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The Impact of New Technologies on Future Primary Care

Edited by
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PROCEEDINGS OF A SEMINAR AT THE NUFFIELD TRUST
1ST FEBRUARY 2000

The background to this seminar is the long-standing interest of the Nuffield Trust in primary care, not least in its support of the annual John Fry Fellowship, awarded for a lecture on a subject in the field of general practice and primary health care. The Trust also believes that primary care is at the heart of the health service in line with the stated objectives of the government's reform agenda for the NHS.[1-3] Finally, the Trust's "Policy Futures for UK Health" project is evidence that looking to the future is one of the Trust's key objectives.

With that stated interest in mind, the Trust invited Professor Aly Rashid from the Department of Health and Continuing Professional Studies at De Montfort University to lead a seminar focusing on new technologies and their influence on primary care.

The seminar was attended by an invited audience of leading contributors in UK health care and included representation from the Royal Colleges, the Department of Health and the NHS Executive.

The format of the seminar was the demonstration of some new technologies followed by discussion on the possible impact of such advances on the delivery of primary health care.

It is hoped that this record of the proceedings will inform the development of primary care in the future.

EDITOR'S ACKNOWLEDGEMENTS

The editor wishes to thank the following:- Welch Allyn Inc. for allowing us to share their work at the forefront of primary care development. The company has a particular interest in miniaturising technology, which has only to date been available in the secondary sector, making it both portable and easy to use in the primary care environment. This workshop took place because of the vision of John Wyn Owen in recognising the potential for new technologies as primary care takes centre stage in the new NHS. Thanks are also due to Mr Eric Allyn, Mr Richard Newman and Mr John Morrish for their non-promotional approach. Dr Andrew Sharp for sharing his ground-breaking Visual Read electronic patient record and to Dr Mark Atkinson for vital technical support without which it would not have been possible to demonstrate the technologies.

The following people contributed to discussion that has informed the contents of this publication.

- Mr John Wyn Owen, Secretary, The Nuffield Trust

- Professor Sir George Alberti, President of the Royal College of Physicians

- Dr Maureen Baker, Secretary of Council, Royal College of General Practitioners

- Mr Alistair Liddell, Head of Policy, NHS Executive, London

- Mrs Sue Norman, Chief Executive and Registrar, UKCC

- Mr Mark Jones, Primary Care Policy Adviser, Royal College of Nursing

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- Mr John Morrish, Managing Director Europe, Middle East and Africa, Welch Allyn UK
- Mr Howard Croft, Director of Medical Publishing, Blackwell Science Ltd
- Dr Nick Salfield, Deputy Director of Public Health, NHS Executive Trent
- Ms Debbie Lee, Nursing Officer, Department of Health
- Dr James Ford, Senior Medical Officer, Primary Care Division, NHS Executive, Leeds

FOREWORD

Since its inception the Nuffield Trust has identified individuals and subjects that would impact on health and health care policy in the UK. Further it has provided opportunities for exchange and discussion of new ideas and new knowledge which can contribute to the achievement of better health and healthcare for the people of the UK. A major contribution to this is the Trust's Policy Futures project examining the future environment for UK health with a time horizon of 2015. As part of this work one of the ten technical papers was on Science and Technology and illustrates how technologies will influence the location of health care with more and more treatment and monitoring able to take place outside the hospital. Further technology will shift the boundaries of health professions as they take new roles in new settings.

This report of a seminar is a contribution of the impact of new technologies on the future of primary care.

John Wyn Owen, CB
London: July 2000

SUMMARY

In the United Kingdom the National Health Service (NHS) attempts to predict the impact of new technologies on health care through the 'early warning' system within its Health Technology Assessment (HTA) programme. The reality is that many technologies which show potential for commercial exploitation are then shrouded in secrecy for fear of jeopardising patents. New technologies may therefore not come to the attention of the HTA programme until development is complete. The technologies presented at this seminar probably represent a tiny fraction of what is out there.

This seminar examined the impact of miniaturising the colour video-camera to less than one centimetre enabling video-otoscopy, video-ophthalmoscopy and video epicoscopy (visualising skin lesions). Video sequences or stills can be captured and transmitted without loss of resolution, possibly obviating the need for an initial consultation in secondary care. This case is particularly well illustrated in the instance of patients presenting with ear problems when a video sequence of the ear canal and drum can be combined with audiometric and tympanometric results and e-mailed to a consultant.

Other technologies were described which are 2-5 years from the health care market. These included micro-sensors which can identify bacteria or viruses and drugs to which these organisms might be sensitive, and the 'optical' biopsy which enables tissue diagnosis at cellular level for epithelial lesions (cervix and skin) without the need to take a tissue sample.

Primary Care Groups and Trusts facing increasing demands from patients and rising costs in commissioning secondary and tertiary care are under some pressure to look at innovative ways of making

savings.[4,5] One obvious route may be to exploit new technologies which enable safe management of patients in primary care, avoiding unnecessary expensive referrals to hospital.

