooms	*Surgeon B's rooms*
Rooms being used for:		
(*a*) Examination	13·3% } 27·4%	12·1% } 30·1%
(*b*) Undressing and dressing	14·1%	18·0%
(*c*) Waiting	27·9% } 72·6%	36·2% } 69·8%
(*d*) Rooms standing empty	44·7%	33·6%

It may be seen that for over two-thirds of the session both surgeon A's pair of examination-rooms and surgeon B's pair were either standing empty or were occupied by patients simply waiting to be examined.

Proportion of Patients receiving Treatment

At all the clinics observed, some patients received treatment, either from the medical staff or from nurses. The proportion of patients treated varied between 2 per cent. at the surgical follow-up clinics and 86 per cent. at the infected-hand clinic. *Table 19* shows the proportion of patients treated at the various clinics, and the average time per patient needed to give treatment.

Table 19. Observations in surgical and skin clinics in a London teaching hospital: *Proportion of patients receiving treatment and average time taken per patient*

Clinic	*Total no. of patients observed*	*Percentage of patients receiving treatment*	*Average time taken per patient to nearest min.*
General surgical	894	19	6
Surgical follow-up	126	2	4
Varicose veins	137	72	5
Daily dressings (including consultation)	357	81	7
Infected hand	93	86	6
Dermatological	869	19	8

Detailed Studies of Consultative Procedure

The consultative procedure—preliminary interview between surgeon and patient, undressing and waiting for examination, the examination itself, dressing again, and the final dismissing of the patient—was complicated by the fact that each time a surgeon sent a patient to undress or left a patient to dress again (and sometimes during consultation, for reasons not evident to the observers) he turned his attention to another case or cases.

Fig. 22 shows in detail the sequence of events for patients who had to undress during a surgical clinic at which a total of 30 patients was seen.

Taking, by way of illustration, the first patient who had to undress, number 2 on *Fig. 22*, he was briefly seen by the surgeon and sent to an examination-cubicle. He had finished undressing in less than a minute and then waited for over 22 minutes before the surgeon came to examine him. The examination lasted about 7 minutes—broken by a short interval—and the patient immediately dressed again, taking 3½ minutes to do so. Ten minutes later he had another minute with the surgeon, and after another 10 minutes was seen for the last time (again for about a minute). Thus the procedure for consultation and examination was spread in the case of this patient over a period of 53 minutes. It may be seen from the diagram that most of the other fourteen patients also had to wait for considerable periods after undressing in the examination-rooms.

Fig. 23 shows from the same time-study how the surgeon moved between the first twenty-four patients seen. The first patient seen at the clinic (number 1 on *Fig. 23*) did not need an examination involving undressing and was dismissed after consultation. The surgeon then briefly saw the second patient (number 2 on *Figs. 22* and *23*) who was sent to an examination-room to undress, as described above. Three more patients who did not need to undress were attended to in quick succession and dismissed. The sixth patient, like the second, was sent to undress. Consultation with the seventh was interrupted by consultation with the eighth (who was then dismissed). When the interrupted consultation with patient number 7 was completed, the surgeon briefly consulted with patient number 9 who, after an interval, was sent to undress. Then the surgeon returned to patient number 6, examined him, left him to dress again, and went to examine patient number 2. After examining patient number 2, and while he dressed, the surgeon returned to the sixth patient and finished with him. Next the surgeon saw patients numbers 10 and 11, but interrupted consultation with the latter to spend one minute with patient number 2, who was not finally dismissed until after the end of the surgeon's consultation with patient number 12. This surgeon wrote the case notes in the course of his discussion with the patients.

In subsequent studies the team found that it was common practice in other hospitals for the surgeon to move about between his consulting-room and his examination-rooms giving very few patients his undivided attention for long at a time, although the example quoted above is undoubtedly extreme.

Progress in the Hospital after leaving the Clinic

Four per cent. of patients were sent on immediately from the clinic to the X-ray department. On average they

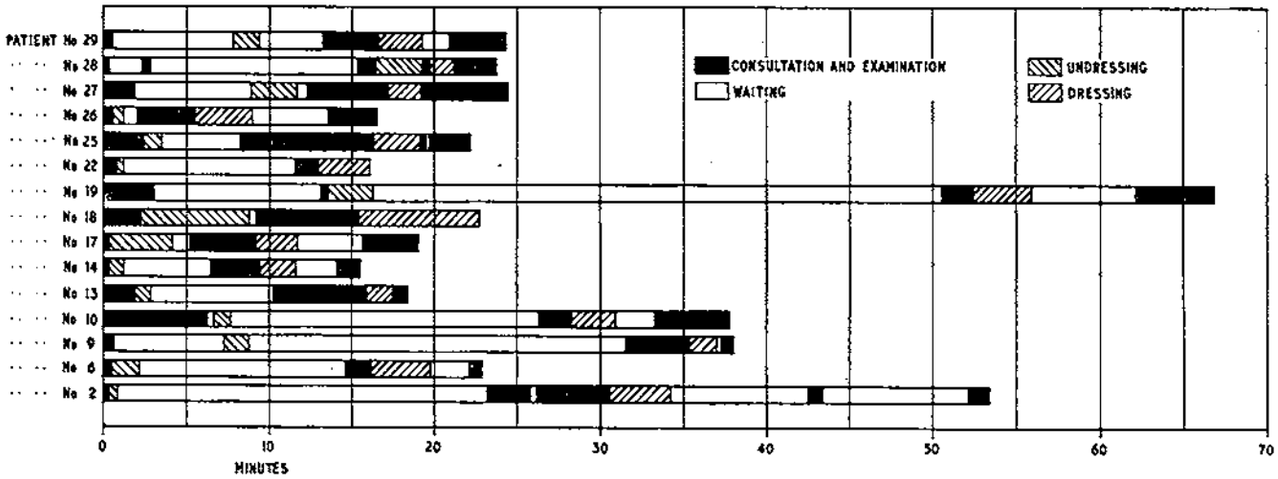
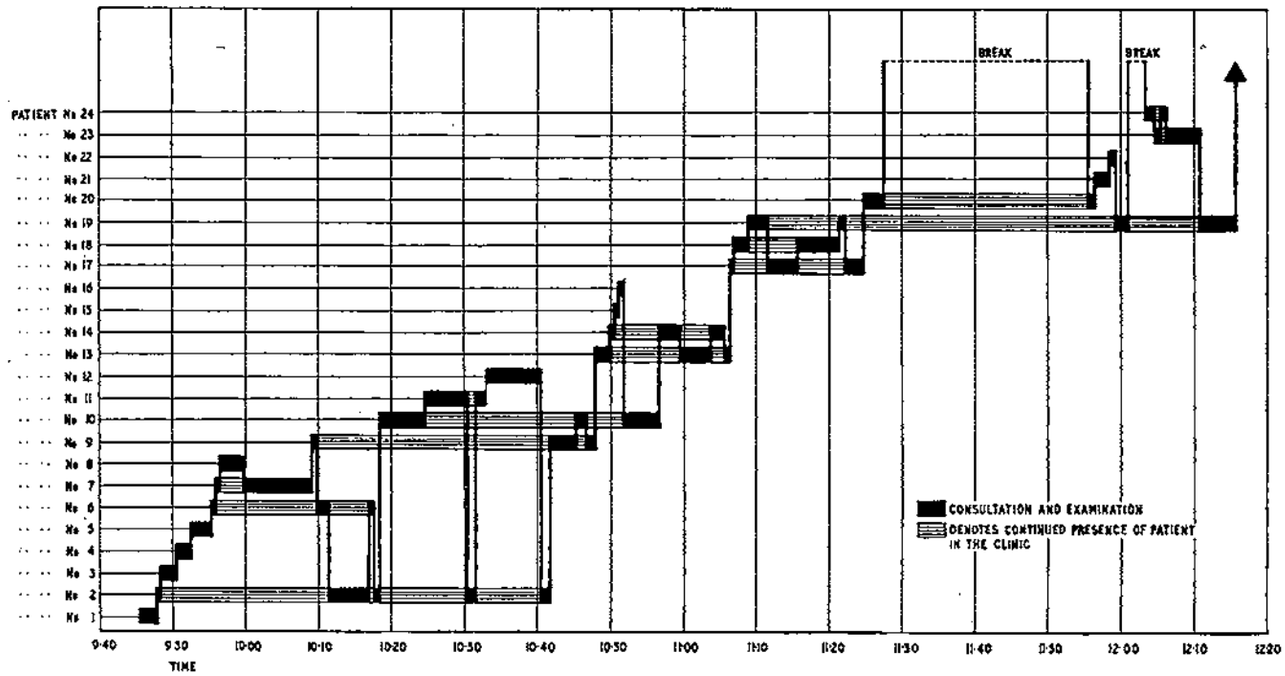


Fig. 22. Sequence of events for patients who undressed for examination in the course of a general surgical clinic (see also *Fig. 23*)

Fig. 23. Order in which the surgeon dealt with the first twenty-four patients at the same general surgical clinic as is shown in *Fig. 22*. The continuous black line follows the surgeon's progress



spent just over an hour there, including waiting to be attended to.

After leaving the clinic 67 per cent. of patients had to go to a desk in the central hall to make fresh appointments. This usually took about 8 minutes, most of it spent in queueing. Thirty-three per cent. of patients visited the dispensary before leaving the hospital. The average time spent there (including waiting) was just over half an hour.

Duration of Visit and Time taken up by Medical Attention

The average time taken over the strictly medical part of a patient's visit to an outpatient clinic has been reckoned to include: the consulting and examination time (*Table 16*), the time for the necessary procedures of undressing and dressing again (*Table 17*), and the time spent in receiving treatment (*Table 19*). The average time taken over the remainder of the visit has been reckoned to include: the first-waiting time (*Table 15*)—by far the longest single waiting period—making a further appointment, and waiting for a prescription to be made up at the dispensary, and waiting to be taken home by ambulance. Time spent in the X-ray department has not been included because only 4 per cent. of patients were sent there.

Table 20 shows for all the patients observed at the various clinics, how the whole length of a visit to the outpatient department compared with the part of it directly taken up in receiving medical attention.

Table 20. Observations in surgical and skin clinics in a London teaching hospital: *Average duration of outpatient visit and time taken up by medical attention*

Clinic	*No. of patients observed*		*Average duration of visit (in min.)*		*Average time taken up by medical attention (in min.)*	
	New	*Old*	*New*	*Old*	*New*	*Old*
General surgical	287	607	135	100	12	8
Follow-up	—	126	—	66	—	7
Neurosurgical	13	78	92	99	11	9
Rectal	26	79	117	127	9	7
Varicose veins	18	119	98	111	10	8
Daily dressings	45	312	142	108	10	10
Infected hand	—	72	—	69	—	8
Dermatological	213	656	152	104	8	5

The contrast between the total time spent in the hospital and the time spent receiving medical attention is sufficiently striking in all specialties. In general surgical clinics, to take only one example, patients usually received 9 minutes' medical attention but spent altogether about an hour and three-quarters in the hospital.

Patients accompanied by Relatives and Friends

During the final week of the survey a record was kept (relating to a sample of patients only) of the number of escorts to be found in the waiting-space, accompanying outpatients attending different kinds of clinic.

At general surgical clinics and at neurosurgical clinics it was usual to find one companion to every three outpatients. At follow-up clinics, daily-dressing clinics, and skin clinics, the proportion was one companion to every four patients; at rectal clinics, one to every six patients; at infected-hand clinics, one to every thirteen patients; and at varicose-vein clinics, one to every thirteen patients. This information throws some light upon the problem of how much waiting-space is needed for different kinds of clinics.

3. Studies in Medical Clinics

After the survey of the pattern of work in surgical and skin clinics, a parallel series of observations was made in the medical clinics of a large, non-teaching hospital in a London suburb.

At that hospital, as in the teaching hospital, the clinical area, including local waiting-spaces, opened off a large central waiting-hall. There was an improvised records office in the central hall; and there was access to the dispensary.

The clinics studied were:

(1) a general medical clinic;
(2) a clinic for new gastric cases;
(3) a follow-up clinic for gastric cases;
(4) a follow-up clinic for diabetic cases;
(5) a clinic for anaemia cases; and
(6) a chest clinic.

Method of Survey

The experience gained in making the preliminary survey and the survey of surgical and skin clinics enabled the team to devise a simplified, combined method of recording both the general progress of patients through the clinics and the time-studies of medical staff at work.

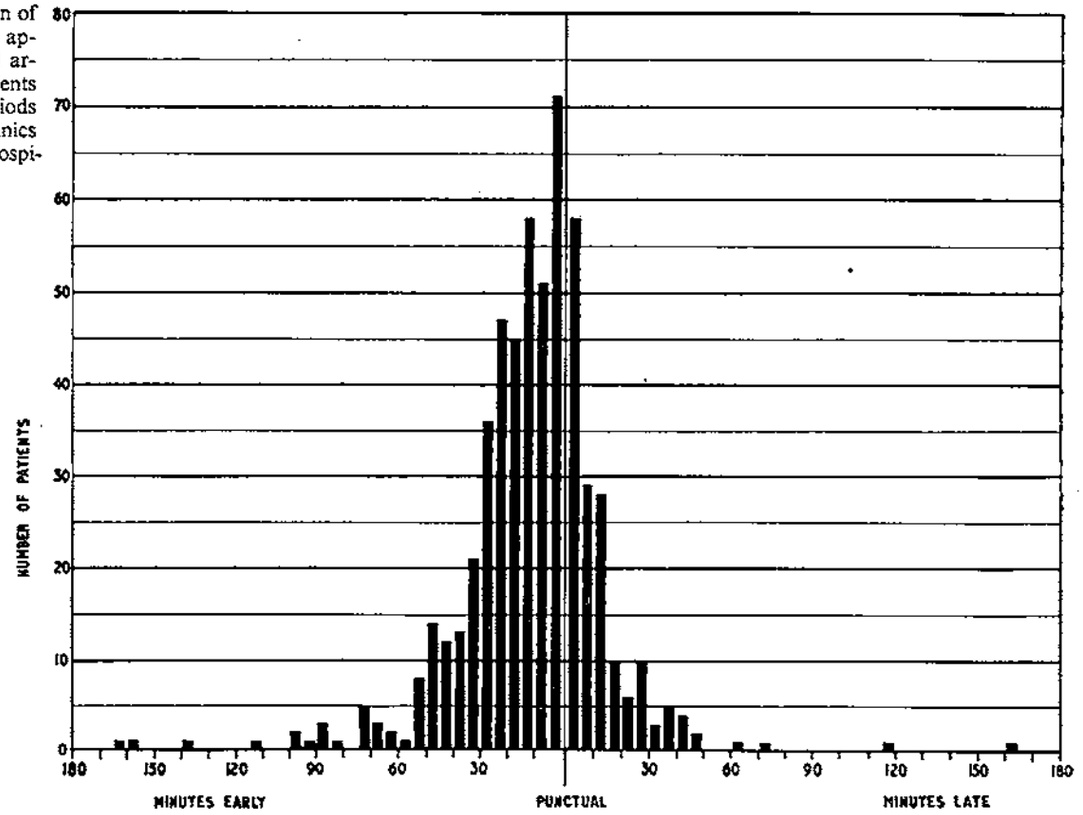


Fig. 24. Distribution of difference between appointment time and arrival time of 557 patients during 5-minute periods at general medical clinics in a non-teaching hospital in London

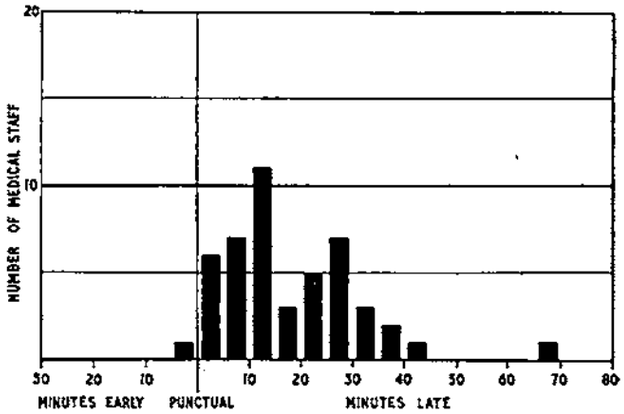
By looking at appointment-cards as patients arrived in the outpatient department it was possible to identify those destined for a medical clinic.

Each was given a card bearing a number, and was asked to wear it pinned on conspicuously. By thus distinguishing these patients, their progress from point to point could be recorded on standard forms by the Investigation's five observers unaided. The survey lasted for a fortnight, and each clinic was observed on two separate occasions.

Punctuality of Patients

In the majority of clinics observed, blocks of between four and ten patients were called to attend at the hospital at half-hourly intervals from the start of the sessions. At the clinic for anaemia cases, however, fifteen old patients were seen, and all of them were called to attend at the start of the session, because arrangements in the pathological laboratory for carrying out the necessary tests for them made it unavoidable. At the follow-up clinic for

Fig. 25. Difference between the appointed time for the session and the arrival time of the doctors conducting medical clinics at a suburban non-teaching hospital in London



gastric cases, patients were given individual appointments at 10-minute intervals.

Fig. 24 shows the standard of punctuality of patients attending the clinics studied. Most patients were early (on average 12½ minutes early). Sixteen per cent. of patients were more than half an hour early, and 3 per cent. were more than half an hour late.

Fig. 25 shows the standard of punctuality of the medical staff.

First-Waiting Time

The average interval between the time at which patients were asked to arrive and the time at which they began to receive medical attention is shown in *Table 21*; it varied from about half an hour to just over an hour. Waiting was in two stages; it was begun in the central hall and continued in the immediate vicinity of the clinic.

Average Consultation and Examination Times

The average consultation and examination times for new patients and for old patients are shown in *Table 22*.

Table 21. Observations in medical clinics in a suburban non-teaching hospital in London: *Average first-waiting time*

Clinic	*No. of patients observed*	*Average time waited*
General medical	81	1 hr. 9 min.
Old gastric cases	225	35 min.
New gastric cases	53	38 min.
Anaemia	90	1 hr. 5 min.
Diabetic	88	41 min.
Chest	97	43 min.

Table 22. Observations in medical clinics in a suburban non-teaching hospital in London: *Average time for consultation and examination*

Clinic	NEW PATIENTS		OLD PATIENTS	
	Receiving consultation	*Average time (to nearest min.)*	*Receiving consultation*	*Average time (to nearest min.)*
General medical	20	19	55	11
Gastric	36	20	242	8
Diabetic	—*	—	87	6
Anaemia	23	17	67	9
Chest	19	15	64	10

* Only one new patient presented himself at this clinic.

In surveying these medical clinics the observers began, and in subsequent studies continued, to include in the average time for consultation and examination any time spent by the doctor in writing case notes in the intervals between seeing one patient and the next. The average times which the doctors spent with each patient (both old and new) are contrasted in *Table 23* with the average time which they spent upon each patient's case (including writing case notes).

Undressing and Dressing Times, and Waiting for Examination

The average times which patients took to undress and dress, and the percentage who had to undress at the various clinics, are shown in *Table 24*. These average times are appreciably longer than those calculated for the surgical clinics previously observed. The main difference in circumstances was that at the medical clinics patients took their clothes off in six undressing-cubicles separate from the examination-rooms. It appeared to the observers that their hesitation in deciding when to leave the cubicles and go to the examination-rooms was sufficient to account for the longer average times.

Table 23. Observations in medical clinics in a suburban non-teaching hospital in London: *Average time per patient spent by doctors in consultation, examination, and writing case notes*

Clinic	*Average working time with patient (new and old) (to nearest min.)*	*Total average working time for patient (new and old) (to nearest min.)*
General medical	12	14
Gastric	9	13
Diabetic	6	7
Anaemia	11	15
Chest	11	13

Table 24. Observations in medical clinics in a suburban non-teaching hospital in London: *Average undressing and dressing times*

Clinic	*Total no. of patients receiving consultation*	*Percentage of patients who undressed**	*Average time taken to undress (min.)*	*Average time taken to dress (min.)*
General medical	81	44	3½	4½
Newgastric cases	53	81	3	4
Old gastric cases	225	8	3½	4½
Anaemia	90	36	3½	4½
Diabetic	88	2	4	6
Chest	97	56	3½	4½

* All patients undressed in undressing-cubicles.

Having undressed, patients put on dressing-gowns provided by the hospital and went to the examination-rooms. Some patients waited scarcely at all outside the examination-rooms, and some did not have to wait inside; others waited in both places. The average time spent waiting outside, and subsequently inside, the examination-rooms and the number of patients in each group is shown in *Table 25*.

Table 25. Observations in medical clinics in a suburban non-teaching hospital in London: *Average time spent (undressed) waiting for and during examination*

Clinic	*Total no. of patients examined*	*Waiting outside examination-rooms*		*Waiting inside examination-rooms*	
		No. of patients	*Average time to nearest min.*	*No. of patients*	*Average time in min.*
General medical	36	5	7	31	11
New gastric cases	43	17	6	32	5
Old gastric cases	18	—	—	16	4
Anaemia	32	6	5	27	13
Diabetic	2	1	11	—	—

Consultative Procedure

Most of the doctors working in the outpatient clinics had two rooms at their disposal (each a combined consulting- and examination-room), one of which they kept for consultation, the other for examination only. Three of the consultants had two examination-rooms, besides a consulting-room, at their disposal; and their colleagues frequently made use of more than one examination-room if sufficient were available.

At this hospital, as at the teaching hospital, it was customary for the doctors not to deal completely with each patient's case in turn, and whenever they sent a patient to prepare for examination they turned their attention to one or more further cases. Thus when the doctor was

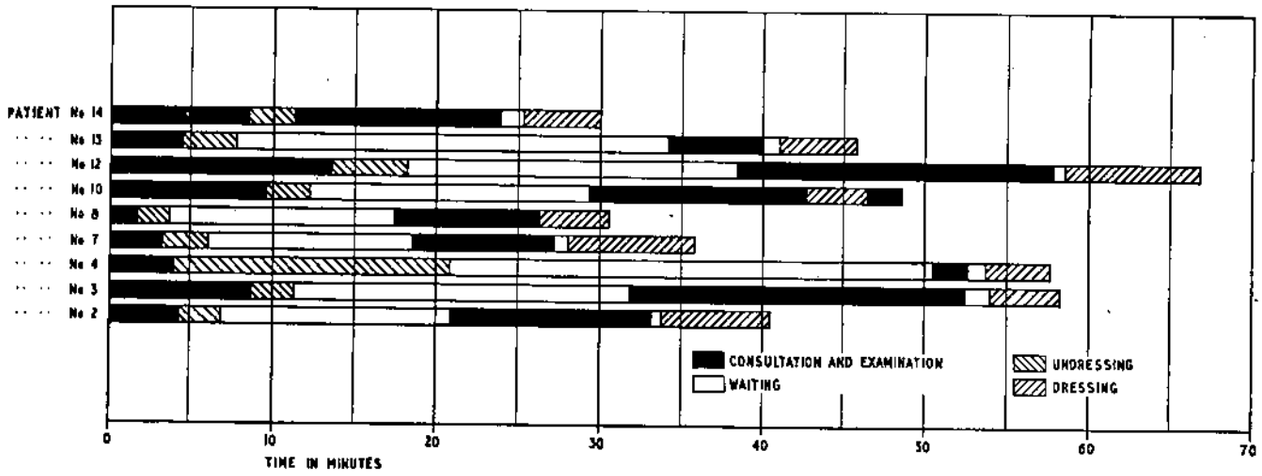


Fig. 26. Sequence of events for patients who undressed for examination in the course of a medical clinic (*see also Fig. 27*)

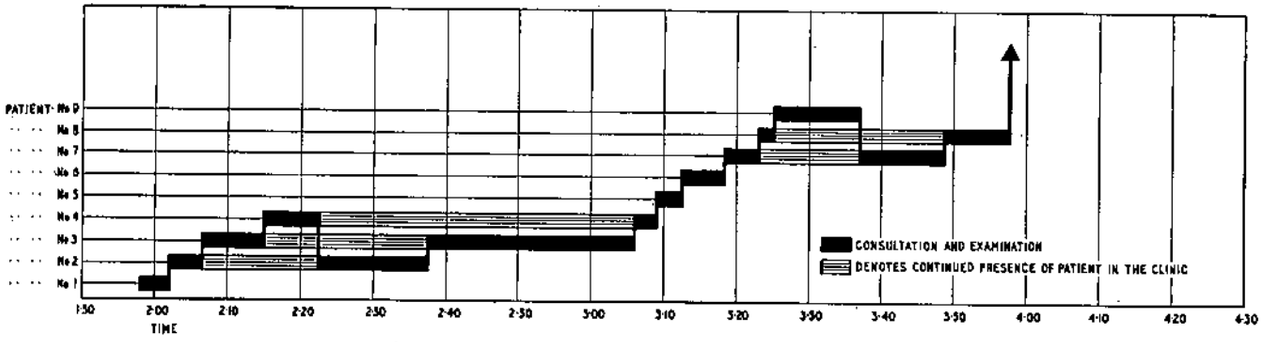


Fig. 27. Order in which the physician dealt with the first nine patients at the same medical clinic as is shown in *Fig. 26*
The continuous black line follows the physician's progress

occupied with one patient in his consulting-room, each of his examination-rooms might contain a patient ready for him, and others might be waiting their turn, undressed, outside the examination-rooms. The registrars working in the diabetic clinic, however, at which only a small proportion of all patients needed a physical examination, used only one room for consultation and such examinations as were necessary.

Detailed Time-Studies

Fig. 26 shows the sequence of events for nine patients examined by the same doctor. He had a consulting-room and one examination-room at his disposal.

The first of these patients (number 2 on *Fig. 26* because patient number 1 did not undress) was seen by the doctor for about 4½ minutes before going to an undressing cubicle. Undressing took 2½ minutes, and the next 14 minutes were spent in waiting for the examination, which lasted just over 12 minutes. Then the patient dressed and left the clinic. Patient number 3 also took 2½ minutes to undress after about 8½ minutes' consultation. He waited 20 minutes for an examination which lasted 20 minutes, after which he, too, dressed and left the clinic. Patient number 4, after 4 minutes' consultation, spent 17 minutes in an undressing-cubicle and a further half-hour undressed and waiting to be examined; the examination was completed in less than 3 minutes. The next two patients did not need to undress. Patient number 7, after 3½ minutes' consultation, undressed in rather less than 3½ minutes and waited 12½ minutes for an examination lasting 8½ minutes. Patient 8 had 2 minutes' consultation, took 2 minutes to undress, and then waited about 14 minutes for about 10 minutes' examination. The short period of waiting which occurs in seven cases, after the final consultation, appeared to be due to patients waiting to be told to dress again. Patient 9 did not undress. And so the session proceeded.

Fig. 27 shows how the doctor himself divided his attention between the first nine patients who attended the clinic. It may be seen that after he had dismissed the first patient, consulted briefly with the second patient and sent him to prepare for examination, he consulted with the third and then the fourth, sending each in turn to undress. He then returned to the second patient and conducted the examination for which the patient had been waiting, undressed, for 14 minutes. Next the doctor examined patient number 3 (who had been waiting undressed for 20 minutes), and afterwards patient number 4 (who had been waiting undressed for half an hour). He consulted with patients 5 and 6 and dismissed them, and after consulting briefly with patient number 7, sent him to undress. He then consulted even more briefly with patient number 8, and sent him to undress. Patient number 9 was dismissed after consultation, and the doctor then returned to patient number 7 (who had been waiting undressed for 12½ minutes). Finally, he examined patient number 8 (who had been waiting, undressed, for about 14 minutes). This doctor wrote case notes in the brief intervals between seeing one patient and the next.

Unbroken Sequence of Consultation and Examination for Each Patient

The pattern of progress just described may be contrasted with that observed at a chest clinic in the same hospital, where the doctor had at his disposal only one room for both consultation and examination—his patients undressing behind a screen. He was therefore compelled to complete both consultation and examination (waiting while the patient undressed and dressed again) for each patient in turn before proceeding to the next one. It may be seen from *Fig. 28* that the first four patients needed only brief consultations. The fifth patient, a woman, after just under 4 minutes' consultation, undressed and during the 2 minutes which it took her the doctor wrote notes. He then immediately examined her

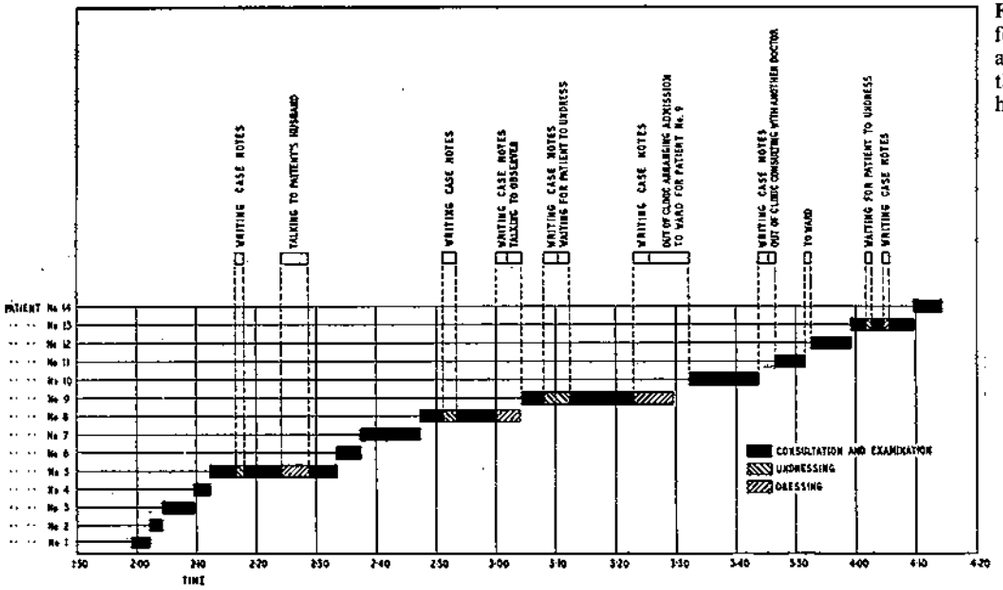


Fig. 28. Sequence of events for physician and patients at a chest clinic at which the doctor gave each patient his undivided attention

and, while she dressed again, talked with her husband. Then after a final 4 minutes' consultation with her, he proceeded to consult with the next two patients (who needed no examination). During the 2 minutes which the eighth patient took to undress the doctor again wrote notes and similarly filled the 4 minutes when the patient was dressing. On only three occasions did the doctor not proceed immediately from one case to the next—on two of them he was making arrangements outside the clinic on behalf of patient number 9, and on the third he consulted with another doctor—and on all three occasions the interval between patients was less than 3 minutes.

The team were greatly impressed by the pattern of work achieved by this physician. His patients virtually did not have to wait at any stage, and had his exclusive attention during consultation and examination; while he himself was never kept waiting very long by patients undressing or dressing again, and appeared to be filling in those intervals with relevant work.

This satisfactory method of working was to some extent due to the fact that the physician had only a single room at his disposal. Remembering how long patients waited during consultation and examination when consultants had two or more examination-rooms at their disposal—and sometimes undressing-cubicles as well (cf. *Table 25*)—and remembering the intermittent use made of pairs of examination-rooms (see p. 40), the team decided that it would be profitable to make further observations of doctors working in limited accommodation.

4. Further Studies of Consultation and Examination in Limited Accommodation

The team arranged to make studies in the outpatient department of a 235-bedded hospital in a west-country town, where two surgeons, Mr. A and Mr. B, used the same consulting-room and single examination-room for their respective general-surgical clinics. Each surgeon saw only one patient at a time, and when an examination was needed they occupied the intervals while the patient undressed and dressed again chiefly in writing case notes and conferring with their house-surgeons.

It was evident that this method of working was to some extent imposed on Mr. A and Mr. B by the nature of the rooms at their disposal. The examination-room opened directly out of the consulting-room and had no separate exit. For that reason it was not really convenient for the consultant to leave a patient in the examination-room to dress and go, while he himself consulted with a second patient, because the first patient, in leaving, would be bound to infringe privacy. In this method of working, once patients entered the consulting-room they scarcely waited at any stage of consultation or examination.

Both Mr. A and Mr. B were able to conduct their clinics in an unhurried way. At two sessions at which observations were recorded, Mr. A saw fourteen patients in the course of 2 hours 10 minutes at an average rate of 9 minutes 17 seconds each, and Mr. B saw fifteen patients in the course of 1 hour 45 minutes, at an average rate of 7 minutes each.

Table 26. Unbroken consultation and examination: (i) *Time spent by surgeon, Mr. A, with 14 patients during a 130-minute session.* (ii) *Time spent by surgeon, Mr. B, with 15 patients during a 105-minute session*

(i)

	Min.	*Sec.*
Consulting	44	57
Examining	17	31
Clerical and administrative work (no patient present)	48	47
Interruptions	16	22
Time unoccupied	0	42
Waiting while patients undressed	1	21
Waiting while patients dressed	0	20
	130	00

(ii)

	Min.	*Sec.*
Consulting	42	51
Examining	24	41
Clerical and administrative work (no patient present)	33	44
Interruptions	0	35
Time unoccupied*	2	16
Waiting while patients undressed	0	30
Waiting while patients dressed	0	18
	105	00

* Time lost owing to mislaid case-papers.

The average waiting-time at Mr. A's clinic was 17 seconds, and the average waiting-time at Mr. B's was 25 seconds. Nine of Mr. A's patients and ten of Mr. B's undressed and were examined.

Table 26 (i) shows how Mr. A divided his time during the clinic, and *Table 26* (ii) shows how Mr. B divided his

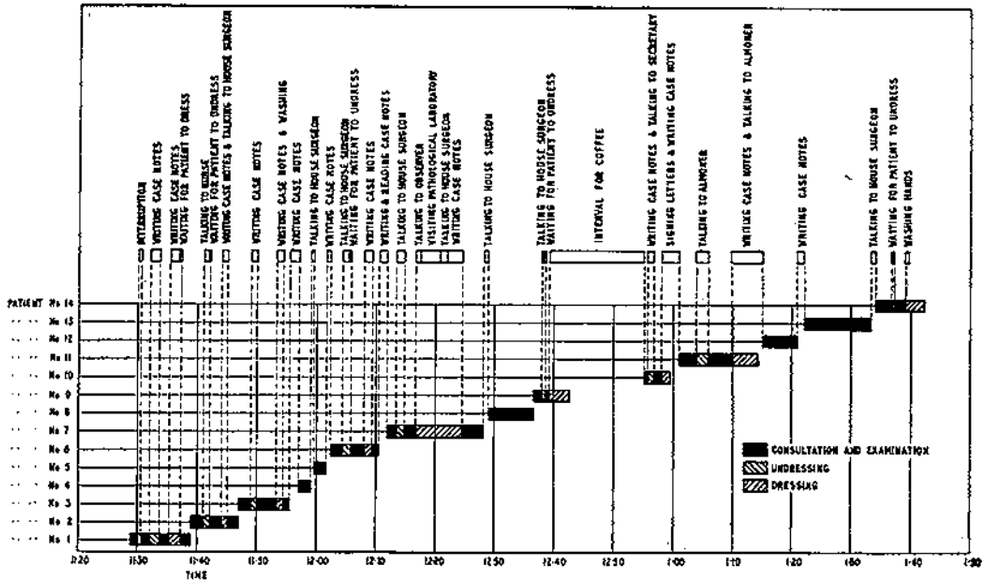


Fig. 29. Sequence of events for the surgeon (Mr. A.) and his patients in the course of one session

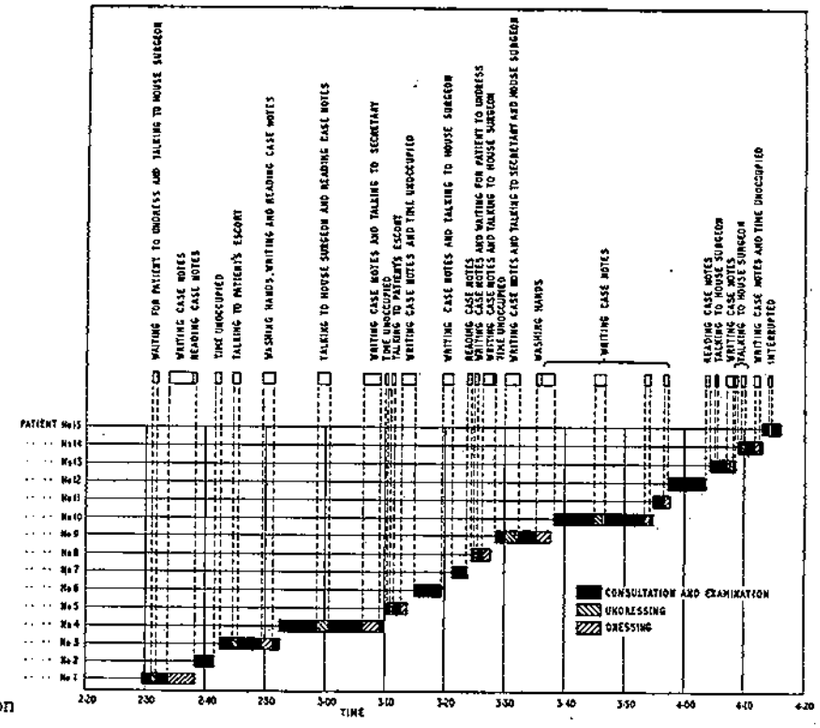


Fig. 30. Sequence of events for the surgeon (Mr. B.) and his patients in the course of one session

time; the exact sequence of events is shown, for Mr. A's clinic, in *Fig. 29* and for Mr. B's in *Fig. 30*.

Medical Opinions on Unbroken Consultation and Examination

After reviewing the work they had so far done in out-patient clinics the Investigation felt the need to canvass expert medical opinion more widely upon the general desirability of giving most patients an unbroken consultation and examination. They submitted this question to the General Purposes Committee of the Nuffield Provincial Hospitals Trust's Medical Advisory Panel, and through them, to Senior Administrative Medical Officers, and finally to a number of clinicians.

The committee were of the opinion that giving consultation and examination in an unbroken sequence whenever possible was desirable, both from the patient's point of view and from the doctor's. The committee were not concerned at the doctor finding himself with a minute or two to spare from time to time, since he needed some leisure during the session to think over the problems of his patients' cases.

Among the clinicians whose opinion was sought were two physicians and two surgeons who, though they had not previously been in the habit of consulting with, and then examining, one patient at a time, tried that way of working (using only one examination-room), and were persuaded of its advantages. They described for the team their personal experience and opinions of the experiment, and it was interesting to find how closely their accounts tallied.

One physician and one surgeon said that they were able to see more patients than previously; all four said that they felt much less fatigued at the end of each session.

'All members of the staff told me spontaneously how surprised they were at the degree of improvement in the whole atmosphere of the work in the clinic with this new arrangement', one of the surgeons wrote.

Appointment Systems

The *Hospitals Year Book* shows that most hospitals use appointment systems; they are known to work efficiently in some places. Yet complaints continue from out-patients who, after arriving to keep a seemingly precise appointment, have been left in the waiting-space for a very long time before being summoned to the doctor; the Investigation's own observations (see p. 44) showed that many patients had just cause for dissatisfaction. The team found that the average period which patients spent waiting between the time of appointment and the time when they first began to receive medical attention was often an hour or an hour and a half, and instances were recorded of patients waiting 2 and even 3 hours before being attended to.

Appointment systems are usually based on an estimation—no doubt varying in accuracy—of the *average* time per patient which the consultant will take in the course of a clinical session, a distinction sometimes being made between new and old patients, who are grouped and seen separately. To allow for patients being late, or not presenting themselves at all, administrators commonly arrange for patients to attend in small groups at the

beginning of stated intervals throughout the session (the numbers of patients in the group being directly related to the number the doctor is prepared to deal with during the interval chosen). This system minimizes the chances of the doctor being kept waiting for the want of a patient, but it inevitably leads to one or more patients in each group waiting disproportionately long as compared with others in the same group. In addition, there is the possibility of further delay, because the *actual* time which the doctor takes over each patient will vary according to the nature of the case—and this variation may be considerable.

Although it is clear that no appointment system can work efficiently if either the doctor or his patients are habitually late in arriving at the clinic, the Investigation was not able to accept the view sometimes put forward that appointment systems are bound to fail because lateness among outpatients is incorrigible. The team found, as other observers have done,[33] that more outpatients come early than come late (p. 39); and it certainly seemed that the punctuality or unpunctuality of patients was directly linked with good or not so good administrative organization in the hospital as a whole.

It appeared to the Investigation that the reasons why appointment systems sometimes fail are complex, but should nevertheless be explicable. They felt they needed more precise information about the ways in which differently constructed appointment systems might be expected to influence: (i) the length of time which patients wait between the appointments given them and the beginning of their consultations; (ii) the length of time which the doctor may be kept waiting between seeing one patient and the next; and (iii) the number of patients in the waiting-space at different stages of the session. It seemed likely that some of the theoretical work recently done upon problems of queues and queueing might help to throw light on these matters, and from that starting-point work was begun on the data supplied by the Investigation's field studies.[34] Some practical applications of this work were later published in a paper to the *Lancet*.[35]

It was found that the variations in actual consulting-times recorded during the Investigation's field studies broadly conformed to a well-known type of frequency distribution curve, certain features remaining constant for different kinds of clinic. A typical example of the sort of frequency distribution curve which can be fitted to observed data is shown in *Fig. 31*. It thus became possible

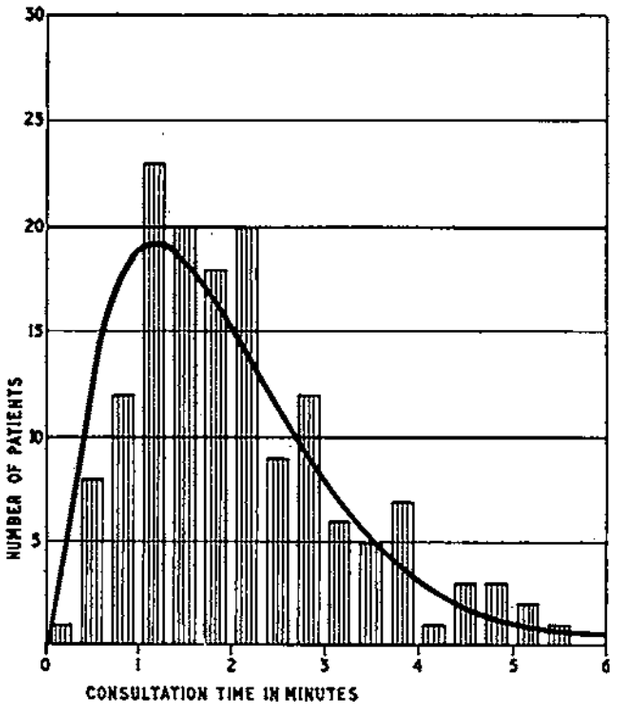


Fig. 31. Frequency distribution of 151 recorded consultation times with fitted curve

to predict the consequences of applying different kinds of appointment systems in differing circumstances, in terms of how long patients would wait, how long the doctor might have to wait between seeing one patient and the next, and how many patients would be together in the waiting-space.

Since the 'block' appointment system, which arranges for groups of patients to arrive at the beginning of predetermined intervals throughout the session, automatically leads to some patients being kept waiting, the team wished to calculate the effects of applying the alternative, rather less commonly used, 'individual' appointment system. That system gives each successive patient a precise appointment, the interval between appointments preferably being chosen to equal the average consulting-time for that clinic. But to ensure that the doctor runs no serious risk of being kept waiting because patients are late or do not come, or because he himself may occasionally work ahead of his time-table, the nucleus of a reserve of patients is established by asking two or more to be present at the start of the session.

Table 27. Appointment system: *Predicted results of varying the number of patients present at the start of a clinic (duration 2½ hours; total number of patients 25; average consulting-time 5 minutes; appointment interval 5 minutes)*

No. of patients present at start	*Patients' average waiting-time (in min.)*	*Consultant's average waiting-time per session (in min.)*
1	7 (18)*	9
2	9 (20)	6
3	12 (23)	3
4	16 (27)	2
5	20 (31)	1
6	24 (35)	½

* One patient in eight waits longer than the number of minutes shown in brackets.

Table 27 illustrates the results of applying variants of the individual appointment system to a series of hypothetical clinics constructed to a very usual pattern. It was assumed that the clinic would last about 2½ hours, during which time the doctor would deal with twenty-five patients in unbroken succession, at the average rate of 5 minutes each, the patients having been given appointments at 5-minute intervals—this coincidence between the average consulting-time and the appointment interval having been found to give the best results.

It may be seen from *Table 27* that if, in the circumstances described, the clinic begins with one patient present, the average waiting-time for patients will be 7 minutes (though one in eight will wait longer than 18 minutes), but the doctor, in the whole course of the session, will on an average be without a patient during 9 minutes. If the clinic begins with four patients present, the average waiting-time will be 16 minutes (though some three patients will wait longer than 27 minutes), but the doctor will wait only about 2 minutes in all. And if the clinic starts with six patients present, he will wait scarcely at all, though his patients will wait, on an average, for about 25 minutes. These are the basic waiting-times consequent upon the use of an appointment system in which the appointment interval and the average consulting-time are equal; in practice these times would be modified by the inevitable slight unpunctuality of people arriving at a destination from a distance. At some clinics, also, it might be found necessary to take into account a certain percentage of outpatients who, without notifying the hospital, failed to keep the appointments given them. If there were many, then no appointment system could be expected to work very satisfactorily. If there were few,

say, not more than 10 per cent., then, at the cost of only a slight loss in efficiency, the number could be offset by increasing the number of patients called to attend at each session and by decreasing the appointment interval by a percentage equal to the defaulting rate (10 per cent. in this instance).

In the circumstances shown in *Table 27* an equitable arrangement would evidently be to start the clinic with three patients present. Then the average waiting-time for patients would be 12 minutes (though some three of them would wait more than 23 minutes), and the doctor would wait only about 3 minutes altogether. If the clinic started with two instead of three patients present, the advantage to the rest of the patients would be appreciably greater, while the disadvantage to the doctor would still not be serious, although the average time he waited would be doubled.

The distribution of the number of patients who would be together in the waiting-space during a session such as that described above was calculated, and *Table 28* shows this distribution for a clinic lasting about 2¼ hours which began with two patients present. Strict punctuality of both patients and doctor was assumed—a state of affairs rarely achieved in practice—and no account was taken of the probable number of escorts.

Table 28. Appointment system: *Predicted distribution of the number of patients together in the waiting-space during a 2¼-hour session, starting with two patients present*

No. of patients waiting together	*Percentage time of whole 2¼-hour session*
	%
0	21
1	34
2	19
3	12
4	7
5	4
6	2
7 or more	1
	100

It may be seen that for over half the time no one or only one patient would be waiting.

General Conclusions

Certain general conclusions may be drawn from the theoretical work described above. The most important seems to be that, if an equitable division of waiting between doctor and patients is decided upon, it is quite feasible to give a series of individual appointments to all but the first few patients who must be present when the session begins. At most clinics, if either two or three patients are called upon to be present at the start, they will form the nucleus of a reserve which will be sufficient to avoid keeping the doctor waiting for longer than a few minutes in the whole course of a session. It needs some self-discipline on the part of consultants, however, not to over-insure against waiting at the patients' expense.

Because the appointment interval must coincide as nearly as possible with the average consulting-time, it is important that the latter should be determined with accuracy. And if patients' waiting-time is to be reduced as much as is practicable, a difference should, whenever possible, be made between the appointment interval for new patients and for old, because the average consulting-time for new patients is usually found to be appreciably longer than that for old patients (cf. p. 38). This difference in the appointment intervals may easily be arranged for if the two classes of patients are grouped and seen separately—either in the course of the same session, or, if there are sufficient patients, at a separate session—but doctors do not always care to work in this manner, preferring to see old and new patients intermingled.

The average waiting-time shows great sensitivity to changes in the appointment interval, and if the latter does not accurately reflect the average consulting-time, the time during which either the doctor or (more probably) his patients have to wait may be dramatically increased. Every doctor holding clinics should note the time which he spends, at each of several sessions, on consulting, examining, case-note writing, and anything else which he regularly does for patients—new and old patients preferably being recorded separately. The number of patients seen for the purpose of determining the average consulting-time should be quite large—preferably about 400. The total time recorded is to be divided by the total number of patients seen and this will give the average consulting-time.

Though it is important for the doctor to know his own average consulting-time with this degree of accuracy, it would be unrealistic to try to run an appointment system on such precise timing. In everyday life the conscientious outpatient will try to be punctual to multiples of 5 minutes, but he cannot reasonably be expected to do more. *Table 29* shows, by way of example, how the

Table 29. Appointment system: *Example of the theoretical and actual appointment times for the first ten patients attending a clinic*

Patients numbered in order of attendance	*Theoretical time of each appointment*	*Actual time of each appointment*
1 and 2	10 hrs. 00·00 min.	9 hrs. 55 min.
3	„ 06·16 „	10 hrs. 5 „
4	„ 12·32 „	„ 10 „
5	„ 18·48 „	„ 15 „
6	„ 24·64 „	„ 20 „
7	„ 30·80 „	„ 30 „
8	„ 36·96 „	„ 35 „
9	„ 43·12 „	„ 40 „
10	„ 49·28 „	„ 45 „

appointments would in practice be allotted if the average consulting-time was 6·16 minutes, the appointment interval was rounded off to the nearest previous multiple of 5 minutes, and the clinic started at 10 a.m. with the first and second patients present.

The actual times of the appointments allotted do not fall out in a strict 5-minute sequence. The average time which patients would wait at the clinic in those circumstances would be 13 minutes. If the appointment interval exactly corresponded to the average consulting-time, the average waiting-time per patient would be reduced by only 2 minutes—to 11 minutes. But if the appointments were simply allotted at strict 5-minute intervals throughout the session, the average waiting-time per patient would be increased to more than 21 minutes.

It is self-evident that the doctor as well as his patients must be punctual. A doctor arriving 20 minutes after the proper starting-time for a clinic such as is illustrated in *Table 29* will find not two but six patients awaiting him, and the average waiting-time for all his patients will have been increased from 9 to 27 minutes.

Little need be said of the ineffectual administration which permits a group of patients to be called at an ostensible starting-time when the doctor holding the clinic regularly comes at a later time, or which allows patients who arrive earlier than the time of their appointments to be seen out of turn. Such happenings, and they are not uncommon, encourage patients to come early in the hope of 'jumping the queue', or to come late because there is no particular advantage in keeping an appointment which the hospital itself does not seriously attempt to honour. But it seems that if the staff of a hospital set

proper standards and observe them, then outpatients may generally be depended upon to observe them as well.

In practice both the doctor himself and a responsible administrative officer ought to watch the conduct of the clinic, so that any adjustments which may become necessary to the appointment interval, the initial number of patients called forward, the total number seen during the session, and so on, can be made at once. A fresh estimation of the doctor's average consulting-times may have to be made if the nature of the cases with which he deals changes, or if the proportion of old to new patients alters. If one doctor sees patients jointly with another, then it may be necessary to consider the average consulting-time of both, in order to fix the correct appointment interval. If there is a rest-break for the staff in the course of a session, it is important to make proper allowance for it in allotting appointments.

Block-appointment systems, as distinct from individual-appointment systems, can work with some efficiency, provided that first, the intervals between calling forward groups of patients are short—generally not longer than say 15 minutes, and only in the most exceptional circumstances as long as 30 minutes; and that secondly, the number of patients in each block has been accurately adjusted to the doctor's average consulting-time.

It is often argued that, in places where the arrival of public transport from country districts is spasmodic, it is impracticable to give patients individual appointments for precise times, but the Investigation is not convinced by this argument. It is usual for appointments clerks at such hospitals to consult patients as to the suitability of the time proposed for an appointment, or, if they cannot do so, at least to refer to the local time-table. If patients who live nearest to the hospital are put at the beginning of the list for the session, they should provide the reserve which will tide over the rest.

A more difficult problem has to be faced in some localities where patients are collected by an ambulance making a round in the district, and are deposited together in the outpatient department—often to attend the same clinical session. In those circumstances the solution seems to lie in maintaining good liaison between the transport officer and the appointments clerk. The clerk will know how many patients are expected to come by ambulance, and if she can also be advised sufficiently in advance, at about what time they are likely to arrive, she can fit them into the list either by treating them as a group to be given block appointments or by dispersing their appointments among the others on the list.

Length of Outpatient Sessions

Some people, among them consultants and hospital administrators, believe that in the long run an appointment system may work to the patients' disadvantage. Their argument is usually somewhat as follows. When an appointment system is used it is customary for an arbitrary limit to be set to the number of patients who will be seen by the consultant at each session. That number is often smaller than the number being referred daily to the clinic by general practitioners, and so what amounts to a waiting-list is built up. In attempting to keep abreast of the mass of applications, record-office clerks allot appointments for weeks ahead. If the clinic lists are thus completed in advance, the general practitioner can never be sure that a patient whose case is urgent, or may soon become so, will not have to wait for longer than is medically advisable before it is his turn to attend at a clinic. In the days before appointment systems were used, the patient would simply have been sent along to the next session. He may have had to wait for 2 or 3 hours before being seen, but at least he would have been seen—because somehow the consultants always managed to deal with everyone in the waiting-room—and it is surely better, they say, to wait for 2 or 3 hours than to wait for 2 or 3 weeks, or even months.[36]

This argument confuses the real issue. With or without the use of an appointment system, the length of outpatient sessions nowadays *must* be fixed. This is no doubt chiefly due to the consultants' commitments elsewhere in the hospital group and outside. It may also be due to lack of accommodation, which makes it necessary to use the same rooms for one clinic in the morning and for another in the afternoon; the rooms have to be prepared in the interval between the two clinics. Moreover, in the course of a given period of time it is not really desirable that the doctor should try to see more patients than he believes he can deal with adequately—and if he has estimated his average consulting-time accurately, he can predict what that number will be, and his lists will be arranged accordingly.

In present circumstances there is a positive obligation upon every doctor to scan regularly, with the responsible administrative officer, all the applications made to him for outpatient consultation. Directly they find that the sessions held are seriously failing to meet the demand, they must try to devise some way of making good the deficiency—by beginning the session earlier or finishing it later, as a temporary expedient, or by readjusting the whole time-table of outpatient clinics to fit in an extra session, temporarily or permanently. This kind of adjustment is now an established part of outpatient organization in hospitals where the understanding between the medical and administrative staff is on a proper footing. Nevertheless, even when every effort at such adjustment has been made, the demand for outpatient consultation may well reach a level at which it becomes necessary to secure the services of more consultants. If such extra help cannot be obtained, because it is not available or because accommodation is limited, or on the grounds of expense, then there is bound to be an endlessly growing waiting-list.

The *average* demand for outpatient consultation, at any hospital, can be calculated from past records; but the *actual* demand, particularly from patients newly referred to the department by general practitioners, fluctuates from day to day. Therefore it is not easy to forecast what the length of a session should be, or how often the clinic should be held, in order to meet this inconstant demand without deferring the attendance of individual patients unduly, and without, at the same time, putting an undue strain upon the hospital staff and resources. Some work has been done towards devising formulae which may give guidance in estimating how the duration and frequency of sessions held may be expected to affect the length of the 'waiting-list' and the average time which the patient will wait between being allotted an appointment and actually attending at a clinic. The subject is complex; more information is needed on the exact relation between an initial visit to the outpatient department and the subsequent visit or visits which may be expected to result from it.

IV. DISCUSSION

THE studies described in the previous section point to certain conclusions as to the design of outpatient accommodation, particularly consultation suites, treatment areas, and the arrangements for waiting. The research on outpatient departments followed that on wards, and time

did not allow the design and construction of an experimental unit demonstrating the results. Some, but by no means all, of the Investigation's conclusions are reflected in the Nuffield Diagnostic Centre at Corby, Northants,[37] designed by the Director and architectural staff of the Investigation. The following discussion is illustrated by reference to that building, and to the recent outpatient department at the West Middlesex Hospital, Isleworth (architect, C. D. Andrews, F.R.I.B.A.).[38] This department, designed without reference to the work of the Investigation, provides accommodation which in some respects fits the conception of outpatient working arising from the Investigation's own studies.

Consultation Suites

Since the incidence of disease and methods of treatment are constantly changing, it is desirable for consulting-room accommodation to be suitable for as many different kinds of clinic as possible. Only in the largest hospitals is the demand likely to necessitate the continuous use of clinic accommodation by any one specialty; but where such use is necessary, the suite can with advantage be designed around the specific needs of that specialty. There is, however, always the risk that accommodation too closely tailored to a particular method of working will in time become unsuitable. Hence, in the majority of cases, interchangeability of use is a sound principle in design.

The Investigation's field studies have shown that the design of clinical suites should facilitate consultation and examination in unbroken sequence, whenever a patient needs both. It follows that examination-rooms should adjoin consulting-rooms, and that separate dressing-cubicles should not be provided.* The Investigation has worked on the assumption that privacy is equally essential for consultation and for examination, and this implies that walls and doors should provide an adequate level of sound-proofing between adjacent rooms, and between rooms and waiting-areas.

Outpatient sessions are frequently conducted by two doctors working together, or by a team—for example, a consultant, and a registrar, or a junior assistant, and perhaps a medical auxiliary. Therefore it is an advantage if suites are grouped in intercommunicating pairs to facilitate consultation between the members of the medical team.

At the Nuffield Diagnostic Centre (*Fig. 32*) consultation suites are provided for the use of general practitioners, and for a limited number of specialist sessions held by staff from the nearby hospital at Kettering. The basic unit of accommodation is two rooms—a consulting-room, with a slightly smaller examination-room opening out of it. The examination-room has its own exit door. In such accommodation the consultative procedure may conveniently be conducted as follows.

The patient is called in to the consulting-room and then, at the appropriate moment, is sent into the examination-room to undress—the doctor occupying the interval in writing case notes or in any other way he thinks fit. The patient, having been examined, can be left to dress and leave by the separate door, while the doctor consults with his next patient. In that way, although the doctor has to fill in the time while the patient undresses, he need not wait during the dressing period unless he wishes to do so.

At Corby two pairs of consulting- and examination-rooms are arranged to form an intercommunicating suite of four rooms. The Centre contains two such suites, and one pair of rooms. The examination-rooms are large enough to act, on occasion, as consulting-rooms.

The Corby consultation suite and the method of working described above are likely to prove satisfactory for a considerable variety of outpatient clinics as well as for general practice. Broadly, the method of working suits clinics in which some time is devoted to consultation before the patient is examined—as in most medical clinics and many surgical clinics. In some surgical follow-up clinics, however, consultation is brief and examination swift, and the surgeon expects to deal rapidly with a succession of cases. Surgical follow-up clinics may with advantage be held in a treatment area of the type described below (p. 53), in which the accommodation includes a number of treatment-cubicles where patients can be prepared for examination, and visited in sequence by the surgeon.

Some consultants prefer not to hold separate follow-up clinics, but to include new and follow-up cases in the same session, and the team wished to test the suitability of the Corby suite for such clinics. Mr. P. H. Lenton, Consultant Surgeon to the Banbury and District Hospitals, co-operated with the Investigation in an experiment.

Mr. Lenton usually saw about twenty-five patients in the course of a 3½-hour session. All were general surgical cases of which approximately one-third were ex-inpatients, one-third new patients, and one-third patients who had been seen previously at the clinic. Over 90 per cent. of these patients had to take off some garments. The consultant himself occasionally gave treatment in the course of the clinic.

Before undertaking the experiment Mr. Lenton had been in the habit of using a suite of four rooms: one consulting-room and three examination-rooms. He found giving consultation and examination in unbroken sequence for each patient to be generally satisfactory, but said that besides one consulting-room and one examination-room for routine use, he needed a reserve room, sometimes for giving treatment, and sometimes for a patient who took a long time to dress.

The Investigation came to the conclusion that the most economical way in which this need could be met was by providing a second couch, in the consulting-room; so that if one of the two rooms continued to be occupied by a patient, the doctor could both consult and examine his next patient in the other.

A new outpatient department was opened at the West Middlesex Hospital in 1952. The medical staff at that hospital had come to the conclusion, in very much the same way as the Investigation had done—by making timed studies of work in progress—that at most consultative clinics patients would benefit by having consultation and examination in unbroken succession, and in the new department they planned for this procedure in an original way.

They provided a series of identical rooms, and furnished each as a combined consulting- and examination-room, with a corner curtained off for undressing (see *Fig. 33*). At some clinics, when few patients were expected to undress, each consultant used only one room. At other clinics, when many patients were expected to undress, each consultant used a pair of adjoining rooms. In those circumstances the procedure was as follows. The first patient would be shown into one of the two rooms by a nurse, and would take off the appropriate garments. When he was ready, the doctor would come to consult

* During field studies the team had noticed the embarrassment evidently felt by patients, first in deciding when was the proper moment to leave the cubicle and return to the doctor's rooms, and secondly, in emerging more or less undressed under a topcoat or wearing a dressing-gown supplied by the hospital. The Investigation agreed with the statement made in the Ministry of Health's annual report for 1949–50, that 'dressing cubicles are almost impossible to light and ventilate thoroughly and are, therefore, unhygienic'.

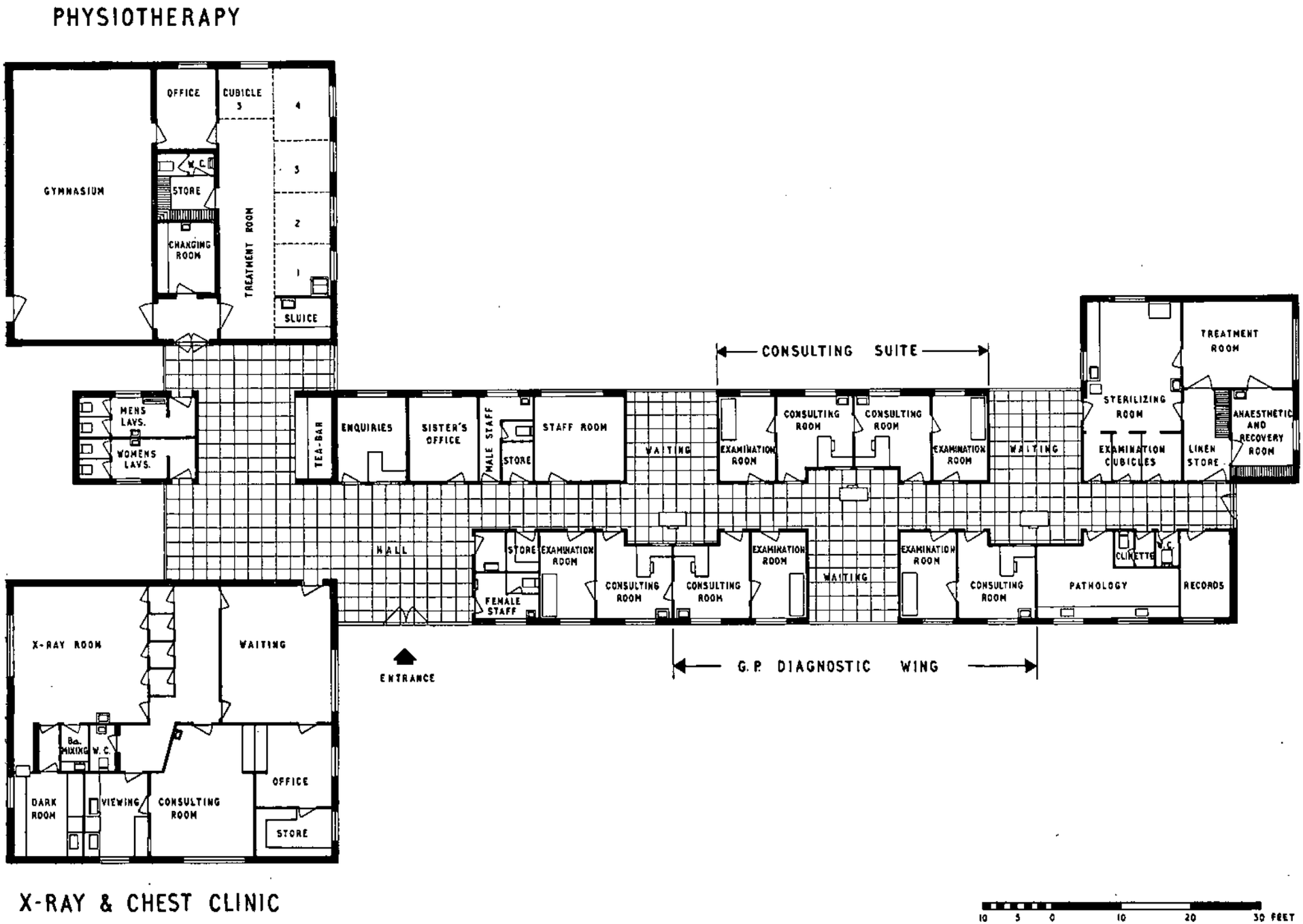


Fig. 32. The Nuffield Diagnostic Centre at Corby, Northants

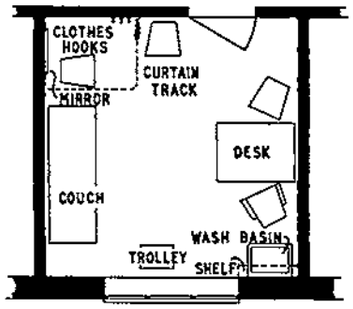


Fig. 33. A combined consulting-room and examination-room at the West Middlesex Hospital, Isleworth

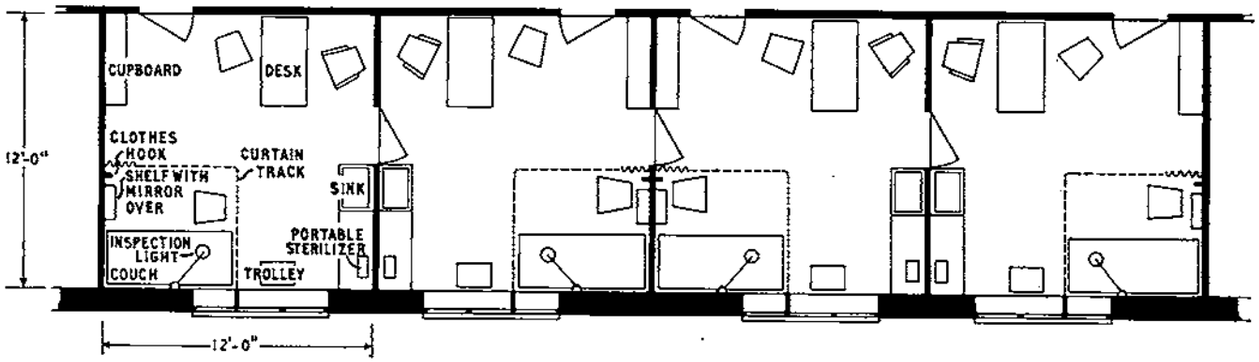


Fig. 34. Four-roomed consultation suite of combined consulting- and examination-rooms

and examine him. After the examination the doctor, leaving him to dress and depart, would go into the other room, where the second patient had meanwhile similarly prepared for consultation and examination—and so on.

The combined consulting- and examination-rooms, whether used singly or in pairs, succeeded in the principal object of facilitating uninterrupted medical attention for every patient, and when they were used in pairs this was achieved without obliging the doctors to wait while patients undressed or dressed. The time during which patients waited for the doctor was satisfactorily brief, and the size and character of the rooms—which were domestic rather than institutional—and the fact that each patient was securely installed in one place throughout the medical part of his visit to the hospital (thus relieving him of most of the responsibility for deciding what he ought to do next) appeared to create a reassuring atmosphere.

An objection which may be raised to using combined consulting- and examination-rooms in pairs is that, if each room is occupied by an unbroken succession of patients, the doctor will have nowhere to discuss a case with a colleague or a relative of the patient, without being overheard either by the patient concerned or by another patient. This occasional difficulty may be overcome by the doctor warning the nurse not to call in the next patient immediately. Nor is it essential for patients to have removed clothes before the arrival of the doctor; they can retire behind the curtain to undress during consultation—a procedure preferred by some consultants.

The Investigation concluded that maximum flexibility in use, with continuity of consultation for the patient, could be provided by a series of identical rooms, equipped on the West Middlesex Hospital pattern, and grouped as a suite of four intercommunicating rooms (see *Fig. 34*), as at Corby. At clinics at which some patients have to undress, each doctor would normally use two rooms. Where consultation precedes examination he could work as at Corby, using one room for consultation and the adjoining room for examination; but if the room used for examination were occupied for longer than usual, then he could consult and examine the next patient in the other room, as at the West Middlesex Hospital. At surgical follow-up or other rapidly conducted clinics, the consultant could regularly use two rooms alternately. At those clinics at which patients are not usually required to undress, each consultant would have the use of one room only.

Flexibility in the use of accommodation leads to an overall economy in provision; its achievement has been a guiding principle in the Investigation's outpatient studies. In the interests of economy, it is no longer desirable that consultation suites should be kept for the exclusive but intermittent use of a single firm. They must be available throughout the week and may serve for a variety of clinics.

The total number of general-purpose units of four rooms to be provided would depend upon the outpatient work-load to be met at the various clinical sessions.

There are certain clinics at which special rooms are needed. For example, ear, nose, and throat clinics need a sound-proof room for audiometry, and orthopaedic clinics need the use of a plaster room.*

Ancillary Rooms for Consultative Clinics

Consulting-and examination-rooms, of whatever design, need various facilities. At the West Middlesex Hospital a unit of ten general consulting-rooms is served by the following ancillary rooms: a sterilizing-room, a linen-room, a small laboratory for urine-testing communicating through hatches with a W.C. on either side (one for men and the other a clinette† for women). At the Nuffield Diagnostic Centre at Corby, the facilities include: a pathological laboratory, a linen-store, and a clinette W.C. —the sterilizing-room is shared with the treatment area, but portable sterilizers can be used in the consultation suites.

Consultation suites should generally be as near as possible to accommodation designed for giving treatment. One advantage of such an arrangement is that the routine sterilizing and issuing of equipment sufficient to meet the expected needs of each clinic can be done in the treatment area in advance of the sessions, thus making it unnecessary to provide a sterilizing-room serving consultation suites only. A further advantage is that the nurse need not

* For eye clinics the standard type of combined consulting- and examination-room, with a black-out blind, will be suitable without adaptation if reflected test-type is used, since in any room with one 12-foot dimension the mirror will provide the equivalent of the necessary reading range of 20 feet.

† The clinette W.C. automatically receives a specimen in a receptacle placed beneath the specially constructed pan.

then leave the consultation suite in the course of the session, in order to sterilize or collect instruments.

The Treatment Area

If each consulting-room contains a couch, sink and slab, adjustable lamp, black-out blind, electrical outlet for a portable sterilizer, and sufficient storage space for the equipment peculiar to each clinic using the room, the medical and nursing staff can do on the spot, without requiring ancillary rooms, most of the treatment incidental to those clinics which are mainly consultative. Those clinics intended primarily for giving treatment are best held in an area specially designed for the purpose.

The layout of the treatment area will depend to some extent on its placing relative to the casualty department* and to the consultative-clinic suites, but it can be designed to ensure that each patient has a measure of privacy when receiving treatment, and that members of the medical team giving treatment shall have the least possible distance to go in disposing of soiled instruments and dressings, washing their hands, and replenishing stocks on their dressings trolleys.

These needs may be met by providing a series of treatment cubicles, each large enough to accommodate the patient—lying on a couch or sitting on a chair—one or two members of the medical team, and a dressings trolley. The patient enters and leaves the cubicle through a door from a waiting-space or corridor. The opposite side of the cubicle should be an unobstructed opening, large enough to push a trolley through with ease, and having a single curtain which can be drawn back. This side of the cubicle would give on to a square or rectangular working-space, in the middle, or possibly along one wall, of which is a battery of equipment for all the supply and disposal needs of a treatment session. *Fig. 35* shows this arrangement. The provision of cubicles avoids the necessity for separate treatment-rooms for men and women.

The Nuffield Diagnostic Centre at Corby contains three small treatment-cubicles, opening on to a large work-room, which also serves a minor operating theatre adjoining it. The work-room has facilities for storing, sterilizing, preparing, cleaning, and disposing of all equipment used for patients in the cubicles and in the minor theatre.

* The Investigation did not study the casualty department or the day-to-day use made of outpatient operating theatres, but the case-study (Chap. 7) produced some relevant information.

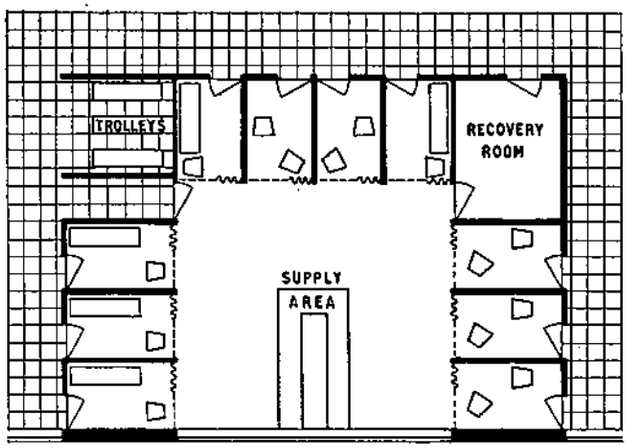


Fig. 35. Layout for a treatment area

Waiting-Spaces

The traditional way of accommodating outpatients while they wait to be summoned to the doctors (the 'first-waiting time', referred to on p. 38) is in one large hall, surrounded by consultation suites. There they all sit together, usually separated into groups under the banners of the consultants whose clinics they are attending. Often they sit in rows, but since benches have been widely replaced by stacking-chairs they are encouraged at some hospitals to group themselves informally.

Central waiting only works smoothly at hospitals where all the clinics can be held in suites of rooms round the waiting-hall. Once the number of clinics necessary to meet the outpatient load exceeds the number which can be so accommodated—and the present volume and complexity of outpatient work has led to this state of affairs in all but the smallest hospitals—it becomes necessary to provide waiting-places in the immediate neighbourhood of the clinics. If this is not done it is very difficult to ensure that the patient reaches the consulting-room at the precise moment when the doctor is ready.

The large central waiting-hall is a survival from the days when the outpatient department threw open its doors at a stated time and admitted a throng of patients who had come prepared to wait several hours for advice and treatment. But nowadays appointment systems, if properly designed and applied (see pp. 46–49), make it unnecessary to accommodate a crowd. The number of outpatients who, at any stage of a session, will be waiting to be summoned into the consulting-room is comparatively small.

Local waiting-spaces have another important advantage besides the principal one that summoning the patient into the doctor's room is made as expeditious as possible. The Investigation accepts the view commonly held among hospital planners that both design and organization should be aimed at minimizing impressions of size and impersonality which may so easily oppress hospital patients. The local waiting-space, because it may be decorated and furnished in a domestic manner and contains only a few patients at a time, has a reassuring effect.

A very desirable arrangement is to have clerk-receptionists on duty in the various local waiting-spaces while clinics are in session, and this is done at some hospitals. The clerks are responsible for the relevant case-papers, for recording attendances, and for making fresh appointments; they also arrange immediate visits to special departments and tell patients how to get there. They deal with telephone and other messages, and at the end of the session act as secretaries to members of the medical staff wishing to dictate letters and memoranda. The Ministry of Health has drawn attention to the value of clerk-receptionists at outpatient clinics, in a memorandum issued in January 1954,[31] but their appointment is sometimes precluded by present restrictions on the size of the clerical establishment.

In the Nuffield Diagnostic Centre each of the four-roomed consultation suites opens on to its own waiting-space where a clerk-receptionist is in attendance. She has all the waiting patients under her eye and can summon each of them to consultation with a minimum of delay. Precautions have been taken to ensure that consultations cannot be overheard or disturbed by noise from the waiting-space.

The provision of local waiting-spaces for each clinic does not wholly do away with the need for some general waiting-place for patients being called for by an ambulance or by friends, or filling in time before the departure of a bus or train. This general waiting-space may conveniently be at the entrance to the outpatient department, and patients' companions may remain there. The amenities should include a refreshment bar, toilet facilities for men and women, and a public telephone. A general-inquiries desk should be conspicuous.

Patients frequently have to wait for some time while

prescriptions are made up, and it is convenient to have the dispensary on the periphery of the general waiting-space—as it often is in a central waiting-hall. The outpatient sister's office and the main office of the almoners' department may also be adjacent to the general waiting-space.

It will be convenient if the records department, or that section of it which is directly concerned with outpatients during their visit to the hospital, can be placed at the entrance to the clinics, on the periphery of the general waiting-space. If clerks are not stationed in local waiting-spaces then the business to be conducted centrally for the patient will include: registering personal particulars (though it is quite common for most of these to be recorded by the patient in advance, on a form supplied through his general practitioner); making the initial appointment (this is frequently done by post or by telephone); recording attendance; and making a further appointment. All this may be done at a desk or counter, but care must be taken that patients cannot overhear each other. Sufficient seating should be so placed that patients may sit in comfort while waiting their turn to give particulars and yet be able to step forward at once when it comes.

SUMMARY

I. Historical Introduction. Outpatients have always been accepted in English voluntary hospitals. Originally numbers were restricted by selection; but during the nineteenth century in many hospitals all comers were attended to without question so that the volume of out patient work became a cause for concern. As hospital work became increasingly specialized it was felt that only outpatients referred by a general practitioner for consultation should be accepted. In the ninteen-thirties appointment systems were introduced.

II. The Outpatient Service Today. Under the National Health Service the consultative character of the outpatient department has been confirmed. In the interests of the individual as well as of the community outpatient rather than inpatient care is given whenever possible.

III. Studies by the Investigation. Organizing the various activities of an outpatient service raises complex problems some of which the Investigation has studied in detail. 1. A pilot study in general medical and surgical clinics in a group of hospitals in northern England aimed at establishing the common pattern of a visit to the outpatient department, with particular reference to the time factor. In the medical clinics the average duration of the visit was one hour, only 9 minutes of which were taken up by medical attention; in the surgical clinics the average duration was 52 minutes for 5 minutes' medical attention. 2. Studies in surgical and skin clinics in a London hospital produced similar information in greater detail. Observations of punctuality showed that while patients tended to arrive early the medical staff in charge of clinics often did not. It was not unusual for a patient, after consultation had begun, to spend a considerable time undressed in an examination-room, waiting while the consultant dealt with a series of patients in other rooms at his disposal. These studies were repeated, with similar results, in medical clinics in a suburban hospital. But in that hospital a physician, working in one combined consulting- and examination-room, gave each patient his uninterrupted attention, with the result that they did not have to wait in the course of consultation and examination. 3. In another hospital further studies were made of two surgeons each using a consulting-room and only one examination-room, and giving all their patients uninterrupted attention. Waiting was greatly reduced for the patients without wasting the surgeon's time. 4. *Appointment Systems* are now generally used yet many outpatients are still kept waiting. Statistical studies by the Investigation indicated that this was probably due to over-insuring against the doctors being kept waiting, by calling forward patients at a rate disproportionately greater than the average consulting rate. Using the consulting times recorded during the Investigation's field studies, the statistician worked out the theory on which efficient appointment systems are based, and showed that the results of any particular system in given circumstances are predictable.

Discussion. Time did not allow the Investigation to plan an actual outpatient department, but experience gained during the field studies was applied in designing the Nuffield Diagnostic Centre at Corby. It was concluded that maximum flexibility in the use of consultation suites could be achieved by providing four intercommunicating rooms, each a combined consulting- and examination-room. This suite can conveniently be shared by members of the medical team, the consultant himself using one room or two according to the kind of clinic. A treatment area is described in which cubicles are served from a centrally placed supply area. The advantages of local waiting-space combined with some general waiting accommodation are discussed.

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3 THE OPERATING THEATRE SUITE

1. Introduction

IN 1867 Joseph Lister introduced carbolic acid dressings in the treatment of compound fractures,[1] and thereafter in the nineteenth century the development, first of antiseptic and then of aseptic techniques, led to spectacular achievements in the surgery of the body cavities. With the change in emphasis from antiseptic to aseptic methods, the advance became extremely rapid, and modern aseptic techniques and equipment were in routine use in some operating theatres in various parts of Europe and America before 1900.[2] Improvements in sterilizing equipment, instruments made in one piece or which could be taken apart for cleaning, the exclusion of all unessential furniture from the theatre, easily cleaned surfaces such as glass shelves and even glass operating tables, gave the theatre an appearance not very dissimilar from that of theatres today. But whereas the first developments of aseptic technique immediately and dramatically reduced the risk of sepsis, subsequent advances have not yet succeeded in wholly abolishing it.

2. General Planning Considerations

The plan and equipment of the theatre suite is of first importance if aseptic techniques are to be carried out satisfactorily. Everything which has contact with the patient, even at second hand, may cause infection, and the juxtaposition of sterile and non-sterile objects at any point in the journey from the sterilizer to the site of operation constitutes a risk. These chances of contamination must be eliminated as far as possible. In particular the plan must make due allowance for the circulation of the different users of the theatre, ensuring that unnecessary movement and mutual hindrance is avoided.

In 1937 the Ministry of Health's Departmental Committee on the Cost of Hospitals[3] summarized the requirements for an operating theatre suite. It was recommended that to ensure quiet and to minimize airborne infection, the whole suite should be planned as a cul-de-sac off the main hospital corridor, that an anaesthetic-room should adjoin and communicate with each theatre, and that all rooms should open into a central enclosed area. The scrub-up room, sink-room, and sterilizing-room should adjoin the theatre with open communication, and there should be direct access to the outside of the building for soiled linen bins. The Committee also recommended that where more than one theatre was required, both convenience and economy would be achieved by combining two theatres in one suite, so that some of the ancillary rooms could be shared (*Fig. 36*). Such a pattern, with only minor variations, is very often followed in this country.

In 1937 three architects in France, A. Gosset, P. Hauduroy, and J. Gosset, reconsidered the design of operating theatres.[4] They deplored the lack of collaboration between surgeon and architect evident in most of the operating suites they visited. In most hospitals they found insufficient separation of the surgical department from the remainder of the hospital, so that there was noise and traffic at the very door of the theatre. They proposed the separation of the complete operating block from the rest of the hospital, the theatre, its ancillary rooms, surgeons' and nurses' changing-rooms, laboratory, and X-ray room being in a cul-de-sac department entered only through an air-lock, and continually supplied with sterilized air. They recommended the provision of a recovery room in addition to the anaesthetic-rooms, with communication between the two.

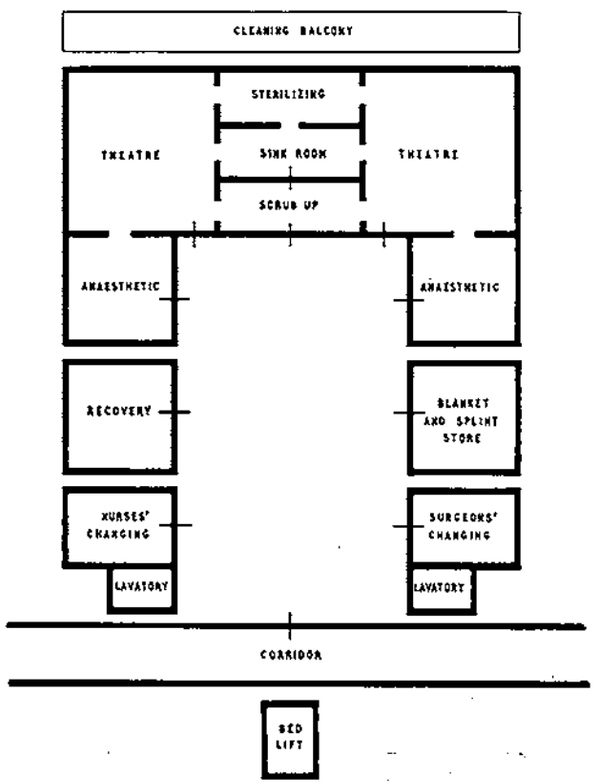


Fig. 36. Diagrammatic layout of a twin operating theatre suite, after Ronald Ward

At the Paris Exhibition, also in 1937, theatres designed by Jean Walter[5] were shown in model form, and it was intended that the theatres should be built in the new hospital at Lille (*Fig. 37*). Walter maintained that hitherto airborne infection had been given insufficient attention, and aimed at nothing much less than complete sterility of the whole theatre and everything in it. This was to be achieved by equipping the theatre so that as much as possible would be done mechanically, and by planning architectural solutions aimed at preventing contaminated objects from entering the theatre. The theatre and other rooms in the sterile block were to be sterilized before an operating session, by passing a mixture of air and formaldehyde, followed by ammonia, through them. The air would then be passed through sterile water to dissolve out the chemical products of this process, and during the operating session the circulating air would be filtered, warmed, and humidified to the required degree. The operating table had a fixed pedestal containing all the electrical controls for moving it, also supply points for electric power, vacuum, and compressed air. Mechanical instruments, such as the diathermy, and the flow of anaesthetic gases were all to be controlled from a mobile desk. The surgeons and their assistants were to enter the theatres through a series of rooms for undressing, washing, dressing, and scrubbing-up. The patient was to be brought first into an unsterile room to be undressed completely and slid through a hatch to a preparation room within the sterile block. There he was to be met by a scrubbed-up nurse who carried out final skin preparation and dressed him in sterilized garments. He would then be transferred to a sterile canvas stretcher hanging from a mono-rail, to be transported first to the anaesthetic-room and then, through another hatch, to the theatre. In that way the entry of trolleys and porters into the sterile block was to be avoided. The sterilizing-room was not included in the sterile block. Dirty instruments and equipment were to be passed out of the theatre through a double air-tight hatch into a sink-room and then put into boiling sterilizers or autoclaves built into the wall between the sink-room and sterilizing-room. The equipment was to be passed back to the theatre through a second air-tight hatch from the sterilizing-room. Access to the sink-room was by a passage outside the sterile block and having no communication with any other room.

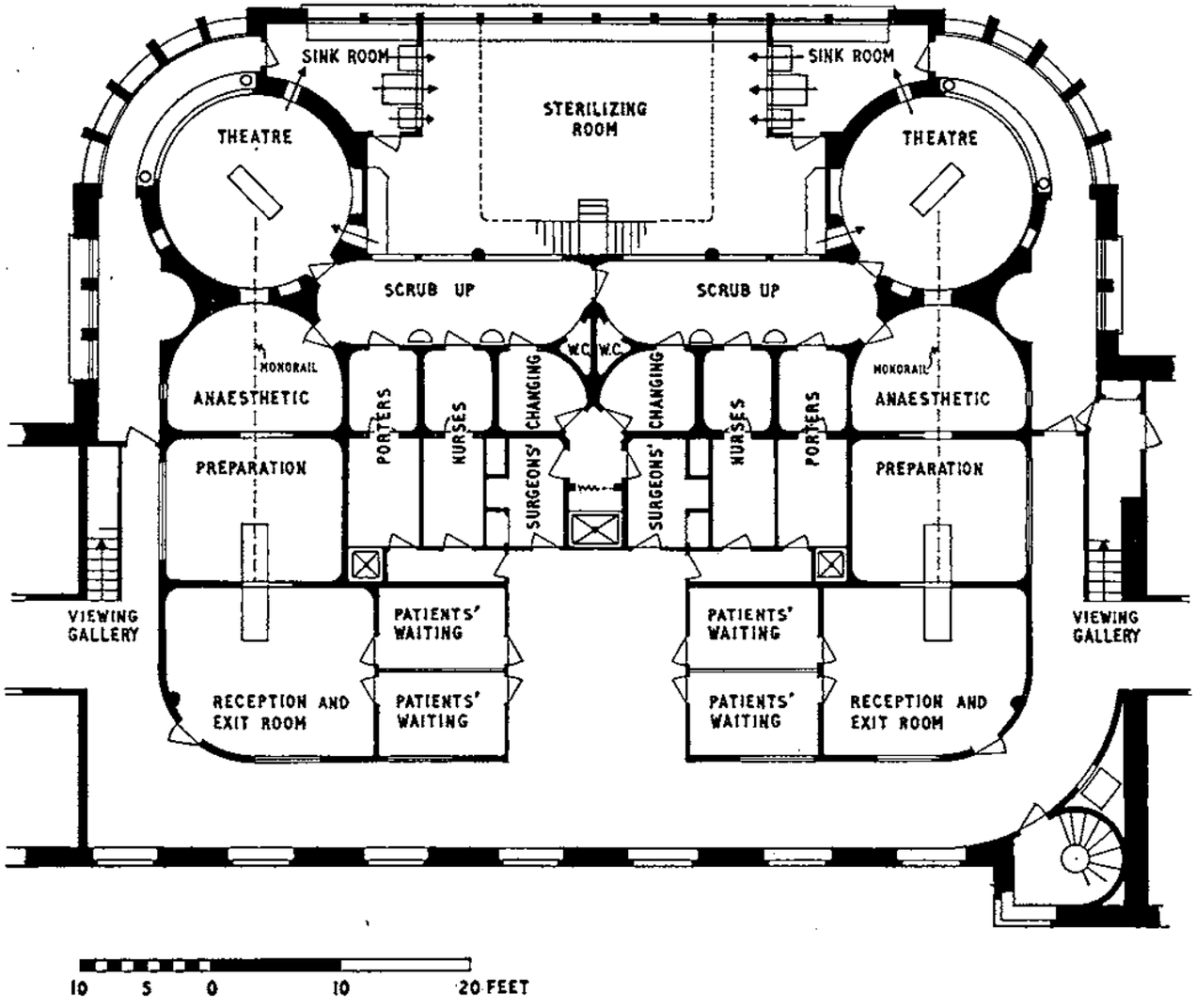


Fig. 37. Plan for 'sterile' operating theatre suite (1937) by Jean Walter

By contrast with Walter's proposals, the plans illustrated in the publications of the United States Public Health Service[6] are very simple (*Fig. 38*). The theatre suites are cul-de-sac departments isolated by swing doors. Anaesthetic-rooms are not provided, the sink- and sterilizing-rooms are quite small, and the surgeons' scrub-up basins are in the corridor between each pair of theatres. These plans include a central sterile supply department which, in addition to serving the wards, also sterilizes and repairs instruments and linen, and prepares solutions for the theatres.

It is usual in America to provide a higher proportion of theatres to surgical beds than in Britain. Rosenfield[7] holds that in a general hospital one theatre for every 50 beds *in all specialties* (which is proportionately 1 to every 20 *surgical* beds) is not excessive for American requirements today. This is in line with the recommendations made by the United States Public Health Service.[8] In

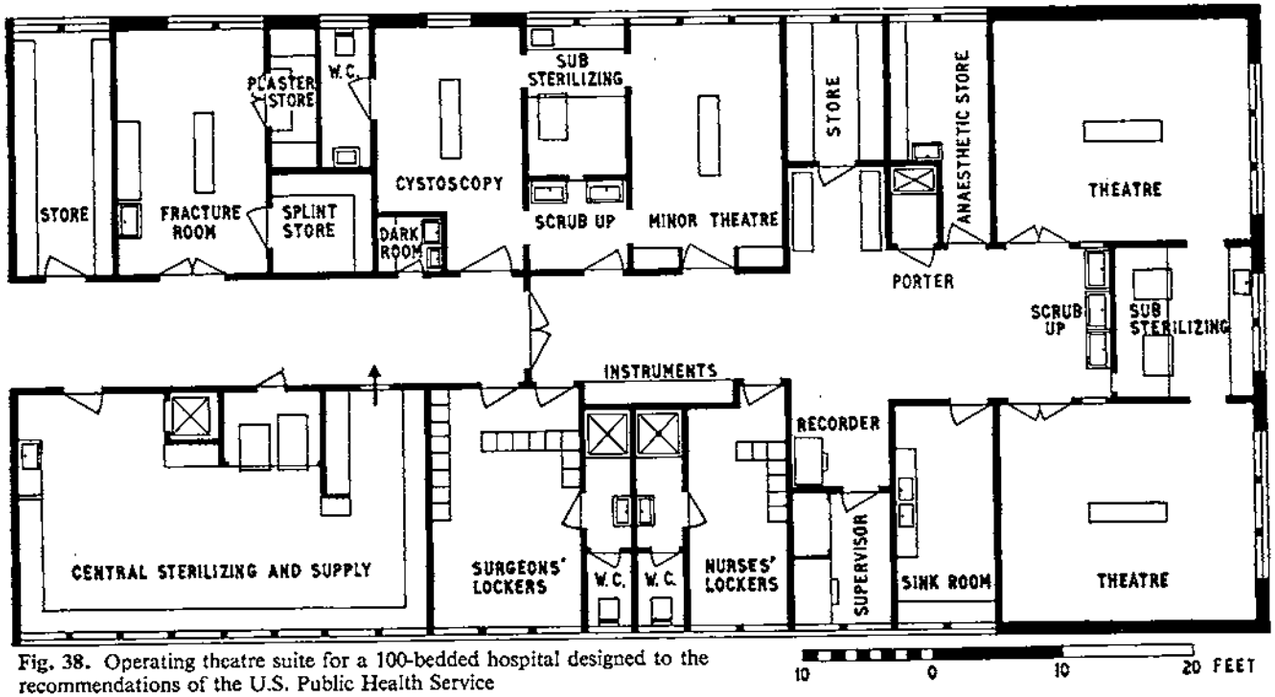


Fig. 38. Operating theatre suite for a 100-bedded hospital designed to the recommendations of the U.S. Public Health Service

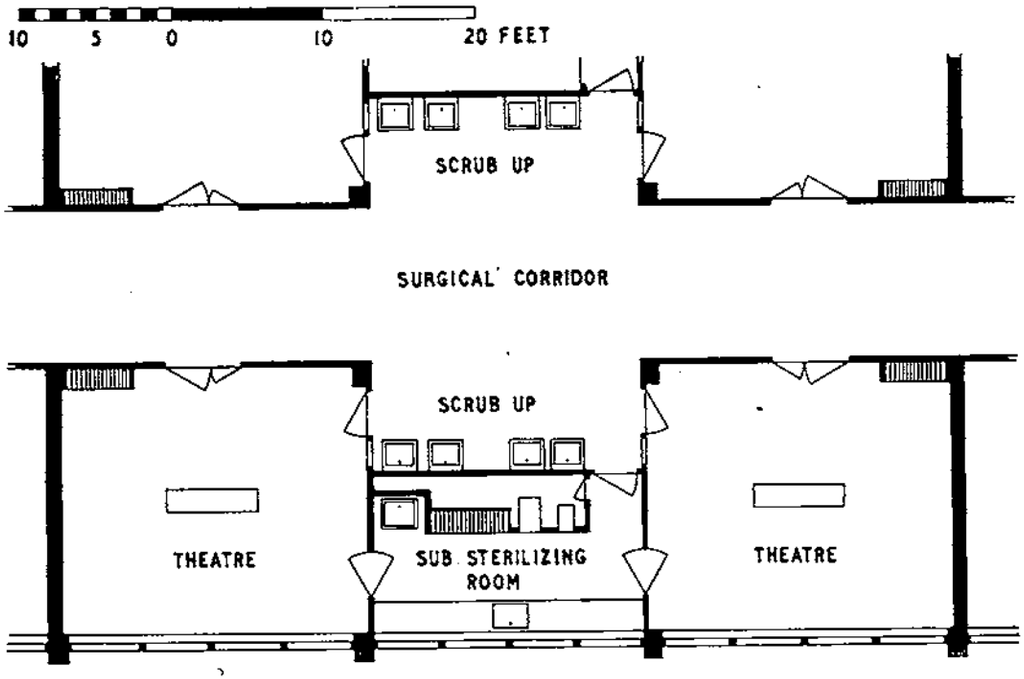


Fig. 39. Twin operating theatres in a suite at the Ponce General District Hospital, Puerto Rico, by Isadore Rosenfield

Britain the ratio of theatres to *surgical* beds varied in 1931 from 1 : 30 to 1 : 120, while thirty out of sixty-two hospitals had one theatre to 60 surgical beds.[9] In 1949 Ronald Ward[10] recommended one theatre to every 50 general surgical beds. Owing to the generous provision of theatres in American hospitals, the list of cases for each operating session is much shorter, and an interval of at least half an hour is usual between cases.[11] Trolleys are laid-up for the next case and surgeons gown in the theatre itself. Although this was also done in some of the theatres in England visited by the Investigation, it was always because of inadequate accommodation in the theatre suite, and was not regarded as good practice by those working there (see p. 79).

Neither the plans illustrated in the United States Public Health Service publications nor those designed by Rosenfield include large sterilizing-rooms. Their place is taken by a small sub-sterilizing-room between a pair of theatres, where instruments are both washed and autoclaved between cases, and a central sterile supply department adjacent to the theatre suite. In the United States Public Health Service plans an additional sink-room is provided opening into the theatre corridor, where equipment other than instruments is cleaned. Rosenfield places a door between the sub-sterilizing-room and the access corridor (*Fig. 39*). This door gives direct access to the sub-sterilizing-room, but in taking equipment back to the central sterile supply department people must pass through the scrub-up compartment. It is evident from these plans that the attitude taken to the problem of obtaining aseptic conditions in the theatre is quite different from that taken by Walter. Whereas he proposed primarily architectural means of attaining the greatest possible degree of sterility in the theatre, by using a very highly organized plan and tightly controlled circulation paths, Rosenfield relies chiefly on discipline among the theatre staff to use the loosely organized accommodation in the best way. The fact that American theatres are generally used less intensively than European theatres undoubtedly eases the problem of maintaining aseptic conditions.

The designs of Walter and Rosenfield represent the two extremes of complexity and simplicity in planning, and the majority of plans recently executed in Britain lie somewhere between the two (*Fig. 40*). The theatre suite ought to be a cul-de-sac department, with sterilizing-rooms adjacent to theatres, and cleaning and sterilizing functions should be given a measure of separation by

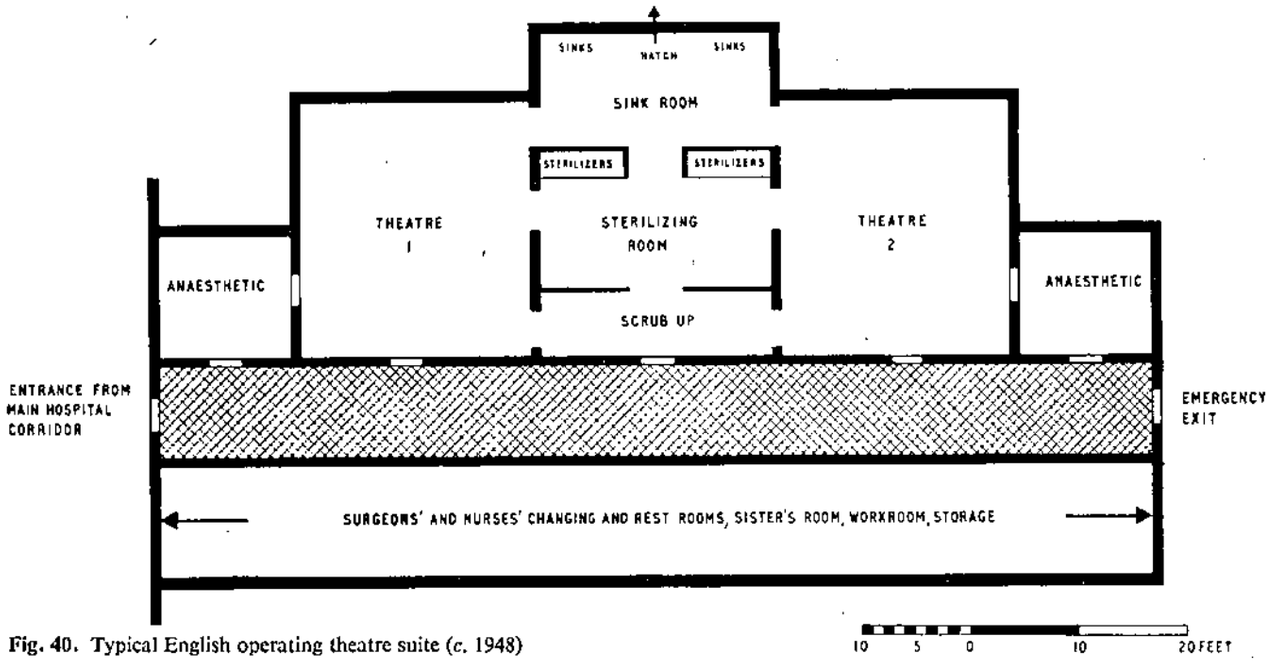


Fig. 40. Typical English operating theatre suite (*c.* 1948)

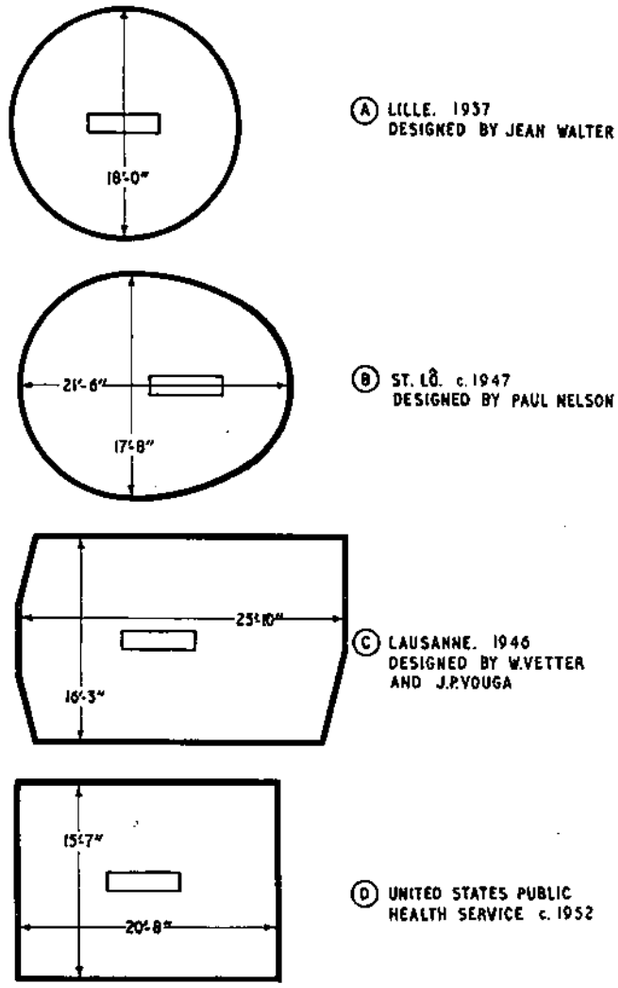


Fig. 41. Examples of variety in the size and shape of operating theatres

planning. But most modern British theatre suites are so arranged that the pattern of work carried out in them is not entirely dictated by planning, and there is advantage in providing for such flexibility rather than in planning rigidly round a pattern of work which may be superseded.

3. The Operating Theatre

Size and Shape

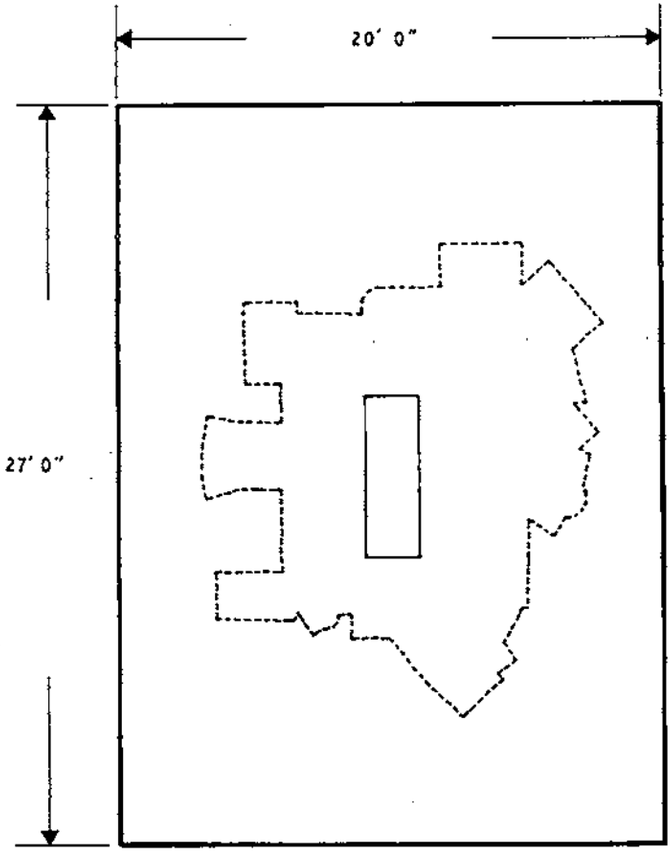
During the past twenty years, particularly in France, theatres of many different shapes and sizes have been designed and built in order to experiment with different arrangements for accommodating students, for improving the lighting of the operating table, and for more efficient ventilation (*Fig. 41*). Some of these are discussed later in this section.

A study was made by the Investigation to discover whether it was possible to determine the optimum size and shape of operating theatres for general surgery. Work in each of two theatres in two large teaching hospitals was observed during the course of general surgical lists, and the positions taken by the surgeon and his team and the exact placing of trolleys and basins were recorded.

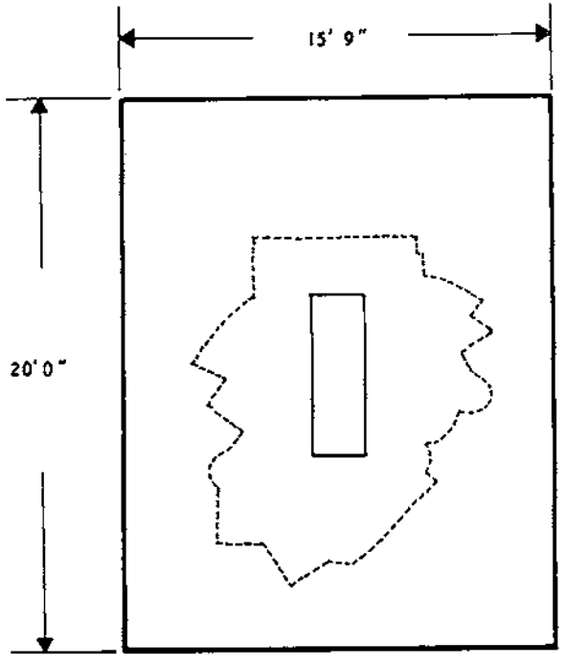
Theatre A (27 feet by 20 feet) was thought by those who worked in it to be too large and theatre B (20 feet by 15 ft. 9 in.) was thought to be too small. *Fig. 42* shows the outlines achieved by linking all the points where the mobile equipment had stood during twenty-two operations in each of the theatres.

In one theatre staff appeared to the observers to be crowding each other, but the degree of inconvenience they experienced could not be assessed objectively. In the other theatre the long dimension of the diagram is distorted owing to the presence of a pillar carrying pipe anaesthetic gases fixed some way from the head of the table. The cross-dimension of the outline measures 14 feet in the theatre which was 15 ft. 9 in. wide, and 15 feet in the theatre which was 20 feet wide. This suggests that though the staff in theatre B appeared to be constrained by the walls of the theatre, they might need only another foot in width for conditions to be comfortable.

Analysis of the plans marking the positions of equipment shows that, even during operations needing the most space, on only one occasion was as much as 17 feet needed in the long axis—and that at a single point. If a 20-foot square is drawn round the core of activity surrounding the table (*Fig. 43*), it is apparent that sufficient peripheral space will be enclosed to allow free movement and the placing of equipment. For general surgery, a square theatre is the most suitable shape, since the bulk of equipment is set out on either side of the operating table, where also stand the surgeon and his assistants. These observations led to the further conclusion that if the operating table remains fixed in the middle of the theatre, the arrangement of the people and equipment, although not symmetrical about the long axis, is nevertheless arbitrarily determined in relation to the containing walls of the

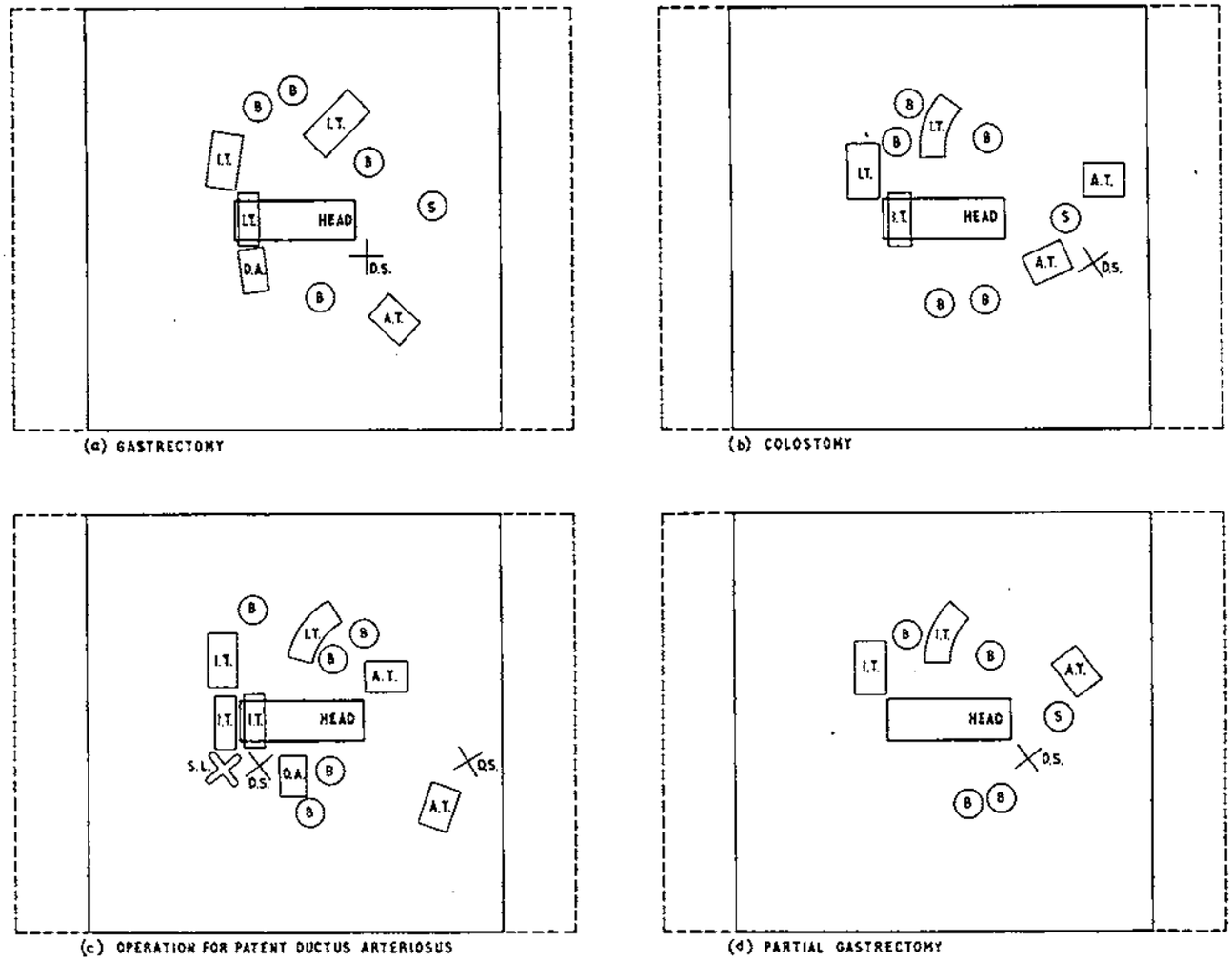


THEATRE A



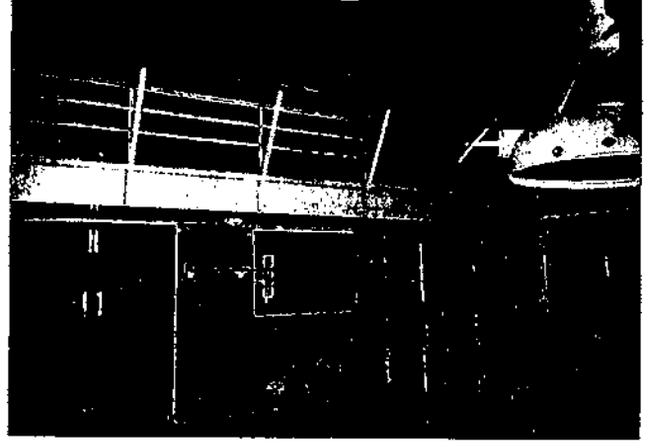
THEATRE B

Fig. 42. Outlines produced by linking the points at which mobile equipment stood during twenty-two operations observed by the Investigation in each of two modern English operating theatres (A and B)



KEY. A.T. Anaesthetist's Trolley. I.T. Instrument Trolley. B. Basin. D.A. Diathermy Apparatus. D.S. Drip Stand. S.L. Spot Light. S. Stool.

Fig. 43. Layout of mobile equipment for four major operations observed by the Investigation in the larger of the two operating theatres (A) shown in *Fig. 42*. The actual shape of the theatre is shown by a broken line; a 20-foot square centred on the operating table has been drawn



the Plastic Surgery Centre, Queen Victoria Hospital, East Grinstead

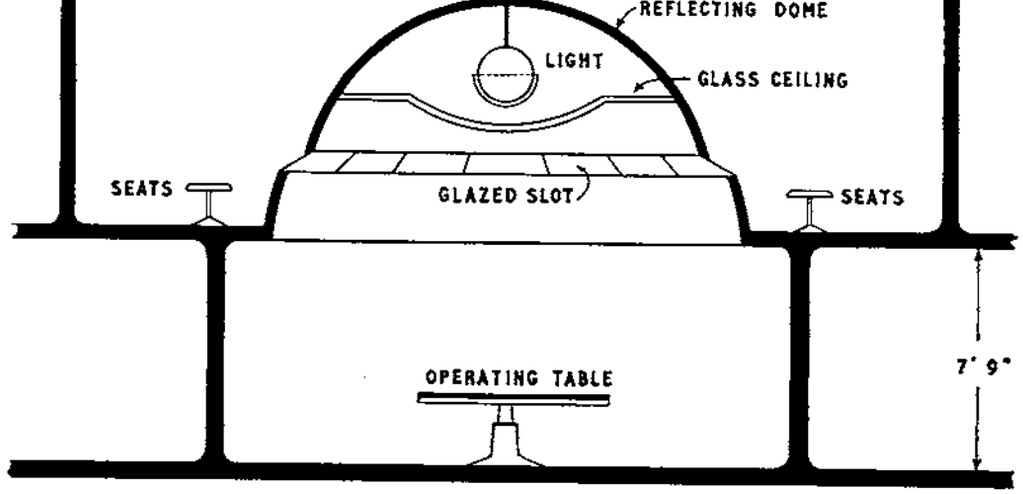


Fig. 45. Section through Jean Walter's operating theatre at Lille, showing observation gallery and lighting

theatre. If, on the other hand, the table is mobile, then its position can be altered to suit the most convenient grouping in the room for any particular kind of operation. Had students been present during the operations observed by the Investigation, a larger total space might have been needed.

Observers' Galleries

The presence around the table of more people than are strictly necessary to assist at the operation is clearly undesirable. For undergraduate students the view of an operation to be gained from the traditional tiers of benches in a gallery is usually unsatisfactory, and various other attempts have been made to accommodate observers so that they are at once out of the way and able to see the details of an operation. *Fig. 44* shows the gallery provided at a plastic surgery centre. Shallow galleries with glazed fronts running along one or more sides of the theatre have sometimes been provided to give a view into a deep operating cavity. Sometimes a gallery has been built above a glazed cupola over the operating table and in which the seated observers are in two-way communication with the surgeon. Jean Walter has used this method[5] (*Fig. 45*) and with a ceiling height of about 7 ft. 6 in. at the edge of the operating theatre, he was able to arrange that the viewing point for all observers was only 10 feet away from the operating field. The theatres built in 1938 at the Royal Infirmary in Edinburgh have a similar arrangement.

The epidiascope and television have both been used for projecting a coloured image of the operating field on to a screen in a lecture-room outside the theatre. Both these methods centre the view immediately over the site of operation at a distance of a few feet. The epidiascope needs brilliant illumination of the subject and has a limited 'throw' and usually it can only be installed in theatres specially constructed for the purpose. There is little doubt that full colour stereoscopic television with very high definition will become a valuable aid for teaching purposes, but at present capital and installation costs are very high.

Artificial Lighting

The design of artificial lighting installations in operating theatres presents special problems. Often the surgeon is working in a deep, predominantly red cavity of low reflectivity; the site of operation is encumbered with instruments, and the head and hands of the surgeon and his assistant are almost immediately over it. It is seldom possible to light surgical work from a single point source, owing to the multiplicity of shadows which might be cast. Because the eye is less sensitive to red light than to colours in the green-yellow zones of the spectrum, exceedingly brilliant illumination of the operating cavity is essential if fine gradations of the red are to be observable. MacInnes and Palmer note[12] that opinions differ widely about the level of illumination of the operating field, levels from 300 to as high as 2,000 lumens/sq. ft. having been recommended at various times. They add that a certain diffusion of light from the centre of the field is desirable. The figure of 300 lumens/sq. ft. is given in the Illuminating Engineering Society Code (1949),[13] where surgical operation is graded as 'very small' work in a field of 'low contrast'. André Walter,[14] pointing out that in order to see in a red field as clearly as in a white, twenty times as much light is required, recommends a level of approximately 4,000–5,000 lumens/sq. ft. He adds that, in general, approximately 1,500–2,000 lumens/sq. ft. is sufficient, and that in case of difficulty an auxiliary source may be used. One of the difficulties of surgical work is that the position and size of the site and angle of work on the patient's body will vary from case to case during a list; a large measure of flexibility both in the angle of throw from the light-fitting and the size of the field illuminated is therefore necessary. As the surgeon's head is usually between the source of illumination and the site of the operation, the surgeon will be unaffected by contrast between the brightness of the source itself and the brightness of the surfaces surrounding it. His field of visual concentration is, however, very brightly illuminated. The relation between the levels of illumination of the task, local surround, and general environment have been discussed by Dr. R. G. Hopkinson[15] of the Building Research Station. He notes: 'Maximum comfort is achieved when the brightness of the local surround is between that of the

general surround and that of the bright visual task.' He also quotes Lythgoe,[16] who studied the effect of the general environment on visual performance. This work showed that the best visual acuity (as distinct from visual comfort) is obtained when the brightness of the work is only a little greater than that of the general environment. If the environment is considerably darker than the work, as, for example, when the work alone is illuminated, visual acuity is low. It follows from this that to reduce the strain on the surgeon's eyes, the level of illumination over the operating field should diminish gradually from the centre to the periphery. A level of about 30 lumens/sq. ft. has been recommended for general illumination elsewhere in the theatre.[13] An emergency lighting system which comes into operation automatically is necessary in operating theatres to enable work to continue without a break if the mains supply fails.

A number of ways of meeting the particular problems of operating-theatre lighting have been proposed by illuminating engineers and architects. The system most used in Britain is based on the *scialytique* principle (*Fig. 46*), making use of a single, high intensity, incandescent source at the centre of a large-diameter, circular reflector. Reflected light converges from a wide angle on to the operating field below. The size of the illuminated field can be varied by adjusting the position of the bulb vertically in relation to the reflector, and the whole fitting can be pivoted about the vertical axis and moved horizontally. The fitting is usually suspended from the ceiling, and is open to the objection that it is not easy to clean the upper surface and the suspension arm. In addition, the heat generated by the incandescent bulb may become uncomfortable to the surgeon and his assistants because the fitting is usually suspended only about 4 to 5 feet above the table. Where the bulb is enclosed and unventilated the outside of the fitting becomes very hot, but special means to cool the bulb can be used. Up to 90 per cent. of the heat produced by the bulb can be absorbed by ferrous-oxide glass and by ventilating the bulb enclosure adequately. In some cases the fitting has been placed above a glass ceiling where it runs on rails, its movement being controlled electrically. There is such an installation, known as the *super-scialytique* (*Fig. 47*), in the Canton and University Hospital in Lausanne.[17] An extension of the *scialytique* principle has been used by Jean Walter[5] in the theatre at Lille, where the theatre is roofed by a reflecting dome, elliptical in section (*Fig. 45*). The fitting may be moved electrically to alter the position or intensity of light on the operating field, and it is water-cooled to prevent heat being concentrated by the reflector on to the operating team and patient. As in the *super-scialytique*, the fitting, being suspended above a sealed glass ceiling, raises no cleaning problems.

Other proposals for achieving the necessary flexibility in the angle of illumination without using a suspended fitting have been made by Jean Blin, Paul Nelson, and André Walter. Blin[18] proposes a theatre with a domed ceiling into which are built multiple fixed projectors which can be switched on in groups, according to the direction from which light is required. The illumination obtained can vary from 360 to 2,000 lumens/sq. ft. according to the number of projectors used and the voltage of the current supplied. The angle of illumination can be altered from any side, from the vertical to 30° above horizontal. For flatter angles, illumination is obtained from an additional battery of six projectors built into one wall of the theatre. The light from the projectors converges at a point in the centre of the theatre, and the operating table may need to be moved to place the patient correctly in relation to the illuminated field. Theatres incorporating Blin's proposals have been built in the emergency department of the Boucicault Hospital in Paris

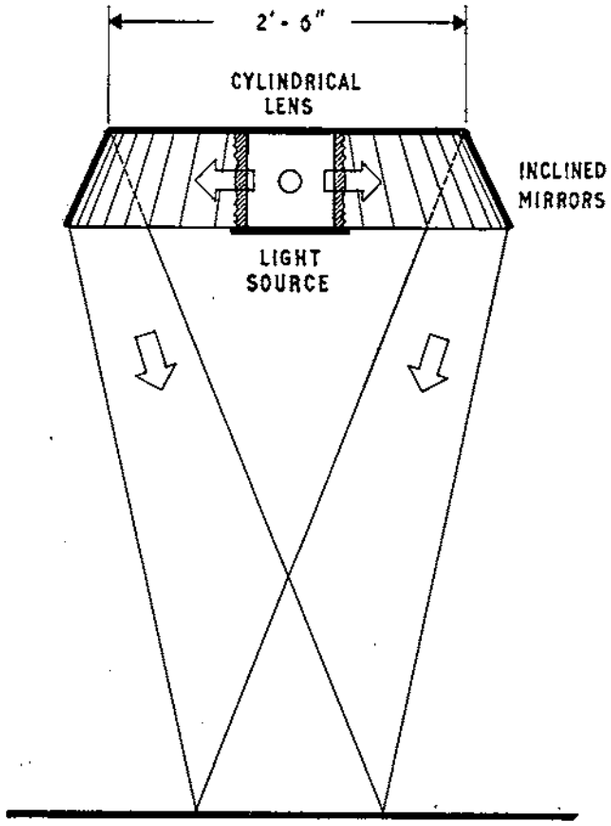


Fig. 46. The *scialytique* principle of lighting the site of operation from a single light source, shown diagrammatically

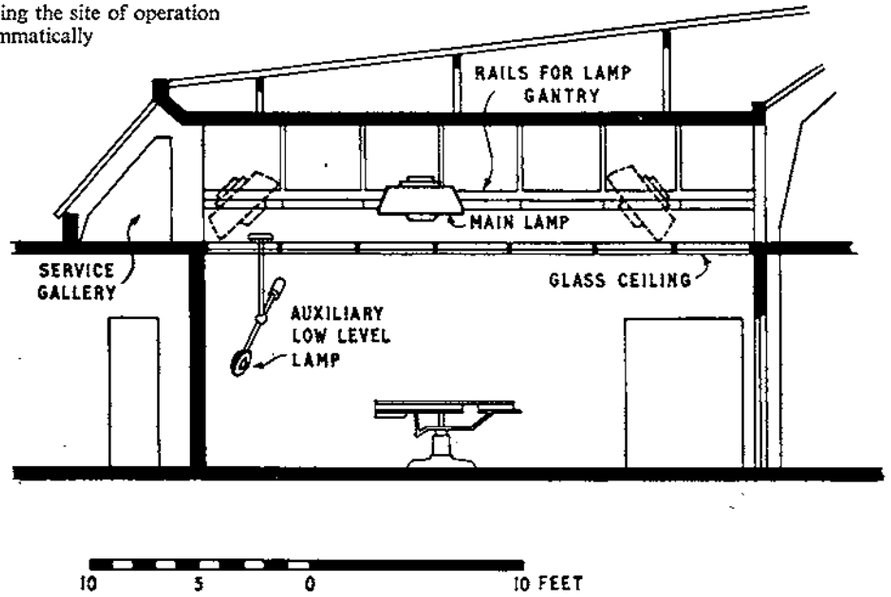


Fig. 47. The *super-scialytique* installation at the Canton and University Hospital, Lausanne; section through theatre

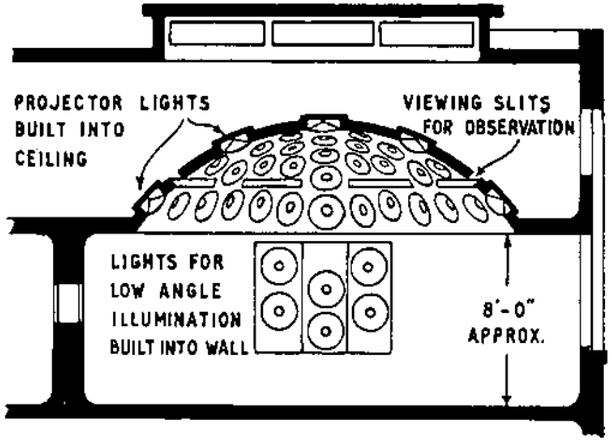


Fig. 48. Multi-projector lighting system and observation gallery at the Boucicault Hospital, Paris; section through a theatre

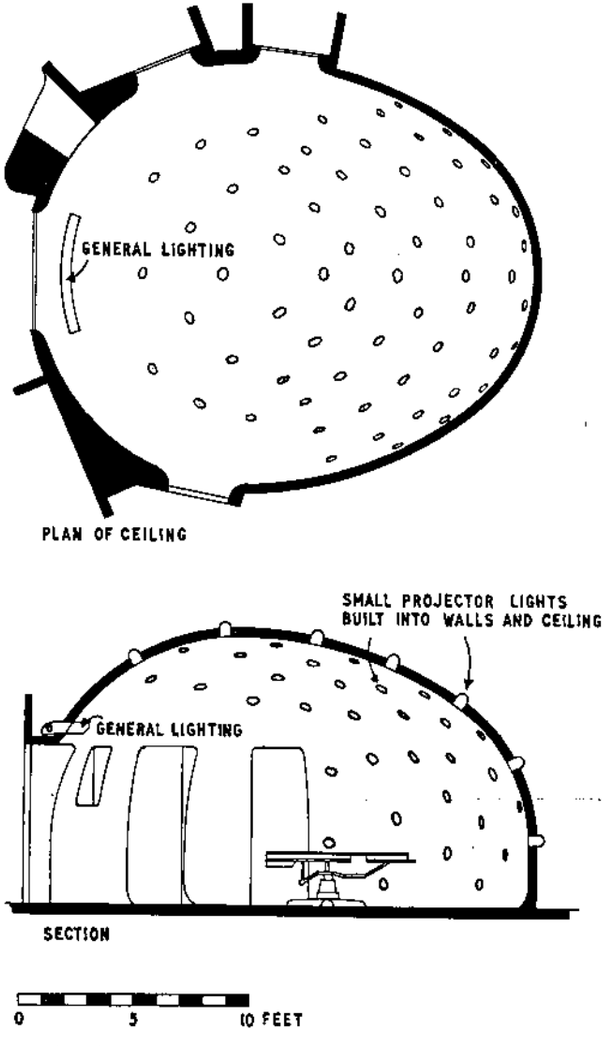


Fig. 49. Lighting system designed for the St. Lô Hospital; plan of ceiling and section through theatre

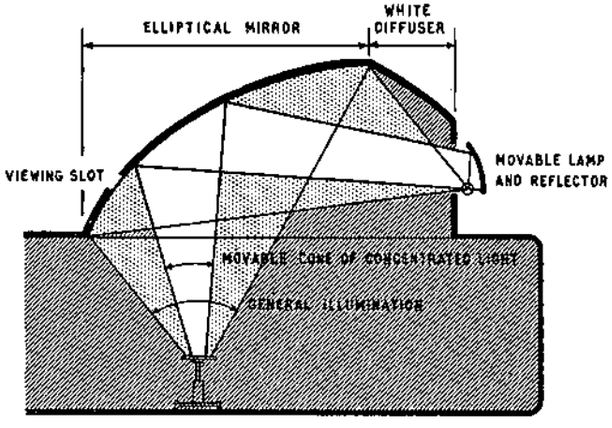


Fig. 50. Diagram of André Walter's *voute elliptique*

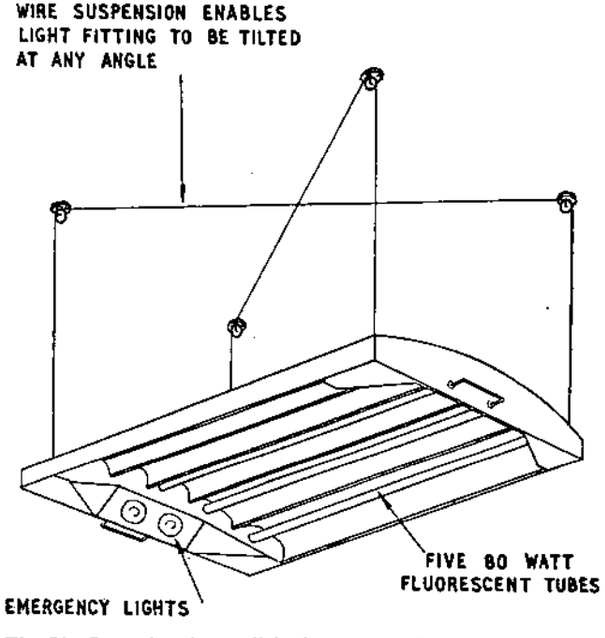


Fig. 51. Operating theatre light fitting using fluorescent tubes

opened in 1948[19] (*Fig. 48*). A similar system is to be incorporated in new theatres being built by the Birmingham Regional Hospital Board.[20] Paul Nelson[21] proposes using seventy-one small projectors embedded in the walls and ceiling of an egg-shaped theatre (*Fig. 49*). He analysed the different classical positions of the operating field and calculated the required lighting angles accordingly. Nine lamps give the illumination needed for any one position, and there is a considerable margin of choice for the illumination of non-classical operating fields. The intensity of illumination is designed to be in the region of 700–800 lumens/sq. ft. A supplementary source of light must be used if it becomes necessary to illuminate two fields simultaneously—as, for example, during a skin-graft operation. The table itself must be moved to alter the position of the illuminated field on the patient's body. Theatres designed by Paul Nelson have been built at the Medico-Surgical Institute, Schaerbuk, Brussels.

André Walter[10] proposed a theatre the ceiling of which was to be an ellipsoidal dome with a reflecting inner surface illuminated by a single movable projector (placed outside the theatre) at one focus, the operating table being at the other focus. The light reflected from the dome would thus converge to a small operating field (*Fig. 50*). Displacement of the field to either end of the table, and at varying angles to the horizontal, would be effected by moving the projector by remote control. A 1,000-watt bulb would be used and general illumination provided by reflection of scatter-rays from the projector. An advantage of this system over those using fixed projectors is that it is not necessary to move the operating table to adjust the illuminated field. The neurosurgical theatre at the Edinburgh Royal Infirmary (1938) uses Walter's lighting principle, but the level of illumination at the table has been found to be only 200 lumens/sq. ft.[22] For many cases it has proved necessary to use a headlight or a floor spotlight in addition to the projector.[23]

Fluorescent lighting has been used for lighting the operating table as well as for general illumination in the theatre (*Fig. 51*). There is such an installation at Ancoats Hospital, Manchester.[24] The principal feature of such fittings is their ability to provide very high intensity light without producing an excessive concentration of heat, and

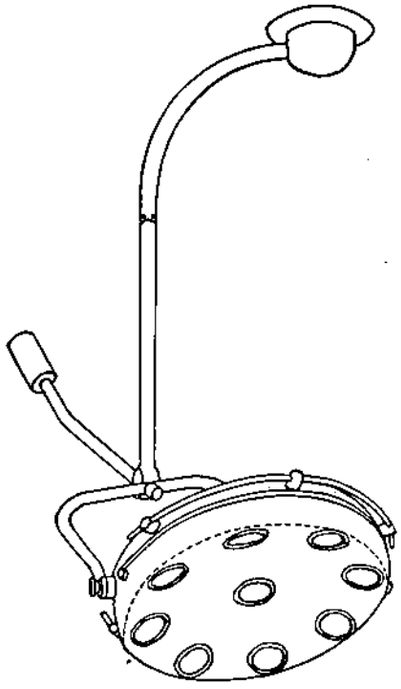


Fig. 52. Operating theatre light-fitting using several low-voltage tungsten bulbs

without shadows. The combination of five tubes produces an intensity of 300–400 lumens/sq. ft. when the fitting is mounted 3 feet above the operating table. This intensity is constant over a large area, and various coloured tubes can be combined with filament lamps to provide light which is correctly balanced for true colour observation.

A light fitting which combines some of the features of the multi-projector systems with the flexibility of the *scialytique* lamp has recently been designed. This consists of a ring of eight small projectors with a ninth at the centre of the ring housed in a circular metal shell which is suspended like a conventional *scialytique* fitting. The angle of the projectors may be adjusted to illuminate fields varying in size from about 6 inches to 18 inches in diameter, and the centre one may be switched on to illuminate the centre of the larger fields. Each projector shines through a layer of heat-absorbing glass, a layer of glass to modify the colour of tungsten bulbs, and a layer of perspex to protect the glasses. The bulbs are rated at 25 watts, and the level of illumination provided is in the region of 600 lumens/sq. ft. (*Fig. 52*).

The surgeon's general requirements for light may be summarized as follows: it should be powerful, cool, 'shadowless' (that is, capable of illuminating the operating field without casting intense shadows from the surgeon's head and hands), and capable of penetrating to the bottom of deep cavities. Some surgeons have expressed the view that all lights in the theatre should be on dimming switches. With regard to the colour of the light required, André Walter contends that since surgeons recognize structures by slight variations of shade at the red end of the spectrum, the operating cavity should be illuminated by light rich in those wavelengths. Against this it may be argued that where all is red it is difficult to distinguish shades in redness. Variations in the shades of different structures may be due to the presence of other colours in the preponderant red, and to accentuate contrasts the operating light should be rich in wavelengths at the other end of the spectrum—blue, green, and yellow. The late J. Eastman Sheehan, the plastic surgeon, wrote in 1950:[25] 'the gradual modification of the red in the spectrum by the other primary colours, yellow and blue . . . improves its quality'; that is, the quality of the light. Eastman Sheehan used a yellow filter over the operating light, and asserted that optical fatigue in long operations was thus greatly reduced. Coloured lighting of the operating zone is bound, however, to influence, by reflection, the colour of the light received by other objects in the room. The anaesthetist needs to observe small changes in the colour of the patient's skin, and so may be disturbed by light which is very different from that used elsewhere in the suite, for example, in the anaesthetic-room.

Conclusions as to the most satisfactory form of theatre lighting cannot be reached without considering the expense of the installation. Indeed, so long as views on the desirable intensity, colour, and flexibility required from a lighting installation are so divergent, the cost factor may be most important in reaching a decision. Most of the installations described above are more expensive in first cost than the conventional suspended lamp of the *scialytique* type. The extra space needed above the theatre itself for the reflecting domes, or the controls for the lamp may, however, be useful in some hospitals for accommodating observers, and there the extra expense involved may be justified.

Natural Lighting

Surgical operations, if they are to be carried out by natural light alone, require a daylight-factor* of at least 20 per cent.[13] To obtain so high a level of illumination at the operating table it is necessary in this country to have a considerable window area in the ceiling as well as the walls of the theatre, unless the ceiling of the theatre is very high.

With the growing emphasis on air hygiene (see p. 78), theatres are now usually ventilated artificially, and so windows need not be opened during operations. Double windows are necessary to avoid excessive loss of heat through large glass areas, to prevent condensation on the inner surface of the glass, and to permit accurate regulation of the temperature in the theatre. Very large windows, particularly skylights, unless they are protected from the sun by orientation or external shutters, may give rise to serious over-heating in summer. Air-conditioning plants may include refrigeration for summer use, but installation and running costs of these are high. Certain types of operation require artificial light, and some surgeons always prefer to work by it so that the installation of dark blinds is a necessity. These should be installed between two panes of glass to prevent dust collecting on them. For very large windows, particularly those in two planes, the provision of blinds is expensive and the method of control complicated.

Although operating by natural light exclusively is becoming rarer, windows in operating theatres may be provided on other grounds. Daylight has an important bactericidal effect (see p. 91) even when it has passed through glass, and for that reason it is a positive advantage to be able to admit daylight to a theatre when it is being prepared for use. Moreover, a room with windows of clear glass is more pleasant for the occupants than one which is completely enclosed. Windows, where possible of clear glass, large enough to provide general lighting and capable of being completely darkened will usually be satisfactory.

Colour

The colours used on the walls, floor, and ceiling of theatres should be light enough to ensure satisfactory integration of light by reflection (see p. 109) no less than to show up dirt. White is often criticized as being 'too glaring'; pale green, blue, and grey have been used successfully. Colours of Munsell value seven or eight, giving a reflection-factor of forty-two and fifty-six respectively (see p. 110), will normally be light enough and, in this range, colours of high chroma are available. Eastman Sheehan has described how, for twenty years, he experimented with

* For the definition of this term, see p. 93.

colour in the 'plastic and reparative' theatres at the New York Polyclinic. After many trials the following colour scheme was adopted: 'the ceiling is now tinted pale yellow, with a border of deeper tone. This deeper yellow is continued downward over the upper third of the walls. It is followed by an intermediate band of green linking it with a blue band extending to the floor. The floor is painted green.' Eastman Sheehan also had views on the colour to be adopted for the immediate surroundings of the field of operation: 'the high powered lamp directly over the table continues to be shaded with a yellow filter. There is a yellow sheet under the patient's head and the lower part of the operating table is the same colour. The upper portion of the patient is draped in green.' This colour scheme conformed to Eastman Sheehan's preference for operating by light modified by the inclusion of colours complementary to the red operating cavity.

As the eye is less sensitive to red light than to colours in the green-yellow zones of the spectrum, it is essential that the surgeon's pupils do not contract against light reflected from light-coloured towels around the operating cavity. Green towels are generally used in theatres in this country and America. H. L. Gloag, of the Building Research Station, believes that visual acuity within the field of concentration would be assisted and optical fatigue reduced if the colour field were graded from a matching colour immediately surrounding the cavity itself towards grey at the edge of the field of vision. He has suggested also that grey towels* should be tried as an alternative to green towels.

Finishes, and Anti-static Precautions

All surfaces in an operating theatre have to withstand constant cleaning. They should be as far as possible jointless. Internal corners in theatres are rounded to facilitate thorough cleaning. The value of small glazed tiles for wall surfaces in theatres is open to question since the joints, unless these are flush with, and as hard as, the tiles themselves, are difficult to keep clean. An alternative to permanent finishes, in which colour is integral with the material, is hard-gloss paint on plaster; although repainting is necessary from time to time, it is less expensive in first cost and is easily cleaned. Floor surfaces, unless flexible in themselves, should be laid in tile form rather than laid wet and allowed to set hard, so as to reduce the chances of cracks due to shrinkage or structural movement. As the theatre floors must often be sluiced down, a shallow sump and trapped gully should be provided at one side to collect and drain away the water. The trap should be designed to be easily cleaned, and should be fitted with a small gauze grill to prevent solid objects being swept down it.

With the increasing use of electrical apparatus in operating theatres, the risk of igniting anaesthetic gases is tending to rise. This risk comes in part from faulty equipment, but there is also the danger of explosion due to the sudden spark discharge of static electricity charges on equipment and persons. In this country the atmosphere is often sufficiently humid to prevent the build-up of dangerous static charges in operating theatres, but, on dry days, if mechanical ventilation plants do not embody means for humidifying the warmed air delivered to the theatre, danger is present. Equipment on non-conductive rubber wheels may be electrified in many ways, as for example, by drawing a dry towel across it. It is therefore necessary to control the electrical resistance of the floor to earth; it must be high enough to prevent shocks due to small leakages from electrical apparatus, and low enough to provide a path for the discharge of static potential to earth. The Ministry of Health's *Interim Note on Static Electrical Risks and Anti-static Precautions in Anaesthetising Locations* (Appendix B)[26] and *Recommended Safe Practice for Hospital Operating Rooms, 1949*[27] include recommendations on the construction of types of floor minimizing the chances of accident from electrical causes. The question of explosions due to static electricity involving anaesthetic equipment is under consideration by the Anaesthetics Explosion Committee set up by the Ministry of Health.

Bullough[28] has described a method of obviating the danger of igniting anaesthetic gas mixtures by preventing them from entering the atmosphere of the theatre. By his method the exhaled mixture is withdrawn to a point outside the building through a pipe built into the floor of the theatre.

Surgeons emphasize the need for quiet conditions in operating theatres, yet the necessity for easily cleaned surfaces makes it difficult to avoid 'bathroom acoustics'. A test of the performance of one type of absorbent finish for ceilings in connexion with aerial bacteria was made for the Investigation by the Public Health Laboratories at Colindale (see p. 119). The results suggested that the effect of such ceiling finishes on the bacteria-count in a room may not be very great. Absorbent ceilings in operating theatres are used in America, and there is little doubt that they help considerably in making acoustic conditions pleasanter. Theatres with domed ceilings (see p. 64) and those which are circular or oval in plan present special acoustic problems.

Anaesthetic Gas Supply

An early form of piped anaesthetic gas supply was installed in 1876 at the London Hospital: it consisted of a large water-bath screwed to the wall, the water being kept at a temperature of 100° F., 'so as to secure the boiling of the ether', and fixed to it with a clamp, the ether-bottle of Hawkesley's inhaler. A length of tubing carried over the heads of the assistants and sufficient to extend over the whole area of the theatre, joined the vaporizer to the facepiece. 'By having this arrangement . . . the apparatus is always at hand and not in the way.'[29] In recent years many hospitals have installed a central supply point, conveniently placed for the delivery of cylinders, from which anaesthetic gases—usually oxygen and nitrous oxide—are piped to various rooms in the theatre suite. The equipment is provided with automatic devices which ensure against any possibility of a failure in supply in the theatre suite. When vacuum also is centrally produced and made available in the theatre and other rooms, the plant is usually housed with the gas cylinders. In some theatres gases and vacuum are delivered at a pillar built up from the floor near the head of the operating-table; in others they are supplied through flexible pipes hanging from the ceiling or from the end of an arm hinged out from one wall of the theatre, and connected directly to the anaesthetic machine for mixing and regulation. The chief advantage of a piped installation is that no handling of gas cylinders is needed in the theatre itself. Gas can be supplied in large cylinders for use in the central supply room more cheaply than in smaller ones for use in the theatre suite. Anaesthetists are divided in their opinions of piped installations, though where such installations are in use general satisfaction has usually been expressed to the Investigation. Nevertheless, with a piped installation there is, of necessity, a gap in the induction of anaesthesia while the patient is moved from the anaesthetic-room to the theatre. Some anaesthetists regard this as an important disadvantage.

The team was impressed by the flexibility in use of the

* A suitable colour would be, for example, Munsell 5·0 R 4/2 or 5·0 Y 4/2.

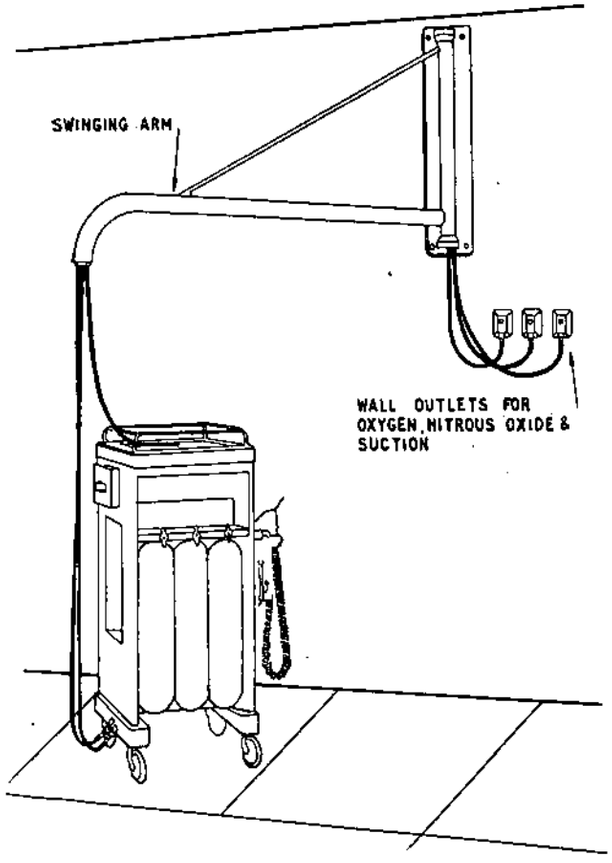


Fig. 53.
Piped anaesthetic gas supply arm at St. Stephen's Hospital, Chelsea

installation at St. Stephen's Hospital in the Chelsea Group (*Fig. 53*), and also of that at Rooksdown House Hospital, Basingstoke. In both theatres the gas supply arm is long enough to reach to either end of the operating table, and the rubber tubing enables the anaesthetic machine to be placed on either side without encumbering the floor of the theatre. Dr. R. M. Davies, Consultant Anaesthetist, Queen Victoria Hospital, East Grinstead, is of the opinion that the gas supply arm should always be on the left of the patient. In his experience, the most usual position for the anaesthetic apparatus is at the head or to the left of the head of the patient, less often towards the feet and to the left of the patient, and rarely towards the feet and to the right of the patient. Installations having a fixed pillar at one end of the operating table do not permit much choice in the placing of the anaesthetic machine. Unless the machine can be used within a fairly small area at the head of the table, rubber tubing connecting it to the pillar may obstruct the floor.

As with all services in hospitals, it is essential that the gas supply pipes are accessible throughout their length for inspection and maintenance. The economics of piped gas supply were not studied closely by the Investigation, but the manufacturers maintain that the extra cost of the installation is paid for in a short time by the reduced rates charged for the larger cylinders. A *before* and *after* study under properly controlled conditions would enable piped gas installations to be considered in terms of installation and maintenance costs.

Equipment

To simplify the task of maintaining aseptic conditions, as little equipment as possible should be kept in the theatre, and what is absolutely necessary should either be built in to save space and to reduce cleaning problems, or should be very easily mobile. The advantage of an easily movable operating table in the general arrangement of equipment for different operations is discussed on pp. 61–62. If two such tables are provided a patient may be brought into the theatre from the anaesthetic-room, and afterwards be taken to the exit-room without transferring him to a trolley and without causing delay in the preparation of the next case on the list (*Fig. 54*).

All mobile equipment in the theatre suite should be fitted with anti-static rubber wheels. Various British Standards include details of anti-static rubber-tyred castors and buffers, of electrical conductivity tests, and of the required resistance of floor-covering materials.[30] The use of trailing chains for dissipating static charges to earth has not been found reliable. The Ministry of Health publication, *Interim Note on Static Electrical Risks and Anti-static Precautions in Anaesthetising Locations*,[26] gives general advice on precautions against anaesthetic explosions due to static electricity, and on the use of anti-static rubber for hospital equipment generally.

All electrical outlets in the theatre suite should be 'sparkless fittings' and be placed at a height of at least 5 feet from the floor, to be above the level of a possible concentration of inflammable mixtures. An earth-proving circuit is recommended by the Ministry of Health for checking earth continuity on electrical equipment immediately before use.[31] This enables the check to be made very easily and gives an immediate visual indication of the state of the earth circuit on the equipment to be used.

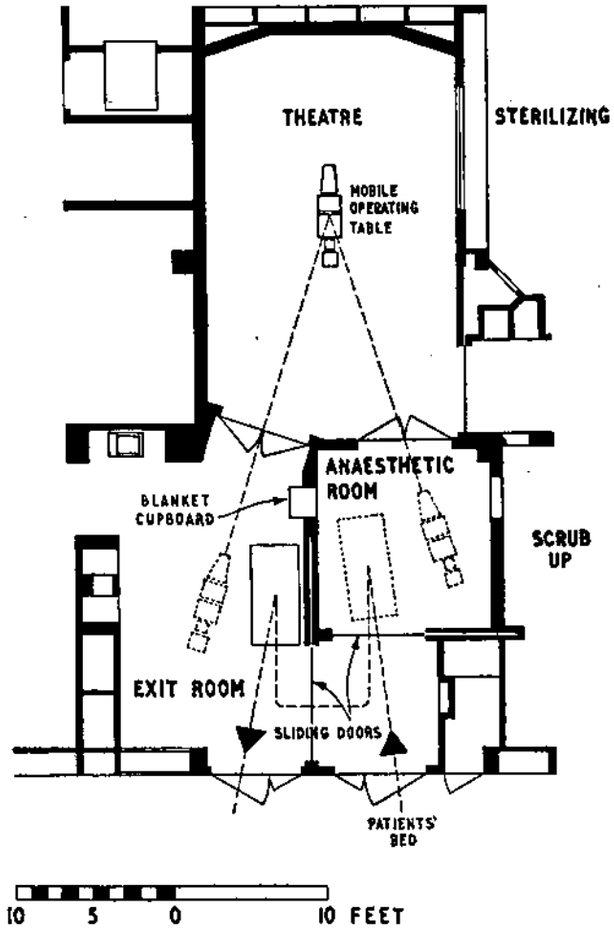


Fig. 54. Plan of operating theatre suite at the Canton and University Hospital, Lausanne, showing movements of the mobile operating table

Electric clocks and X-ray viewing-screens are preferably built into the walls of operating theatres. An elapsed-time clock for timing procedures is sometimes provided in addition to an ordinary clock with a sweep seconds hand. In some theatres a portable timer with an audible alarm, but no clock face, is used for measuring periods up to one hour.

Surgeons and anaesthetists usually prefer visual rather than audible signalling for telephones, staff-location systems, and fire-alarms in the operating theatre and its ancillary rooms.

Doors into the operating theatre should have vision panels in them, with shutters to enable the theatre to be

darkened when necessary; they should also have check-hinges which will hold them open while trolleys are pushed through.

4. Anaesthetic-room

General Planning Considerations

The induction of anaesthesia in a room adjoining the theatre was practised at the Massachusetts General Hospital in Boston in 1873 (where in 1846 ether anaesthesia had been publicly demonstrated for the first time). 'The patients are etherised in small ante-rooms adjoining the operating theatre . . . [and] when anaesthesia is complete, the patient is picked up and carried in the arms of a stout attendant into the theatre. . . .'[32] The Surgical Registrar at St. Thomas's Hospital, London, wrote in 1876: 'Chloroform should always be administered, as it is at this hospital, in a small room adjoining the theatre, previously to the patient being brought in for operation, as he does not then become excited, and is more quickly brought under the influence. Great objection should be made to the administration of chloroform in the wards.'[33] It is not known how long this had been the custom at either place, but it is evident that at St. Thomas's the use of a room for anaesthesia, separate from the theatre, was recognized as being of benefit to the patient as well as the anaesthetist.

The advantages to the anaesthetist of a separate room for induction are that he can have close at hand all the apparatus and instruments he needs, and he and his patient are away from the bustle in the theatre while preparation for an operation is in progress. He can, if necessary, darken the anaesthetic-room to obtain better conditions for induction without interfering with work elsewhere in the theatre suite. The provision of an anaesthetic-room also enables induction of a patient to be started during the completion of the previous case.

The Ministry of Health's Departmental Committee on the Cost of Hospitals (1937)[3] recommended that each theatre in a suite should have its own anaesthetic-room, 'that there should be direct access from the anaesthetising room to the theatre', and that 'exit from the theatre should not be through the anaesthetising room'. In the planning recommendations published by the United States Public Health Service, anaesthetic-rooms are not shown, though anaesthetic-stores, equipped with a sink, and adjacent to but not communicating with the theatre, are shown in most plans, one being provided for every two operating-rooms.

Size of Anaesthetic-rooms

The Ministry of Health's Departmental Committee (1937) recommended a floor area of 140 sq. ft. for anaesthetic-rooms, and in the theatre suites visited by the Investigation anaesthetic-rooms usually approximated to this area.

A small study of the working of the anaesthetic-room at a 300-bedded general hospital was made by the Investigation. Thirty-five operations distributed over four consecutive days were observed, the lists comprising ear, nose, and throat cases, general surgical cases, and orthopaedic cases. Of the thirty-five operations, five were done under inhalation anaesthesia, twenty-one under intravenous and inhalation anaesthesia, one under intravenous anaesthesia alone, and six under local analgesia. Local anaesthetics were usually given in the operating theatre. The anaesthetic-room (*Fig. 55*) measured 21 feet by 14 feet. One corner measuring 10 feet by 7 feet, opposite the door, was curtained off to form a lay-by. This left a working-space of 14 feet by 14 feet where patients were anaesthetized. *Fig. 56* shows the arrangement of equipment and persons for induction of general anaesthesia. An 8-foot square superimposed on the layout shows that all the mobile equipment and persons concerned with each case were contained within its boundary. Outside this square was the fixed equipment, the work-bench, wash-basin, and storage cupboards, &c. An area of 140 sq. ft. gives a square with a side of a little under 12 feet, thus allowing

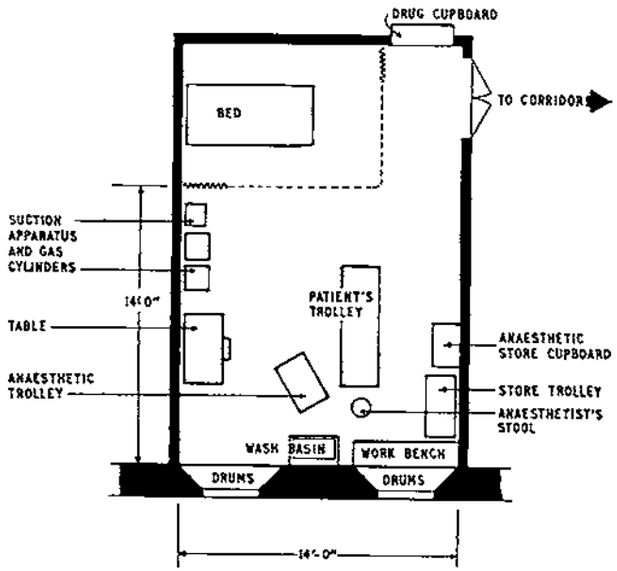


Fig. 55. Anaesthetic-room and recovery lay-by at the Royal Hampshire County Hospital

2 feet on all sides of the 8-foot square mentioned above. As part at least of this 2-foot strip will be occupied by fixed equipment, and as space must be left for a door to open and shut, it seems that an area of 140 sq. feet may be too small. In the twin theatre suite designed by the Investigation for Musgrave Park Hospital, Belfast, the anaesthetic-rooms (see pp. 86–87) will each have an area of 150 sq. ft., the fixed equipment being disposed so that those using it need not disturb work round the patient.

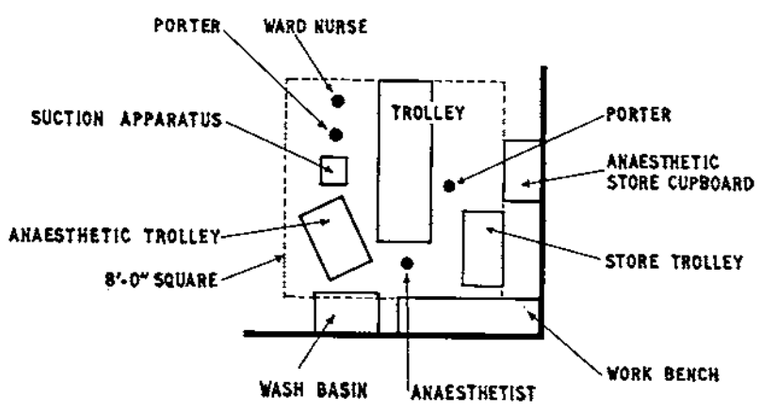


Fig. 56. Arrangement of equipment and positions of persons in the anaesthetic-room shown in *Fig. 55* during the induction of general anaesthesia

Lighting and Equipment

Artificial lighting in an anaesthetic-room should provide a high level of general illumination. The Illuminating Engineering Society's Code gives a figure of 30 lumens/sq. ft. as suitable for 'fairly small' work of 'moderate' contrast. In addition to the general lighting, an adjustable, high-powered light is necessary during intravenous work and for close inspection generally. When the room is darkened during induction, a light over the work-bench, sink, and sterilizer, shaded so as not to be visible to the patient and giving about 10 lumens/sq. ft. at working-height will be sufficient for work at these points. The general lighting should be so designed that the patient lying on his back is not subjected to glare from the light sources. The colour of artificial light used in the anaesthetic-room should be such that small changes in the colour of the patient's skin are readily observable. It should also be similar to that used in the theatre and in the recovery-room.

Natural lighting in the anaesthetic-room should give a daylight factor of 4 per cent. for general lighting, which may be supplemented by the local artificial light sources. Natural lighting from a skylight, although good from the viewpoint of the anaesthetist, is not pleasant for the patient, since, lying on his back, he looks directly up at it. Window blinds should be provided.

In general the requirements for floor, wall finishes, and doors, anti-static and electrical safety precautions, piped anaesthetic gases, telephones, and signalling are the same as for the theatre. Working surfaces in the anaesthetic-room should be at a height suitable for people standing (see p. 26).

Some anaesthetists like to have a sterilizer in the anaesthetic-room, so that they can make all their preparations without disturbing work in the theatre sterilizing-room.

In a number of anaesthetic-rooms visited by the Investigation, a heated blanket-cupboard was provided on one wall where blankets from the patient's bed were kept warm against his return from the theatre. If the anaesthetic-room is placed alongside an exit-room (*Fig. 54*), this cupboard can with advantage open into both rooms.

Nothing should be kept in the anaesthetic-room except the equipment and drugs necessary for anaesthesia; this reduces the chances of the patient being unnecessarily disturbed while semi-conscious, thus hindering smooth induction.

As patients may be brought into the anaesthetic-room while they are conscious, their possible reactions to the room should be considered in designing it. The possibilities of using colour to create an 'atmosphere' are discussed on p. 113. Colour in the anaesthetic-room should create a restful atmosphere. High chroma colours (see p. 110) should not be used where they will affect, by reflection of light, the apparent colour of the patient's skin.

5. Sink- and Sterilizing-rooms

General Planning Considerations

To permit the highest standard of technique at the operating table, the layout, equipment, and organization in the sterilizing-room and sink-room must also be of the highest order possible. There is general agreement among hospital planners about the position which these rooms should take in relation to the theatre and to each other, though there is considerable variation in the details of equipment, and of arrangements of access between the rooms.

In the proposals outlined in the Ministry of Health's Departmental Committee in 1937 it was recommended that two theatres should share an instrument-cleaning-room and sink-room and a sterilizing-room. Both rooms should open directly off the theatre through open doorways (*Fig. 36*), and this pattern is common in Britain.

In the plans for theatre suites proposed by Jean Walter (*Fig. 37*) and by Gosset and his associates (see p. 57) double-ended autoclaves are built into the wall between the sink-room and sterilizing-room to make possible an 'ideal flow' of instruments: autoclave—sterilizing and lay-up room—theatre—sink-room and back to autoclave without involving cross-circulation from 'dirty' to 'clean' rooms or vice versa.

In ordinary practice a rigid routine is difficult to maintain and a layout like that proposed by Walter dictates a way of working and gives little scope for varying procedure. In particular, the absence of doorways between the theatre and the sink/sterilizing-rooms suggests that the techniques practised in this theatre suite would have to be different from those usual either in Britain or abroad. At the other extreme, theatre suites included in the United States Public Health Service recommendations are so simple that virtually no planning discipline is imposed. In these plans provision is made for local, combined sterilizing- and sink-rooms, as well as for a central sterile supply department—the functions of which are discussed on pp. 75–77. The sub-sterilizing-room is used both for washing dirty instruments and for sterilization; all laying-up of trolleys is done in the theatre itself. In Britain the division of a sink-room/sterilizing area into two rooms with separate doorways into the theatre preserves a distinction between 'dirty' and 'sterile' procedures, yet provides also for flexibility. Imperfect techniques in the sink-room and the sterilizing-room may be due to the way in which those rooms have been planned, but the risks which patients run on that account cannot be assessed with any degree of accuracy; therefore the relative advantages of variations in planning remain to a great extent a matter for informed personal judgement.

In many modern theatre suites the sink- and sterilizing-rooms are between a pair of theatres with access from a lobby which also gives access to other rooms in the suite. The sink-room is sometimes on an outer wall and provided with a hatch to the outside, or a hoist, for the disposal of soiled articles. The two rooms are usually connected with the theatres by open doorways, and this facilitates movement generally and avoids possible contamination through touching doors.

In some of the theatre suites visited by the Investigation, autoclaves were in routine use for sterilizing all instruments and ware. These were often placed in the partition between the sink-room and the sterilizing-room —the theoretically correct position since the process of sterilization is intermediate between the 'dirty' and the 'sterile' states. *Fig. 57* shows diagrammatically two such arrangements. In the plan shown in *Fig. 57 A* autoclaves with doors at one end only were built into the partition between the sink- and sterilizing-rooms, and the sole direct means of communication between the two rooms was through a large hatch in this partition. In the plan shown in *Fig. 57 B* autoclaves with doors at either end were similarly built in the partition between the rooms, but the rooms communicated through an open doorway. In both suites the autoclaves were controlled from the sterilizing-room side and instrument-storage cupboards were in the sterilizing-room. Where a hatch was provided (*Fig. 57 A*) the observers noticed that as there was often no member of the staff in the sterilizing-room to receive trays of washed instruments from the

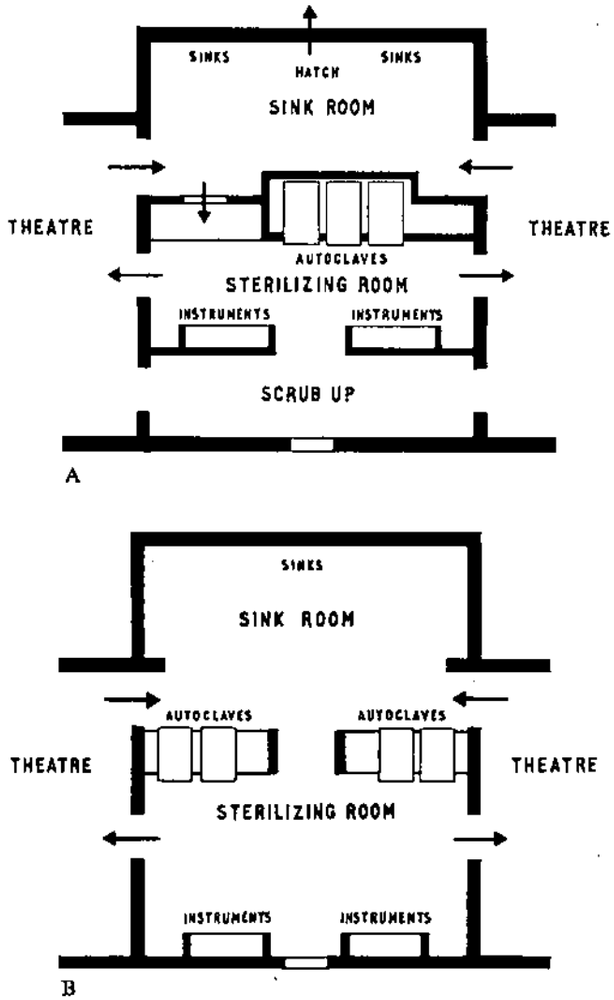


Fig. 57. Autoclaves built into the partition between the sink- and sterilizing-rooms

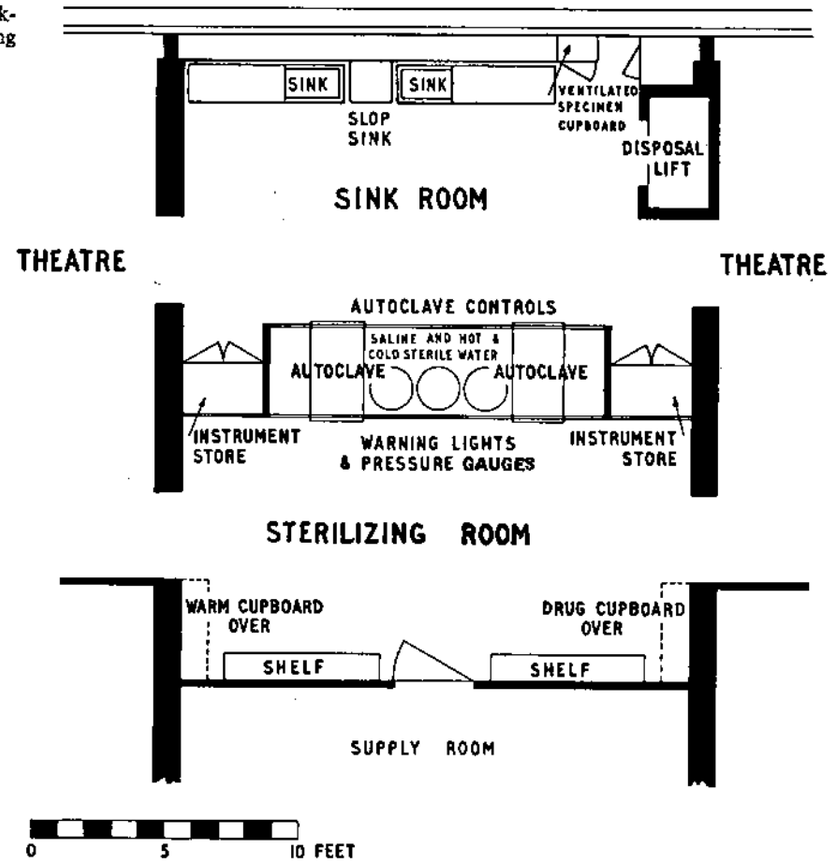


Fig. 58. The Investigation's plan for a sink-room and sterilizing-room in a twin operating theatre suite

sink-room, it was more convenient to bring the trays on a trolley through an unoccupied theatre than to wait for someone to receive them through the hatch. In the other arrangement, there was a doorway between the rooms (*Fig. 57 B*) and the autoclaves could be opened at both ends, but they were often loaded from the sterilizing-room because the controls were on the sterilizing-room side. It seemed to the observers that a better arrangement would have been to place the controls, as well as cup-boards for storing instruments, in the sink-room (*Fig. 58*). Then the autoclaves could have been loaded and the sterilizing process controlled without visiting the sterilizing-room before it was time to unload the autoclaves and lay-up trolleys.

A twin theatre suite to the Investigation's design is being constructed in Northern Ireland and the sink- and sterilizing-rooms are described on p. 87. A study of work in the suite will be made.

Detailed Planning

Work in the sink-room can be divided into two stages: the first is concerned with the cleaning and disposal of equipment immediately after an operation; the second is concerned with organization for using the cleaned equipment again. The various facilities needed during these two stages should be arranged in the room in such a way that people do not obstruct one another as they work. This may best be done by placing sinks, draining-boards, and disposal arrangements down one long wall, and instrument-stores and sterilizers, with their controls, on the other (*Fig. 58*). There must be sufficient space between these two banks of equipment to park trolleys while they are stripped, and for people to be at work on both sides of the room, and to pass freely through it.

In the sterilizing-room, work falls into two categories: unpacking and laying-up material brought from outside the theatre suite, and laying-up trolleys with sterilized equipment taken from the theatre sterilizers. These procedures may be done either in sequence or simultaneously. In the sterilizing-room the arrangement of the equipment along the walls and the allowance of working space (with room for trolleys to be parked in the middle) may follow the pattern in the sink-room.

ACTIVITY		STERILISING ROOM	THEATRE	SINK ROOM
LAY UP TROLLEYS FOR FIRST AND SECOND OPERATIONS		▮▮▮▮▮▮		▯
TROLLEYS TAKEN TO THEATRE	FIRST PATIENT IN	▮▮▮	▮▮▮	▯
	OPERATION 1 COMMENCES	▮▮▮	▮▮▮	▯
TROLLEYS TAKEN TO SINK ROOM, CLEARED AND CARBOLISED	FIRST PATIENT OUT	▮▮▮		▮▮▮▯
CLEAN THEATRE		▮▮▮▯▯▯		▮
TROLLEYS TAKEN TO THEATRE	SECOND PATIENT IN	▯▯▯	▮▮▮	▯
LAY UP TROLLEYS FOR THIRD OPERATION	OPERATION 2 COMMENCES	▮▮▮	▮▮▮	▯
TROLLEYS TAKEN TO SINK ROOM, CLEARED AND CARBOLISED	SECOND PATIENT OUT	▮▮▮		▮▮▮▯
CLEAN THEATRE		▮▮▮▯▯▯		▮

KEY. ▯ UNLOADED TROLLEY ▮ LOADED TROLLEY

Fig. 59. The placing of loaded and unloaded trolleys during the first two cases of a general surgical list observed by the Investigation

In the course of observing in the sink- and sterilizing-rooms of a twin theatre suite in a 220-bedded general hospital the team recorded that while a general surgical list was in progress in one of the theatres, seven trolleys were used. Six of these were prepared in the sterilizing-room before the list started, and between cases there were in the room three completed trolleys and three ready for lay-up. The theatre sister told the team that the space in the sterilizing-room was adequate for dealing with equipment from one theatre at a time, but was too small for the number of trolleys needed when both theatres were in use. The sterilizing-room was used also by the surgeons scrubbing-up and gowning. *Fig. 59* shows the placing of the trolleys in the theatre suite during the first two cases on the general surgical list observed.

In the sterilizing-room sufficient space should be available to park 'sterile' trolleys where they will not accidentally be touched. The advantages and disadvantages of providing fixed, free-standing drum-stands near the middle of the room, such as were seen by the Investigation in some of the theatre suites visited, must be very carefully considered, because any immobile object in either sink- or sterilizing-rooms may cause congestion at busy times. To provide enough space for people working at sinks, &c., for parking trolleys, and for circulation, a distance of about 9 feet clear should be allowed between banks of equipment on opposite walls. This estimate is approximate only, and would be modified by the actual size of the trolleys to be used and the pressure of work in the theatre suite. A series of short cases for which trolleys for several operations can be laid-up in advance may require more space in ancillary rooms than will a series of longer operations.

Equipment of the Sink-room

Where twin theatres are in use together, an operation in each may finish at the same time, and where one sink-room serves both, it must be big enough to supply the needs of both simultaneously. A large enough drainage-slab should be provided alongside each of two sinks to ensure that instruments from one theatre do not get mixed with those from the other, and to enable instruments to be kept separate from other equipment to facilitate checking. One slop-hopper can serve two theatres and may be placed between the sink units. Hot and cold taps for each sink should have lever heads for elbow operation, and a special tap with a small-bore nozzle for washing through rubber tubing is useful. Adjacent to or over the sinks should be racks for draining rubber tubing, and a ventilated cupboard for specimens to be sent to the pathology department. On the same side of the room as the sinks there should be space for linen-rounders, some for used and some for unused towels and dressings.

In many of the theatre suites visited by the Investigation, special provision had been made for the disposal of soiled linen and theatre refuse directly to the outside through hatches near the sinks. This was generally thought to be a satisfactory arrangement by the staff at these hospitals. Where theatres are on an upper floor, chutes, hoists, or outside galleries are necessary. Owing to the difficulty of cleaning long chutes, the team considered that they would only be satisfactory for theatres situated one, or at most two, floors above the receiving level. Hoists were in use in some suites, and where care had been taken to see that they discharged at a suitable place at ground-level they were satisfactory. Precautions should be taken against noise caused by opening and closing gates and loading the hoists. Access to the hoist in the sink-room should be in a line with the sinks. A cupboard for theatre-cleaning equipment should be provided in the sink-room. On the side of the sink-room opposite the sinks there should be the sterilizers and their controls, with instrument-cupboards at each side.

Instrument-cupboards should have tightly closing glass doors and easily cleaned, adjustable, glass shelves. To make the removal of selected instruments easier, these cupboards should be as shallow as is practicable for the purpose.

If the clock in the theatre is not easily visible from the sink-room, a separate clock should be provided there.

Methods of Sterilization

During the last decade of the nineteenth century Hugo Davidsohn 'justified the use of boiling water as a germicide because it was readily available', and since then its use for sterilizing has been almost universal.[34] Although most bacteria are killed by boiling for less than an hour, it is now known that very long periods of boiling in water are necessary to kill certain sporing bacteria,[35] including those of tetanus and gas-gangrene. The risk that sporing bacteria are present on instruments cannot often be discounted, and as it is impracticable to insist that all instruments requiring resterilization during a list should be boiled for one hour, steam autoclaves which sterilize effectively in a shorter time have come into more general use in operating theatres. Saturated steam destroys, upon a relatively short exposure, spores which would remain unaffected by boiling water in a similar length of time. The period required varies, according to the temperature of the steam, from a few minutes at a temperature of 140° C., to over an hour at temperatures below 115° C.

It is possible to sterilize small instruments, sutures, plastic tubes, &c., which might be damaged by immersion

Sterile water is often piped from large, combined water sterilizers and sterile-water containers to taps in the theatre or the sterilizing-room.

It is possible that further development of sterilizing techniques using ultra-violet light may affect the methods now generally used. Ultra-violet sterilization is regularly used to a limited extent by some manufacturing chemists, but no large-scale installations were seen by the Investigation. Installations in hospital departments are at present experimental.

Equipment of the Sterilizing-room

The Investigation's plan for a theatre suite (*Fig. 58*) does not follow the traditional concept of a sterilizing-room as a place in which the sterilizing equipment is provided. Instead, the sterilizing-room is designed primarily as a place for laying-up trolleys. The controls of the autoclaves are in the sink-room and only the doors of the autoclaves, essential pressure and temperature gauges and warning lights (duplicates of those on the sink-room side) are in the sterilizing-room itself. The arrangement of the room allows sterile supplies to be taken from theatre autoclaves on one side of the central trolley-parking space and supplies brought from outside the suite to be taken from the other. As in the anaesthetic-room, working-surfaces in both sink- and sterilizing-rooms, and doors to autoclaves, are arranged at a height convenient for a nurse standing to use them (cf. p. 26).

In both the sink-room and the sterilizing-room artificial light should give a level of about 30 lumens/sq. ft. over the whole working area.

Care should be taken in placing the light sources so that persons using equipment placed round the perimeter of the room do not work in their own shadow. Fluorescent-tube lighting has the advantage that the long light sources may be arranged to given even illumination, but if tungsten lamps are used in the theatre, fluorescent lighting may confuse the colour perception of people moving between the rooms.

As in theatres, floor and wall finishes should be selected for ease of cleaning and a crack-free surface. Drainage sumps in the floor of each room should be provided so that the rooms can be sluiced down and the water swept away quickly.

Various opinions were expressed to the Investigation as to the advisability of providing large glass inspection panels between the sink- and sterilizing-rooms, and between them and the theatre. While such panels are useful between rooms which do not otherwise communicate, the view through open doorways should be adequate for general supervision.

In a modern twin theatre suite, doorways are usually provided from each theatre into the ancillaries, and these rooms are in effect the link between the two theatres.

In one of the theatre suites visited by the Investigation where there were no doors between theatres and the ancillary rooms—a suite in which the theatres were frequently used simultaneously—some of the surgeons objected to this arrangement on the grounds of noise. But this was not a general objection.

The colour scheme in the ancillary rooms should follow that in the theatre itself. The use of sheets of black plastic as a surround to autoclaves is not desirable, as it introduces an abrupt contrast in what should be an unobtrusive colour-scheme.

6. Scrub-up Room

General Considerations

The usual practice for surgeons and others needing to scrub-up is to change in a changing-room into theatre cap and clothes, waterproof aprons and footwear, and, after putting on masks, to proceed to the scrub-up area. After scrubbing-up, they put on sterilized gowns and gloves. The scrub-up area should therefore be as close as possible to the theatre and communicate with it through an open doorway. In some of the theatres visited by the Investigation the scrub-up area was part of the sterilizing-

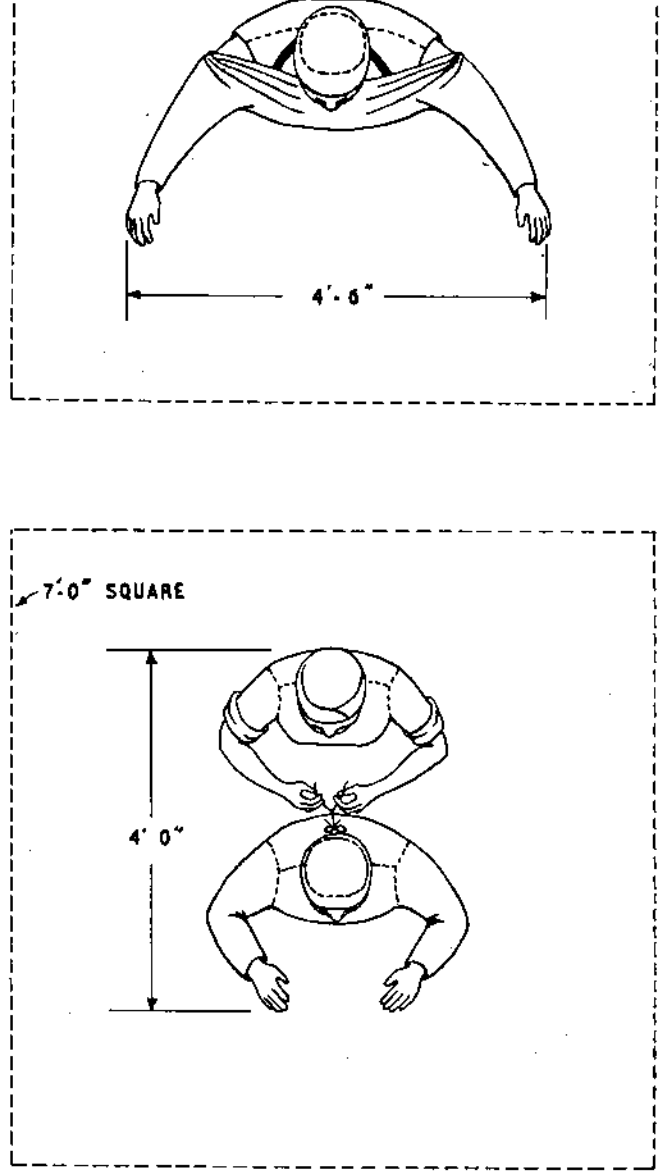


Fig. 60. Space needed for gowning: two positions seen in plan view

room—an unsuitable arrangement because the number of people using the sterilizing-room should be kept to a minimum. In one instance the scrub-up sinks were in lobbies too narrow for surgeons gowning; they gowned in the theatre, where were kept the drums containing sterile gowns and gloves.

In American plans, proposed by the United States Public Health Services[6] and by Isadore Rosenfield, the scrub-up sinks are in a recess between theatres, and are open to the theatre corridor. Surgeons scrub-up at the sinks and then walk into the theatre through doors held open for them by a nurse or a porter. There they are helped into their sterile gowns. This practice is workable because of the longer interval between cases general in America (cf. p. 59).

The Investigation came to the conclusion that, to meet normal requirements, space should be provided for two people to scrub-up while a third is gowning and a fourth is putting on gloves. The room should be planned so that gowning can be done without danger of contamination by splashing from the scrub-up troughs. There should be space for a drum-stand, with pedal-operated levers for lifting lids. It is difficult to lay down precise dimensions, but for one person at a time to gown without fear of touching walls or equipment, and for the accommodation of the drum stand, a space of about 7 feet square should be allowed (*Fig. 60*). The taps at the scrubbing-up position should be about 2 ft. 6 in. apart, to give each person adequate elbow-room. Space should be sufficient to allow people to pass behind those scrubbing-up, without crowding them. The scrub-up room should not be used for the storage of equipment.

Equipment, Lighting, Finishes, &c.

Three types of scrubbing-up equipment are in general use in this country: individual wash-basins or sinks, long sinks for two or three persons, and terrazzo stalls for two or three persons, with glass anti-splash aprons and floor trough (*Fig. 61*). Of these, the long sink is the least expensive, but as is also the case with individual wash-basins, there is some danger that water may be splashed on to the clothes of the person using them. The third arrangement avoids this, for all water drops down to floor-level where it is collected in a trough, and the inclined glass apron has sufficient projection and height to protect the clothes from chance splashing as the hands and arms are scrubbed. A stainless steel, open-mesh rack,

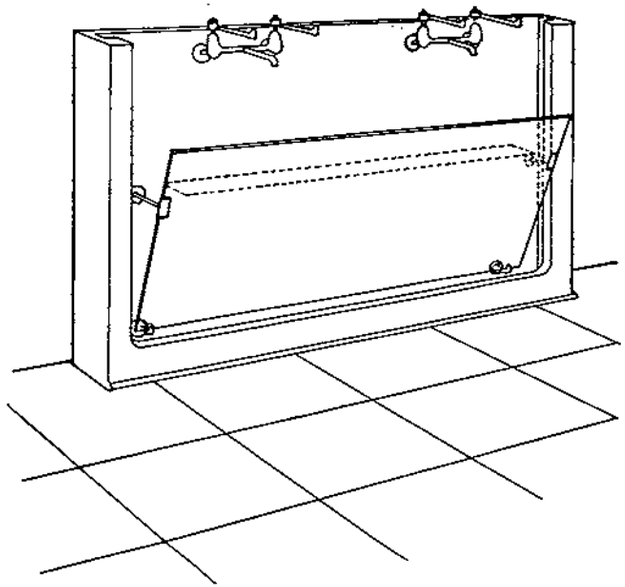


Fig. 61. Scrubbing-up stalls with anti-splash glass apron

fixed 2 ft. 6 in. above the trough, is useful to catch dropped soap or brushes. Those using this system expressed satisfaction with it, and the Investigation was impressed with its advantages.

Taps should be at a height of 4 ft. 4 in. above floor-level. The Investigation understands that elbow-operated taps need less maintenance than those which are knee- or foot-operated. Soap trays from which the user picks out the soap without touching the tray were in use at one hospital.*

Artificial lighting of the scrub-up room should be at a level of 20–30 lumens/sq. ft.,[13] and the sources should be placed so that those scrubbing-up do not do so in their own shadow.

Finishes and colour should be similar to those in the theatre, sink-, and sterilizing-rooms.

7. Recovery-rooms

General Considerations

The advantages of a special ward for nursing patients immediately following surgery, where they can be watched until the anaesthetist is satisfied with their condition, have been noted by a number of writers. As summarized by Schafer and Galbraith[36] they are: (1) the mortality and morbidity of surgical patients are decreased because complications during the critical post-anaesthetic period can be prevented, or instantly treated, by nurses present at all times with all the necessary equipment at hand; (2) the amount of special equipment needed is less when patients requiring the same kind of care are accommodated in one area; (3) post-operative accidents during transit from the operating theatre to a ward some distance away are avoided; (4) better care is available to the patients, since the recovery-room staff can give them their undivided attention; (5) other patients in the ordinary surgical wards are spared the interruption to ward routine, and the sometimes disagreeable or frightening sounds made by patients during the immediate post-anaesthetic period.

At the Queen Victoria Hospital, East Grinstead, which is a regional centre for plastic repair operations, including maxillo-facial surgery-cases particularly liable to be difficult during the post-operative period—a recovery suite of ten single rooms is provided through which pass 95 per cent. of all patients operated on. Since the recovery unit is not large enough to retain all patients for 24 hours, a survey is made half-way through operating sessions by the anaesthetist and recovery-unit sister to decide which patients are sufficiently well to be returned to the surgical wards. Dr. Russell M. Davies, who is Consulting Anaesthetist to the Plastic Surgery Centre at this hospital, has charge of the unit, and states that it enables the physiological complications following anaesthesia to be far more easily controlled, because care and supervision are uninterrupted and specialized. Deaths due to mechanical obstruction of the air-way have been wholly avoided. Dr. Davies considers that ideally the recovery ward should provide for the greatest estimated number of patients to be operated on under general anaesthesia in one day; failing that, the number of beds should equal the average number of patients operated on daily.[37] Other anaesthetists, while agreeing with Davies's ideal figure, consider that the provision of even one recovery bed for each theatre would be extremely valuable.

In this country, where recovery wards are provided, this has usually been done because the nature of the surgical work, or the physical limitations of the hospital, have made it essential. For instance, at the Robert Jones and Agnes Hunt Orthopaedic Hospital at Oswestry, the

* Similar trays may be used with advantage in all parts of a hospital and have been adopted for use throughout the experimental blocks designed by the Investigation.

orthopaedic wards are planned with one long side completely open to the weather. Under inclement conditions these wards are not suitable for the post-operative recovery of patients, and an ordinary enclosed ward, adjacent to the theatres, accommodates all patients for 24 hours after operation.

In America recovery wards are more frequently provided than in England and are increasing in number because they offer an economical and efficient way of giving post-operative care.[38]

Estimates of the number of beds to be provided in a recovery ward vary. Anaesthetists cannot forecast beyond doubt which patients they may wish to keep in the recovery ward until their physical condition is sufficiently satisfactory for return to the ordinary wards. The number of beds required will clearly relate to the number and nature of operations performed. Schafer and Galbraith,[36] on the basis of information collected in various hospitals, propose 4 recovery beds for 10 general surgical operations per day, 7 for 20, 9 for 25, 12 for 30, and 13 for 35.

Planning and Equipment

Opinions differ as to whether an open ward or single-bedded rooms should be provided in a recovery-unit. American practice is to provide an open ward with individual bed-curtaining and one or two fully glazed, single-bedded cubicles. Sometimes patients are placed with their heads towards the centre of the room. Practice in England varies. In the orthopaedic hospital at Oswestry the 25-bedded recovery ward is not divided into cubicles, and no attempt is made to segregate the sexes except by grouping. In the unit at East Grinstead (*Fig. 62 (a)*) each of the ten single-bedded rooms has a glazed wall on the corridor side. Owing to the nature of some of the plastic operations performed, patients sometimes remain in the recovery-unit for more than twenty-four hours after they have recovered consciousness. The decision to put all patients into single rooms was made largely because of the special needs arising from the nature of the surgery. For general surgical cases an open ward with curtains which can be drawn between beds is quite suitable.

In this country there is as yet no precise schedule offering guidance on recovery-unit accommodation. A utility-room is necessary with sterilizer, sinks, and slop-sink, cupboards for instruments and drugs, and a desk where records and notes may be written without leaving the bed-area. At East Grinstead the unit includes a small kitchen. *Fig. 62 (b)* shows the plan of a typical room in the East Grinstead unit. Oxygen and suction are available at each bedside. In the recovery ward at Oswestry, oxygen is provided at each bed, piped from large cylinders at one end of the ward, but suction is provided only from a mobile apparatus. *Fig. 63* shows the plan for a 7-bedded recovery-unit illustrated by Schafer and Galbraith.[36] Each bed has an oxygen and a suction outlet adjacent to it, and one completely partitioned isolation cubicle is provided. The utility-room is divided from the rest of the ward by a glass partition.

A certain number of general recommendations can be made for the planning of recovery-units, but details must be considered for each unit individually. The unit must be immediately adjacent to the theatre suite. Doors into it, and into each patient's room in the unit, must be wide enough to allow beds and any special apparatus which may accompany the patient to pass through easily. The internal planning should be so arranged that the patient's head is always clearly in view, and work areas must be planned so that those using them face towards the patients. Enough space should be left between beds for several people to attend to a patient simultaneously and use bulky apparatus and trolleys. Unless sterile supplies are brought from a central department, or sterilizers are available near by, facilities for sterilizing instruments, syringes, and needles must be provided in the recovery-unit. Storage-space should include cupboards for drugs, linen, surgical trays laid-up for emergency use, and bulky pieces of equipment such as drip-stands, oxygen tents, emergency suction apparatus, and bed-rails.

Natural daylight is desirable in recovery-units, but windows should be shaded from direct south and west sun. Blinds should be provided so that individual beds or

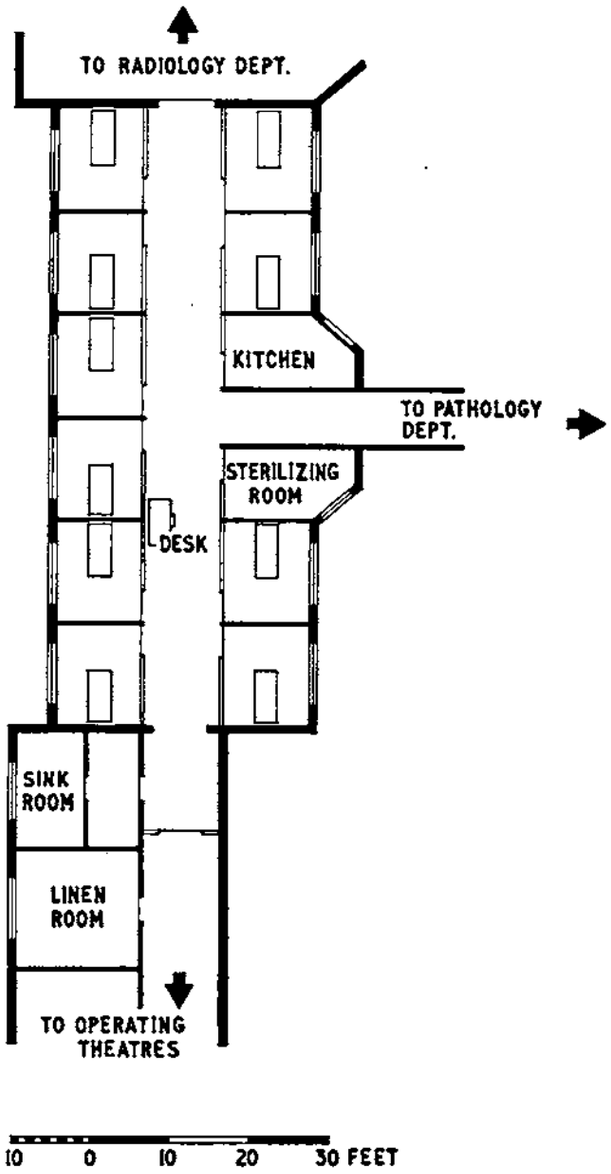


Fig. 62 (a). Plan of the recovery-unit at the Plastic Surgery Centre, Queen Victoria Hospital, East Grinstead

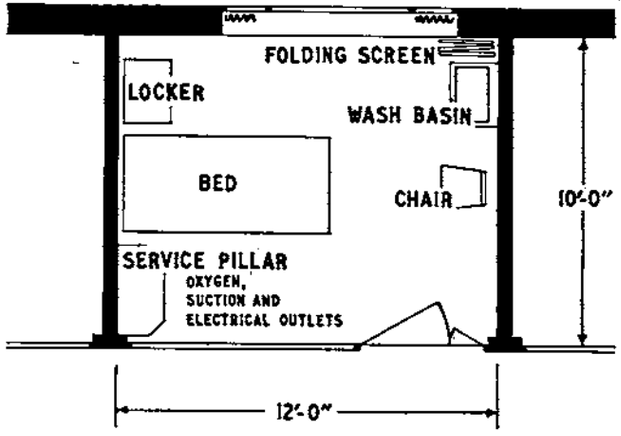


Fig. 62 (b). Plan of a typical recovery-room at the Plastic Surgery Centre at East Grinstead

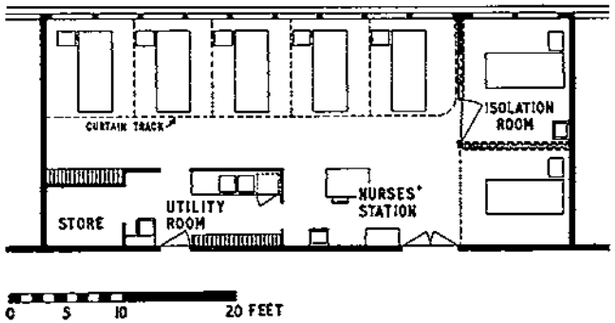


Fig. 63. Plan of a recovery-unit for a 200-bedded general hospital; from Schafer and Galbraith's 'Recovery room service'.[36]

cubicles can be darkened. Artificial light should be fairly uniform throughout the unit, and designed to give a level of 20–30 lumens/sq. ft. The light-sources should be controlled by separate switches so that the intensity can be varied locally if required. A local, high-intensity light-source should be provided at each bed, or a mobile spot-light be available for use in the unit. Electrical outlets should be provided so that electric blankets, portable X-ray machines, and other apparatus may be used. There should be telephone communication with other parts of the hospital, but the bell signal should be muffled. A call-system should be provided for summoning the anaesthetist or other help in an emergency. If patients are likely to remain in the recovery-unit for some time after they have regained consciousness, it will be necessary to install a nurses' call-system within the unit. Natural ventilation as in general wards will be satisfactory if special care is taken to design windows which cannot cause cold draughts. The temperature in a recovery-unit should be maintained steadily, and some anaesthetists have expressed the view that it should be midway between that of the theatres and that of the wards.

If the size of the unit warrants the capital expenditure, a piped oxygen-supply outlet and vacuum point adjacent to each bed can be provided. This is an undoubted convenience in a recovery-unit, since either may be needed very quickly.

Floor, wall, and ceiling finishes can be similar to those in single rooms in general wards. Since quietness is desirable, an acoustic ceiling should be provided. It is not necessary to have an electrically conductive floor.

Recovery-bays

Where there is insufficient space, or other difficulties prevent the provision of a recovery-unit on the lines described above, it may sometimes be possible to provide a small recovery-bay for one or two patients, and many anaesthetists look on such a bay as a very useful amenity. Dr. R. P. W. Shackleton, at the Royal Hampshire County Hospital, has for some time used a curtained recovery-bay (*Fig. 55*). Dr. Shackleton installed this unit because the theatre suite is connected to some of the surgical wards by a long ramp, and the incline can have an adverse effect on the patient's blood-pressure. Space for a complete recovery-unit was not available.

In some of the modern theatre suites which were visited by the team a room had been set aside to receive selected patients after operation. The room generally opened off the theatre-lobby, close to the main doors into the theatre suite.

In the theatre suite designed by the Investigation for Musgrave Park Hospital, Belfast, two recovery-bays are to be provided, one adjacent to each theatre (*Fig. 69*). Access to the bays is from the exit-rooms and each is designed to contain one bed.

8. Other Rooms in the Theatre Suite

Exit-rooms

The exit-room should provide a place which is draught-free, at the same temperature as the theatre, and away from the main circulation routes in the theatre suite, where the patient may be prepared for return to the ward. The patient's bed may remain in the exit-room during the operation and afterwards he may there be made comfortable in it, thus avoiding the need for taking bed-coverings into the theatre. If a mobile operating table is used, the table itself can be moved into the exit-room, so that the whole transfer procedure takes place outside the theatre.

The exit-room should be separated by doors from the theatre and the main corridor of the suite, the doors being wide enough to permit easy passage not only of the bed but of any equipment, such as a transfusion stand, accompanying it.

Finishes in the exit-room may be similar to those in the recovery-ward, and artificial lighting should give an even, general illumination of about 20 lumens/sq. ft. Natural light, though pleasanter for working in, is not essential. The room itself should not be used for the storage of articles needed elsewhere in the theatre suite.

An exit-room for each theatre has been planned in the theatre-block designed by the Investigation for Musgrave Park Hospital, Belfast.

The Work- and Autoclave-rooms

The traditional theatre suites in hospitals in Britain often include a nurses' work-room and autoclave-room. The work-room is used for many of the jobs incidental to the running of a theatre suite, for example, stock-making, inspection and repairs of linen, glove care, drum-packing, and routine care of instruments. Storage is provided for linen, surgical stock, and other theatre stores. The autoclave-room is used not only for autoclaving theatre stock, but also dressings and other articles for the whole hospital.

The work-room should have ample natural light, since theatre staff spend a considerable time there engaged in fairly close work, and it need not be artificially ventilated. Easily accessible cupboard space adapted to the various storage requirements should be provided along the walls. Work-benches under the cupboards, or tables in the middle of the room, should be provided at which staff can sit while they work. Before these are designed in detail the procedures involved should be studied to discover where drawers and racks for easily accessible, temporary storage will be most needed during routine work.

Artificial lighting should provide a general level of 20–30 lumens/sq. ft., the sources being arranged in relation to the working surfaces so that staff do not work in their own shadow. Local, adjustable, bright sources of illumination may be necessary where fine work is to be carried out.

In a few of the theatre suites visited by the Investigation, the autoclave-room is divided into two compartments completely separated by the autoclave, which is placed between them and has doors at each end. This division enables a rigid distinction to be kept between unsterile objects which are loaded into the autoclave at one end, and sterile objects which are removed from the autoclave at the other end.

Central Sterile Supply Department

In recent years in the United States, Canada, Australia, and some countries in Europe a number of central departments have been set up for the maintenance, sterilization,

storage, and supply of all sterile materials and instruments used in the various clinical departments of a hospital or group of hospitals.

The centralized autoclaving of drums for use in wards and theatres has long been common in this country. The chief reasons for this are the high capital cost of the autoclaves and the need for regular maintenance, and the close control over the sterilizing process which is necessary.

The Investigation visited a number of central syringe departments which have in recent years been set up. In these departments syringes and needles are processed, sterilized, and issued daily according to the needs of the various clinical departments. The advantages of such a service have become increasingly recognized as the number of drugs given by injections and the demand for dry sterilized syringes for various procedures have mounted.

The nucleus of a central sterile supply department may be said to exist in any hospital which has a central autoclave-room for sterilizing ward-dressings. A further step is the addition of a central sterile syringe department. The final step, to a complete sterile supply department, has not yet been taken in Britain.

The advantages of a central sterilizing and supply department are believed to lie partly in economy in the provision of expensive servicing equipment, saving of nurses' time, better care and therefore longer life of instruments and utensils, and fewer losses of all materials because of better control at all stages. But the advantage lies principally in the provision of facilities which make possible the routine use of the most reliable aseptic techniques.

There is considerable variation in the sizes of the central sterile supply departments which have come to the notice of the Investigation, and apart from the United States Public Health Service recommendations, and outline recommendations published by the Bouwcentrum[39] in Holland, no standards have been published.

Since the department is intended to serve all parts of a hospital or group of hospitals, it will need careful placing on the site, if possible near to a service road. If the hospital has a central equipment and material store, the central sterile supply department may conveniently be placed between it and the hospital service corridor. The departments which the central sterile supply department will be likely to serve include the wards and outpatient department and operating theatres. It has been accepted practice hitherto for the theatres to be supplied with all the sterile stock required, with the exception of the instruments for the various operations. Margeret Schafer[40] writes: 'Since the conception of "Central Supply" is still new, we still do not know at what point centralization reaches the point of diminishing returns. . . . It is usually not considered advisable to include operating-room and delivery-room instruments in the Central Supply because of the numbers required, control, and the necessity for emergency sterilization.'

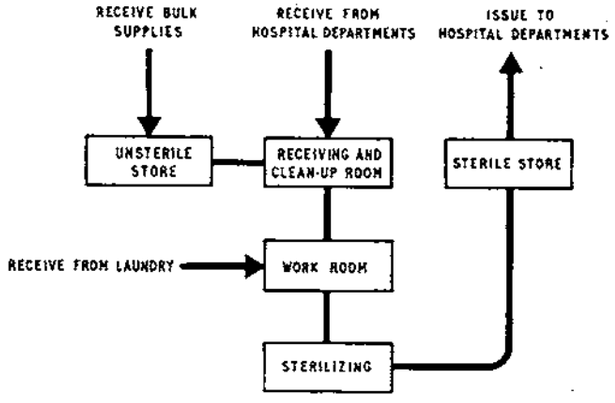


Fig. 64. Sequence of work in a central sterile supply department

The planning of a central sterile supply department must conform to the sequence of work from the reception of materials for sterilization to their dispatch from the department. In outline the sequence is as follows: (i) materials are received into the department from various sources, for example, from central stores, from the laundry, and from hospital departments; (ii) all used materials and some new materials are cleaned—preliminary cleaning to remove blood, pus, and other substances difficult to remove when dried on, having been done by the users before returning the articles to the central sterile supply department; (iii) clean materials are inspected, assembled, and packed, ready for sterilization; (iv) they are sterilized; (v) they are either stored in a sterile storage-area in the department or distributed directly as required (*Fig. 64*).

Fig. 65 shows a plan for a central sterilizing and supply room for a 200-bedded general hospital as recommended by the United States Public Health Service.[40] Studies which are to be carried out in the department designed by the Investigation for Musgrave Park Hospital, Belfast, will, it is hoped, give fuller information about the equipment and planning requirements.

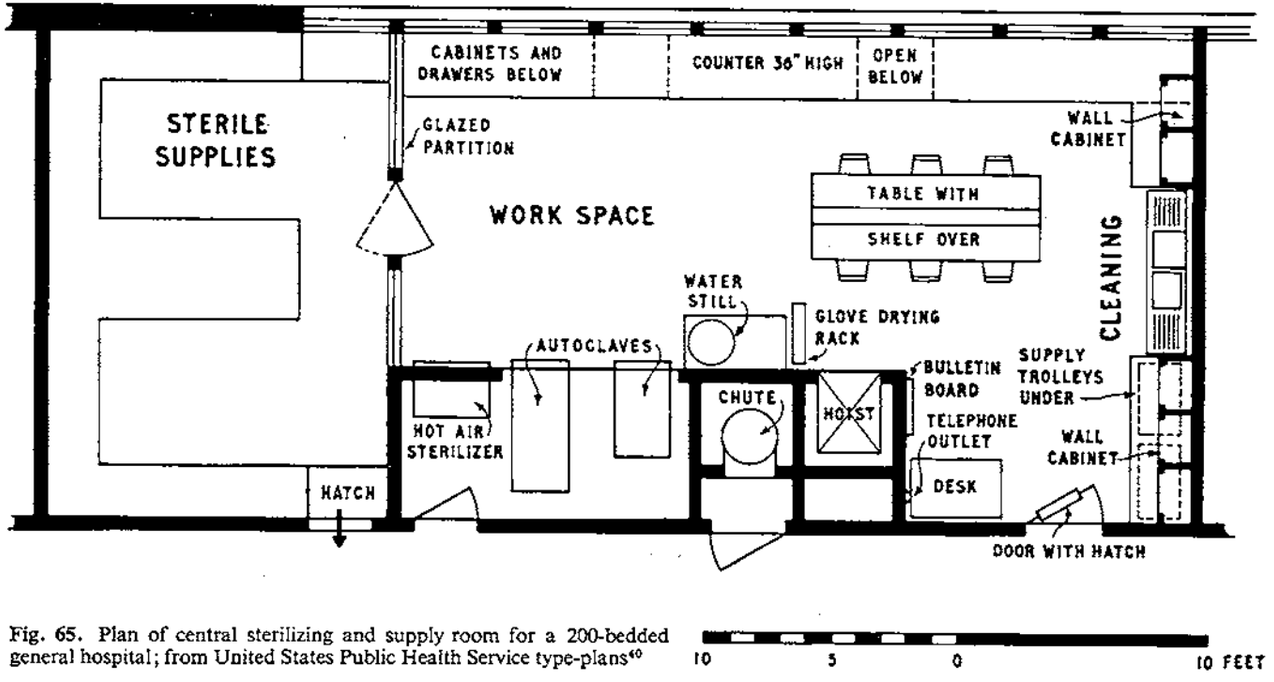


Fig. 65. Plan of central sterilizing and supply room for a 200-bedded general hospital; from United States Public Health Service type-plans[40]

Autoclaves are generally used in central sterilizing departments, provision being made for adjusting the steam pressure in the autoclaves according to the nature of the articles to be sterilized.

In most of the central syringe departments visited by the Investigation syringes were sterilized in hot-air ovens at a temperature of at least 145° C. for one hour.

The central sterile supply department need not be air-conditioned. Natural light is desirable, but if planning exigencies make it necessary, the storage-area may be wholly artificially lit. Artificial light should provide a general level of illumination of 20–30 lumens/sq. ft., and local and adjustable light-sources for fine work requiring concentration, such as needle-sharpening, will be required. There must be telephone communication with the main hospital switchboard, and an intercommunication system with other departments. Floor and wall finishes should be easily cleanable, but it is not necessary to provide for sluicing down the floor, except in the clean-up room. An acoustic ceiling is desirable; but in rooms where large quantities of fabrics, or fabric-wrapped packages, are stored on open shelving it will not be necessary because the materials themselves provide enough acoustic absorption. Working-surfaces may be covered with hard-surfaced plastic sheeting, as far as possible jointless. Suitable colour schemes are discussed on p. 113.

The method of supplying goods from the central sterile supply department to the theatre suite will depend on the broad principles of planning for the hospital as a whole. In a single-story plan, supply will usually be by trolley, unless the central sterile supply department is next to the theatres. In a multi-story plan it would be a convenience to connect the two departments by special supplies-lifts. Direct telephone connexion between them is essential.

Where the needs of the theatre for all sterile supplies except instruments are met by a central sterile supply department, the work-room in the theatre suite (see p. 75) may be replaced by a small room for receiving the sterile supplies. In this room may be kept a 24-hour stock of sterile goods and linen and also such things as drugs, lotions, and blood for immediate transfusion. The room may also be used for routine instrument-care and for various management jobs concerned with the supply of equipment. A supply-room, designed to fulfil such functions as these, will be included in the theatre suite designed by the Investigation for Musgrave Park Hospital, Belfast (*Fig. 69*).

Changing- and Rest-rooms

Changing-rooms for male and female staff should be provided within the suite. They should be large enough to contain full-length lockers for clothes and other belongings for as many people as need to change, and should include wash-basins, a W.C., and a shower cubicle.

It is uncommon in England to find a shower cubicle in the nurses' changing-room, probably because formerly most nurses were resident and it was supposed that the bathroom in the nurses' home would serve. Nowadays, when many nurses are non-resident, a shower in the nurses' changing-room in the theatre suite is appreciated. A changing-room separate from that of the nursing staff is not usually provided for women surgeons though the number now working in hospitals warrants such a provision. Enough space should be allowed in each changing-room for two or three persons to use it simultaneously without undue crowding. The Investigation's arrangement of changing- and rest-rooms is shown in *Fig. 69*.

In addition to the wash-basin (or basins) and the lockers, racks for theatre footwear, hooks for rubber aprons, and shelves for caps and masks should be provided, and a dirty-linen container for discarded clothing. Floors and walls should have easily cleaned surfaces. It is not essential that the changing-rooms should have natural light, and artificial light should give a general level of illumination of about 10 lumens/sq. ft.

The rest-rooms should be big enough for four or five people to sit in comfortable chairs, and should contain book-shelving and at least one writing-table and chair, with a desk lamp. A notice-board is a useful amenity, also a telephone with an outside line as well as internal lines to other departments, and a clock. There should be natural light. Artificial light should give a general level of about 10 lumens/sq. ft. Ordinary domestic finishes for floor and walls are suitable in rest-rooms, and, unless it is impossible to provide a window, colours of high chroma and low value may be used without adversely affecting the light distribution (see p. 110).

Changing-rooms must also be provided in the theatre suite for porters and orderlies. These rooms should include a shower, wash-basin, W.C., and lockers, all as in the surgeons' and nurses' changing-rooms. If the number of visitors to the theatre suite warrants it, it may be expedient to provide separate changing accommodation for them. It is usual in English theatres for the theatre-sister to use the nurses' changing-room. She must also have a private office, with the same facilities as the rest-rooms, including a desk and locking cupboard.

Additional Rooms

In some recently designed theatre suites a small pantry is included where meals sent up from the main kitchen can be kept hot and snacks prepared. Thus refreshments are made easily available in the theatre suite with the minimum disorganization in the suite itself and in the rest of the hospital. The pantry should have a sink and draining-board, a table or shelf for preparing food, shelving for trays, and cupboards for crockery, cutlery, and dry foods, a small refrigerator, and a clock. As only simple cooking need be done there, a small boiling-plate with a rapid heating element, an automatic electric toaster, and a point for an electric kettle should be all that is required. This room can be solely dependent on artificial light, though such an expedient is disagreeable; and where it is situated in the interior of the suite it should be artificially ventilated.

Even in modern theatre suites there is not always sufficient storage space. Since each room in the suite has a specialized use, each should contain storage space only for those items of equipment which will be needed there. Some items, such as sand-bags, table-fittings, and stands, are needed in the theatre, but cupboards there add to the amount of cleaning. A cupboard should therefore be readily accessible to the theatre but outside it and not in any of the ancillary rooms. In the Investigation's plan for the theatre suite at Musgrave Park Hospital (*Fig. 69*), a large cupboard for such items of equipment is placed in the lobby between the exit-rooms and the recovery-bays.

There should be a trolley-parking recess at one side of the theatre corridor. If a piped supply of anaesthetic gases is installed, the manifold room will be away from the theatre suite itself. If there is no piped supply, a cupboard with racks must be provided for the storage of cylinders. This cupboard should be in the theatre corridor, where it can be replenished without the necessity of entering the 'sterile' area.

If a mobile X-ray plant is allocated exclusively for use in the theatre suite, either a recess or a cupboard in the theatre corridor should be provided for it.

In the theatre corridor floor finishes should be slightly resilient to reduce impact noise, and an acoustic ceiling

is useful in reducing reverberation. Wall finishes should be easy to clean. Natural light is not essential, and artificial light should be well distributed, at a level of about 10 lumens/sq. ft. The ventilation of the corridor should be considered at the same time as that of the theatre and ancillary rooms. It may be advisable to supply filtered air to the corridor so that any movement of air from it into the theatre ancillary rooms will not seriously contaminate them. The colour scheme in the theatre corridor should create a cheerful atmosphere.

A room for cleaners' equipment should be provided in the theatre suite, with a low-level sink or slop-hopper. This room should open off the theatre corridor. It can be quite small and does not need natural light, but where natural ventilation cannot be arranged, an air-extract vent should be provided.

The telephone may conveniently be placed in the theatre corridor either in a telephone-box or in a recess lined with acoustically absorbent material. There should be a shelf by the telephone for note-taking and perhaps a small blackboard on the wall.

Special Rooms

The rooms discussed above are those which may be considered as essential to the proper functioning of any theatre suite. Though their relative importance may vary, the procedures round which they are designed do not vary fundamentally. Some surgical specialties, however, may need additional rooms, for example, a cystoscopy-room, a plaster-room, an X-ray room, and a dark-room close to the main theatre. A careful assessment of the

It is generally accepted that some form of air-conditioning is essential in the theatre suite. Only by controlling the quantity and quality of the air supplied to the suite can accurately defined conditions be attained and maintained. Under conditions prevailing in the field in war-time, or where facilities are primitive, major surgery has been carried out successfully in the open air. But in hospitals operating goes on throughout the year in rooms which are necessarily shut away from the open air. In such an enclosed space, where operations follow each other rapidly, the build-up of bacteria suspended on dust or droplets in the air may become dangerous unless steps are taken to ensure that ventilation is at all times adequate.

Ventilation

The variables in an air-conditioning system are temperature, humidity, velocity, direction, and degree of filtration of the air supplied to the rooms. Opinions differ considerably on what environmental conditions should be aimed at in operating theatres. Manual control is sometimes provided so that the surgeon may, within limits, adjust air-temperature and humidity to his own needs. Different temperatures within a fairly wide range have been recommended by different authorities as being suitable in operating theatres. Conditions of comfort cannot be assessed in terms of air-temperature and humidity only, but must be considered as well in relation to air-movement. Dr. R. B. Bourdillon (Director, Electro-medical Research Unit, Stoke Mandeville, Aylesbury) believes that 'nobody is happy in still air in an operating

65° to 80° F. with 4 to 20 air-changes per hour.[10] Recently the tendency has been towards lower temperatures and it has been observed that comfortable conditions may be obtained at 70° to 75° F. with 10 to 12 air-changes per hour. At this temperature the efficiency of the surgical team is likely to be maintained more consistently than at higher temperatures. Professor R. Milnes Walker[44] finds that his patients are not adversely affected at 65° F. and Professor N. M. Dott[23] prefers to operate in a temperature of 60° F. A ventilation rate of 12 air-changes an hour has been shown to be effective in reducing air-borne infection.[45]

As has been said, the relative humidity of the air in a theatre affects the risk of anaesthetic gas or vapour explosions due to sparks from the discharge of static electricity potentials on equipment. The relative humidity in the theatres is controlled at 50 per cent. in the emergency department of the Boucicault Hospital in Paris.[19] This may be compared with 60 to 70 per cent. relative humidity which is recommended in the British Standard Code of Practice as 'desirable to reduce explosion hazard'.[46] In the theatres designed by Paul Nelson, at St. Lô (see p. 64), the humidity is variable between 60 and 65 per cent. High humidity will not by itself eliminate the risk of explosions and 55 to 60 per cent. has now been recommended as contributing to the reduction of static electrical risks while providing less onerous conditions for those working in the theatre.[26]

An adequate degree of humidification will assist the natural die-away rate of air-borne organisms and prevent dehydration of exposed tissue. Under experimental con-

co-authors, when 'the number of fresh infections from dirty air becomes an appreciable fraction of all cases of infection'.[49]

The main sources of air-borne infection in theatres may be roughly classified as follows: (1) dust-borne organisms reaching the theatre in ventilating air, or sucked under doors by extract fans, or carried on shoes or clothing or entering through windows; (2) bacteria liberated into the theatre air from blankets, and any woollen clothing exposed; (3) organisms borne on the exposed hair and skin of all persons in the theatre, particularly the surgeon and his immediate assistants, from whose forehead, eyelashes, and eyebrows bacteria may fall into the wound; (4) droplets from noses and mouths of everyone in the theatre, including the patient. The first two items in this list can be dealt with more or less satisfactorily by a properly designed ventilating system, by planning the suite so that as far as possible all dust-raising activities may be excluded from the theatre, and by discipline to ensure that they are so excluded. The third and fourth sources of infection can be controlled by skin-creams, more efficient masking, the use of sweat-bands, and the wearing of efficient and sterile covering clothing. Some satisfactory types of mask are discussed by Bourdillon and his co-authors.[50]

The ventilating system must be so designed that incoming air is free from dust. Any air from an area where the degree of asepsis is lower than that in the theatre must either be filtered or prevented from entering the theatre. The sterilizing-room, where instruments are laid out on trolleys for use in the theatre (see pp. 69–72), needs its own air supply and is the only room in the suite from which air-movement to the theatre may be permitted. *Fig. 66* shows how the number of bacteria-carrying particles per cubic foot of air increases sharply with increased activity in the operating theatre. The dotted curve shows how, in an experiment with two ventilating systems in the same theatre, when exhaust ventilation was provided for the theatre only, the continual sucking into the theatre of dirty air under the doors prevented the bacterial count from falling to low values at any time.[51] The second curve was recorded in the same theatre after the installation of a plenum ventilation system, which maintained the air in the theatres at a slight positive pressure relative to the surrounding rooms. *Fig. 67* shows the recordings made during a single long operation in another theatre with plenum ventilation. The high count in the theatre

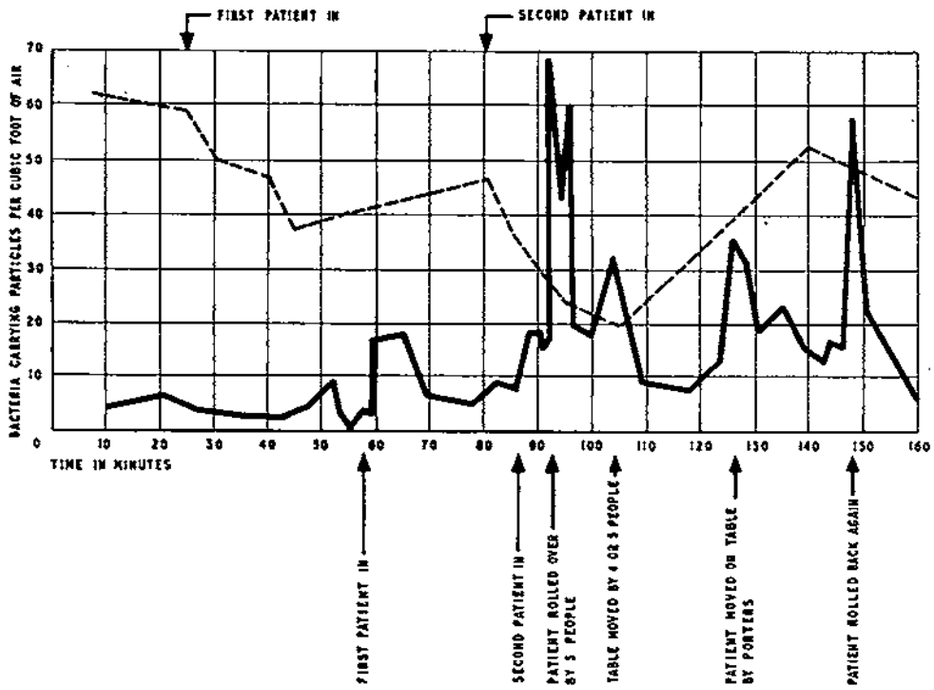
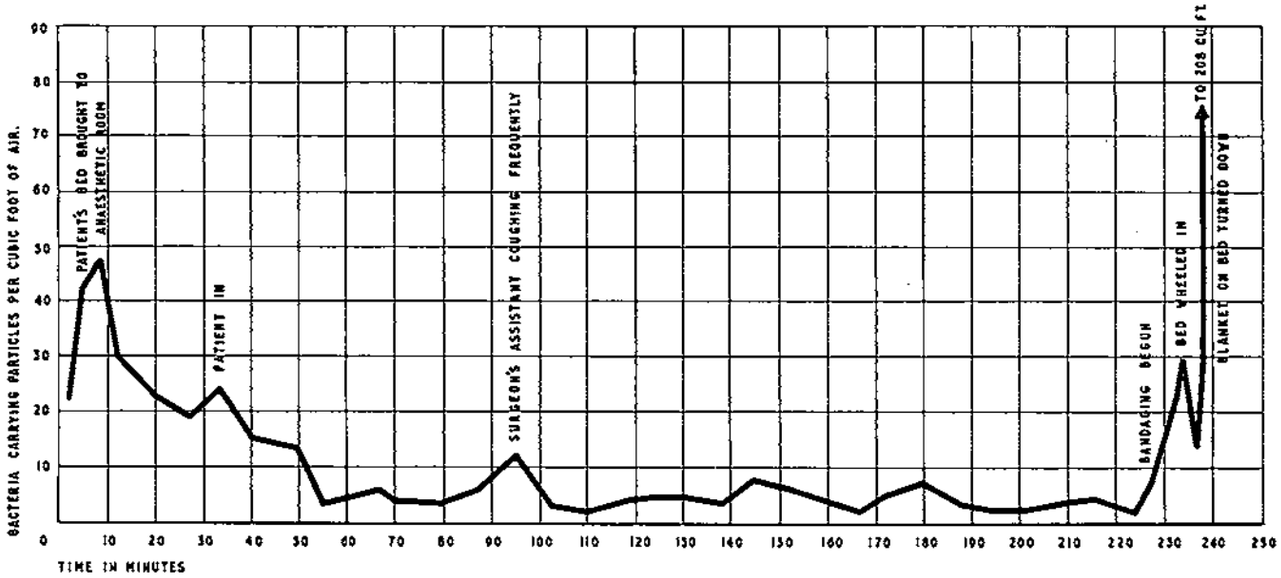


Fig. 66. Bacterial counts in a theatre before and after the installation of plenum ventilation. The dotted curve shows the counts found during a morning's operating with exhaust ventilation only; the continuous curve shows the counts similarly found with plenum ventilation

Fig. 67. Bacterial counts during a long operation in a theatre with plenum ventilation



obtained when the patient was brought into the anaesthetic-room was caused by the movement of air from the anaesthetic-room to the theatre, owing to an imperfect balance of air-pressure between the rooms. The curves seem to show that the chief causes of high contamination of the theatre air were the air sucked under the doors from the hall and anaesthetic-room floor, which was contaminated by dust from the ward blankets, the porters' feet, and so on, and dust liberated in the theatre every time the patient was moved. Great improvement was demonstrated in the bacterial counts when a plenum system giving about twelve air-changes per hour was used. All counts were then less than 10 per cu. ft. until the arrival of the first patient. Although higher counts were produced when the patient was brought in and arranged on the table, these counts fell rapidly during the operation, when movement was reduced, to a point below 10 per cu. ft. Control of the air-flow in the theatre in which the counts shown in *Fig. 67* were taken was by means of adjustable louvres through which the air entered the theatre and flowed towards the heads of the operating team without causing any appreciable draughts at the level of the patient. Temperature was manually controlled. The theatre was rectangular, with a lamp suspended over the table, and contained all the usual theatre equipment.

When the doors are opened between the theatre and its ancillary rooms, any pressure difference quickly disappears, and movement of air between the rooms then depends upon difference in temperature; the greater the temperature-difference, the more violent will be the interchange of hot air moving into the colder room at the top of the door, and cold air moving into the hotter room at the bottom. All rooms in the theatre suite, where sterile or mainly sterile procedures are carried out, should therefore be included in the air-conditioned system, and the variation in temperatures should be as small as possible.

The introduction of air at high level in the theatre with extraction at low level is necessary to ensure the removal of anaesthetic gases and vapours. Careful placing of extracts can induce a directional flow, so that air movement is from the wound towards the patient's head, to reduce risk of air-borne organisms being carried to the wound by the patient's exhalation or from his exposed facial skin or hair.[45] Simple filtration of the air-input through double-layer textile filters can reduce the dust-borne contamination by 86 per cent.[52] and more efficient methods of filtration, such as oil filters or electrostatic precipitators, can reduce it still further. Although these methods are more expensive in initial cost they may be cheaper to maintain than cloth filters which, to retain their efficiency, need frequent cleaning. Studies of the microbic content of the air made by Leonard Colebrook and W. C. Cawston have shown in connexion with plenum systems how important is the placing of the air-intake from the open air. Samples of air taken at street-level, at roof-level, and in the wards of a city hospital show that much advantage is to be derived from placing intakes at or above roof-level.[53]

Heating

Of the various forms of heating which are commonly used in large buildings (see p. 128), some are unsuitable in operating theatres. Heat sources, such as wall-mounted radiators with or without circulating fans, which heat the room by warming the air as it passes over their surfaces, are inefficient in rooms with a high rate of air-change. They are also undesirable because they tend to circulate dust.

Radiant heating from the ceiling has almost no effect on air movement, and has the advantage that its efficiency is not affected by the rapidity of the air-changes in the room.

In the theatre suite designed by the Investigation for Musgrave Park Hospital, Belfast, some heating will be provided in the ceiling, sufficient to counteract any heat losses through the structure and to provide background warmth. The remainder of the heat will be provided by the air-conditioning system, with no recirculation of air. Ceiling heating provided in the rooms below the theatre suite will ensure that the floor also is very slightly warmed.

As air supplied to the theatre should be at a high relative humidity, condensation will occur on any cold surfaces in the rooms, and the walls, ceiling, and floor should be warmed to a temperature above the 'dew-point'. Normal thermal insulation on outside walls, giving a 'U' value* of 0·3, will be effective in preventing condensation. Double-glazed windows are essential, though at relative humidities above 60 per cent., and an outside temperature of 32° F. or below, they may not entirely prevent condensation on their inner surfaces.

* 'U' value: Overall thermal transmittance, B.T.U. per sq. ft. per hour/degree F. difference between indoor and outdoor air temperatures. (Institute of Heating and Ventilating Engineers, 1950, 'The computation of heat requirements for buildings', 227.)

In a number of hospitals visited by the Investigation theatre staff complained that their theatres became intolerably hot on warm summer days, particularly towards the end of an operating session. In some of those hospitals this was due to the size of the windows and skylights, which were inadequately screened against the sun; in others it was due to the slow rate of air-change in the theatres. The high temperature of the outside air taken into the air-conditioning system was evidently a contributing factor. In a climate such as ours, in theatres where the walls and roof are adequately insulated, where the windows are screened externally against direct sun, and where the air-conditioning plant delivers air at a rate of about twelve air-changes an hour, there will be few days when the temperature in the theatre becomes uncomfortably high. It would be difficult therefore to justify a refrigerating system on economic grounds.

Air Sterilization

The work done by Bourdillon and Colebrook[54] led to the formulation of recommended standards of permissible contamination levels during quiet periods of work in theatres. The figures relate to bacteria-carrying particles per cubic foot obtained by an efficient slit-sampler:

For minor operations or dressing small wounds in casualty theatres	20
For major operations on tissues with normal resistance to infection	10
For dressing burns, for operations on the central nervous system, or other procedures where the dangers of infection are particularly great	2·0–0·1

The results of the experiments referred to above showed that the first two values could be obtained by a carefully designed air-conditioning system, using air filtration in a normal type of theatre. The last value is difficult to maintain because, although the number of particles carried in the air can be reduced to the acceptable minimum by efficient filtration, the normal movements and breathing of the theatre staff may quickly increase the count. Techniques which may be expected to aid in the maintenance of this low value include the oiling of all clothing worn by the patient in the theatre, more efficient masks for the surgeon and his assistants, the application of a cream to the surgeon's face and exposed hair, and lastly, the disinfection of theatre air by ultra-violet radiation or by chemical agents. These last-mentioned methods act by

killing organisms in the air irrespective of the presence of dust particles. Air disinfection by ultra-violet radiation as well as by chemical agents has been used in many countries, but as yet no final recommendations can be made as to the most satisfactory methods of application for general use.

Ultra-violet radiation makes it necessary to take precautions to ensure that the patient and surgical team are screened from the lamps, either by reflectors under the lamps, which limit the irradiated area to above 7 feet from the floor, or by special clothing and spectacles worn by the surgeon and his assistants. The desirable speed of air-circulation when using ultra-violet irradiation has been discussed by Dr. Lidwell,[55] who notes that the density of air-suspended bacteria in the lower portion of the room decreases as the speed of circulation rises. Bourdillon and his co-workers point out that the bactericidal effect is decreased as the size of the particles suspended in the air increases, and that the effect is less at high humidity than at low. They made the provisional judgement (1948) that: 'while laboratory trials suggest that ultra-violet radiation may become of great importance in the improvement of air hygiene, the practical results of ultra-violet radiation in field trials are not yet fully established'.[56]

Isadore Rosenfield states that in America the use of ultra-violet light seems to have been superseded by the use of atomized glycol introduced into the air-stream, because this method is safer and more positive than ultra-violet light. The killing-rate of most aerosols is greater at high humidities than at low, which makes them particularly useful in operating theatres.[57]

Both Jean Walter[5] and André Walter[14] describe air-sterilization techniques in which gases are used but which necessitate the rooms being unoccupied at the time—Jean Walter used formaldehyde vapour (cf. p. 58), and André Walter ozone. Both systems rely on efficient filtration when the theatres are in use.

Continuous disinfection of the air in operating theatres is difficult to achieve and the necessary apparatus is expensive and must receive constant maintenance if it is to function reliably. The Investigation is of the opinion that it should only be resorted to when exceptionally low bacterial counts (as in Dr. Bourdillon's third category) are essential, and no other known methods of achieving them are thought to be effective.

10. Design for a Twin Theatre Suite and Central Sterile Supply Department at Musgrave Park Hospital, Belfast

1. General Considerations

When the Investigation was invited by the Northern Ireland Hospitals Authority to design an experimental surgical ward block at Musgrave Park Hospital, Belfast, it was decided also that new theatres were needed, since the existing ones were already overloaded. Further, the Northern Ireland Hospitals Authority was interested in the possible economies of a central sterile supply department (there is no example of such a department in the British Isles at the present time) and, as part of the experiment, wished to build one to serve the whole of Musgrave Park Hospital. The Investigation was requested to design in addition an X-ray department to serve the whole hospital, as the existing department had become inadequate.

At an early stage it was decided that all four departments, the wards, theatres, central sterile supply, and X-ray, should share the same site on the south-east of the existing hospital (*Fig. 68*), the most suitable one for the long-term rebuilding plans.

At the outset of detailed planning it was decided that the needs of the wards and the theatre suite were such that they could not conveniently be accommodated one above the other in the same structural unit. The ward block is to be about 50 feet deep (see p. 21); but the precise planning requirements of the theatre suite made it apparent that it would require greater depth as well as a different arrangement of structural columns and service ducts. Rather than compromise the planning of either department, therefore, the theatre block has been planned separately from the ward block, the two being connected by a central portion including the bed-lift, stairs, and main entrance from the existing hospital. The X-ray department, designed to the requirements of the Northern Ireland Hospitals Authority, and the central sterile supply department, will be connected to the theatre suite above by two goods-lifts, one clean for supplies from the central sterile supply department, the other for return or disposal of material from the theatres (*Fig. 69*).

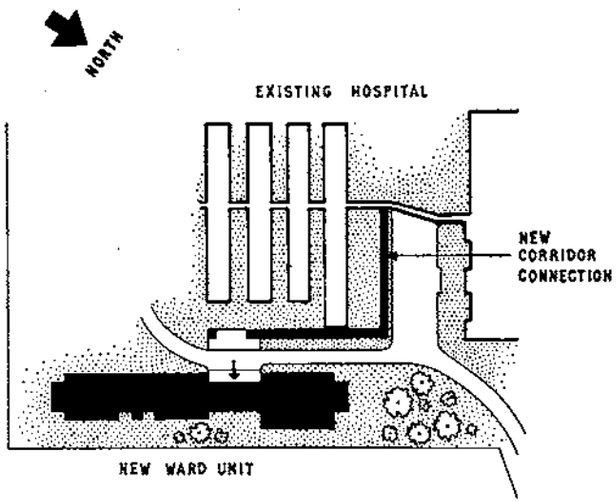
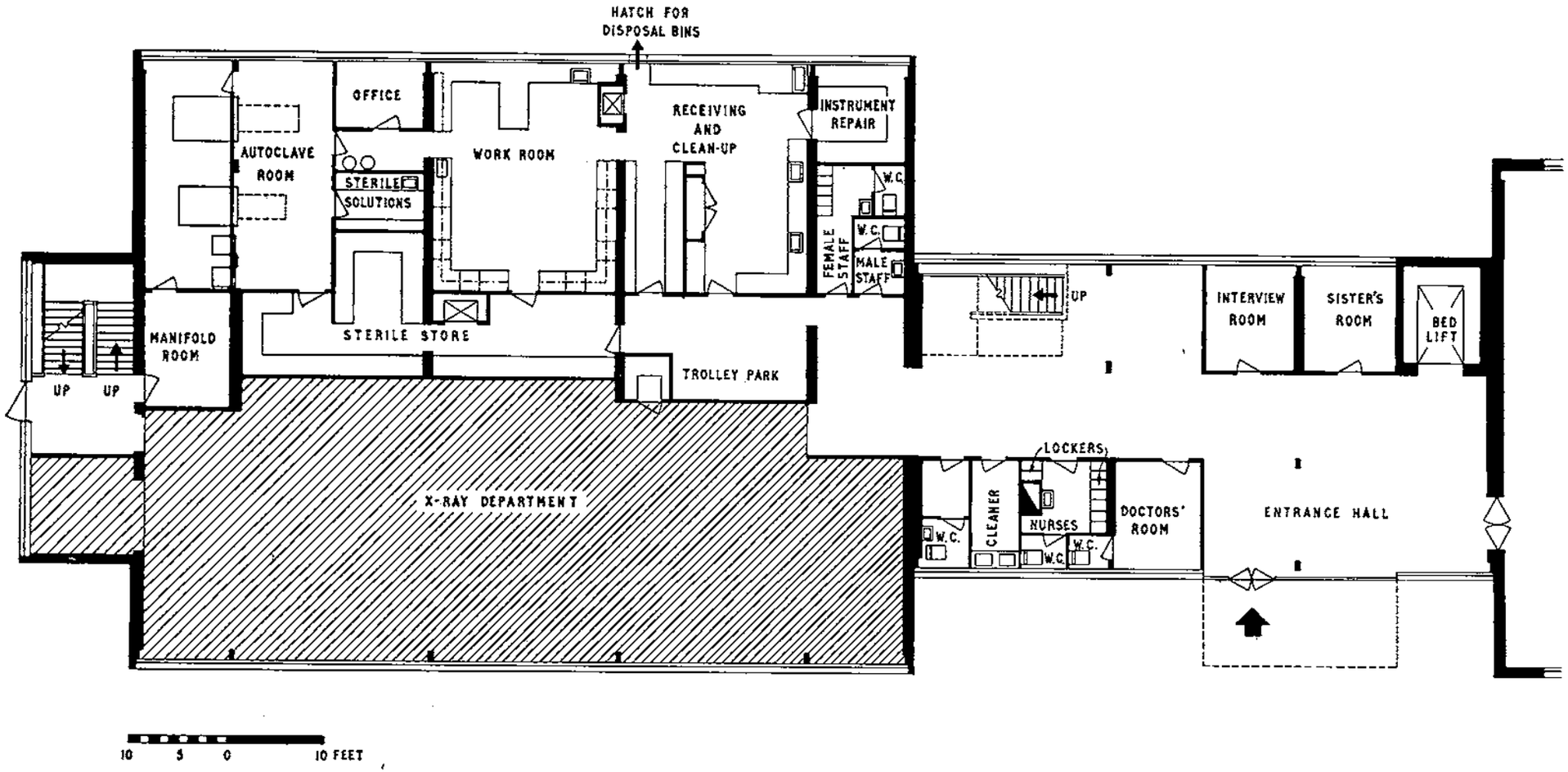


Fig. 68. Musgrave Park Hospital, Belfast; site plan of experimental ward unit

A rough estimate of the monthly number of surgical operations for the whole hospital, taking the new wards into account, showed that one new theatre would barely meet the existing requirements, and the possibility of an increase in the number of general surgical cases had to be considered. The provision of two rather than one theatre need not involve a strictly proportional increase in capital cost, since many of the ancillary services can be shared. It was therefore decided to plan a twin theatre suite. This would also give more flexibility in use, since one theatre could be kept in use even if the other had temporarily to be closed for any reason.

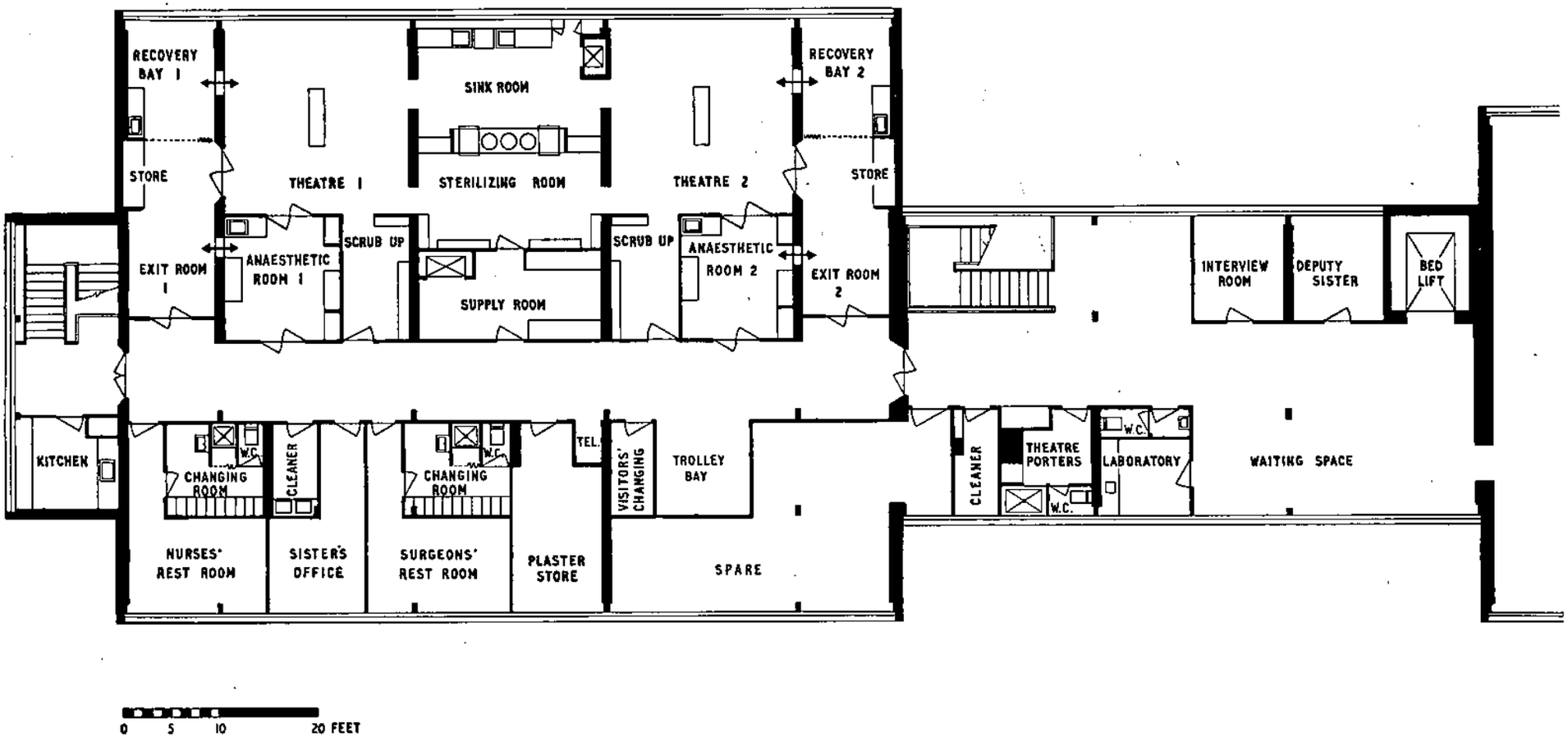
The shape of the site dictated the placing of the new blocks with the long axis running north–south. The theatres and central sterile supply department will be on the east side. Although theatres facing north or north-east would have been ideal (cf. p. 80), it was not thought that an east aspect would lead to any real difficulty as the climate in Belfast is generally cool, and the building will be sheltered by a row of trees on the east boundary of the site.

The same structural system will be used in both the theatre block and the ward block. Provision for vertical service ducts has been made in the double-skin partition walls (*Fig. 70*, see p. 84). The air-conditioning plant for the theatre suite, the electrical distribution boards, and calorifiers for both blocks are to be accommodated in a basement under the theatre block.



GROUND-FLOOR PLAN

Fig. 69. Musgrave Park Hospital, experimental building: *Ground- and first-floor plans of theatre block, with entrance hall common to theatre and ward blocks*



FIRST-FLOOR PLAN

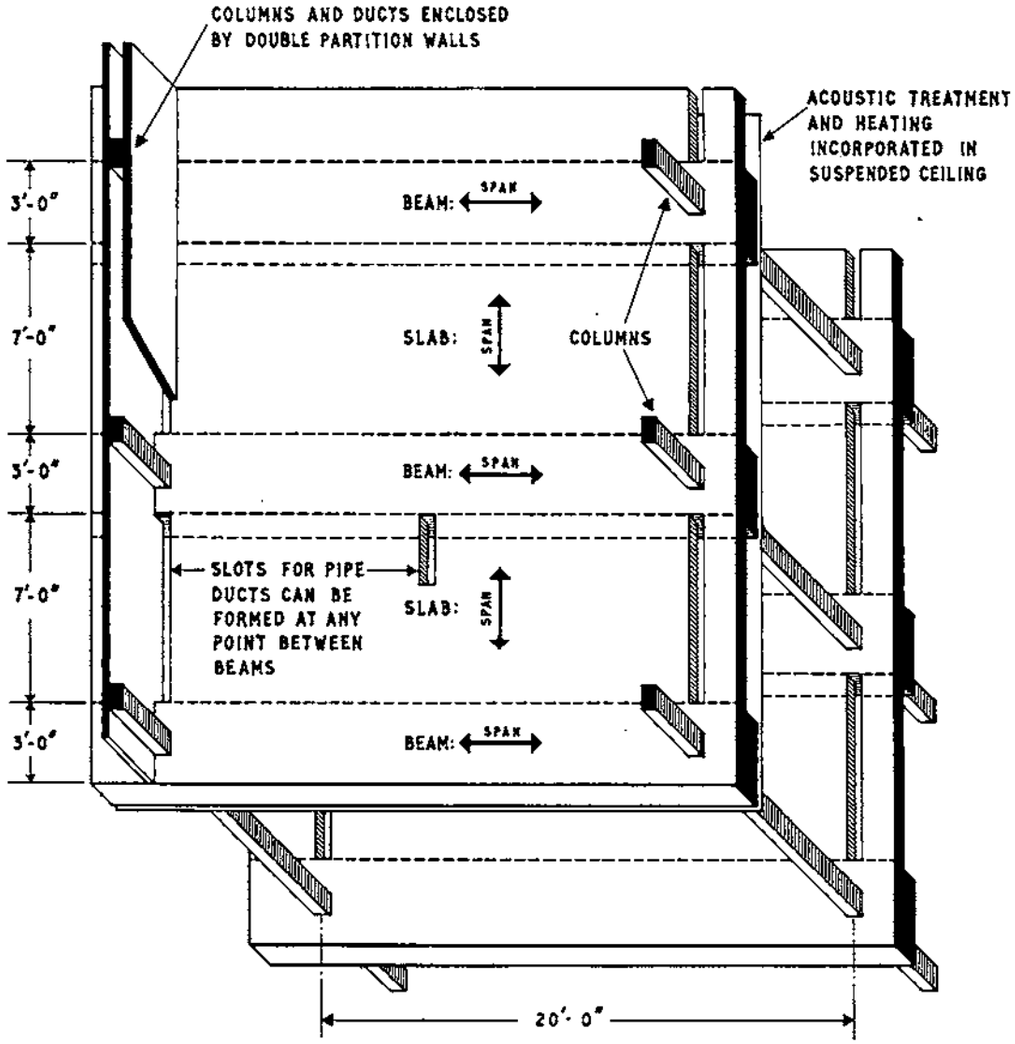


Fig. 70. Structural system used for the experimental buildings at Musgrave Park Hospital showing provision made for vertical service ducts

2. Design of the Twin Theatre Suite

General planning.—In the plans now being executed, the theatre suite is a cul-de-sac department on the first floor of the theatre block. It is planned on both sides of a corridor, at one end of which are the emergency exit and stairs, and at the other the doors from the central entrance and lift block. On one side are changing-rooms and rest-rooms for surgeons and nurses, the theatre-sister's office, a parking-bay for trolleys, and a changing-room for visitors. A cleaners' cupboard for the suite, and a telephone booth, also open off this side of the corridor. By the trolley-bay are hooks and a shelf for ward-nurses' gowns and masks, so that when they are accompanying patients to the theatres they may put on theatre clothes there without leaving their patients. An area of the plan is left spare on this side of the corridor to allow for the possible future inclusion of a plaster department. A small servery is included in the suite, at the north end of the theatre corridor.

On the east side of the building two theatres, anaesthetic-rooms, and scrub-up rooms are grouped on either side of a sink-room, a sterilizing-room, and a supply-room. An exit-room and a recovery-bay open off each theatre. All these rooms are artificially ventilated—warmed, filtered, and humidified air being supplied to each room independently. The supply and disposal of all goods will take place within the central zone of the block, clean and sterile supplies being brought by lift into the supply-room, and used objects for return to the central sterile supply department for disposal being sent down by lift from the sink-room. Patients entering or leaving the theatres will do so by doors at the side of the theatres remote from the central zone.

The theatres.—Each theatre (*Fig. 71*) is approximately 19 feet square, with a ceiling height of 10 feet. Musgrave Park Hospital is not a teaching hospital, and so the problem of accommodation for medical students does not arise (see p. 62).

Windows with a sill of 3 ft. 4 in. above floor-level and glazed with clear glass are continuous along the east side of the theatres. These windows are double glazed, the outer frames being fixed, the inner frames opening for cleaning. Between the two panes blinds may be pulled up by remote control from a slot in the sill. Artificial light is from tungsten lamps throughout the suite; in the theatres lighting is of two kinds. General lighting is provided by four sealed and recessed ceiling-fittings towards the corners of the theatres, designed to give a general level of illumination of about 20 lumens/sq. ft. at 3 feet above floor-level. The operating light is of the type described on p. 65.

The floors of the theatres are of terrazzo laid in 2-foot squares. The construction of the floors, laid on a screed containing carbon black in which is embedded an earthed steel mesh, is as recommended by the Ministry of Health.[26] This floor is designed to give a resistance to earth for electrical discharge, which will minimize the occurrence of sparks from equipment which has become charged. Gullies and sumps are provided to carry away water used to sluice down the floors. The walls are plastered, the finish being hard-gloss paint. The walls and floor will be coloured, and the ceiling will be white. Return corners and the junction of walls and floor are rounded, and the

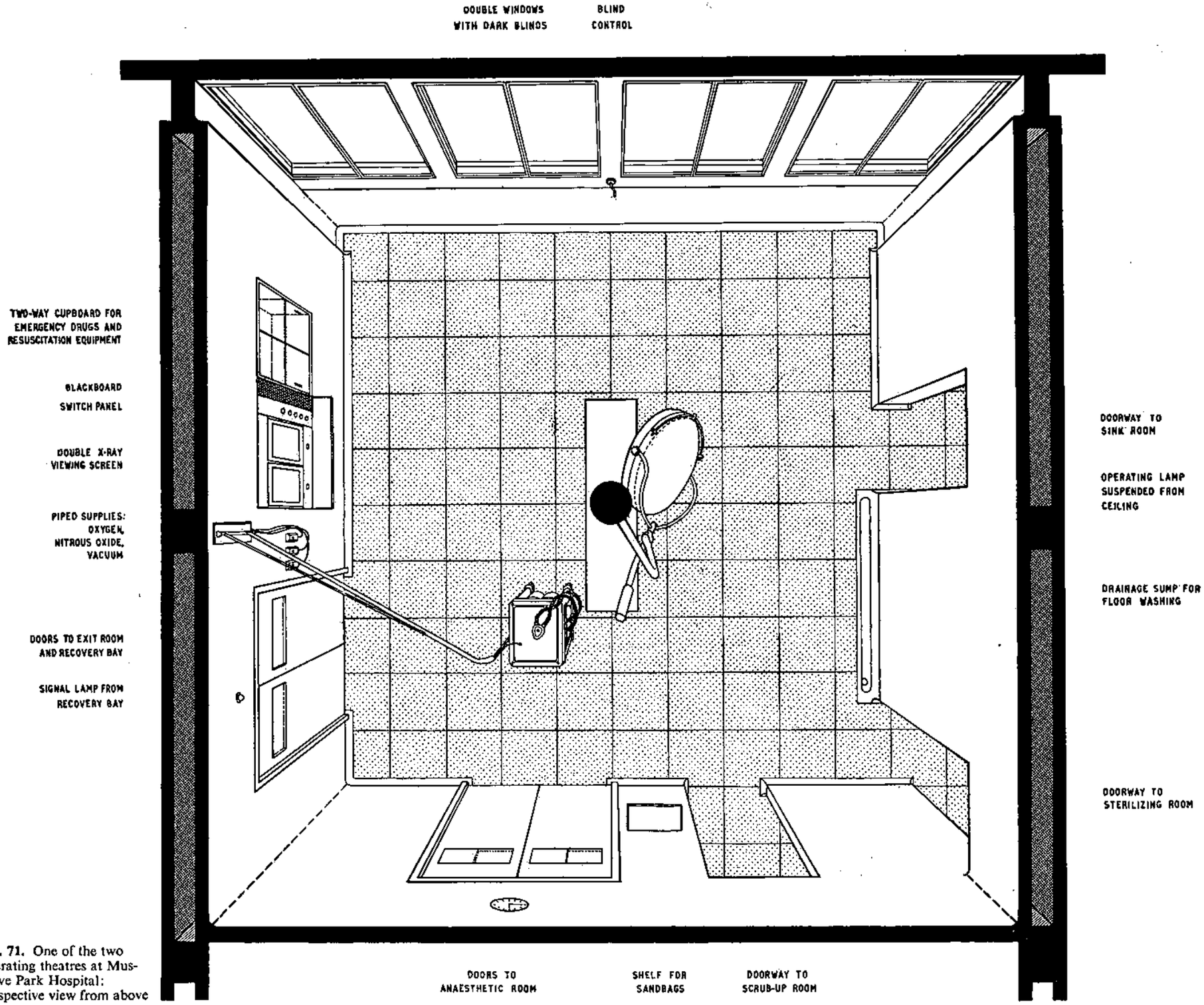


Fig. 71. One of the two operating theatres at Musgrave Park Hospital: perspective view from above

edges of doorways, which are liable to be damaged by trolleys, are protected by steel angles set into the plaster. In each theatre all fixed equipment is in the same position relative to the head of the operating table. On the north wall of each theatre, fixed at a height of 7 ft. 6 in. above floor-level, is a swinging arm which carries nitrous oxide, oxygen, and a suction pipe to the table (*Fig. 53*, pp. 66–67). On the same side in each of the theatres are two X-ray viewing screens with dimming switches, a blackboard, and the main electric control-panel which carries outlets and switches for high- and low-voltage electricity, and the theatre lighting-switches. All switches to outlets are of the spark-proof type, and the whole panel is mounted 5 feet from the floor to be well above the level of explosive gases and vapours. An earth-proving circuit is incorporated which enables continuity of the earthing circuit in any electrical apparatus to be easily checked. In the north wall of the north theatre, and the south wall of the south theatre, is a cupboard for resuscitation equipment and drugs for emergency use. This cupboard opens into the theatre and also into the recovery-bay and has clear glass doors on each side. On the wall at the head of the table is a small shelf for sandbags. Double swing-doors into the anaesthetic- and exit-rooms, and throughout the theatre suite, are fitted with check-spring hinges which will hold them open while trolleys are pushed through. All these doors have clear glass panels in them, fitted with sliding shutters. The emergency call-system in the recovery-bay operates a signal light over the door to the exit-room.

Anaesthetic-rooms.—There is an anaesthetic-room for each theatre, placed between the theatre suite corridor and the theatre itself. The anaesthetic-rooms are 12 ft. 9 in. long and 11 ft. 9 in. wide, giving a floor area of 150 sq. ft. (cf. p. 68). The fixed equipment—cupboards, desk, and sink—has been so arranged that people using it are at the corner of the room or in recesses and work round the patient is not disturbed. As in the theatres, fixed equipment in each anaesthetic-room is arranged in an identical, not a mirrored, position. *Fig. 72* shows the arrangement of fixed as well as mobile equipment. Below the instrument cupboard, on the left-hand side in *Fig. 72*, are wall outlets for oxygen, nitrous oxide, and suction, hooks for rubber tubing, and a holder for adhesive-strapping rolls. In the tall cupboards on the right-hand side of the room are kept intravenous infusion fittings and stand, a mobile injector-sucker, and additional anaesthetic equipment. A warmed cupboard is provided in the thickness of the wall between the exit-room and the anaesthetic-room; it can be opened from either room. In this cupboard blankets taken from the patient's bed can be kept warm against his return from the theatre. Floor and wall finishes are similar to those in the theatre. Artificial lighting is provided by three types of fitting. General lighting is by a sealed and recessed fitting in the ceiling, at the centre of each room. Adjacent to this is an adjustable inspection light on a telescopic arm (*Fig. 73*), for use when a bright local light is required. Towards one corner of the room, over the preparation area and the sink and slab, is a narrow-beam light, recessed into the ceiling. This can be used when it is necessary to induce

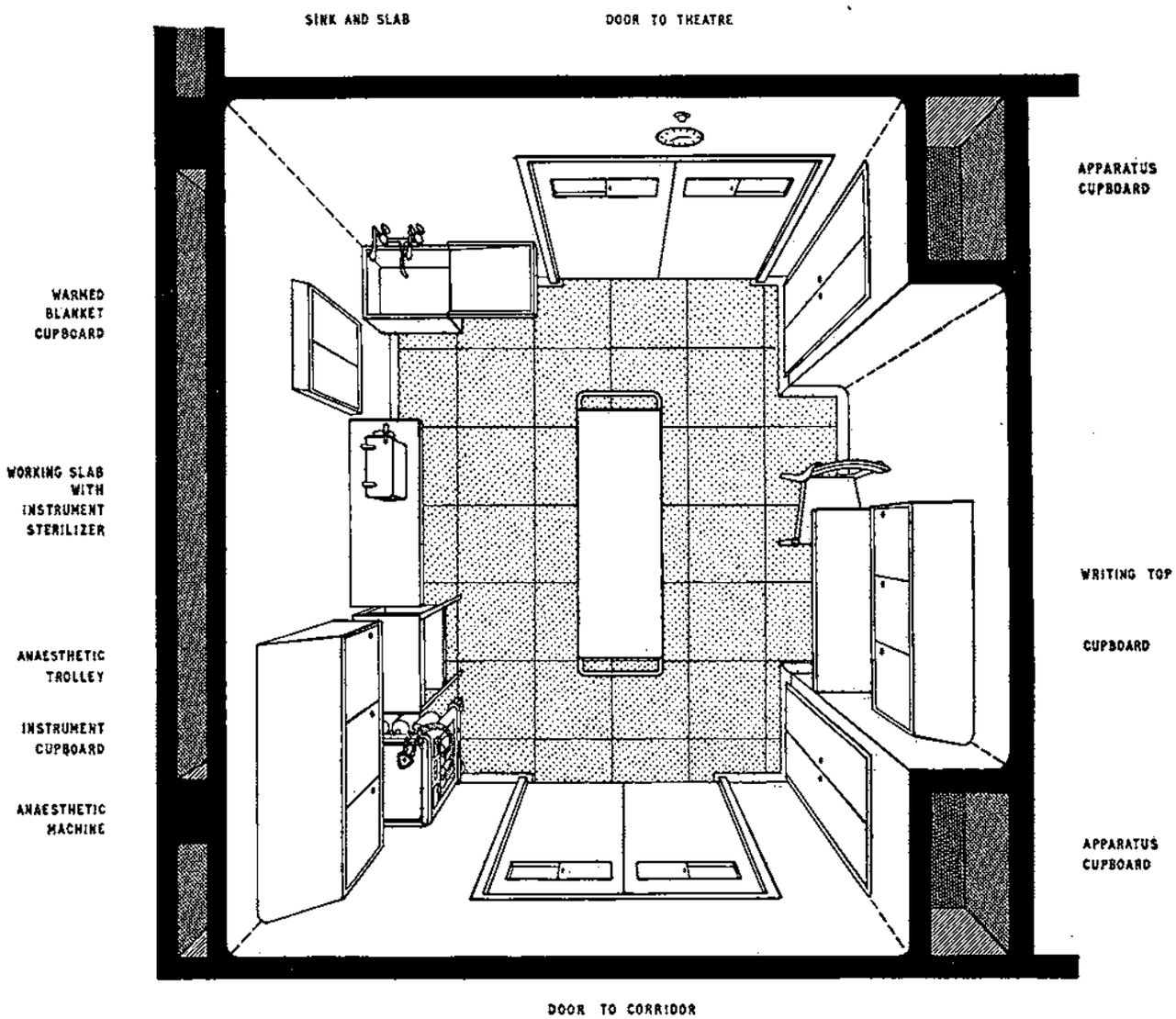


Fig. 72. An anaesthetic-room in the experimental block at Musgrave Park Hospital: perspective view from above

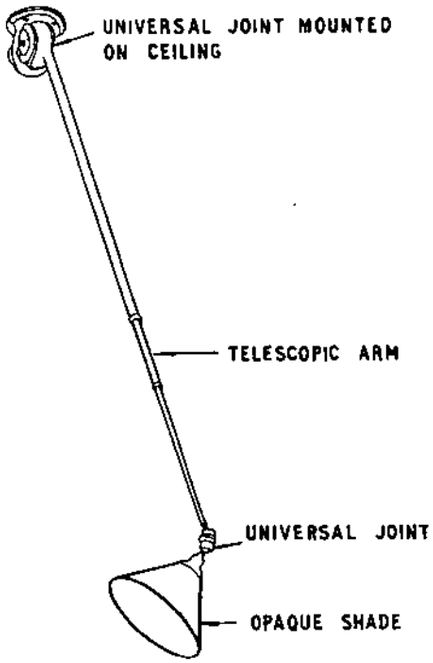


Fig. 73. Inspection light-fitting used in the anaesthetic-room, recovery-room, and exit-room at Musgrave Park Hospital, Belfast

anaesthesia in semi-darkness, and it gives enough light to enable work to continue without disturbing the patient. Each of these lights is operated by a separate switch.

There are no windows in the anaesthetic-rooms, and the glazed inspection panels in the doors can be closed by shutters. A small writing-table is built against one wall, where the anaesthetist's register and notes may be written up. There is no telephone in the anaesthetic-room, but the emergency call system from the recovery-bay is connected to a signal lamp over the door to the theatre. Working surfaces at which people will stand to work in the anaesthetic-rooms are 2 ft. 9 in. above the floor-level.

Sink- and Sterilizing-room.—The planning of sink- and sterilizing-rooms has been discussed on pp. 69–72, and the design of these rooms at Musgrave Park is in line with the conclusions drawn there. Each room is 19 feet wide, and about 9 feet clear floor space is left from front to back between the faces of equipment on opposite sides of the rooms (*Fig. 74*). Finishes and colour are similar to those in the theatres, as also is the artificial lighting from sealed, recessed ceiling-fittings, and the double windows with blinds between the panes. Two sinks are provided, each with a large drainage-slab to one side. A slop-hopper is placed between them, and to one side is the disposal lift. The space under the sinks is left open for disposal bins. Above the slabs are racks for draining rubber tubing. Elbow-operated taps are provided, and one tap has a small-bore corrugated nozzle for washing through rubber tubing. To one side of the sinks is a ventilated specimen-cupboard, and at the side of the lift is a cupboard for the floor-cleaning equipment. The lift is lined with rubber, and the vertically sliding access-doors open and close against rubber buffers to minimize noise.

On the opposite side of the sink-room are the doors to two autoclaves and their controls and temperature and pressure gauges. These are flanked by two recessed glass-fronted instrument cupboards. The height of the autoclaves is 2 ft. 9 in. from floor-level to the underside of the doors, so as to facilitate loading. They are designed to work up to a pressure of 30 lb. per sq. in. for rapid sterilization. The instrument cupboards are about 1 ft. 6 in. deep and 3 feet wide, and each has two doors 1 ft. 6 in. wide. Glass shelves fitted in each cupboard are adjustable vertically. The bottoms of the cupboards are 1 ft. 6 in. above floor-level and the tops are 6 feet above floor-level. The backs of these cupboards are of glass so that through them one room may be seen from the other.

The sterilizing-room is the same size as the sluice-room and has no equipment in it except two shelves and two cupboards (*Fig. 74*). The doors for unloading the autoclaves, tell-tale gauges (duplicates of those on the sink-room side), and warning lights are built into one wall. Between these are the controls and outlets of two water sterilizers, one hot and one cold, and a saline-solution sterilizer. These all have means for flushing through the taps with steam before liquid is drawn off. On the flank walls at this side of the sterilizing-room are electric outlets into which may be plugged a mobile, electrically heated, formalin cabinet. On either side of the door to the supply-room is a shelf for unpacking sterile equipment brought in from the supply-room. Two built-in cupboards with open space below are provided. One of these is heated for the storage of sterile lotions to be kept at body temperature; the other is unheated, for lotions and drugs to be stored at room temperature.

The Supply-room.—Between the theatre corridor and the sterilizing-room is the supply-room. This is connected to the central sterile supply department below by the clean-supplies lift. Opposite the lift is space for trolleys so that supplies may be loaded directly on to them. At the opposite end are work-benches at which routine care of instruments is carried out, store-cupboards above and below the benches, and a refrigerator. In this room is kept a reserve stock of sterile goods, linen for daily use, drugs, and blood for immediate transfusion. Finishes, colour, and artificial lighting are similar to those in the sink- and sterilizing-rooms.

Scrub-up Rooms.—One surgeons' scrub-up room is provided for each of the theatres, opening into the theatre through a doorway, and is entered from the theatre suite corridor through a door with a glazed viewing panel in it. Each room is 13 ft. 9 in. long and 7 feet wide, and at one end, placed against the long wall, are the scrubbing-up positions, of the anti-splash apron type (*Fig. 61*) with a stainless steel open-mesh rack to catch dropped soap and scrubbing brushes. At the end of the room nearest the theatre is space for gowning; against the short wall beside the doorway is a drum-stand for three gown-drums with foot-operated lids. Alongside is a shelf for sterile gloves. Finishes, colour, and artificial lighting are similar to those in the sink- and sterilizing-rooms.

Recovery and Exit-rooms.—Adjacent to each theatre is a room extending from the theatre suite corridor to the outside wall of the building. This room has three uses: the end nearest the window is a recovery-bay, where a patient may be kept under supervision post-operatively until the anaesthetist is satisfied that he is fit to return to his ward; at the end nearest the door to the corridor patients may be prepared for return to the ward; opposite the door from the theatre, table fittings, sandbags, intravenous infusion stands, and operating-table linen are stored in a large cupboard. Finishes and colour are similar to those in the theatres.

A curtain can be drawn across this room to separate the recovery-bay from the remainder of the room. The bay is equipped with a sink and drainage-slab, a bed-head fitting which includes oxygen and suction outlets, an emergency call button, and an electric outlet. In the wall between the recovery-bay and the theatre is a cupboard, with glass doors on both sides, in which resuscitation equipment is kept. The glazing enables the anaesthetist to observe the patient without leaving the theatre.

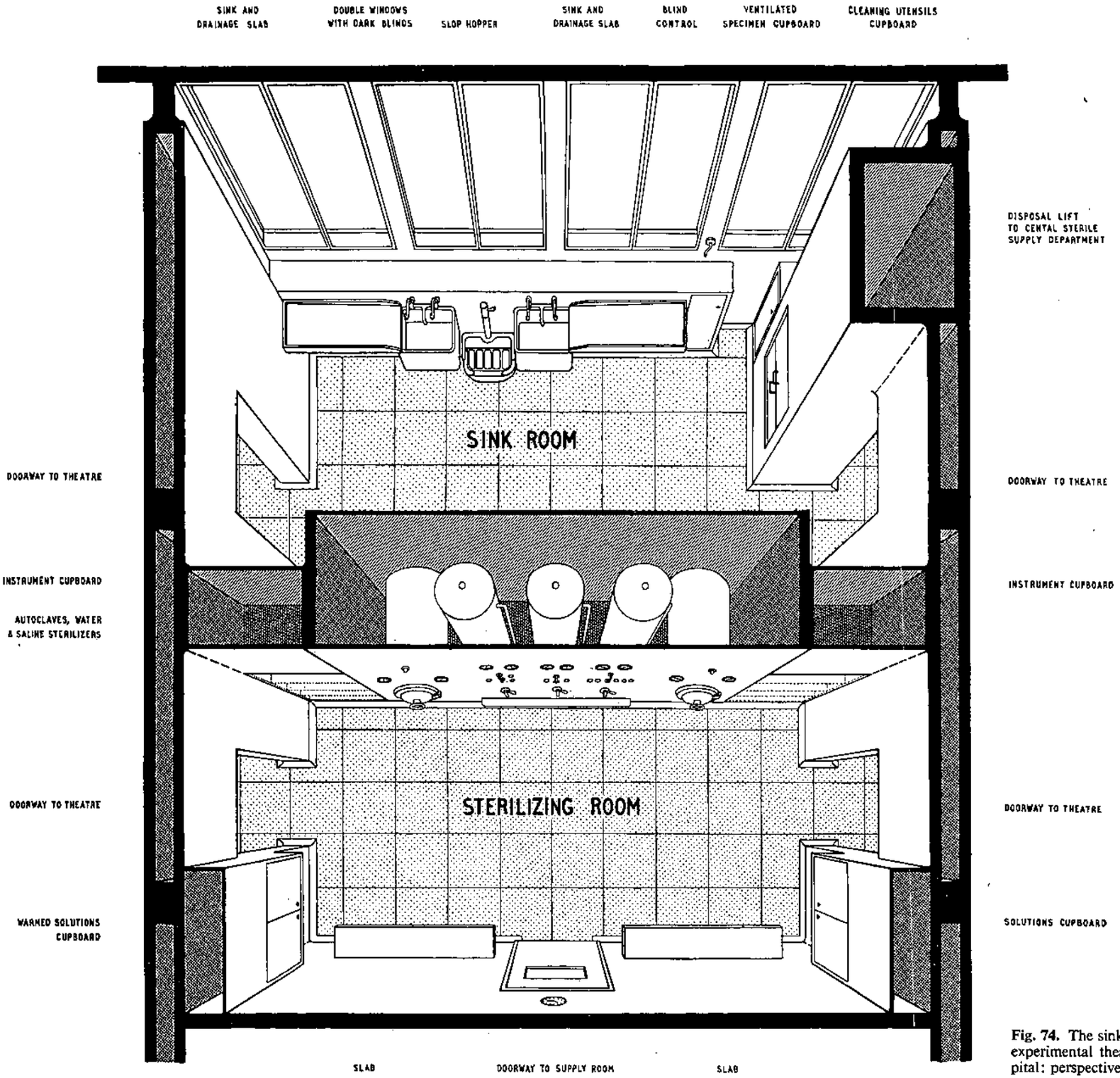


Fig. 74. The sink-room and sterilizing-room in the experimental theatre suite at Musgrave Park Hospital: perspective view seen from above

The double windows have blinds between the two panes of glass to enable the room to be darkened. Artificial lighting, as in the anaesthetic-room, is of three types: general—from a recessed ceiling-fitting; inspection—from an adjustable telescopic arm-fitting mounted on the ceiling; shaded—from a recessed narrow-beam fitting, over the sink and drainage-slab. These fittings have separate switches. The patient's own bed will be used in the recovery-bay. Other movable furniture consists only of a small table and chair for whoever is attending the patient.

The exit-bay, at the other end of the room, has no equipment beyond a sink and the built-in blanket cupboard previously mentioned. Here the blankets may be put on the patient's bed without fear of contaminating the air in the theatre, and he may be made comfortable for his return to the ward away from the bustle of the remainder of the suite. So that the room may be used if need be for post-operative plaster work, the floor has a drainage channel at one side, and the sink has a plaster-trap. Artificial lighting is provided from a recessed ceiling-fitting and an inspection fitting as in the recovery-bay and anaesthetic-room. The latter fitting would normally be used only for plaster work.

Other Rooms in the Theatre Suite.—All changing- and rest-rooms and the corridor in the theatre block have an acoustic ceiling and heavy linoleum floor covering. Walls are finished in emulsion paint and the colour schemes will be designed to give a cheerful atmosphere. Artificial lighting is provided generally from ceiling-fittings of the type used in the corridors in the ward block, and in addition desk lamps are provided in the rest-rooms and sister's office. Natural lighting and ventilation for these rooms, which are on an outside wall, is through ordinary single-glazed windows in timber frames.

Heating and Ventilating.—The theatres, sink-room, sterilizing-room, supply, scrub-up, anaesthetic-room, exit-room, and recovery-room, and the theatre suite corridor are artificially ventilated with filtered and humidified air. The temperature of the air is controlled within the range of 65°–70° F. in the rooms, and the humidity is controlled at 55–60 per cent. (cf. p. 78). The air is brought into the building at roof-level and delivered to the conditioning plant in the basement. All machinery has been chosen for silence in operation, and is mounted on resilient bases to prevent vibration being transmitted to the structure. An electrostatic precipitator is used for filtering the air supplied to the theatres themselves and the main ancillary rooms. Distribution is by means of vertical ducts running in the double walls (*Fig. 70*), delivery of air to the rooms being at high level, and extraction at low level. In the theatre the movement of air is across the patient, to minimize the chances of self-infection (see p. 80). The temperature is even throughout the suite of conditioned rooms, and the pressure of air is balanced to prevent air moving from any room into the theatres and sterilizing-room. Air is delivered to all rooms at a rate sufficient to ensure twelve air-changes an hour.

The rooms in the theatre suite are heated from the ceiling, which is built of aluminium panels clipped on to heating pipes—as in the remainder of the building (see p. 131)—as well as by warmed air. The ceiling is designed to give enough heat to offset any losses through the structure, windows, &c., and to provide background warmth, and the air-conditioning system is designed to adjust the temperature to the required degree by supplying warmed air. The warmed structure minimizes condensation due to the high relative humidity. No refrigeration system is to be installed.

3. The Central Sterile Supply Department

General planning.—No central sterile supply department exists in the United Kingdom, and so the Investigation was unable to carry out work-studies as was done, for example, in connexion with ward design. Members of the team visited and observed work in central syringe departments in England, at a central sterile supply department in Holland, and at an American military hospital in England. In addition, much information was obtained from United States Public Health Service publications, from reports from nurses who had visited central sterile supply departments in the United States and Canada, and from correspondence with Dr. McCaffrey, of the Royal Newcastle Hospital, New South Wales.

The department at Musgrave Park Hospital, on the ground floor of the theatre block, is to be accessible from the entrance hall in the link between the theatre and ward blocks (*Fig. 69*). The general planning takes the form of a 'U' with the receiving room at one end and the issuing room at the other (*Fig. 64*).

Goods received from other hospital departments will be washed thoroughly in the receiving and clean-up room. A hatch opening directly to the outside air is planned at one end of the room for the disposal of waste material in bins. This hatch is close to the foot of the disposal lift from the theatre suite above.

The work-room is equipped with a continuous working surface round the walls.

Sterilizing will be done in two rectangular autoclaves and two hot-air sterilizers built into one wall of the autoclave room. The backs of these are accessible for maintenance, but only doors and controls will be visible from the front. Operation of the sterilizing sequence in the autoclaves is automatic with continuous recording of temperatures reached in the chamber. The supervisor will have a small office.

A store for sterilized goods opens off the autoclave room. At one end of the store-room is the clean-supplies lift to the theatre suite above, and the door for issuing supplies to other hospital departments.

Artificial lighting throughout the department is from totally enclosed glass fittings mounted on the ceiling. Points for desk lights are provided in the work-room and over writing-desks. Natural light is provided by a continuous range of windows on the east wall of the department.

The department is not air-conditioned, but filtered air is supplied to the sterile store, and air is removed mechanically from the autoclave room. The heating system is similar to that in the remainder of the building.

SUMMARY

Operating Theatres. Advances in aseptic technique and improvements in surgical equipment have not wholly abolished the risk of sepsis in surgical operations. The planning and equipment of the theatre suite is of first importance if aseptic techniques are to be carried out satisfactorily. In experimental theatre suites a physical distinction has sometimes been made between 'clean' and 'dirty' procedures. It is by no means certain that a suite which imposes a pattern of work on those who use it, no matter how theoretically excellent, is in practice as useful as, or much more likely to maintain aseptic conditions, than one which may be used in a variety of ways. The size of each room in the suite and the relation of the rooms one to another should be determined by the work to be carried out in them, and lighting, finishes, colour, and equipment should all be designed to assist those using the theatre suite to carry out their work in the most efficient manner.

The risks to patients in the immediate post-operative period have led in some hospitals to the establishment of recovery rooms, and in a few instances, recovery wards.

Central sterile supply departments have recently been established in some countries. The advantages of such a department are believed to lie not only in better service to patients through more reliable sterilization but to better maintenance of equipment and other economies.

The system of heating and ventilating in an operating theatre suite must not only provide conditions of comfort for the patient and theatre staff, but must also make a positive contribution to air hygiene, and reduce the risks of explosion.

The Investigation was invited by the Northern Ireland Hospitals Authority to design a theatre suite, a central sterile supply department, and an X-ray department. These departments occupy the same site as the experimental ward unit designed by the Investigation, but are planned as a separate two-story block making use of a common entrance hall, lift, stairs, and some staff rooms. The twin theatre suite has been planned as a cul-de-sac department on the first floor of the block and will be connected directly with the central sterile supply department below by two goods-lifts, one 'clean' and one 'dirty'. The central sterile supply department is designed to serve the whole of Musgrave Park Hospital.

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4 THE PHYSICAL ENVIRONMENT WITHIN THE HOSPITAL

DAYLIGHTING
ARTIFICIAL LIGHTING IN WARD UNITS
COLOUR
THE CONTROL OF SOUND
HEATING AND VENTILATING

Problems of physical environment are discussed in this chapter under the headings of daylighting, artificial lighting, colour, the control of sound, and heating and ventilating.

In the immediate past, heating, lighting, and ventilating services for large buildings have usually been provided by engineers called in too late to make any contribution to the general design. Daylighting and colour have more often been regarded as an integral part of architecture; but the full contribution which the physical sciences can make has only recently been realized.

In these matters the Investigation has worked in association with the Building Research Station of the Department of Scientific and Industrial Research and arrangements were made for a member of the Investigation to be seconded to the Station, where he worked in the Physics Division. In planning the Investigation's experimental ward units it was found possible to apply some of the results of previous research carried out by the Physics Division into the physical requirements of other types of building, particularly houses and schools. In addition, other published material has been reviewed and considered in relation to the work of the Investigation.

Physical environment has a bearing both on major problems of hospital planning and on the detail of design. So far as detail is concerned, the architect can generally meet the requirements—for example, he can specify door-closers which are quiet or window arrangements which will minimize glare. But conclusions having a direct bearing on planning cannot always be implemented. For example, it might be desirable from the point of view of sound-control to remove the ward kitchen far from the vicinity of the patients' beds, but if that were done the serving of food would be made very inconvenient. Again, requirements for good daylighting might to some extent contradict those for efficient heating. Therefore the conclusions to be drawn from this chapter, in so far as they relate to planning, have to be weighed against the functional needs of the building and against one another.

DAYLIGHTING

Introduction

THE insistence on good natural daylight in hospitals became particularly strong in the nineteenth century as a result of the efforts of Florence Nightingale and others to improve standards of cleanliness and hygiene, and very large windows have become a characteristic feature of hospital design.

That good lighting encourages cleanliness by showing up dust and dirt is obvious. But, as Professor L. P. Garrod confirmed in studies made in 1944,[1] it has also direct bactericidal effect: the action of light on haemolytic streptococci was carefully investigated, and it was found that close to windows even the thickest dust was consistently free from streptococci. In experiments with films of dried pus containing haemolytic streptococci, Garrod found that the streptococci died most rapidly in a position exposed to sunlight. Diffused daylight from a north window was also lethal within 13 days or less; in a dark cupboard survival was prolonged for many weeks. Similar results were obtained with infected dust. Garrod established that light which has passed through glass still has a bactericidal action; and so has daylight on dull, cloudy days.

Thus, on grounds of hygiene, there is every reason for strong light and large windows. Indeed, for hygiene, the larger the window the better; but there are opposing considerations, some of which point in a different direction. Some heating engineers have argued that large areas of glass increase the heat-loss from the building, and hence the heating bill. Too much weight should not be allowed to this argument for reasons discussed in the section on heating and ventilating (p. 129). A more serious objection to large areas of glass is the discomfort that patients may suffer from glare, which can be a very real source of distress, especially to the very sick.

Designing a hospital window is not easy; it must simultaneously give maximum light and minimum glare—conditions which are difficult to combine. It was comparatively easy to ensure good light in a pavilion hospital, open in plan, but in a modern one, partly to reduce walking distances and partly to reduce building costs, the planning is compact. There are, therefore, deeper rooms to light, and often windows can only be placed on one

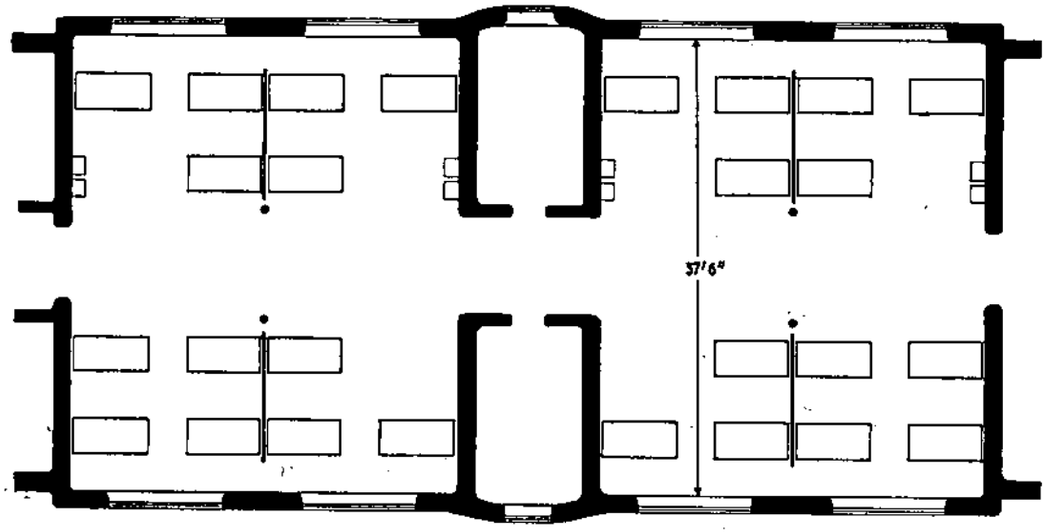

Fig. 75. Plan of a partitioned ward, with beds parallel to the windows, in the Rigs Hospital, Copenhagen (1910)

side. In addition, economy frequently demands low ceilings, which add to the difficulty of good daylighting.

In the course of studies on ward planning, the Investigation became convinced that functional efficiency could best be met by very compact layout (see p. 145). It was found that ventilation was unlikely to prove a critical difficulty (see pp. 124–8), but that daylight penetration would probably be a limiting factor. Accordingly an investigation into ward lighting was carried out in collaboration with the Building Research Station.[2] The methods and results of these studies are described below. No special research has been undertaken by the Investigation into daylighting problems in other parts of the hospital. In many cases these problems are similar to those occurring in other types of building, such as schools and offices, on which work has already been carried out and published.[3]

Ward Design in relation to Daylight

The traditional English hospital ward is a long room, high in proportion to its width, with the beds arranged with their heads against the outside walls. Windows often reach up to the ceiling. Consequently the ward is usually brightly lit over its whole area, and since every patient faces a window in the wall opposite him, and is also flanked by windows, he cannot turn away from the light unless his bed is at the end of the ward. When he sits up in bed the window opposite is inevitably distracting, since it is the brightest surface visible, and the flat areas of wall on either side appear to be comparatively dark. Unless these areas of wall are very light in colour, so as to reflect most of the light entering from the windows opposite, a patient sitting up in bed is subjected to conditions of glare sufficient to cause discomfort.[4]

The Rigs Hospital arrangement (see *Fig. 75*), in which the beds are placed parallel with the window walls, is now often used and has advantages over the 'Nightingale' layout in regard to daylighting. The patient has the choice of lying facing or away from the light, and, when sitting up, he faces a wall which is receiving and reflecting light obliquely and which has no bright sources of light in it.

Fig. 76 shows the three different arrangements which are the basis for most modern ward planning. Type (A) is an open ward with bays each containing 4 beds, on either side of a passage-way; light is obtained from both sides of the room. Type (B) is a 4-bedded room with a window on one side only. Type (C) is a 6-bedded room with a window on one side only. This last plan lends itself to highly concentrated and economical planning, and is used in the most recent hospitals in Switzerland and Sweden, but has been little used in Great Britain.

The experimental wards designed by the Investigation include all three arrangements. The first experimental building, at Larkfield Hospital, Greenock, includes type (A) and, in modified form, type (B). The experimental wards at Musgrave Park Hospital, Belfast, have 6-bedded and 4-bedded rooms, that is, types (B) and (C).

In the early stages of planning, daylighting in wards was studied at the Building Research Station to determine whether a building as deep as the proposed wards and

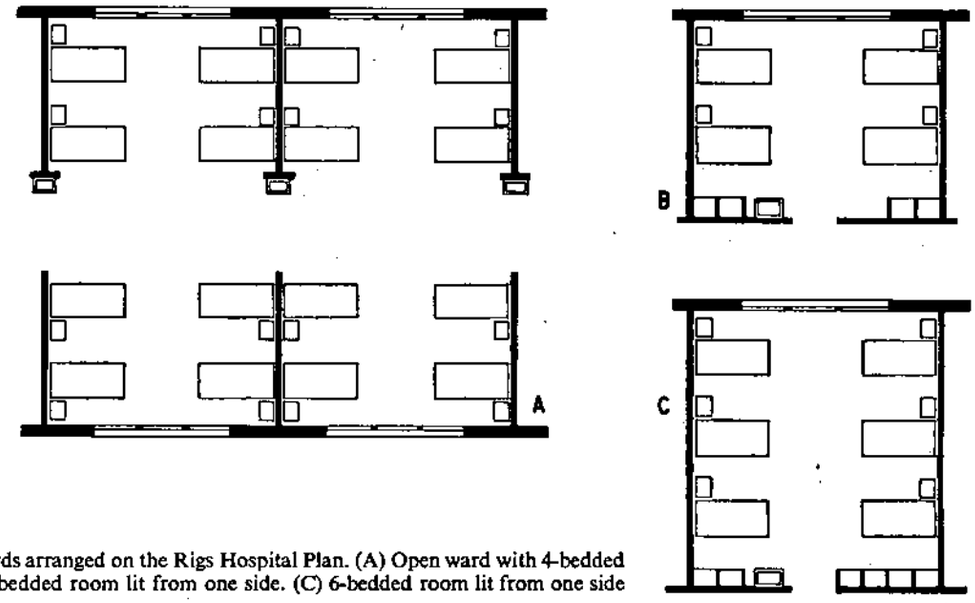

Fig. 76. Daylighting in three wards arranged on the Rigs Hospital Plan. (A) Open ward with 4-bedded bays lit from both sides. (B) 4-bedded room lit from one side. (C) 6-bedded room lit from one side

with a maximum ceiling height of 12 feet could be adequately lighted by daylight alone. Besides the provision of a satisfactory level of illumination in the parts of the ward remote from the windows, it was equally important to achieve visual comfort for the patients in beds near the windows.

The studies were conducted in two stages. First, a thorough appraisal of the physical lighting problems was made both by calculation from the proposed plans and by a detailed photometric study in a scale model of the ward (see *Fig.* 77). The 2 per cent. daylight factor specified in the Ministry of Education Regulations[5] was adopted as a minimum at the beds and measurements were made to determine whether this value could be achieved with the given conditions. Secondly, a general subjective appraisal of conditions in the ward based on previous work on discomfort from glare done at the Building Research Station was made in the model.

Studies for the Wards at Larkfield Hospital, Greenock

A number of methods have been devised for determining the amount of light admitted to a room through windows. These methods give a measure of relative illumination termed the 'sky-factor'. Sky-factor at a point within a building is defined as the ratio of the illumination on a horizontal or other defined plane due to light received directly from the sky, to the illumination due to an unobstructed hemisphere of sky of uniform luminance (that is, brightness) equal to that of the visible sky. It does not include light reflected from the ground outside, or from the walls, floor, or ceiling within the room, and takes no account of losses due to absorption or reflection at the windows. This ratio, which is expressed as a percentage, is a geometric property of the building design.

The Building Research Station has developed a protractor with the aid of which sky-factor at any point in a room can be calculated from architects' drawings.[6]

Sky-factor has been much used in daylighting studies for schools and factories and provides a means of rough comparison; but for the ward study it was felt that a more accurate comparison was desirable. For this the determination of 'daylight-factor' is required. Daylight-factor is the ratio between illumination, both direct and reflected, received on a horizontal plane at a point in a building, and that received from a hemisphere of sky. Although methods of calculating daylight-factor existed at that time, they were laborious, particularly where precision was

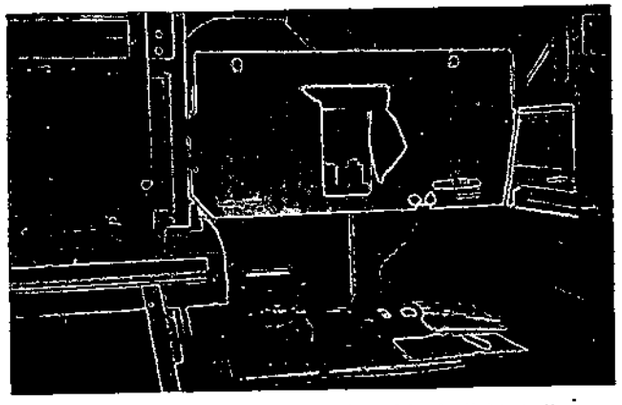

Fig. 77. General view of ward model used in daylight studies

required. Since light transmission and reflection are dimensionless, illumination, particularly natural illumination, can be conveniently studied by the use of models. Following the studies made in the model of the ward, work has continued on other configurations of building, and less laborious techniques have been developed for calculating daylight-factors.[7]

A model of a section of the experimental ward at Larkfield Hospital was constructed to a scale of 1 inch to 1 foot. The ceiling could be raised or lowered and the windows and internal walls were made removable, to enable comparative measurements to be made with different wall formations and window designs. Panels in the floor were also made removable so that by sitting underneath observers were able to place their heads inside the model. In this way the lighting conditions could be inspected from approximately the same position as in the completed building.

Since prolonged and detailed investigation would be impossible under the natural sky, which is continually and rapidly changing in brightness distribution, artificial skies were specially designed for use with the model. *Fig. 77* is a general view of the apparatus and shows the placing of the artificial skies relative to the model.

Measurements were made of illumination, and hence daylight-factor, using a series of small selenium rectifier photocells. *Figs. 78* and *79* show the positions at which measurements were taken. The positions were chosen as being at significant points in the pattern of work in wards.

The results of the experiment may be summarized under three general headings:

(*a*) The effect of ceiling height on the daylight-factor.

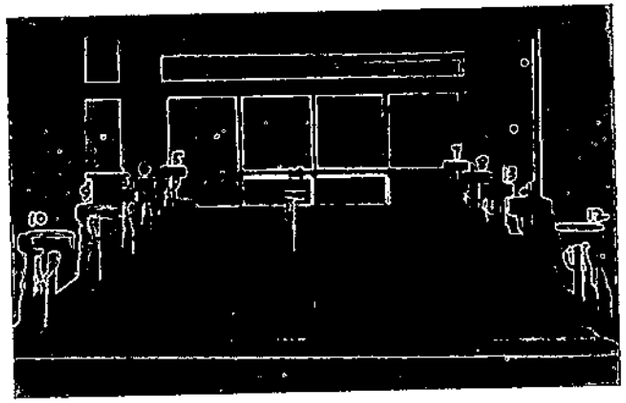

Fig. 78. Interior view of model of Larkfield experimental ward used in daylighting studies, showing photocells and baffle window

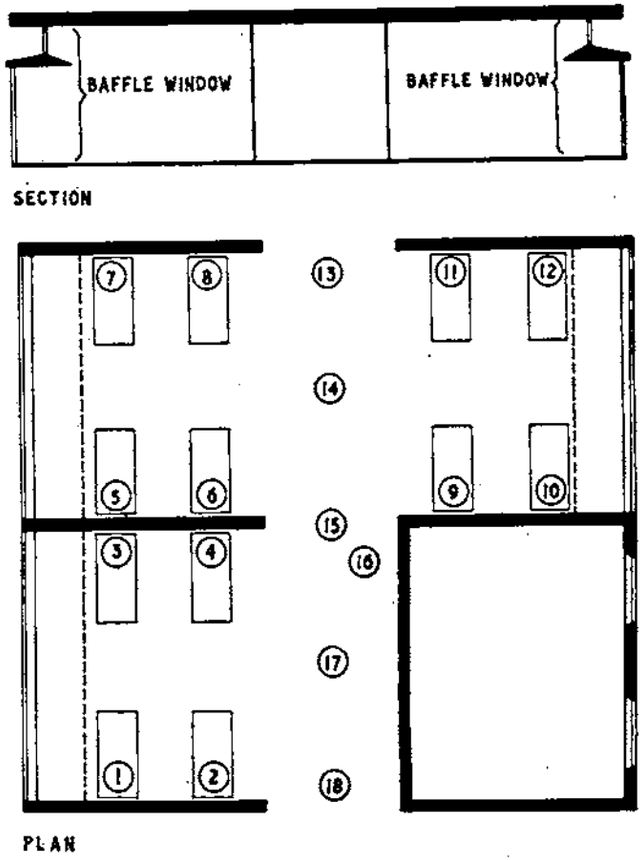

Fig. 79. Plan and section of model of Larkfield experimental ward used in daylighting studies, showing positions of photocells

(*b*) The effect of window design on the daylight-factor.

(*c*) The contributions of walls, ceiling, and floor to the daylight-factor.

(*a*) *The effect of ceiling height on the daylight-factor.* Sky-factors were computed, using B.R.S. protractors, at each photocell position, with three different ceiling heights, and with completely unobstructed window walls. The figures obtained are compared in columns 2 to 4 of *Table 30*, and from these it will be seen that even when the ceiling height is made 10 feet, or approximately one-quarter of the width of the room, the sky-factor falls below 1 per cent. at only one point.

Daylight-factor measurements made in the model for each ceiling height are compared in columns 2 to 4 of *Table 31*. The ceiling and all wall-surfaces were painted matt white with a reflection-factor* of 83 per cent., and the floor was plain plywood of 36 per cent. reflection-factor. The floor was not painted white as this would give a result not normally attainable in practice. The window was a sheet of $\frac{3}{16}$ in. clear perspex. From the results obtained it is seen from *Table 31* that relatively high daylight-factors are obtained if ceiling height is reduced to 10 feet, provided that walls, ceiling, and floor have relatively high reflection-factors.

(*b*) *The effect of window design on the daylight-factor.* Sky-factor computations were made for several window designs as a preliminary to trying them in the model. It was evident that a considerable area of glass would be necessary to obtain good penetration of light to the centre of the ward, but it was at the same time necessary to protect the patients nearest the windows from too extensive a view of the sky. To meet this requirement a window was designed with a horizontal baffle, projecting 3 ft. 6 in. into the room at a height of 7 ft. 4 in. above the floor, with the inner edge tapered, and with windows above it set back from the building face (see p. 97). The baffle completely obscures the view of the high sky from the patient nearest the window, while the glass above allows light to penetrate deeply into the room. Part of the window extends down to the floor so that a portion of the floor can, by reflection, make a useful contribution to the light of the room (see *Fig. 78*). It was also hoped that light would be reflected from the top surface of the baffle on to the ceiling and thence down into the room, thus further

* Reflection-factor (R.F.) is the ratio of light reflected from a surface to the light falling on that surface.

Table 30. Illumination measurement in the model of the Larkfield Experimental Ward: *Sky-factor comparison at different ceiling heights.* (*After R. G. Hopkinson et al.*[2])

Photocell position (see Fig. 79) 1	*10-foot ceiling with clear windows (per cent.)* 2	*12-foot ceiling with clear windows (per cent.)* 3	*10 ft. 9 in. ceiling with clear windows (per cent.)* 4	*10 ft. 9 in. ceiling with 'Baffle' windows (per cent.)* 5	*Reduction due to baffle windows expressed as fraction of value obtained with clear windows* 6
1	10·9	13·7	11·9	5·0	0·58
3	10·9	13·8	12·0	5·1	0·58
5	11·1	14·0	12·2	5·2	0·57
7	11·1	14·0	12·2	5·2	0·57
10	11·1	14·0	12·2	5·3	0·56
12	11·1	14·0	12·2	5·3	0·56
2	2·1	3·2	2·5	1·6	0·36
4	2·4	3·7	2·9	1·9	0·34
6	2·5	3·9	3·0	2·0	0·33
8	2·5	3·9	3·0	2·0	0·33
9	2·9	4·4	3·5	2·4	0·31
11	2·5	3·9	3·0	2·0	0·33
13	1·7	2·8	2·1	1·6	0·24
14	2·0	3·2	2·4	1·8	0·25
15	2·2	3·5	2·7	1·9	0·30
16	1·0	1·7	1·3	1·1	0·15*
17	1·0	1·6	1·2	0·9	0·25
18	0·9	1·4	1·1	0·8	0·27

* At this position the internal wall formations used in the two sets of measurements on the 10 ft. 9 in. ceiling were slightly different

Table 31. Illumination measurement in the model of the Larkfield Experimental Ward: *Daylight-factor comparison at different ceiling heights.* (*After R. G. Hopkinson et al.*[2])

Photocell position (see Fig. 79) 1	*10-foot ceiling with clear windows (per cent.)* 2	*12-foot ceiling with clear windows (per cent.)* 3	*10 ft. 9 in. ceiling with clear windows (per cent.)* 4	*10 ft. 9 in. ceiling with 'Baffle' windows (per cent.)* 5	*Reduction due to baffle windows expressed as fraction of value obtained with clear windows* 6
1	28·3	29·3	28·7	18·5	0·35
3	27·0	27·8	27·3	17·8	0·35
5	30·0	30·2	30·1	18·0	0·40
7	27·3	28·4	27·7	17·6	0·36
10	29·0	29·6	29·2	17·7	0·39
12	28·3	29·6	28·8	18·6	0·35
2	11·3	12·7	11·8	8·6	0·27
4	11·2	12·5	11·7	8·8	0·25
6	13·2	14·2	13·6	9·8	0·28
8	11·8	13·4	12·4	9·4	0·24
9	12·7	14·7	13·4	10·5	0·22
11	13·6	15·6	14·3	11·0	0·23
13	9·3	10·7	9·8	7·6	0·22
14	10·6	12·2	11·2	8·4	0·25
15	9·8	11·3	10·4	8·7	0·16
16	7·2	8·0	7·5	7·8	−0·04*
17	8·6	9·5	8·9	7·0	0·21
18	8·2	9·0	8·5	5·8	0·32

* At this position the internal wall formations used in the two sets of measurements on the 10 ft. 9 in. ceiling were slightly different

Table 32. Illumination measurements in the model of the Larkfield Experimental Ward: *Measurements made to determine the contribution to daylight-factor of each surface in the ward*

Note: The surfaces referred to in this table are shown in *Fig. 79*

	Beds near windows						*Beds farthest from windows*						*Central line of ward*					
Photocell position	*1*	*3*	*5*	*7*	*10*	*12*	*2*	*4*	*6*	*8*	*9*	*11*	*13*	*14*	*15*	*16*	*17*	*18*
No surfaces blackened																		
Daylight-factor (R.F.s: walls and ceiling 83%, floor 36%)	18·5	17·8	18·0	17·6	17·7	18·6	8·6	8·8	9·8	9·4	10·5	11·0	7·6	8·4	8·7	7·8	7·0	5·8
Computed sky-factor	5·0	5·1	5·2	5·2	5·3	5·3	1·6	1·9	2·0	2·0	2·4	2·0	1·6	1·8	1·9	1·1	0·9	0·8
Difference between daylight- and sky-factor	13·5	12·7	12·8	12·4	12·4	13·3	7·0	6·9	7·8	7·4	8·1	9·0	6·0	6·6	6·8	6·7	6·1	5·0
Surfaces blackened																		
Wall of single room parallel to windows	18·1 −0·4	17·2 0·6	18·2 +0·2	17·2 −0·4	17·9 +0·2	18·9 +0·3	7·5 −1·1	7·8 −1·0	9·6 −0·2	9·5 +0·1	10·5 0	11·1 +0·1	7·6 0	8·3 −0·1	7·1 −1·6	3·8 −4·0	4·2 −2·8	3·7 −2·1
Wall of single room at right angles to windows	18·6 +0·1	17·8 0	18·2 +0·2	17·1 −0·5	13·4 −4·3	17·6 −1·0	8·6 0	8·9 +0·1	9·8 0	9·3 −0·1	7·0 −3·5	9·9 −1·1	7·1 −0·5	7·8 −0·6	8·3 −0·4	7·8 0	6·9 −0·1	5·9 +0·1
Far side of centre wall	18·5 0	17·7 −0·1	14·1 −3·9	16·3 −1·3	17·8 +0·1	18·7 +0·1	8·6 0	8·9 +0·1	7·7 −2·2	8·8 −0·6	10·4 −0·1	10·8 −0·2	7·2 −0·4	8·0 −0·4	8·4 −0·3	7·8 0	6·9 −0·1	5·8 0
Near side of centre wall	17·3 −1·2	12·7 −5·1	18·1 +0·1	17·4 −0·2	17·9 +0·2	18·9 +0·3	7·7 −0·9	6·4 −2·4	10·1 +0·3	9·6 +0·2	10·6 +0·1	11·1 +0·1	7·7 +0·1	8·5 +0·1	8·3 −0·4	7·4 −0·4	6·2 −0·8	5·3 −0·5
Far end wall	18·2 −0·3	17·5 −0·3	16·3 −1·7	12·0 −5·6	15·9 −1·8	13·2 −5·4	8·3 −0·3	8·4 −0·4	8·3 −1·5	5·3 −4·1	8·5 −2·0	6·3 −4·7	5·1 −2·5	6·5 −1·9	7·5 −1·2	7·1 −0·7	6·5 −0·5	5·6 −0·2
Near end wall	13·0 −5·5	16·5 −1·3	17·7 −0·3	17·2 −0·4	17·5 −0·2	18·4 −0·2	4·8 −3·8	7·5 −1·3	9·7 −0·1	9·2 −0·2	10·2 −0·3	10·7 −0·3	7·4 −0·2	8·3 −0·1	8·0 −0·7	7·1 −0·7	5·6 −1·4	4·1 −1·7
Floor (natural wood 36% R.F.)	15·1 −3·4	14·4 −3·4	14·6 −3·4	14·0 −3·6	14·7 −3·0	15·8 −2·8	5·9 −2·7	5·9 −2·9	6·8 −3·0	6·6 −2·8	7·1 −3·4	7·8 −3·2	4·9 −2·7	5·3 −3·1	5·5 −3·2	5·0 −2·8	4·4 −2·6	3·8 −2·0
Ceiling	13·8 −4·7	13·3 −4·5	13·9 −4·1	12·8 −4·8	13·0 −4·7	14·1 −4·5	4·4 −4·2	4·2 −4·6	4·9 −4·9	5·0 −4·4	5·3 −5·2	5·9 −5·1	3·6 −4·0	3·4 −5·0	3·7 −5·0	3·9 −3·9	2·9 −4·1	2·8 −3·0
Underside of left-hand baffle	15·9 −2·6	15·4 −2·4	15·8 −2·2	15·0 −2·6	17·5 −0·2	18·6 0	8·3 −0·3	8·5 −0·3	9·6 −0·2	9·1 −0·3	10·4 −0·1	10·9 −0·1	7·4 −0·2	8·3 −0·1	8·4 −0·3	7·6 −0·2	6·6 −0·4	5·6 −0·2
Underside of right-hand baffle	18·2 −0·3	17·6 −0·2	17·8 −0·2	17·4 −0·2	15·3 −2·4	16·3 −2·3	8·5 −0·1	8·8 0	9·8 0	9·4 0	10·1 −0·4	10·7 −0·3	7·4 −0·2	8·3 −0·1	8·5 −0·2	7·8 0	6·9 −0·1	5·8 0
Upperside of left-hand baffle	16·3 −2·2	15·6 −2·2	16·1 −1·9	15·8 −1·8	17·4 −0·3	18·3 −0·3	7·2 −1·4	7·5 −1·3	8·5 −1·3	8·4 −1·0	10·0 −0·5	10·5 −0·5	7·1 −0·5	7·9 −0·5	7·8 −0·9	7·1 −0·7	6·1 −0·9	5·2 −0·6
Upperside of right-hand baffle	18·2 −0·3	17·5 −0·3	17·6 −0·4	17·3 −0·3	15·8 −1·9	16·7 −1·9	8·5 −0·1	8·7 −0·1	9·6 −0·2	9·1 −0·3	9·0 −1·5	9·5 −1·5	7·1 −0·5	7·9 −0·5	8·3 −0·4	7·7 −0·1	6·8 −0·2	5·8 0
Underside of left-hand canopy	17·3 −1·2	16·9 −0·9	17·1 −0·9	16·6 −1·0	17·5 −0·2	18·5 −0·1	7·8 −0·8	8·0 −0·8	9·0 −0·8	8·7 −0·7	10·2 −0·3	10·8 −0·2	7·3 −0·3	8·1 −0·3	8·1 −0·6	7·4 −0·4	6·4 −0·6	5·4 −0·4
Underside of right-hand canopy	18·2 −0·3	17·6 −0·2	17·7 −0·3	17·3 −0·3	16·8 −0·9	18·0 −0·6	8·5 −0·1	8·8 0	9·8 0	9·3 −0·1	9·6 −0·9	10·1 −0·9	7·3 −0·3	8·1 −0·3	8·4 −0·3	7·8 0	6·9 −0·1	5·8 0
Vertical surfaces and sill of left-hand window	16·7 −1·8	16·0 −1·8	16·3 −1·7	15·9 −1·7	17·7 0	18·6 0	8·0 −0·6	8·3 −0·5	9·3 −0·5	9·0 −0·4	10·3 −0·2	10·8 −0·2	7·4 −0·2	8·2 −0·2	8·3 −0·4	7·4 −0·4	6·5 −0·5	5·5 −0·3
Vertical surfaces and sill of right-hand window	18·2 −0·3	17·5 −0·3	17·6 −0·4	17·3 −0·3	15·9 −1·8	17·0 −1·6	8·6 0	8·9 +0·1	9·7 −0·1	9·3 −0·1	9·8 −0·7	10·3 −0·7	7·3 −0·3	8·2 −0·2	8·5 −0·2	7·8 0	6·9 −0·1	5·8 0

reducing the contrast in brightness at the window and at the centre of the ward. This would not be apparent from the sky-factor curves, since these take no account of the reflected light. This window was inserted into the model, and the daylight-factor readings were taken. *Table 33* shows that the baffle makes a considerable reduction in the total light, although even in the centre of the ward the amount of light is still adequate. Part of the loss is due to the thickness of the window frames which had not been taken into account previously. Although the baffle makes little difference to the uniformity of light distribution, subjective assessments, made in the model, suggest that distribution will be comfortable and that the baffle will provide a smooth gradation between the high brightness of the window and lower brightness of the surfaces inside the ward.

(*c*) *The contributions of walls, ceiling, and floor to the daylight-factor.* The studies show that the satisfactory distribution of light in rooms is largely the result of reflection from the walls, ceiling, and floor. Any scheme of decoration in colours other than white would therefore result in a lowered average daylight-factor in the ward as compared with the measurements already noted. For guidance in the choice of colour it is necessary to discover the contributions of each surface of the daylight-factor at any point in the room. The walls, ceiling, and floor of the model were divided up into what were considered to be the sixteen major components of any scheme of decoration, and the contribution of each to the daylight-factor was measured at the various points used in previous studies.

The surfaces were covered with black card, one at a time, and the reduction in illumination produced by each alone was measured. This reduction was thus due to the removal of all light reflected by that surface, either directly, or indirectly via other surfaces. *Table 32* gives in detail the results obtained. The upper figure in each square is the daylight-factor, measured at each position when one particular surface was covered with black card, and the lower figure is the actual reduction from the total daylight-factor measured when all the surfaces were white. From this table it can be seen that if the ceiling is black, and thus reflects no light, it produces an overall reduction of almost 5 per cent. daylight-factor—more than half of the maximum possible light factor at points far from the window. Similarly, if the floor is black, an overall reduction of 3 per cent. daylight-factor results—more than one-third of the maximum at these points. The contribution of the floor is, however, greater than that of the ceiling, since the ceiling reduction was from white, with a reflection-factor of 83 per cent., and the floor reduction was from plywood, with a reflection-factor of 36 per cent. Another fact which can be seen from *Table 32* is that any one wall has a considerable effect on the light at points close to it, but has little effect on the overall illumination of the ward.

A further series of measurements was then taken in the model with walls coloured grey, with a reflection-factor of 44 per cent. corresponding to colours of value 7 in the Munsell range (see p. 110) and with a cork floor of the same colour and texture as is used in the completed ward block at Greenock. This floor has a reflection factor of 18 per cent. *Table 33* gives the figures obtained in a related series of measurements, and shows the progressive decrease in the daylight-factor at the measuring points as the reflection-factor of the walls and floor is reduced. At the worst, the daylight-factor at any bed does not fall below 3·2 which is more than 50 per cent. above the minimum standard already referred to on p. 93.[5]

Table 33. Illumination measurement in the model of the Larkfield Experimental Ward: *Daylight-factor measurements with baffle window and various schemes of decoration.* (*After R. G. Hopkinson et al.*[2])

Ceiling height	10 ft. 9 in.	10 feet	10 feet	10 feet	10 feet
Walls at right angles to windows	White	White	White	Blue	Blue
Walls parallel to windows	White	White	White	White	White
Ceiling	White	White	White	White	White
Floor	Wood	Wood	Cork	Cork	Cork
Beds	None	None	None	None	In position
Photocell position	*Daylight-factor (per cent)*				
1	18·2	14·6	13·0	11·3	11·6
3	16·8	13·8	12·1	10·9	11·2
5	17·0	14·3	13·0	11·7	12·1
7	16·9	13·8	11·7	10·0	10·3
10	18·6	15·7	14·0	12·8	12·8
12	19·4	15·8	14·0	12·5	12·8
2	7·9	5·8	4·5	3·4	3·2
4	8·3	6·0	4·7	3·8	3·6
6	9·6	7·2	5·6	4·7	4·5
8	9·2	6·6	5·2	4·2	3·9
9	10·5	7·6	5·9	4·5	4·3
11	11·0	7·8	6·4	5·1	4·7
13	6·6	5·0	3·8	3·2	3·2
14	8·1	6·2	4·6	3·9	3·8
15	8·2	6·2	4·8	3·9	3·7
16	7·0	5·6	—	—	—
17	6·1	5·0	3·9	3·2	3·0
18	4·6	3·7	2·9	2·3	2·2

NOTE. *Reflection-factors:* Ceiling and white walls . 83%
Blue walls . . . 44%
Wooden floor . . . 36%
Cork floor . . . 18%

Several important conclusions may be drawn from the measurements of the contributions to the daylight-factor from reflecting surfaces within the ward.

Provided that the average reflection-factor of the walls, ceiling, and floor is high, the ward acts as a very efficient integrator of light. Thus there is considerable scope for the design of colourful schemes of decoration, if these are considered as a whole and if the average reflection-factor of the scheme is maintained comparatively high. A point worthy of mention here is that complementary colours, if saturated, will not exhibit their white-light reflection-factors when used together. This is because the average reflection-factor is relatively low, each colour absorbing light from opposite parts of the spectrum.

If the average reflection-factor of the walls, ceiling, and floor is low, the contribution of any one wall, even if of a very high reflection-factor, will be small at points other than those in its immediate vicinity, where moreover it will be much smaller than might be expected; and it will be smaller still if the colour of that wall contrasts with those of the general scheme.

As the ceiling height is reduced, so the scope for the design of colour schemes becomes more restricted, because the proportional contribution of each wall to the total illumination is greater. *Tables 30* and *31* illustrate the fact that with lower ceiling heights the difference between daylight-factor and sky-factor is proportionally greater.

The ceiling derives much of its illumination from the floor, and together they make a considerable contribution to the daylight-factor. The floor and the lower parts of the walls should be finished in as light a colour as possible if full value is to be obtained from a ceiling of very high reflection-factor.

This work shows that the use of sky-factor alone, as a measure of the illumination to be expected in a building, may be misleading. It will be seen by comparing *Tables 30* and *31* that the daylight-factor can be as much as five times the sky-factor. The conclusion is drawn that the sky-factor gives a measure of the interior illumination only in cases where the internal surfaces are dark, and that in all other cases the uses of daylight-factor is recommended.

The reflection-factor of the ground outside the ward also influences the interior lighting. The ceiling receives light from the sky by reflection from the ground outside, and if this ground is dark, the ceiling will receive less light than it would if the ground were of high reflection-factor.

Daylight Measurements in the Ward at Larkfield Hospital, Greenock

To check the studies made in the model direct measurements were made in the experimental wards at Larkfield Hospital. The building was complete except that the floor-finish had not then been laid. Measurements of daylight-factor were made at the points corresponding to the positions of the photocells in the model, shown in *Fig. 79*.

The first studies in the model were to assess the differences between sky-factors and daylight-factors under similar conditions. The measurements were all made using an artificial sky equivalent to a natural sky of uniform brightness (the classical conditions normally assumed for the computation of sky-factors, but rarely met with in practice—the nearest thing to a uniform sky being clear blue sky). These conditions give a somewhat different picture of natural lighting from that which obtains when natural lighting is at its worst, i.e. when the sky is completely overcast. A densely overcast sky may appear to be uniform but in fact it is not: the brightness increases from the horizon to the zenith according to a simple formula calculated by Moon and Spencer.[8] The zone of sky near the horizon which is the main source of light for rooms as deep as those at Larkfield is of a much lower brightness than that at the zenith, and hence daylight-factors measured under such conditions will be considerably lower than those measured under a uniform sky, particularly at points far from the windows.

The measurements made at Larkfield Hospital (*Table 34*, col. 3) were averaged from four complete sets of observations made under overcast sky conditions. Thus they are the minimum daylight-factors to be expected; under most other sky conditions the values will be higher.

The effective areas of glass in the actual building are less than those considered in the model, the reflection-factors (wall 62 per cent., ceiling 83 per cent., and floor 43 per cent.) differ slightly from those shown in *Table 33*, and the surrounding hills reduce the effective area of sky visible through the window—a fact which had not been taken into account in the studies in the model. The values measured in the model were modified to take account of a non-uniform sky as well as of the other differences between conditions in the model and those in the actual building. This allowed direct comparison to be made between the model and the actual building.

Figs. 80 and 81. Two views of ward windows in the Larkfield experimental ward (under construction) showing the baffle, before the installation of light-fittings

Table 34.* Comparison of mean values of daylight-factor measured at the Investigation's experimental ward unit at Larkfield, with values derived from model studies with uniform and non-uniform skies

	(1)	(2)	(3)
Position No.	*Original model conditions uniform sky*	*Modified model measurements: Moon and Spencer sky distributions*	*Mean of measurements taken in building*
1	14·6	7·4	7·3
3	13·8	7·0	8·8
5	14·3	7·0	8·2
7	13·8	6·8	9·7
10	15·7	7·5	6·3
12	15·8	7·7	6·4
2	5·8	2·6	2·7
4	6·0	2·7	3·0
6	7·2	3·0	2·9
8	6·6	2·7	3·0
9	7·6	3·1	2·5
11	7·8	3·3	2·4
13	5·0	2·2	1·8
14	6·2	2·8	2·2
15	6·2	2·8	2·2
17	5·0	2·4	1·9
18	3·7	1·8	1·4

* Since this table was prepared, a further analysis of the measurements has been made, taking more detailed account of the prevailing sky conditions. The analysis gives values of daylight-factor which are not significantly different from those shown above. Further measurements are to be taken in the finished building and a complete record of the daylighting experiment at Larkfield will be published separately.

A comparison between columns (2) and (3) of *Table 34* shows that for the inside bed positions (Nos. 2, 4, 6, 8, 9, and 11) good agreement is attained between model studies and full-scale measurements. The agreement is not quite so good for the outside bed positions (Nos. 1, 3, 5, 7, 10, and 12), but the discrepancies are not of great concern since the values of the daylight-factor are well above 2 per cent. For the positions shown down the centre of the ward (Nos. 13, 14, 15, 17, and 18) the values derived from the model measurements are all greater than those obtained in the full-scale ward (by 0·4–0·6 per cent. daylight-factor).

Positions 13 and 18 are each adjacent to relatively dark parts of the ward. Position 13 is next to a 'recess', the main wall of which is decorated in a deep red colour (reflection-factor about 16 per cent.). Position 18 is next to the corridor joining the ward to the day-space, the corridor being predominantly finished in a grey of reflection-factor of about 26 per cent. Positions 13 and 18 each 'see' large dark surfaces in their immediate vicinity and consequently there is a reduction in daylight-factor owing to a localized absence of reflected light. The reason for the reduction at position 13 is not so evident

since it is cross-lit from both north and south windows, whereas at position 18 direct light is received only from the south side.

It will be seen that daylight-factor at bed-head positions does not fall below 2·4 per cent., but this may be reduced to a value nearer the 2 per cent. limit by the darker floor covering (18 per cent. daylight-factor).

Thus the measurements made in the actual building at Larkfield Hospital give values of the same order as those derived from the model study. Although at the time the building was not quite completed, the ward gave a general impression of being well lit and no serious discomfort from glare was noticed when the brightness of the sky was of the order of 500 foot-lamberts.* *Figs. 80* and *81* show the ward under construction.

Model Studies for the Wards at Musgrave Park Hospital, Belfast

The Musgrave Park experimental ward unit (see *Fig. 10*) has a highly concentrated plan. The building is the same length as that at Larkfield Hospital, but in this length 40 patients are accommodated on a floor as compared with 32 at Larkfield. To achieve this concentration it was convenient to use 6-bedded rooms (see pp. 21–22). These rooms were to be lit only from one side and to be 24 ft. 6 in. deep and 10 feet high, and it was thought necessary to predict the daylight in them before proceeding with the design. Model studies similar to those already described were made at the Building Research Station. *Fig. 82* shows a plan of the model room and the positions of the photocells. A non-uniform artificial sky (Moon and Spencer distribution) was used in these studies, and it was assumed that the windows had an unobstructed view. The reflection-factors for walls, ceiling, and floor were constant throughout the series of experiments at the following figures: walls 80 per cent., ceiling 70 per cent., floor 22 per cent. The reflection-factor of the walls was high—it is intended that light colours shall be used in the actual building.

A range of window designs was simulated by cardboard masks, and readings were taken from the photocells. The

* The foot-lambert is the unit of brightness. One foot-lambert is the brightness of a uniform diffuser which reflects all the light received upon it when illuminated to a level of 1 lumen per sq. ft. One lumen per sq. ft. is the illumination produced at a point on a plane at a perpendicular distance of 1 foot by a source of unit intensity—1 *candela*, an internationally agreed standard.

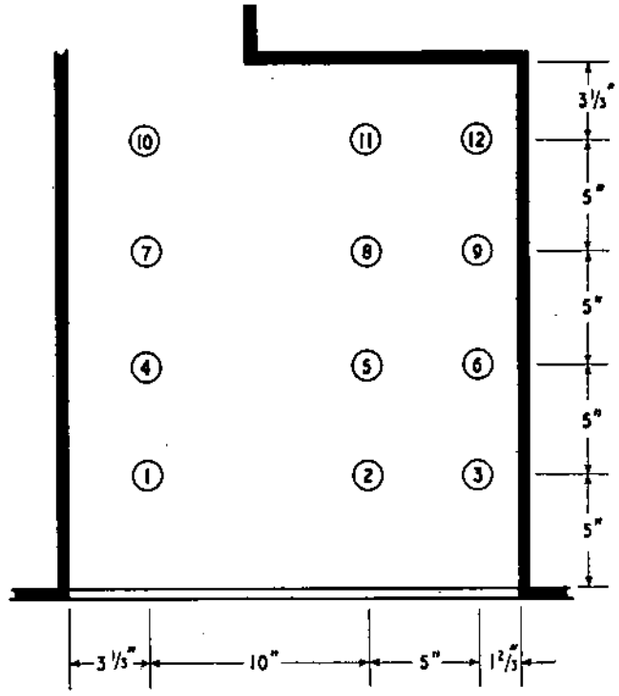

Fig. 82. Plan of model of Musgrave Park experimental ward used in daylighting studies, showing position of photocells in 6-bedded ward

masks had no glazing bars. The back wall of the ward is open on one side to the corridor, and on this side there is therefore less reflected light. Readings were taken on both 'dark' and 'light' sides. *Fig. 83* shows the daylight-factors at each bed-head for the range of windows tested. These values were obtained by interpolation between the readings obtained on the photocells. The range of windows tested included an experimental design evolved specially for Musgrave Park, the Larkfield design, and seven other arrangements, lettered A–G. Types A, B, and C each have a glass area of 140 sq. ft., i.e. an area similar to that in the design proposed for Musgrave Park. Types D, E, F, and G are somewhat smaller and represent window arrangements commonly found in practice. In general it was found that windows with an area of 120 sq. ft. (not allowing for window bars) would give a daylight-factor of over 2 per cent. at the back of the ward on both 'dark' and 'light' sides.

Fig. 84 shows the daylight contours for the Musgrave Park and Larkfield windows and also for types A and C. The light colours on walls, floor, and ceiling contributed

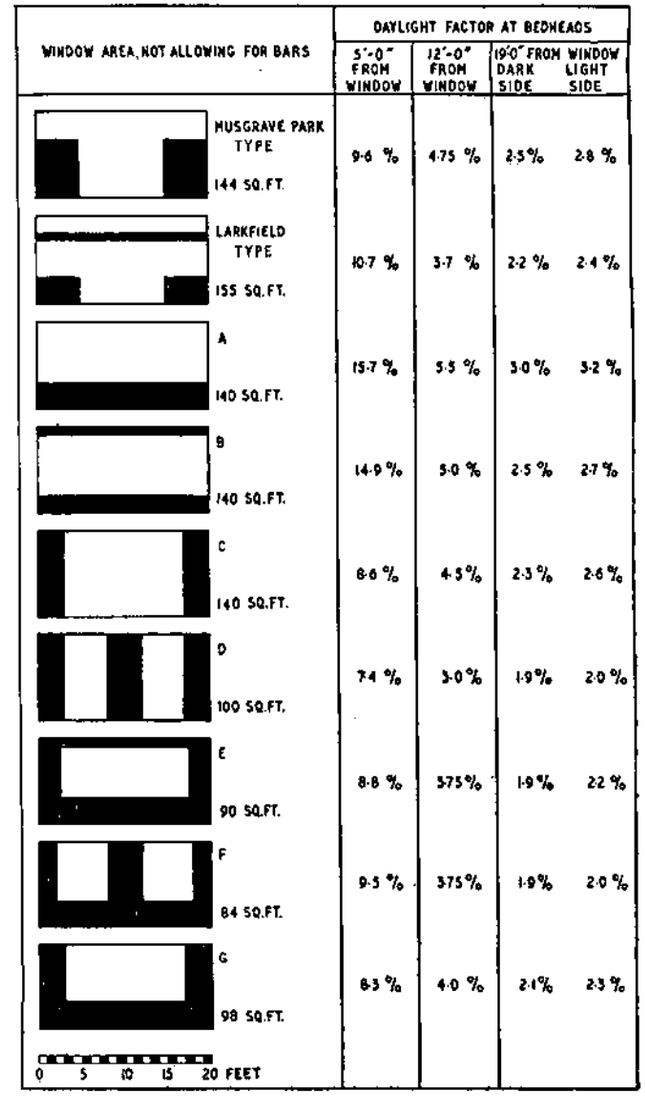

Fig. 83. Daylight-factors in the model of Musgrave Park experimental ward measured at each bed-head for different types of windows

a great deal of reflected light, and tended to mask the differences in lighting due to different designs of window. With darker colours these differences would be more striking.

The daylight contours in *Fig. 84* show that window A—which stretches the whole width of the window wall, from ceiling to within 3 feet of the floor—gives a uniform spread of lighting across the ward from side to side, but

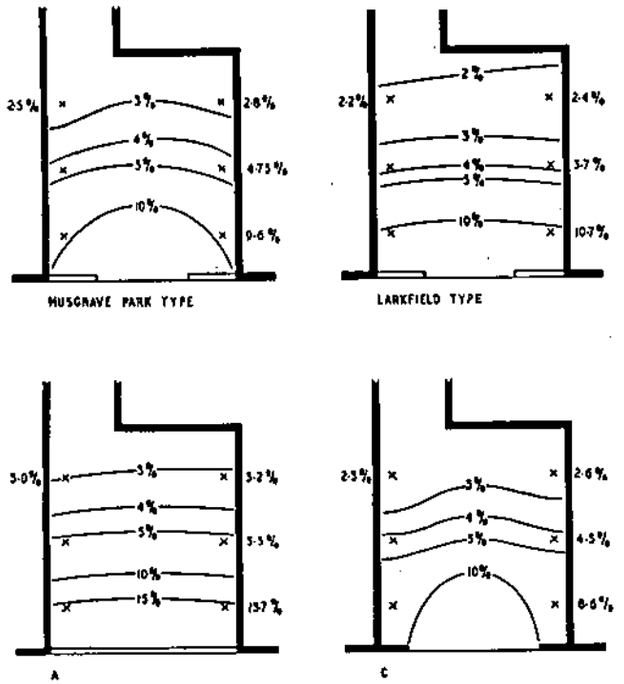

Fig. 84. Daylight contours for each of four different types of windows, obtained from studies in the model of Musgrave Park experimental ward

a steep rise from the back to the front. While the daylight-factor at one of the beds at the back is about 3 per cent., it is over 15 per cent. at the bed nearest the window. The Larkfield window, which also stretches right across the window wall, gives a lower value (10 per cent. daylight-factor) at the bed nearest the window and a correspondingly lower illumination (2 per cent.) at the back of the room. Window C—which is of the same total area as window A but stretches from floor to ceiling with 3 feet of wall on either side—gives an unequal distribution of light across the room from side to side, but a more even gradation from back to front along the sides of the room: the bed nearest the window has a daylight-factor of 8·6 per cent. and the bed farthest back has 2·6 per cent. The Musgrave Park design has an effect somewhat similar to window C, except that it gives rather more light at the back of the ward.

From the somewhat limited data obtained in these comparative studies it appears that all these types of window can be considered as giving reasonably good lighting towards the back of the room, but those with side walls, such as type C or the Musgrave Park design, have the advantage of giving better protection to the bed nearest the window. Windows D, E, and F are common types and give fairly good distribution; they do not, however, give quite enough light at the back of a room of this depth. A comparison of windows A and B, which are similar in size and shape, shows that more light reaches the back of the room when the window reaches right to the ceiling. In the interpretation of these findings the original aim to achieve a 2 per cent. daylight-factor in all important parts of the ward has been linked with the subjective appraisals made in the original model and, more recently, in the completed Larkfield ward. It appears that, even if the amount of light at some points is just below 2 per cent. daylight-factor, the lighting conditions can be subjectively satisfactory provided the light is composed of a combination of direct and indirect lighting, free from harsh shadows or dominating light at glancing incidence.

With these points in mind the Investigation concluded that a 6-bedded ward can be adequately lit from a window on one side only. Good penetration to the back of the ward is more likely to be achieved if the window reaches the ceiling. Useful protection can be given to the beds nearest the window by the use of reveals or screen walls. To obtain the necessary standard of light it will, however, be necessary to ensure that the reflection-factors of the walls, ceiling, and floor are high. This will mean the use of a light floor finish and very light colours on the walls and ceiling. Information about the selection of colours of appropriate reflection-factors is given on p. 111.

SUMMARY

1. Daylighting. Good daylighting encourages cleanliness and has been shown to have direct bactericidal properties. Measures must be taken, however, to ensure that large windows do not counteract the heating system or cause the patient discomfort from glare.

The limiting factor in the compact planning of wards was found to be the depth to which daylight could penetrate. Studies were carried out to determine whether a building as deep as that planned for the experimental ward block at Larkfield Hospital, with a low ceiling, could be adequately lit by daylight. A model of the ward was used with an artificial sky, and the effects were assessed of reducing ceiling height and of changing window-design and the colours of interior decoration. A window was designed with a horizontal baffle to limit the view of the sky for patients in the beds nearest to the windows and thus reduce discomfort from glare. The model studies showed that with this window a 2 per cent. daylight-factor, which had been adopted as the minimum permissible value, could be obtained at positions farthest from the windows with a ceiling as low as 10 feet, if suitably light colours were used on walls, floors, and ceilings. Subsequent measurements of daylight-factor in the nearly completed building agreed well with predicted values.

Further studies with a range of different windows and using improved experimental techniques have shown that it is possible to plan 6-bedded wards with economical ceiling heights, lighted from one side only, without glare. Such wards are planned for the experimental unit for Musgrave Park Hospital, Belfast.

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ARTIFICIAL LIGHTING IN WARD UNITS

Introduction

EACH part of a hospital has its own problems in artificial lighting. In some parts the requirements are similar to those in other buildings; in others, particularly operating theatres and wards, the hospital has special needs. The operating theatre is dealt with separately in Chapter 3. Daylighting in the experimental wards has been the subject of special study by the Investigation and the Building Research Station; but a systematic study of artificial lighting has not been possible. This section takes into account the limited work which the Investigation and the Building Research Station have been able to complete.

Usually wards are lighted by a row of translucent pendant fittings, with supplementary lighting at the head of each bed. In practice it has been found difficult to provide a level of illumination high enough for nursing tasks without exposing the patients to glare, and complaints, on the one hand of insufficient illumination and on the other of discomfort, are not uncommon. With the Building Research Station the Investigation attempted to establish principles on which ward lighting should be designed, and to develop fittings which will give the required results.

The Requirements of Ward Lighting

When lights are on during waking hours, patients should be able to rest without discomfort from glare from light-sources in the field of vision, and be able to see to read or write while sitting up in bed. The nursing staff must be able to see clearly in every part of the ward to carry out bedside nursing duties and to read or write. From time to time a high level of illumination may be needed at the bedside for the carrying out of treatment or examinations. During the hours of sleep a level of illumination must be maintained sufficient for the night nurses to move freely around the ward, but low enough to allow patients to sleep without distraction. The nurses' station and the ancillary rooms must be adequately lit for close work, without distracting the patients. Corridor lighting should facilitate safe movement during the night.

Design Criteria

In meeting the needs for lighting during waking hours, there is some conflict between requirements for the work to be done in the ward and for the comfort of the patients. A recent report of the National Illumination Committee of Great Britain, entitled 'The Design of the Visual Field',[1] points out that 'lighting may be designed with visual efficiency or with visual comfort as its principal aim, according as the users will be engaged in critical or in casual seeing. The two aims are not necessarily in conflict; for example, critical work will demand comfort as one requirement. But lighting designed with comfort as a principal aim would not necessarily be suitable for critical seeing nor promote the highest visual efficiency.'

The amount of light is usually specified in terms of the level of illumination on the working plane, expressed in *lumens per square foot* (formerly called 'foot-candles' in this country and still so called in the U.S.A.). Research has established in general terms the level of illumination needed for the efficient performance of a variety of tasks. Until the last few years most studies of artificial lighting have been concerned with achieving appropriate levels of illumination for different purposes. More recent studies show that the pattern of brightness—that is the relative brightness of the light, ceiling, and walls—must be given considerable attention if conditions are to be comfortable. Relative brightness can be specified and some limits set to contrasts in brightness, to minimize discomfort.

The British Illuminating Engineering Society's *Code for the Lighting of Building Interiors*,[2] based largely on H. C. Weston's work on visual performance in relation to levels of illumination,[3] specifies a general level of 3 lumens/sq. ft. for single rooms and wards, as well as for corridors and stairways, and special lighting in the range of 10–30 lumens/sq. ft. over beds. These levels correspond roughly with those in lighting codes adopted in other countries. For example the French code, 'Recommendations relatives à l'éclairage des bâtiments et de leurs annexes' (1952), recommends 30 lux (3 lumens/sq. ft. approx.) for general illumination and 200 lux (20 lumens/sq. ft. approx.) for bed-lighting. The French code also specifies 10 lux (1 lumen/sq. ft. approx.) for night lighting. Weston points out, however, that values assessed on high levels of performance in visual tasks (as are the Illuminating Engineering Society's code values) can be increased or decreased by 30 per cent. without greatly affecting the performance.[4]

Visual tasks needing higher levels of illumination can be better and more easily done if the surrounding areas of the visual field are at somewhat lower brightnesses than the immediate field in which the task is being done. The greatest aid to concentration on the task is obtained by making the surroundings substantially less bright than the task.[5] Therefore any task carried out at the bedside will be made easier if the lighting there is at a higher level than elsewhere in the ward. It follows that readily controlled local lighting is more suitable than a high general level of illumination in the ward, which would be difficult to provide without causing visual discomfort to the patients.

Thus, in addition to general illumination, local lighting will be required at each bed. Patients will need illumination in the range of 15 to 20 lumens/sq. ft. for reading and writing.[2] A fairly high level of illumination will also be needed from time to time for medical examination, but because of the high cost of providing a fitting which can be extended for use over the whole area of the bed, it seems better to provide, in addition to the patient's reading-lamp, a socket at each bed for an examination lamp.

If the area around the beds has local lighting, the general lighting in the ward should be designed to give an adequate level of illumination for the nurses' tasks done in the centre of the ward (preferably not less than 10 lumens/sq. ft.) and a comparatively low level of illumination on the beds (3 lumens/sq. ft.).[2] This general lighting must be adequate for supervision; for the performance of nursing procedures the bed-head light or a mobile lamp would be used.

To achieve, without glare, the illumination levels suggested, it is necessary to specify the limiting brightness of the sources in relation to the brightness of the surroundings. With walls and ceilings of high reflection-factor as defined on p. 111, general brightness levels of 1–5 foot-lamberts could be expected. The work carried out at the Building Research Station on discomfort due to glare

makes it possible to specify with reasonable accuracy the limiting brightness of the fitting.[6]

Table 35 shows limiting brightness values for light sources 10 feet away (the approximate distance of the patient from the centre fittings in the Larkfield and Musgrave Park experimental wards) where the general background brightness is of the order of 1–5 foot-lamberts (see above). In its original form *Table 35* was used by R. G. Hopkinson and P. Petherbridge in a paper on glare discomfort and the lighting of buildings.[6] It has been modified by them for the conditions which will obtain in the Investigation's experimental ward units, and in particular, allowance has been made for the probable increased sensitivity to glare of sick people.

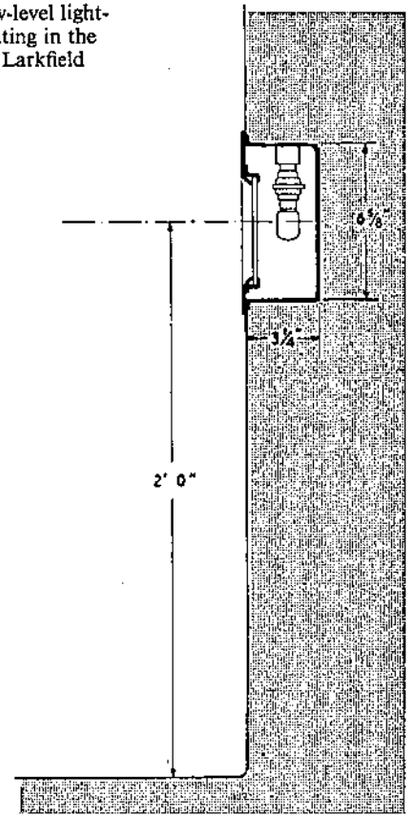
Table 35. Prevention of discomfort from glare in artificially lit wards: *Limiting brightness-values for light sources 10 feet away from patient, where the general background brightness is of the order of 1–5 foot-lamberts*

Diameter of source (10 feet away)	*Brightness for just-perceptible glare*	*Brightness for just-uncomfortable glare*
3 inches	270 foot-lamberts	1,000 foot-lamberts
10 inches	100 foot-lamberts	400 foot-lamberts
30 inches	30 foot-lamberts	170 foot-lamberts

Researches at the Building Research Station[6] have shown that discomfort from glare is reduced significantly if sharp gradations of brightness between a bright light-source and its background are avoided; this is known as contrast grading. An opal globe fitting, for instance, produces sharp contrasts and is consequently more glaring than a fitting with a brighter central area but which decreases gradually in brightness towards the edges.

Dimmed lighting during the hours of sleep has often been achieved in the past by shrouding selected ceiling-lights with pieces of material. More recently, dimmed lighting has been provided by separate low-wattage lamps, sometimes colour-sprayed or shielded by an opaque shade, these lamps being incorporated in the general lighting-fittings, and sometimes placed on the walls, near floor-level. Although no special study has been made of lighting during the hours of sleep, it seems probable that at least enough light to silhouette furniture is required, to permit safe movement for nurses and ambulant patients. This can be obtained by placing fittings behind the bed-head and about 18 inches from the floor, with the light directed downwards. One type of fitting for this method of lighting is illustrated in *Fig. 85*.

Fig. 85. Section of low-level light-fitting for dimmed lighting in the experimental wards at Larkfield Hospital



If light is needed at the bedside during the night it can be provided by the bed-head lamp or the examination lamp. Disturbance to other patients can be reduced by drawing bed-curtains. The light on the nurses' desk must be sufficient for reading and writing (15–20 lumens/sq. ft.) without disturbing the patients.

Where the drug cupboard is in the ward itself, lighting should preferably be provided inside the cupboard, to enable the nurse to dispense drugs easily. Automatic switching when the door is opened or closed is an advantage.

Recent Examples of Ward Lighting

Recently a number of new lighting installations have been introduced into hospital wards, and the more interesting of these may be examined in terms of the criteria suggested above. The first two installations, at the Royal Surrey County Hospital and the Bürgerspital, Basle, conform to these criteria for illumination distribution. The other two, which are American, are indirect systems giving an entirely different brightness pattern in the ward. Of the four, that at Basle uses only tungsten lamps; the Royal Surrey County Hospital uses fluorescent and tungsten lamps, and the American examples use only fluorescent lamps.

Example 1

At the Royal Surrey County Hospital the ward is 70 feet long, 25 feet wide, and 14 feet high, and there are six light-fittings evenly spaced longitudinally down the centre of the ward, each carrying one 5-foot 80-watt fluorescent 'natural' lamp, suspended 4 feet from the ceiling. A flush transverse louvre system is arranged to give a 45° cut-off (that is, the lamp itself is only visible when the angle between the line of vision and the horizontal is greater than 45°); an open top to the trough allows light to reach the ceiling. For night-lighting one 15-watt, blue-sprayed tungsten lamp is installed at each end of the fitting and additional louvres maintain the cut-off for these lamps. Dark-grey matt paint was chosen for the main louvres after experiments with other colours, and dark-brown matt for the louvres to the blue dimmed lights. Local lighting at the beds is by fixed, high-mounted, tungsten lamp fittings. *Table 36* gives the measured illumination levels for general lighting only, which is roughly within the range referred to on p. 101. It seems possible, however, that the brightness of the fitting may exceed the recommended maximum (see *Table 35*), and if the ceiling height were reduced to 10 feet—as is likely when new hospitals are built—problems of glare might become acute.[7]

Table 36. Illumination levels in a ward at the Royal Surrey County Hospital: *Measurements at floor level and 3 feet from the floor. (After M. W. Peirce and D. J. Reed[7])*

Position	*Illumination (lm. per sq. ft)*	
	At floor-level	*At 3 feet from floor*
Under end of fitting	6·5	8·0
Under centre of fitting	7·0	10·0
Midway between fittings	6·0	7·0
At bed-foot	3·0	1·5
At bed-head	1·0	1·0

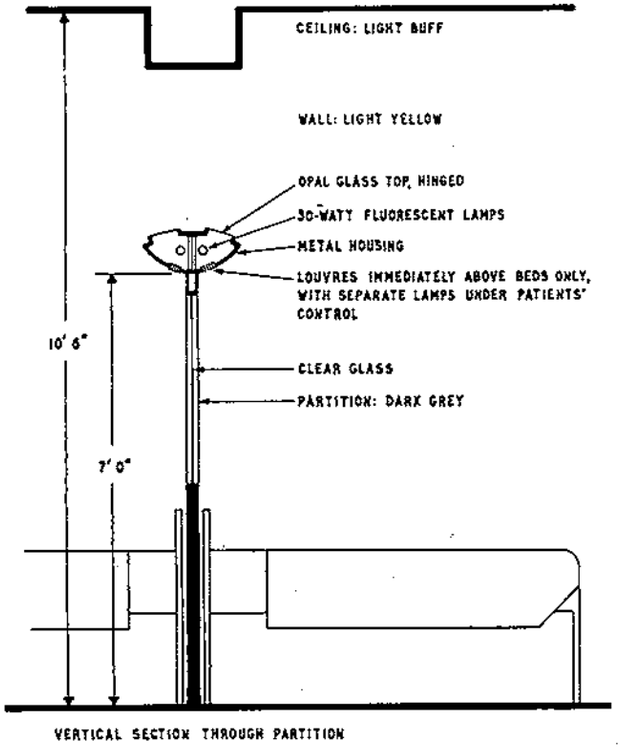


Fig. 86. Section of fluorescent light-fitting in a ward in the Riverside Hospital, New York City

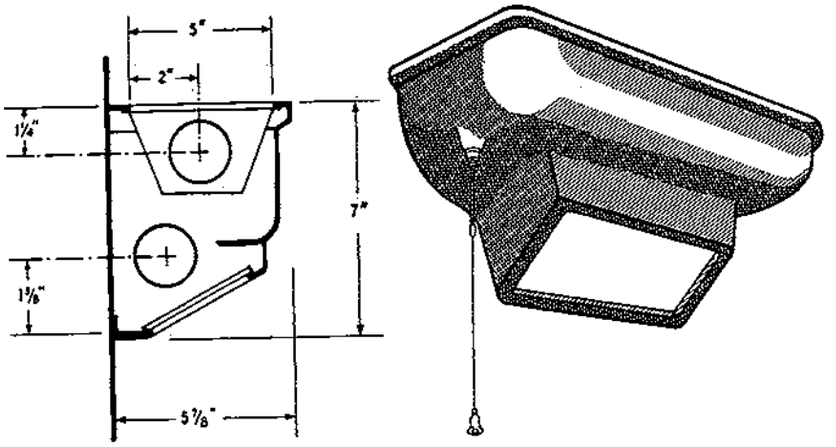


Fig. 87. Fluorescent light-fitting (short lamp) for general and local lighting mounted above beds

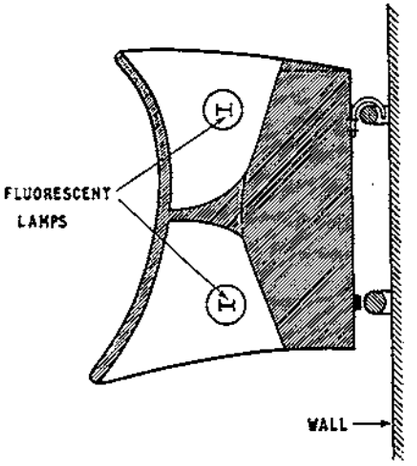


Fig. 88. Fluorescent light-fitting (long lamp) for general and local lighting mounted above beds

Example 2

No illumination measurements are available for the 6-bedded ward in the Bürgerspital, Basle, but it is included here as being one of the few recent installations using a single general-lighting pendant fitting of opaque material in the centre of the ward. The ward measures 23 feet in width, 23 feet deep, and 11 ft. 6 in. high. The bed-lights are fully adjustable and are controlled by the patient by a switch mounted on the rim of the shade. An attachment which fits over the end of the shade to reduce the illumination enables the bed-lights to be used as night-lights.[8]

Example 3

In the wards in the Riverside Hospital, New York City, fluorescent troughs mounted above partitions 7 feet high, below a ceiling 10 ft. 6 in. high, provide indirect, general illumination. Immediately above each bed the trough is louvred and contains a separate lamp (controlled by the patient) which provides bed-lighting. Ceiling brightnesses are of the order of 5–20 foot-lamberts, and the brightness of the louvred opening over the beds is 75 foot-lamberts. An interesting comparison may be made between these values and the criteria discussed above. The brightnesses are similar to those usually found in this country, but illumination levels measured on the bed are lower than those considered necessary here for patients' activities. They are in the range 1·5–8 lumens/sq. ft. No illumination levels are given for the circulation-space between the beds, but it may be assumed that these are somewhat lower than those measured on the bed (*Fig. 86*).

Example 4

Another American example makes use of smaller fittings mounted above each bed. The source consists of two short fluorescent lamps, one having its light directed upwards to provide indirect general illumination, the other directed downwards, through a translucent lens, towards the bed. The downward light is controlled by the patient. No brightness or illumination-levels are given for this system, but as its use is recommended for small wards it may be assumed that the levels are somewhat lower than those given in the previous example[9] (*Fig. 87*).

A similar system but with larger fittings carrying longer tubes is recommended by J. K. Frisby[10] (*Fig. 88*). This system gives illumination-levels ranging from 5 lumens/sq. ft. in the centre of the ward to 17·5 at the bed-head. The fitting has two 3-foot 30-watt lamps with a solid baffle between them; it is said to be comparatively cheap. *Fig. 89* shows the distribution of illumination given by this fitting when both lamps are in use.

The distribution of illumination from the fitting described by Frisby, as well as those in the two American examples, is characteristic of indirect lighting systems from side fittings. The ceiling and wall brightnesses would be high immediately above the patient's head and low at the centre of the room. This would be uncomfortable for the patient when lying down and would probably make nursing supervision from a distant viewpoint more difficult because of the bright areas in the field of view near the patient's head. The reduced level of illumination in the centre of the ward, even with both lamps in use (*Fig. 89*), might hamper nursing procedures; and the level

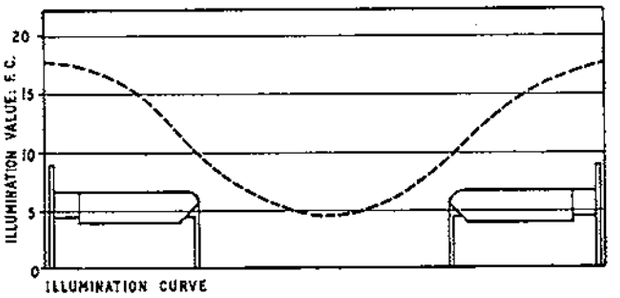


Fig. 89. Distribution of illumination where combined general and local lighting fittings are fixed above beds

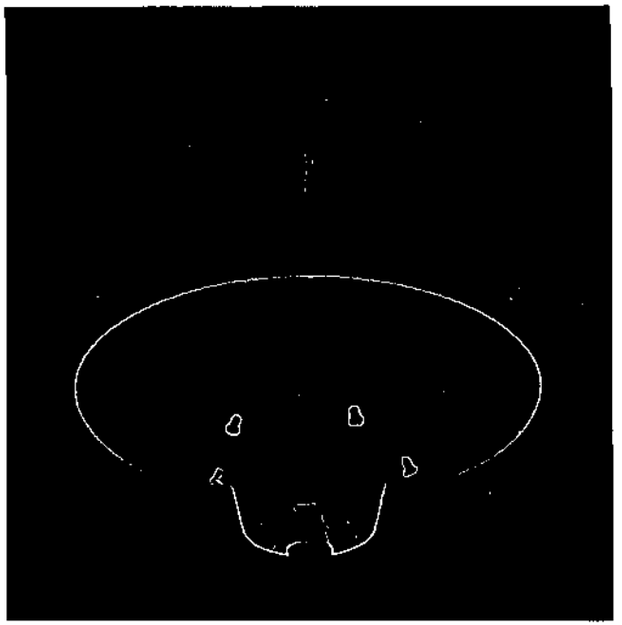


Fig. 90. 'Witch's hat' tungsten light-fitting used in a ward at Farnham Hospital

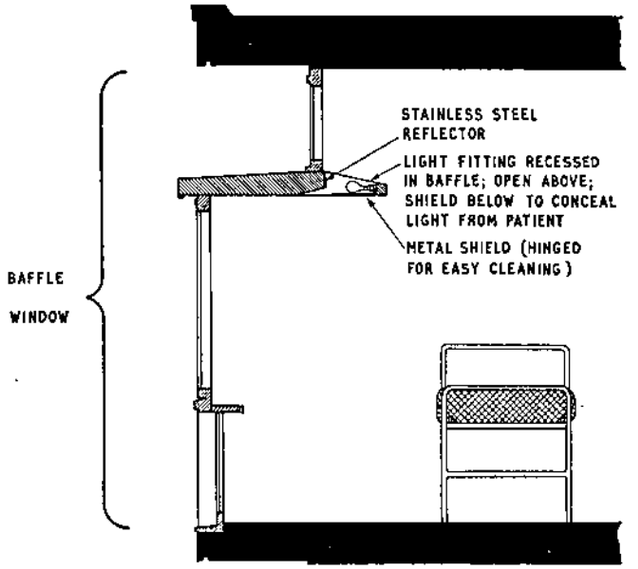


Fig. 91. Section of tungsten light-fitting (mounted in baffle) designed by the Investigation for the experimental wards at Larkfield Hospital

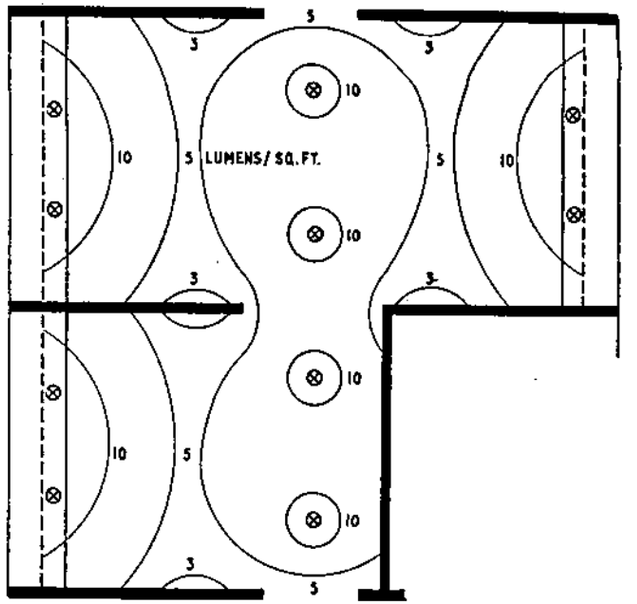


Fig. 92. Distribution of illumination on working plane (2 ft. 9 in. above floor) measured in model of Larkfield experimental ward

would presumably be further reduced if any of the lower lamps were switched off by patients who wished to rest. Only a wide subjective survey in many types of ward could discover what patients may prefer in the way of lighting. Lighting can be soporific or stimulating in character, or can be somewhere between the two. Opinions on what is desirable differ widely. Peirce and Reed, for instance, believe that general lighting should engender a cheerful atmosphere in the ward; Frisby argues that there is every advantage in indirect lighting which 'provides the softest and most comfortable conditions'.

Development of New Fittings for Lighting the Experimental Wards

When deciding on the artificial lighting for the experimental wards at Larkfield and Musgrave Park, the Investigation came to the conclusion that none of the fittings at present on the market was wholly suitable. The design and testing of appropriate fittings was therefore undertaken jointly by the Building Research Station and the Investigation.

The Investigation decided to study only tungsten lighting. The capital cost of installing fluorescent lighting is high, and though eventually this is offset by the smaller consumption of current, recent studies by the Building Research Station on fluorescent lighting in schools and offices have shown that the cheaper the current the longer the offsetting process will take, so that where, for example, electricity is 1*d.* a unit and the lamps are burned for say 1,000 hours or more during the year, capital and cleaning costs will not be offset for some ten to fifteen years.

In developing fittings for ward lighting, consideration was given, not only to the illumination requirements for hospital use, but to general simplicity in design. Special attention was given to ease of cleaning and—so far as was consistent with the other design criteria discussed above—the fittings were shaped to collect as little dust as possible.

In the early stages of the study a fitting for general lighting, now known as the 'witch's hat' (*Fig. 90*), was designed and installed in a ward at Farnham Hospital. It was made from translucent white perspex, and, unlike the opal sphere commonly used, it achieved some contrast grading (see p. 102) and thus reduced discomfort from glare. Nevertheless, the installation at the Farnham hospital caused some discomfort to patients. The experiment showed that it was inadvisable to place a row of pendant fittings directly in the patient's line of vision if the brightness values were in the region of 1,000 foot-lamberts.

Two more fittings were designed, one of which is being used in the experimental wards at Larkfield, the other, incorporating later ideas, will be tried at Musgrave Park.

Artificial Lighting in the Investigation's Experimental Wards at Larkfield Hospital, Greenock

In the experimental wards at Larkfield Hospital, fittings are built into the baffles over the windows (see p. 97; *Fig. 91*), and supplementary fittings, made of opal glass with open louvred bottoms, are fixed above the circulation spaces and in the day-spaces. Enclosed opal glass fittings, close to the ceiling, are used in the ancillary rooms and at points in the corridors where they cannot be seen from the patients' beds. The baffle fitting gives upward and downward distribution of light, and each of the two 150-watt pearl lamps in the bed-bays is screened from the patients' view by a metal shade which is hinged to simplify cleaning and maintenance. The installation was tested experimentally in the model of the ward used also for daylight measurements (see p. 93; *Fig. 92*).

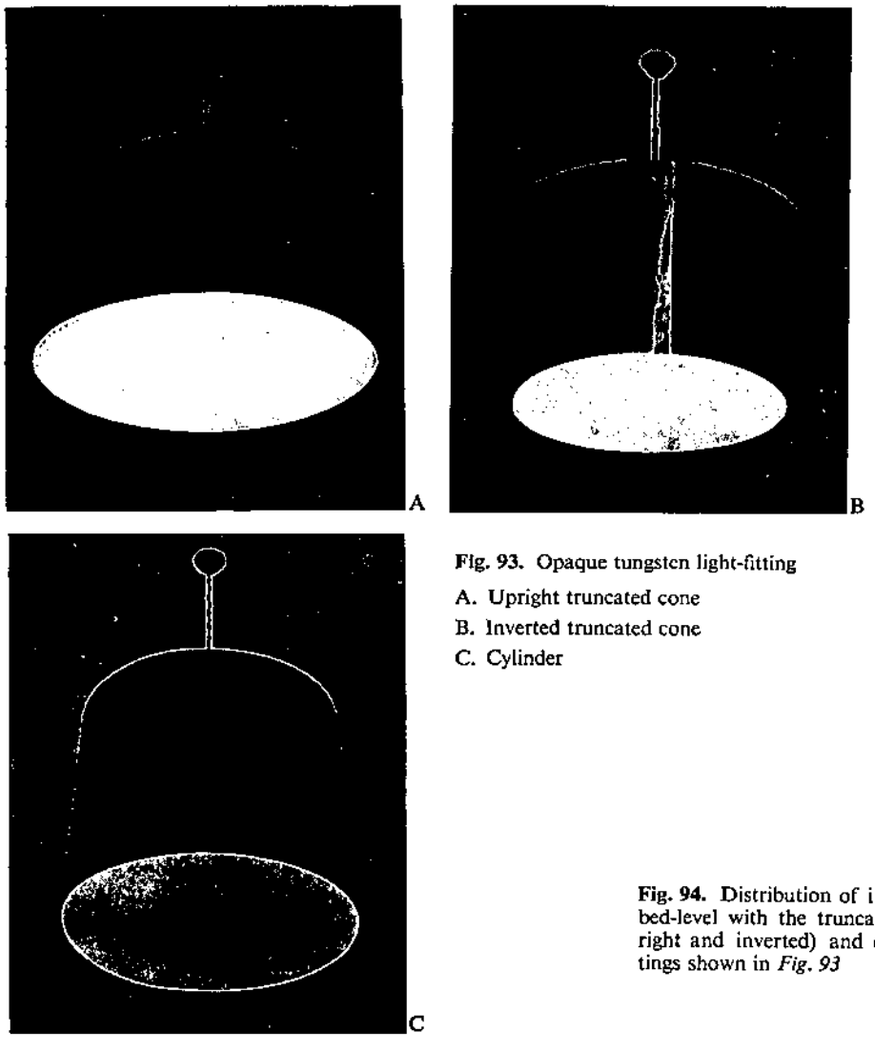


Fig. 93. Opaque tungsten light-fitting
A. Upright truncated cone
B. Inverted truncated cone
C. Cylinder

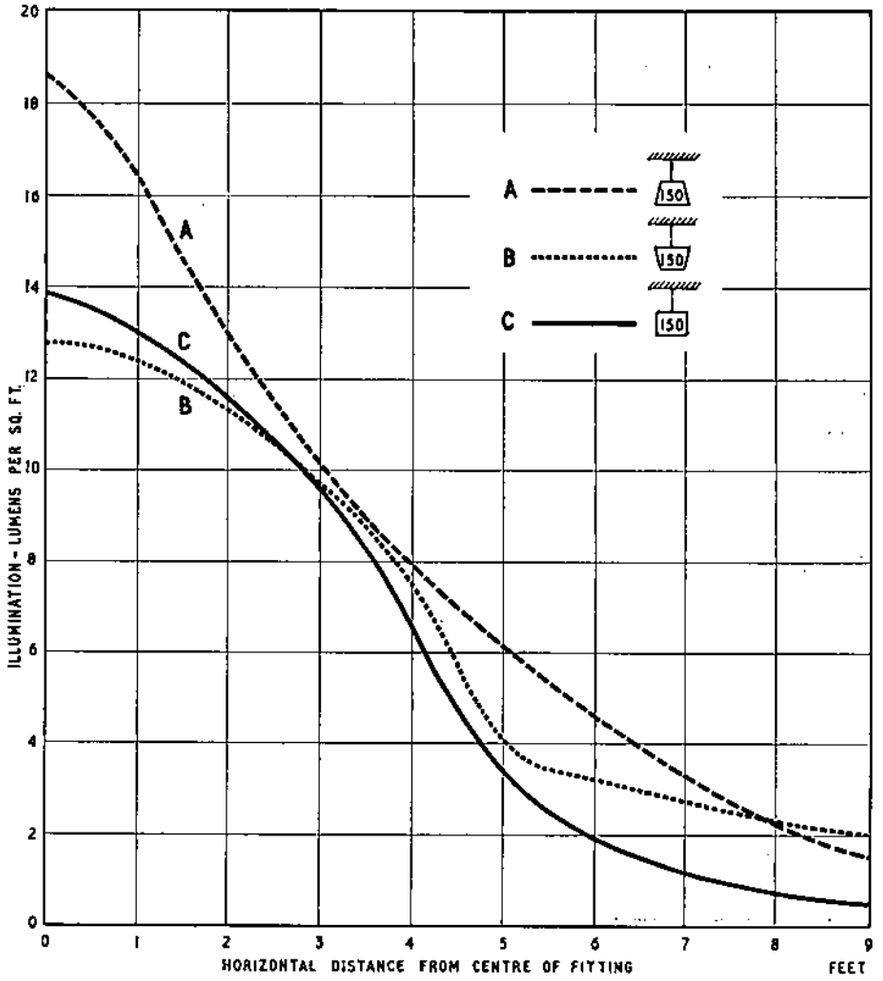


Fig. 94. Distribution of illumination at bed-level with the truncated cone (upright and inverted) and cylindrical fittings shown in *Fig. 93*

Two types of adjustable bed-head lamp fittings are used for local lighting. In one the action is balanced by springs; in the other friction-disks provide the necessary rigidity. Their relative durability, and ease of cleaning and maintenance under ward conditions, will be compared. The fitting for dimmed lighting of the ward at night is illustrated in *Fig. 85*.

The nurses' desk is lit by an adjustable table-lamp with an opaque shade, giving 15 to 20 lumens/sq. ft. on the working plane. The drug cupboard in the nurses' station has interior lighting with automatic switching.

Artificial lighting in the Investigation's Experimental Wards at Musgrave Park Hospital, Belfast

The Building Research Station suggested opaque cylindrical shades with a specular metallic finish outside and an inside finish of about 55 per cent. reflection-factor. The specular finish was intended to provide bright spots of light and reflected colour, to add interest and sparkle to the general appearance of the ward. It was calculated that, suitably placed, these units would give illumination levels of between 3 and 10 lumens/sq. ft. over the ward, and would fulfil all the technical demands. In the first experiments the fittings were mounted on standards placed on the floor, but standard lamps are inconvenient in wards and a pendant adaptation of the fitting will be tried in the experimental wards at Musgrave Park. Two different forms of the shade, one a truncated cone (*Fig. 93 A* and *B*), the other a cylinder (*Fig. 93 C*), have been tested suspended from ceilings of sufficiently similar reflection values to allow direct comparison. The truncated-cone fitting has been tested in the laboratory in two positions: upright (small diameter nearest the ceiling, *Fig. 93 A*), and inverted (large diameter nearest the ceiling, *Fig. 93 B*). The light-distribution from these fittings, with 150-watt pearl lamps, is shown in *Fig. 94*. The highest illumination levels were obtained with the truncated cone

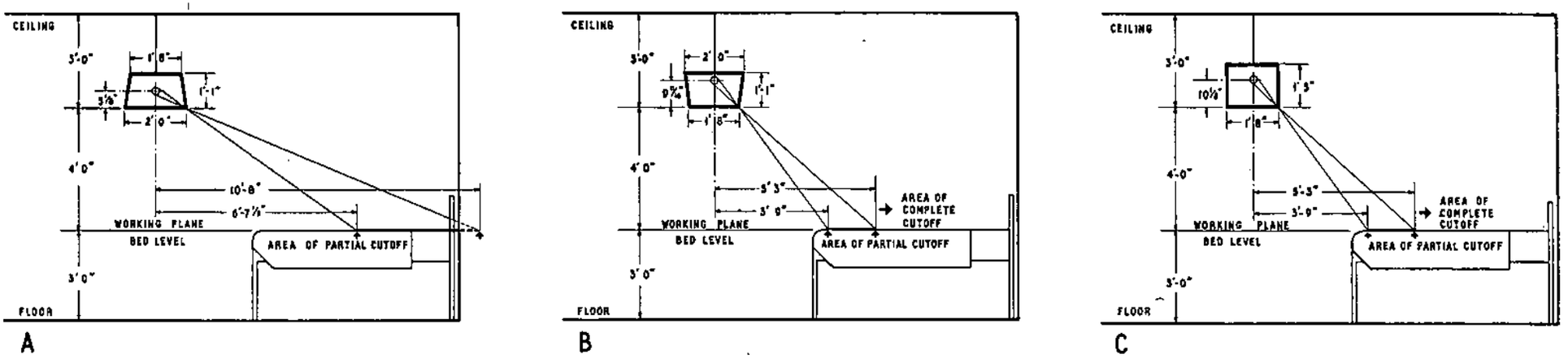


Fig. 95. 'Cut-offs' obtained by the fittings shown in *Fig. 93*

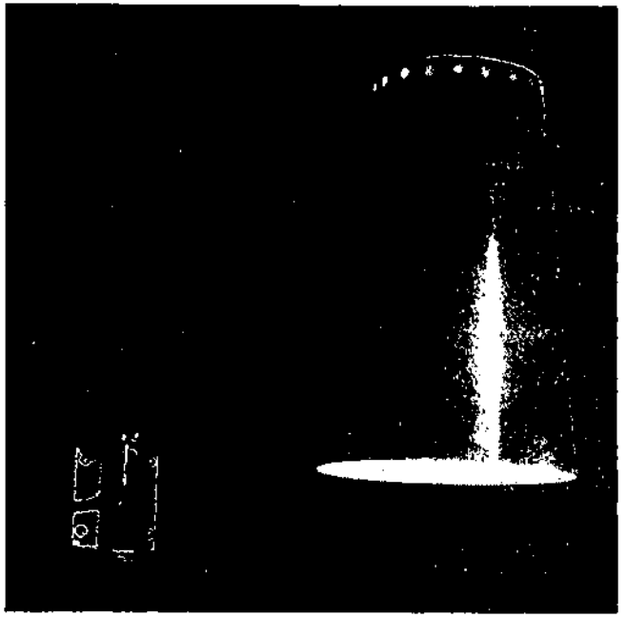


Fig. 96. Bed-head fitting to be used in the experimental wards at Musgrave Park Hospital

in the upright position, but the cut-off was found to be inadequate (*Fig. 95 A*). Complete cut-off was achieved only at some 10 ft. 8 in. from the fitting, at bed-level. A better cut-off was achieved with the fitting inverted (*Fig. 95 B*), and although illumination immediately beneath the lamp was lower (13 as against 18·5 lumens/sq. ft.) it was equal to the fitting with the upright shade at 8 feet from the source, and was actually superior at bed-head position, 10 feet from the lamps (*Fig. 94*, curves B and C). *Fig. 95 C* shows the cut-off for the cylindrical shade which gave similar illumination beneath the lamp (13·8 lumens/sq. ft.); but the level fell off more rapidly, and was only 0·8 lumens/sq. ft. at 9 feet from the source (*Fig. 94*, curve A), as compared with 2 lumens/sq. ft. for the inverted truncated-cone (*Fig. 94*, curve C).

The inverted cone provided the highest ceiling-brightness (36–39 foot-lamberts immediately above the fitting) as compared with a maximum of 27 foot-lamberts in the other cases. Both fittings would present inner surfaces of brightness of the order of 140–160 foot-lamberts to the patients' view, and consequently would satisfy the conditions stated in *Table 35* for freedom from discomfort due to glare.

These fittings will be combined with local bed-lights which the patient himself can adjust without shining the light into the eyes of his neighbours, because the adjustment is only in a lateral plane (*Fig. 96*).

Lighting on the nurses' desk and in the drug cupboards will be as in the experimental wards at Larkfield Hospital (see p. 105)

SUMMARY

An attempt has been made to establish criteria for efficient, glare-free artificial lighting in hospital wards. It is suggested that a balance may be achieved between the levels of illumination necessary for nursing duties and patients' activities, and the limits which must be set to the range of brightnesses in the field of view to prevent discomfort or disturbance to the patient.

General illumination of at least 10 lumens/sq. ft. should be provided at the centre of the ward for nursing tasks, falling off towards the bed-head to levels low enough to allow the patient to rest or sleep but high enough to allow efficient supervision by nursing staff. Separately controlled local lighting at the bed-head should provide 15–20 lumens/sq. ft. when the patient wishes to write or read, and can be used in conjunction with a mobile examination lamp for nursing procedures or medical examination in the ward. A table, based on previous work at the Building Research Station on discomfort from glare, gives limiting brightness values for light-fittings of various sizes, in relation to a given background brightness. Some existing installations using fluorescent and tungsten lamps are reviewed with these criteria in mind.

The installations designed by the Investigation for the experimental ward units at Larkfield and Musgrave Park use tungsten lamps because of the high capital cost of fluorescent lighting. Some of the fittings used have been tested at the Building Research Station, and predicted levels of illumination and brightness ratios are given.

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COLOUR

Introduction

THE proportion of window space to cubic space in a room, but especially in a ward, is a point of the first importance . . . for the same purpose of ensuring a sufficiency of light, the wards should always be light coloured, excepting perhaps for some cases of ophthalmia. . . .

A good colour and not a dull dirty one is necessary in all . . . wards.[1]

Florence Nightingale was specific in her requirements for the decoration of hospital wards, and they seem to be in line with present-day ideas; nevertheless, in many hospitals built since she expressed these views, the essentials of 'sufficiency of light' and 'good colour and not a dull dirty one' have been almost totally neglected. In many people's minds the corridor, waiting-spaces, and public rooms of hospitals are still associated with dark greens, browns, and heavy cream.

In the eighteenth century hospital wards were usually white-washed, though rarely each year, as John Howard thought proper,[2] but during the nineteenth century the use of more permanent finishes and dark colours for economy in maintenance became almost universal. Recently, however, particularly in newly built extensions to hospitals, lighter colours, and in some cases very bright colours have been used in a way which is without historical precedent.

In addition to a small amount of experimental work on colour therapy, some work has been done on the effect of colour on the 'atmosphere' of wards and consequently on patients. In 1917, for example, the *Lancet*[3] reported on an experiment in the decoration of a ward by H. Kemp-Prosser.

He claims that it is of the first importance to remove from the patient the idea of being shut in. . . . Therefore he paints the ceiling a bluish colour so as to resemble so far as possible the blue of the sky . . . the walls are painted . . . to represent the colour of the foliage in spring . . . the floor is painted with a yellowish green. . . . Mr. Prosser maintains that it is essential that no browns and reds should be used, for these colours are saddening.

Most of the work on these lines has been done on an empirical basis with no co-ordination of the results achieved by the different experimenters. Until recently no data acquired under true experimental conditions were available.

Shortly after the 1914–18 war, ideas about the use of colour were being developed as part of the new movement in architecture. In 1921 Le Corbusier began to use colour as part of his overall conception of architecture.* Unlike Kemp-Prosser, he made no attempt to simulate nature, but was concerned only to intensify the feeling of space within his buildings, sometimes using different colours on adjacent walls, and very dark tones in conjunction with a great deal of white. In 1937, in a series of articles in the *Architectural Review*, the painter Ozenfant, who had worked with Le Corbusier, emphasized the architectural value of colour and gave a number of rules for the choice of colours in interiors. He, like Le Corbusier, proposed the use of carefully controlled areas of strong, clear colour contrasted with white, and the use of different colours on adjacent walls according to the amount of light they received and their architectural context.

Colour as it affects the Lighting of Rooms

The use of colour as a dominant factor in an environment can lead to visual discomfort, unless the principles of the behaviour of light in rooms are applied. For some years studies of these principles have been in progress at the Building Research Station, and at the outset of the Investigation's work on the design of the experimental ward block for Larkfield Hospital, the Station was invited to collaborate in assessing the efficiency of the ward in terms of daylight distribution, and to advise on schemes of decoration. The studies, which began with calculations to determine the amount of daylight at critical points in the ward, were developed to show how the distribution throughout the ward would be affected by reflection from the walls, floor, and ceiling. Previous methods of calculation neglected this factor, and new techniques of calculation have been developed as a result of measurements of daylighting in a scale model of the ward.* It was found that when inter-reflection of light between the walls, floor, and ceiling was taken into account, the total illumination of the ward was considerably greater than that indicated by the earlier methods of calculation. This means that, if walls, floors, and ceiling are given colours of a high reflection value, rooms can be deeper and can have a lower ceiling than has hitherto been considered possible, while still maintaining satisfactory daylighting. Further studies showed that the contribution made by inter-reflection of light is so great that some of the wall surfaces can be quite dark and can exhibit rich colour, without adversely affecting the daylighting conditions, provided that the average reflection value of all surfaces remains high.

Colour Identification Systems

The emphasis on the value of reflected light in rooms makes it essential that the reflection value of each colour in a scheme of decoration is known before it is applied. A system of colour identification which relates colours to their reflection values and which is comprehensive and unambiguous is clearly a prerequisite to the study of colour problems.

Various types of colour systems and atlases have been devised from time to time. They fall into three main categories: (1) the 'colorant' type, showing ranges of colours produced by mixture of certain pigments or dyes; (2) the objective type, in which the division of colours is based on measurable physical properties, for example, reflectance, dominant wave-length, and purity; (3) the subjective type in which subdivision of the whole field of surface colours is attempted by visual judgement. All these systems are distinct from the very large number of catalogues or collections of colours relating to particular products such as paints or textiles, where the choice of the colours included is usually arbitrary.

Colour systems have been in use in some trades and among scientists for some time, but only recently has serious attention been given to their use in the field of

* His work was paralleled to some extent by W. Gropius at the Bauhaus, and by members of the Dutch *Stijl* group.

* The studies are described on pp. 93–97.

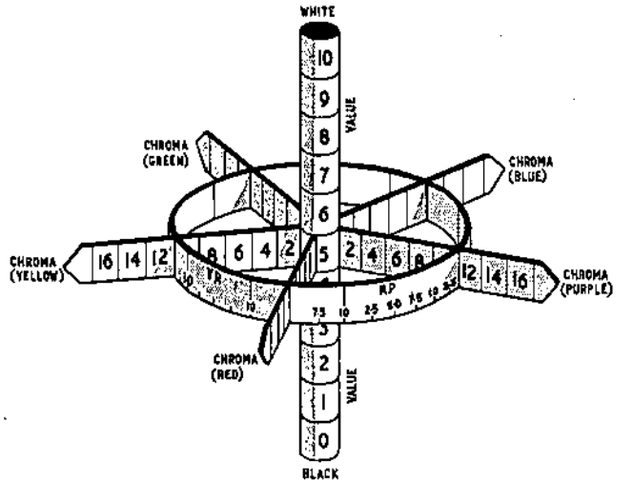

Fig. 97. Three-dimensional diagram of the Munsell colour system —the Munsell solid

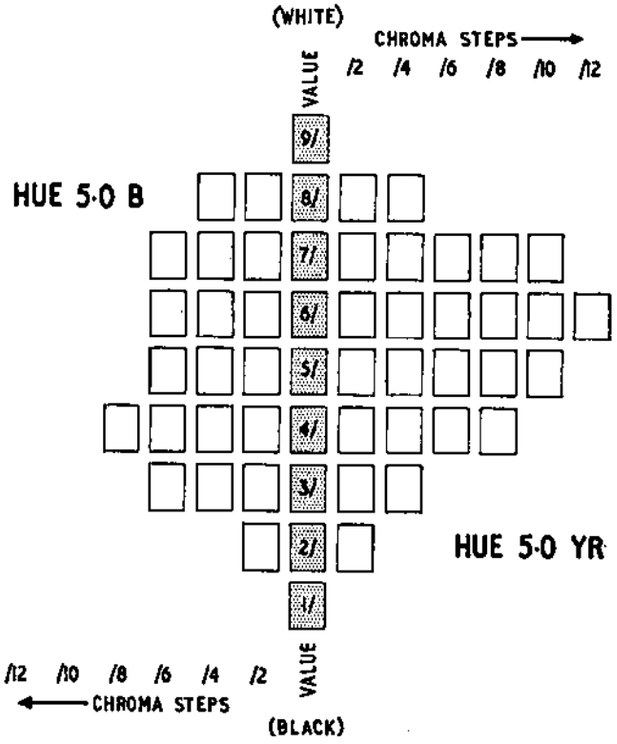

Fig. 98. Vertical section through the Munsell solid at hues blue and yellow-red

architectural colouring. Studies at the Building Research Station which have clearly shown the advantages to be derived from the use of a suitable system have now been confirmed by practical experience. Work in association with the Ministry of Education, for example, led to the introduction of a range of paint colours linked to a systematic approach to the colouring of schools. For architectural design, the subjective type of colour system has proved the most useful because the designer is concerned ultimately with subjective effects, and here the Munsell system is outstanding.[4]

In the Munsell system, colours are divided in such a way that uniform steps of difference in the appearances of colours may be appreciated by the eye. The three main qualities demonstrated are *hue* (for example, red as opposed to blue), *chroma* (the strength of a colour), and *value* (lightness or darkness). *Fig. 97* shows diagrammatically the three-dimensional form taken by the Munsell system. The hues are represented on the circular band in sequence so that complementary hues are opposite each other; there are five principal hues, five intermediate hues, and each of these ten divisions is divided into ten parts, providing for identification of a hundred different hues. Munsell charts illustrate forty of these hues, which is sufficient for practical purposes. The central axis is the scale of *value* in ten equal steps from black at the base to white at the top. Under normal conditions of daylight, all colours of the same value, that is the same horizontal plane of the solid, have approximately the same reflection-factor. Along the horizontal branches, the scale of *chroma* is shown in steps of equal increase in strength. In the colour charts the alternate steps only are shown. A Munsell colour reference consists of the hue reference, followed by the value and then the chroma reference, for example: 7·5 B 6/6. *Fig. 98* shows a vertical section through the solid, showing the complementary hues of blue (5·0 B) and yellow-red (5·0 YR) opposite each other. The solid is irregular as the number of steps from the central axis varies at different value levels for the different hues. In *Fig. 98*, for example, the blue reaches its highest chroma at low value level, and the yellow-red at high. A reference to the colours in the Munsell atlas allows the three properties, hue, chroma, and value, to be considered separately and thus not only opens the way to systematic analysis in the choosing of colours, but also simplifies the application of research which is often concerned with one or other of the three properties. The lighting research undertaken in connexion with the Investigation's ward buildings, for example, was particularly concerned with the lightness or value of colours and its influence on the lighting conditions.

Accepting the Munsell atlas as an instrument for translating analysis into actual colours and for considering the whole colour field, it should be possible, with experience, to arrive at a more limited range of colours for paints selected from the system, and therefore bearing a specified relation to each other, which will answer the common needs in one or more categories of buildings. The fact that the main surface colouring in an interior usually forms a background to the colours of many other objects, such as fabrics, floors, furniture, each of which tends to influence the appearance of the others, confirms the fact that very fine differences in the range of colours available for paints and distempers are unnecessary in practice. A range of colours has been selected for schools, known as the 'Archrome' range, the shade-card for which sets the colours out in groups of equal value and similar hue and identifies each by an approximate Munsell reference.[5] Alterations or additions to this range can be systematically considered by referring back to the Munsell atlas, and the range itself is used by some paint manufacturers in Britain as a standard shade card.

The Munsell system can very satisfactorily provide a convenient means of specifying colours for many different materials as well as for paint and distemper. The Commission Internationale d'Éclairage has adopted a system of colour measurement and specification which is widely used, and which comes near to being a complete specification. The system is not so readily applicable to the present problem because in practice it requires the use of a colorimeter. A system of specification based on direct visual judgement and on comparison with a limited number of colour samples in an atlas cannot be expected to give precise references. Nevertheless, it is nearly always possible to give an approximate reference for a colour and so define its properties in terms which have a practical significance. The general adoption of the Munsell system would provide a common language for research and reference, and its simplicity could lead to a more general appreciation of the essentials of colour theory, and hence a higher standard of design in practice.

The Use of Colour in Practice

Some attempt has been made to study subjective reactions to colour, particularly in factories, but little material of direct value for hospital designs is available.* The claims made for colour therapy—that colour can contribute to the recovery of patients—are unfortunately not backed, so far, by any experimentally verifiable data.

* Some of the problems of subjective research have been discussed by Dr. R. G. Hopkinson: 'Subjective judgments. Some experiments employing experienced and inexperienced observers' and 'The multiple criterion technique of subjective appraisal'.[6]

If properly controlled experiments could be devised to investigate this subject, they would be of value.

Meanwhile there is scope for considerable experiment in a far bolder use of colour than has been customary in the recent past. Such schemes as those proposed by Kemp-Prosser can now be attempted with much clearer knowledge of what they will achieve.

A notable example of the bold but controlled use of colour can be seen in the schools designed by the Hertfordshire Education Authority.[7] Here colour has been used to give character appropriate to the use of different rooms and, as proposed by Le Corbusier and Ozenfant, to define and develop architectural volumes.

The Investigation has sought opportunities for making similar experiments in hospitals. The first undertaken was the redecoration of an existing ward; later, each of the buildings designed by the team was made the subject of an experiment in the use of colour.

Colour in Hospital Wards

In 1949 the Investigation was asked by the Farnham Group Hospital Management Committee to advise in the redecoration of an existing ward at Farnham Hospital, Surrey.[8] The Building Research Station was invited by the Investigation to take a leading part in preparing a scheme —the Investigation then being at the outset of its studies, whereas the Building Research Station already had considerable experience in the interior use of colour, though not in the hospital field. The ward was of the 'Nightingale' type, with a high ceiling, and high windows in opposite walls, between the heads of the beds. A balance between 'cool' and 'warm' colours was aimed at, a pale blue-green ceiling opposing a light, polished-birch floor. The window walls were painted a pale, warm grey, and the end walls violet, providing contrast to the almost unrelieved lightness of all other surfaces (*Table 37*). The coloured ceiling has effectively prevented glare, which is so common in this type of ward when the ceiling is white, and contributes greatly to the visual comfort of the ward. The light grey walls and light wood floor also give good integration of light with a complete absence of glare.

The cool colours of the walls and ceiling were intended to be balanced by orange and white bedspreads. In the event, it was impossible to obtain these colours, and blue bedspreads were substituted.

While the experiment was successful in achieving good integration of light in a type of ward where integration is difficult, it has shown that in a thoroughly considered scheme of decoration the omission of one element may seriously detract from its success. In this case, the substitution of blue bedspreads for orange and white weighted the effect of the whole scheme too far towards the cool colours.

Table 37. Colours used in redecorated ward at Farnham Hospital, Surrey

Location	*Finish*	*Colour*	*Munsell Code No.*
Entrance wall	eggshell	violet	2·5 P 6/1
Other walls	eggshell	pale warm grey	5·0 Y 8·5/2
Ceiling	matt	blue-green	5·0 B 9/2
Radiators and pipes	glossy	ivory	5·0 Y 9/4
Window frames	eggshell	broken white	—
Doors	glossy	light orange	7·5 YR 7·5/6
Door-frames other than main entrance frame	eggshell	broken white	—
Main extrance— continuous cover-moulding next to plaster reveal—	eggshell	broken white	—
main frame and glazing bars	eggshell	pale warm grey	5·0 Y 8·5/2
Bed-frames	glossy	blue-green	5·0 B 9/2
Folding-screens framing	glossy	ivory	5·0 Y 9/4
Folding-screens curtains	—	blue	5·0 PB 8/8
Bed-covers	—	natural ground with flower pattern in neutral grey and orange with dark blue accents.	—
Floor	—	natural birch	—
Bedside light-fittings	eggshell	blue-green	5·0 B 9/2

The design of the experimental ward unit at Larkfield presented problems of daylighting which the Building Research Station was invited to study. The plan was for a building 43 ft. 4 in. deep, and the ceiling height was to be as low as was consistent with the requirements of good daylighting. The type of the heating adopted in fact set a minimum of 10 feet. The construction of a model of the ward at the Building Research Station, and the studies carried out in it, have been described on pp. 93–97, but it is convenient to summarize here the results which have a bearing on colour.

It was found that, if the average reflection value of all the surfaces, including the floor of the ward, was high, the use of a dark colour on any one wall had only a small effect on the general lighting of the ward, except at points very close to that wall. It was particularly important to have light colours on the floor and ceiling because they contributed a great deal by reflection. To maintain a daylight-factor* of at least 2 per cent. at the beds farthest from windows, it was found advisable, with a floor of light cork having a reflection-factor* of 18 per cent., to have a white ceiling, with a reflection-factor of 80 per cent., and walls with a reflection-factor which did not fall below 44 per cent. Under these conditions the daylight-factor, at the beds farthest from windows, was 3·4 per cent. under a uniform sky, and somewhat less under an overcast sky. Even in rooms such as the Larkfield ward, which are deep in proportion to their height, there is scope for bold decoration, particularly as it was shown that some of the wall surfaces could be given quite dark colours without affecting the daylighting conditions in the ward as a whole. A point of importance noted is that pure complementary colours do not help the illumination of a room by inter-reflection if they are used together, because each absorbs the spectrum components reflected by the other. Designs for colour schemes to be used at Larkfield were made in the knowledge of these experimentally acquired data, and the model of the ward was used to try out the various proposals.

The plan of the ward (*Fig. 99*) shows that the intensity of light in the central corridor will vary greatly down the length of the building. There will also be differing degrees of enclosure noticeable to a person walking about the ward, emphasized by the varying directions from which light from the windows falls. To bring out the contrast between large and small spaces it is proposed to use high chroma colour in those areas which are most enclosed, and light colour on those walls which receive most light and contribute most by reflection to the integration of light within the wards (see *Table 38*). This colour treatment provides variety for the patients in bed, whose view is fixed, as well as interest for ambulant patients. High chroma colour in the nurses' station and on the end walls will be visible to almost every patient in bed and will provide contrast to the predominant areas of light colour in his immediate vicinity, thus avoiding an 'anaemic' effect. In the open wards, colours of a slightly stimulating character have been chosen, but too great contrast has

* These terms are defined on p. 93.

Fig. 99. Plan of the experimental ward unit at Larkfield Hospital. The letters A to G refer to wall areas listed in *Table 38*

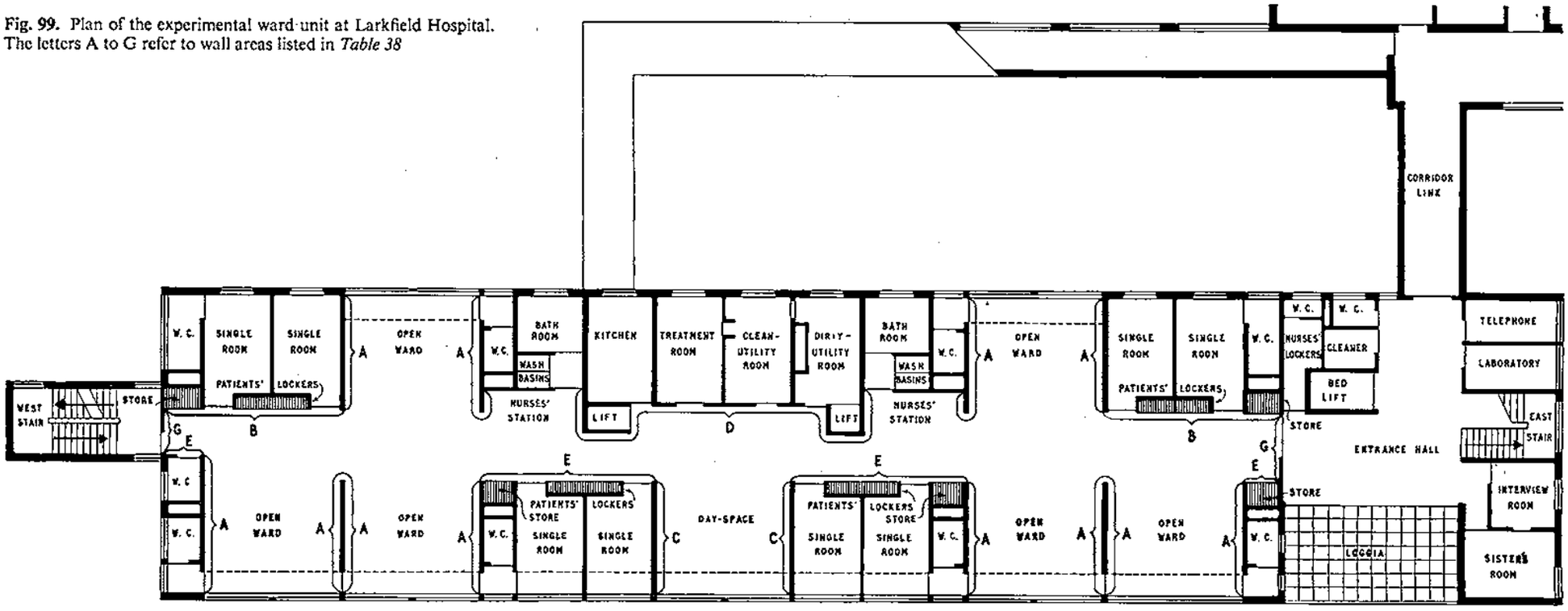

Table 38. Colours used in the experimental wards at Larkfield Hospital. *Note*: The references are to the Munsell colour atlas (e.g. 7·5 B 3/4) and the 'Archrome' range (e.g. A. 39)

Corridor Link to Existing Hospital	
Walls	blue: 7·5 B 6/6 (A. 38)
Doors and frames	white
Ceiling	white
Entrance Hall	
Walls and ceiling	white
Doors	grey: N. 5 (A. 46)
Door-frames	grey: N. 5 (A. 46)
East and West Stair	
Windowless walls	blue: 7·5 B 6/6 (A. 38)
Window walls	white
Doors, frames, ceilings, and soffits	white
Balustrade	black
Sisters' and Interview Rooms	
Walls	blue: 5·0 B 9/2 (A. 36)
Doors and frames	white
Ceiling	red: 7·5 R 6/10 (A. 3)
Wards	
Walls A	yellow: 5·0 Y 8/2 (A. 17)
Doors in walls A	grey: N. 5 (A. 46)
Door-frames in walls A	white
Walls B (including locker doors and frames)	white
Walls D	white
Wards (cont.)	
Doors in walls D	grey: N. 5 (A. 46)
Frames	grey: N. 5 (A. 46)
Walls E (including locker doors and frames)	grey: N. 5 (A. 46)
Doors in walls E and frames (including store door)	white
Walls G	red: 7·5 R 4/16 (A. 5)
Doors and frames	white
Walls C	green: 2·5 GY 7/10 (A. 28)
Bed-curtains	white and yellow black and white
Bed-covers	white and grey
Bed-frames	white
Lockers	black and white
Ceilings throughout open ward area and day-space	white
Window walls throughout open ward area and day-space	white
Windows	white
Window curtains	natural cotton fibre
Carpet in day-space	grey haircord
Cupboards in day-space	black and white
Upholstery on easy-chairs in day-space, Sisters' room, and interview-room	blue: 7·5 B 3/4 (A. 39)
Cupboards in nurses' station on walls F	yellow (A. 15) green (A. 30) blue (A. 38)
Wards (cont.)	
Cupboards in nurses' station on walls F (*cont.*)	grey (A. 43) red (A. 4) black
Single Rooms, North Side	
Walls	yellow: 5·0 Y 8/2 (A. 17)
Doors and frames	white
Ceilings	red: 7·5 R 6/10 (A. 3)
Fabrics and furniture	as open wards
Single Rooms, South Side	
Walls	grey: N. 8 (A. 43)
Doors and frames	white
Ceilings	red: 7·5 R 6/10 (A. 3)
Fabrics and furniture	as open wards
Service-rooms, Lavatories, W.C.s, Bathrooms, Laboratory, Doctors' Room, Telephone Room, and Basement Rooms	
Walls	very light grey: N. 9 (A. 42)
Doors	grey: N. 5 (A. 46)
Frames	grey: N. 5 (A. 46)
Ceilings	white
Cupboard frames	white
Cupboards and drawer faces	grey: N. 5 (A. 46)
Stores	white throughout

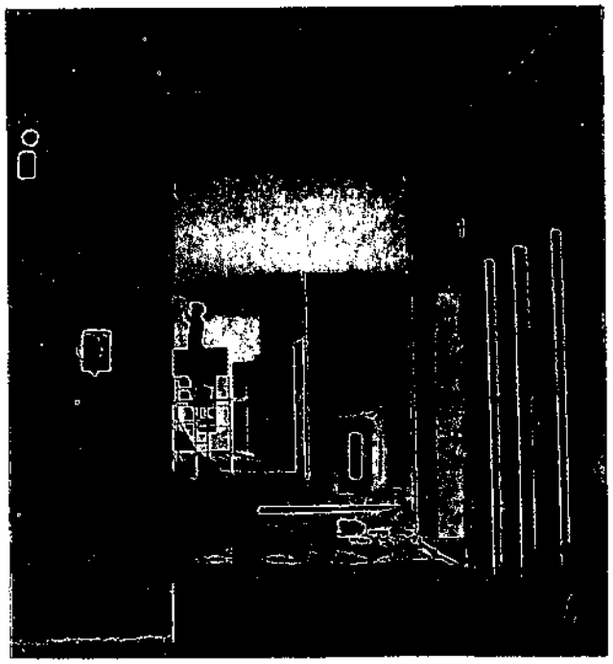

Fig. 100. View down centre circulation area of experimental ward unit of Larkfield Hospital, Greenock (building under construction)

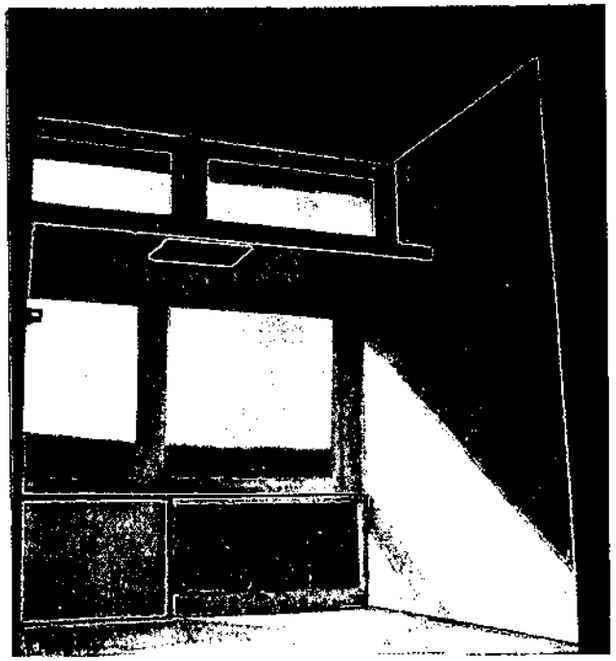

Fig. 101. Single room in the experimental ward unit at Larkfield Hospital, Greenock, showing the coloured ceiling

been avoided between the main colours on the walls, and those on curtains, furniture, and bedspreads (*Fig. 100*). In the day-spaces (*Fig. 101*) greater stimulation, and consequently greater contrast, can be allowed, and as the daylighting is not so critical more intense colour can be used on the main wall areas.

In the single-bedded rooms, where the very sick patients will usually be nursed, the colours need to be chosen to give an atmosphere of quiet. The use of different colours on the various wall surfaces—valuable in a large irregular space—can produce a restless effect in small rectangular rooms (see *Table 38*). The colours give varying emphasis to the enclosing planes, which are themselves inevitably broken up by furniture placed against them. Often in single-bedded wards the only completely unobscured surface is the ceiling, and this may be the part of the room most in the view of the patient. The judicious use of colour should remove the possibility of glare to which very sick patients are particularly sensitive, and as the rooms are small the lighting problem is not acute, and a comparatively low reflection from the ceiling will not seriously interfere with the lighting conditions. At Larkfield these rooms will have light warm grey walls and coloured ceilings; the ceiling colour will be darker in tone than the walls, but the contrast has been minimized so that the total effect shall be restful.

Within the working areas of the ward—the utility rooms, &c.—the choice of colours is limited only by the need to have a background light enough to give good distribution of light round the various working areas and to avoid such contrasts as might distract attention from the task in hand. At Larkfield these rooms will have very light grey walls, white ceilings, and dark grey cupboard doors and drawer fronts.

Outpatient Departments and the Nuffield Diagnostic Centre, Corby

In outpatient departments there are two main uses of space; circulation and waiting areas, and working areas. Colour can never, by itself, compensate for an insufficiency of light or make a badly planned department into something entirely satisfactory, but it can mitigate the unpleasantnesses of an ugly place and make a dull one attractive. Unlike hospital wards, the public spaces of an outpatient department should be stimulating, and, since patients do not spend very long in them, can be extremely colourful. Where there is plenty of natural light, high chroma colours, and white and black, may be used on walls and other painted surfaces, together with coloured textiles; where artificial light only is available, areas of white, and colour selected for its quality under artificial light, can help to overcome this disadvantage. It is of course essential to use finishes which are not easily damaged and which, when marked, can be readily cleaned by routine methods. Some modern lining materials, for example plastic sheets, are resistant to scratching and denting, and have colour integral with their hard, smooth surfaces. Many of the older materials, such as vitreous tiles, are now available in a wide range of colours.

The consulting-, examination-, and other small rooms in outpatient departments need to be well lit, and the colours used must not make a background which is distracting to those people who work in them. Light colours should normally be used.

In rooms where it is not possible to provide sufficient interest on the walls, a coloured or patterned ceiling may be used, provided that the lighting conditions are suitable. For example, in a large, lofty, waiting-space, surrounded by walls which are very much broken by doors, but with ample clerestory light and a flat ceiling, the ceiling could be boldly patterned geometrically, using, perhaps, primary colours and white. Floors, too, can be coloured and also patterned, not merely as part of a scheme of decoration, but in order to define areas of different use within a large department, or to give unity to one which is irregular in shape.

In the Nuffield Diagnostic Centre at Corby (*Fig. 32*) designed by the Investigation, where the decoration problem was similar to that in an outpatient department, colour has been used to emphasize the plan. It provides interest throughout the building, and helps visitors to identify the different departments in the Centre (*Fig. 102*).

The Centre consists of a number of blocks of rooms isolated from each other by waiting- and circulation-spaces and large areas of glass. Each block of rooms is given a different colour to emphasize this differentiation. The colour (see *Table 39*) is applied directly to the unplastered brick walls, whose undulating surface further contrasts with the smooth white ceiling and black-and-white chequered floor common to all areas (*Fig. 103*). The colours have been chosen to give at least one light wall in each waiting-space, and to contrast where the walls are opposed to each other. A matt paint was used to avoid reflections or over-emphasis of the irregular surface of the brick walls.

Table 39. Colours used at the Nuffield Diagnostic Centre, Corby

Block	*A*	*B*	*C*	*D*	*E*	*F*	*G*
Walls	Buff facing-brick	White	Blue: 2·5 PB 6/8*	Light grey: N 8	Light grey: N 8	Veridian green: 5·0 G 5/6	Buff facing-brick
Doors throughout	Light grey: N 8						
Door-frames throughout	white						
Floor throughout	black-and-white chequered tile 18 inches × 18 inches						
Ceiling throughout	white						
Radiators throughout	matt black						

* The numbers refer to the Munsell Colour Atlas

The walls of consulting-, examination-, and treatment-rooms, and of all other rooms within the blocks, are painted a very light grey, with darker grey paint on doors, door-frames, and skirtings. Where there are curtains in these rooms, varying colours in the same pattern fabric have been used. In the minor operating theatre and the treatment suite, white terrazzo has been used for the floor.

SUMMARY

Despite the eighteenth-century tradition of whitewash for the interior decoration of wards and Florence Nightingale's writings in favour of light colours, colour schemes in hospitals have for many years tended to be drab and unenterprising. Following experimental work at the beginning of this century by artists and architects, more adventurous schemes have recently been executed.

The principles of the behaviour of light in rooms have been studied at the Building Research Station. This work has shown the importance of reflected light in the total lighting condition of rooms.

A colour identification system which relates colours to their reflection values, and which is comprehensive and unambiguous, is a prerequisite to the study of colour problems. The Munsell system, described in outline, has proved most useful for studies in relation to architectural design.

Little material is available of direct value to those who wish to experiment with colour in hospitals, but some of the post-war schools in England show that there is scope for experiment in a far bolder use of colour. An experiment carried out by the Investigation in collaboration with the Building Research Station in an existing ward indicated that in an integrated scheme of decoration the omission of one element may destroy the lighting and colour balance.

The colour scheme devised for the Investigation's experimental ward unit at Larkfield Hospital has been designed so that each surface contributes to the total lighting conditions in the rooms, as well as to the architectural whole. The model used for the daylighting experiments was also used to try out colour schemes and record their effect on lighting.

There are considerably greater possibilities for the use of colour in outpatient departments than in wards. The colour scheme designed for the Nuffield Diagnostic Centre at Corby, where the problem approximates to that of an outpatient department, is described.

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Fig. 102. View along central corridor at the Nuffield Diagnostic Centre, Corby

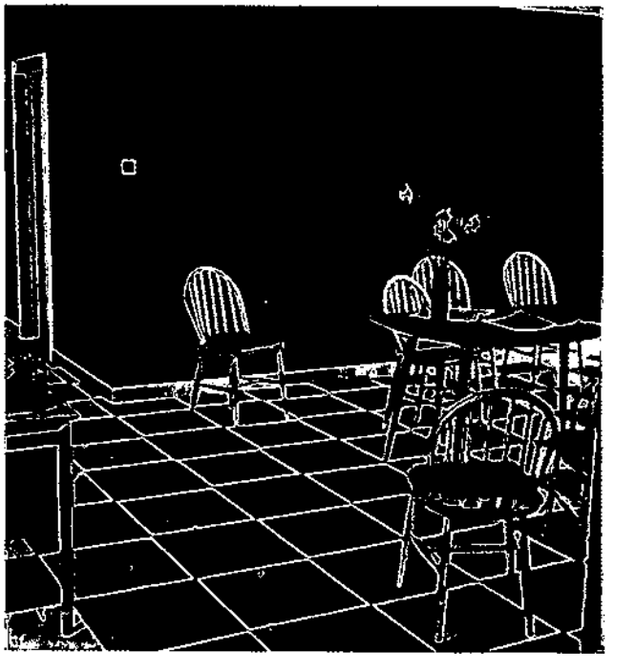

Fig. 103. Waiting-space at the Nuffield Diagnostic Centre, Corby

THE CONTROL OF SOUND

Introduction

For the last quarter of a century hospitals have been becoming steadily noisier, and it is now generally accepted that this is a serious problem.[1] The principal reasons for the present noisy conditions are known. There is more nursing and medical activity because more patients are in an acute condition, and the sources of noise have increased. There is more walking, more transport—especially by trolley—more mechanical equipment, and there are more sanitary fittings. Compact planning has brought these sources of noise nearer to the patient, and the lighter, panel walls and partitions of modern framed-structures are less resistant to sound than the heavier, solid masonry walls used in the past.

Knowing the causes of the present situation has not pointed to any simple cure. It is to be assumed that the level of activity in hospitals will be maintained or increased, and compact planning and light structures are likely to remain among the most economical methods of building. If money were no object every room in the hospital could be sound-proofed, but it is difficult to achieve control by this means within the limits of reasonable economy.

There is still a lack of precise information about noise in hospitals, in particular about its loudness and pitch in different areas, and its toleration by different classes of patients. Considerable research has been carried out in connexion with the control of noise in houses and flats, but there has been little similar study in hospitals.

Two studies on noise undertaken jointly by the Investigation and the Building Research Station are reported in this section, together with a discussion of what may be acceptable noise levels, and an account of the practical measures for control which have been taken in the experimental ward block at Larkfield Hospital, Greenock, and which will be taken in the experimental block at Musgrave Park Hospital, Belfast.

Noise in a Hospital Corridor

The first sound-measurement survey made for the Investigation by the Building Research Station was concerned with one of the chief sources of noise in hospitals—the corridors.

The survey was made in June 1953, in a two-story hospital on the outskirts of London, completed during the nineteen-thirties. *Fig. 104* shows the general plan of this hospital. The walls, which are load-bearing, are mainly of 9-inch and 13½-inch solid brick; the first floor is of reinforced concrete and the roof is of tiles on a timber frame. Interior finishes are of the hard, smooth kind usual in hospitals—hard plaster on all walls and ceilings, and composition flooring in the corridor.

To make the sound measurements a microphone was placed at the busiest point in the corridor system (shown as x on *Fig. 104*). *Fig. 105* shows the average noise-level over half-hourly periods throughout the twenty-four hours. It will be seen that during the night the average noise-level was about 45 decibels, rising steeply from 5.45 a.m. to 8.30 a.m., when it reached 65 db. Noise continued to increase until lunch time, and then there was a slight fall during the afternoon. There was a marked rise at tea time, and again at supper time, at 7.30 p.m. After that there was a steady reduction in noise until 11 p.m. The noise-levels shown in *Fig. 105*, being averages over half an hour, are useful only in giving a general picture over the twenty-four hours. *Fig. 106* shows the incidence of the individual loud noises which were perhaps the principal cause of distress to the occupants of the hospital. For instance, at 8 a.m. noises louder than 70 db. were

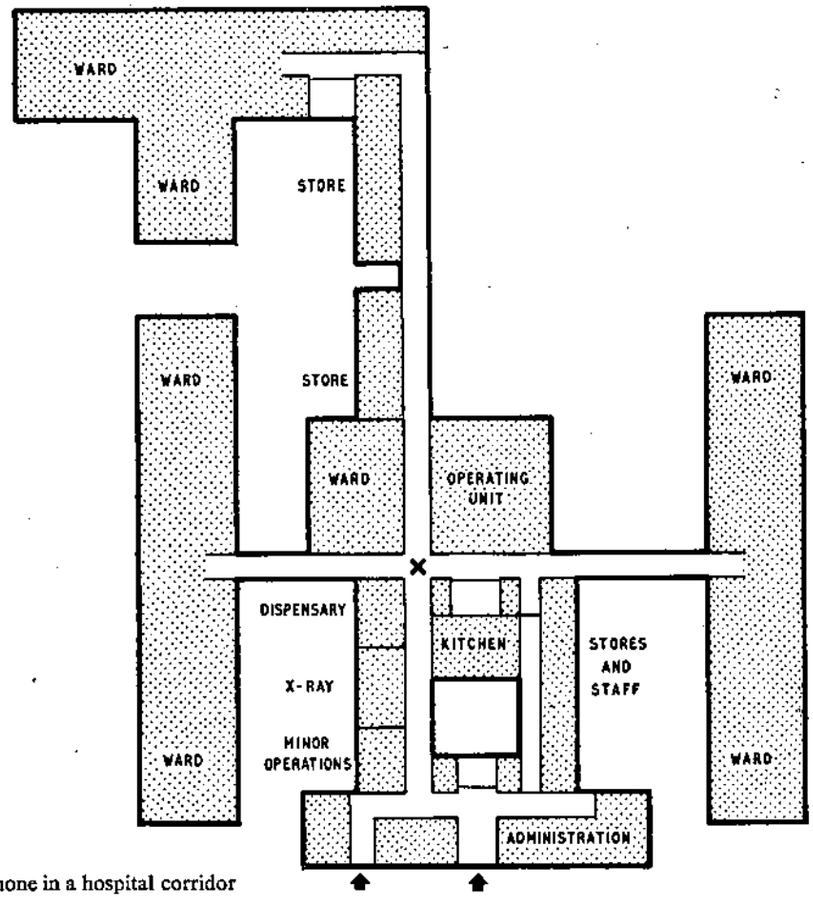

Fig. 104. Sound survey: position (X) of a microphone in a hospital corridor

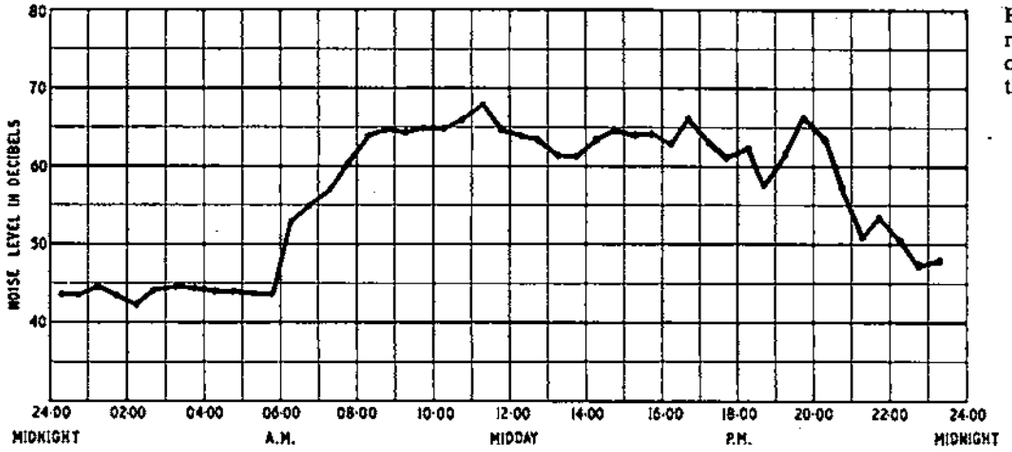

Fig. 105. Average noise-level recorded in a hospital corridor over half-hour periods throughout 24 hours

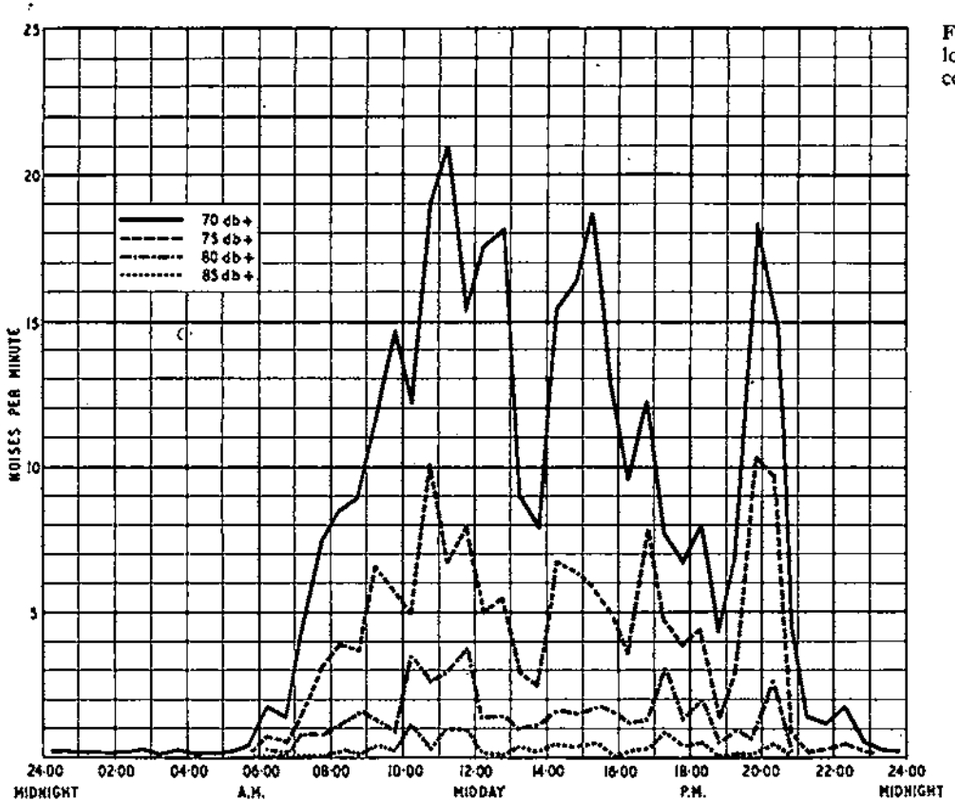

Fig. 106. The incidence of individual loud noises recorded in a hospital corridor

occurring about eight times a minute, and noises louder than 80 db. about once a minute. At 11 a.m. noises louder than 70 db. were occurring over twenty times a minute, and those louder than 80 db. about three times a minute. *Fig. 106* shows three marked peaks at about 11 a.m., 3 p.m., and 8 p.m.

Fig. 107 shows how the frequency of loud noises was related to the average noise-level. For example, when the average noise-level was 60 db., then noises louder than 75 db. were occurring about three times a minute. This was the case at about 7.30 a.m. and again just after lunch, at 1.30 p.m.

Fig. 108 relates the frequencies in cycles per second of the various noises which occurred during one fifteen-minute period to the average, maximum, and minimum noise-levels during the same period. It shows that the frequency range is large (60–7,500 cycles per second). To reduce the average noise-levels, therefore, it would be necessary to use absorbents capable of dealing with a wide range of frequencies.

Reverberation-time in the corridor varied with the frequency range of noises encountered during the period studied. The noises in the lower frequencies (150–2,000 cycles per second) have longer reverberation-times than those in the higher frequencies. This again would be relevant data if absorbents were to be used to reduce noise in the corridor.

The survey showed that the corridor was a source of considerable noise. The average levels were high for most of the day and the incidence of individual loud sounds was marked. Even at night noise did not die away completely. The principal causes of noise in daytime appeared to be trolleys and the slamming of doors—between 9 and 10 a.m. 300 door-slams were counted. The non-absorbent finishes in the corridor increased reverberation and prevented noises from dying away. The average night-levels are attributed principally to mechanical noises within the building. Two main sources were suspected: running machinery and water- or steam-pipes.

Noise from Sanitary Fittings

The second sound-measurement survey in which the Building Research Station assisted was concerned with sanitary equipment, namely w.c.s and bedpan-washers, because both are often sited fairly close to the actual bed-areas in wards—as in fact they are in the experimental wards designed by the Investigation.

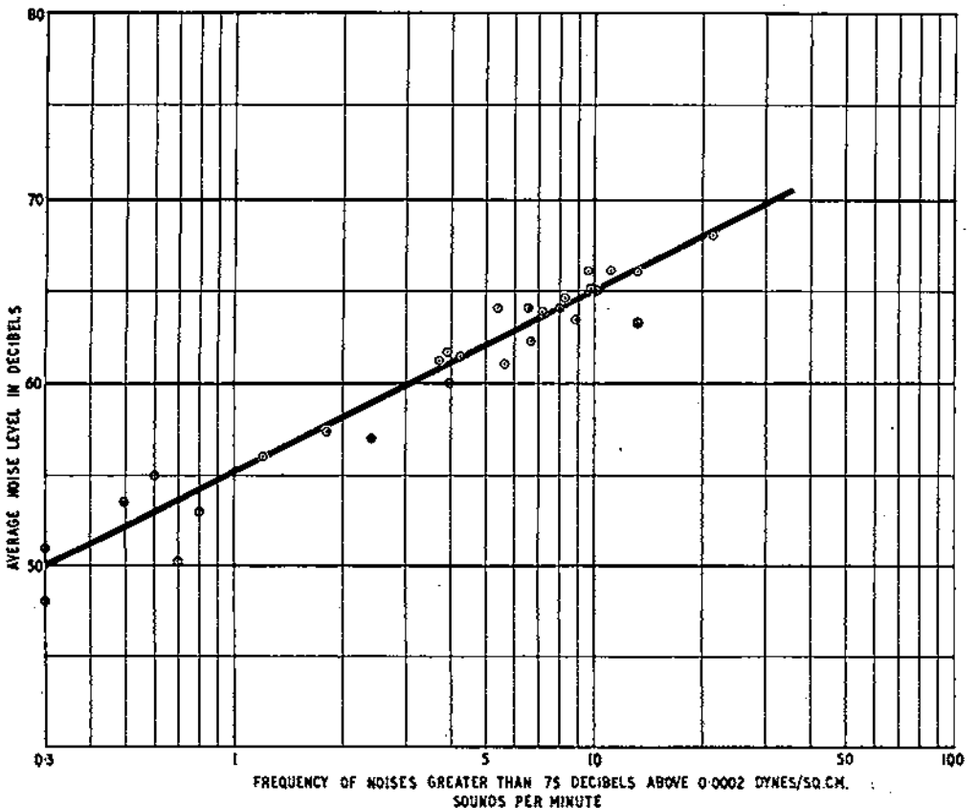

Fig. 107. The incidence of loud noise related to the average noise-level in a hospital corridor

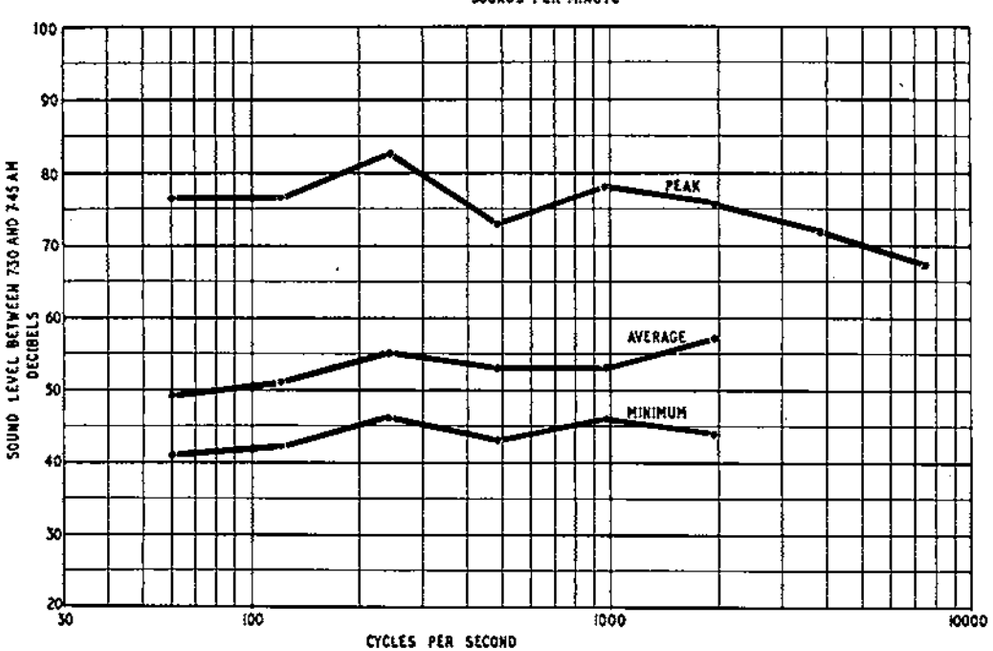

Fig. 108. Frequencies in cycles per second of the various noises occurring during one fifteen-minute period

It was found that the sound of flushing in a bedpan-washer registered between 68 and 70 db., but that the noise of shutting the lid of its hopper registered between 90 and 100 db. The noise made by a stainless-steel bedpan being placed in a metal rack was 80 db., and in a teak rack, 70 db. The results of recordings made in W.C.s are summarized in *Table 40.*

Table 40. Measurements of noise-levels recorded in W.C.s: *The meter was placed on a chair 12 feet in front of the pan*

	Description of W.C.		*Highest noise-level (in decibels)*	
Type	*Model*	*Cistern*	*Operating lever*	*Flushing*
Washdown	(*a*) Built-in Corbel type	High level	72	68
,,	(*b*)	Low level	72	64–66
,,	(*c*)	,,	72	64–66
Syphonic suite	(*d*)	,,	70	71
	(*e*)	,, (2 gall.)	70	65
	(*f*)	Low level (behind panel)	70	62–63 (flushing) 64 (final suction)
,,	(*g*)	,,	68	68
,,	(*h*)	,,	70	72
,,	(*i*)	,,	72	68
Washdown	(*j*)	Flushing valve	—	70

It is interesting to note that in W.C.s, as with the bedpan-washer, the noise of flushing was considerably less loud than the noise made by putting the machine into operation. While there is little likelihood of reducing the noise of the flush itself, redesigning the flushing mechanism to be quieter in use is feasible and would probably be worth doing. It may be deduced from the recordings that where a W.C. immediately adjoins a ward, a reduction of 45 db. through the partition between the two should be aimed at if the noise is to be tolerable for patients in bed.

Acceptable Levels of Noise

The studies just described are objective, that is to say they are direct measurements of noise. More such studies are to be made, and when further results are available it is hoped that they will give a comprehensive picture of noise conditions as they are in present-day hospitals. In determining what steps should be taken to control noise, it is necessary to know the level to which noise must be

reduced. This depends on what human beings find tolerable, which can only be determined subjectively.

In discussions on acceptable noise conditions in buildings, a subjective unit, the phon, is commonly used. Over a fairly wide range of frequencies covering most of the noises common in hospitals, the phon can be considered the equivalent of the decibel, the objective measure. *Table 41*, which is taken from R. Fitzmaurice's *Principles of Modern Building*,[2] shows the equivalent loudness in phons for a variety of commonly occurring noises. They can be compared with the measured noise-levels in hospitals given on p. 116.

Table 41. Loudness of indoor noise: *Approximate equivalent loudness in phons (B.S.). (After R. Fitzmaurice[2])*

Threshold of painful sound	130
Boiler-factory	100
Loud restaurant music	90
Typing-room	80
Loud radio speech	70
Moderate restaurant clatter	60
Quiet restaurant	50
Whisper at about 2-foot distance	30
Threshold of hearing	0

There is some difficulty in laying down precise standards for permissible noise in buildings, because what one person may find a tolerable noise-level another may not. Further, the acceptable noise-level may well vary from time to time and from place to place. Today people have become accustomed to levels of noise which they might have found disagreeable some years ago, and patients in a city hospital who are town-dwellers may well tolerate an amount of noise at night which would certainly be found disagreeable by patients from the country. Despite these difficulties, attempts have been made to propose certain sound levels as a standard for design, and these are given in *Table 42*.

The recommendations shown in *Table 42* are taken from a report made by the Acoustics Committee of the Building Research Board of the Department of Scientific and Industrial Research.[3]

Table 42. Tolerance levels of air-borne noise. *(After 'Post-War Building Study No. 14'[3])*

	Loudness in phons
Study or sleeping	15
Reading and writing	20
Sedentary office work; quiet conversation	35
Average office, telephone work; restaurant	40
Noisy office	60

It was suggested in the report that, depending on whether a building is in a quiet or noisy district, an allowance of between 5 and 10 phons up or down the scale should be made. In particular it was suggested that a level of 15 phons would be suitable in hospital wards, with an increase to 20 phons if the hospital was in a town. No specific recommendations were made for parts of the hospital other than wards, but the level suitable for sedentary office work and quiet conversation, namely 35 phons, might perhaps be considered suitable for consulting and treatment areas generally.[3]

There are many factors which affect the toleration of noise in hospital wards—among them patients' normal tolerance of noise, the nature of their illnesses, and the stage of convalescence they have reached. The standards quoted are based on the general experience of experts in sound problems, but they were made ten years ago. More recent work suggests that these standards are too high. They should therefore be regarded with considerable reserve until they are supported by objective research of the kind recently sponsored by the Building Research Station and carried out by the Social Survey, into noise problems in houses and flats—research which has been useful in determining the standards to be aimed at in housing construction.[4]

The reduction values for various types of structure, given later in this section, are average values over the normal frequency range. P. H. Parkin and E. F. Stacey[5] have shown that it is better to consider the insulation value of a structural element over the whole range of frequencies, because actual reduction values for noises over some parts of the range may be considerably less than the average. Standard curves have been prepared, based on the researches into noise problems in houses and flats, showing recommended insulation values over the whole of the normal frequency range for houses and flats. Grades of insulation have been established for both air-borne and impact noises. The sound insulation value of a structure can be assessed by using a graph on which the insulation value is given over a range of frequencies.[5]

Design to control Noise

The wards designed by the Investigation have provided the opportunity for a practical experiment in acoustic control. Each presented a different problem in design against noise and in each different measures have had to be taken. The results will be studied by the Building Research Station. It will then be possible to obtain a picture of the noise-level in wards designed with a measure of acoustic control as a primary consideration.

The Experimental Wards at Larkfield Hospital, Greenock

(For plan see *Fig. 9*)

The Larkfield ward unit is designed to facilitate medical and nursing procedures, and it presented a particularly difficult problem in sound-control. The design of the unit is a compromise between the traditional open ward and the corridor type of ward (see pp. 4–6). Three-quarters of the beds are in open bays divided from each other by partitions, but giving directly on to a central circulation space; the remaining beds are in separate single rooms. There is no enclosed corridor anywhere in the unit.

For the majority of the patients the noise of the various ward activities is not greatly lessened by the partitions, and moreover, to encourage patients not to remain bedfast longer than is medically necessary, easily accessible W.C.s are distributed about the ward, further increasing the difficulties of sound-control.

Service-lifts are provided within the ward unit, so that supplies reach the ward kitchens and the utility rooms with a minimum of handling. The main lift, for passengers and beds, is outside the ward unit.

Structural Measures

Load-bearing cross-walls are used as the main supporting structure of the building, in place of the more usual steel or reinforced concrete frame. Although in some ways inflexible, load-bearing wall construction has two advantages from the point of view of sound-control. First, it is likely to be less reverberant than are many types of frame-construction and so ensures a general reduction in structure-borne sound. Secondly, the heavy bearing-walls can be so placed as to act as barriers between sources of noise and areas where quiet is desirable. In the Larkfield plan the W.C.s are disposed at approximately 40-foot centres throughout the building, and the bearing-walls are paired at these points so that the W.C.s and the ducts housing their service-pipes are boxed in between them. The W.C. compartments are backed by deep cupboards, and each is further cut off from the ward by a small lobby.

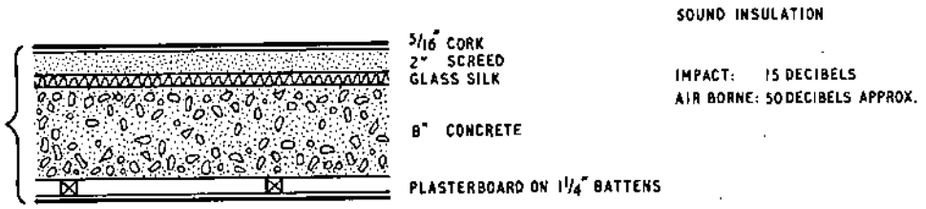

Fig. 109. Control of sound in the experimental ward unit at Larkfield Hospital. Detail of floating floor

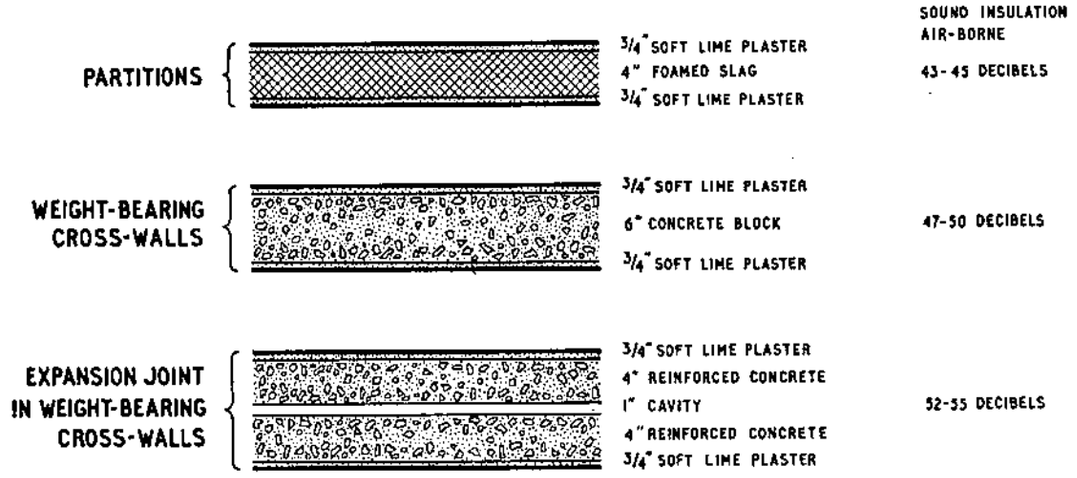

Fig. 110. Control of sound in the experimental ward unit at Larkfield Hospital. Details of wall construction

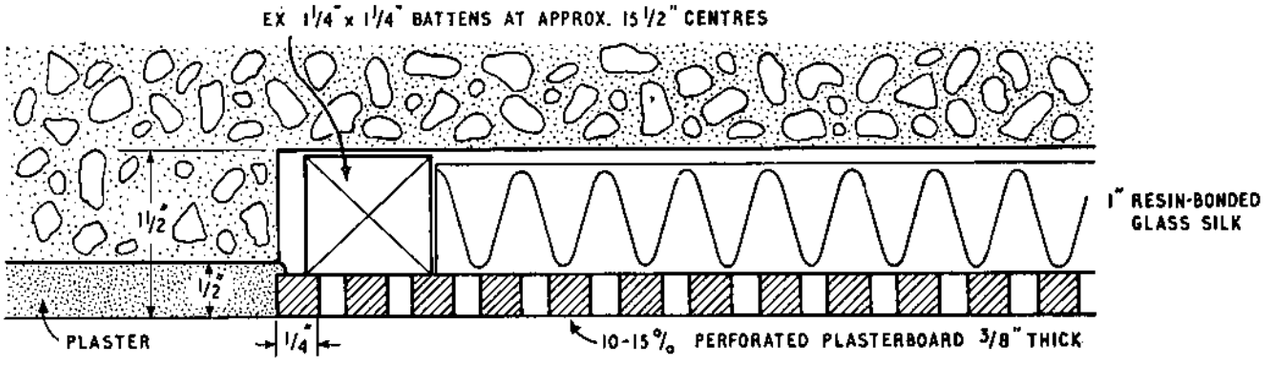

Fig. 111. Control of sound in the experimental ward unit at Larkfield Hospital. Detail showing how sound-absorbing panels are fitted into the ceilings

The shafts for the service-lifts are surrounded by solid load-bearing walls.

The structural floor is a flat reinforced-concrete slab, spanning between bearing-walls, without any beams. A floating floor is provided, isolated from the structural slab by a layer of glass silk (see *Fig. 109*). This construction gives a sound reduction of about 50 db. Partitions are generally of 4-inch clinker-block construction, giving a sound reduction of 43–45 db.; the bearing-walls are of 6-inch concrete and give a sound reduction of 47–50 db. *Fig. 110* shows the different types of wall used.

Finishes and Sound-absorbment Treatment

Cork tile has been selected as a floor-covering because it combines good noise-reducing qualities with a smooth, hard-wearing, and pleasant-looking surface. A carpet in the day-space, where convalescent patients sit, further absorbs the noise there. The use on ceilings of various materials designed to absorb noise is already common in hospitals in the United States and on the Continent. In planning the experimental wards, it was evident to the Investigation that some sound-absorbent treatment of the ceilings would greatly improve conditions in wards, and the Building Research Station advised the use of perforated gypsum plaster-board backed with glass silk (see *Fig. 111*). This treatment can be designed to be effective over an appropriate range of frequencies and, unlike some other forms of acoustic treatment, it is free from fire risk.

Because of the common objection, on bacteriological grounds, to the use of absorbent surfaces in wards, sample ceiling-panels were submitted to the Central Public Health Laboratory at Colindale. A panel was attached to the ceiling in a room at Colindale where bacteria were being sprayed in the course of experiments. Subsequently the panel was taken down, and tested. Very few bacteria could be obtained from it. It was concluded at Colindale that, when the panel is attached to the ceiling in a ward, it need not be regarded as increasing the risk of infection. The Laboratory has agreed to make further tests after the board has been in use for a sufficient time in the experimental wards at Larkfield.

Fig. 112 shows the extent of the acoustic ceiling at Larkfield; the area is limited because ceiling-heating of the embedded-panel type is used.

Certain doors in the experimental unit which are in continual use, for instance those leading to the ward kitchen, have double leaves which swing both ways yet

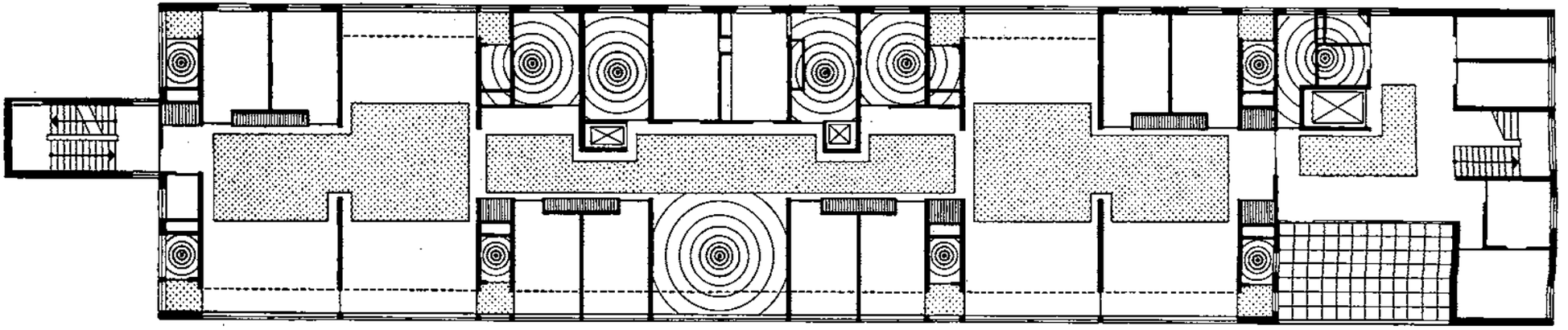

Fig. 112. Control of sound in the experimental ward unit at Larkfield Hospital. Sources of noises and positions of sound-absorbing panels in ceilings

come to rest silently in a closed position. Though swing doors cannot fit tightly into their frames, and provide only a partial sound-barrier, they are still preferable, in very busy rooms, to doors which can be set wide open and so offer no barrier at all. All other doors in the unit are provided with an automatic closing device. The door is free until it reaches a point within a few inches of the door-frame where an overhead mechanism takes charge and shuts it gently against a cushioned jamb. These doors cannot be slammed and are without latches.

In a modern lift the principal source of noise is the opening and closing of the doors. Bi-parting doors sliding to one side were adopted as being the most silent in operation, and special buffers have been incorporated to eliminate any impact noises.

The bed-curtain rail has fibre runners which greatly reduce the noise made in drawing the curtains.

Experimental Wards at Musgrave Park Hospital, Belfast
(For plan see *Fig. 10*)

The plan on which the Musgrave Park Hospital experimental block is to be built makes the problem of sound-control easier than at Larkfield. The wards are more cut off from the central circulation area, and each unit of 20 beds is separated by doors from the main utility rooms and day-space. The W.C.s are grouped, and, although still close to the beds, are entered from the circulation area, instead of from the bed-area as at Larkfield. There are no service-lifts for the utility rooms at Musgrave Park, as the passage of trolleys through the more enclosed

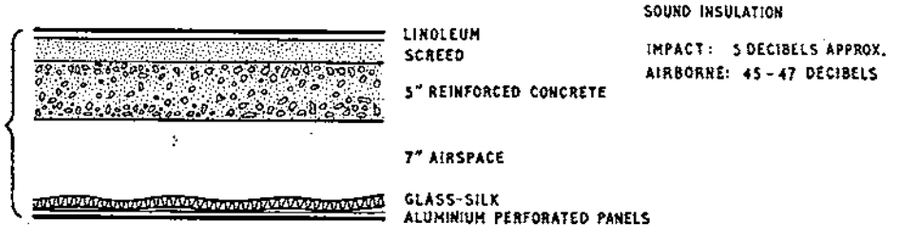

Fig. 113. Control of sound in the experimental ward unit for Musgrave Park Hospital. Detail of floor construction

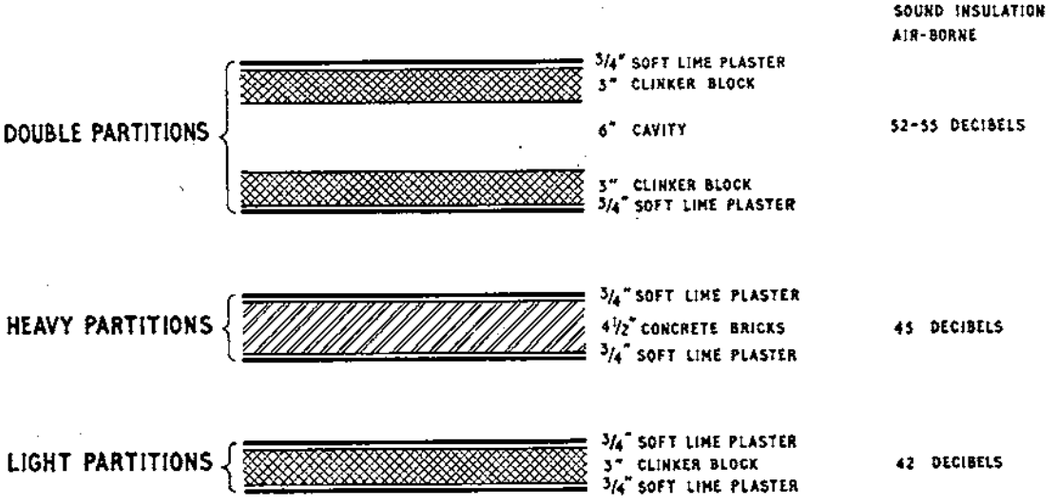

Fig. 114. Control of sound in the experimental ward unit for Musgrave Park Hospital. Details of wall construction

circulation areas is not expected to disturb patients in the wards.

Structural Measures

At Musgrave Park reinforced-concrete framed construction will be used, and the cross-walls are partitions only. Framed construction is likely to transmit sound from one part of the building to another unless the frame is insulated, particularly against impact noises. The partitions running across the building are formed of concrete blocks in two leaves completely enclosing the stanchions. The structural frame is muffled in this way against noise originating in rooms. The double partition gives a reduction of 52–55 db. between adjacent rooms. The floor construction (*Fig. 113*) gives a reduction of 45–47 db. The W.C.s are isolated from the wards by 4½-inch brick walls giving a reduction of 45 db., and the flushing valves are fixed to the wall between two W.C.s, the wall being isolated from the ward partition. *Fig. 114* illustrates the types of wall-construction used.

Finishes and Sound-absorbent Treatment

The finishes are similar to those at Larkfield, but linoleum instead of cork is used as a floor covering. At Musgrave Park absorbent materials incorporated in the ceiling are used over the whole area. The ceiling is of perforated aluminium panels, fixed on to a grid of heating pipes, hung below the structural slab. There is a 2-inch glass-silk quilt between the ceiling and the slab. This ceiling is a proprietary product and provides heating as well as acoustic correction in all rooms and corridors.

Furniture and Fittings

The measures for noise-reduction are similar to those described for Larkfield. As there will be a central sterile supply department elsewhere in the experimental block, it has been possible to reduce the amount of sterilizing of equipment which ordinarily takes place within the ward unit and which can cause a good deal of noise.

SUMMARY

To obtain objective knowledge of the noise-levels experienced in existing hospitals two limited surveys were undertaken. Further studies are to be made and a subjective survey undertaken to establish what levels of noise may be tolerable to hospital patients. Meanwhile levels to which noise should be reduced, and the degree of reduction to be aimed at in designing structural elements, which have been suggested by other workers, have been accepted as the basis for experiments in the control of sound in the experimental ward units at Larkfield and Musgrave Park.

Sound is controlled by minimizing noise at its source, by isolating or muffling structure-borne reverberations caused by impact, by providing sound-reducing walls and floors between the sources of noise and the patients (the heavier the structural elements, the greater their sound-reduction properties), and by applying absorbents to surfaces in areas where noise is likely to occur.

In the experimental units at Larkfield, measures taken to reduce noise at source include doors which close silently, fibre runners to bed-curtains, and cork floor-finish. Heavy load-bearing structural walls minimize structure reverberation, provide 47–50 db. reduction in air-borne sound between the wards, and isolate W.C.s and service ducts. A floating floor, laid over the concrete slab spanning between cross-walls, gives a reduction of 50 db. between stories. Perforated plaster-board backed with glass silk is applied to ceilings over the open circulation spaces. Tests carried out at the Central Public Health Laboratory showed that this material, applied to ceilings, need not increase the risk of infection, and further tests will be made after the board has been used for some time at Larkfield.

Similar precautions are to be taken to reduce noise at source in the experimental wards for Musgrave Park Hospital. A reinforced-concrete frame is to be used, and non-load-bearing cross-walls, consisting of two leaves of concrete blocks, which separate the wards, will also enclose the structural columns and muffle structure-borne noise. These partitions give a reduction of 52–55 db. between rooms, and the floor construction gives a reduction of 45–47 db. between floors. Perforated aluminium panels, backed by glass silk (part of a proprietary system of combined ceiling-heating and acoustic control) will provide absorption over the whole ceiling area.

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HEATING AND VENTILATING

Introduction

It was believed in the eighteenth century that a connexion existed between the spread of disease and lack of ventilation in hospital wards. In recommending the use in hospitals of a mechanical ventilator which had been invented by Stephen Hales in 1743, Sir John Pringle complained of 'the impossibility of convincing either the nurses, or the sick themselves, of the necessity of opening the doors or windows, at any time, for air'.[1] Hales's extract ventilators were, in fact, installed at the County Hospital at Winchester and at St. George's Hospital, Hyde Park Corner. Air was drawn out of the wards by fans, through trunking systems, and discharged outside the buildings. The intake was though the doors of the wards, for Hales had pointed out that 'the fresh air must by no means enter at the windows in cold weather because such cool air will fall precipitately down thro' the warmer air of the ward, and thereby greatly incommode the patients'.[2]

When additions were made to the buildings of the Infirmary at Newcastle upon Tyne in 1801, each story was planned as a single row of wards with a gallery, to facilitate natural ventilation. Opening lights were placed high in each window, and similar openings were placed opposite them on the gallery side. This is an example of planned natural ventilation, and such systems seem generally to have been preferred to mechanical ones during the middle years of the nineteenth century.

Nevertheless, Neil Arnott, Queen Victoria's 'physician extraordinary', devised an air-conditioning system for the County Hospital, York, in 1851. This was an input system in which the air was heated by a self-regulating stove in winter and cooled by running water in summer.[3] A plenum system, designed by William Key, a Glasgow engineer, was installed at the General Hospital, Birmingham, in 1895. Sufficient warmed and filtered air was passed into the rooms to maintain a positive pressure 'of about four ounces per square foot in excess of the outside atmospheric pressure at the time'.[4] A similar wholly mechanical system was installed in the Royal Victoria Hospital, Belfast, which was built in 1903. Clerestory lighting with fixed glazing, combined with input ventilation, made possible an unusually compact building. The system is still in use and has remained almost exactly as it was originally installed.

Circular wards were proposed in 1878 by J. Marshall, who was Professor of Surgery in the University of London, because they allowed natural ventilation from all points of the compass. Marshall also suggested a central source of radiant heat, supplemented by warm water pipes 'around the circumference of the ward'.[5] Soon afterwards circular wards were built at the Victoria Hospital, Burnley, and the City Hospital, Antwerp, but their advantages were outweighed by the extra cost of building.

In the British Isles many hospital planners continued, until quite recently, to rely solely on ventilation through windows on opposite sides of open wards; in the United States of America, however, large cross-ventilated wards have gradually been abandoned in favour of the corridor type of ward (see p. 4).

Ventilation and Bacterial Control in Wards

It is only comparatively recently that efforts have been made to establish the precise relation between air change and the incidence of infection. The evidence so far collected has been equivocal. Nevertheless, as Dr. Thomas Bedford pointed out in a discussion at the Royal Society of Medicine in 1950:

> There can be no doubt that infective material can be transmitted from one person to another *via* the air, but there seems to be no clear indication as to whether, in ordinary buildings, direct infection or airborne infection is the greater risk. . . . In *hospital wards*, where patients are in bed, it can be assumed that the chances of direct infection will be less than in, say, a factory or office, and that in hospitals, therefore, aerial infection will be relatively more important. . . .
>
> Dust, particularly that loosened from blankets, harbours bacteria. An adequate ventilation system can greatly reduce the number of bacteria-laden dust particles in the air of the ward, and the oiling of floors, linen, and blankets will lessen the number of particles liberated. For the same reason vacuum cleaning is to be preferred to sweeping.

The rate of ventilation as a primary means of reducing air-borne infection was stressed by Dr. Bedford, but in commenting on the standard recommended in the report of the Departmental Committee on the Cost of Hospitals (1937), namely three air changes per hour with convection heating systems, he said:

> A ventilation rate of 3 air changes per hour does *not* mean that the air within the room is completely renewed three times each hour. Instead, it means that the volume of air entering and leaving the room in one hour is three times the volume of the room. As the air enters the room it mixes to greater or less extent with the air already in the room, so that if any polluting agent is present in the room atmosphere it is gradually diluted by the ventilating air. If mixing is perfect, after the time taken for one air change—twenty minutes in our example—the concentration of the polluting material is still 37 per cent. of the original value.
>
> The other basis on which ventilation calculations are made is that of the fresh air supply required for each person. In ordinary practice a fresh air supply of 1,000 or 1,200 cubic feet per person per hour represents good ventilation in cold weather. . . . In a hospital ward, where the space allowance is probably 1,000 to 1,500 cu. ft. per patient, 3 air changes per hour represents 3,000 to 4,500 cubic feet of fresh air per hour per person. This seems to be a very good figure, judged by ordinary ventilation requirements, and it makes a considerable demand on a heating system, yet it may not be good enough to be effective in preventing cross-infection.

Dr. Bedford pointed out that other factors had to be taken into consideration—the rate at which bacteria-laden particles will settle from the air, and the temperature difference to be maintained between the outside air and air in the ward.

> It is [he said] probably reasonable to assume the rate of removal of particles by sedimentation to be about that which would be achieved by a ventilation rate of 4 air changes per hour. If we accept that figure, with an actual ventilation rate of 3 air changes per hour, ventilation and sedimentation together would remove bacteria-laden particles at a rate corresponding to 7 air changes per hour, and with ventilation at 6 air changes per hour the removal rate would be equivalent to 10 air changes per hour. With these removal rates the bacterial concentrations five, ten, and twenty minutes after the dispersion of the organisms would be 56, 31, and 10 per cent. of the original concentrations with the ventilation rate of 3 air changes per hour, and 43, 19 and 3½ per cent. with ventilation at 6 air changes per hour. . . . I understand that it is

recommended that heating arrangements should provide for the maintenance of a temperature up to 30° F. in excess of the outside temperature. Thus, except on relatively few days, when the outside temperature is below 35° F., it should be possible to maintain a temperature of 65° F. in the wards. . . . A 30° F. excess above the outside temperature will only be possible, however, if the ventilation rate is limited to that for which the engineer has made allowance—generally 3 air changes per hour.[6]

The British Standard Code of Practice on ventilation recommends three air changes per hour for wards, but suggests that lower rates might be used in hospital rooms intermittently occupied.[7] In addition to providing for an adequate rate of ventilation in hospital wards, other methods of preventing the build-up of infection due to dust-borne organisms are being studied.

Since the early nineteen-forties experiments have been in progress in treating blankets and other textiles with oil and bactericidal agents during laundering, and the technique is now more or less perfected. The use of oil on floors has also been tried.

Studies have been made of the content of the air in a children's ward for burn cases, where both blankets and floors had been oiled, and in a women's surgical ward, where they had not. Samples were taken in various circumstances—during bed-making, for example, while dressings were being done, and during quiet periods. Both wards were cross-ventilated through opposite windows, and counts were taken with doors and windows open, and with doors and windows shut.[8] In the children's ward, where the blankets and floor had been oiled to control dust, the number of bacterial colonies per cubic foot of air was lower, even under winter conditions with windows shut, than in the women's ward. These counts were compared with others made on the roof of the hospital and in the street outside. Dr. L. Colebrook and W. C. Cawston, who carried out this particular experiment, noted:

> In the surgical wards of the hospital, in cold weather, with most of the windows closed, the total counts were considerably higher than those for outside air, even when the ward was quiet (no bed-making or dressings in progress and no patients ambulant). In warm weather, with many windows open on each side of the ward, the total counts were not much higher than the average for outside air at ground level, but rose steeply during bed-making. β-haemolytic streptococci were isolated from the air of both wards tested.

They urged that windows should be opened as a routine procedure after bed-making, and after dressings carried out in the ward. They also recommended that oiling of floors and blankets should be adopted generally.[9]

More recent experiments, aimed at controlling cross-infection with penicillin-resistant *Staph. aureus* in a ward at the Bristol Royal Infirmary, showed that, although oiling floors and blankets and all bed-linen had a considerable effect in reducing the liberation of dust and bacteria, it had little effect on cross-infection rates so far as that particular organism was concerned.[10]

As part of the Medical Research Council's studies in air hygiene, Bourdillon and others made tests in offices, factories, and some hospital wards to determine acceptable limits of bacterial contamination of air. They suggested 50 bacteria-carrying particles per cubic foot as an upper limit, to be considered satisfactory in any ordinary occupied space, but added: 'air hygiene is still far too backward for the enforcement of any limit'. Bourdillon, McFarlan, and Thomas considered 20 bacteria-carrying particles per cubic foot to be an upper limit in treatment-rooms.[11]

In addition to the oiling of textiles and floors as a means of controlling dust, Bourdillon also advocated vacuum cleaning where it was possible and sweeping with a wet or oiled brush or with moist or oiled sawdust where it was not. He suggested that 'in new institutions a built-in vacuum pipe line is worth considering'.[12] It has now been demonstrated that if a vacuum cleaner with an enclosed metal cylinder for dust collection is used, there is probably no danger of bacteria being drawn into the machine and then scattered again in the exhaust air.

The removal of surgical dressings in the ward is a further source of air-borne infection, and is an added argument for the provision of treatment-rooms in ward units (see p. 8). Special precautions must be taken, however, to ensure that the treatment-room itself does not become a potential source of cross-infection (see p. 24).

Ventilation in Wards and Pleasantness of Conditions

Besides the medical need to control air-borne bacteria in wards, there is the ordinary domestic need to provide an atmosphere which is comfortable in temperature and free from draughts, and at the same time reasonably fresh. The Investigation considers that wards need two rates of ventilation—a moderate, continuous air-change, and the means for a rapid blow-through when occasion demands it. In this respect, completely mechanical ventilation has the great advantage of certainty. A properly designed plant will deliver the required amount of air, heated, washed, and if necessary filtered, with great regularity, the system being more or less independent of weather conditions.

But whereas natural ventilation is cheap, mechanical ventilation is costly and lacks flexibility. It is, for example, expensive to provide for an occasional blow-through solely by mechanical means, for to do so requires the installation of plant and ducting sufficient to give ten air changes an hour, whereas for most of the time only three are needed. Nor is it possible to provide for any saving in the running costs of mechanical ventilation by recirculating used air, for such a system would be open to the risk of building up a high bacterial content.

In fact, mechanical systems are so expensive that they are rarely employed except in special circumstances as, for example, in wards where all the air must be filtered because of atmospheric pollution, or where sealed windows are needed to exclude noise. If for such reasons as these a complete mechanical system is installed, it seems that it should be designed to give at least three air changes an hour in the wards.

In many modern hospitals on the Continent partially mechanical systems are used in conjunction with the ordinary windows in the wards—an arrangement probably due in part to a strong and understandable reluctance to open windows in winter time. Partial mechanical ventilation does ensure some air change when all the windows are shut. Unfortunately when any windows are opened, as they must be from time to time for a blow-through, the whole mechanical system is thrown out of balance. In normal circumstances, however, by suitable placing of inlet and outlet points, mechanical ventilation can ensure that the whole of the air in a room is changed.

Mechanical ventilation can be either by extract or by input. With the extract method, air is liable to be drawn into the rooms from corridors, and perhaps from lavatories and ward kitchens, bringing dust, bacteria, and smell with it. Therefore, where patients' rooms are mechanically ventilated, it should be by the input method. Conversely, ventilation of such rooms as lavatories and ward kitchens should be by the extract method.

Natural ventilation has the great advantages of simplicity and economy, and the vast majority of hospital wards in this country depend on windows alone for their ventilation. Natural ventilation is also generally believed

to be more acceptable to patients than artificial ventilation.

Until recently, comparatively little has been known in detail about the process of natural ventilation in buildings. In particular, it has not been known how many air changes are to be expected under given conditions or how thorough natural ventilation is likely to be. Recent scientific studies have shown that ventilation takes place because of differences in air pressure, which may be set up by a number of causes.[13] The two most important for hospital buildings are wind pressure and stack effect. When there is a wind blowing there will be a differential pressure across the building—that is, pressure on the windward side will be greater than that on the leeward. This tends to set up horizontal currents of air through the building from the windward to the leeward side. Owing to the cracks round windows and doors, these horizontal currents continue to flow even when the windows are closed. Stack effect occurs principally during the winter, when the air in the building is heated and therefore lighter than the outside air. This tends to set up a vertical flow in the building, warm air escaping at high level, and cold air entering from outside at low level. It is possible to calculate the air-flow through openings under given conditions of wind velocity and temperature difference, and the results of these calculations have been found to be in good accord with direct measurements of ventilation-rates in experimental buildings. It is therefore possible to predict, with a fair degree of accuracy, the number of air changes to be expected in a room from a given window-opening under given climatic conditions.

The thoroughness of the ventilation to be expected is also an important question. It is reasonable to assume that ventilation will be thorough in traditional wards where large, widely opening windows are provided on both sides. Some doubt has been expressed, however, as to whether a single window, or windows on one side of a room only, will provide effective ventilation without pockets of dead air. An interesting series of experiments, made by Rydberg in Stockholm, has been directed towards investigating this problem.[14] Rydberg was able to demonstrate that, because of stack effect, air-flow through a window into a room could be accurately simulated by the use of liquids in a model of a room. By colouring the inflowing liquid, which corresponded to the outside air, he was able to take photographs of changing conditions in the model which were equivalent to the gradual change of air after opening a window. He also measured, for various types of windows and for ventilators placed at high and low level, the length of time elapsing between opening the window or ventilator and the total replacement of air in the room.

Fig. 115 shows the results of using a casement window which, it will be noticed, is fairly small in relation to the volume of the room. At the beginning of the experiment the casement was fully open, and the gradual replacement of the air in the room can be followed. The light area represents the air in the room, and the dark area air entering through the window. Half the air in the room has been replaced after 30 seconds, and after 1 minute there is still a small proportion of old air at high level; in less than 2 minutes the air in the room has been almost completely changed.

Fig. 116 shows the replacement of air when a pivoted casement is used. This is a somewhat slower process because a pivoted casement does not open fully, but the air has been almost completely changed within 3 minutes of opening the window. In all cases Rydberg found that replacement of air was complete up to the level of the window-head, but that, above the window-head, the window had no ventilating effect whatever. No matter how long the window remained open, the air above head-level was unchanged. This effect is not shown in *Figs. 115* and *116* because the field of the camera was cut off at window-head level. It can be seen in *Fig. 117*, because in that example the head of the window was 4 ft. 2 in. below the ceiling. In practice, however, even in calm weather, some mixing would occur at high level because of eddies in the incoming air, and comparatively low wind speeds would quickly complete the air change.

Rydberg's experiments were made under conditions which simulated a temperature difference of 20° C. and zero wind velocity. This would occur when the outside temperature was near freezing and the inside of the building was heated to normal requirements. In this country, for much of the winter, the temperature difference would be far less. On the other hand, zero wind velocity is a rare occurrence here, and even light wind would more than compensate for a lower temperature difference. It can therefore be assumed that the rates of air change found in Rydberg's experiments would be generally similar to those to be expected here. Further, Rydberg showed, by another series of experiments, that the general pattern of air movement is similar for a wide variety of rates of air change.

Since complete and rapid air change can be achieved by providing windows of suitable size on one side of a room only, it may be concluded that cross-ventilation in wards is not essential. Furthermore, the efficiency of natural ventilation is unaffected by room height except in so far as high placing of inlets gives the incoming air a greater distance to travel and mix with the warm air already in the room before it reaches the patients. This contributes to comfort by minimizing room draughts.

The experiments so far described are concerned with the effect of a short period of intense ventilation when the windows are open wide—the rapid blow-through discussed earlier. In fact window ventilation in Sweden generally takes this form, and Rydberg's experiments were designed accordingly. He was, however, struck by the completeness of the ventilation obtained and proceeded to consider the question of continuous slow ventilation. In particular, he experimented with the pivoted window, opened to give narrow chinks at sill and window-head level. He found that a chink 9 mm. wide gave steady ventilation at the rate of one air change an hour. He concluded, apparently with some surprise, that:

> From the foregoing it is evident that from the technical standpoint of flow there is nothing to prevent suitably strong, continuous ventilation by windows or simply by ventilators in external walls. The fact that ventilation arrangements of that kind in spite of their simplicity have not been used to any considerable extent in practice up to the present is, therefore, to be attributed to other circumstances, in the first instance, the difficulty of preventing the discomfort of draughts.

The best position and design for the opening panes must now be considered. So far as the quick blow-through is concerned, the type of window used does not greatly matter; but whatever arrangement is chosen, it should allow a clear opening of at least one-fifth of the floor area, as required by the Model By-laws, though this area may perhaps be reduced with advantage in wards on the upper floors of tall buildings. At such levels wind pressure is generally considerable, and there would be an advantage in reducing the size of the opening area in order to reduce the risk of draughts around the sashes when the window is shut.

When the outside temperature is similar to that inside a room, there is usually every advantage in promoting the maximum ventilation, and windows used for a quick blow-through in cold weather can therefore with advantage be left wide open during warm periods. During the winter

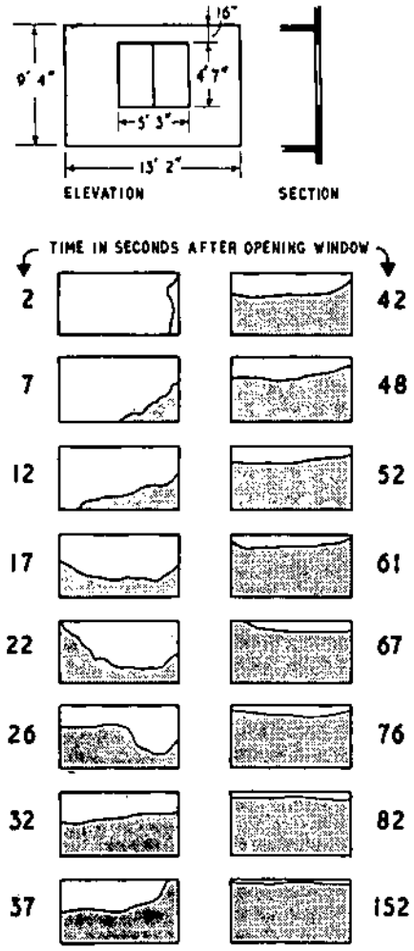


Fig. 115. Movement of fresh air into a room through a casement window, with top of window 16 inches below the ceiling

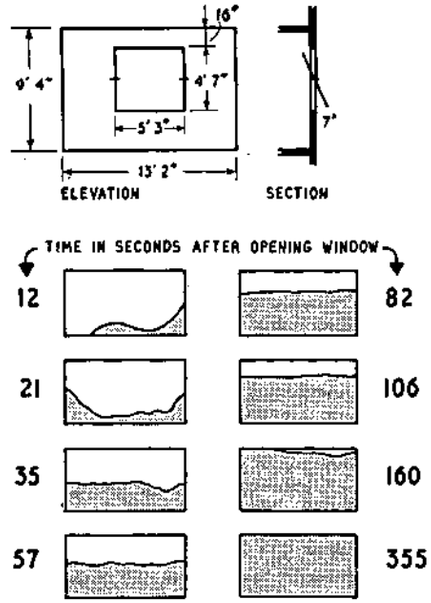


Fig. 116. Movement of fresh air into a room through side-hung pivoted window, with top of window 16 inches below the ceiling

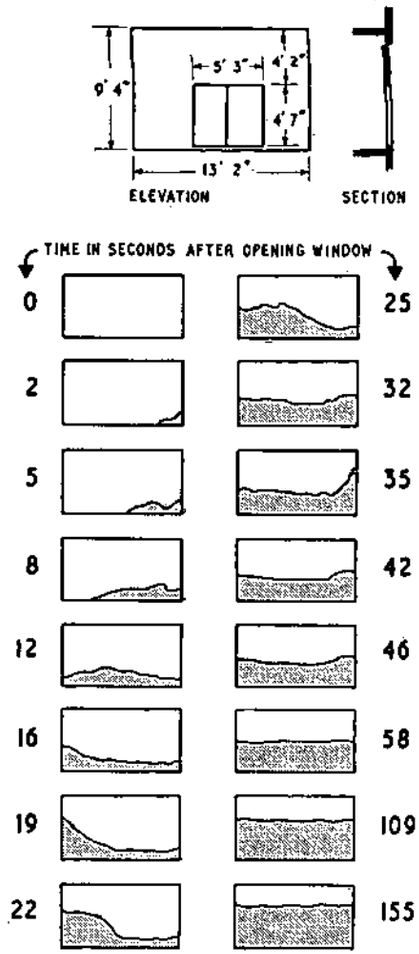


Fig. 117. Movement of fresh air into a room through a casement window, with top of window 4 ft. 2 in. below the ceiling

continuous ventilation at a lower rate must be provided—probably in the region of three air changes per hour. The air admitted from outside, being cold, is liable to cause draughts; that risk is minimized if fresh air is admitted at high level in the room. On entering the room the colder air immediately falls, mixing as it does so with the warmer air inside.

In determining the necessary size for opening window-panes for single-sided ventilation, the Investigation is of the opinion that flow due to temperature difference alone should be taken into account. This will give the size of the window-opening required on still days in winter. When there is a wind blowing, however, the window need not be opened so widely. J. B. Dick[13] gives the following formula for relating the flow of air into a room to inside and outside temperature differences.

$$V = 4{\cdot}0A\{h(T_i - T_e)\}^{\frac{1}{2}},$$

where V = volume of air required in cubic feet per hour.
A = area of opening, either inlet or outlet, in square inches.
h = the vertical distance apart of the inlet and outlet.
T_i = internal temperature.
T_e = external temperature.

In applying this formula, the bottom half of the window-opening is assumed to act as an inlet and the top half as an outlet. It may be seen that a tall, narrow window will produce a greater air-flow than a long, horizontal window of the same area. To avoid draughts, however, the best type of window for winter ventilation is a long horizontal one at high level. With such a window, the opening area will have to be rather larger to produce a given air change than would be the case if a tall window were used. *Fig. 118* is a nomogram* derived from the formula, allowing for a temperature difference of 12° F. between inside and outside. The nomogram may be used as follows:

- A 6-bedded ward has a volume of 4,560 cu. ft. If three air changes are required, the necessary air-flow

* A nomogram is a set of related scales, juxtaposed in such a way that a straight line drawn between known values on two of them can be extended to give the related value on the third.

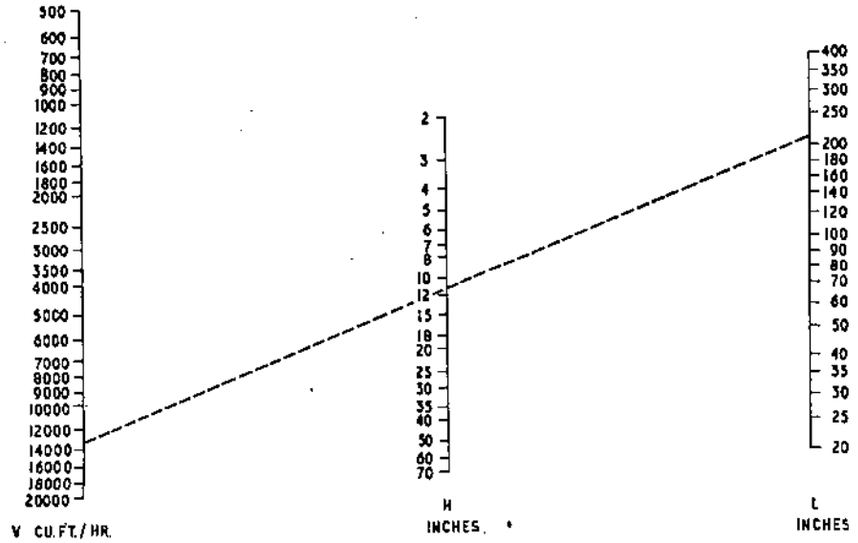


Fig. 118. Nomogram of the volume of the air-flow through openings when there is a temperature difference of 12° F. between the air inside and outside

will be 13,680 cu. ft. of air an hour, and if the total length available for opening windows is 17 ft. 6 in., i.e. 210 in., and a ruler is laid across the nomogram from the appropriate figures in the columns for air-flow and rate of ventilation, it will be found that the necessary height of the opening is 11 in. Thus an opening 17 ft. 6 in. long and, say, 11 in. high, placed immediately below the ceiling, would give the necessary ventilation (see dotted line on nomogram in *Fig. 118*).

The dimensions obtained from the nomogram are those of a clear opening such as would be given by a sash or sliding window. Hopper windows, which do not give a clear opening, will need to be somewhat larger. It is suggested that the area of such windows should be 50 per cent. greater than that found from the nomogram.

The foregoing discussion has referred to the ventilation of patients' rooms. Certain of the ward ancillary rooms present ventilation problems of a different character.

The Investigation has assumed that treatment-rooms are desirable in all ward units (see p. 8). In the treatment-room a series of different cases dealt with in quick succession may cause heavy bacterial contamination, and therefore the room should have continuous ventilation at the rate of ten air changes an hour (as in operating theatres). This can only be achieved with certainty by mechanical means (cf. p. 130). The ventilating plant should take in fresh air, preferably at the roof of the building, and be fitted with means for warming and, if necessary, filtering the air. Input to the treatment-room should be at high level and extract at low level, and the system should be so designed that a slight positive pressure is maintained in the room to prevent the ingress of contaminated air from the corridor and adjoining rooms. If the treatment-room has an opening window it should be kept closed while the room is in use for treatment, otherwise the ventilation system will become imbalanced.

Sterilizers in ancillary rooms can have hoods fitted with mechanical extract for removal of steam. At the present time manufacturers are developing vapour-control fittings intended to reduce the amount of steam escaping from sterilizers, and should these fittings be effective it may be possible to dispense with extract hoods. A mechanical extract ventilation system in the ward kitchen will help to prevent food smells from reaching other parts of the ward.

The ventilation of W.C.s must minimize the risk of smell reaching the patients' rooms. In this country natural ventilation by windows has generally been preferred for W.C.s, and in many places the by-laws require it. By-laws generally require also that there should be a ventilated lobby between the W.C. and other parts of the building, with the exception that in a single-bedded room a W.C. provided exclusively for the use of that room may open directly out of it. Hospital W.C.s are likely to be often in use. Where a W.C. serves a small group of patients only, it may be sufficient to use natural ventilation if a ventilated lobby is provided; but natural ventilation alone is not wholly satisfactory, because wind pressure acting on one side of the building will set up horizontal currents through the building from the windward to the leeward side (cf. p. 125). Wherever wind blows on the face of a building in which W.C. windows are set, the air currents within the building may carry smell from the W.C.s into other rooms. In that way natural ventilation may actually increase the nuisance from W.C.s. There is much to be said, therefore, for providing some form of permanent extract, particularly where two or three W.C.s are grouped together to serve a number of patients.

In a multi-story building where lavatories are arranged above each other on each floor, mechanical extract can be provided simply and economically. The extract fan is usually placed on the roof and is connected to the W.C.s by vertical trunking. Most modern by-laws permit mechanically ventilated W.C.s to be internal—that is to say away from an outside wall. This is of great convenience in planning, particularly where a thick, compact ward block is desirable. On the Continent W.C.s and lavatories are often internal. These are naturally ventilated either by means of vertical trunking acting by stack effect, or by horizontal trunking acting by wind pressure. In the latter case, the trunking can be arranged to provide extract from the W.C. no matter on which side of the building the wind is blowing. The use of natural ventilation by trunking for internal W.C.s is being studied at the Building Research Station to determine the sizes of ducts required. It appears that it should be possible to provide adequate ventilation with comparatively small horizontal or vertical ducts. Mechanical extract ventilation is desirable in dirty-utility rooms for reasons similar to those enumerated for W.C.s.

Methods of Heating Wards

Local, as opposed to central, heating has commonly been used in British houses, and even in hospital wards open fires are still to be found—though not as the sole source of heat. In recent years the use of central heating has spread, and uniform heating to given temperatures is now required in most buildings other than small dwelling-houses. The Code of Functional Requirements for

Buildings[15] makes the following recommendations for the heating of hospital wards and ancillary rooms:

Wards	65–67° F.
Day-rooms	60–62° F.
Staircases and corridors	55–57° F.
W.C.s	55–57° F.
Bathrooms	65–67° F.

These temperatures are recommended as *air temperatures* in buildings heated by convection, and as *equivalent temperatures* in buildings heated mainly from radiant sources.

Air temperature is the temperature of the ambient air in a room as measured on a thermometer. The comfort of a human being in a room is affected not only by the air temperature but by radiation. He may feel cold even when the air temperature is high, if his body is losing heat by radiation to cold walls or windows. Equally, he may feel warm as a result of radiant heat from warm walls or a fire, even when the air temperature is low. *Equivalent temperature* is measured on a scale which takes into account these factors as well as the air temperature.

A large proportion of hospital patients are now allowed to get out of bed and use W.C.s and bathrooms (see p. 16), and it is not medically desirable that the temperature in the ancillary rooms should be lower than that in the ward itself; therefore every part of the ward unit used by the patients should be maintained at the same uniform temperature.

The ambulant patient is likely to be susceptible to chill, and may not be able to move about freely. From his point of view a temperature in the region of 70° F. would be desirable. On the other hand, the nurses whose daily work in the ward includes a good deal of hard physical exertion might be expected to find an air temperature of 70° F. too great for their comfort. The need to provide conditions acceptable both to patients and nurses points to the use of systems which as far as possible rely on radiation rather than convection heating; for with radiant sources, a high equivalent temperature can be reached while the air temperature remains lower.

There are several ways in which heat can be supplied to a building and the advantages and disadvantages are considered below.

(*a*) Heating by warmed air has the advantage of being capable of rapid control, and where intermittent heating is required it can also be economical; but for wards it has the disadvantage of producing a high air temperature, and so with this form of heating it is difficult to meet the needs both of the patients and of the nurses. Where a completely mechanical ventilation system is installed it is possible to use it for heating as well. The central plant takes in fresh air from outside the building and filters, warms, and, if necessary, humidifies it before passing it into the rooms. But even where air-conditioning plant is installed, it is sometimes necessary, in the interests of comfort, to supply a part of the heat by other means so that air temperatures can be kept within agreeable limits.

(*b*) Heating by radiators, the method most commonly used today, involves a partial misnomer because although the 'radiator' does supply some heat by radiation, about 80 per cent. of the heat is, in fact, convected or passed into the room by the natural circulation of air over its surface. The radiators must be placed in such a way as to counteract cold currents set up by windows and exposed walls. A small number of radiators operating at high temperature sets up strong convection currents, causing appreciable temperature gradients between high and low levels in the room. Better results are obtained by using a larger number of radiators, distributed round the room under cold surfaces. This prevents the pooling of cold air at low level, and larger areas of heating surface reduce temperature gradient at high level. A well-designed radiator system can provide comfortable conditions in a ward and can give an equivalent temperature slightly above the air temperature. But although the special hospital pattern is superior in design to the ordinary radiator, it is still difficult to clean around and behind it.

(*c*) Heating by warming the fabric of the building. In these systems, the temperature of the fabric of the building is raised, and they depend more upon radiation than convection for their efficiency. Desired equivalent temperatures, therefore, are reached with comparatively low air temperatures. This type of heating is generally more expensive to install than is the conventional radiator system, though it is economical in use where continuous heating is required. Because more heat is stored in walls, floors, &c., than in the air, less heat is lost by natural ventilation than in buildings which rely on convection systems. Fabric heating can obviate completely the need for exposed pipes and radiators and thus makes the cleaning of the ward easier while reducing the number of harbouring places for dust and bacteria. Unfortunately fabric heating is not susceptible to rapid control, for the fabric of a building may have considerable heat capacity so that there is a time-lag between operating the controls and increasing or reducing the temperature in the rooms.

Fabric heating is usually in the form of panels in the floor or the ceiling; wall panels are possible but seldom practicable, because of difficulties in a hospital ward of finding sufficient suitable wall surface.

Ceiling heating has been in use for many years and has given satisfactory service in many types of building, including hospitals. It may take the form either of heating-pipes embedded in the structure, or of attached panels. The proportion of radiant heat is about 80 per cent. of the total heat. As a rule, a considerable proportion of the ceiling area has to be heated in order to provide the necessary warmth in the room. But there is a limit to the temperature at which heated ceilings can operate without causing discomfort to the occupants of the room through excessive warmth on their heads. A recent study by the Environmental Hygiene Research Unit of the Medical Research Council has been directed towards discovering what this limit is.[16] In that study a number of persons were exposed to radiant heat from a ceiling panel at various heights and the incidence of subjective discomfort was recorded. As a result, desirable limits of temperature were put forward (*Table 43*). It will usually be found that a sufficient area will be available in the ceiling to enable wards to be heated satisfactorily to these limits of temperature. Where ceiling heating is used, it may be necessary to combat down-draught by providing subsidiary heating under the sills of large windows or in the floor near by.

Table 43. Ceiling heating: *Maximum desirable temperatures of ceiling panels, in relation to size of panel and height of ceiling.* (*After F. A. Chrenko*[16])

(It is assumed that there is only one panel in the ceiling, and that the subject is seated beneath its centre.)

Panel dimensions (feet)	*Maximum desirable temperatures (°F.) of panels of various dimensions when the height of the ceiling is*					
	7 feet	*8 feet*	*9 feet*	*10 feet*	*11 feet*	*12 feet*
4×6	89	100	112	130	147	164
5×7½	84	91	101	111	123	137
6×9	81	87	93	101	111	120
7×10½	80	84	89	95	102	109
8×12	78	82	86	91	96	103
9×13½	78	81	84	88	93	97
10×15	77	79	82	85	90	93
11×16	77	79	82	84	87	91

Floor heating is generally by hot-water pipes embedded in a cement screed above the structural floor. The spacing of the pipes and their depth below the floor surface are adjusted to provide a uniformly warm floor without hot spots over each pipe. The maximum temperature at the floor surface must be low enough not to cause discomfort to the feet, and this temperature is usually taken to be 75° F. Most floor finishes will give satisfactory service at this temperature. The conditions which floor heating gives are very suitable for hospital wards, particularly since such heating combats cold down-draughts.

For comfort, floor heating has the advantage that the air in the room is warmer at low than at high level. This means that the occupants of the room enjoy cool heads and warm feet, a benefit less frequently achieved with other types of heating, particularly radiators or warmed air.

A difficulty found with floor-panel heating is that, owing to the restricted temperature at which the panels function, it may not be possible to put sufficient heat into the building by this means alone. In multi-story buildings, however, this difficulty can sometimes be met by arranging that some heat leaks downwards from the floor-panels to warm the ceiling of the room beneath. Another practical difficulty with floor heating is that it may require a considerable thickness of screed, thus increasing the thickness and weight of the floor.

Heat Loss and Insulation

Both the capital and running costs of a heating installation depend on the heat losses due to ventilation, conduction through walls, floors, and roofs, and conduction through window glass.

To accord with the ventilation rates in wards (see pp. 126–7) the design of the heating system should be based on at least three air changes an hour. If allowance is made for fewer changes, there is a risk that the ward will become chilled when windows are opened during cold weather. The volume of the building affects the heat loss due to ventilation, particularly where convection methods of heating are used.

The rate of heat loss through the walls and roof of the building depends on the degree of thermal insulation they incorporate. Increasing the insulation will usually increase the first cost of the building, but will reduce the heating bill. The optimum degree of insulation therefore depends on an economic comparison. While it is difficult to make any precise recommendations as to the optimum insulation, there are one or two general considerations which should be borne in mind when reaching a decision in any particular case. The first of these is that much of the hospital, and certainly the ward, is heated continuously throughout the twenty-four hours and throughout the week. For this reason, a rather higher level of insulation may be more economical in hospital buildings than in some others. In a single-story building far more heat will be lost through the roof than through the walls, and additional expenditure on insulation for the roof is therefore warranted.

The heat loss through the walls and roof varies according to the design of the building. Straggling and spread-out designs increase the amount of wall space per square foot of floor area and, therefore, the rate of heat loss. Similarly, it has been calculated that in schools the building of two stories instead of one reduces heat loss by some 15 per cent.[17]

Because windows provide poor insulation, the heat loss is increased as the proportion of window to wall is increased, but as the size of windows is determined by the need for daylight it is not normally possible to reduce their dimensions in order to save heat. Windows, however, admit heat in the form of radiation from the sun and sky, and over the year the gain from solar heat may be such that the running costs of a thermostatically controlled heating system are only slightly increased as a result of increased window area. But an increase in glass area will make it necessary to install a heating plant of sufficient capacity to keep the building warm through periods of maximum loss and thus will increase installation costs.

Though it is common in countries with greater extremes of temperature, double glazing has been little used in Great Britain. There are two forms of double glazing. The usual continental type consists of two complete windows with separate frames and opening lights. The space between the windows is ventilated to prevent condensation, and rather complicated opening arrangements are necessary to enable both faces of each pane of glass to be accessible for cleaning. More recently it has been possible to obtain special glazing units consisting of two sheets of glass held a small distance apart—the space between them being sealed. Units of this kind, while thicker than normal glass, can usually be accommodated in window-frames of normal pattern. Both types are expensive in comparison with the ordinary single-glass window. As with other forms of insulation, the decision whether or not to install double glazing is primarily one of cost. A cost comparison between double glazing and single glazing was made for one of the experimental ward buildings designed by the Investigation. The annual saving on heating with double glazing was shown to balance the increased capital cost after a period of twenty years. The Investigation considered this period too long to justify the use of double glazing.

Even if there is no clear economic justification for double glazing, it may sometimes be desirable on grounds of amenity. In an adequately heated ward a patient whose bed is very close to a large window may suffer discomfort from the coldness radiated from the glass. Double glazing would obviate this.

Heating and Ventilating in the Experimental Wards

This chapter has so far been concerned with the work recently done by a number of investigators in various fields, on the broad principles of ventilating and heating for hospital wards. Their work has been so comprehensive that it did not seem necessary for this Investigation to undertake independent studies on similar lines. In designing the experimental ward blocks at Larkfield Hospital, Greenock, and Musgrave Park Hospital, Belfast, therefore, the members of the team have applied the principles established by others, to achieve the ventilating and heating conditions which seemed the most desirable. The Investigation's own contribution to the subject will be made when the efficiency of the ventilating and heating methods adopted can be assessed in the experimental blocks under ordinary working conditions.

The precise methods adopted in a particular case have to be determined to some extent by the planning and construction of the building, and the arrangements for ventilation and heating in the two experimental ward buildings designed by the Investigation exemplify this. The object was to achieve similar conditions in both, but by different methods in each case.

(*a*) *Larkfield Hospital, Greenock*

It may be seen from the plan of the experimental ward at Larkfield (*Fig. 9*) that the open portion of the ward is cross-ventilated, although the windows on either side of the block are not directly opposite one another. All rooms and other areas occupied by patients are ventilated by

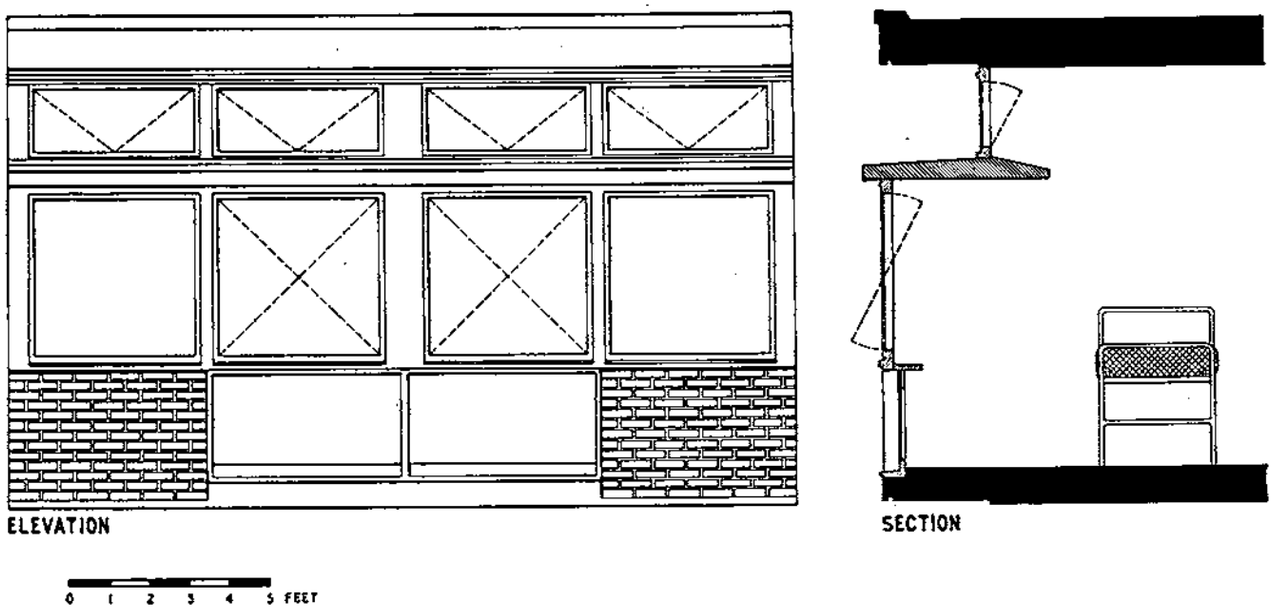


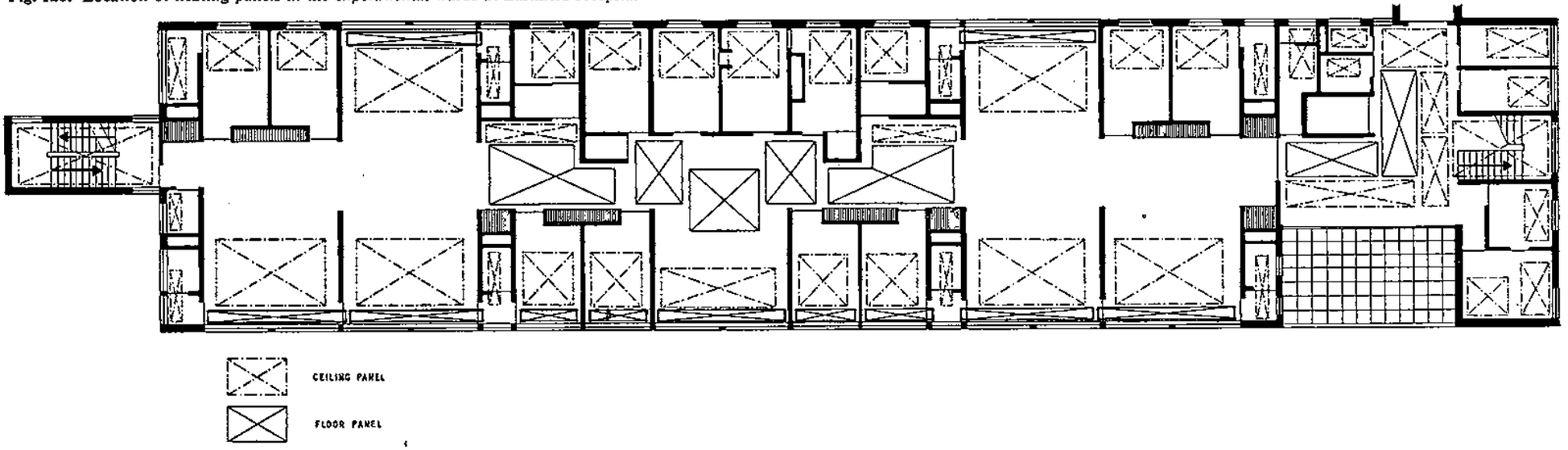
Fig. 119. Elevation and section of the windows in the experimental wards at Larkfield Hospital

windows. *Fig. 119* shows windows at Larkfield in elevation and section. This window incorporates the horizontal baffle described on p. 97. The strip of window above the baffle consists of four lights bottom-hung and opening inwards. These provide for continuous winter ventilation. Two of the four panes below the baffle are fixed and the remaining two are centre-pivoted. A pivoted window was used because of the very exposed nature of the site, where gusts up to 100 m.p.h. are experienced. Casement windows are apt to be slammed or wrenched from their hinges under such conditions, but a pivoted window can be opened slightly to give ventilation when strong winds are blowing.

Extract is provided from the dirty-utility room and from the hood over the sterilizer in each of the clean-utility rooms and ward kitchens. Treatment-rooms are supplied with air by a small air-conditioning plant capable of giving ten air changes per hour. The plant maintains a positive pressure in the treatment-room to prevent infected air entering from other parts of the ward. Patients' w.c.s are ventilated by windows above the baffle, and each is separated from the bed-area by a ventilated lobby.

The Larkfield building was constructed with load-bearing walls carrying a reinforced-concrete floor slab, designed without beams, to give a flat ceiling. Heating panels were formed by embedding hot-water pipes in appropriate positions (see *Fig. 120*). The panels are in the

Fig. 120. Location of heating panels in the experimental wards at Larkfield Hospital



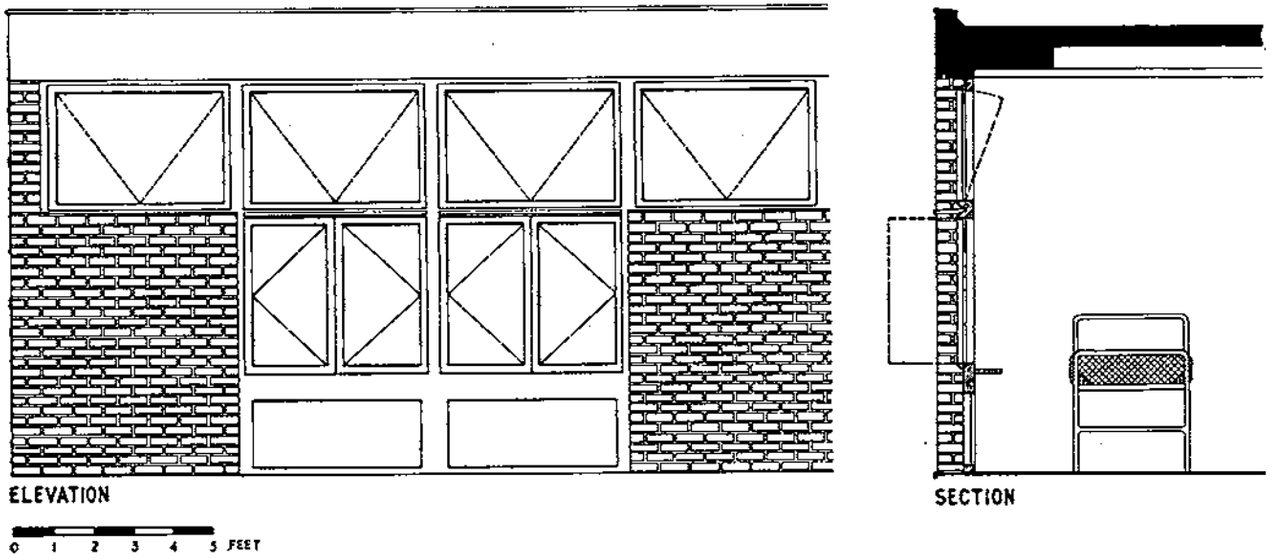


Fig. 121. Elevation and section of the windows in the experimental wards for Musgrave Park Hospital

centre of the ward space, the patients' beds being to either side. The maximum mean surface temperature in the ceiling is 93° F. This limit derives from Chrenko's studies (cf. p. 128). It allows for the angle subtended by the panels to the patient's bed. In addition to the ceiling panels, small floor-heating panels were placed under the large windows to combat down draughts.

(*b*) *Musgrave Park Hospital, Belfast*

In the experimental wards at Musgrave Park (*Fig. 10*), the large, 6-bedded rooms will be partly open to the corridor and there will be some degree of cross-ventilation between these rooms and the day-space. As at Larkfield, the patients' rooms are ventilated by windows. *Fig. 121* shows the design of the windows. Continuous winter ventilation is provided by a strip of top-hung casements at high level. The site at Musgrave Park is comparatively sheltered and the lower windows are therefore ordinary casements opening outwards.

Mechanical extract is provided for the dirty-utility room, the sluice-room, and the ward kitchen, and mechanical input with ten air changes an hour, for the treatment-room. Patients' W.C.s are grouped in twos in the centre of the building and have been provided with mechanical extract ventilation designed to give up to ten air changes an hour.

The structural system to be used in this building will be a reinforced-concrete frame, with beams, which will not give a flat ceiling. As at Larkfield, ceiling-panel heating will be used. Instead of embedding the heating pipes in the concrete, a proprietary system will be used in which the panels are suspended beneath the structural slab, in close contact with the aluminium panels forming the ceiling. This type of ceiling-panel gives a quicker response to control than is obtainable with embedded pipes; it also enables the whole area of the ceiling to be used simultaneously for sound absorption and for heating. The ceiling area is heated all over and the maximum mean surface temperature is 95° F. It is not considered necessary to provide subsidiary floor heating in these wards.*

Heating and Ventilation in Hospital Departments other than Wards

The operating theatre suite has highly specialized needs for heating and ventilation, and the measures taken to meet them are an integral part of the design. They are dealt with in Chapter 3, The Operating Theatre Suite (pp. 78–79). No special study of the heating and ventilation of other departments has been made by the Investigation.

* The Building Research Station has arranged to record temperature, humidity, air change, and fuel consumption in both experimental ward blocks. It is hoped that these recordings will provide useful information on the comparative performances of the two systems, as well as on the general requirements of ward heating and ventilation.

SUMMARY

An adequate ventilating system will reduce the concentration of bacteria-laden dust particles in the air, and oiling floors and textiles leads to a further reduction. For hospital wards a rate of three air changes an hour is thought to be adequate, but provision should be made for an occasional rapid blow-through. Natural ventilation can provide this rate of air change and, in particular, the means for a rapid blow-through more simply and economically than can a mechanical ventilating system, and it is also believed to be more acceptable to patients. Recent experiments have shown that air change due to stack effect, in rooms with windows on one side only, is continuous and complete, and the placing of opening panes is related to room height.

Some ancillary rooms, for example treatment-rooms, need special systems of ventilation, and so do W.C.s not on outside walls. Natural ventilation has been chosen for the bed-areas in the experimental units at Larkfield and Musgrave Park, but mechanical extraction will be provided in the internal W.C.s in the latter unit, and over sterilizers in the clean-utility rooms and ward kitchens in both. In the treatment-rooms mechanical input of air will ensure ten air changes an hour.

After considering various ways of heating by radiation and convection, the Investigation concluded that wards may conveniently be heated by ceiling-panels, which in certain circumstances might need to be supplemented by small floor-heating panels placed under large windows to counteract down-draughts. In such systems up to 80 per cent. of the heat is radiant.

The Investigation's experimental ward units at Larkfield are heated by ceiling-panels supplemented by small floor-heating panels, but at Musgrave Park they will be heated solely by panels suspended from the structural slab and in contact with the perforated aluminium panels which form the ceiling.

Though double glazing is desirable to reduce heat loss through the windows the Investigation had to reject its use in the experimental units for Larkfield and Musgrave Park because of high capital cost.

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5 FIRE PROTECTION IN HOSPITALS

No comprehensive recommendations on fire protection in hospitals have been made in this country, although there are codes published in other countries. It was therefore decided, on the advice of the Building Research Station, to set up a panel of experts to study some aspects of fire protection in hospitals and to make a report. Members of the panel have also from time to time advised the Investigation on specific problems.

The chairman of the panel is Mr. E. L. Bird, M.B.E., M.C., A.R.I.B.A., *editor of the* Journal of the Royal Institute of British Architects, *and the members of the panel represent the following organizations: The Building Research Station; The Fire Research Station; The Home Office Fire Service College; The Ministry of Health; The Fire Protection Association.*

This chapter is the report prepared and written by the Fire Panel on their studies into planning and constructional aspects of fire protection in hospitals.

Members of the Fire Panel

Chairman: Mr. Eric L. Bird, M.B.E., M.C., A.R.I.B.A., *Editor, R.I.B.A. Journal.*

Members: Mr. R. C. Bevan, M.A., B.SC., *Building Research Station.*
Mr. K. R. Lack, A.R.I.B.A., *Ministry of Housing and Local Government.*
Mr. G. Langdon Thomas, A.A. DIP., A.R.I.B.A., *Building Research Station.*
Mr. E. W. Marshall, *Home Office, Fire Service College.*
Mr. P. Nash, *Joint Fire Research Organization, Fire Research Station.*
Mr. M. C. Tebbitt, A.R.I.B.A., *Ministry of Health.*
Mr. W. H. Tuckey, O.B.E., *Fire Protection Association.*
Mr. D. J. Petty, M.B.E., M.A., A.R.I.B.A., *representing the Investigation.*

INTRODUCTION

The Nature of the Risk

THE predominant fire risk in hospitals is to human life. Unlike the occupants of most other buildings, many patients are unable to save themselves and must be carried or helped to safety; for this, the staff and firemen may have to make several journeys. Consequently the time required to get all patients to safety is very much longer than for able-bodied persons. The hospital has a severe handicap compared with other types of building in this race against time.

Therefore particular emphasis should be on preventing outbreaks of fire; this is ensured chiefly by safe storage and handling of combustibles and the proper installation and maintenance of equipment. It is equally important to ensure that any outbreak can be quickly detected and attacked at once with first-aid extinguishing appliances, of which there must be both adequate provision and maintenance, together with training of staff in their use. At the same time there must be efficient arrangements for immediately summoning the fire brigade and warning the hospital staff.

There is, however, the risk that a small outbreak may grow into a serious fire. The building must therefore be so constructed and planned that any such fire is prevented as far as possible from spreading through the building; this involves consideration of the fire resistance of the structure* and the placing of certain doors of appropriate fire resistance. The provision and proper planning and construction of adequate means of escape from all parts of the building are also required.

It happens that in recent years fires in British hospitals have resulted in small loss of life and injury. This has not been the case in other countries; for example in 1949 at St. Anthony's Hospital, Effingham, U.S.A., 80 persons (mostly patients) lost their lives. Such disasters are not outside the bounds of possibility in this country if planning construction and maintenance are inadequate. No hospital however modern and well constructed is entirely free from the risk of a serious fire, unless the staff know

* The fire resistance of an element of building is the time during which it continues to perform its functions of load-bearing or prevention of fire spread, as the case may be, while subjected to standard fire conditions. The method and conditions of the test for fire resistance are specified in B.S. 476 : 1953. The grades of fire resistance are ½, 1, 2, 3, 4, and 6 hours. Typical elements of building structure are walls, columns, floors, &c.

what to do in the event of fire. There should be regular fire drills, and instruction on the importance of complying with fire notices.

The Safety of Patients and Staff

In most cases the occupants of a burning building try to seek safety by leaving it. This is not always necessary in a building of fire-resisting construction, provided it is planned and built as a series of compartments which are adequately fire-tight. The term 'compartment' is used to describe the planning and construction as a series of cells, each of which is separated from the remainder by walls and floors having a grade of fire resistance sufficient to withstand a complete burn-out of the contents. Any openings in walls separating compartments should be fitted with a door of an appropriate fire resistance.

If a hospital building is properly divided into compartments a policy of two-stage evacuation of patients can be considered. In the first stage, those patients who may be affected by an outbreak of fire near them can be moved into the comparative safety of other compartments. Should the fire be quickly extinguished or confined to the compartment where it started, there would be no need to take the patients out of the building, which might expose them to inclement weather. Movements of patients in this way is clearly easiest when each story consists of two or more compartments as described above, beds being simply wheeled into another compartment. If each story forms a single compartment, stairs will have to be used, with consequent slowness in moving patients to safety.

If, however, the fire should grow to large size, endangering the whole building, the second stage of evacuation, namely the removal of patients from the building, must be put into operation. Dividing a building into compartments retards the fire spread and extends the time for escape. But, when prompt action is taken to summon the fire brigade, to evacuate and close the compartment affected, and to attack the fire with the extinguishing apparatus provided in the building, this second stage of evacuation should not become necessary.

Apart from the structural aspects of the problem there are requirements peculiar to each building and to the local conditions. These necessitate early consultations with the Chief Officer of the local fire brigade. He is responsible for advising on preventative measures to minimize the risks of outbreaks and it is important to ensure that his recommendations are implemented. He advises, for example, on the disposition of extinguishing equipment, means of alarm, and other detailed measures. He is also responsible, if a fire does occur, for the rescue of occupants, for ensuring that the fire is extinguished promptly, and for advising on measures that will avoid a recurrence.

The greater part of our report is devoted to the planning and constructional aspects of hospitals, and as such is addressed primarily to the architect; but some of the non-structural measures are the day-to-day concern of the hospital staff and administration and comments on those aspects are therefore addressed primarily to them. The report is divided into two parts, Part I dealing with 'Planning to minimize fire risk', Part II 'Construction and materials', together with two appendixes.

The report has been written without taking into account Civil Defence requirements which are now very specialized, although the recommendations made for fire protection will assist Civil Defence. Also the report does not make any recommendations on very special departments such as those using cyclotrons. The recommendations are intended primarily to apply to new buildings which will incorporate proper fire precautions. There are also many existing hospital buildings of inferior construction and planning in respect of fire safety, and there are some buildings erected for other purposes which have been converted for use as hospitals. To bring such buildings fully up to adequate standards may require major structural alterations which, under present-day conditions, may not be practicable. Nevertheless, in many cases important safety measures can be undertaken at comparatively small expense.

It is useful at this stage to refer to two terms that occur frequently in this report, namely 'high fire-risk' and 'high life-risk'. By 'high fire-risk' is meant either (i) a room or compartment containing a large quantity of combustible material, the amount being known as the fire load, which if ignited would tend to produce a more severe fire than would be expected in most other parts of a hospital; or (ii) a room or compartment that contains highly inflammable materials, which are more readily ignitable than other room contents. The term 'high life-risk' refers to any part of a hospital in which the condition of the occupants is such that their lives would be particularly endangered by an outbreak of fire.

PART I. PLANNING TO MINIMIZE FIRE RISK

Hospitals should be so designed as to reduce the risk of fire spread from one part to another. Within a block this is mainly accomplished by dividing it into compartments. There is also the risk of fire spreading into the building from outside, and it is necessary to consider what hazards may arise where there are openings in opposing external walls or lower roofs, either in the same block or in adjoining blocks. The risk of fire spreading from outside is termed 'exposure hazard'.

Formation of Compartments

In general the principle to be followed is that each story and, on any one story, each area of high fire-risk or high life-risk should be a separate compartment. The boundaries of a compartment will be the floors above and below—and on the top floor, the roof; the walls separating compartments; and the external walls (see *Fig. 122*). All of these should have an adequate fire resistance. In the majority of cases it will be found that the brick and concrete walls and floors normally found in hospital buildings can provide sufficient fire resistance between compartments. Detailed recommendations for standards of fire resistance are given in Part II.

Fire can spread vertically very rapidly and it is essential to prevent fire, hot gases, and smoke passing into staircases and other vertical ducts. Staircases are of particular importance because, although they are intended as possible means of escape, they are also potential fire-carriers. Each staircase should in effect form a separate compartment.

The size of the compartments should be limited, and provided this is done there need be no other limit, on the grounds of safety from fire, to the size and height of a hospital building, whether of single or multi-story construction. However, for very high buildings the installation of fire-protection equipment will need special consideration. Usually the size of a compartment is determined by

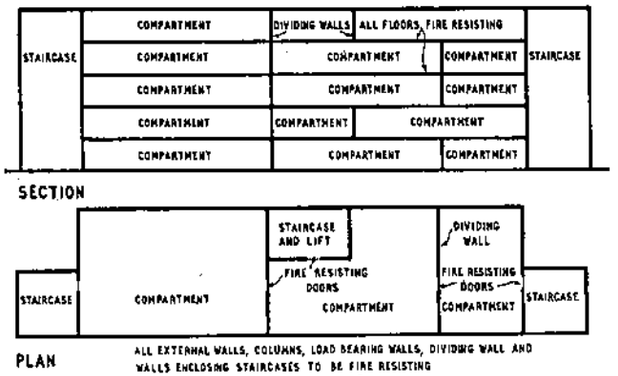

Fig. 122. Formation of compartments

the use to which the building as a whole is put, e.g. whether it is an office, a warehouse, or a factory. But in a hospital, storage and other high fire-risks exist side by side with a high life-risk so that the whole question of setting limits to the size of compartments has to be considered primarily from the point of view of patients' safety.

The way in which compartments are formed will depend to some extent on the detailed layout of the different parts of the hospital. In many cases it will be convenient to provide between compartments a wall which extends the full width of a block from external wall to external wall. Any corridor within a block would then also be within a compartment, together with the rooms in that compartment. In other cases it may be more convenient to make the corridor walls the boundaries of the compartments so that the corridor itself becomes a separate compartment. In this latter case the doors into rooms would have to be of appropriate fire resistance. The recommendations which follow refer chiefly to compartments which include the corridor, although they apply equally to compartments bounded by a corridor wall.

It will be seen that the dividing of a building into compartments should be considered at an early stage of the design in order to achieve safe planning, and be considered again, in more detail, when the placing of the high fire-risk parts is being considered.

The high life-risk and high fire-risk departments should be contained in separate compartments. The high life-risks are the wards, and the high fire-risks are the main stores, main laboratories, boiler-houses, maintenance shops, kitchens, laundries, and garages. In operating theatres the gravest risk is not that of fire *per se* but of explosions involving anaesthetic equipment. The last question is under consideration by the Anaesthetics Explosion Committee set up by the Ministry of Health, whose recommendations, when published, will provide information on this aspect of the problem, and it will not be discussed here (see p. 66). Nevertheless, since inflammable materials are in common use in operating theatres, the theatres and their ancillary rooms should be housed within a separate compartment. The number of operating theatres in a compartment should be restricted so that if there is a fire the damage is limited and not all the operating theatres are put out of action or their occupants endangered. Operating theatres are conveniently planned in pairs (see Chapter 6, The Operating Theatre Suite) and it is recommended that not more than two operating theatres with their ancillary rooms should be in a compartment.

Wards

Because of the high life-risk in ward units they must be in compartments separate from all other parts of a hospital building. Any compartment containing a ward unit will contain also the usual ancillary rooms—ward kitchen, clean- and dirty-utility rooms, treatment-rooms, and so on. The treatment-room need not be in a separate compartment because, although anaesthetics may be given there, the fire-load in the room is very small.

On all stories above the ground and first, any ward compartment should adjoin on the same level another compartment of adequate size to receive all the patients from it in an emergency. The compartment into which patients are to be received may contain another ward unit or any other department of the hospital which is not a high fire-risk or an operating theatre suite. Where any story contains a ward and its ancillaries only, or where an adjoining compartment is unsuitable for receiving patients, the ward compartment itself must be suitably subdivided into two or more compartments in order to comply with this recommendation (see *Fig. 123*).

At ground-level, or on the first story above the ground, the difficulty of carrying patients out of the building is not so considerable, so that although it is preferable, even on those stories, to have adjoining compartments into which patients can be moved in emergency, it is not perhaps essential. Nevertheless, a ward unit, even on the ground or first stories, should form a compartment separate from any other adjoining department of the hospital.

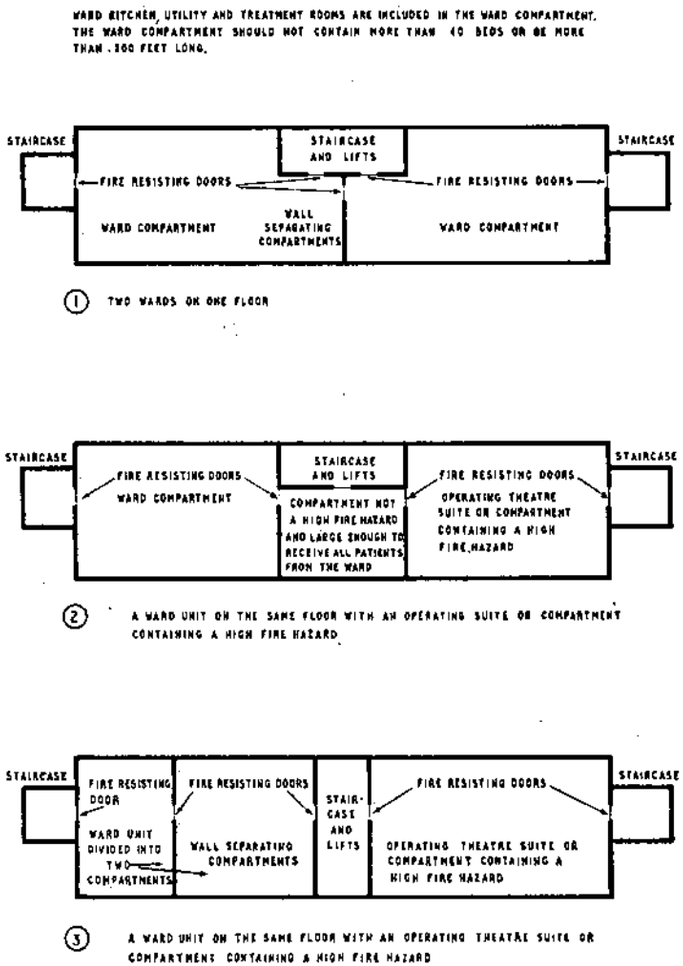

Fig. 123. Layout of ward compartments above first-floor level

In order to ensure the rapid evacuation of patients in the event of fire it is recommended that no ward compartment should contain more than 40 beds or exceed 200 feet in length.

Main Stores

The risk that arises from main stores is mainly due to the fact that they have a high fire-load and are therefore likely to give rise to a more severe fire than that in many other parts of the hospital. Basements are often used for storage, but it is most undesirable especially under ward blocks that they should be used for unlimited storage.

Fires in basements always present a difficult fire-fighting problem.

In general it is recommended that storage compartments should be limited to 50,000 cu. ft., and where basement storage is provided the size of the compartment should not exceed 20,000 cu. ft.

The following special items relating to storage should be noted:

1. Main stores of inflammable liquids should, where site conditions permit, be housed in a separate building or buildings. The walls, roof, and floor should be of brick or concrete, the entrance should have a raised sill of sufficient height to retain on the floor the whole of the liquids in that store, permanent ventilation should be provided to the outside air, and light switches should be flame proof.

The amounts of inflammable liquids kept within the main building should be limited to what is required for current use.

2. Cellulose nitrate film is now rarely used in hospital photography. Where existing records on cellulose nitrate film have to be kept, they should be stored in accordance with the requirements of the Celluloid and Cinematograph Films Act, 1922, and the *Report of the Committee on Celluloid Storage* (April 1950), published by H.M. Stationery Office. Where site conditions allow the store should be located in a separate building.

Boiler-houses

Boiler-houses should, where possible, be in a separate building; but where they are part of any other building they should be in a separate compartment, entered from the outside only. Permanent ventilation to the outside air should be provided. General guidance on the storage of oil fuel may be found in the London County Council publication (1952) *Building of Excess Height and/or Additional Cubical Extent requiring Approval under Section 20 of the London Building Acts (Amendment) Act 1939.*

Paint-spraying Shop

The paint-spraying shop of the maintenance department is particularly susceptible to fire, and should therefore be in a compartment separate from the remainder of the maintenance department. For further guidance reference may be made to *Recommendations in Connection with Spraying and other Painting Processes including the use of Inflammable Liquids*, published by the Fire Offices' Committee.

Garages and Car-parks

Garages should be either detached buildings, or if they form part of another building, they should be in a separate compartment. Vehicle parks should be away from buildings and certainly not immediately beneath windows.

Other High Fire-risk Departments

These departments include main laboratories, maintenance shops, kitchens, and laundries. They require no special provisions so long as they are each in separate compartments.

Remaining Parts of the Hospital

The forming of compartments in the remaining parts of the hospital will only be necessary if the area of any one story is considerable. We suggest that the breaking down of the remaining parts of the hospital into compartments becomes necessary when the area of any one story exceeds approximately 15,000 sq. ft.

Exposure Hazard

Fire may enter a building through the windows, or by igniting the external walls or roof if they are clad or covered with combustible material. If an adjoining building or another part of the hospital is on fire, the threat of fire may come from the windows of that building, from its roof if that is combustible or its fire resistance inadequate to contain the fire, from openings in the roof even when the roof itself is of adequate fire resistance, or from the building as a whole if it collapses early in the fire. The subject is a complicated one and it is not possible to cover it fully here. Some general guidance is given below, but for further information reference should be made to the Report of a Joint Committee of the Building Research Board of the Department of Scientific and Industrial Research and the Fire Offices' Committee (1946), *Fire Grading of Buildings*, Part I, pp. 49–73, published by H.M. Stationery Office.

Our recommendations for general guidance are as follows:

(i) External walls of combustible cladding (recommended only for single-story buildings see p. 139) should be spaced at least 20 to 30 feet away from the external walls of any other building (*Fig. 124 (i)*).

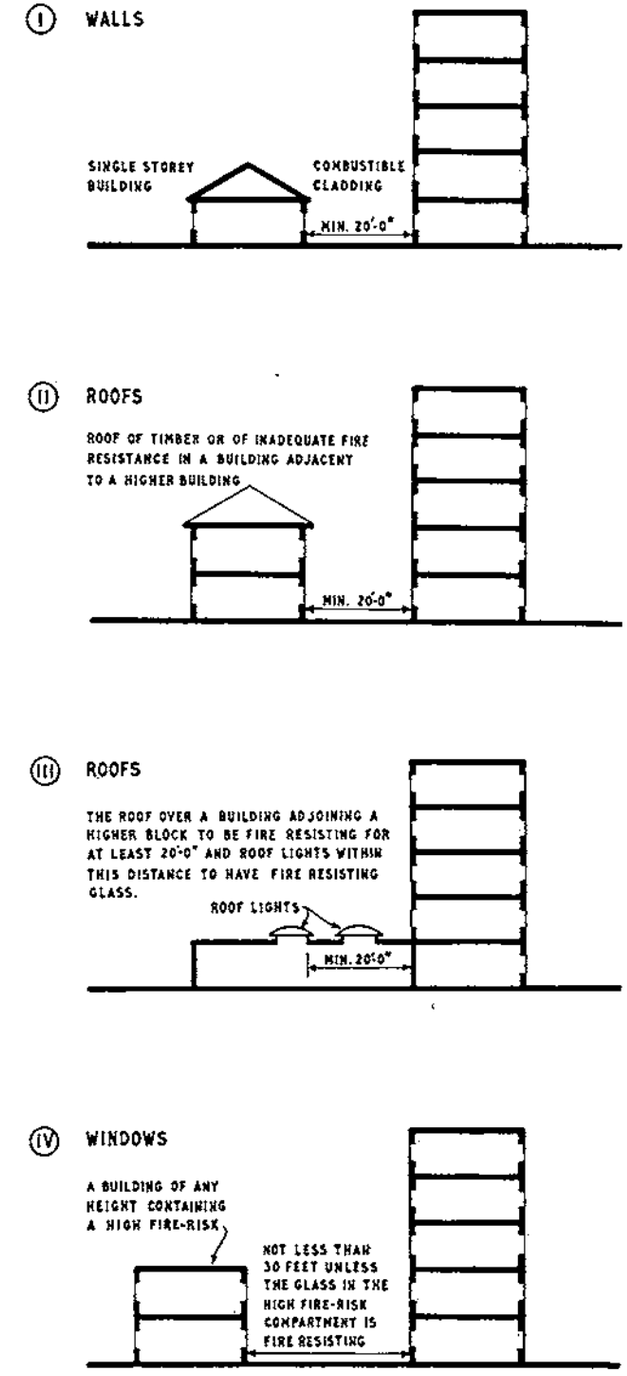

Fig. 124. Exposure hazard

(ii) Roofs constructed of timber, or roofs with lights not of fire-resisting glass, or a roof structure having a fire resistance less than that recommended on p. 138 for a floor in a multi-story building of the same occupancy, should be spaced at least 20 to 30 feet away from any adjacent or adjoining higher blocks (*Fig. 124* (*ii*) and (*iii*)).

(iii) Fire-resistant glazing should be used in windows of rooms with a high fire-risk if they are within 30 feet of a window in an opposing wall (see *Fig. 124* (*iv*)). If there are high life-risk departments with window openings in the stories immediately over high fire-risk departments, the openings of the latter should be protected either by fire-resisting glass in fixed frames or by a fire-resisting imperforate non-combustible material projecting 2 feet over the openings, such as a reinforced concrete balcony.

Means of Escape and Vertical Shafts

In hospitals the problem of escape must be considered from the standpoint of whether the persons concerned are able-bodied, bedfast, or otherwise incapacitated. It has been assumed that patients in wards will require help to escape. For the remainder of the hospital it has been assumed that most patients will be able to help themselves, or that the staff/patient ratio will be such that there are sufficient able-bodied persons to assist all who are not. The following recommendations lay down the general principles that should be followed.

Types of Exits

Where the word *exit* is used in this report it means any one of the following:

(*a*) a door in a staircase enclosure, which stair discharges to the open air at ground-level;
(*b*) a door in a wall between two compartments;
(*c*) a door opening directly to the outside air at ground-level;
(*d*) a door in an external wall connected, by a safe, lighted route across a roof or along a balcony, to a door in an external wall of another compartment, or to a door into an enclosed staircase which discharges to the open air at ground-level.

Number of Exits

(i) *From stories.* Every story should normally have at least two *type* (*a*) exits. More than two may be necessary to satisfy the travel-distance recommendations below. From stories of limited size, not at a great height above the ground and not containing a ward, one *type* (*a*) exit might be adequate; but circumstances may vary so considerably that we do not think it wise to make any specific recommendations. Reference may be made to *Fire Grading of Buildings*, Part III (see p. 136 above).

(ii) *From compartments.* Every compartment exceeding 2,000 sq. ft. should normally have at least two exits. More than two exits may be necessary to satisfy the travel-distance recommendations below. Every ward compartment situated higher than the first story above the ground story should have at least one *type* (*b*) exit.

Arrangement of Exits

Stairs should be so placed that it is not necessary to pass through a stair enclosure to reach a second exit. The layout of compartments and stairs should make it possible to reach two different exit-stairs, from any point on a floor, by alternative routes not passing through the same compartment, unless that compartment is a corridor, a waiting-hall, or an area used for circulation.

Travel-distance to Exits

In ward blocks no point in a ward compartment should be more than about 100 feet (measured along the line of travel) from the nearest exit. If the escape routes from any point in a compartment to two exits coincide for any part of the way, that part which coincides should not exceed 50 feet. This recommendation is to restrict the distance of travel in cul-de-sac areas (*Fig. 125*).

In compartments other than ward compartments we recommend that the maximum travel-distance to the nearest exit should not exceed about 150 feet. If the escape routes from any point in a compartment to two exits coincide for any part of the way, that part which coincides should not exceed 75 feet.

In most buildings recommendations would generally be applicable to travel-distances to staircases (*type* (*a*) exits). In hospitals, designed in accordance with the recommendations of this report, many exits will be through doors in dividing walls between compartments (*type* (*b*) exits). To recommend that there should be a *type* (*a*) exit from every compartment would add too greatly to the difficulties of hospital planners, and it is suggested therefore that there should be no limit to the number of compartments which may be strung together with *type* (*b*) exits, provided that no point on any floor is more than 250 feet from a *type* (*a*) exit. It should be appreciated that this unusually large figure can only be justified where the travel-distances to exits from compartments are limited to the shorter distances recommended above.

Escape from Wards

It has been recommended on p. 135 that ward compartments generally should be placed adjacent to a compartment of adequate size and suitability to receive all the patients in emergency. The door in the wall between the compartments would, of course, constitute a *type* (*b*) exit and should be of ample width for beds to be moved through easily.

It has also been recommended that a ward compartment should not contain more than 40 beds (p. 135). In a compartment of this size the beds might be arranged in a number of rooms and not in one large open ward. The ways out of these rooms would not necessarily be exits as defined above, and so might not be controlled by the recommendations for exits. It is necessary therefore to make an additional recommendation that there should be at least two ways out of rooms containing more than 8 beds.

Stairways

Evacuation of patients down an external staircase is slow and difficult in the dark and in bad weather conditions. An external staircase may also become impassable

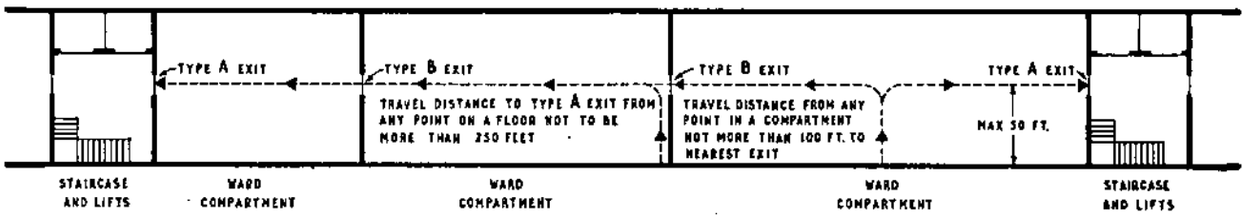

Fig. 125. Exit and travel-distances in wards

because of smoke and flames. Therefore all stairways in new buildings should be enclosed. The recommendations for the construction of the enclosures and doors in them are given in Part II.

Where a door into a staircase enclosure comprises an exit necessary to comply with the recommendations noted under the heading 'Types of exits' above, it is essential that the stairway should discharge into the open air at ground-level.

It is difficult to make recommendations for the detailed design of stairways since the purpose served by them varies so greatly in different parts of the hospital. The width of staircases will usually be determined by considerations other than those of *means of escape*. Where stretchers may have to be carried, all stairs should be wide with ample space on the landings for turning.

Lifts

Where lifts are included within a stair enclosure, and the motor-room is at the top of the shaft, there is no need to take any special precautions regarding the lift enclosure itself or the doors to the lift. Where the motor-room is at the bottom of the shaft, or the shaft is not within a stair enclosure, both the shaft and the motor-room should be enclosed—recommendations for the construction of the enclosing walls and for the types of doors in them will be found in Part II.

Ducts and Pipes

Ducts, especially where they pass through compartments of high fire-risk, form a possible path whereby fire may spread from one compartment to another. Ducts which serve more than one compartment should be wholly encased in fire-resisting construction of a grade of resistance equivalent to the structural elements bounding the compartment. Access doors to ducts within the building should be tightly fitting and should have the same fire resistance as that required for the casing.

All holes or openings in walls and floors of compartments through which pipes pass should be effectively sealed either by asbestos-fibre packing or by concrete poured round the pipes after they are installed.

PART II. CONSTRUCTION AND MATERIALS

Structural means for attaining the desired standard of safety against fire in hospital buildings must now be considered, for example, the method of constructing walls and floors so that they will provide effective compartments. There is the further consideration of the materials to be used in construction. They must be selected from those which do not ignite easily and would not contribute materially to a fire. It is necessary to consider: (1) the fire resistance of the various parts of the structure (in the sense in which that term is used in British Standard 476: 1953, *Fire Tests on Building Materials and Structures*, published by the British Standards Institution), and (2) the use of combustible materials.

Fire Resistance

The degree of fire resistance needed in the various parts of any building to ensure that the structure will continue to perform its functions throughout a fire depends primarily on the fire load that the various rooms contain. It is accepted that many types of small buildings need not be of a standard of fire resistance sufficient to resist a complete burn-out. For hospitals, however, it is considered that, with the exception of single-story buildings, the grade of fire resistance should generally be sufficient to enable the elements of structure to withstand, without collapse or penetration of fire, the full effects of any fire that may break out.

Single-story Buildings

With the exception of walls separating compartments for which standards set out for multi-story buildings should apply, no special standards of fire resistance are considered necessary for single-story blocks, apart from the limitations on the use of combustible materials for the structure and for linings (see p. 139).

Multi-story Buildings

The fire resistance of load-bearing walls, external walls, walls separating compartments, floors, and structural frames should be 2 hours for any compartment consisting of main storage-rooms, maintenance shops, main laboratories, garages, and boiler-houses, and 1 hour for all other parts of the hospital. Although kitchens and laundries are classified as high fire-risks, the fire load is small and it is considered that a fire resistance of 1 hour should be adequate for these rooms.

Walls enclosing stairs should have the fire resistance recommended for the structure of the compartment adjoining the staircase.

Roofs to ward blocks should have a fire resistance of 1 hour.

Doors

The success of dividing a building into compartments is largely dependent upon protecting all openings in walls separating compartments and in stair and lift enclosures by doors having an adequate degree of fire resistance. Where compartments are large, and especially where they contain any considerable quantity of combustible material, the doors in walls separating compartments must have a high degree of fire resistance in order to prevent the spread of fire. The size of compartments recommended in this report is comparatively small and it is graded largely on the basis of the fire risk contained within them. The overall risk of serious fire spread will thus be greatly reduced, and it follows that the fire resistance of doors introduced to restrict fire spread may be less than would otherwise be required.

It is recommended that doors in walls between compartments and in stair and lift enclosures should have a fire resistance of approximately half an hour. Solid timber doors not less in thickness than 1½ inches would be adequate. Glazed panels in these doors should be small and of wired glass. Any fanlights should be fixed and glazed with wired glass in small panes.

In order to develop its full fire resistance a door must close against a wide rebate. The most useful kind of door in the positions under discussion (except lift enclosures) is, however, a double swing-door and this cannot close against a rebate. Because of the circumstances discussed above it is considered unnecessary to insist that such doors, excepting those to high fire-risk areas, should close against rebates.

As doors must be closed in order to be effective in preventing the spread of fire, it is usual to fit a self-closing mechanism to the kinds under discussion. While an auto-

matic closer is in most ways desirable and is recommended in principle, there are occasions when it can be inconvenient unless a device to hold the door open is provided. Although the provision of such a device is contrary to the principle that the doors should usually be kept closed, some account must be taken of the fact that these doors are mostly used by members of the hospital staff. Doors in walls between compartments should be kept closed at night, while those in staircase enclosures should be kept closed at all times. Notices to this effect should be fixed above each door. The staff should be instructed in the proper use of doors in compartment walls and in staircase enclosures, and especially warned of the need to see that these doors are closed immediately on an alarm of fire.

Use of Combustible Materials

The fire resistance of structural elements is determined without reference to the combustibility of the constituent materials, but it is desirable, from the standpoint of minimizing the risk of outbreak and spread of fire, to restrict the use of combustible building materials as far as is practicable.

In the past it has been customary in hospitals to use incombustible finishes such as plaster or tiling, but in recent years there have been introduced into buildings generally numerous sheet and board materials for internal linings, many of which are combustible. Combustible materials vary widely in their ease of ignition and the contribution they subsequently make to the spread and severity of the fire. The standard test for classifying combustible wall and ceiling-linings is the spread of flame test (described in British Standard 476: 1953). This test places the surfaces of linings in one of four classes:

Class 1. Surfaces of very low flame-spread.
Class 2. Surfaces of low flame-spread.
Class 3. Surfaces of medium flame-spread.
Class 4. Surfaces of rapid flame-spread.

The classification of surface spread of flame also indicates to what extent it is easy for a surface to be ignited by a small source of flame and hence its safety or otherwise from chance ignition. A Class 1 surface is regarded as safe in this respect while a Class 4 surface is hazardous.

There are many situations in hospitals where, although the risk of ignition of walls and ceiling-linings is not sufficiently great in itself to warrant extremely rigorous requirements, the additional rescue time afforded by an incombustible lining or a lining with a very low flame-spread would provide a valuable increase in the chance of saving lives of patients once a fire had taken hold.

In the following recommendations the classification should apply to the material itself untreated in any way.

In Single-story Buildings

Combustible external cladding should be used only in buildings or parts of buildings not exceeding 50,000 cu. ft. Where a building with combustible exterior cladding is attached to a single-story building not so clad, the two areas should be separated from one another by a non-combustible wall having a fire resistance of not less than 2 hours, carried through the external wall and ceiling and up to the roof.

Timber roofs may be used in blocks of any size, but the roof-void should be further divided by walls to prevent unrestricted spread of fire. All walls separating compartments should be carried up through any roof-void, and if the distance between these walls exceeds 100 to 150 feet, the space should be divided by walls of a fire resistance of not less than half an hour. When buildings with combustible exterior cladding are attached to multi-story buildings, the walls and roof should be of non-combustible construction for a distance of from 20 to 30 feet from the multi-story building, as recommended on p. 136 under 'Exposure Hazard'.

All walls and ceiling-linings in single-story blocks attached to multi-story buildings should be Class 1 or non-combustible. In single-story blocks not attached to multi-story buildings the walls and ceiling-linings in high fire-risk departments should be at least Class 1 or non-combustible and in the other departments at least Class 2.

In Multi-story Buildings

In a multi-story building combustible materials should not be used in any part of the main structure, including partitions.

In two-story buildings traditional timber-joist floors with boarded finish may be used in conjunction with a ceiling that provides the necessary grade of fire resistance; but the area should be limited to 5,000 sq. ft. on each story unless the building is divided by walls of 2-hour fire resistance into areas each of which does not exceed 5,000 sq. ft.

Combustible materials may, however, be used for items such as window-frames and doors.

Timber roofs may be used, except over wards, in blocks of any size, but the roof-void should be divided as recommended for single-story buildings.

Where buildings of different heights adjoin, the roof of the lower building should be non-combustible and have the same fire resistance as that recommended for the structure of the building, for a distance of from 20 to 30 feet as recommended on p. 136 under 'Exposure Hazard'.

Walls and ceiling-linings throughout multi-story buildings should be Class 1 or non-combustible.

Appendix A. FIRE PROTECTION EQUIPMENT

The nature of the alarm system to be installed in a hospital should be considered at an early stage with the Chief Officer of the local fire brigade. Owing to the complex nature of the risks in a hospital it is necessary to consider carefully the appropriate form of alarm to be installed in each of the various departments. Part II of the report of the Fire Grading of Buildings Committee (paragraph 11) states: 'In places where there is always someone awake and where the building is patrolled at intervals of say not less than 1 hour through the night, a manual system may serve the purpose. It is, however, a wise precaution to install an automatic system in addition to the manual system in those parts of the building which are rarely visited by the staff, particularly during the night.' In deciding on the nature of the system to be installed, account should also be taken of whether or not there is a continuously operated telephone switchboard. Preferably there should be a direct line from the hospital to the fire brigade station.

Fire-fighting Equipment

The Chief Officer of the fire brigade should also be consulted on requirements of fire-fighting equipment such as hose-reels,

hydrants, and portable equipment. The whole hospital should be equipped with a system of wet rising mains under adequate pressure of supply, with (*a*) hose-reels at suitable points and (*b*) hydrant outlets to take Fire Service standard coupling. The hose-reels are for the use of staff in fighting incipient fires, and the hydrants for the Fire Service and for any staff especially trained to use them. It is not desirable to provide hose and branches at the hydrants because they cannot be efficiently used by untrained persons who may nevertheless try to use them.

Portable equipment should include:

(*a*) Water (gas pressure) or soda-acid type extinguishers for the general protection of all departments;

(*b*) Foam for places where inflammable liquids not miscible with water are stored and used;

(*c*) Carbon dioxide for the protection of electrical equipment.

Wherever necessary (*b*) and (*c*) should be installed in addition to (*a*).

Buckets of sand should be provided for use on small fires of inflammable liquids in laboratories and other places where spillages may occur, and should be additional to other equipment.

Automatic Sprinklers

Automatic sprinklers are a good form of protection and when installed in a building can, on outbreak of fire, apply water and give the alarm. However, the fire risk normally associated with hospitals does not justify their installation throughout the building.

Appendix B. ELECTRICAL EQUIPMENT AND INSTALLATION

Equipment and wiring of good quality should be installed in accordance with the Rules of the Institution of Electrical Engineers. All wiring should be protected against mechanical damage.

Main electricity intakes should be indicated by a notice painted on the door stating the voltage and, if necessary, drawing attention to any particular source of danger present. The door should be kept locked by night and by day. The notice should also give the name and telephone number of the responsible department of the British Electricity Authority.

Outlets for non-luminous electrical appliances should visually indicate when current is on.

FIRE PROTECTION IN THE INVESTIGATION'S EXPERIMENTAL BUILDINGS

Fire Protection: Larkfield Hospital

The experimental ward block at Larkfield Hospital was designed before the Fire Panel made its report. At one of the first meetings of the panel the plans of the experimental block were discussed and general recommendations were made. The block at Larkfield does not comply with some of the minor detailed recommendations subsequently made by the panel. The report of the Fire Panel attempts to make recommendations for all types of plans and constructions, and because of this, the recommendations may in some respects be more stringent than is strictly necessary for an individual building.

The experimental block is a two-story building, and each ward unit together with its ancillary rooms forms a compartment. The staircase forms a fire-tight enclosure and contains the lift and several rooms which are not high fire- or life-hazards. At the far end of the wards there is an escape stair leading to exit doors at ground-level. No horizontal escape is provided, but as the building has only two stories, such an exit was not considered essential.

The basement extends under the whole building and, except for the few service rooms and the calorifier-room, forms a large undivided area in one compartment. Access to it is from the open-sided covered way from the existing hospital. There are three exits from the basement, one at the centre, the others at each end of the building.

Originally it was intended that there should be a staircase down to the basement from the entrance hall, but the panel asked for this to be omitted. At the time there had been no decision on how the basement was going to be used and the panel considered that this large area might at some time in the future be used for storage, and if it were so used, it could constitute a high fire-hazard to the rest of the building. The hazard could be reduced by dividing the basement into a number of compartments, but the panel considered this to be too onerous in the circumstances. The panel then suggested that the hazard to the rest of the building could be reduced by omitting the staircase from the entrance hall, and by having a good fire-resisting floor without openings over the main part of the basement.

The pipe duct under the covered way from the existing hospital is fire-stopped where it enters the main building. The vertical pipe ducts from the basement to the wards are sealed at floor-levels. The bed-lift serving the wards does not go down to the basement, and the lift-shaft is sealed at basement level. The service lift-shafts terminate at basement level in rooms which are sealed from the rest of the basement and have access only from outside the building. All the lifts have metal doors.

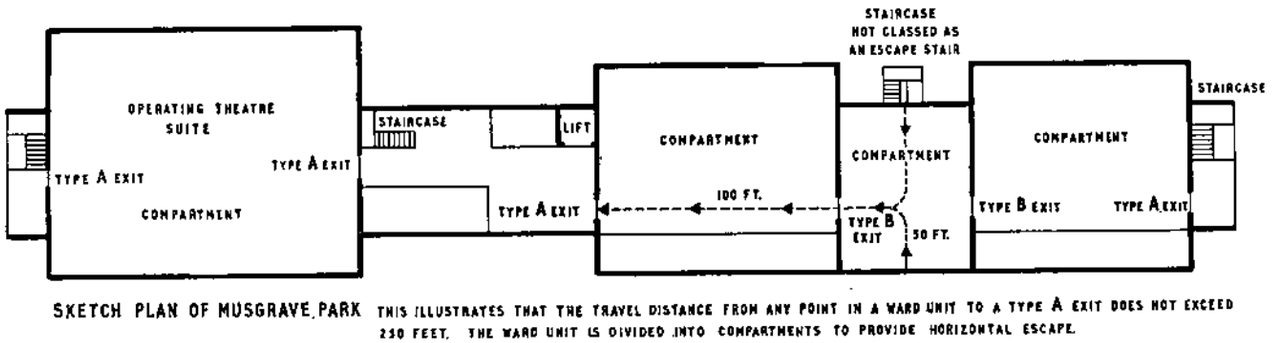

Fig. 126. Exit and travel-distances in the experimental ward unit at Musgrave Park Hospital

The travel-distances to exits are within the recommended maximum (100 feet), and the number of beds on a floor (32) within the recommended maximum of 40.

The building has load-bearing reinforced-concrete cross-walls and reinforced-concrete floors. The outside walls are 11-inch cavity slag blocks. This construction provides good fire resistance well above the standard recommended by the Fire Panel. The doors separating the compartments are 2-inch thick solid doors and have more than half an hour's fire resistance.

The perforated acoustic plasterboard ceilings have glass silk in the cavity. Plasterboard is classified as Class 1 spread of flame test; the remainder of the ceilings and walls are plaster and are non-combustible.

The fire-fighting equipment consists of ¾-inch hose reels fixed to the wall on brackets. There are two hoses on each floor, one in the ward by the nurses' station, the other in the staircase enclosure. The hoses are permanently connected to the water-supply and are turned on automatically when the nozzle is pulled.

The telephone is used for giving the alarm in the main hospital and will be used also in the experimental ward building.

Fire Protection: Musgrave Park Hospital

The Musgrave Park experimental building is designed with a central entrance hall and staircase enclosure, with wards on one side and operating theatre suite, X-ray unit, and central sterile supply department on the other side. There are escape stairs at each end of the building.

The wards on the two floors are divided into three compartments, so that there is horizontal escape for all the beds into a compartment that is not a high fire-hazard or an operating theatre suite (see p. 135). The travel distances to exits is well below that specified in this report (see *Fig. 126*).

On the first floor the operating theatre suite, containing two theatres, forms one compartment, and on the ground floor the X-ray unit and central sterile supply unit also form one compartment.

The basement extends under the whole of the building and contains a room under the X-ray unit for the mechanical plant. The basement, which is used solely for the distribution of the services, can be regarded as a large horizontal duct. The ceiling height is low, and access to the basement is through small doors down 'cat' ladders. Where pipes go through the ceiling, the junction is sealed.

The construction gives adequate fire resistance. The 11-inch, cavity, exterior walls have an outer leaf of 4½-inch brick and an inner leaf of 4-inch clinker blocks. The walls dividing compartments are two leaves of 3-inch clinker blocks and the floors are 7-inch and 8-inch concrete. The doors are 1⅝-inch solid timber, and where viewing panels are incorporated they are of fire-resisting glass.

The ceilings throughout are covered with metal heating-panels. Some of these panels are perforated for sound absorption and have glass silk in the cavity. The rest of the surfaces are plaster.

The same type of fire extinguishing equipment as at Larkfield is being installed. There are three extinguishers on each floor, two being in the wards and one at the entrance to the operating theatre.

The method of giving alarm of fire in the main hospital is by telephone, and this system will continue to be used in the new building.

SUMMARY

Introduction. The report is mainly concerned with the planning and constructional aspects of fire protection in new buildings. The predominant fire-risk in hospitals is to human life and many patients may have to be helped or carried to safety. Hospitals must be planned and constructed to provide adequate means of escape and to confine the fire and prevent it spreading through the building. In a hospital building of fire-resisting construction planned as a series of fire-tight compartments, patients and staff can seek safety in the first instance by moving into another compartment. It may not become necessary to evacuate the building. The moving of patients to safety is easiest where each story consists of two or more compartments.

Part I. Planning to minimize Fire Risk. In hospitals high fire-risks exist side by side with high life-risks and the limitation to the size of compartments has to be considered primarily from the point of view of the patients' safety. High life-risk and high fire-risk departments of the hospital require to be in separate compartments and to be limited in size.

Protection is required against spread of fire between buildings, and general guidance is given on this aspect of fire protection. Recommendations are made on the number of exits and the travel-distance to exits in compartments.

Part II. Construction and Materials. The construction of a building should have a degree of fire resistance sufficient to enable it to continue to perform its functions throughout a fire. Materials used should not ignite nor contribute materially to a fire. Recommendations are made on the fire resistance of walls, doors, floors, and roofs forming the boundaries of compartments, and on the use of combustible materials.

The two appendixes at the end of the report are on Fire Protection Equipment and Electrical Equipment and Installation.

At the end of the chapter will be found a description of the fire protection measures taken in the experimental ward units designed by the Investigation.

6 SOME GENERAL CONSIDERATIONS AFFECTING DESIGN

OTHER sections of this report deal in detail with parts of the hospital and with environmental considerations, such as heating and the control of noise. The Investigation's work has thrown light also on some general problems of planning, and the most important of them are discussed in the present chapter.

Hospital design must constantly develop to keep pace with medical and social changes. Research can illuminate certain aspects of design; it can furnish information and can point to profitable methods of approach. It must never be thought of as providing definitive answers. There can be no single or ideal solution, because every hospital presents its own problems each requiring an individual solution, and the task of thinking out the needs in a particular case and of finding the best organizational and architectural expression must remain with the hospital authorities and their architects.

Considerations arising from Studies of Demand

The way in which the demand for hospital services arising from a population can be measured is discussed in Chapter 7. Any hospital authority undertaking an important building programme should consider making a survey of demand in its own area, as has been done by the Hospital Board for the Eastern Region of Scotland before drawing up a schedule of requirements for the new hospital centre to be built in Dundee. If such a quantitative basis can be established we need not, as Professor H. W. C. Vines has said, 'continue to plan by guesswork, opinion and probability, an unhappy triumvirate, which makes the architect's work difficult and which may lead equally to over-building or to under-building the hospital'.[1]

The unit on which hospital services in Britain are organized is no longer the individual hospital but the hospital group within the framework of the region. Studies of demand can be made for the population served by a particular group—as was done by the Investigation at Northampton and in East Anglia (see Chapter 7)—or for a whole region—as was done at Dundee. When the service provided by the existing institutions is related to the recorded demand, it becomes possible to see whether and where there are serious deficiencies, and to plan to meet them.

In working out a development programme for a group or a region, questions of distribution and the degree of concentration of hospital facilities will have to be considered. Studies of demand will not give a complete answer to these complex questions but they enable comparisons to be made between alternative solutions. For instance, the following question might arise: should the clinics for a particular specialty serving an area be provided at a major central hospital or be provided locally? If the distribution of demand for clinic attendances over the area is known, then the problems arising from centralization can be assessed and considered against the difficulties of providing a local service.

Methods of estimating the numbers of beds and of outpatient clinic sessions needed to meet a recorded demand are discussed in Chapter 7. There are some data on the demand for radiodiagnosis, pathology, and surgical operations coming both from inpatients and outpatients, but further research into the functioning of these departments is necessary before demand can be translated into estimates for provision.

Considerations of Physical Environment

In Chapters 4 and 5 the problems of physical environment and of fire protection are considered in detail. Daylight, sunlight, noise, and fire risk, as they affect the general planning of the hospital, are discussed below.

Daylight and Sunlight

The arrangement of the buildings will affect the amount of daylight and sunlight entering the rooms. On restricted sites some measure of obstruction may be unavoidable, and where this is so the designer should always calculate the angle of light available to the wards. The standards laid down by the London County Council for buildings for domestic use may be taken as a guide in hospital design.[2] It will generally be worth while to make a study of the shadows cast by the larger buildings in any hospital scheme before reaching conclusions about the position and orientation of the blocks.[3] In temperate latitudes orientation somewhat to the east of south is likely to be preferable to due south. West orientation is undesirable because the afternoon sunlight in summer can be extremely hot and comes in a horizontal direction so that it is difficult to control its entry.

Daylighting is particularly important when considering the shape of ward blocks and their relation to other buildings on the hospital site. Strong daylight has a bactericidal effect, promotes cleanliness, and makes for a pleasanter atmosphere in the hospital. The daylight-factor should not be allowed to fall much below 2 per cent. at the back of a ward (see p. 93). It seems reasonable to regard this as an appropriate standard for many parts

of the hospital. In Chapter 4 (see p. 90) the size and shape of window necessary to give effective daylighting in wards is discussed on the assumption that there is an uninterrupted view of the sky from the window. If the view of the sky is obstructed by parts of the ward block or by other buildings, daylight penetration into the rooms will be reduced. From the point of view of daylight, therefore, cruciform blocks are undesirable, and so also is any form of enclosed light-well.

Opinions on the orientation of ward blocks have changed with changes in the internal planning. The pavilion ward usually faced east and west, and sometimes had a veranda at the south end. A report on the orientation of buildings, published in 1933 by the Royal Institute of British Architects, included a section on hospitals. In this report an analysis of sunlight penetration to the 'Nightingale' ward was given and the conclusion drawn that narrow vertical windows were unsatisfactory. The report recommended the use of much larger windows, and beds arranged parallel to the window-wall as in the Rigs Hospital, Copenhagen. It was assumed in the report that wards would remain unpartitioned, with windows on both sides. East and west orientation was not criticized.

The widespread adoption of the corridor plan led to buildings with wards facing south and ancillary rooms on the other side of the corridor, facing north—the Söder Hospital in Stockholm and the Bürgerspital in Basle are well-known examples. To provide the wards with unobstructed sunlight and view, the architects of both these hospitals placed the other buildings to the north. The ward blocks, which are high and long, thus cast a shadow over much of the rest of the hospital.

The Investigation suggests that in an acute general hospital patients' bedrooms need not necessarily be given priority in sunlighting over all other accommodation. Many patients will spend much of their time not in bed but in a day-room, which can be on the sunny side of the building. Those who are acutely ill will probably not benefit greatly from sunlight and indeed may prefer shade. The patient's stay in an acute general hospital is now usually short and he therefore suffers no serious hardship if it is not passed in a south-facing room. The hospital staff, on the other hand, may spend the whole of their working day in the hospital, and it seems undesirable that all the rooms they particularly use should face north or be in permanent shadow. A broader view might well be taken of orientation in hospital design, aimed at equitable standards throughout the hospital.

Planning Against Noise

It is cheaper to plan against noise than to check it by structural means. Parts of the hospital needing quiet, particularly the wards, should so far as is possible be kept away from areas of noise. The kitchens, boiler-house, and laundry are inevitably noisy. Fuel, stores, food supplies, and gas cylinders should be unloaded at points remote from the wards. Car-parks and ambulance entrances should not be too close to ward windows. Traffic noise is often a problem in towns. Where a hospital is close to a public road carrying heavy traffic, it will be wise to carry out a noise survey to determine what measures are necessary to reduce the noise-level within the building to acceptable limits. The question of what these limits should be is discussed on pp. 117–18. The noise-level is usually found to fall off fairly rapidly with height. A sound-survey made in Leeds, preparatory to building a hotel on a busy street, showed that whereas double windows would be required up to third-floor level, they were not necessary at higher floors. As wards require a great measure of quiet, they should be given the quietest available position on the site.

Planning Against Fire

Chapter 5 contains the recommendations of an expert panel on fire precautions in hospital buildings. In it those hospital departments with a high fire-risk are listed, the most important being main stores, main kitchens, laboratories, boiler-house, and garages. The design must be such as to prevent, so far as possible, the risk of fire spreading from those departments to other parts of the hospital and particularly to the wards. This protection can be given either structurally or by separation. Wherever separation can be obtained by planning, significant economies in construction are likely, and if the high fire-risk departments are separate single-story buildings there will generally be no need for heavy fire-resisting construction. The boiler-house and garages are usually designed as separate buildings, except on very restricted city sites. The kitchens and stores have often been designed as part of the ward block. While there may be some inconvenience in removing them a small distance from the ward building, this is most desirable from the point of view of fire protection.

The Requirement of Individual Departments

Chapters 1, 2, and 3 of this report describe the Investigation's studies in wards, outpatient departments, and operating theatres. The needs of each in so far as they affect the general planning of the hospital are discussed below.

Ward Buildings

How to group wards in blocks is a perennial subject of debate. In the eighteenth century, when small rooms were common, wards were often grouped compactly in buildings two or three stories high. The open, pavilion ward which was first introduced on the Continent during the first half of the nineteenth century, and which was approved by Florence Nightingale, lent itself specially to single-story design. A long corridor forms the spine of this arrangement; the wards form spurs on one or both sides with the long axis at right angles to that of the corridor. The space between the wards is commonly about 40 feet. Each ward overlooks its neighbour on either side, but the lighting is usually good, and the sun can, for much of the day, shine over adjoining buildings and through the windows. Such wards usually have a pleasant character, and the enclosed gardens or courts can be very agreeable.

The major objection to this layout is that for a hospital of any size it occupies a great deal of ground and results in considerable walking distances. Attempts have been made to reach a greater compactness while preserving the essentials of the layout. A unique and ingenious modification of the single-story layout is to be seen at the Royal Victoria Hospital, Belfast, built in 1903. There the wards are artificially ventilated, and are lit by clerestory windows and so can be placed side by side without any intervening open spaces, giving a very compact arrangement.

The arguments for stacking wards one above another are quite strong. The majority of wards can be identical in plan and this lends itself to economical structural design with bearing-walls so that columns can run unbroken through the height of the building. The same services, supplies, and arrangements for disposal are required at the same points in each ward, and plumbing stacks, pipe-runs, and service-lifts can therefore be planned to serve a large number of wards placed one above another. Vertical planning can allow unobstructed outlook, sunlight, and ventilation to all the wards. Such considerations

have led many architects, particularly on the Continent and in the United States, to design tall ward blocks, even on country sites where space is more or less unlimited.

In considering the different forms which a ward block may take, the position of the main vertical circulation, containing stairs and bed-lifts, is critical. It is now a recognized principle that each ward should be a cul-de-sac so that it shall not be used as a corridor for traffic to other wards or other parts of the hospital. Thus, each ward must have direct connexion with the point of vertical circulation. The more beds on a floor, the lower can be the overall height of the ward block for a given total number of beds and the fuller the use made of the lifts and stairs. Broadly speaking, the more beds on a floor, the more economical will be the building, both in first cost and in maintenance. Blocks with only one ward on a floor have been used in several new hospitals in Scandinavia. A block with two wards on a floor is often used for hospitals of medium size, a recent example being that at St. Lô in Normandy. This gives more beds on a floor with the great advantage that views from all wards are unobstructed and all have an equally good chance of sunlight. Blocks with three or four wards on a floor arranged radially about a centre hub containing lifts and stairs provide still more beds on a floor, but outlook and orientation are less satisfactory. The cruciform block with four wards on a floor allows a maximum number of beds to be served from one circulation point but view and sunlight are much obstructed, and the outlook from windows near the centre of the block is apt to be forbidding.

To avoid the use of tall buildings, a number of blocks three or four stories in height are sometimes grouped together. If the cul-de-sac principle is maintained, this results in several points of vertical circulation, each of which needs stairs and bed-lifts. Circulation at ground-level is complex, as access to the foot of each staircase has to be provided for persons, and for a considerable variety of supplies, coming from different points.

The total number of beds required in the hospital, and the limits set to the height of the building, are generally the crucial factors in determining which solution is adopted. The limits to be set for height are difficult to fix, and technical considerations in themselves do not provide an answer. In Chapter 5 it is suggested that the essence of fire protection in a ward building is the division of each floor into two or more separate compartments so that evacuation from any one of them will be in a horizontal direction. If this is done, and provided also that proper arrangements are made for fire-fighting, there need be no limit to the height of ward buildings on grounds of fire hazard. Attempts have been made to relate the height of buildings to constructional cost, but such studies as have been made are inconclusive. Again, little is known about the economics of lift provision except that a group of lifts concentrated in a single vertical shaft is likely to be cheaper than a similar number of lifts distributed at different points in the building. Thus for efficient lift service a single tall ward block is preferable to several blocks of medium height. In practice, height is generally fixed by less tangible considerations, such as the appearance of the building on the site in relation to neighbouring buildings and the landscape.

The number of beds in the ward, or nursing unit, has important implications in determining the best form for the ward block. Current planning is based on a ward size of 25–30 beds, 28 beds being sometimes recommended as a compromise between nursing requirements and economy. Studies reported in Chapter 1 have pointed to a different approach to ward organization and design. In the experimental ward block at Musgrave Park Hospital, designed by the Investigation to demonstrate and test this approach, ward planning is based on units of 20 beds, four such units being grouped on a floor, giving a total of 80 beds. This 80-bed floor is not greater in length than would be a floor containing a pair of 'traditional' wards housing perhaps 56 beds. The extra accommodation has been obtained partly by compact planning and partly by increasing the thickness of the building. That this thickness is practicable from the point of view of ventilation and daylighting has been shown by the Investigation's studies described in Chapter 4.

For a given total number of beds, an increase in the number of beds on a floor reduces the number of floors, and thus the total height of the ward block, and achieves economies by reducing the number of lift stations, service points, and service rooms. The compact block, providing more floor space per square foot of external wall, is cheaper to heat. Apart from the economic advantages, the ability to place more beds on each floor increases the designer's freedom in the choice of building form. With 80 beds instead of 56 on each floor many more beds can be accommodated within a given height limit, and it will often be possible to use a single ward block where with traditional ward planning several might have been necessary. Similarly this more compact ward plan reduces the spread of single-story layout, and makes that arrangement practicable for hospitals of up to 200 beds.

The Outpatient Department

In Chapter 2 the arguments for and against centralizing the provision for outpatients are given, and the conclusion is reached that a centralized department is to be preferred. One of the arguments in favour of such a department is that a very large number of outpatients visit the hospital daily, and it is undesirable for them to pass through other areas. Hence the outpatient department requires direct access to the public road. Where central departments for radiodiagnosis, pathology, and physiotherapy serve both inpatients and outpatients these departments should be conveniently placed for the outpatient clinics. Access to radiodiagnosis is particularly important. It may be seen in Chapter 7 (p. 181, n.) that in one year 82 per cent. of all X-rays made in one hospital group were for outpatients.

Operating Theatres

Theatres may be grouped together or, as was often done in the past, they may be dispersed and placed close to the wards they serve. The principal advantage of the latter arrangement is that the journey made by the patient from ward to theatre and back again is short. But dispersed theatres have disadvantages. More theatres will almost certainly be needed if every department has its own; and many departments may produce insufficient operations to make full use of their theatres. Single theatres are more expensive to provide than grouped theatres, which can share a great deal of the very expensive ancillary accommodation and services. As it is impossible to foretell over a period of years exactly which wards will be occupied by surgical cases, it is advantageous if all wards are planned with equally convenient access to a central group of theatres, thus ensuring the maximum flexibility in the allocation of beds.

The provision of recovery-rooms within the theatre suite is discussed on pp. 73–74. The main purpose of these rooms is to ensure that patients whose immediate post-operative condition gives cause for anxiety may be kept constantly under the eye of a nurse and may be directly supervised by the anaesthetist with resuscitation equipment available. These needs are not fully met if such

patients are at once returned to the wards, even where—as is always desirable—the journey is short.

The planning of a group of theatres is discussed in Chapter 3. It will be seen that two or more theatres placed together on one floor, with the necessary ancillary accommodation, tend to give a very thick, almost square, block of building, with some internal rooms. In these circumstances some top lighting and top ventilation will be useful. Hence there are advantages in planning the theatres in a single-story building.

Some Other Considerations in Planning

Flexibility and Growth

It has sometimes been argued that the accommodation required in hospitals is likely to change so rapidly that the internal walls should be demountable, so that they can easily be taken down and re-erected in different positions. There is no technical difficulty in designing the structure so that the internal walls are not load-bearing, and indeed this is done in most modern multi-story hospital buildings. If the internal walls are built in a normal manner with bricks or blocks they can be demolished and re-erected elsewhere without affecting the structural stability of the building. Rearrangement will, however, be a dirty and noisy business and will involve closing parts of the hospital while it is being carried out. Alternatively, various forms of prefabricated partition, specially designed for easy dismantling and re-erection, can be used. These partitions are more costly than conventional construction and very difficult to sound-proof. Further, any major rearrangement is almost certain to involve changing the position of the services, including electricity, water, drainage, and perhaps also heating and ventilation. Alterations to these services will mean taking up floors or taking down ceilings. Thus the fact that a demountable partition has been used will not necessarily avoid the need for substantial building work when alterations are made. To meet this difficulty a uniform grid of services, all of which are available at any point, may be installed. But this is extremely expensive and only a small proportion of the outlets is in use at any one time. Generally the attempt to provide for a high measure of flexibility by changing the walls and services in a building can only be justified if there is a reasonable certainty of substantial changes being made at frequent intervals. It is therefore worth considering what kinds of changes are most likely to be wanted in the various parts of a hospital.

In Chapter 1 the historical evolution of ward design has been traced, and from this it appears that the requirements of ward-planning change with somewhat less rapidity than do those for many other departments. Patients are still being nursed in wards built 100 years ago to which only minor alterations have been made. Though such wards are generally most inconvenient, they may be contrasted with other parts of the hospital where buildings of similar age have often been found wholly inadequate for present-day purposes and have had to be drastically remodelled. The reason for this contrast lies in the function of the ward. The basic nursing needs for a sick human being are unchanging. He must have a bed, there must be space around it for the nurse and the doctor to attend to him, and there must be facilities for his toilet and for feeding him.

While the needs of a sick human being—and hence the space and services required in a ward—may not change very rapidly, we must expect considerable changes to take place, well within the life of a hospital building, in the number of cases requiring admission from a given population and, still more, in the proportion of these cases as between the different specialties. These changes can, however, be provided for in the right approach to planning and do not necessarily call for frequent alterations to the fabric of the building. Wards, for example, should be designed so far as possible to be suitable to house all types of patients. With the exception of children and maternity cases, there is no reason why the same ward plan should not serve for all departments in an acute general hospital, so that accommodation can be switched from the use of one department to another without structural change. This will also facilitate the temporary allotment of beds to meet seasonal fluctuations in demand. To ensure that the beds are as far as possible interchangeable between the different departments, the ward block should be sited so that all wards have convenient access to the theatres, the department of radiology, and other special facilities for diagnosis and treatment.

Studies described in Chapter 7 show that the numbers of male and female patients in any specialty are not usually the same and that fluctuations from time to time may be considerable. Hence ward design should be such as to enable the proportion of beds for men and for women within any department to be varied so as to meet the demand. This means that the ward should be divided into reasonably small units, each provided with its own toilet facilities. The degree of subdivision required to give the necessary flexibility will depend on the overall size of the hospital—the larger the hospital, the larger the unit can be. In a small hospital it will be best not to have rooms containing more than 6 beds in order to give maximum flexibility and therefore a high occupation rate.

Today the diagnosis and treatment of outpatients is a major part of the hospital's function; growth and change have been continuous in recent years, and in almost every hospital in Great Britain the outpatient department has been or needs to be greatly extended or altered. Demand for outpatient care may level off, but considerable fluctuations, particularly as between the different specialties, must be expected. Further, alterations in methods of diagnosis and treatment are likely to continue and this is bound to be reflected in changes in the accommodation and services needed. Ability to meet changing requirements is thus fundamental to the design of outpatient departments.

An outpatient department consists of clinics for each specialty and various facilities for diagnosis and treatment. Over a period of years each of these will have its own problems of growth and alteration, and the plan should allow for each to grow and change so far as possible without interfering with its neighbours. This is an ideal not always realizable in practice, particularly on restricted sites. It should, however, be the aim. It means that the various units within the department should be related like branches on a tree, each with freedom to grow without disturbing the general pattern. Full flexibility in this sense can be obtained with single-story construction, if space is available. In a multi-story building an important measure of flexibility is immediately lost in that it is impossible to expand a unit on an upper floor without displacing other departments in the process, or extending the whole building including the floors below.

In Chapter 2 it is suggested that a simple, general-purpose, consulting suite can provide accommodation for a wide variety of consultative clinics. If the clinics are designed on this principle, it will be possible without structural alteration to allot suites to different specialties to meet changed needs. To ensure maximum flexibility in use, the consultative clinics should all have convenient access to services such as radiodiagnosis, pathology, the dispensary, and the almoners.

Internal Traffic

Internal traffic has long been considered important in hospital design. Some authorities, for example Jean Walter,[4] argue strongly for vertical transportation. To achieve direct vertical transport to every, or almost every, department in the hospital, Walter advocates hospitals built as towers with four or more wings radiating from a central hub containing lifts and stairs; but a great deal has to be sacrificed in the use of this principle, particularly daylighting, sun, and outlook. From the other point of view, Rombouts[5] has argued that for hospitals containing up to 300 beds it is quicker to get from point to point in a one-story building than it is in a multi-story block. Rombouts's arguments take into account the time needed to summon a lift and get in and out of it. All arguments based on internal transport are somewhat inconclusive in the absence of reliable data as to the volume and frequency of traffic from point to point within the hospital. If a journey from one department to another is rarely if ever made in practice, then the fact that these departments are some distance apart may be immaterial. Rombouts makes use of the only published data on the volume and frequency of hospital traffic—those of M. E. Molander[6], taken from surveys in Swedish hospitals, which deal only with movements of nurses and other hospital staff, excluding doctors, patients, and visitors.

In Great Britain, owing to the steady development of outpatient work, hospitals have traffic patterns different from those in most other countries. The Investigation made studies of traffic in two hospitals and the results suggested that traffic will vary greatly from hospital to hospital, depending on local circumstances and the method of work within the hospital. The Investigation concluded that traffic is an important consideration, but in relation to any particular hospital it should be considered on its merits; general arguments on hospital design derived from hospital traffic surveys are likely to be fallacious.

When planning a particular hospital some predictions can be made as to the nature of the traffic. For instance, the number of patients visiting the outpatient department throughout the day will have been calculated in order to determine the number of clinics, and some allowance can be made for escorts accompanying patients (cf. p. 42). Again, the number of visitors to the wards in visiting hours is generally limited to two at a time at the bedside; an average of two visitors in all was found in the hospitals surveyed. The volume of transport required to carry meals and supplies for the various departments can generally be estimated with considerable accuracy by the hospital authorities.

Much of the internal transport in hospitals is by trolley and so must go on the level or by lift. Lifts are therefore necessary at all points of vertical traffic. A more efficient lift service is obtained where several lifts are grouped together to serve a number of floors. Lifts go out of action from time to time because of breakdown or for routine maintenance, and if only one lift is provided at any particular point traffic will be disrupted while it is not in service.

Considerations of internal transport therefore suggest that the number of multi-story blocks should be as few as possible, and that there should be preferably only one.

Architectural Character

M. E. Molander[7] has observed that the great bulk of most hospitals presents architectural and town-planning problems of considerable difficulty. Even a hospital of moderate size represents a mass of building liable to contrast strongly in scale with its surroundings. Molander urges architects to consider the design of the hospital in relation to an urban or country setting, and believes that technical considerations should not necessarily be permitted to override those of aesthetic amenity.

It is often and rightly urged that the hospital architect should give particular thought to the difficult problem of investing the building with a reassuring appearance. Unfortunately this aim is not often attained, and many modern hospitals are monumental in scale and awe-inspiring in character. Earlier in this chapter it has been suggested that several important parts of a hospital, notably the outpatient clinics and the medical service departments, including the operating theatres, may advantageously be designed as low buildings, one or perhaps two stories high. The architect may thus have an opportunity to dispose these low buildings so as to give the hospital a pleasant character, related to its environment. Generally, whenever it is possible to provide for views through, under, or between the various blocks comprising the hospital, a lighter or less menacing character will be attained.

Hospital buildings, leaving aside the nurses' home and staff accommodation, can be thought of as falling into four groups: (i) the wards; (ii) the outpatients and casualty departments; (iii) the medical service departments, including operating theatres, radiology, pathology, physiotherapy, &c.; and (iv) the non-medical service departments, including the main kitchens, stores, boiler-house, laundry, &c. All are subject to growth and change and ideally all should be free to expand. This ideal can only be achieved in a hospital entirely of one story, on an unrestricted site—a solution which should be considered for small hospitals where ground is available. For hospitals which are larger and on restricted sites, multi-story design will be necessary for at least part of the hospital, and for several reasons multi-story design is more suitable for wards than for any of the other groups. When this construction has been decided upon for the wards the aim should be to group all of them, with the possible exception of those for children and for maternity cases, in one block served by one centre of vertical circulation. This is generally possible in hospitals of up to 500 beds. The remaining accommodation is preferably to be disposed in low buildings grouped around the base of the ward block, each individual department so far as possible being left free to expand.

The outpatient department should have direct access from the public road. The wards can lie behind or to one side, and the medical service departments, which will generally serve both inpatients and outpatients, should be between the wards and the outpatient clinics. The non-medical service departments can conveniently be grouped together, forming an industrial zone, with a road for delivery-vehicles.

In some ways the design of a hospital is like the development plan for a new town. A hospital is essentially a growing organism, not a finite building, and the plan should start from considerations of zoning and traffic routes. Zoning a hospital site means dividing it into areas allotted to the different elements as defined above. In allowing room for each department of the hospital to expand without disorganizing the general plan, particular attention must be paid to the interrelation of the zones and to the traffic routes. Too often, today, it is impossible to modify the arrangement of the hospital so that a more convenient use can be made of the site, because in the past no development plan was thought out for the future.

SUMMARY

Many of the Investigation's detailed researches—for example, on the annual case-load borne by hospitals, on particular departments of the hospital, and on environmental conditions in them—have direct bearings upon wider problems of general planning such as the distribution of hospital facilities in the population served, the arrangement of hospital buildings on a chosen site, and the physical interrelation of component parts within the hospital.

Hospital buildings must be so arranged that they allow an equitable share of sun and daylight for the staff as well as the patients, and give adequate protection from noise and fire hazards. The hospital as an institution necessarily reflects changes in medical methods and in social concepts, and the designer, knowing that adaptation will be inevitable as time passes, but not how or where it will be needed, must attempt to allocate space on the site and within the main buildings so that periodic reorganization and some degree of expansion will not become wholly impossible within the foreseeable life of the building.

History seems to show that wards are among the most stable elements in the hospital, because the essential needs of the sick do not change. Economy in building and maintenance, and convenience in administration, are achieved by grouping wards in a multi-story block (served by centrally placed stairs and lifts) which should prove sufficiently flexible in use if the in-patients themselves are grouped in small, more or less self-sufficient units.

The diagnostic and therapeutic departments, in which work is continuously being modified by advances in medicine, may suitably be housed in low buildings each capable of some alteration independently of the rest. Among such buildings will also be the outpatient department and operating theatre suites. Entrance to the outpatient department should be directly from the public road, and the diagnostic and treatment services most used by outpatients should be within easy reach.

The association of a multi-story ward block with smaller, low buildings housing the diagnostic and therapeutic services can help the designer to avoid that forbidding character which large unbroken architectural masses are apt to assume. A variety in the scale of the buildings on the site should also make it easier to bring the hospital into an aesthetically satisfying relation with other buildings in the neighbourhood and with the landscape in general.

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7 PLANNING TO MEET DEMAND

THE need to plan and to control hospital provision so that the community may have proper access to it was recognized more than sixty years ago by the Select Committee of the House of Lords on Metropolitan Hospitals. Although the committee's conclusions related specifically to London, they were applicable also in the provinces.

> The prevailing though not unanimous opinion, as appearing from the evidence, seems to be that on the whole the hospital accommodation in London is sufficient, but that much inconvenience and a partial inability in some parts to cope with the demands for admission are caused by the unequal distribution of the hospitals, and by want of organisation.[1]

Before the 1914–18 war attempts at co-ordination produced little result, but during the years between the wars, when the voluntary hospitals were being assisted by grants of public money, surveys were undertaken to discover how provision was meeting demand and further efforts were made to impose some order upon the facilities provided by the various hospitals, voluntary and other. Not until the National Health Service came into operation, however, was it possible effectively to plan and to integrate hospital services throughout the country.

An essential basis to planning is an understanding of the nature of the load of cases which hospitals, jointly and severally, must bear. A comprehensive body of knowledge about morbidity in the community is now beginning to be built up and some of this knowledge relates specifically to hospitals and the contribution they make.

Two examples are the studies of hospital-treated sickness in Ayrshire and Stirlingshire,[2] and Donald MacKay's study of inpatient discharges.[3] But as yet the information available from such studies is too limited for planners to use it directly in solving actual problems of how to add to an existing hospital or design a new one.

The Ayrshire and Stirlingshire surveys gave a complete picture of all types of hospital-treated sickness occurring among the known populations of the two counties, but no attempt was made to assess whether the existing resources were adequately meeting the demand for hospital care. It is explicitly stated that 'no such survey can by itself afford an accurate index of the ill health of a community and caution is needed in interpreting the results. Even within the hospital field, the outcome is necessarily a record of the facilities actually available and used, as distinct from the hospital needs of the community, and the official hospital survey reports published by H.M. Stationery Office have made it plain that the two are by no means the same.'[4]

Donald MacKay's study was based on the analysis of a sample of inpatient discharges from several teaching hospitals and a few other hospitals in England and Wales during the first six months of 1949. MacKay warns his readers that the figures which he gives relating to hospital-treated diseases and conditions 'are not representative of the overall hospital services in the country' and that 'the proportionate distribution of the discharges in each age group should not be used to provide estimates of allocations between clinical specialties since the bias in the aggregate of hospitals surveyed may have given rise to an undue preponderance of those diseases requiring special facilities for investigation and treatment'. He also points out that there were waiting-lists of varying lengths for conditions other than emergencies, so that the figures only related to those people who were admitted to the available beds, and did not necessarily reflect the demand.

The supplement on hospital inpatient statistics, which forms part of the Registrar General's Statistical Review of England and Wales for 1949,[5] includes a year's figures for the hospitals studied by MacKay. The *British Medical Journal*[6] criticized these inpatient statistics because the figures did not relate to any definite population and were consequently difficult to interpret. Although for planning purposes this lessens the immediate use which can be made of MacKay's inpatient inquiry, when it is extended to all hospitals in the country it will be both a useful source of information for the administrator and a guide to morbidity in the community.

Various attempts have been made to estimate the numbers of beds required in particular circumstances, and to assess the adequacy of the existing facilities. The most comprehensive of such inquiries in this country were the hospital surveys organized jointly in 1941 by the Ministry of Health and the Nuffield Provincial Hospitals Trust. The objects of the surveys were to

> gather information about the hospital facilities normally available which has hitherto never been collected but which is essential as a basis for any planning of the future services . . . to assess the adequacy of the facilities available . . . and to provide a body of expert advice on the way in which the existing facilities could best be co-ordinated and if necessary expanded to serve the community in each area.[7]

The reports of these surveys, which covered the whole of England and Wales divided into ten areas, presented a valuable account of the nature and extent of hospital work; but, in the absence of any standard, recommendations

were based on the opinions of the various surveyors. The difficulties of assessing the adequacy of the hospital services are mentioned by Gray and Topping, who surveyed London and the surrounding area:

Any exact measure of adequacy of the hospital services, whether in quantity or quality, is almost impossible, since a number of factors enter in, many of which are quite intangible.

They give examples of various criteria which have from time to time been adopted in attempts to assess the need for beds:

The first criterion is that of the percentage occupation and size of waiting lists of individual hospitals. It has, for example, been suggested that a hospital which has an average occupation over the whole year of more than 80 per cent. of its total beds—or 90 per cent. for chronic or tuberculosis beds—is overcrowded and needs relief. The validity of this proposition must clearly depend *inter alia* on the length of stay and the efficiency of the hospital. Similarly the value of waiting lists as a measure of need depends on a number of factors. . . . However inexact these criteria may be, they do provide some guidance. . . .

Secondly, there have been put forward various theoretical estimates of the beds required for different types of cases based on the experience of difference hospitals and areas.

Gray and Topping included a table comparing three estimates of the numbers of different kinds of beds needed per thousand of the population. The estimates of the number of general acute beds thought to be required were 4·5, 5·8, and 6·4 beds per thousand of the population, and to quote a particular example, one estimate of the number of thoracic beds needed for each million of the population was 120, another was 10.[7]

In the Nuffield Provincial Hospitals Trust's report on the regional planning of hospital services in the counties of Buckinghamshire, Berkshire, and Oxfordshire, the suggested number of beds for the acute sick was 5 per 1,000 of the population.

This estimate was arrived at after careful consideration of the position revealed by the official survey . . . of the region, and after studying the views of other hospital and health authorities, but figures arrived at on such a basis can be no more than approximately correct, and will need modification in the light of particular circumstances.[8]

A further example of the speculative way of planning is to be found in the Ministry of Health's memorandum on the Development of Consultant Services, issued in 1950.[9] The primary object of that memorandum was to assist Regional Hospital Boards in the development of the consultant services, and estimates are given of the numbers of beds to be provided, for example:

For a population of 100,000–120,000 in an area served by one Hospital Centre, it is probable that some 250 medical beds will be required apart from those for the chronic sick, tuberculosis and infectious diseases. . . .

The number of hospital beds which should be provided for children has been stated as 0·5 beds per 1,000 of the population. This is probably insufficient. The number of whole time paediatricians required, according to the British Paediatric Association, is about six to eight per million of the population but the number available at the present time falls very far short of this and it will be some years before there are sufficient fully trained men to meet the needs of the country. On the basis of these proposals it is suggested that for the standard population of 100,000–120,000, 50 general children's beds should be provided.

The total of these estimates for the different specialist services amounts to about 7 acute beds per 1,000 of the population. The estimates of the number of beds required, which is given in the general instructions in the report on the Scottish Hospitals Survey, is even higher.

As a result of [various] . . . considerations, we are of opinion that in a closely-knit industrial area the general hospital beds should number at least 8 per 1,000 of population. In the rural areas probably 4–5 beds per 1,000 will suffice. Other areas of mixed industrial and agricultural population may be graded between the two figures . . . 8 beds per 1,000 should be the figure *after all the overcrowding which at present exists in the hospitals system has been removed. . .*.[10]

In the United States of America the Commission on Hospital Care, in its pilot survey in Michigan,[11] began to develop a formula for estimating bed needs based on vital statistics. The Hospital Council for Greater New York also has studied the use of formulae, and

has analysed the relationships that exist between certain socio-economic characteristics of a population, its vital statistics and actual utilization of general care facilities. These studies indicate that although many socio-economic factors influence the need for hospital care, they are fully reflected in the deaths experienced by a population. These studies have yielded a formula which indicates that 0·41 general care beds should be available for each death occurring during the year. The number of general care beds needed may, therefore, be determined by multiplying this factor (0·41) by the annual number of deaths in the community or area under study.[12]

According to the bulletin of the Hospital Council of Greater New York, the derivation of this factor rests on one basic assumption:

It is assumed that during the period under study the people of New York City have been receiving adequate care; that is they are admitted to a hospital when necessary and they stay hospital as long as is warranted by medical considerations.[13]

The fact that the ratio of general care patient-days to deaths has been constant from 1936 to 1950, with the exception of the war years, is thought to be evidence for the validity of the assumption. Support for this view is given by Deardorff and Fraenkel in their analytical study of 576,623 patients discharged from hospitals in New York City in 1933.[14] They found that 'the discharge data coincide closely with the death rates in each district'. In the most recent American assessment of the overall need for beds in acute general hospitals, made by an economist and a statistician sponsored by the U.S. Department of Health, Education, and Welfare, the conclusion was reached that between 4·4 and 4·7 beds per 1,000 of the population were required for patients (including geriatric patients) needing active medical treatment.[15]

In France, R. F. Brigman[16] has attempted to solve the problem of providing a balanced hospital service in yet another way. He described a method of comparing hospitals with one another, in which the figures representing the actual characteristics of a hospital are plotted against hypothetical standard characteristics. This method seems open to criticism in that assumptions have to be made about 'optimum' demands, use, costs, and so on, and that data used in making them appear to be largely theoretical.

In an article in the *British Medical Journal*[17] Vera Norris included a table showing that estimates of the numbers of beds required all differ and that they are mostly the results of guesses. She recommended that at present the aim should be to remedy deficiencies in the hospital service:

a reasonable target for the immediate future is the provision of sufficient beds so that the bed/population ratio of every locality is at least equal to the present average for the country as a whole. This done, it would be time enough to estimate future requirements on the basis of predicted changes in the age structure of the population.

The late Sir James Spence[18] believed that: 'there is yet no formula by which the need for hospital beds can be

accurately calculated. Other things being equal, the need should depend only on the incidence and type of illness in the town or district concerned.' His estimate of the numbers of children's beds required is based on surveys made in 1943 and 1944, and repeated in 1950, of all children admitted to hospitals in the Newcastle area.

It is interesting that though the importance of developing outpatient services has been recognized for some time, the estimates of the hospital facilities required are always made in terms of inpatients and the beds they will occupy, no thought being given to the provision required for outpatients, or to the ancillary diagnostic and therapeutic services which both inpatients and outpatients will use. Furthermore, the estimates of the numbers of beds required are usually made in general terms, for example, that 5 acute general beds are required for each 1,000 of the population.

At present, attention is being concentrated on the problem of making the fullest use of existing resources rather than on assessing their adequacy. The number of patients waiting and the length of time which they wait before they are admitted to hospitals are sources of concern. A large-scale hospital building programme has recently become possible, but attempts have still to be made to increase the numbers of patients treated in existing hospitals, by shortening the length of stay, ensuring a high rate of occupancy in the wards, developing home-care schemes which further reduce the length of stay, and giving general practitioners the opportunity to refer patients directly to the diagnostic departments. The Ministry of Health's report for the year 1952[19] draws attention to the increased demands on the hospital service and the consequent need for making better use of hospital beds.

> Taking together patients died and discharged and patients on the waiting list, hospitals have had to face since 1949 an increased demand of 15·1 per cent. on their beds for the physically sick. They have passed an additional 17·2 per cent. of patients through their beds; nevertheless the total waiting list increased by 2 per cent. Demand on the hospital shows no sign of abating, the waiting lists are still large and it is probable that these lists do not reflect the whole need. Something more is needed if hospitals are to cater adequately for need. Under the present circumstances it is only with great difficulty that the number of available beds can be increased. There is, therefore, all the more reason for ensuring that the most effective use is made of what beds are available.

The report gives examples of the means of measuring the efficiency of the hospital, by recording such information as the numbers of patients occupying a bed during the year, and the interval the bed is empty between the discharge of one patient and the admission of the next.

A leader in the *Lancet*[20] on the subject of hospital beds drew attention to the wastage of beds attendant on a low rate of occupancy: 'In an 800-bed hospital an [average] occupancy rate of 85 per cent. means that every night an average of 120 beds are not in use.' Recommendations for remedying this state of affairs included the provision of cubicles—so that patients of opposite sexes need not be otherwise segregated—and the redistribution of beds between the different departments.

Michael Hay of the King's Fund Administrative Staff College wrote in March 1954:

> At first there would appear to be both an excess of beds and an unsatisfied demand for beds, for nearly one in every four general hospital beds was empty in 1952, while the 'general' waiting lists stood at 382,000 at the end of the year.[21]

King Edward's Hospital Fund for London has also published a report on hospital bed occupancy in the general hospitals of Greater London, which indicates that the length of time which patients wait for admission may be due to unevenness in demand rather than to an actual shortage; the reasons for this are analysed. The recommendations for increasing the number of patients treated involve for the most part making use of records which are already in existence but which many hospitals do not, at present, use.

Though better use could often be made of existing resources, there still remains the problem of deciding what facilities are needed to serve a community when a new hospital has to be built or an old one added to.

Study 1: THE NORTHAMPTON SURVEY

The Investigation came to the conclusion that it could make a contribution towards solving the problem of planning to meet demand if it analysed in appropriate detail the whole recorded load of cases dealt with during a complete year by one hospital group serving a clearly defined population of ascertainable size. It was thought important that the group should be without serious rivals in serving this population, and that the community and the component hospitals should be accounted 'ordinary' from both the social and the medical points of view. It was clearly important also that the records kept by those hospitals, which had to be the raw materials for the survey, should be comprehensive and easily available. The Investigation was ready to begin the survey in 1951; the records to be analysed were therefore those for the latest complete year, 1950.

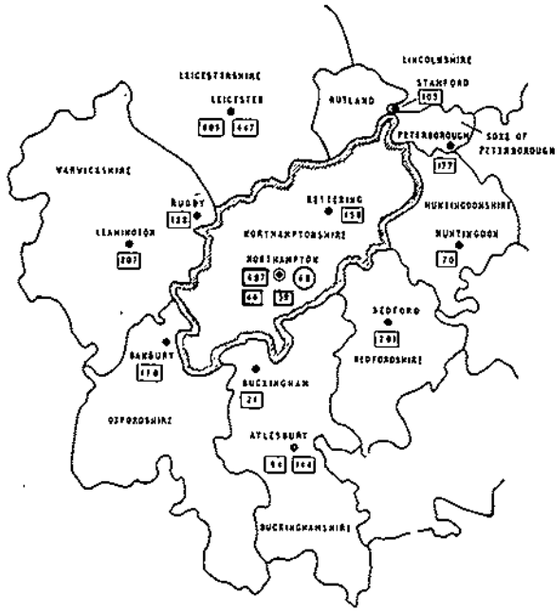
The Northampton Group of Hospitals was chosen for the first study. This group centres on an ex-voluntary general hospital with 487 beds (and 48 beds in a post-acute recovery home) providing the whole range of services appropriate to a district hospital: general medicine, general surgery, obstetrics, gynaecology, orthopaedics, ophthalmology, ear, nose, and throat, and paediatrics, with pathology, radiology, and ancillary services. Neurosurgery, thoracic surgery, and plastic surgery are provided at the regional centre in Oxford.

The Northampton General Hospital, in the county town, was neither seriously under-bedded nor over-bedded, under-staffed nor over-staffed, and the records were satisfactory for the Investigation's purposes. The group was known to serve the county town (population 104,429)[22] and the surrounding county (population 255,121), which is predominantly rural apart from an industrial belt across the north-east corner. *Fig. 127* shows the geographical situation of the general hospitals of the group and the nearest hospitals in adjoining groups. The small corner of the county adjoining the Soke of Peterborough was served by the Peterborough Memorial Hospital and the Northampton group served the northern part of Buckinghamshire. The adjacent groups of hospitals, on the whole, provided a similar range of services. The only serious drawback was that the group centred on the Kettering General Hospital was known to draw patients from the same area as the Northampton group.

The Northampton Hospital Management Committee allowed the Investigation to make the survey and gave full access to the hospital records. The survey was limited to those hospitals or parts of hospitals caring for the acutely sick, irrespective of whether these were or were not wholly general.* There were three such hospitals, and with the recovery home they had between them 620 acute beds.

According to the annual return to the Ministry of

* Wholly general hospitals are defined by the Ministry of Health as providing for 'medical and surgical cases, including children, gynaecological and obstetric cases, but with no specific allocation of beds for the chronic sick or less than 5 per cent.'[23]



KEY

NUMBER OF ACUTE BEDS, INCLUDING MATERNITY, IN HOSPITAL

POST-ACUTE RECOVERY HOME

HOSPITALS OF NORTHAMPTON GROUP SHOWN IN HEAVY LINE.

Fig. 127. Numbers of beds for the acutely sick available in 1950 in hospitals in Northampton and towns in the surrounding area

Health (Form S.H. 3) for the year 1950, the ex-voluntary general hospital had 487 beds, of which

77	were allocated	to	general medicine
174	,,	,,	general surgery
38	,,	,,	gynaecology
73	,,	,,	obstetrics
31	,,	,,	paediatrics
38	,,	,,	ear, nose, and throat
14	,,	,,	ophthalmology
10	,,	,,	radiotherapy
4	,,	,,	venereal diseases
28	,,	,,	private patients

There was no special allocation of beds for dentistry—dental cases being admitted to the surgical wards—nor for dermatology, which was included in general medicine. Orthopaedic cases were admitted to the special orthopaedic hospital, only accident cases being admitted to the surgical wards of the general hospital.

A recovery home of 48 beds was used both by general surgical and gynaecological specialties, patients being transferred from the general hospital at the post-acute stage of their illness.

There were 46 general care beds in the former public assistance institution, which was mainly used for the chronic sick.

The isolation hospital had 39 general care beds, of which 21 were allotted to general medicine and dermatology and 18 to paediatrics. These beds were used partly for cases which, on admission, were suspected of being infectious.

The outpatient department was in the general hospital, where all the consultants held clinics. Two peripheral clinics—one a diagnostic clinic and the other a physiotherapy treatment clinic—were also held. During 1950 the total number of clinic sessions each week was 59: general medicine 7, general surgery 9, gynaecology 2, obstetrics 6, paediatrics 2, psychiatry 5, dentistry 2, dermatology 3·5, ear, nose, and throat 3, ophthalmology 5, radiotherapy 1, traumatic and orthopaedic surgery 4, venereal diseases 4, physical medicine 5·5.

The special hospitals in the group included an orthopaedic hospital of 200 beds, serving as a regional as well as a local hospital, and providing orthopaedic clinics at numerous centres throughout the county, a tuberculosis sanatorium of 152 beds, a maternity home of 12 beds, and 5 hospitals for the chronic sick previously administered by the Local Authority. Two eye clinics for school children were held by the consultant ophthalmologists in co-operation with the County Borough of Northampton and the Northamptonshire County Council.

The survey was begun in May 1951 and lasted for three months, during which time information was recorded about every patient, including private patients, who had received general hospital care during 1950, whether as inpatient or as outpatient. For each specialty the following items of information were recorded: (1) the numbers of patients admitted, classified into immediate admissions, admissions from waiting-list, or cases transferred from other hospitals; (2) the state of the waiting-list; (3) the numbers of patients discharged; (4) patients' average length of stay in hospital; (5) the numbers of new outpatients, and the total number of attendances at the various clinics and in the casualty department; (6) the length of time elapsing between a patient being referred to the outpatient department and attendance for consultation.

In obtaining this information the Investigation used various records, including the admission and discharge register, the casualty-admission register, the outpatient-attendance register, and the summary statistics compiled by the hospital for the returns required by the Ministry of Health. Occasional use was made of the registers kept by the ward sisters, but patients' case notes were not consulted because a secondary object of the survey was to see whether the statistics normally kept by the hospital would provide data on which an estimate of the demand for hospital services could be based. The chief limitation of using such sources is that inconsistencies or imperfections in the hospital records are reflected in the results, so that, in addition to the errors which are liable to occur in extracting and analysing information, there may be undetectable errors in the information itself.

The information extracted was analysed to show the demand for beds by specialty and the load coming on to the outpatient department. It proved possible to make fairly accurate estimates both of the numbers of beds and the number of outpatient clinic sessions which would be required to satisfy demand.

Table 44 shows the total numbers of admissions during 1950 to all the acute beds in the group, including all those which were immediate (i.e. emergency admissions), admissions from the waiting-list, the number of re-admissions, and transfers from one hospital to another. The immediate admissions include: (1) patients admitted directly at the request of a general practitioner; (2) patients admitted directly after having been seen in the casualty department; and (3) patients admitted directly after having been seen by a consultant in the outpatient department.

The waiting-list admissions comprised such patients seen in the outpatient department as the consultant wished to admit but whose condition was not sufficiently serious to warrant immediate admission. Their names were put on a waiting-list and they were advised when a bed was available, a system of medical and social priorities being used by the hospital. The figures showing the numbers readmitted and transferred do not include the surgical and gynaecological cases which were transferred to the post-acute beds in the recovery home or the medical cases transferred to the isolation hospital. Healthy babies born in hospital are not shown in the admission figures, but if they immediately came under the care of the paediatrician they are shown as admissions to the paediatric beds.

Table 44. Northampton Group of Hospitals: *Analysis, by specialty and source, of all admissions to acute beds during the year 1950*

Specialty	*Total number of admissions*	*Number of immediate admissions*	*Number of waiting-list admissions*	*Number of readmissions and transfers from other hospitals*	*Immediate admissions as a percentage of total admissions (approx. figures)*
General medicine	1,370	1,169	119	82	85%
General surgery	4,244	2,498	1,707	39	59%
Gynaecology	1,335	545	786	4	41%
Obstetrics	2,381	622	1,759	—	26%
Paediatrics	568	534	27	7	94%
Ear, nose, and throat	2,612	651	1,951	10	25%
Ophthalmology	399	139	258	2	35%
Radiotherapy	166	57	100	9	34%
Traumatic orthopaedics	489	482	2	5	99%
Dermatology	62	56	6	—	90%
ALL SPECIALTIES	13,626	6,753	6,715	158	50%

Only 50 per cent. of the total admissions to the hospitals studied were immediate; but the medical departments (which had small waiting-lists) had a very high proportion of immediate admissions as compared with the surgical departments. Thus the percentage of immediate admissions in the general medical department was 85 per cent. and in the paediatric department 94 per cent., whereas in the general surgical department it was 59 per cent., and in the ear, nose, and throat department only 25 per cent. The figure of 99 per cent. immediate admissions to the traumatic and orthopaedic department is misleading because in general all waiting-list cases were admitted to the special long-stay hospital, which was not included in the survey.

In using material extracted from hospital records to estimate the number of beds required in any specialty, it is important to consider the number of immediate admissions, because a department in which almost all the admissions are immediate cannot achieve such a high rate of occupancy as a department admitting only a small proportion of such cases.

A study of the changes in the length of the waiting-list during the course of a year gives some indication of the extent to which any particular department is meeting the demand. If the waiting-list is increasing, even though more patients are being admitted than formerly, then the department is short of beds, whereas if the waiting-list is decreasing and all the emergency cases are admitted, then it may be assumed that the department has enough beds. Almost invariably there are waiting-lists for beds and only urgent cases are admitted immediately, so that the number recommended for admission in any period is the sum of the immediate admissions in that period and the number of names added to the waiting list during the same period. This is equivalent to the number of patients discharged during this period of time plus or minus the increase or decrease in the waiting-list, provided that the occupancy of the ward remains more or less constant throughout the period of time under consideration.

The Investigation recorded for each fortnightly period throughout the year the state of the waiting list and the numbers of patients discharged, to discover whether there was any appreciable seasonal variation in demand. Only the date of final discharge was recorded, and patients who were transferred at the post-acute stage of illness were not counted as discharged until they left the recovery home. The seasonal variations were not so pronounced as had been expected. For example, the analysis of the work of the Emergency Bed Service[24] had shown that in the London area a considerable increase occurred in applications for the admission of acute medical cases during the month of January, and an estimated 11·6 per cent. of all patients requiring admission had not been admitted. In the Northampton Group the figures for medical admissions were 692 for the six winter months (January, February, March, October, November, and December) and 635 for the six summer months. In other words, 52 per cent. of the total admissions were recommended in the winter and 48 per cent. in the summer. In ophthalmology and radiotherapy 10 per cent. more patients, and in dermatology 12 per cent. more, were recommended during the winter months; but taking the results as a whole the variations in the other specialties were insignificant and all of them probably reflected differences in administrative policy and procedure rather than medical differences. For example, admissions in the surgical specialties —apart from the immediate admissions which formed only a small proportion of the total—were governed by the number of operating sessions and the days on which they were held.

In any year the number of patients recommended for admission multiplied by the average length of stay of the patients discharged gives the number of bed-days which would have been spent in hospital had all the patients recommended been admitted. This total of bed-days divided by the number of days in the year gives the critical number of beds for an occupancy rate of 100 per cent.; from this, in turn, the actual number of beds required to meet the demand for admission may be derived for various occupancy rates. Estimates were made of the critical numbers of beds for various rates of bed occupancy. The accuracy of such estimates is affected by the size of the sample, and the standard error which attaches to each was calculated. To shorten waiting-time to a reasonable length, the supply of beds must slightly exceed the demand for them, the actual number provided being greater than the critical number for any given occupancy rate. If the average demand in any specialty is fairly constant throughout the year, this method will give a fairly satisfactory estimate of the number of beds required. On the other hand, if there are marked seasonal trends, then although a slightly greater number of beds will cope with the demand in the long run, average waiting times may be greater than expected. It would be difficult to obtain sufficient data to make accurate monthly estimates of the critical numbers because sampling variations are liable to be considerable in dealing with small numbers. Moreover, even if the pattern were accurately discernible, it would be administratively difficult to keep changing the numbers of beds in service. Until further investigations are made into the effect of a fluctuating level of demand, the best plan seems to be to estimate the critical numbers on the basis of a year's results and, unless there are marked seasonal variations, to provide a few extra beds. It is important when making such estimations to allow for

variations due to the size of the sample from which the demand and the average length of stay are calculated. To ensure a reasonable provision of beds to meet the overall demand the estimated critical number should have added to it twice its standard error plus one or more, according to the extent to which it may be desirable to reduce the average waiting time for beds—in most circumstances when the average length of stay is relatively short, one extra bed should prove sufficient. Thus, for example, on the 1950 Northampton figures, the estimated critical number of general medical beds required for an occupancy rate of 80 per cent. was 91, but the number which should have been provided to give a margin of safety, according to the method suggested above, was 99—a difference of 8. Assuming an overall occupancy rate of 90 per cent. for the whole hospital, the estimated critical number was 554, whereas the actual number which should be provided to meet the demand was 569—a difference of 15 beds.

Table 45 (p. 155), which is based on the records of the Northampton Group of Hospitals for 1950, shows the estimated critical numbers of beds for the various specialties, with the standard errors and the actual numbers of beds which should be provided to ensure that the supply is sufficient to avoid undue waiting for admission. Occupancy rates of 100, 95, 90, 85, and 80 per cent. are given in this table; other rates of occupancy may be calculated from the figures given in the column showing 100 per cent. occupancy, and thus the rate appropriate to any specialty can be selected. There is a considerable increase in the numbers of beds required as the occupancy rate decreases. For example, the number of general medical beds required increased from 88 at an occupancy rate of 90 per cent. to 99 at an occupancy rate of 80 per cent.; thus an increase of 10 per cent. in the occupancy rate for this specialty is equivalent to providing 11 extra beds at the lower occupancy rate. The larger the department, the greater this difference in provision becomes, so that for an occupancy rate of 80 per cent. the number of general surgical beds required at Northampton was 240, while for an occupancy of 90 per cent. it was 213, a difference of 27 beds. Considering all specialties together, the number of beds required for an occupancy rate of 90 per cent. was only 569, whereas 639 beds would have been required for an occupancy rate of 80 per cent., which would have amounted to an extra provision of two large wards (70 beds).

A formula was devised for calculating the average waiting-time in terms of the beds available, the demand, and the average length of stay, and this makes it possible to predict the consequence of the supply being insufficient to meet the demand.[25] If there is a marked seasonal variation, then the average waiting-time before admission will be greater than the estimation indicates. A longish waiting-list might be built up in winter to be worked off in the following summer, at the end of which period waiting times would be short until the waiting-list began to increase again. At Northampton, for example, 692 patients were recommended for admission to the general medical beds in the winter months of 1950, compared with 635 in the summer months. The estimated critical number of beds required to meet the overall demand, assuming an 80 per cent. occupancy, was 91, whereas the estimated critical number required for the winter months was 98 and the corresponding number for the summer was 86. If, for any reason, large groups of patients cannot be admitted—for example children waiting for tonsillectomy, who are not admitted during epidemics of communicable diseases—then the waiting-list will increase and for a time patients will wait longer than if the admission rate had remained constant. There are three ways, used separately or together, which will lead to the absorption of an initial waiting-list: more beds may be provided, the length of time which patients spend in the ward may be reduced, and the interval between discharging one patient and admitting another to the vacated bed may also be reduced.

The Northampton estimates did not take into account the number of patients who were already waiting for admission when the survey began—that is before 1950; they related only to the current demand. For example, the waiting-list for ophthalmic beds increased considerably during the year—from 145 on 31 December 1949 to 301 on 31 December 1950, so that the number recommended for admission (549) was considerably greater than the number actually discharged during the year (393). Had the beds estimated as being required been available they would have been sufficient to avoid the increase in the waiting-list, but not to accommodate all those patients who were already waiting for admission at the beginning of the year. On the other hand, the waiting-list for admission to the ear, nose, and throat beds decreased during the year, so that fewer patients were recommended for admission than were actually admitted, and consequently fewer beds were needed to meet the current demand than were actually available, which enabled the waiting-list to be gradually reduced.

Although the object of the survey was not to assess the adequacy of the resources available in 1950 but simply to measure the demand for hospital services, it is none the less interesting to consider how far the various departments were able to meet the demand. It appears that in 1950 sufficient beds were available to meet the overall demand. Six hundred and twenty-six beds for acute cases were available in the group while the estimated number required was 602 for an occupancy rate of 85 per cent., or 639 for an occupancy rate of 80 per cent. Assuming that an average occupancy rate of 85 per cent. was attainable by the group as a whole, then the existing provision of 620 beds was sufficient to meet the overall demand. This does not mean that all the various specialties had a sufficient number. Indeed, it is apparent that some specialties, particularly the surgical ones, were short of beds.

Thus the number of beds for general surgery and traumatic orthopaedics was insufficient, as the overall increase in the waiting-list shows (*Table 45*). Even if there had been a special allocation of beds for orthopaedic cases, the number available for general surgical cases (174 plus a proportion in the recovery home—say, 209 altogether) was barely adequate, because the estimated number required to meet the demand was 213 for an occupancy rate of 90 per cent. Both the ophthalmic and gynaecological departments seem to have been seriously short of beds and the increase in the waiting-lists for those beds was proportionately greater than for any other specialist beds. Sixteen beds were available for ophthalmic cases, whereas at least 25 were required for an occupancy rate of 85 per cent. Professor Arnold Sorsby, in his study of the causes of blindness, discovered in the community a considerable unsatisfied demand for ophthalmic treatment.[26] In view of Sorsby's findings and the recommendations of the Ministry of Health[27] that every effort should be made to treat all patients with glaucoma and cataract, the provision of 16 beds at Northampton could probably have been doubled.

The medical departments appeared, on the whole, to have just a sufficient number of beds to meet the overall demand, though because the demand fluctuated there may have been occasional seasonal shortages. Furthermore, some of the medical wards were not in the general hospital and lacked the full range of services, so that it was

Table 45. Northampton Group of Hospitals: *Data for assessing the demand for inpatient care in all specialties during 1950, with estimates (with standard errors) of the critical numbers of beds at different rates of occupancy.*

Specialty	*Number of patients discharged*	*Increase or decrease in waiting-list*	*Number of persons recommended for admission*	*Average stay of patients discharged (days)*	*Average number of beds occupied*	*100% bed occupancy*		*95% bed occupancy*		*90% bed occupancy*		*85% bed occupancy*		*80% bed occupancy*	
						Critical number	*Actual* number required*	*Critical number*	*Actual* number required*	*Critical number*	*Actual* number required*	*Critical number*	*Actual* number required*	*Critical number*	*Actual* number required*
General medicine	1,325	+ 2	1,327	20·0	72·6	72·7±2·8	79·3	76·5±3·0	83·5	80·8±3·1	88·0	85·5±3·3	93·1	90·9±3·5	98·9
General surgery	4,239	+234	4,473	14·9	173	182·6±3·9	191·4	192·2±4·1	202·4	202·9±4·3	212·5	214·8±4·6	225	228·3±4·9	239·1
Gynaecology	1,327	+228	1,555	13·1	40·88	55·8±2·1	61·0	58·7±2·2	64·1	62·0±2·3	67·6	65·7±2·5	71·7	69·8±2·6	76·0
Obstetrics	2,261	0	2,261	11·5	71·49	71·2±2·1	76·4	75·0±2·2	80·4	79·1±2·4	84·9	83·9±2·5	89·8	89·0±2·6	95·2
Paediatrics	581	+ 4	585	22·3	36	35·7±2·1	40·9	37·6±2·2	43·0	39·7±2·3	45·3	42·0±2·5	48·0	44·7±2·6	50·9
Ear, nose, and throat	2,622	−102	2,520	4·477	33	30·9±0·9	33·7	32·5±0·9	35·3	34·3±1·0	37·3	36·4±1·0	39·4	38·6±1·1	41·8
Ophthalmology	393	+156	549	12·707	14	19·1±1·3	22·7	20·1±1·3	23·7	21·2±1·4	25·0	22·5±1·5	26·5	23·9±1·6	28·1
Radiotherapy	197	+ 2	199	24·69	14	13·5±1·4	17·3	14·2±1·4	18·0	15·0±1·5	19·0	15·8±1·6	20·0	16·8±1·7	21·2
Traumatic orthopaedics	472	− 3	469	13·63	18	17·5±1·1	20·7	18·4±1·2	21·8	19·5±1·3	23·1	20·6±1·3	24·2	21·9±1·4	25·7
Dermatology	70	− 6	64	31·3	6	5·5±1·0	8·5	5·8±1·0	8·8	6·1±1·1	9·3	6·5±1·1	9·7	6·9±1·2	10·3
TOTALS FOR YEAR 1950	13,487	+515	14,002	13·0	478·97	498·7±6·08	511·7	524·9±6·3	538·5	554·1±6·7	568·5	586·7±7·1	601·9	623·4±7·5	639·4

* The *actual number required* is derived from the critical number by adding twice its standard error plus one (or more, according to the extent to which it is wished to reduce the average waiting-time).

probably difficult to make full use of them. One hundred and four beds were available for medical and dermatological cases; 103 were required for an occupancy rate of 85 per cent. and 109 for an occupancy rate of 80 per cent. But the bulk of the admissions to the medical wards are immediate and an occupancy rate of more than 80 per cent. may be difficult to maintain.

In the obstetric department, in proportion to the demand, which in this case had to be taken as the number of patients actually admitted, 95 beds would have been required for an occupancy rate of 80 per cent.; but this estimate takes no account of the remarkable variations in the numbers admitted. The average number of patients discharged in each fortnight of the year was 87, but in several months the figure was 100 or more, and in the first fortnight of the year only 21 patients were discharged.

The accuracy of the method of analysis used by the Investigation appears to be sufficient to enable fairly precise estimates to be made of the general level of provision required, but not to assess the variations in provision necessary to meet a fluctuating demand.

The Demand for Outpatient Services

For each specialty covered by the hospital group it is necessary to know the outpatient load and to be able to relate that load to the population served. The problem of demand in connexion with new outpatients* is rather more difficult than is the case with old outpatients because it depends on the numbers referred to hospitals by general practitioners and it cannot be regulated administratively by the hospital. The hospital has some latitude in making appointments for old patients; the consultant will state whether he wants to see patients again and when, and the clerk recording the appointments can regulate the queue to some extent.

New outpatients attending a clinic are often seen one after the other, as a group. The maximum number in the group is largely determined by the consultant holding the clinic (see p. 46). The clinic sessions recur at more or less regular intervals. The Investigation studied the effects of this kind of organization and the main conclusions were that the average waiting-times might be expected to be short provided that the rate at which patients were given appointments is only slightly greater than the rate at which they are referred to the clinic.

The total load on the outpatient department depends on the population served and other factors, but the way in which the load is dealt with is a matter in which there is some choice in organization. If, for example, the load were 50 patients a week, then one session a week at which the maximum number seen was set at, say, 52 or 53 patients, or two sessions of 26 or 27, or three sessions of 17 or 18, would all satisfy the demand; the more frequently sessions of adequate length are held, however, the shorter will be the time which patients wait for an appointment. The number of patients a consultant sees in the course of a session is usually determined by the rate at which he works. Once that maximum is fixed the number of sessions required in any given period of time will be evident. Ideally the requirements for new and for old patients should be dealt with separately though similarly. The demands arising from both groups of patients can be related to the maximum numbers of new and of old patients the consultant wishes to see during a session.

Questions of sampling variations may be important and must be taken into consideration. If seasonal variations in the general level of demand are well established, then instead of basing the clinic programme on the average

* It should be noted that a new patient means new to the specialty, not new to the hospital. The Ministry of Health's definition of a new patient is one 'whose first attendance of a continuous series at a consultative department for the same ailment (or whose single attendance if only one is needed) falls within the year under review. A person attending different departments (whether for the same or different ailments) is counted as a separate new outpatient in each department.'

demand throughout the year it should be based on the number and length of sessions required at different times of the year. These variations are inherently easier to deal with than those occurring in connexion with inpatients, whose comparatively long stay in hospital complicates the issue.

Table 46. Outpatient clinics in the Northampton Group of Hospitals, 1950: *The number of new patients and the total number of attendances for each specialty and for the casualty department*

Specialty	*Number of new patients*	*Total attendances*
General medicine	2,729	13,251
General surgery	6,023	20,890
Gynaecology	1,882	4,527
Obstetrics	2,119	17,102
Paediatrics	572	2,181
Ear, nose, and throat	4,456	10,536
Ophthalmology	2,307	10,415
Radiotherapy	977	8,529
Traumatic orthopaedics	3,233	10,294
Dermatology	1,321	5,606
Dentistry	118	198
Psychiatry	578	3,819
Physical medicine	927	5,447
All specialties	27,242	112,795
Casualty	18,725	33,227
TOTAL	45,967	146,022

Discovering the demand for outpatient clinics in the Northampton Group was particularly difficult because no comprehensive waiting-lists were kept. *Table 46* shows for the year 1950, by specialty, the total numbers of new patients and the total attendances at the clinics in the group. These figures represent the total outpatient load and include figures for peripheral clinics as well as for those held in the main outpatient department. Patients attending for treatment at the physiotherapy and radiotherapy departments who were not seen by a consultant were excluded.

There were considerable variations in the numbers of patients attending each week, but it seems probable that these variations chiefly reflected differences in administrative procedure. If there were actual variations in the demand for outpatient consultation, they could have been measured only by making a special count of the number

Table 47. Outpatient clinics in the Northampton Group of Hospitals, 1950: *The maximum, minimum, and average numbers of new patients and total attendances each week*

Specialty	*Number of new patients*			*Total attendances*		
	Maximum	*Minimum*	*Average*	*Maximum*	*Minimum*	*Average*
General medicine	73	27	52·48	347	160	254·83
General surgery	181	62	115·83	503	280	401·73
Gynaecology	49	15	36·19	125	56	87·06
Obstetrics	52	23	40·75	400	236	328·89
Paediatrics	17	0	11·00	75	0	41·94
Ear, nose, and throat	125	59	85·69	243	144	202·62
Ophthalmology	75	9	44·37	269	124	200·29
Radiotherapy	58	6	18·79	348	55	164·02
Traumatic orthopaedics	87	36	62·17	262	74	197·97
Dermatology	46	4	25·40	156	53	107·81
Dentistry	7	0	2·27	12	0	3·81
Psychiatry	20	5	11·12	99	37	73·44
Physical medicine	—	—	17·82	—	—	104·75

of requests for appointments received each day, or week, during a defined period. The attendances recorded in the routine way reflect fluctuations in demand resulting from the use of an appointments system, making allowance also for urgent cases without appointments, for holiday periods, and for the unavoidable absences of the consultants from the clinic. *Table 47* shows the weekly average, the maximum and the minimum numbers of new patients seen, and the total attendances, for each specialty.

Though no waiting-list as such is kept for outpatients, the Investigation concluded that if patients were waiting for appointments then that amounted to a waiting-list, A record was therefore compiled of the length of time elapsing between a patient being referred to the outpatient department and being seen by the consultant. The information was not available for the period of time to which the main survey related—the year 1950—because requests for appointments were made on forms which were destroyed once they had been dealt with, but the records officer agreed to keep current forms for one month. These forms showed that in the early part of 1951 all patients were waiting, on the average, 19 days for an appointment. In some specialties the waiting-time was considerable; for example, patients referred to the orthopaedic surgeons were waiting, on the average, 61 days before being seen. The average waiting-times for other clinics were 10 days for general surgery, 13 days for psychiatry, 20 days for ear, nose, and throat clinics, 20 days for general medicine, 38 days for dermatology, 30 days for paediatrics, 17 days for ophthalmology, and 9 days for radiotherapy.

These figures may have reflected a shortage of clinic sessions at that period or they may have been the result of a shortage in the past. It is possible that for some clinics the observed waiting-times may have been due to over-cautiousness on the part of the administrative officer responsible for making the appointments so that he consistently underbooked each session. To determine whether the waiting times were due to a shortage of clinic sessions or to administrative procedure it would be necessary to record over a longish period the daily demand and the time patients waited. If both the demand and the waiting-time continued to be considerable or were found to be increasing, then it could be assumed that the number of clinic sessions provided was inadequate; but if the waiting-time increased without any corresponding increase in the demand, it might be assumed that the delay was due to the method of booking appointments.

In general it can be said that the actual number of attendances at the various clinics will serve as a guide to the number of clinic sessions required, provided that allowances are made for any shortages indicated by the length of time patients wait. The number of new and old patients who can be attended to in the course of one session is based on the consultant's average consultation time for that clinic, preferably calculated for old and new patients separately (see p. 46), divided into the time allotted to the session. When the number of sessions needed to meet the demand has been determined, the clinic programme can be worked out. The number of consulting-rooms needed can be estimated with a fair degree of accuracy, allowance being made for the particular requirements of the different specialties.

Definition of the Population served by the Hospital Group

In an isolated area with well-defined boundaries the population at risk will be more or less the total population of the area. In many cases, however, overlapping will occur between any one group and those adjacent. For example, in the district near the main hospital of the group the majority of patients will go to that hospital, but on the boundary of the area served by the group half the patients may go to hospitals in adjacent groups. To determine the population served by any group of hos-

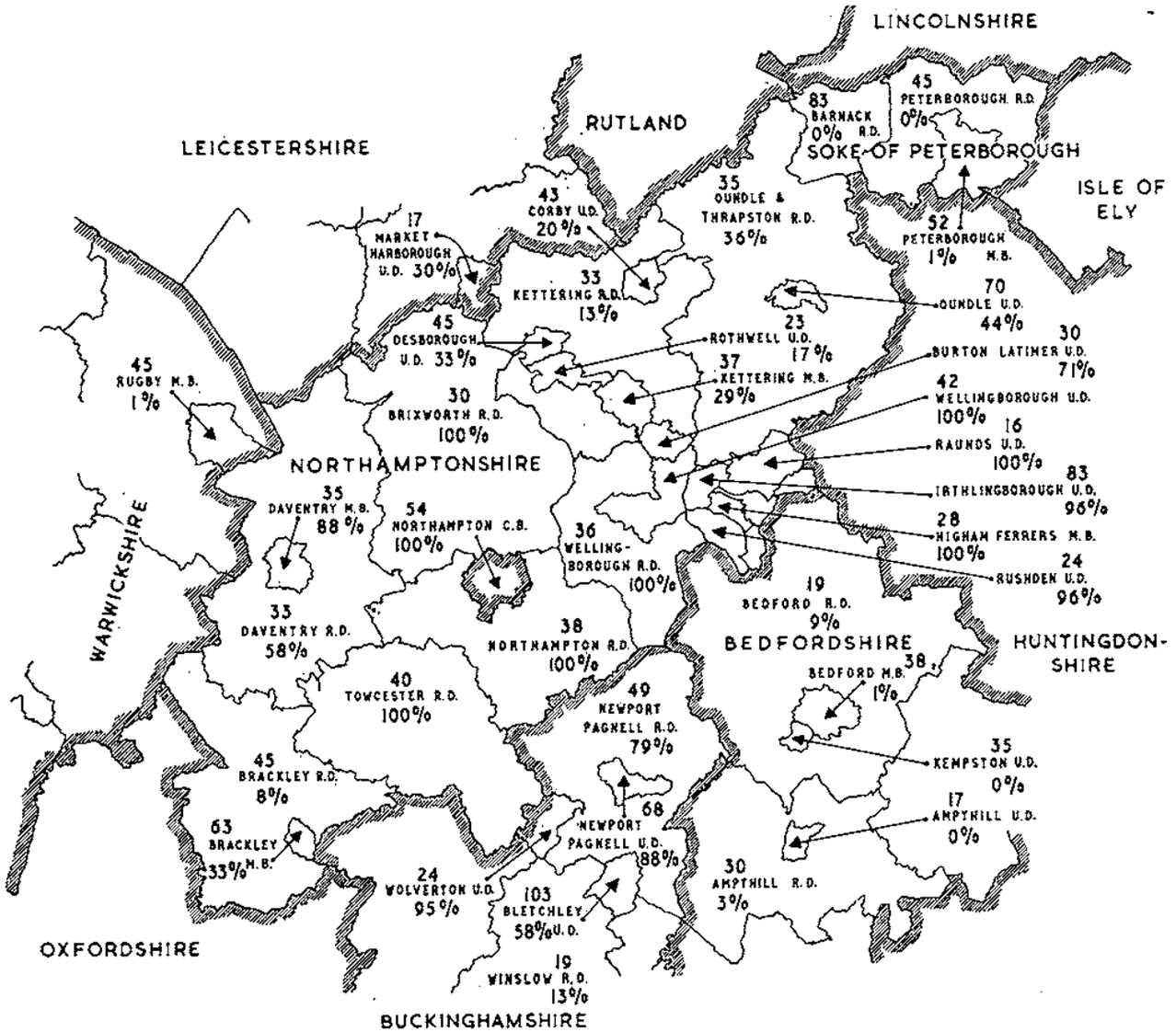


Fig. 128. The provenance of inpatients in Northampton and the surrounding area, a 21 days' sample recorded during 1950: the numbers of patients admitted to the Northampton Group of Hospitals shown as percentages of the total number of patients admitted to hospital; the rates of admission per thousand of the effective population are shown as for the whole year

(Based upon the Ordnance Survey Map with the sanction of the Controller of H.M.S.O. Crown Copyright reserved)

pitals it is necessary to analyse comparable samples of patients' addresses taken from the group under investigation and from adjacent groups. This analysis will show how many patients in any district went to the group being studied and how many went to other groups. The effective population at risk, that is the proportion of the population served by the group, in any district is equal to its total population multiplied by the proportion of patients going to hospitals in the group. If the number of admissions to the hospitals under investigation is X and the number of admissions to other hospitals in adjoining groups is Y and the total population of the district is N, then the effective population served by the group is $NX/(X+Y)$.

To estimate the effective population served by the Northampton Group of Hospitals, the addresses of all patients admitted, during two periods of 21 days, to all the general hospitals in the groups serving areas adjoining the Northampton Group were obtained. These addresses were plotted on a map and the results analysed. With the exception of the Kettering Group—which was known to serve an area coinciding with part of that served by the Northampton Group—all the groups appeared to serve distinct areas (see *Fig. 128*). Overlapping occurred only

Table 48. Northampton Group of Hospitals: *The whole demand for inpatient care and outpatient consultation and treatment recorded for the year 1950; with estimates for the critical numbers of beds at an occupancy rate of 85 per cent.*

	Number of patients admitted	*Number of new out-patients*	*Total number of out-patient attendances*	*Number of in-patients per 100 new out-patients*	*Number of new out-patients per 100 total attendances*	*Number of new out-patients per 1,000 effective population*	*Number of inpatients admitted per 1,000 effective population*	*Critical number of acute beds (with standard errors) assuming 85% occupancy rate per 1,000 effective population*
(a) Specialties and consultative clinics								
General medicine	1,370	2,729	13,251	50	21	8·758	4·397	0·274±0·011
Paediatrics	568	572	2,181	99	26	1·836	1·823	0·135±0·008
Dermatology	62	1,321	5,606	5	24	4·239	0·199	0·021±0·004
General surgery	4,244	6,023	20,890	70	29	19·329	13·620	0·689±0·018
Gynaecology	1,335	1,882	4,527	71	42	6·040	4·284	0·211±0·009
Obstetrics	2,381	2,119	17,102	112	12	6·800	7·641	0·269±0·009
Traumatic surgery	489	3,233	10,294	15	31	10·375	1·569	0·066±0·004
Ophthalmology	399	2,307	10,415	17	22	7·404	1·280	0·072±0·005
Ear, nose, and throat	2,612	4,456	10,536	59	42	14·300	8·382	0·117±0·004
Radiotherapy	166	*See under treatment clinics*					0·533	0·051±0·005
ALL SPECIALTIES AND CONSULTATIVE CLINICS	13,626	24,642	94,802	55	26	79·081	43·728	1·905±0·028
(b) Treatment clinics and ancillary services								
Radiotherapy	—	977	8,529	—	11	3·135	—	—
Dentistry	—	118	198	—	60	0·379	—	—
Psychiatry	—	578	3,819	—	15	1·855	—	—
Physical medicine	—	927	5,447	—	17	2·975	—	—
ALL TREATMENT CLINICS AND ANCILLARY SERVICES	—	2,600	17,993	—	14	8·344	—	—
ALL HOSPITAL SERVICES.	13,626	27,242	112,795	50	24	87·425	43·729	1·905±0·028
Attendances in casualty	—	45,967	146,022	—	31	147·517	—	—

at places with a relatively large population equidistant from two adjacent groups of hospitals. For example, during the 21 days considered, 37 patients from Bletchley, which is between Northampton and Aylesbury, went to the Northampton Group of Hospitals and 27 went to the Aylesbury Group. Though in theory Bletchley is served by the Aylesbury Group of Hospitals, in practice communications with Northampton are easier and no doubt some patients prefer to attend at the Northampton Group for that reason. Where overlapping occurred, it was possible by using the data provided by the analysis of addresses to delimit the area served by the Northampton Group from the areas served by adjacent groups and to estimate the population of that area.

As the addresses referred only to 21 days' admissions the sample is a small one. The proportion of patients coming from the larger centres of population, such as Northampton itself, is probably representative, but if the size of the sample were increased a greater proportion of the smaller centres of population—the hamlets and villages—would be represented with a consequent blurring of the lines of demarcation between different groups.

The size of the sample was too small to allow a precise estimate to be made of the effective population for each of the different specialties,* and so the effective population has been calculated for all specialties taken together; it was found to be 311,602. The load coming on to any group is influenced by such factors as the range of services provided and the reputation of the consultants, and therefore there may be considerable differences in the effective population for different specialties.

The total demand arising from the population of 311,602 required the provision of 602 acute beds, assuming an occupancy rate of 85 per cent., which represents about 2 acute beds for each 1,000 of the population.

A total of 13,487 inpatients was discharged from acute beds during 1950, which means that nearly 4·4 people in every 100 of the population were admitted to hospital. The total number of new outpatients attending the consultative and treatment clinics of the Northampton Group was 27,242. Thus, at least 8·7 persons in every 100 of the population received outpatient care during the year 1950 (see *Table 48*).

Study 2: THE NORWICH SURVEY

Planning the Survey

The study at Northampton had shown that the statistical material needed a great deal of interpretation, and the value of such a study would clearly be increased if the information could be interpreted by the consultants responsible for providing the services and by an independent medical assessor. Professor A. L. Banks, Professor of Human Ecology in the University of Cambridge, and Dr. J. A. Hislop agreed to act as medical advisers to the Investigation. In planning a further study the possibility of recording more detailed information about the condition of patients and the treatment they received was rejected because the Investigation believed that if such surveys were to be of practical use in the planning of hospital services, they must be easy to conduct. Provided that the information to be recorded was comprehensive rather than detailed, and easy to collect and analyse, then any hospital authority could initiate a survey of its own resources.

In the time available the Investigation could hope to complete only one more detailed survey. It was decided that the area chosen for the next study should be like rather than different from Northampton, so that the results would be comparable. The original criterion that the group of hospitals chosen for the study should without

* Further investigation of the available material for possible differences in the effective population as between one specialty and another is being undertaken.

serious competition serve a well-defined area remained the most important consideration governing the choice of hospitals. It was again accepted that the group of hospitals should be centred on a good, ordinary, general hospital, neither seriously under-bedded nor over-bedded, under-staffed nor over-staffed. The choice was difficult because not only had the Investigation to assess whether the hospitals were suitable for such a study, but also whether the areas served by the hospitals were comparable with that served by the Northampton Group.

The following points were taken into consideration when deciding whether areas were comparable or not: (1) that the age and sex structure of the populations should be comparable, although they might differ from the national average; (2) that the distributions of populations should be similar, and thus the gross populations should be of the same order; and (3) that the industries of the two areas should be comparable both in nature and extent.

It was found that the Norwich, Lowestoft, and Great Yarmouth Group of Hospitals most nearly satisfied these requirements. This group is centred on the Norfolk and Norwich Hospital. The group of hospitals serves the whole of Norfolk—with the exception of King's Lynn and its immediate environs—and part of Suffolk. It provides the whole range of specialist services usual in a non-teaching general hospital and in addition, because of its relative isolation, some of the services which are usually provided at the regional centres, for example, plastic surgery and thoracic surgery. The self-contained character of the area, emphasized by a long coastline, made it eminently suitable for such a study. Although it is considerably larger, the area served by the Norwich Group did not appear to be very different in character from that served by the Northampton Group.

The Registrar General supplied figures showing the age distributions of the populations of Norfolk and Northamptonshire, compared with England and Wales as a whole.

In both counties the proportion in the age group 15–44 is small compared with England and Wales as a whole. Northamptonshire has a high proportion aged between 45 and 64, and both counties have a high proportion over 65, this being particularly marked in Norfolk. The gross population of Norfolk administrative county and associated county boroughs was 546,550, of which 270,757 were male and 275,793 were female. The corresponding figures for the Northamptonshire administrative county and associated county boroughs were 359,550, 174,029, and 185,521. In Northamptonshire a slightly higher proportion of the population was female.[22]

In both counties the county town is the industrial centre and the surrounding area is predominantly rural. In Norwich approximately 13 per cent. of the total employed population was engaged in the manufacture of boots and shoes, 13 per cent. in building and constructional engineering, and 11 per cent. in the distributive trades. In Northampton approximately 24 per cent. of the total employed population was engaged in the manufacture of boots and shoes, 8 per cent. in building and constructional engineering, and 11 per cent. in the distributive trades. The surrounding country in both cases is mainly agricultural; Northamptonshire has an industrial belt running across the north-east corner, and Norfolk has fisheries on the east coast.

The choice of the Norwich, Lowestoft, and Great Yarmouth Group of Hospitals proved particularly fortunate because both Professor Banks and Dr. Hislop knew the whole region well and Dr. Hislop, under the direction of Professor Banks, was already engaged in making a study of certain aspects of the health services of East Anglia for the Nuffield Provincial Hospitals Trust.

The Hospitals Surveyed

The survey was limited to hospitals officially designated as acute general hospitals, the acute and maternity beds in a hospital mainly for the chronic sick, a maternity hospital, and an orthopaedic hospital for children. There were nine hospitals in all having between them some 1,000 beds. There were 471 beds for the chronic sick in the Norwich, Lowestoft, and Great Yarmouth Group. They were not included in the survey; their positions are shown in *Fig. 129*.

The principal hospital in the group, the Norfolk and Norwich Hospital, has 440 beds and provides the following services for both inpatients and outpatients: general medicine, general surgery, gynaecology, obstetrics, dentistry, dermatology, ear, nose, and throat, ophthalmology, plastic surgery, radiotherapy, thoracic surgery, traumatics, orthopaedic surgery, venereology, with pathology, radiology, physiotherapy, and other ancillary services. This hospital, with the children's hospital (80 beds), provides the most highly specialized services in the group and all patients requiring highly skilled treatment or comprehensive diagnostic facilities are admitted to these hospitals. Both these hospitals have outpatient and casualty departments, and, though some peripheral clinics are provided at the outlying hospitals, carry most of the group's outpatient load.

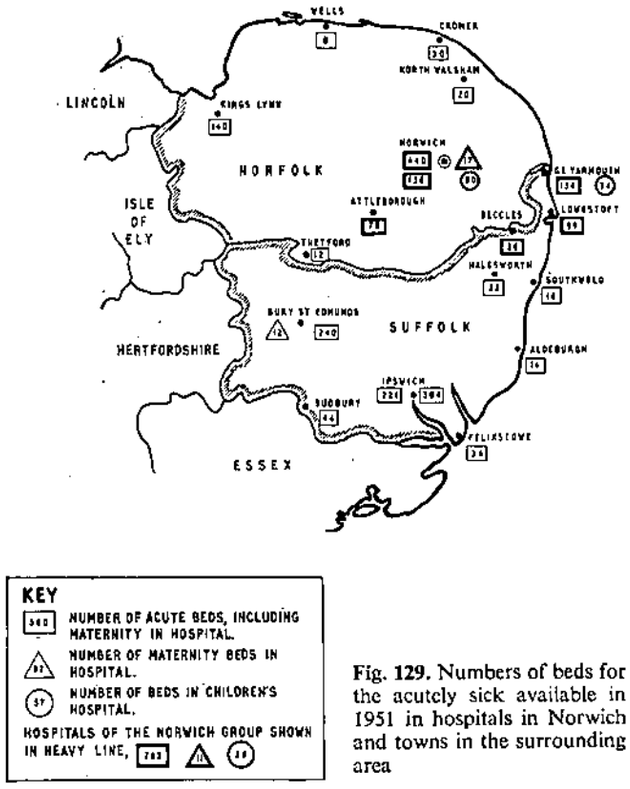


Fig. 129. Numbers of beds for the acutely sick available in 1951 in hospitals in Norwich and towns in the surrounding area

The former public-assistance institution, in Norwich, has 136 general care beds. This hospital, which is administered as part of the Norfolk and Norwich Hospital, admits some emergency surgical and medical cases, but for the most part admissions are from the waiting-list. There is no separate waiting-list for these beds so that patients waiting for admission to medical or surgical beds may be admitted to either this hospital or the Norfolk and Norwich Hospital. The hospital provides some plastic surgery and obstetric care, but the facilities for pathological and radiological examinations are limited, and all the more complicated examinations are done at the main hospital. At the time of the survey the chronic-sick beds of the institution were administered separately, but a consultant geriatrician has now been appointed and

the chronic-sick beds are closely linked with the acute beds. During 1951 substantially all acute cases, irrespective of age, were admitted to acute beds in the first instance.

A former public-assistance institution some miles outside Norwich is administered as part of the surgical unit. Seventy-eight beds are available at this hospital, of which 10 are for gynaecological cases and the remainder for surgical cases. Some patients are transferred to the surgical beds in this hospital from the Norfolk and Norwich Hospital at the post-acute stage, but most of the patients are admitted from the waiting-list common to both hospitals, for gynaecological or surgical operations of a straightforward nature.

Two hospitals (having 99 and 134 beds respectively) are on the periphery of the area and provide the simpler specialist services for patients in the immediate neighbourhood. These hospitals were formerly staffed by general practitioners but are now staffed by consultants. The diagnostic departments are staffed by technicians who perform only routine tests; more complicated tests are carried out at the main hospital. Both these hospitals have outpatient departments, and clinics are held by their own consultants and by the consultants to the Norwich hospitals. Patients whose names are put on the waiting-list at these clinics are admitted either to one or other of these hospitals or to the main hospital according to the nature of their illness and the range of diagnostic and treatment facilities which they require.

A cottage hospital (26 beds) also on the periphery of the area is staffed by general practitioners but maintains close liaison with the Norfolk and Norwich Hospital. The other institutions included in the survey are a maternity hospital (17 beds) and a small children's home for orthopaedic cases requiring treatment over a long period.

In the survey the service was considered as being provided by the group as a whole and not by individual hospitals; therefore the results do not refer to the load coming on to any particular hospital.

The work of collecting the information, relating to the year 1951, was begun in March 1952.

The Medical Assessment

The demand for both inpatient and outpatient care was recorded by specialty, and the whole load which both inpatients and outpatients in each specialty put upon the various therapeutic and diagnostic departments of the hospitals was recorded.* In this survey the term *demand* thus refers to an explicit and measurable quantity.

The medical advisers sought the opinion of each consultant on the correct medical interpretation of the recorded demand in his department; and Dr. Hislop, through consultation with general practitioners in the area, tried to discover whether the need for hospital care was being adequately met.

Thirty-two general practitioners were selected at random from 120 living in the area served by the Norwich, Lowestoft, and Great Yarmouth Group. A questionnaire was prepared, to discover whether the general practitioners had any difficulty in securing for their patients admission to hospital or consultation, and also to find their attitude to the service offered them by the hospitals in the group. Each of the chosen practitioners was visited by Dr. Hislop, who personally put the questions to them and recorded their answers. He noted in his report on this inquiry that though all general practitioners kept clinical records, they did not necessarily keep detailed records of the numbers of the cases referred to hospital; consequently their answers were based on memory and not on precise records. All the thirty-two general practitioners used hospitals in the Norwich, Lowestoft, and Great Yarmouth Group; twenty-three used these hospitals exclusively and nine used in addition hospitals in other groups.

Because the Norwich, Lowestoft, and Great Yarmouth Group of Hospitals serves a predominantly rural area in which transport facilities are not uniformly good, it was thought that some general practitioners might on that account be deterred from referring patients to the outpatient department for consultation. Only four of the general practitioners said that this was a factor influencing their decision to refer patients to hospital; the others said that if it was difficult for patients to reach the hospitals by public transport, the hospital car service was used.

Analysis of the delay between the application by an outpatient for consultation and the holding of the consultation had shown that it was considerable for some clinics (see p. 177). Practitioners were asked if this delay deterred them from referring patients for consultation at outpatient clinics. Eleven said that it did. It was impossible to assess how strong this deterrent was, but in his larger survey of the medical services of East Anglia, of which this survey was a small part, Dr. Hislop recorded that seventeen of the sixty-two practitioners were deterred because the waiting times were so long. On the whole the general practitioners thought that the various clinics were held sufficiently frequently for their needs.

The practitioners were asked if they experienced any difficulty in securing immediate appointments for urgent cases at the outpatient clinics. Ten practitioners said that they occasionally had difficulty, and three that they frequently had difficulty. In most cases these difficulties were overcome when the practitioners personally made the arrangements with the consultants at the hospital.

All the practitioners were satisfied with the arrangements for admitting urgent cases. One practitioner occasionally experienced difficulty in securing the admission of patients for whom there was no ultimate prospect of recovery, and another said that he sometimes had difficulty in securing the admission of medical cases in the winter months; but, in general, it seems probable that all the urgent cases were admitted. Patients whose condition did not warrant immediate admission sometimes waited a considerable time before admission; though the general practitioners were concerned about the effect of the delay on their patients, it did not affect their attitude to the hospitals in the group.

Thirteen doctors expressed the opinion that some consultants required patients to continue attending the hospital as outpatients at a stage of recovery when general-practitioner care would probably have been more appropriate. This, besides putting an unnecessary load on the outpatient department, was thought to be a hardship for patients living in rural areas. This matter was also discussed with the consultants, who felt that certain cases (for example, carcinomas, diseases of the eyes and skin, and of the ear, nose, and throat, and patients who had undergone plastic surgery) should return for supervision, both for their own sakes and so that the results of the treatment could be studied.

In discussing the results of the case-load survey with each consultant the aim was to try to see the pattern of work through his eyes and thus to get the feel of the hospital.[23] Each of the consultants was interviewed separately and the work done by the main hospitals of the group was discussed in terms of inpatient care, the outpatient departments, and the special departments.

The medical advisers made the comment that 'the load

* In addition to patients seen in the hospitals of this group, consultants in various specialties saw 1,586 patients at home, under the Domiciliary Consultation Service, during 1951.

coming on to the inpatient accommodation (beds, theatres, and special departments) is now so heavy in quality, quite apart from quantity, that any further increase is likely to affect adversely the efficiency of the medical and nursing staffs'; they had gained the impression that patients sometimes had to be discharged earlier than was medically desirable, to make room for other cases. In addition to the increased volume of work done by the hospitals, which was apparent in the increase in the numbers of patients admitted during the year, the work had become more complicated. Instead of interspersing major operations with some comparatively minor ones, the senior surgeons now operated on a succession of difficult cases, so that the load of work on them was increasing, although the length of their operating list might be shorter. The reasons for these changes are complex, but Professor Banks and Dr. Hislop noted the following as being contributory causes: the increasing age of the population and the operative achievements made possible by advances in the techniques of anaesthesia, blood transfusion, and radiodiagnostic procedures, and the increasing use of antibiotic substances.

During the discussions with the consultants particular attention was paid to the adequacy of the outpatient accommodation and the methods of organizing the work, and it was noted 'that much of the work that was formerly performed in the wards and theatres is now undertaken as a routine in the outpatient department'. The consultants thought that inadequate accommodation and the shortage of junior staff were two of the factors limiting the further development of the work of the hospital along these lines.

In general, the number of outpatient clinic sessions was believed to be adequate for the needs of the community, but some consultants thought that there were not enough. Most of the consultants agreed that there was sufficient time to get through the work of the clinics, but many felt that there was insufficient time for the niceties of consultation.

One of the objects of the inquiry was to find out whether any patients were attending the outpatient department unnecessarily. Though a few general practitioners were apt to send patients to hospital when they themselves could care for them, regular meetings between the consultant staffs and the general practitioners had proved to be of great value in adjusting difficulties of this kind. A few patients referred for consultation were suffering from conditions of no great severity, but these patients required the reassurance of the consultant, and this was accepted as a legitimate reason for visiting the hospital.

As a result of these inquiries among the general practitioners and consultants it was believed that a true picture had been gained of the demand for hospital services during 1951. The inquiry among general practitioners established the fact that from their point of view there was little unsatisfied demand for hospital care—the majority of cases requiring hospital care in fact received it; the discussions with the consultants confirmed that all the patients who received hospital care were properly hospital cases.

The Estimation of the Population served by the Group of Hospitals

As at Northampton, the address was recorded of every patient admitted during the year under consideration to the general hospitals in the group and to all the general hospitals in the adjoining groups; at Norwich they were recorded by specialty. Originally it was hoped that patients could be related to each parish, but the numbers of admissions proved too small to give satisfactory results. The hospitals in the groups from which this information was obtained are those described on pp. 159–60. Comparable information was obtained from the fourteen hospitals in the adjoining groups, which had between them some 1,340 general-care beds. These fourteen hospitals served the whole of Suffolk, with the exception of the northern part of the county (which was served by the Norwich, Lowestoft, and Great Yarmouth Group) and the extreme west of Norfolk.

The population figures for every rural district, urban district, municipal borough, and county borough in the two counties of Norfolk and Suffolk were extracted from the preliminary *Census Report* (1951), and this enabled the percentage number of all patients admitted to hospital in the Norwich, Lowestoft, and Great Yarmouth Group of Hospitals to be related to their place of origin.

In areas where nearly all the patients during 1951 went to hospitals in the Norwich, Lowestoft, and Great Yarmouth Group, the effective population was to all intents and purposes the same as the total population of the area. For example, 99 per cent. of all patients from the rural district of Forehoe and Henstead were served by the Norwich hospitals, and the total population was 23,373, so that the effective population served by the group was 23,243. In some areas, however, for example in the Felixstowe urban district, all patients were admitted to hospitals in the adjoining groups, and the effective population served by the Norwich Group was nil. Nevertheless no clear boundary was traceable between one hospital group and another such as would define a catchment area within which the population could be measured.

Fig. 130 shows how in each group the proportion of patients receiving care decreases from the centre, becoming very small where the area of influence of one group merges into that of another group, for example, from Norwich and the adjoining rural district of Forehoe and Henstead at the centre to Samford rural district on the periphery.

The total effective population served by the Norwich, Lowestoft, and Great Yarmouth Group in 1951 was 484,583, which is slightly less than the total population of the county of Norfolk. The effective population has been estimated for all specialties together (cf. p. 159).

The rate of admission per 1,000 of the population for urban and rural areas together was 42 per 1,000 of the effective population, but rates of admission appear to be different in urban and in rural areas. In the rural areas 31 out of every 1,000 of the population at risk were admitted to hospital during 1951; in urban areas 52 out of every 1,000 were admitted. In *Fig. 130* the figures for the extreme edge of the area do not represent the complete rate, because some patients were admitted to hospitals outside the area. For example, the rate of 2 per 1,000 for Newmarket urban district cannot be taken as representing the total rate of admission because patients would have been admitted also to the Newmarket and Cambridge hospitals. If a difference in the admission rates for urban and rural areas were to be confirmed by similar data from other parts of the country, it would then be an important consideration to be taken into account when assessing the hospital needs of a community.

The Demand for Hospital Services from the Population of 484,583

As at Northampton, to determine whether there was any seasonal variation, the information about inpatients was recorded for each month separately, and the information about outpatients was recorded for each week separately. The load on the special departments also was recorded for each week separately. Where it was thought

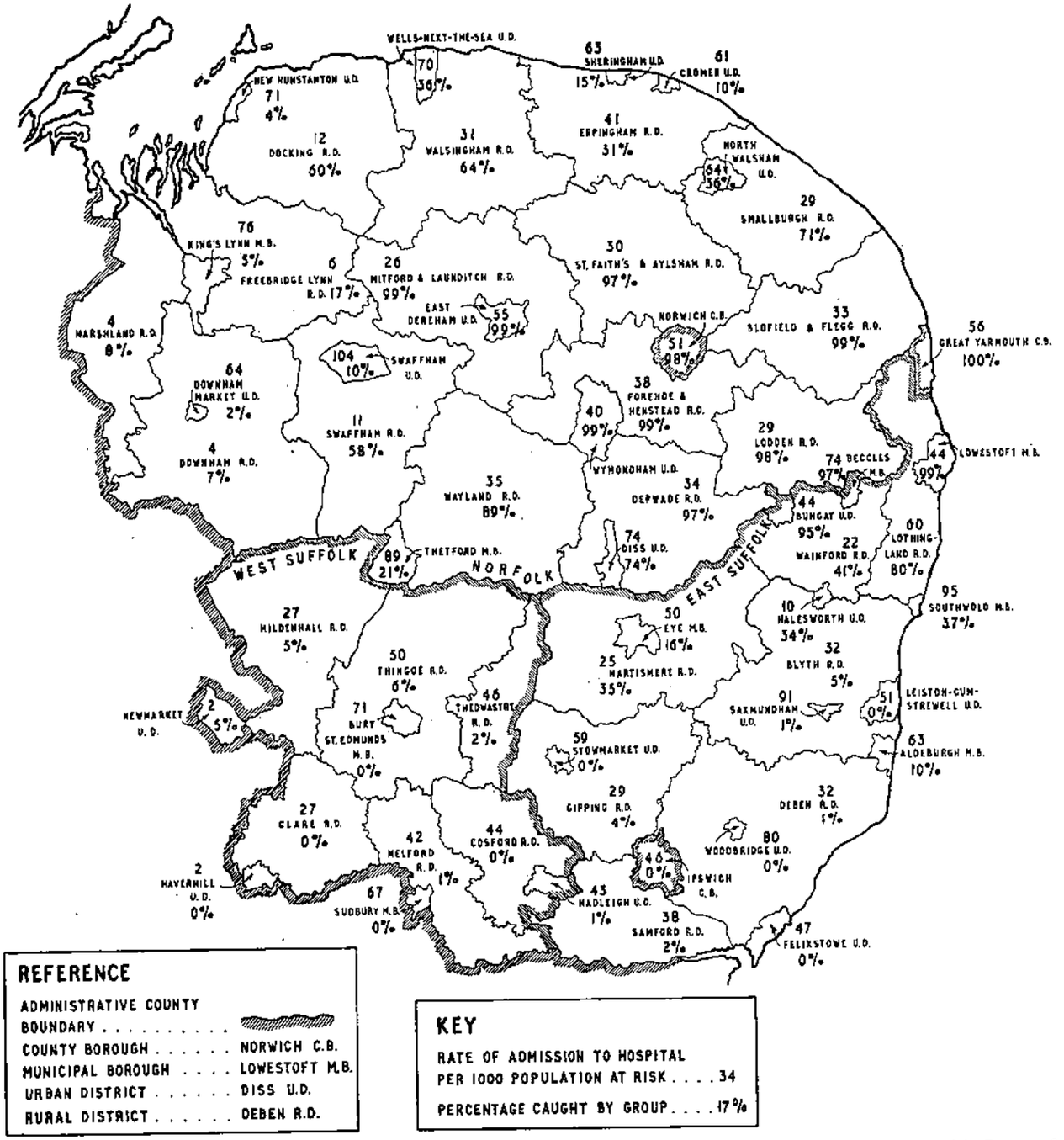


Fig. 130. The provenance of inpatients in East Anglia during 1951; for each district the numbers admitted to the Norwich, Lowestoft, and Great Yarmouth Group of Hospitals are shown as percentages of the total numbers of patients admitted to hospital; the rates of admission per thousand of the effective population are also shown

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that the sex and age of patients was relevant to hospital planning and organization they were recorded. All the information concerning inpatients was collected separately for male and female patients. Children were classified in three age groups, 0–4 years, 5–9 years, and 10–14 years.*

The outpatient figures were not separated according to the sex and age of patients. In future surveys it might be worth recording that information, because if it were found, for example, that children and old people required a longer time for consultation, then fewer of them could be seen in the course of a clinical session; this difference would certainly affect the running of the sessions and might affect the amount of accommodation to be provided.

During the survey at Northampton the number of patients occupying private beds was not recorded separately. In the Norwich survey private patients were recorded separately, and a further distinction was made between private patients and amenity patients. All paying patients within the area of the group were included in the survey, whether they were admitted to National Health Service hospitals or to privately owned nursing homes.

Inpatients

The explicit demand for inpatient beds was estimated by the method used in the Northampton study (see p. 153). Some difficulty was experienced in estimating the number of children because the upper age-limit at which they were admitted to beds reserved for children varied from hospital to hospital—at one the waiting-list for children's beds included children up to the age of 13, at another the upper limit was 8 years. Although the figures showing the actual numbers of children admitted to the hospitals in the Norwich, Lowestoft, and Great Yarmouth Group during 1951 are as complete as the records allowed, estimates of the number of children's beds required, which involved considering changes in the waiting-lists, should not be taken as more than a guide to the relative proportions of children's beds to adult beds.

* Separate accommodation has to be provided for young children admitted to hospital, but paediatricians are undecided at what age children may properly be admitted to adult wards or how they should be grouped in children's wards. The Investigation asked the opinion of a number of paediatricians, and the general view was that though no absolute ruling could be given, special accommodation might be required for all children under the age of 14 years.

Because the various items of information had to be collected from different sources, slight discrepancies have inevitably appeared in the figures. In general, the discharge figures, which are recorded for the annual returns which the Ministry of Health requires all hospitals to make, are the most accurate. A few patients transferred to other hospitals in the group have been counted as being separate admissions. Transfers from one ward to another were ignored; the classification according to specialty is based on the discharge diagnosis.

Though the numbers of immediate admissions were recorded, it was not possible from the records available to give separate estimates for the number of beds required for urgent cases and for cases from the waiting-list, and indeed a rigid allocation of beds between the two might result in a lower rate of occupancy. It is, however, important to know the *proportion* of immediate admissions which may be expected during any period of the year, so that an appropriate number of beds can be reserved for them.

As in the Northampton survey, the load coming on to any particular hospital in the group has been discussed only when it had a direct influence on the findings. In general the results are expressed in terms of the group as a whole. Where there was a joint waiting-list for two groups of beds—as, for example, for general medicine and dermatology—the number of beds required has been calculated for both specialties together.

The Investigation was allowed to use the annual returns to the Ministry of Health for the year 1951, which made very clear the range of work undertaken by the group as a whole, and showed how the service was organized. As at Northampton, the medical officers of health for the county and county borough supplied details of attendances at the various clinics provided by the Local Authorities; but with the exception of the maternity and child welfare service, which is closely linked with the hospital service, these clinics seemed to take the load off the general practitioner rather than the hospital.

General Medicine and Dermatology

Of the 3,303 patients admitted to medical beds during 1951, 67 were dermatological cases. The waiting-list was relatively small and increased by only 2 during the year, so that the number recommended for admission was, virtually, the same as the number actually admitted. It does not follow from this coincidence between recommendation and admission that the number of medical beds available was sufficient; the considerable variation in demand, the high proportion of immediate admissions, and the comparatively long time which other patients waited all suggest that there were not sufficient beds. At one hospital, though 57 per cent. of the men admitted from the waiting-list waited less than one month, 19 per cent. waited from one to two months, and 12 per cent. waited from two to three months.

Table 49 shows, for general medicine and dermatology, the whole demand for beds month by month throughout the year 1951, and quarterly estimates of the critical number of beds for various rates of occupancy, with the standard error of the estimates. The critical numbers of beds have been separately estimated for the six winter months and for the summer; these seasonal estimates are shown in *Table 49 (a)*.

Table 50 shows an analysis of general medical admissions during each month of the year and whether they were immediate, from the waiting-list, or transfers from other hospitals. The numbers of immediate admissions for all medical patients were considerably higher in January, February, and March, and the level of demand varied noticeably throughout the year. Some of the

Table 49. General medicine and dermatology: *Data for assessing the monthly and total demand or inpatient care in the Norwich Group of Hospitals* during 1951; with estimates of the critical numbers of beds at different rates of occupancy, and an analysis relating the data to men, women, and children.*

	Number of patients discharged	*State of waiting-list*	*Increase or decrease in waiting-list*	*Number of patients recommended for admission*	*Average length of stay (days)*	*Average number of beds occupied*	*Critical number of beds for various rates of occupancy (with standard errors)*			
							100%	*95%*	*90%*	*85%*
December (1950)	—	51	—	—	—	—	—	—	—	—
January (1951)	307	61	+10	317	18	—	188·3±8·7	198·2±9·2	209·2±9·7	221·5±10·2
February	319	66	+ 5	324	17	—				
March	313	59	− 7	306	18	—				
April	267	65	+ 6	273	19	—	169·3±8·6	178·2±9·1	188·1±9·6	199·2±10·1
May	303	59	− 6	297	21	—				
June	213	54	− 5	208	19	—				
July	245	49	− 5	240	20	—	166·1±8·4	174·8±8·8	184·6±9·3	195·4±9·9
August	291	55	+ 6	297	19	—				
September	246	44	−11	235	21	—				
October	262	40	− 4	258	21	—	189·8±9·4	199·8±9·9	210·9±10·4	223·3±11·1
November	288	50	+10	298	23	—				
December	253	53	+ 3	256	19	—				
TOTALS FOR THE YEAR	3,307	—	+ 2	3,309	19·7	178·2	178·6±4·4	188·0±4·6	198·4±4·9	210·1±5·2
Men	1,248	18†	− 6	1,242	21·3	72·9	72·5±2·9	76·3±3·1	80·5±3·2	85·5±3·4
Women	1,217	30†	+ 7	1,224	20·9	69·7	70·1±2·8	73·8±3·0	77·9±3·2	82·4±3·3
Children	842	3†	+ 1	843	15·4	35·6	35·6±1·7	37·4±1·8	39·5±1·9	41·8±2·0

* For the sake of brevity the Norwich, Lowestoft, and Great Yarmouth Group of Hospitals is referred to as the 'Norwich Group of Hospitals' in the titles to the tables.

† State of the waiting-list at 31 December 1950.

Table 49 (a). General medicine and dermatology: *The critical numbers of beds for the winter and the summer months, estimated from the 1951 inpatient load carried by the Norwich Group of Hospitals*

	Critical number of beds for various rates of occupancy (with standard errors)			
	100%	*95%*	*90%*	*85%*
Winter (Jan.–Mar., Oct.–Dec.)	189·4±6·4	199·4±6·7	210·4±7·1	222·8±7·5
Summer (Apr.–Sept.)	167·7±6·0	176·5±6·3	186·3±6·7	197·3±7·1

Table 50. General medicine: *Monthly classification of admissions to beds in the Norwich Group of Hospitals during 1951*

	Total number of admissions				*Number of immediate admissions*				*Number of waiting-list admissions*				*Number transferred or readmitted*			
	Men	*Women*	*Children*	*Total*	*Men*	*Women*	*Children*	*Total*	*Men*	*Women*	*Children*	*Total*	*Men*	*Women*	*Children*	*Total*
January	123	134	78	335	110	120	74	304	12	14	4	30	1	—	—	1
February	105	112	100	317	99	101	96	296	4	11	4	19	2	—	—	2
March	106	108	97	311	95	94	90	279	11	13	7	31	—	1	—	1
April	85	96	66	247	76	87	59	222	9	9	7	25	—	—	—	—
May	94	100	70	264	78	86	66	230	16	13	4	33	—	1	—	1
June	93	76	45	214	76	69	42	187	17	7	3	27	—	—	—	—
July	102	69	84	255	92	60	81	233	8	9	3	20	2	—	—	2
August	125	83	68	276	114	67	65	246	11	16	3	30	—	—	—	—
September	91	94	56	241	72	70	53	195	18	20	3	41	1	4	—	5
October	105	110	62	277	83	78	59	220	20	29	3	52	2	3	—	5
November	88	114	62	264	76	96	52	224	11	15	10	36	1	3	—	4
December	88	93	54	235	78	85	50	213	10	6	4	20	—	2	—	2
TOTALS FOR THE YEAR	1,205	1,189	842	3,236	1,049	1,013	787	2,849	147	162	55	364	9	14	—	23

monthly variations may have been due to sampling variations, but there can be no doubt that there was an increase in demand during the winter. Seventeen hundred and fifty-nine patients were recommended for admission to medical and dermatological departments in the six months January, February, March, October, November, and December (it must be remembered that there are always fewer admissions during the Christmas holiday period) as compared with 1550 during the six summer months. In February 324 patients were recommended for admission as compared with 208 in June (*Table 49*).

Over the year 1951, the critical number of beds for an occupancy rate of 85 per cent. was 210. During the six winter months the critical number of beds was 222·8 and during the summer months 197·3. The provision needed to meet the overall demand without excessive waiting-

Table 51. General surgery, including thoracic and plastic surgery: *Data for assessing the monthly and total demand for inpatient care in the Norwich Group of Hospitals during 1951, with estimates of the critical numbers of beds at different rates of occupancy, and an analysis relating the data to men, women, and children*

	Number of patients admitted	*Number of immediate admissions*	*Number of patients admitted from waiting-list*	*Number of patients transferred or readmitted*	*Number of patients discharged*	*The state of the waiting-list*	*The increase or decrease in waiting-list*	*Number of patients recommended for admission*	*Average length of stay of patients discharged (days)*	*Average number of beds occupied*	*Critical number of beds for various rates of occupancy (with standard errors)*			
											100%	*95%*	*90%*	*85%*
December (1950)	—	—	—	—	—	1,467	—	—	—	—	—	—	—	—
January (1951)	654	372	257	25	579	1,460	− 7	572	15	—				
February	567	315	240	12	557	1,457	− 3	554	15	—	281·6±9·5	296·4±10·0	312·9±10·6	331·3±11·2
March	622	351	247	24	662	1,393	− 64	598	14	—				
April	645	342	296	17	618	1,311	− 82	536	13	—				
May	611	363	235	13	632	1,289	− 22	610	14	—	266·5±8·9	280·5±9·4	296·1±9·9	313·5±10·5
June	633	375	244	14	631	1,208	− 81	550	15	—				
July	749	462	275	12	708	1,201	− 7	701	12	—				
August	755	475	253	27	751	1,084	−117	634	13	—	275·7±8·6	290·2±9·1	306·3±9·6	324·4±10·1
September	727	424	277	26	746	969	−115	631	14	—				
October	724	415	286	23	717	1,024	+ 55	772	13	—				
November	705	389	292	24	699	979	− 45	654	15	—	317·6±9·8	334·3±10·3	352·9±10·9	373·7±11·5
December	649	366	254	29	707	918	− 61	646	14	—				
TOTALS FOR THE YEAR	8,041	4,649	3,146	246	8,007	—	−549	7,458	13·8	306·0	284·0±4·6	298·9±4·8	315·6±5·1	334·1±5·4
Men	3,909	2,275	1,483	151	3,885	784*	−253	3,632	14·6	155·8	145·3±3·4	152·9±3·5	161·4±3·7	170·9±3·9
Women	3,080	1,697	1,288	95	3,046	517*	−240	2,806	14·8	123·7	113·8±3·0	119·8±3·1	126·4±3·3	133·8±3·5
Children	1,052	677	375	—	1,076	166*	− 56	1,020	9·0	26·6	25·2±1·1	26·5±1·2	27·9±1·2	29·6±1·3

* State of the waiting-list at 31st December 1950.

Table 51 (a). General surgery, including thoracic and plastic surgery: *The critical numbers of beds for the winter and the summer months, estimated from the 1951 inpatients load carried by the Norwich Group of Hospitals*

	Critical number of beds for various rates of occupancy (with standard errors)			
	100%	*95%*	*90%*	*85%*
Winter (Jan.–Mar., Oct.–Dec.) . . .	300·3±6·8	316·1±7·2	333·7±7·6	353·3±8·0
Summer (Apr.–Sept.) .	272·1±6·2	286·4±6·5	302·3±6·9	320·1±7·3

times was 222 beds for an occupancy rate of 85 per cent. During the winter months 239 beds were needed and during summer months 213, a difference of 26. Clearly the actual provision of 233 beds was adequate in the summer months but did not meet the winter demand, which explains the apparent paradox of a short waiting-list and relatively long waiting-times. The slightly shorter average stay in the winter months, particularly noticeable in the case of children, may also have been an effect of the increased demand. It seems probable that some extra beds for medical cases should be provided during winter months. During the summer these beds could be used by other specialties with long waiting-lists.

During the year 1951 slightly more men (1,242) than women (1,224) were recommended for admission to medical and dermatological beds, and the average length of stay for men was slightly higher than for women—21·3 days as compared with 20·9 days. The critical number of beds for men was 85·5 and for women 82·4. The seasonal variation in demand was more apparent in the case of women than men. Six hundred and fifty-one male patients were recommended for admission in the six winter months as compared with 591 in the summer months—a difference of 60; whereas 663 female patients were recommended for admission in the winter months as compared with 561 in the summer months—a difference of 102.

A total of 926 children aged 0–14 years were admitted to hospital for medical and skin conditions during the year, most of them in the 0–4 years age group.

	0–4 years	*5–9 years*	*10–14 years*	*Total*
Boys .	354	130	54	538
Girls .	262	92	34	388
TOTAL .	616	222	88	926

The estimate of the critical numbers of beds for children refers to those in the 0–9 age group. There was virtually no waiting-list for children's beds so that the number discharged was almost the same as the number recommended for admission. The critical number of beds for an occupancy rate of 85 per cent. was 41·8 with a standard error of ±2·0, so that the number of beds required to meet the demand would have been 47; but this would probably not have been sufficient to meet the demand in the winter, when 445 were recommended for admission, as compared with 398 in the summer.

The distributions of the lengths of stay of patients admitted to the medical wards of all the hospitals during 1951 were analysed; *Fig. 131* shows the distribution. It is interesting to note that 64·6 per cent. of all patients were discharged within 20 days. Although the distribution was similar in all the hospitals, patients admitted to the former public-assistance institution tended to stay in hospital longer—only 51·6 per cent. of the patients admitted to the former public-assistance institution had been discharged within 20 days. Patients were discharged from the hospital for sick children slightly earlier—77·4 per cent. of the patients admitted to the sick children's hospital were discharged within 20 days.

General Surgery and Plastic Surgery

A total of 8,041 patients were admitted to the beds allotted to the general surgical and plastic specialties, and the total number of operations performed on these patients numbered 7,346 (see *Table 69*). Of these patients, 96 were admitted for plastic surgery (62 males and 34 females). The few patients admitted for thoracic surgery have been included in the figure for general surgery.

Over 50 per cent. of the admissions were immediate, the proportion being greater in the case of men and children

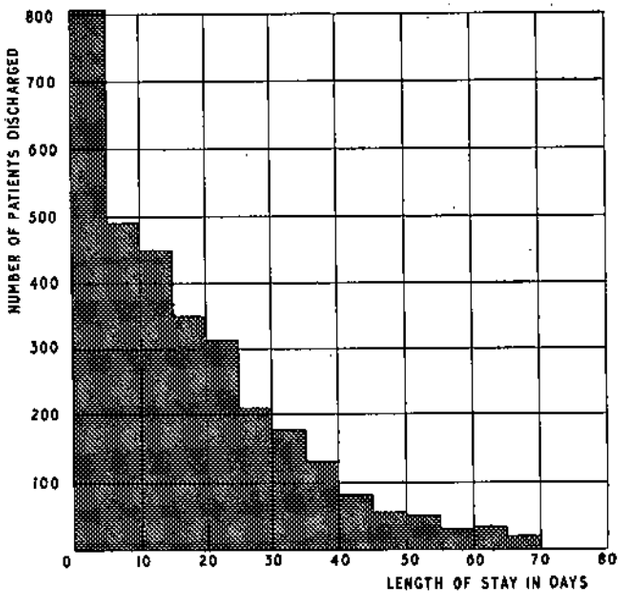

Fig. 131. General medicine: *The distribution of the length of stay (in days) of all inpatients discharged from hospitals in the Norwich, Lowestoft, and Great Yarmouth Group during 1951*

than in the case of women. This difference is probably accounted for by the greater liability of men to accidents.*

The proportion of surgical patients transferred from one hospital to another was higher than in the case of medical patients, because some patients were transferred from the main hospital at the post-acute stage of their illness, though the transfers amounted only to 3 per cent. of the total admissions. No children under 10 years of age were transferred.

During the year the surgical waiting-list decreased considerably, from 1,467 on 31 December 1950 to 918 on 31 December 1951; though the waiting-list for men was longer than that for women, the decrease during the year was approximately the same for both. The longer waiting-list and the longer waiting-time for beds for men reflect a greater number of immediate admissions.

Because the waiting-list decreased, the number estimated as recommended for admission was less than the number actually admitted. The estimated critical number of beds for the year 1951 was 334 for an occupancy rate

* The figures relating to admissions due to accidents, poisoning, and violence given in Dr. Donald MacKay's study of inpatient discharges show that nearly twice as many men as women were admitted for these causes.[3]

Table 52. General surgery, including plastic and thoracic surgery: *Summary of the lengths of stay (in days) of all inpatients discharged from the Norwich Group of Hospitals during 1951.*

Length of stay in days	Men		Women		Children		Total	
	Total number of patients discharged	Cumulative % of patients discharged	Total number of patients discharged	Cumulative % of patients discharged	Total number of patients discharged	Cumulative % of patients discharged	Total number of patients discharged	Cumulative % of patients discharged
1–5	921	23·7	564	18·5	474	44·1	1,959	24·5
6–10	882	46·4	764	43·6	318	73·6	1,964	49·0
11–15	777	66·4	678	65·9	158	88·3	1,613	69·1
16–20	443	77·8	468	81·2	37	91·7	948	81·0
21–25	344	86·7	213	88·3	24	94·0	581	88·2
26–30	168	91·0	113	91·9	24	96·2	305	92·0
31–35	88	93·3	70	94·2	7	96·8	165	94·1
36–40	66	95·0	31	95·2	11	97·9	108	95·5
41–45	40	96·0	34	96·4	5	98·3	79	96·4
46–50	32	96·8	19	97·0	4	98·7	55	97·1
51–55	36	97·7	22	97·7	4	99·1	62	97·9
56–60	25	98·4	16	98·2	1	99·2	42	98·4
61–65	16	98·8	13	98·7	1	99·3	30	98·8
66–70	14	99·2	10	99·0	2	99·4	26	99·1
Over 70	33	100·0	31	100·0	6	100·0	70	100·0
TOTALS	3,885	—	3,046	—	1,076	—	8,007	—

of 85 per cent.—approximately 170 beds for men, 134 for women, and 30 for children. These estimated numbers of beds would not have been sufficient to reduce the waiting-list already in existence in 1951. The standard error attached to the overall estimate is ±5·4, so the actual number of beds required to meet the demand during the year was 346. The difference between the number required and the number actually available was approximately 60 beds; this number would have enabled the waiting-list to be gradually reduced. Indeed, during the period of the survey 583 more patients were admitted than were estimated as recommended for admission, so that if the demand remained at the same level the initial waiting-list would be cleared off in three years.

There appeared to be a definite seasonal variation in demand for surgical beds. The estimated critical number of beds required to meet demand in the winter was 353·3 for an occupancy rate of 85 per cent., and in the summer 320·1. Taking into account the standard error of the estimate, this would have meant a provision of 370 beds in the winter and 336 beds in the summer. *Tables 51* and *51 (a)* show the whole demand for general surgical beds (including thoracic and plastic surgery) month by month throughout the year 1951, and the quarterly and seasonal estimates of the critical numbers of beds for occupancy rates of 100 per cent., 95 per cent., 90 per cent., and 85 per cent., with the appropriate standard errors.

Table 52 shows as a summary the lengths of stay of all patients discharged from general surgical beds during 1951. Children stayed in hospital a noticeably shorter time than did adults; 73·6 per cent. of all child patients were discharged within 10 days, as compared with 46·4 per cent. of men and 43·6 per cent. of women discharged within the same length of time. This illustrates the importance of making separate estimates in connexion with children wherever possible, because estimates based on the average lengths of stay for all patients are distorted by such differences between the various groups.

Gynaecology

Table 53 summarizes the information recorded about gynaecology. As at Northampton, this department seemed to be short of beds during 1951 even though the waiting-list decreased slightly in the course of the year. The estimated critical number of beds for an occupancy rate of 85 per cent. was 52, so that making allowances for the standard error the actual number required was about 57. In fact only 42 beds were available in the whole group, so that some 15 extra beds were needed. Even at an occupancy rate of 90 per cent., which could perhaps have been achieved as the number of immediate admissions was relatively small, at least 12 more beds would have been required to avoid long waiting-times. There seemed to be no significant seasonal variations in demand.

Obstetrics

The number of confinements which take place in hospital is to a certain extent a matter of social policy. Most abnormal conditions of pregnancy are preferably to be treated in hospital, and a certain number of normal cases, primiparae, are admitted to hospital for medical reasons; the rest are admitted for social reasons.

Excluding private patients, a total of 2,330 cases were admitted to hospital during 1951 for confinement or for treatment during pregnancy. Fifteen per cent. of those cases were admitted because they were abnormal. The medical officers of health for the city of Norwich and the county of Norfolk supplied figures showing the number of maternity cases referred to hospital by the Public Health Department: 41 cases were referred for consultation; 87 cases were referred for confinement in hospital because of medical abnormality; 592 for confinement in hospital on social grounds; 2 were referred for antenatal treatment, and 6 postnatal cases were referred for consultation.

Twenty-five per cent. of the total admissions were admitted to hospital on the recommendation of a health visitor, who had assessed the home conditions of the patients as unsuitable for confinement.

Table 54 shows the estimated critical numbers of beds for various occupancy rates calculated on the basis of the numbers of patients discharged. There is no waiting-list in the ordinary sense of the term and, for the purpose of this survey, the demand was taken to be the same as the number admitted. The estimated critical number of beds for 1951 at an occupancy rate of 85 per cent. was 99—of which 17 were estimated to be needed for abnormal cases and 26 for patients admitted for social reasons. When allowance had been made for the standard error the number required was 106 for an occupancy rate of 85 per cent. Ninety-seven beds were actually available in 1951. In that year the Minister of Health expressed the official view that 'booking to a postulated 80 per cent. occupation

Table 53. Gynaecology: *Data for assessing the monthly and total demand for inpatient care in the Norwich Group of Hospitals during 1951*

	Number of patients admitted	Number of immediate admissions	Number admitted from waiting-list	Number of patients transferred or readmitted	Number of patients discharged	State of the waiting-list	Increase or decrease in waiting-list	Number of patients recommended for admission	Average length of stay of patients discharged (days)	Average number of beds occupied	Critical number of beds for various rates of occupancy (with standard errors)			
											100%	95%	90%	85%
December (1950)	—	—	—	—	—	187	—	—	—	—	—	—	—	—
January (1951)	113	34	78	1	104	154	− 33	71	12	—				
February	104	37	65	2	92	151	− 3	89	13	—	39·4±3·3	41·5±3·5	43·8±3·7	46·4±3·9
March	94	39	55	—	106	162	+ 11	117	14	—				
April	105	41	64	—	90	164	+ 2	92	14	—				
May	103	42	60	1	114	160	− 4	110	14	—	46·9±3·8	49·4±4·0	52·1±4·2	55·2±4·5
June	98	27	71	—	96	167	+ 7	103	14	—				
July	99	28	68	3	102	164	− 3	99	13	—				
August	107	45	61	1	105	148	− 16	89	12	—	39·8±3·3	41·9±3·5	44·2±3·7	46·8±3·9
September	103	39	64	—	98	137	− 11	87	14	—				
October	96	31	65	—	94	146	+ 9	103	13	—				
November	78	25	53	—	80	161	+ 15	95	16	—	51·6±4·4	54·3±4·6	57·3±4·9	60·7±5·2
December	76	36	40	—	89	165	+ 4	93	20	—				
TOTALS	1,176	424	744	8	1,170	—	− 22	1,148	14·0	44·9	44·0±1·8	46·4±1·9	48·9±2·0	51·8±2·1

Table 54. Obstetrics: *Admissions to and discharges from obstetric beds in the Norwich Group of Hospitals, month by month for the year 1951, and the estimated critical number of beds for the year*

	Number of patients admitted	Number of patients discharged	Average stay of patients discharged (days)	Average number of beds occupied	Critical number of beds for various rates of occupancy (with standard errors)			
					100%	95%	90%	85%
December (1950)	—	—	—	—	—	—	—	—
January (1951)	197	190	12	—				
February	161	154	14	—	84·4±5·1	88·9±5·3	93·8±5·6	99·3±6·0
March	212	212	15	—				
April	207	208	12	—				
May	206	225	13	—	87·3±4·9	91·9±5·2	97·0±5·5	102·8±5·8
June	217	194	13	—				
July	192	203	13	—				
August	213	212	13	—	83·7±4·8	88·1±5·1	92·9±5·4	98·4±5·7
September	195	188	13	—				
October	184	194	14	—				
November	158	175	14	—	81·0±4·9	85·2±5·1	90·0±5·4	95·3±5·7
December	188	184	13	—				
TOTALS FOR THE YEAR	2,330	2,339	13·1	84·1	84·1±2·5	88·5±2·6	93·4±2·7	98·9±2·9

—or rather less where the proportion of domiciliary confinements is high or more where [it] is low—gives a reasonable margin of safety'.[28] The average length of stay in the Norwich, Lowestoft, and Great Yarmouth Group was less than the 14 days suggested by the Ministry as desirable; if the average length of stay had been increased by one day then at least 110 beds would have been required.

Ear, Nose, and Throat, and Dental Cases

The waiting-list for ear, nose, and throat cases and for dental cases were combined, and these specialties have therefore been considered together, though separate figures are also given. The provision needed for cases for the removal of tonsils and adenoids is discussed separately, partly because the extent of the demand arising in that connexion is medically controversial and partly because patients admitted for tonsillectomy usually have a much shorter stay in hospital than patients admitted for other ear, nose, and throat conditions.

Table 55. Ear, nose, and throat cases, (*a*) excluding tonsil and adenoid cases, (*b*) tonsil and adenoid cases only: *Summary of lengths of stay (in days) of all patients discharged from the Norwich Group of Hospitals in 1951*

	Length of stay in days	Men: Total number of patients discharged	Men: Cumulative % of patients discharged	Women: Total number of patients discharged	Women: Cumulative % of patients discharged	Children: Total number of patients discharged	Children: Cumulative % of patients discharged	Total: Total number of patients discharged	Total: Cumulative % of patients discharged
(*a*) Excluding tonsil and adenoid cases	1–5	188	43·0	152	42·5	68	37·4	408	41·8
	6–10	127	72·1	110	73·2	46	62·6	283	70·7
	11–15	54	84·4	51	87·4	38	83·5	143	85·4
	16–20	14	87·6	10	90·2	11	89·6	35	88·9
	21–25	16	91·3	10	93·0	5	92·3	31	92·1
	26–30	9	93·4	6	94·7	4	94·5	19	94·1
	31–35	8	95·2	5	96·1	2	95·6	15	95·6
	36–40	6	96·6	3	96·9	—	95·6	9	96·5
	41–45	8	98·4	3	97·8	2	96·7	13	97·8
	46–50	3	99·1	4	98·9	2	97·8	9	98·8
	51–55	2	99·5	1	99·2	1	98·4	4	99·2
	56–60	—	99·5	—	99·2	—	98·4	—	99·2
	61–65	1	99·8	2	99·7	—	98·4	3	99·5
	66–70	1	100·0	—	99·7	1	98·9	2	99·7
	Over 70	—	—	1	100·0	2	100·0	3	100·0
	TOTALS	437	—	358	—	182	—	977	—
(*b*) Tonsil and adenoid cases only	1–5	131	50·4	205	52·4	1,902	95·8	2,238	84·9
	6–10	121	97·0	179	98·2	80	99·8	380	99·3
	11–15	8	100·0	7	100·0	4	100·0	19	100·0
	TOTALS	260	—	391	—	1,986	—	2,637	—

Table 56. Tonsil and adenoid cases: *Data for assessing the monthly and total demand for inpatient care in the Norwich Group of Hospitals during 1951; with estimates of the critical numbers of beds at different rates of occupancy, and an analysis relating the data to men, women, and children*

	Number of patients admitted	Number of immediate admissions	Number of patients admitted from waiting-list	Number of patients transferred or readmitted	Number of patients discharged	State of the waiting-list	Increase or decrease in waiting-list	Number of patients recommended for admission	Average length of stay of patients discharged (days)	Average number of beds occupied	Critical number of beds for various rates of occupancy (with standard errors): 100%	95%	90%	85%
December (1950)	—	—	—	—	—	985	—	—	—	—	—	—	—	—
January (1951)	116	8	108	—	133	1,056	+ 71	204	4	—				
February	90	7	83	—	87	1,142	+ 86	173	5	—	28·1±1·8	29·6±1·9	31·2±2·0	33·1±2·1
March	183	15	168	—	188	1,193	+ 51	239	4	—				
April	257	31	226	—	269	1,196	+ 3	272	3	—				
May	293	28	265	—	317	1,146	− 50	267	3	—	23·7±1·2	24·9±1·3	26·3±1·3	27·9±1·4
June	290	17	273	—	317	1,061	− 85	232	3	—				
July	262	22	240	—	258	1,086	+ 25	283	3	—				
August	212	17	195	—	209	1,107	+ 21	230	3	—	20·3±1·1	21·4±1·2	22·6±1·2	23·9±1·3
September	200	12	188	—	212	1,075	− 32	180	3	—				
October	241	14	225	2	248	1,030	− 45	203	3	—				
November	247	11	235	1	251	920	−110	141	3	—	19·5±1·1	20·5±1·2	21·7±1·2	22·9±1·3
December	125	11	114	—	148	989	+ 69	217	4	—				
TOTALS FOR THE YEAR	2,516	193	2,320	3	2,637	—	+ 4	2,641	3·1	22·2	22·4±0·6	23·6±0·6	24·9±0·7	26·4±0·7
Men	243	22	220	1	260	104*	+ 31	291	5·5	3·9	4·4±0·4	4·6±0·4	4·9±0·4	5·2±0·4
Women	368	35	331	2	391	183*	− 9	382	5·5	5·9	5·8±0·4	6·1±0·4	6·4±0·5	6·8±0·5
Children	1,905	136	1,769	—	1,986	698*	− 18	1,968	2·3	12·4	12·4±0·4	13·1±0·4	13·8±0·5	14·6±0·5

* State of the waiting-list at 31 December 1950.

Table 55 shows the differences in the distribution of the lengths of stay for all patients, men, women, and children, in the two groups—cases for tonsillectomy and ear, nose, and throat cases. Whereas 84·9 per cent. of the patients admitted for the removal of tonsils and adenoids had been discharged by the end of 5 days, only 41·8 per cent. of the other ear, nose, and throat cases were discharged in that time.

Of the total of 3,722 admissions to beds in the ear, nose, and throat department 2,516 were tonsil and adenoid cases—243 men, 368 women, and 1,905 children.

Tables 56 and *57* illustrate the demand for inpatient care in the ear, nose, and throat wards during 1951. There were separate waiting-lists for tonsil and adenoid cases and for other ear, nose, and throat cases (with which the dental cases were included). The waiting-lists, though large, remained fairly constant through the year. For tonsil and adenoid cases (*Table 56*) the critical number of beds for an occupancy rate of 85 per cent. was 27. Because of the short stay and the consequent difficulty in ensuring a quick turnover, it would probably be impossible to achieve an occupancy rate higher than 85 per cent. Of the 27 beds, men would need 5, women 7, and children 15. The fact that the adults required nearly as many beds as the children, who made up about 75 per cent. of the admissions, is explained by the longer average stay of the adults—5·5 days as against 2·3 days.

Most of the children were aged between 5 and 9 years, as the following admission figures show:

	0–4 years	*5–9 years*	*10–14 years*
Boys	227	796	138
Girls	183	697	221
TOTAL	410	1,493	359

Table 57. Ear, nose, and throat cases (excluding tonsil and adenoid cases) and dental cases: *Data for assessing the monthly and total demand for inpatient care in the Norwich Group of Hospitals during 1951; with estimates of the critical numbers of beds at different rates of occupancy, and an analysis relating the data to men, women, and children*

	Number of patients discharged	*State of waiting-list*	*Increase or decrease in waiting-list*	*Number of patients recommended for admission*	*Average length of stay (days)*	*Average number of beds occupied*	*Critical number of beds for various rates of occupancy (with standard errors)*			
							100%	*95%*	*90%*	*85%*
December (1950)	—	257	—	—	—	—	—	—	—	—
January (1951)	88	278	+21	109	9	—				
February	87	248	−30	57	9	—	26·8±2·4	28·2±2·5	29·8±2·7	31·5±2·8
March	89	244	− 4	85	10	—				
April	105	244	0	105	9	—				
May	107	259	+15	122	7	—	28·7±2·3	30·2±2·4	31·9±2·6	33·8±2·7
June	98	238	−21	77	10	—				
July	91	247	+ 9	100	7	—				
August	88	260	+13	101	10	—	28·7±2·5	30·2±2·6	31·9±2·8	33·8±2·9
September	63	283	+23	86	11	—				
October	94	246	−37	57	11	—				
November	95	234	−12	83	8	—	27·3±2·3	28·7±2·4	30·3±2·6	32·1±2·7
December	99	254	+20	119	10	—				
TOTALS FOR THE YEAR	1,104	—	− 3	1,101	9·2	28·0	28·1±1·2	29·6±1·3	31·2±1·3	33·1±1·4
Men	496	132*	+ 4	500	9	12·4	12·3±0·8	13·0±0·8	13·7±0·9	14·5±0·9
Women	425	109*	−18	407	8·6	10·0	9·6±0·7	10·1±0·7	10·7±0·7	11·3±0·8
Children	183	16*	+11	194	11·2	5·6	6·0±0·6	6·3±0·6	6·6±0·7	7·0±0·7

* State of the waiting-list at 31 December 1950.

One hundred and twenty-eight dental cases were admitted to the ear, nose, and throat wards. The waiting-list remained constant throughout the year, so that the calculated demand was practically the same as the number admitted. The critical number of beds for ear, nose, and throat cases other than tonsil and adenoid cases was higher because the average length of stay was longer; for the year 1951 it was estimated as 33—15 for men, 11 for women, and 7 for children under 10 years of age.

The total estimated critical number of beds for all patients was 59—20 for men, 18 for women, and approximately 21 for children. Contrary to what might be expected, no appreciable seasonal variation in demand was apparent in the group in 1951 in connexion with tonsil and adenoid cases and other ear, nose, and throat cases (*Tables 56 (a)* and *57 (a)*). Allowing for the standard error of the estimate, 29 beds would have been required for tonsil and adenoid cases, and 37 would have been required for other ear, nose, and throat cases and dental cases, making a total of 66 beds—12 more than the number available in 1951.

Table 56 (a). Tonsil and adenoid cases: *The critical numbers of beds for the winter and the summer months, estimated from the 1951 inpatient load carried by the Norwich Group of Hospitals*

	Critical number of beds for various rates of occupancy (with standard errors)			
	100%	*95%*	*90%*	*85%*
Winter (Jan.–Mar., Oct.–Dec.)	22·6±1·0	23·8±1·1	25·1±1·1	26·6±1·2
Summer (Apr.–Sept.)	22·4±0·8	23·6±0·8	24·9±0·9	26·4±0·9

Table 57 (a). Ear, nose, and throat cases (excluding tonsil and adenoid cases) and dental cases: *The critical numbers of beds for the winter and the summer months, estimated from the 1951 inpatient load carried by the Norwich Group of Hospitals*

	Critical number of beds for various rates of occupancy (with standard errors)			
	100%	*95%*	*90%*	*85%*
Winter (Jan.–Mar., Oct.–Dec.)	27·2±1·7	28·6±1·8	30·2±1·9	32·0±2·0
Summer (Apr.–Sept.)	28·7±1·7	30·2±1·8	31·9±1·9	33·8±2·0

Table 58. Ophthalmology: *Data for assessing the monthly and total demand for inpatient care in the Norwich Group of Hospitals during 1951; with estimates of the critical numbers of beds at different rates of occupancy, and an analysis relating the data to men, women, and children*

	Number of patients admitted	Number of immediate admissions	Number of patients admitted from waiting-list	Number of patients transferred or readmitted	Number of patients discharged	State of the waiting-list	Increase or decrease in waiting-list	Number of patients recommended for admission	Average length of stay of patients discharged (days)	Average number of beds occupied	Critical number of beds for various rates of occupancy (with standard errors)			
											100%	95%	90%	85%
December (1950)	—	—	—	—	—	107	—	—	—	—	—	—	—	—
January (1951)	42	6	36	—	44	147	+ 40	84	10	—				
February	49	8	41	—	44	115	− 32	12	16	—	22·5±2·6	23·7±2·7	25·0±2·9	26·5±3·1
March	47	8	38	1	51	130	+ 15	66	11	—				
April	41	12	29	—	36	136	+ 6	42	12	—				
May	40	8	32	—	39	117	− 19	20	18	—	22·9±2·8	24·1±2·9	25·4±3·1	26·9±3·3
June	41	6	35	—	47	151	+ 34	81	14	—				
July	44	4	40	—	37	143	− 8	29	13	—				
August	45	14	31	—	48	135	− 8	40	15	—	16·4±2·1	17·3±2·2	18·2±2·3	19·3±2·5
September	42	3	38	1	44	130	− 5	39	14	—				
October	52	9	43	—	48	156	+ 26	74	11	—				
November	44	7	37	—	44	235	+ 79	123	14	—	33·6±3·6	35·4±3·8	37·3±4·0	39·5±4·2
December	43	9	34	—	46	230	− 5	41	13	—				
TOTALS FOR THE YEAR	530	94	434	2	528	—	+123	651	13·5	19·46	24·1±1·4	25·4±1·5	26·8±1·6	28·4±1·6
Male patients*	272	54	217	1	269	51†	+ 49	318	13·8	10·15	12·02±1·0	12·66±1·0	13·36±1·1	14·14±1·2
Female patients‡	258	40	217	1	259	56†	+ 74	333	13·1	9·31	11·95±1·0	12·58±1·0	13·28±1·1	14·06±1·2

* These figures include children:

0–4 years of age	15
5–9 ,,	50
10–14 ,,	15
Total	80

† State of the waiting-list at 31 December 1950.

‡ These figures include children:

0–4 years of age	8
5–9 ,,	48
10–14 ,,	7
Total	63

Table 58 (a). Ophthalmology: *The critical numbers of beds for the winter and the summer months, estimated from the 1951 inpatient load carried by the Norwich Group of Hospitals*

	Critical number of beds for various rates of occupancy (with standard errors)			
	100%	95%	90%	85%
Winter (Jan.–Mar., Oct.–Dec.)	27·9±2·2	29·4±2·3	31·0±2·4	32·8±2·6
Summer (Apr.–Sept.)	19·6±1·7	20·6±1·8	21·8±1·9	23·1±2·0

Table 59. Fracture cases: *Data for assessing the monthly and total demand for inpatient treatment in the Norwich Group of Hospitals during 1951; with estimates of the critical numbers of beds at different rates of occupancy, and an analysis relating the data to men, women, boys, and girls*

	Number of patients admitted	*Number of patients discharged*	*Average stay of patients discharged (days)*	*Average number of beds occupied*	*Critical number of beds for various rates of occupancy (with standard errors)*			
					100%	*95%*	*90%*	*85%*
January	38	48	20	—	27·4±3·4	28·8±3·6	30·4±3·8	32·2±4·0
February	36	42	19	—				
March	54*	41	18	—				
April	44	48	17	—	26·6±3·3	28·0±3·5	29·6±3·7	31·3±3·9
May	49	44	21	—				
June	36	41	17	—				
July	57	59	16	—	31·6±3·6	33·3±3·8	35·1±4·0	37·2±4·2
August	60	47	18	—				
September	37	46	24	—				
October	43	51	25	—	33·8±4·2	35·6±4·4	37·6±4·7	39·8±4·9
November	40	37	25	—				
December	36	39	24	—				
TOTALS FOR THE YEAR	530*	543	20·1	29·9	29·9±1·8	31·4±1·9	33·2±2·0	35·1±2·1
Men	219*	223	20·4	12·5	12·5±1·2	13·1±1·2	13·9±1·3	14·7±1·4
Women	216	221	23·1	14·0	14·0±1·3	14·7±1·4	15·5±1·5	16·4±1·6
Boys	60	66	12·3	2·2	2·2±0·4	2·3±0·4	2·5±0·4	2·6±0·5
Girls	35	33	13·1	1·2	1·2±0·3	1·2±0·3	1·3±0·3	1·4±0·3

* Includes 2 transfers.

Ophthalmology

The ophthalmic department was the only one completely centralized at the main hospital in the group. There were 22 ophthalmic beds to meet the needs of all patients, including children. No separate waiting-list was kept for children, and therefore it was not possible to estimate the demand for beds for children. A total of 143 children was admitted—23 aged 0–4 years, 98 aged 5–9 years, and 22 aged 10–14 years.

The total number of admissions to the eye beds during the year 1951 was 530, of which 272 were male patients and 258 were female patients. Eighty of the male patients and 63 of the female patients were 14 years of age or under. Immediate admissions formed less than 20 per cent. of all admissions.

The waiting-list increased considerably throughout the year, from 107 on 31 December 1950 to 230 on 31 December 1951. As at Northampton, the ophthalmic department seemed relatively to have the most serious shortage of beds. The estimated critical number of beds for an occupancy rate of 85 per cent. was 28—14 for male patients and 14 for female patients (see *Table 58*).

There were noticeable seasonal variations in demand during 1951 (*Table 58 (a)*)—whereas 28 beds were required during the summer months, 39 were required during the winter months. The minimum number of beds required to meet the demand over the year was 33, and even at an occupancy rate of 90 per cent. 31 would have been required. With a provision of only 22 beds the department appeared to be short of at least 10 beds.

Traumatic and Orthopaedic Surgery

Five hundred and thirty patients were admitted to the orthopaedic beds for the treatment of fractures. Though the proportion of men and women admitted was about the same, almost twice as many boys as girls were admitted.

The estimates of the critical numbers of beds were based on the numbers actually discharged. For an 85 per cent. occupancy rate, the critical number of beds was 35—15 for men, 16 for women, and 4 for children. The standard error of the estimate is ±2·1 (see *Table 59*), so that 40 beds would have had to be provided for these cases.

Though there appeared to be a certain amount of variation in the demand throughout the year, it was not of much significance. The average length of stay was affected by the very long stay of some patients. *Table 60* shows the distributions of the lengths of stay of all patients, men, women, and children. Thirty-six patients stayed in hospital for more than 70 days.

Excluding fractures, the total number of orthopaedic cases admitted was 1,218—516 men, 425 women, and 277 children. The waiting-list increased by 178 during the year, the increase in the number of women waiting for beds being the greatest. The critical numbers of beds for an occupancy rate of 85 per cent. for all patients was 113—34 for men, 44 for women, and 35 for children. The greater number of beds required for women reflects the relatively greater number of women on the waiting-list and their longer average stay once admitted—24·3 days as compared with 18·5 days for men. *Table 60* compares the distribution of the lengths of stay for men, women, and children.

The variations in the demand during the year are shown in *Table 61*. The actual number of beds required to meet

Table 60. Orthopaedic cases (*a*) excluding fracture cases, and (*b*) fracture cases only: *Summary of the length of stay, in days, of all patients discharged from orthopaedic beds in the Norwich Group of Hospitals during 1951*

	Length of stay in days	Men		Women		Children		Total	
		Total number of patients discharged	*Cumulative % of patients discharged*	*Total number of patients discharged*	*Cumulative % of patients discharged*	*Total number of patients discharged*	*Cumulative % of patients discharged*	*Total number of patients discharged*	*Cumulative % of patients discharged*
(*a*) Orthopaedic cases excluding fractures	1–5	139	26·4	48	11·2	136	45·6	323	25·8
	6–10	95	44·4	66	26·7	38	58·4	199	41·7
	11–15	99	63·2	90	47·8	24	66·4	213	58·7
	16–20	68	76·1	70	64·2	19	72·8	157	71·2
	21–25	36	82·9	21	69·1	12	76·8	69	76·8
	26–30	18	86·3	26	75·2	5	78·5	49	80·7
	31–35	16	89·4	26	81·3	2	79·2	44	84·2
	36–40	13	91·8	17	85·2	3	80·2	33	86·8
	41–45	7	93·2	10	87·6	4	81·5	21	88·5
	46–50	5	94·1	6	89·0	2	82·2	13	89·5
	51–55	5	95·1	8	90·9	2	82·9	15	90·7
	56–60	6	96·2	3	91·6	—	82·9	9	91·5
	61–65	4	97·0	2	92·0	4	84·2	10	92·3
	66–70	4	97·7	7	93·7	—	84·2	11	93·1
	Over 70	12	100·0	27	100·0	47	100·0	86	100·0
	TOTALS	527	—	427	—	298	—	1,252	—
(*b*) Fracture cases only	1–5	80	35·9	67	30·3	62	62·6	209	38·5
	6–10	38	52·9	37	47·1	10	72·7	85	54·1
	11–15	17	60·5	18	55·2	1	73·7	36	60·8
	16–20	20	69·5	19	63·8	2	75·8	41	68·3
	21–25	10	74·0	18	71·9	1	76·8	29	73·7
	26–30	9	78·0	11	76·9	5	81·8	25	78·3
	31–35	11	83·0	7	80·1	7	88·9	25	82·9
	36–40	1	83·4	7	83·3	2	90·9	10	84·7
	41–45	4	85·2	3	84·6	—	90·9	7	86·0
	46–50	7	88·3	—	84·6	3	93·9	10	87·8
	51–55	3	89·7	5	86·9	—	93·9	8	89·3
	56–60	4	91·5	4	88·7	4	98·0	12	91·5
	61–65	4	93·3	2	89·6	2	100·0	8	93·0
	66–70	—	93·3	2	90·5	—	—	2	93·4
	Over 70	15	100·0	21	100·0	—	—	36	100·0
	TOTALS	223	—	221	—	99	—	543	—

the overall demand, allowing for the error of the estimate, was 122. The total number of beds which would have been required for both orthopaedic and fracture cases was 162; only 104 beds were allotted to the specialty during 1951, although in the children's hospital there was no special allocation of orthopaedic beds, patients being admitted to the general surgical ward. Orthopaedic cases, on an average, need a long stay in hospital and so relatively few patients can be admitted to a bed in the course of a year. It is not surprising therefore that some patients admitted to beds in the group during 1951 had been waiting for five years.

Radiotherapy* (*see Table 62*)

There was no waiting-list for this specialty during 1951, and the estimates of the critical numbers of beds are based on the number of patients actually discharged. The standard error of the estimate for an occupancy of 85 per cent. was ±0·78, so that the number of beds required was about 8.

* Patients who received radiotherapy treatment while primarily under the care of another department have not been included under radiotherapy.

Venereology (*see Table 63*)

Table 63 summarizes the information relating to this specialty. For an occupancy of 85 per cent., the number of beds required, allowing for the standard error of the estimate, was 4; this was, in fact, the number provided.

Table 61. Orthopaedic cases (excludidg fracture cases): *Data for assessing the monthly and total demand for inpatient care in the Norwich Group of Hospitals during 1951; with estimates of the critical numbers of beds at different rates of occupancy, and an analysis relating the data to men, women, and children*

	Number of patients admitted	*Number of immediate admissions*	*Number admitted from waiting-list*	*Number of patients transferred or readmitted*	*Number of patients discharged*	*State of the waiting-list*	*Increase or decrease in waiting-list*	*Number of patients recommended for admission*	*Average length of stay of patients discharged (days)*	*Average number of beds occupied*	*Critical number of beds for various rates of occupancy (with standard errors)*			
											100%	*95%*	*90%*	*85%*
December (1950)	—	—	—	—	—	1,066	—	—	—	—	—	—	—	—
January (1951)	108	35	69	4	94	1,082	+ 16	110	38	—				
February	108	36	66	5	104	1,104	+ 22	126	25	—	109·1±8·6	114·8±9·1	121·2±9·6	128·4±10·1
March	97	36	58	3	108	1,102	− 2	106	24	—				
April	118	50	61	5	107	1,124	+ 22	129	21	—				
May	107	50	54	5	119	1,150	+ 26	145	28	—	108·3±8·1	114·0±8·5	120·3±9·0	127·4±9·5
June	94	24	62	6	105	1,150	0	105	29	—				
July	101	44	53	5	96	1,136	− 14	82	21	—				
August	110	49	59	4	113	1,156	+ 20	133	22	—	84·4±6·6	88·8±6·9	93·8±7·3	99·3±7·8
September	89	32	54	3	96	1,187	+ 31	127	25	—				
October	112	48	60	4	115	1,193	+ 6	121	19	—				
November	102	39	60	3	93	1,211	+ 18	111	16	—	81·0±6·2	85·3±6·5	90·0±6·9	95·3±7·3
December	72	34	35	3	102	1,244	+ 33	135	26	—				
TOTALS FOR THE YEAR	1,218	477	691	50	1,252	—	+178	1,430	24·4	83·9	95·6±3·7	100·6±3·9	106·2±4·2	112·5±4·5
Men	516	224	269	23	527	446*	+ 33	560	18·5	26·7	28·4±1·7	29·9±1·8	31·5±1·9	33·4±2·0
Women	425	150	259	16	426	598*	+135	561	24·3	28·3	37·4±2·4	39·3±2·5	41·5±2·7	43·9±2·8
Children	277	103	163	11	299	22*	+ 10	309	35·2	28·9	29·8±2·4	31·4±2·5	33·1±2·7	35·1±2·8

* State of the waiting-list at 31 December 1950.

Table 62. Radiotherapy: *Data for assessing the monthly and total demand for inpatient treatment in the Norwich Group of Hospitals during 1951; with estimates of the critical numbers of beds at different rates of occupancy, and an analysis relating the data to men and women*

	Number of patients admitted	*Number of patients discharged*	*Average length of stay of patients discharged (days)*	*Average number of beds occupied*	*Critical number of beds for various rates of occupancy (with standard errors)*			
					100%	*95%*	*90%*	*85%*
December (1950)	—	—	—	—	—	—	—	—
January (1951)	4	4	24	—				
February	3	3	31	—	3·0±1·2	3·2±1·3	3·3±1·3	3·5±1·4
March	6	6	13	—				
April	12	6	20	—				
May	8	15	18	—	5·1±1·4	5·4±1·5	5·7±1·6	6·0±1·6
June	9	7	11	—				
July	12	13	9	—				
August	9	6	42	—	5·9±1·5	6·2±1·6	6·6±1·7	6·9±1·8
September	8	11	16	—				
October	9	7	10	—				
November	11	9	20	—	4·5±1·3	4·7±1·4	5·0±1·4	5·3±1·5
December	3	9	19	—				
TOTALS FOR THE YEAR	94	96	17·6	4·6	4·6±0·7	4·9±0·7	5·1±0·8	5·5±0·8
Men	41	43	17·1	2·0	2·0±0·4	2·1±0·5	2·2±0·5	2·4±0·5
Women	53	53	18·0	2·6	2·6±0·5	2·8±0·5	2·9±0·6	3·1±0·6

Table 63. Venereal cases: *Data showing the monthly and total demand for inpatient care in the Norwich Group of Hospitals during 1951; with critical numbers of beds for the year at different rates of occupancy, and an analysis relating the data to men and women*

	Number of patients admitted	Number of patients discharged	Average length of stay of patients discharged (days)	Average number of beds occupied	Critical number of beds for various rates of occupancy (with standard errors)			
					100%	95%	90%	85%
December (1950)	—	—	—	—	—	—	—	—
January (1951)	4	3	11	—				
February	2	1	10	—	1·1±0·6	1·2±0·6	1·2±0·7	1·3±0·7
March	1	4	14	—				
April	4	4	9	—				
May	2	—	—	—	1·0±0·5	1·1±0·5	1·1±0·6	1·2±0·6
June	5	5	11	—				
July	5	4	8	—				
August	5	7	12	—	1·8±0·7	1·9±0·7	2·0±0·8	2·1±0·8
September	5	4	13	—				
October	4	5	8	—				
November	2	2	13	—	1·3±0·6	1·4±0·6	1·4±0·7	1·5±0·7
December	2	3	16	—				
TOTALS	41	42	11·2	1·3	1·3±0·3	1·4±0·3	1·4±0·3	1·5±0·4
Men	26	26	11·4	0·8	0·8±0·2	0·9±0·2	0·9±0·2	0·9±0·3
Women	15	16	10·8	0·5	0·5±0·2	0·5±0·2	0·5±0·2	0·6±0·2

Private Patients and Amenity Patients

In addition to the 20,985 patients admitted to the ordinary beds in the hospitals of the group during the year 1951, a further 101 patients were admitted to amenity beds, and 1,572 to private beds.

The 101 patients admitted to the amenity beds included 36 general medical cases, 39 general surgical cases, 3 gynaecological cases, 5 ear, nose, and throat cases, 8 orthopaedic cases, 2 fracture cases, 1 dermatological case, 5 ophthalmic cases, and 2 radiotherapy cases. These patients, although they were admitted to beds in single rooms, received treatment under the National Health Service and so were part of the ordinary hospital load. *Table 64* gives for each specialty details of the numbers of amenity patients discharged, the average length of stay in hospital, and the average number of beds occupied during the year.

Of the 1,572 private patients, 690 were admitted to private beds in the group and 882 were admitted to beds in privately owned nursing homes. Only patients receiving acute general care, including obstetric cases, were taken into account; chronic and convalescent cases were excluded. Most of the patients admitted to privately owned homes (maternity homes apart) were under the care of the consultant staff of the group and enjoyed very much the same range of facilities as the patients admitted to private beds in the various hospitals.

Table 65 gives details of the total numbers of patients and the numbers of male and female patients admitted to and discharged from private beds in hospitals and acute beds in privately owned nursing homes, with the average length of stay and the average number of occupied beds.

Seventy-one per cent. of the total numbers of patients admitted were women; this is partly accounted for by the high proportion admitted for confinement—31 per cent. of the total number of women were obstetric cases. In nearly every specialty the proportion of females was greater than the proportion of males and, on the whole, they tended to stay longer.

The estimates of the critical numbers of beds are based on the actual numbers of patients discharged and their average length of stay. The critical number for the year 1951, assuming an 85 per cent. occupancy rate, was 65·27 for all patients, of which general medical, general surgical, and obstetric cases accounted for 47·80. The estimated critical number for male patients was 17·24 and for female patients 48·03. Thus nearly three times as many beds were required for female patients as for male patients. Allowing for the errors of the estimates, it appeared that the total number of beds required for all private patients was approximately 71.

Outpatient Clinics

Table 66 shows the whole outpatient load which came on to the various outpatient and casualty departments in the hospitals of the Norwich, Lowestoft, and Great Yarmouth Group during 1951. The numbers of new outpatients and the total attendances at the various consultative clinics are shown for each month of the year. Similar figures relating to the treatment clinics, the radiotherapy department, and the casualty department are shown separately. The average number of new patients seen and the weekly total attendances at each consultative clinic, at each treatment clinic, and at the radiotherapy clinics are also shown. The proportion of new patients seen at treatment and radiotherapy clinics was, as might be expected, smaller than for the consultative clinics; the proportion was one new patient to about every eight re-attendances.

The monthly variations in the numbers of new patients and in the total number of attendances at the various consultative and treatment clinics did not seem to be significant; they were probably due to the method of making

Table 64. Amenity patients in the Norwich Group of Hospitals during 1951: *The total numbers of men, women, and children admitted to and discharged from Section 4 (part payment) beds in various specialties, with average lengths of stay*

Specialty	Men			Women			Total		
	Total admissions	*Total discharges*	*Average length of stay of patients discharged (days)*	*Total admissions*	*Total discharges*	*Average length of stay of patients discharged (days)*	*Total admissions*	*Total discharges*	*Average length of stay of patients discharged (days)*
General medicine	20	20	11·6	16	16	15·4	36	36	13·3
General surgery	16	16	14·7	23	23	18·2	39	39	16·8
Gynaecology	—	—	—	3	3	7·0	3	3	7·0
Dermatology	—	—	—	1	1	6·0	1	1	6·0
Ear, nose, and throat	3	3	7·3	2	2	7·0	5*	5*	7·2
Ophthalmology	1	1	16·0	4	4	13·8	5	5	14·2
Radiotherapy	1	1	4·0	1	1	17·0	2	2	10·5
Orthopaedic surgery	4	4	12·0	4	4	15·3	8	8	13·6
Fractures	—	—	—	2	2	15·0	2	2	15·0
TOTALS	45	45	12·4	56	56	15·5	101	101	14·1

* These figures include 2 children.
Average number of beds occupied: men 1·5; women 2·4; total 3·9.

Table 65. Patients (in all specialties) treated in private nursing homes in Norfolk, and in the Section 5 pay-beds of hospitals in the Norwich Group of Hospitals during 1951: *Data from which the total demands for all kinds of private beds may be assessed*

Specialty	*Total admissions*	*Total discharges*	*Average length of stay of patients discharged (days)*	*Average number of beds occupied*	*Critical number of beds for various rates of occupancy*			
					100%	*95%*	*90%*	*85%*
General medicine	321	317	16·6	14·40	14·40	15·16	16·00	16·94
General surgery	382	379	12·8	13·24	13·24	13·94	14·71	15·58
Gynaecology	118	117	13·4	4·29	4·29	4·52	4·77	5·05
Normal obstetrics	225	225	13·4	8·25	8·25	8·69	9·17	9·71
Abnormal obstetrics	126	123	14·0	4·73	4·73	4·98	5·26	5·57
Orthopaedics	171	168	11·5	5·31	5·31	5·59	5·90	6·24
Fractures	51	50	12·5	1·72	1·72	1·81	1·91	2·02
Ear, nose, and throat	63	63	7·3	1·26	1·26	1·33	1·40	1·48
Tonsils and adenoids	53*	53*	4·2	0·61	0·61	0·65	0·68	0·72
Dentistry	20	20	2·0	0·11	0·11	0·11	0·12	0·13
Ophthalmology	32	32	10·9	0·95	0·95	1·00	1·06	1·12
Dermatology	5	5	25·2	0·35	0·35	0·36	0·38	0·41
Radiotherapy	5	5	18·8	0·26	0·26	0·27	0·29	0·30
TOTALS	1,572	1,557	13·0	55·48	55·48	58·40	61·64	65·27
All Specialties: Men	455†	454†	11·8	14·65	14·65	15·43	16·28	17·24
All Specialties: Women	1,117‡	1,103‡	13·5	40·82	40·82	42·97	45·36	48·03

* Includes 8 children. † Includes 5 children. ‡ Includes 3 children.

appointments and to the effect of holiday periods rather than to any real difference in demand. The numbers of new patients seen in the casualty department, however, showed a considerable variation from month to month, and, from the very nature of casualty work and because such patients are seen without appointments, those numbers may be taken as representing a real variation in demand. There was, for instance, a noticeable increase in the numbers of new patients attending the casualty department during July and August which was directly attributable to the presence of holiday visitors in the area.

Because the number of clinic sessions to be held depends not only on the demand, but also on the numbers of new and of old patients which the consultants are prepared to see, no attempt was made to estimate the actual number required. Such an estimate would be entirely arbitrary. However, analysis of the delays occurring between the time patients were referred to the outpatient department by their general practitioners and the time of their first attendance indicated that there was a considerable shortage of clinic sessions in all specialties. Information relating to short periods in 1952 was collected for all the various clinics held in the hospitals in the group; *Table 67* shows the distribution of the lengths of time elapsing between requests for appointments being made and the dates of the appointments. At one hospital 25·2 per cent. of the male patients and 19·8 per cent. of the female patients waited from 3 to 4 weeks before being seen at the general medical clinics. In the orthopaedic clinics at the same hospital only 8·2 per cent. of the male patients and 4·7 per cent. of the female patients were seen within a fortnight of the request for consultation, and as many as 17 per cent. of the male patients and 24 per cent. of the female patients waited from 6 to 7 weeks before being seen. Long waiting-time before being seen at orthopaedic clinics was general in the group, and indeed exceeded that for any other specialty.

General Figures for the Inpatient and Outpatient Load during 1951 (*Table 68*)

A total of 35,946 new outpatients attended the various consultative clinics during the year 1951. A further 2,340 new patients attended the treatment clinics, and 28,819 new patients were seen in the casualty department. The total outpatient attendances during the year were 128,226—107,674 at consultative clinics and 20,552 at treatment clinics. The total attendances in the casualty department

Table 66. Outpatient clinics and ancillary services in the Norwich Group of Hospitals: *The number of new patients and the total number of attendances in each specialty for each month of 1951*

	1. OUTPATIENT CLINICS																													
	General Medicine		*General Surgery*		*Thoracic Surgery*		*Plastic Surgery*		*E.N.T.*		*Obstetrics*		*Gynaecology*		*Orthopaedics*		*Fractures*		*Paediatrics*		*Ophthalmology*		*Dermatology*		*Dentistry*		*V.D.*		*Total*	
	N.	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*
January	415	1,491	501	2,116	—	13	—	—	370	1,000	186	662	176	551	501	1,788	185	944	59	161	304	1,138	204	820	20	66	29	240	2,940	10,990
February	388	996	507	1,614	—	12	—	—	373	908	177	466	132	287	521	1,393	122	708	52	126	264	803	211	655	17	35	26	262	2,790	8,265
March	375	1,147	520	1,864	—	9	—	—	414	954	186	539	168	315	503	1,325	129	655	58	151	256	815	249	694	16	26	26	237	2,900	8,731
April	410	1,098	565	1,965	—	14	—	—	517	1,090	238	571	128	312	520	1,457	120	621	58	181	325	895	268	705	24	36	32	298	3,205	9,243
May	429	1,200	536	1,845	4	11	—	—	457	1,073	210	631	205	420	642	1,693	101	602	46	120	354	921	287	736	33	57	19	255	3,323	9,564
June	403	1,146	582	1,858	2	11	24	28	417	923	159	458	148	308	608	1,562	122	647	48	171	380	919	262	676	20	39	52	361	3,227	9,107
July	322	987	613	2,037	6	11	32	48	483	976	139	422	137	314	592	1,632	89	541	78	167	288	841	222	579	44	44	30	294	3,075	8,893
August	368	1,087	521	1,828	7	18	19	46	399	873	130	433	138	303	420	1,096	115	548	58	142	286	806	260	637	32	48	27	290	2,780	8,155
September	354	1,002	541	1,968	2	8	23	76	361	856	155	405	132	285	508	1,423	122	525	32	110	320	910	237	575	33	40	31	279	2,851	8,462
October	442	1,191	592	2,105	4	14	13	48	446	1,073	169	408	170	381	576	1,503	129	598	70	171	310	990	250	591	37	52	49	333	3,257	9,458
November	394	1,111	629	2,119	5	16	19	65	405	1,000	164	421	178	368	551	1,413	144	657	57	129	296	903	266	731	34	41	32	323	3,174	9,279
December	290	859	453	1,808	3	20	18	57	381	850	129	329	130	269	395	1,077	144	578	39	138	212	695	198	561	6	16	16	252	2,414	7,509
TOTAL ATTENDANCES	4,590	13,315	6,560	23,127	33	157	148	368	5,023	11,576	2,042	*5,745	1,842	4,113	6,337	17,362	1,522	7,624	655	1,767	3,595	10,636	2,914	7,960	316	500	369	3,424	35,946	107,674
Average weekly attendances	88	256	126	446	1	3	5 (29 weeks only)	13	97	223	39	110	35	79	122	334	29	147	13	34	69	205	56	153	6	10	7	66	691·3 (over 52 weeks)	2,070·7

	2. ANCILLARY SERVICES														3. CASUALTY	
	Radiotherapy		*Orthoptics*		*Speech Therapy*		*Chiropody*		*Audiometry*		*E.N.T. treatment*		*Total*		*Casualties*	
	N.	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*	*N.*	*T.*
January	95	570	1	157	—	—	9	169	61	590	—	169	166	1,655	1,857	5,175
February	124	598	4	193	—	—	12	159	53	608	—	140	193	1,698	1,737	4,618
March	106	572	—	117	—	—	10	154	68	638	—	145	184	1,626	2,120	5,458
April	129	667	—	201	—	—	12	149	93	647	—	145	234	1,809	2,171	5,407
May	127	645	—	150	—	—	8	139	54	622	—	154	189	1,710	2,443	5,725
June	103	561	—	78	—	—	20	166	59	675	—	150	182	1,630	2,622	4,898
July	118	497	13	363	16	27	10	172	64	582	—	149	221	1,790	3,192	6,668
August	97	427	19	182	8	31	5	152	49	660	—	153	178	1,605	3,262	6,964
September	88	415	48	272	8	48	9	145	29	601	—	115	182	1,596	2,748	6,230
October	112	556	46	284	4	62	15	160	64	697	—	153	241	1,912	2,440	5,903
November	105	448	36	286	2	28	9	187	47	749	—	151	199	1,849	2,215	5,567
December	73	375	47	259	4	24	10	141	37	700	—	173	171	1,672	2,012	4,788
TOTAL ATTENDANCES	1,277	6,331	214	2,542	42	220	129	1,893	678	7,769	—	1,797	2,340	20,552	28,819	67,401
Average weekly attendances	25	122	4	49	2 (25 weeks only)	9	2	36	13	149	—	35	45·0 (over 52 weeks)	395·2	554·2	1,296·2

N. = New patients. T. = Total attendances.
* This figure includes some gynaecological patients.

Table 67. Outpatient clinics in the Norwich Group of Hospitals during 1951: *The time (in weeks) elapsing between the request for consultation and consultation itself, for each specialty, with the numbers of patients concerned and their sex*

Number of weeks patients waited for an appointment	*Number of patients who waited for an appointment*										*Total number of patients who waited*	*Percentage number of patients who waited*
	General medicine	*General surgery*	*Ear, nose, and throat*	*Ophthalmology*	*Orthopaedics*	*Obstetrics*	*Gynaecology*	*Dermatology*	*Dentistry*	*Paediatrics*		
Male patients												
0–1	15	35	8	6	6	—	—	13	1	4	88	6·5
1–2	47	89	21	25	22	—	—	32	5	4	245	18·1
2–3	50	73	56	37	27	—	—	43	3	—	289	21·3
3–4	68	86	68	24	28	—	—	31	—	—	305	22·5
4–5	59	57	40	7	30	—	—	6	—	1	200	14·7
5–6	43	14	20	6	28	—	—	—	—	—	111	8·2
6–7	11	4	4	3	29	—	—	1	2	—	54	4·0
7–8	3	3	5	1	16	—	—	1	—	—	29	2·1
8–9	—	—	10	—	19	—	—	—	—	—	29	2·1
9–10	—	—	2	—	2	—	—	—	—	—	4	0·3
10–11	—	—	—	—	—	—	—	—	—	—	—	—
11–12	—	—	1	—	1	—	—	—	—	—	2	0·2
TOTALS	296	361	235	109	208	—	—	127	11	9	1,356	—
Female patients												
0–1	17	27	8	4	2	5	15	10	11	5	104	6·3
1–2	58	59	21	8	21	20	45	41	4	4	281	17·0
2–3	58	56	28	8	33	21	46	56	1	1	308	18·7
3–4	53	66	43	5	33	17	66	31	—	—	314	19·1
4–5	57	56	70	27	23	3	45	14	—	1	296	18·0
5–6	34	8	29	26	32	—	19	—	—	—	148	9·0
6–7	16	3	9	7	48	—	8	—	—	—	91	5·5
7–8	5	4	7	1	38	2	4	2	—	—	63	3·8
8–9	2	—	5	1	14	—	3	1	—	—	26	1·6
9–10	—	—	7	3	3	—	—	—	—	—	13	0·8
10–11	—	—	—	—	3	—	—	—	—	—	3	0·2
11–12	—	—	1	—	—	—	—	—	—	—	1	0·06
TOTALS	300	279	228	90	250	68	251	155	16	11	1,648	—

were 67,401. The number of new outpatients in every 100 total attendances was 33 for consultative clinics, 11 for treatment clinics, and 30 for all clinics. The number of new patients in every 100 attendances at the casualty department was 43.

The total number of inpatients admitted during the year was 20,985. Twenty-six per cent. of all patients admitted were children in the age group of 0–14 years. Eighteen hundred and thirteen were in the group 0–4 years, 2,643 were in the group 5–9 years, and 992 were in the group 10–14 years. Of the 9,693 women admitted to hospital 2,330 (24 per cent.) were obstetric cases. Fifty-eight patients were admitted for every 100 new outpatients seen.

The total population served by the group of hospitals has been estimated at 484,583. During 1951, 4·3 out of every 100 of the population were admitted to hospital, 7·4 out of every 100 attended outpatient departments as new patients, and 5·9 out of every 100 attended the casualty department as new patients.

Special Departments

The number of patients who can be treated in hospital depends on the range and amount of service provided by the various diagnostic and therapeutic departments as well as on the numbers of beds and consulting sessions available. If the treatment of patients is not to be delayed there should be sufficient diagnostic and therapeutic facilities to meet the needs of inpatients, outpatients, and casualty patients.

The problem of assessing the scale of provision in connexion with the special departments is somewhat different from that of deciding upon the rest of the provision for inpatients and outpatients. Whereas, broadly speaking, the demand for general facilities for outpatients and inpatients depends primarily upon the nature and size of the population at risk, the load coming on to the special departments depends to a somewhat greater extent upon individual medical decisions. Two consultations in the same specialty may refer a quite different proportion of patients for diagnosis in a special department. Nevertheless it should be possible to determine the approximate

Table 68. Norwich Group of Hospitals: *The whole demand for in-patient care and outpatient consultation and treatment recorded for the year 1951; with estimates for the critical numbers of beds at an occupancy rate of 85 per cent.*

	Number of inpatients admitted	*Number of new out-patients*	*Total number of out-patient attendances*	*Number of in-patients per 100 new out-patients*	*Number of new out-patients per 100 total attendances*	*Number of new out-patients per 1,000 effective population*	*Number of inpatients admitted per 1,000 effective population*	*Critical number of acute beds (with standard errors) assuming 85 per cent. occupancy rate per 1,000 effective population*
(*a*) *Specialties and Consultative Clinics*								
General medicine (with Paediatrics)	3,236	5,245	15,082	62	35	10·824	6·678	0·434±0·011
Dermatology	67	2,914	7,960	2	37	6·013	0·138	*included in Gen. Med.*
General, thoracic, and plastic surgery	8,041	6,741	23,652	119	29	13·911	16·594	0·689±0·011
Gynaecology	1,176	1,842	4,113	64	45	3·801	2·427	0·107±0·004
Obstetrics (normal and abnormal)	2,330	2,042	5,745	114	36	4·214	4·808	0·204±0·006
Orthopaedics	1,218	6,337	17,362	19	36	13·077	2·514	0·232±0·009
Fractures	530	1,522	7,624	35	20	3·141	1·094	0·073±0·004
Ophthalmology	530	3,595	10,636	15	34	7·419	1·094	0·059±0·003
Ear, nose, and throat	1,078	5,023	11,576	21	43	10·366	2·225	0·068±0·003
Tonsils and adenoids	2,516	—	—	—	—	—	5·192	0·054±0·001
Radiotherapy	94	*See under treatment clinics*					0·194	0·011±0·002
Dentistry	128	316	500	41	63	0·652	0·264	*included in E.N.T.*
Venereology	41	369	3,424	11	11	0·761	0·085	0·003±0·001
ALL SPECIALTIES AND CONSULTATIVE CLINICS	20,985	35,946	107,674	58	33	74·179	43·305	1·934±0·020
(*b*) *Treatment clinics and Ancillary Services*								
Radiotherapy	—	1,277	6,331	—	20	2·635	—	—
Orthoptics	—	214	2,542	—	8	0·442	—	—
Speech Therapy	—	42	220	—	19	0·087	—	—
Chiropody	—	129	1,893	—	7	0·266	—	—
Audiometry	—	678	7,769	—	9	1·399	—	—
Ear, nose, and throat	—	0	1,797	—	0	0	—	—
ALL TREATMENT CLINICS AND ANCILLARY SERVICES	—	2,340	20,552	0	11	4·829	—	—
(*a*)+(*b*) All hospital services	20,985	38,286	128,226	55	30	79·008	43·305	1·934±0·020
(*c*) Attendances in casualty	—	28,819	67,401	—	43	59·472	—	—

provision needed to meet a given load. If the numbers of examinations and procedures taking place within a given period are known and the times taken to perform them, then it should be possible to estimate the size of the departments which would be needed to deal with such a load (sampling variations and other factors must be taken into account). During the survey in the Norwich, Lowestoft, and Great Yarmouth Group for the year 1951, the loads coming on to three chosen departments—the departments of radiology and pathology and the operating theatres—by inpatients, outpatients, and casualty patients were recorded by specialty. An attempt was made to classify examinations in such a way that some account was taken of the degree of complexity and the length of time involved. For the want of a more suitable basis, the pathological and radiological examinations were classified according to a specification prepared for the Nuffield Provincial Hospitals Trust's Experiment in Hospital Costing, made for the Ministry of Health. Apart from the Trust's costing experiments, this attempt by the Investigation appears to be the first to give a detailed account of

Table 69. All surgical operations performed in the Norwich Group of Hospitals during 1951: *The monthly number of operations, by specialty, for inpatients and outpatients; and total numbers and monthly average numbers for males and females separately*

	General surgery			*Gynaecology*			*Obstetrics*			*Orthopaedics*			*Ear, nose, and throat*			*Tonsils and adenoids*			*Ophthalmology*			*Dentistry*			*All specialties*		*Casualty*	*Total*
	I.P.	*O.P.*	*Total*	*I.P.*	*O.P.*	*Total*	*I.P.*	*O.P.*	*Total*	*I.P.*	*O.P.*	*Total*	*I.P.*	*O.P.*	*Total*	*I.P.*	*O.P.*	*Total*	*I.P.*	*O.P.*	*Total*	*I.P.*	*O.P.*	*Total*	*I.P.*	*O.P.*		
January	637	127	764	112	—	112	7	—	7	128	27	155	39	2	41	97	—	97	43	—	43	5	—	5	1,068	156	136	1,360
February	567	127	694	106	—	106	7	—	7	130	21	151	74	—	74	86	—	86	39	2	41	10	—	10	1,019	150	112	1,281
March	597	132	729	90	—	90	9	—	9	153	26	179	63	—	63	173	—	173	39	—	39	8	—	8	1,132	158	149	1,439
April	565	120	685	90	—	90	10	—	10	146	39	185	85	1	86	244	—	244	36	—	36	12	—	12	1,188	160	153	1,501
May	642	166	808	95	—	95	8	—	8	155	33	188	78	2	80	282	—	282	33	—	33	18	—	18	1,311	201	207	1,719
June	596	147	743	112	—	112	7	—	7	117	27	144	76	—	76	294	—	294	36	1	37	10	—	10	1,248	175	204	1,627
July	633	135	768	108	—	108	9	—	9	148	32	180	54	—	54	226	—	226	50	9	59	13	—	13	1,241	176	163	1,580
August	664	125	789	94	—	94	9	—	9	164	24	188	80	1	81	210	—	210	38	2	40	17	—	17	1,276	152	172	1,600
September	602	105	707	102	—	102	4	—	4	122	35	157	54	—	54	200	—	200	37	2	39	10	—	10	1,131	142	174	1,447
October	677	146	823	106	—	106	5	—	5	127	20	147	74	3	77	237	—	237	48	—	48	8	—	8	1,282	169	152	1,603
November	644	174	818	94	—	94	6	—	6	155	14	169	83	—	83	239	—	239	45	—	45	12	—	12	1,278	188	149	1,615
December	522	135	657	60	—	60	10	—	10	107	16	123	45	—	45	135	—	135	31	—	31	4	—	4	914	151	115	1,180
TOTAL FOR YEAR	7,346	1,639	8,985	1,169	—	1,169	91	—	91	1,652	314	1,966	805	9	814	2,423	—	2,423	475	16	491	127	—	127	14,088	1,978	1,886	17,952
Monthly Average	612	137	749	97	—	97	8	—	8	138	26	164	67	1	68	202	—	202	40	1	41	11	—	11	1,174	165	157	1,496
Male Patients																												
TOTAL FOR YEAR	3,410	1,143	4,553	—	—	—	—	—	—	909	166	1,075	463	5	468	1,200	—	1,200	230	12	242	64	—	64	6,276	1,326	1,140	8,742
Monthly Average	284	95	379	—	—	—	—	—	—	76	14	90	39	—	39	100	—	100	19	1	20	5	—	5	523	110	95	728
Female Patients																												
TOTAL FOR YEAR	3,936	496	4,432	1,169	—	1,169	91	—	91	743	148	891	342	4	346	1,223	—	1,223	245	4	249	63	—	63	7,812	652	746	9,210
Monthly Average	328	41	369	97	—	97	8	—	8	62	12	74	29	—	29	102	—	102	20	1	21	5	—	5	651	54	62	767

I.P. = Inpatients. O.P. = Outpatients.

the volume of work undertaken throughout a group by the special departments. Such information may serve as a starting-point in attempting to predict changes in the composition of the load borne by the special departments due to administrative adjustments, such, for example, as a reallocation of beds between different specialties.

The Operating Theatres

In 1951 there were altogether eighteen operating theatres in the seven acute general hospitals of the Norwich, Lowestoft, and Great Yarmouth Group included in the survey. Among these eighteen theatres there were nine theatres for general surgical cases, two for orthopaedic cases, two for ear, nose, and throat cases, one for obstetric cases, one for ophthalmic cases, one for infectious and septic cases, and two casualty theatres. *Table 69* shows, by specialty, the total number of operations performed in these theatres during each month of the year. Operations on inpatients and outpatients are shown separately.

A total of 17,952 operations were performed during the year 1951—14,088 on inpatients, 1,978 on outpatients, and 1,886 on patients attending the casualty department. Of all these operations, 8,742 were performed on male patients and 9,210 on female patients. The monthly average of operations was 1,496—1,174 on inpatients, 165 on outpatients, and 157 on patients attending the casualty department. In each of these groups of patients there were considerable variations in the number of operations performed each month, but a detailed analysis of the variation in the numbers of urgent operations performed would be necessary in order to assess trends in demand. As admissions from the waiting-list greatly outnumbered immediate admissions in all the surgical specialties, it seems probable that the variations recorded reflect chiefly administrative procedure. The most noticeable variation was in the number of operations for the removal of tonsils and adenoids. The average number performed each month was 202, but in January, February, March, and December the actual number was noticeably lower, while in April, May, and June it was higher.

Of the 14,088 operations on inpatients, 7,346 (52 per cent.) were for general surgical conditions. Because patients may have undergone more than one operation, it has been impossible to establish a direct correlation between the number of patients admitted and the number who received operative treatment during 1951. It is nevertheless interesting to compare the number of operations performed with the number of patients admitted to the various specialist beds. Thus 8,041 patients were admitted to the general surgical wards, and 7,346 operations were

Table 70. Surgical operations on children treated in the Norwich Group of Hospitals during 1951: *The numbers of operations done in each specialty related to children in different age groups, from under 1 year old to 14 years old*

(a) All Children

Age group	General surgery	Orthopaedics	Ear, nose, and throat	Tonsils and adenoids	Ophthalmology	Dentistry	All specialties
0–4 years	536	181	43	416	45	—	1,221
5–9 years	336	206	84	1,399	85	—	2,110
10–14 years	197	146	87	323	19	6	778
All ages	1,069	533	214	2,138	149	6	4,109

(b) Male Children

Age group	General surgery	Orthopaedics	Ear, nose, and throat	Tonsils and adenoids	Ophthalmology	Dentistry	All specialties
0–4 years	395	105	19	233	30	—	782
5–9 years	211	118	51	744	41	—	1,165
10–14 years	113	88	38	120	8	3	370
All ages	719	311	108	1,097	79	3	2,317

(c) Female Children

Age group	General surgery	Orthopaedics	Ear, nose, and throat	Tonsils and adenoids	Ophthalmology	Dentistry	All specialties
0–4 years	141	76	24	183	15	—	439
5–9 years	125	88	33	655	44	—	945
10–14 years	84	58	49	203	11	3	408
All ages	350	222	106	1,041	70	3	1,792

performed on these patients. Assuming that only a small proportion were operated upon more than once, this means that approximately 91 per cent. of the patients admitted received operative treatment. Similarly 1,169 (99 per cent.) out of 1,176 patients admitted to the gynaecological beds received operative treatment.

Three thousand five hundred and ninety-four patients were admitted to the ear, nose, and throat wards, and 3,228 operations were performed, which means that 90 per cent. of these patients received some form of operative treatment. Two thousand five hundred and sixteen patients were admitted for the removal of tonsils and adenoids and 2,423 tonsillectomies and adenoidectomies were performed. Ninety-nine per cent. of the patients admitted for dentistry and 90 per cent. of the patients admitted to the ophthalmic beds received operative treatment.

Ninety-one operations were performed on the 2,330 patients admitted to obstetric beds.

Eighty-three per cent. of all operations on outpatients were for the treatment of general surgical conditions; 16 per cent. were for the treatment of orthopaedic conditions and the remaining 1 per cent. was for the treatment of ophthalmic, and ear, nose, and throat conditions. Nearly twice as many males as females received operative treatment in the outpatient and casualty departments and this probably reflected the higher accident rate among men—1,326 operations were performed on male outpatients and 1,140 on male casualty patients, as compared with 652 on female outpatients and 746 on female casualty patients.

Table 70 shows, by specialty, the number of operations performed on children in the age groups 0–4 years, 5–9 years, and 10–14 years; all were admitted to hospital. Of the 4,109 operations performed, more than half related to children in the age group of 5–9 years, and 29 per cent. to children in the age group 10–14 years. Of all the operations performed on inpatients during 1951, 15 per cent. of the general surgical operations, 88 per cent. of the operations for removal of tonsils and adenoids, 27 per cent. of all other ear, nose, and throat operations, 32 per cent. of the orthopaedic operations, and 31 per cent. of all the ophthalmic operations were performed on children of 14 years or under. A considerably higher proportion of operations were performed on boys than on girls and this reflects the higher admission rate of boys. Three thousand and thirty-six boys were admitted to hospitals in the group during 1951, and 2,317 operations were performed on them, as compared with 2,412 girls admitted on whom 1,792 operations were performed. This difference appears in all specialties, with the exception of ear, nose, and throat and dentistry, but it is most noticeable in general surgery.

When the numbers of operations performed are related to the total numbers of patients admitted, it appears that during 1951 two out of three adults received operative treatment, and three out of every four children aged 14 years or under who were admitted received operative treatment. One out of every 18 new patients attending the consultative outpatient clinics and one out of every 15 new patients attending the casualty departments received operative treatment without being admitted to a bed.

Department of Radiology

A total of 39,050 radiological examinations were made, 6,926 on inpatients and 32,124 on outpatients (see *Table 71*). The average number of examinations each week was 751—133 on inpatients and 618 on outpatients. There were considerable variations in the number of examinations performed each month: the average number was 3,254, the maximum number was 3,765 in April and the minimum 2,592 in December. These variations did not seem to be directly related to variations in the number of patients admitted or of new outpatients attending the consultative clinics.

As might perhaps be expected, the casualty department was the source of the greatest number of patients referred for radiodiagnostic examinations—27 per cent. of all examinations performed during the year. The orthopaedic department put the next greatest load on the radiodiagnostic department with 17 per cent. of all examinations. General medicine gave rise to 14 per cent. of the total radiodiagnostic load, general surgery to 13 per cent., and ear, nose, and throat cases to 10 per cent. Although general practitioners were free to refer patients directly to

Table 71. Classified diagnostic X-ray examinations: *Numbers of examinations done for inpatients and for outpatients in each specialty in the Norwich Group of Hospitals during 1951*

Type of examination	General medicine		General surgery		Ortho-paedics and fractures		Ear, nose, and throat		Gynae-cology and obstetrics		Paediat-rics		Derma-tology		Ophthal-mology		Dentistry		Referred by general practitioners		Chest clinic		Referred from other hospitals		Referred from casualty		Miscel-laneous (RAF and staff)		Chronic sick		Other radiology		Total		
	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	I.P.	O.P.	Total
A	723	716	737	650	1,372	3,651	56	1,223	119	240	101	243	—	6	4	1	—	—	3	1,682	—	1,130	2	212	—	8,020	2	194	89	—	7	47	3,215	18,015	21,230
B	751	1,643	802	673	205	851	198	1,452	149	256	64	64	—	14	—	14	1	18	—	342	—	1,071	—	16	—	2,186	1	255	6	—	19	99	2,196	8,954	11,150
C	107	263	159	83	19	20	152	756	6	3	17	38	1	7	6	14	2	8	—	32	—	1	—	5	—	348	—	29	4	—	4	11	477	1,618	2,095
D	38	164	95	362	57	288	10	22	15	7	4	1	2	—	1	7	4	71	—	7	—	—	—	—	—	49	—	38	—	—	3	11	229	1,027	1,256
E	233	824	337	1,235	26	7	13	51	8	8	10	11	4	1	—	—	—	—	—	29	—	—	—	7	—	21	—	2	9	—	5	21	645	2,217	2,862
F	54	106	37	78	57	4	1	13	2	2	5	—	—	—	—	—	—	—	—	66	—	1	—	4	—	11	—	—	—	—	—	4	156	289	445
G	7	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	8	4	12
Total Inpatients	1,913		2,167		1,736		431		299		201		7		11		7		3		—		2		—		3		108		38		6,926		
Total Outpatients	3,718		3,081		4,821		3,517		516		357		28		36		97		2,158		2,203		244		10,635		518		—		195		32,124		
TOTAL ALL PATIENTS	5,631		5,248		6,557		3,948		815		558		35		47		104		2,161		2,203		246		10,635		521		108		233		39,050		

I.P. = Inpatients. O.P. = Outpatients.

the department, less than 6 per cent. of all the examinations were made at their request.

The appropriate scale of provision for the radiodiagnostic department may be arrived at by analysing, specialty by specialty, the number of examinations done for all inpatients and outpatients receiving hospital care during a defined period of time. The ratio between the total number of examinations done and the numbers of inpatients and outpatients can be illustrated as follows. Two examinations were made for every three patients admitted to general medical beds, and one examination was made for every four attendances at general medical outpatient clinics. One examination was made for every four patients admitted to general surgical beds, and one examination was made for every eight attendances at general surgical clinics. Approximately three examinations were made for every two patients admitted to orthopaedic beds, and one examination was made for every four attendances at orthopaedic and fracture clinics. Examples from other departments were:

Ear, nose, and throat	1 examination for every	8 inpatients
	1 ,, ,,	3 outpatient attendances
Gynaecology and obstetrics	1 ,, ,,	12 inpatients
	1 ,, ,,	19 outpatient attendances
Dermatology	1 ,, ,,	10 inpatients
	1 ,, ,,	28 outpatient attendances
Ophthalmology	1 examination for every	48 inpatients
	1 ,, ,,	295 outpatient attendances
Dentistry	1 ,, ,,	18 inpatients
	1 ,, ,,	5 outpatient attendances
Casualty	1 ,, ,,	6 attendances

As an instance of the use to which such information may be put, it might be deduced that an increase in the attendances at general medical outpatient clinics would lead to a greater load falling upon the radiodiagnostic department than would a corresponding increase in the attendances at general surgical clinics.

Although the kind of information collected by the Investigation indicates the extent of the load put upon the department of radiology by the various specialties, it is not by itself sufficient to determine the size of the department needed to deal with that load. The nature and complexity of the examinations must be considered as well as the actual number. An attempt was therefore made to classify each examination according to the degree of complexity and the length of time needed to perform it.* *Table 72* shows examinations classified according to a unit of cost for inpatients and outpatients in each specialty, and for patients referred from other hospitals and by general practitioners. Twenty-seven per cent. of all the examinations were occasioned by patients referred from the casualty department, but of these 75 per cent. of the total number (8,020) were simple examinations—mainly for suspected fractures—which rated only one unit. Medical and surgical cases, on the other hand, gave rise to highly complex examinations, although the total number was much smaller—only 26 per cent. of these examinations rated a value of one unit.

* The Investigation adopted the classification used in the Nuffield Provincial Hospitals Trust's Experiment in Hospital Costing undertaken, with the King's Fund, for the Ministry of Health. This classification is shown in *Table 72*. It was prepared by a panel drawn from the Faculty of Radiologists.

Department of Pathology

Table 73 shows for each specialty the *actual* number of pathological tests made on account of inpatients and outpatients during every fourth week throughout the year 1951 (beginning with the week 1–7 January) and the *average* number made each week. Most of the work related to inpatients.* The average weekly number of pathological examinations made for outpatients was only 174, as compared with 460 for inpatients.

General medicine put a greater load on the department of pathology than did any other specialty, even though the number of patients receiving general surgical care exceeded those receiving general medical care. An average

* In the department of radiology, on the contrary, most of the work related to outpatients and casualty patients—32,124 examinations (82 per cent.) out of the total of 39,050 done during 1951.

Table 72. Diagnostic X-ray examinations: *Key to the grouping of examinations classified according to the nature of the work and its rating in units of cost.*

A (1 unit)	Chest, without screening Chest (miniature) Extremities, one area Foreign body, demonstration of Gall-bladder, plain Pelvis Teeth, one area
B (2 units)	Abdomen, plain Chest, with screening Foreign body, localization of Jaws Pregnancy, demonstration of Salivary glands Sinuses, frontals and antra Spine, one area Urinary tract, plain
C (3 units)	Abdomen, with screening Cholangiography Fistula, injection of contrast media Kymography Mastoid and petrous temporal bones Sinuses, complete Skull
D (4 units)	Cephalo-pelvimetry Cholecystography Cystography Foreign body in the eye, localization of Hysterosalpingography Sialography Spine, more than one area Teeth (all) Urethrography Urography (instrumental)
E (6 units)	Arteriography Arthrography Barium meal, oesophagus Barium meal, stomach and duodenum Barium enema Cineradiography (1 investigation) Tomography Urography (intravenous) Venography
F (8 units)	Aortography Barium meal, small intestine Barium meal, full Bronchography Encephalography Myelography Smith Petersen pin, insertion of and similar procedures Ventriculography
G (10 units)	Angiocardiography Cardiac catheterization

of 306 tests a week were carried out in connexion with general medical cases, of which on average 211 were for inpatients and 95 for outpatients. For general surgery the corresponding figures were an average total of 182 a week, of which 161 were for inpatients and 21 for outpatients.

The facilities to be provided in the department of pathology depend not only on the number of tests but also on their nature and the facilities and time needed to do them. The recorded tests for the year 1951 were therefore classified according to a specification prepared by the Central Pathological Advisory Committee of the Central Health Services Council of the Ministry of Health in connexion with the Nuffield Provincial Hospitals Trust's Experiment in Hospital Costing. This analysis showed that of all the tests done during 1951 (9,948) nearly half (4,820) could be classified within four groups: microscopic examinations of specimens, urine tests, estimations of haemoglobin, and erythrocyte sedimentation rates.

Discussion

In analysing and comparing the recorded load of acute cases borne in the course of a year by hospitals in the Northampton Group and the Norwich, Lowestoft, and Great Yarmouth Group (see *Table 74*), the Investigation found the similarities in the demand, and in the provision needed to satisfy it, more striking than the differences. The correspondence was particularly close for inpatients in the two principal fields of hospital activity, general medicine and general surgery, which in each group together accounted for about half the total number of admissions during the year under review. The estimated critical number of medical beds was 0·430 per thousand of the effective population in the Northampton Group and 0·434 in the Norwich Group; the estimated critical number of general surgical beds was identical for both groups—0·689 per thousand. Among the specialties the critical number of beds needed for ear, nose, and throat cases (including tonsils and adenoids) was 0·117 at Northampton and 0·122 at Norwich; in each group these cases accounted for about one-fifth of all admissions.

Although parallels between the estimated critical numbers of beds were not so close in other specialties, an analogous pattern of demand was evident, except in the case of gynaecology where the demand at Northampton was nearly double that in the Norwich Group. It was noticeable that in both groups the demand for gynaecological and ophthalmic beds was appreciably greater than the number provided, but despite these and some other, smaller, deficiencies in the number of beds for particular specialties, both groups were meeting the overall demand for beds with considerable success. Assuming a bed occupancy of 85 per cent. (the corresponding figures for other occupancies are easily calculated) the estimated *critical number* of all kinds of acute beds for each thousand of the population was about 2 in both areas (Northampton *1·905*, Norwich *1·934*). The *actual number* of beds for the acutely sick (including paying patients) provided by the Northampton Group in 1950 was 2·0, and the number in the Norwich Group in 1951 was 2·1. The estimated critical number of beds allows no safety margin in the size of the bed complement and on that account some addition is necessary (cf. pp. 153–4); but having regard to the size of the effective population of Northampton and Norwich, the total number of beds provided appeared to be sufficiently greater than the estimated critical number without addition, although in both groups some adjustment was evidently needed in the allocation of beds among the various specialties. The number of acute beds per thousand of the population found in the Northampton and Norwich Groups (2·0 at Northampton and 2·1 at Norwich) is much smaller than the numbers often suggested as being necessary (cf. pp. 149–50).

In the surveys at both Northampton and Norwich the Investigation found that seasonal differences in the demand for beds and for outpatient consultation were far smaller than had been expected, and some of the variations indeed seemed to be attributable to administrative rather than to medical causes. General medicine was an exception. In both hospital groups there was an appreciable increase in the demand for inpatient care during the winter months not accounted for by admission policy. In the Norwich Group there was also an increase in the demand for general surgical inpatient care during the winter.

The surveys brought out clearly the well-known preponderance of immediate admissions over admissions from the waiting-list in the department of general medicine. At Northampton 85 per cent. of all adult patients and 94 per cent. of all children admitted to general medical beds were admitted immediately. In the department of general surgery 59 per cent. of all admissions were immediate.

Some not wholly unexpected differences in age and sex were also found in the demand for hospital care. The

Table 73. All pathological tests made in connexion with inpatients and outpatients in the Norwich Group of Hospitals in 1951, and in addition tests made on behalf of hospitals outside the Norwich Group and for the medical officer of health: *The actual numbers of tests done during each fourth week throughout the year (beginning 1–7 Jan.) for each specialty, with average weekly numbers*

		1–7 Jan.	*24 Jan.–4 Feb.*	*26 Feb.–4 Mar.*	*26 Mar.–1 Apr.*	*23–29 Apr.*	*21–27 May*	*17–24 June*	*16–22 July*	*13–19 Aug.*	*10–16 Sept.*	*8–14 Oct.*	*5–11 Nov.*	*3–9 Dec.*	*Total number of tests performed*	*Average number of tests performed weekly*
General surgery	I.P.	128	110	117	159	178	140	203	149	137	140	228	186	221	2,096	161
	O.P.	24	27	33	10	20	19	25	27	17	17	22	12	22	275	21
	Total	152	137	150	169	198	159	228	176	154	157	250	198	243	2,371	182
General medicine	I.P.	217	242	250	157	223	200	170	177	191	180	259	268	205	2,739	211
	O.P.	84	79	92	99	109	134	93	101	84	101	108	57	96	1,237	95
	Total	301	321	342	256	332	334	263	278	275	281	367	325	301	3,976	306
Ear, nose and throat	I.P.	5	14	5	6	14	15	6	8	9	13	2	17	10	124	10
	O.P.	—	6	7	8	3	—	2	—	4	1	1	6	4	42	3
	Total	5	20	12	14	17	15	8	8	13	14	3	23	14	166	13
Obstetrics and gynaecology	I.P.	42	35	61	27	26	61	36	20	38	47	34	37	28	492	38
	O.P.	31	17	28	20	22	25	10	20	5	19	4	20	15	236	18
	Total	73	52	89	47	48	86	46	40	43	66	38	57	43	728	56
Orthopaedics	I.P.	29	20	22	36	28	22	24	19	30	28	26	5	16	305	23
	O.P.	4	9	1	11	7	3	5	7	5	5	8	6	5	76	6
	Total	33	29	23	47	35	25	29	26	35	33	34	11	21	381	29
Dermatology	I.P.	—	2	2	—	—	6	—	—	2	1	—	1	—	14	1
	O.P.	1	2	8	5	4	10	2	3	4	4	6	—	5	54	4
	Total	1	4	10	5	4	16	2	3	6	5	6	1	5	68	5
Ophthalmology	I.P.	4	1	8	1	2	—	—	3	3	4	2	4	—	32	2
	O.P.	6	7	1	4	10	1	—	3	3	—	1	2	4	42	3
	Total	10	8	9	5	12	1	—	6	6	4	3	6	4	74	5
Radiotherapy	I.P.	16	6	6	6	—	5	—	3	—	1	—	1	10	54	4
	O.P.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Total	16	6	6	6	—	5	—	3	—	1	—	1	10	54	4
Dentistry	I.P.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	O.P.	1	—	2	—	—	—	—	1	—	2	—	1	1	8	1
	Total	1	—	2	—	—	—	—	1	—	2	—	1	1	8	1
Chronic sick	I.P.	2	5	1	6	16	12	24	13	6	—	5	9	10	109	8
Paediatrics	I.P.	6	2	1	—	—	—	2	—	—	1	3	—	3	18	1
	O.P.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Total	6	2	1	—	—	—	2	—	—	1	3	—	3	18	1
Chest clinic	O.P.	12	37	34	14	28	35	30	14	5	2	24	23	38	296	23
TOTALS	I.P.	449	437	473	398	487	461	465	392	416	415	559	528	503	5,983	460
	O.P.	163	184	206	171	203	227	167	176	127	151	174	127	190	2,266	174
Total number of tests made for hospitals of the group by their own departments		612	621	679	569	690	688	632	568	543	566	733	655	693	8,249	634
Additional tests made at the main hospital for hospitals inside the group		79	120	86	132	165	89	79	116	140	84	101	103	109	1,403	108
Tests made in the group for hospitals outside the group and for the medical officer of health		21	12	17	23	23	31	27	22	20	18	15	23	44	296	23
Total number of tests made		712	753	782	724	878	808	738	706	703	668	849	781	846	9,948	765

Table 74. Northampton and Norwich Groups of Hospitals: *The demand for acute beds arising from the effective populations of the two groups (derived from the hospital records for 1950 and 1951 respectively)*

Specialty	Critical number of beds at an 85% occupancy per 1,000 of the effective population: Northampton	Norwich	Remarks
General medicine	0·274 } 0·430	0·434 { No separate figures	Close
Paediatrics	0·135		
Dermatology	0·021		
General surgery	0·689	0·689	Identical
Gynaecology	0·211	0·107	—
Obstetrics	0·269	0·204	—
Orthopaedics	—	0·232	—
Fractures	0·066	0·073	Similar
Ophthalmology	0·072	0·059	Similar
Ear, nose, and throat	0·117 } No separate figures	0·068 } 0·122	Close
Tonsils and adenoids		0·054	
Radiotherapy	0·051	0·011	
Dentistry	Included in general surgery	Included in ear, nose, and throat	
Venereology	—	0·003	
TOTAL	1·905	1·934	

Note.—When all specialties are considered together the numbers of beds required per 1,000 of the effective population are respectively 1·883 and 1·919 for an 85% occupancy.

average length of stay of children, for instance, tended to be shorter than that of adults, particularly in medical and general surgical beds. In the department of traumatic and orthopaedic surgery in the Norwich Group during 1951, twice as many boys as girls were admitted. The number of men and women admitted to these beds was about equal, but the average length of stay was longer for women. In the department of general surgery in the Norwich Group there were fewer immediate admissions among women than among men and among children. In the department of general medicine slightly more men than women were admitted to beds and their average length of stay was a little longer.

These factors—a high proportion of immediate admissions, seasonal fluctuations in demand, differences in the requirements of men, women, and children, and deliberate alterations in admission policy—all confirm the need to plan hospitals so that beds can be grouped together in small, more or less self-contained, units. If this is done then beds can with greater facility be reallocated between the sexes, between different age groups, and, to a certain extent, between different specialties as changes in the demand or in administrative policy may require.

The Investigation found that existing hospital records, even in the dispersed form in which they are usually kept,* provided adequate case-load data, and the methods evolved in surveying demand and provision in the Northampton and Norwich Groups should therefore be readily applicable to other hospital groups. Relating demand to population certainly entails compiling and analysing a sample of patients' addresses, but the Investigation's techniques for establishing the size and location of the effective population are not difficult to use (see pp. 156–7).

The various methods of analysis described above will reveal in precise terms *actual* conditions of sufficiency as well as of deficiency in provision for each of the various departments of the hospital or group of hospitals, with supplementary information about the particular needs of each sex and of the different age groups. The Investigation is still working on a method of showing, by specialty, the particular localities from which the demand arose in the geographical area containing the effective population.

The Investigation's techniques enable the number of beds which would be required for any chosen rate of occupancy to be determined with a high degree of accuracy. For the purposes of this report the Investigation has generally postulated an occupancy rate of 85 per cent., but, as is stated in a memorandum on the more effective use of beds, published by the Ministry of Health in October 1954, 'a number of hospitals—teaching and non-teaching—have shown by experience in recent years that a figure of over 90 per cent. occupancy is practicable'.[28]

In deciding upon the number of outpatient sessions needed to meet the demand, a decisive factor is the actual average consulting-times of the doctors concerned. The Investigation has shown, however, that approximate average consulting-times can be predicted for each of the various specialties (see *Table 14*, p. 37), and such estimates can be used in making preliminary forecasts of the number of sessions required.

The Northampton Group of Hospitals and the Norwich, Lowestoft, and Great Yarmouth Group were chosen for the surveys because their circumstances appeared to be at once comparatively simple and directly comparable. Nevertheless, the Investigation had not expected to find so close a correspondence either in the recorded demand for the services of the various hospital departments or in the estimations of what was needed to satisfy that demand. The discovery that the pattern of demand in the two groups was similar and in some important instances nearly identical is interesting. It may well be that other patterns of demand could be established for hospital groups differently situated from the two surveyed by the Investigation but comparable one with another. A series of studies like those made at Northampton and Norwich, if they could be undertaken in different hospital regions, might furnish important demographic information, with precise data about the nature and provenance of the demand for the various hospital services. Though this kind of information would undoubtedly be valuable in assessing trends in hospital care and in allowing forecasts to be made about the nature and scope of hospital provision, it seems likely that an *ad hoc* case-load survey with evaluation of the results by the medical staff and administrative officers concerned would always need to be undertaken before any major hospital planning project was begun in detail.

* The chief difficulty which the Investigation experienced in collecting information from the records was that in almost all the hospitals concerned, various particulars about each patient had to be picked out and pieced together from several registers (usually four or more). These were compiled and kept in different departments of the hospital—for example, by the records officer, casualty sister, ward sister, and theatre sister. The Investigation found one hospital in the Norwich Group already recording all particulars about each patient in a single, easily accessible register. As the result of experience gained during the Investigation's study, another hospital in the group adopted a similar system. It was evident that the unified method of recording, besides expediting the study of demand and provision, would greatly reduce the chances of errors and discrepancies occurring in compiling the annual statistics required by the Ministry of Health.

SUMMARY

The need for planning all hospital facilities so that they are readily accessible to the community has been recognized for more than half a century; but for many reasons effective co-ordination could not be brought about until after the National Health Service began to operate in July 1948. Since then each individual hospital has to a greater or lesser degree tended to become merged in the group of hospitals to which it belongs.

The Investigation believed that it would be useful to study the whole load of acute cases requiring hospital care which arose in a delimited community during one year and was borne more or less exclusively by a single group of hospitals. The group which seemed best to meet the requirements for such a study was the Northampton Group of Hospitals. The work of collecting information about the load of acute cases was begun in 1951, and the year chosen for survey was 1950.

The methods finally evolved for collecting and analysing the data were as follows. All inpatient admissions and discharges were recorded by specialty, sex, and age, from the hospital records for each month of the year (so that seasonal variations might be noted). The monthly decrease or increase in the waiting-list for each specialty was also recorded; so were the lengths of stay of patients discharged. These data were taken as showing the *demand* for hospital care, and they were used to estimate the critical number of beds for different rates of occupancy. From the critical numbers the actual numbers of beds needed fully to meet the demand could be calculated. The Investigation also analysed by specialty the records of outpatient attendances, separating the numbers of patients attending clinics for the first time from the numbers of patients reattending. The total number of tests and examinations made in the departments of pathology and radiodiagnosis, and the numbers of surgical operations performed, were related to the numbers of inpatients and outpatients occasioning them. Using information supplied by the Registrar General a method was devised for estimating the effective population at risk.

No general conclusions could properly be distinguished from the results of a study of one year's load of cases relating to a single group of hospitals. In the time remaining to the Investigation and with the resources available it was feasible to make one more similar study. To validate comparison as completely as possible the Investigation needed for the second study a group of hospitals as similar in all respects to the Northampton Group as could be found. The Norwich, Lowestoft, and Great Yarmouth Group fulfilled that requirement. The year studied in the Norwich Survey was 1951.

In connexion with the Norwich study, Professor A. L. Banks (of the Department of Human Ecology in the University of Cambridge) on behalf of the Investigation asked each consultant whose department had been surveyed to assess the results; the opinions of general practitioners on the adequacy of the hospital facilities available to them were also sought.

When the final results of the Northampton and Norwich surveys were compared the similarities in the pattern of the recorded demand and in the scale of provision to meet it were more remarkable than the differences. Both groups of hospitals were found to be meeting the total demand for acute beds satisfactorily; both needed some reallocation of beds between specialties.

More hospital case-load surveys, if they could be done region by region for the whole country, might be expected to yield important demographic information and would certainly throw light upon trends in hospital care in the community. But in detail the results of each survey would be applicable only in the local context. For direct planning purposes, whether in modifying existing hospital facilities or in establishing new ones, an *ad hoc* survey must usually be undertaken. In every case the findings need interpretation, at the time, by the medical and administrative officers concerned, in the light of their special knowledge of current conditions and requirements in that area.

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