The second part of the seminar showed how information can be entered into an electronic health record using anatomical images. The advantage of this approach is that it allows data from each consultation to be appropriately coded so that clinical audit and decision making in enhancing patient care becomes more meaningful.

Inevitably many of these technological advances will lead to changes in roles within healthcare provision, with greater levels of skill mix which may have significant social consequences.

The following quotation emphasises the imperative need to evaluate each technology thoroughly.

> *"Technology has the power to mesmerise. The desire to possess the latest gadget and the fear of being left behind in a technological revolution may prove irresistible to some."*[6]

INTRODUCTION

"Policy Futures for UK Health[7-16] examined the future environment for UK health with a time horizon of 2015. Amongst the issues discussed were the implications of trends in science and technology for health care,[10] health economics,[11] organisation and management, and the health workforce[14] and are of particular relevance to the seminar.

The Science and Technology publication in this series[10] envisaged the growing importance of technologies for health screening and the capture and transmission of visual images facilitating diagnosis and treatment, so blurring the distinctions between primary, secondary and tertiary care. What may not have been predictable was the rapidity with which some of these developments might be introduced within health care[17,18] despite the establishment of early warning systems for identification prior to widespread adoption in the UK.[19-21]

During the seminar Professor Alberti confirmed that medical student teaching in UK medical schools in ENT, ophthalmology and dermatology remains limited. This is also the case in general practitioner training with few GP registrars having opportunities to engage in rotations which include ENT, ophthalmology or dermatology, (Dr J Allen, Secretary of the Joint Committee on Postgraduate GP education in general practice - personal communication).

The technologies presented at this seminar are broadly categorised into three groups:

1. Miniaturised systems currently available

Software was demonstrated at the seminar that operates with miniature colour video cameras which are self focussing and work in the poorest of light conditions. This technology enables picture archiving of the eardrum, skin lesions and retina of the highest quality and these records can be accompanied by the storage of recorded speech for electronic transmission between primary and secondary or tertiary care.

A further two technologies demonstrated were miniaturised systems of equipment which have to date mainly been available within a secondary care environment. A hand held otoacoustic emission audiometer allows assessment of the sensorineural pathway for hearing without feedback from the patient. A hand held vision screener allows the exact refractive error in adult or children's eyes to be determined without the need for patient feedback.

2. Technologies impacting on primary care in the next 2-3 years

In addition to the above technologies which are currently available, there was discussion on two technologies of the future; the 'optical biopsy' which allows tissue diagnosis at cellular level without the need to take actual tissue sample, and 'sniff-technology' which allows clinicians to distinguish between bacteria and viruses using micro-sensor odour detection.

All of these technologies either alone or in combination are likely to impact on the health service by potentially offering lower cost screening, improved clinical outcome, a decreased use of secondary care and improved patient and provider satisfaction. UK Primary care is relatively (at present) ill equipped to operate without referral to other sectors. The strain on secondary and tertiary care as evidenced by waiting lists for treatment underlines the urgent need to adopt this new approach.[22] Four criteria for the technologies and their impact on primary care identified at the seminar include accuracy, ease of use, portability and affordability.

3. The Electronic Health Records

The seminar also concentrated on a unique visual interface that generates a coded patient record based on anatomical drawings. Such electronic patient record keeping would allow more accurate clinical audit through improved data input, thus enhancing quality in health care provision.

These individual technologies mentioned in categories 1 and 2 above are now described in more detail with a discussion of the potential benefits of their use in combination. The final section describes the concept of electronic health records and discusses some of the issues raised if this technology is implemented.

THE NEW TECHNOLOGIES AND THEIR POTENTIAL IN PRIMARY CARE

Video Imaging: general issues

The miniaturisation of the video camera means that it is now possible to have a colour video camera measuring less that 1cm sq working in the poorest of light environments. Such video cameras are integral to the video otoscope, dermatoscope (episcope) and ophthalmoscope, and produce images of the eardrum, skin lesions and the retina respectively, which are both crisp and dramatic. (Video cameras miniaturised to less than 5mm are currently under development which will further enhance their uses in medicine.) These video images can either be captured as stills or as full motion video, being recorded at one site and then electronically transmitted to another site enabling conferencing in telemedical examination procedures, distance learning applications, long distance referrals or image management for the electronic patient record. The video otoscope and dermatoscope require very little skill to use; indeed it is perfectly possible for patients to visualise their own eardrums on a monitor or to magnify or see skin lesions that would be difficult to see with the naked eye.

The Video Ophthalmoscope

The video ophthalmoscope needs to be used by an experienced clinician and has particular applications in teaching. How many times have teachers asked medical students or inexperienced doctors to look at the retina and not been able to see what the student is viewing? Such difficulties may now be consigned to history and student teaching of ophthalmoscopy enhanced (see Figure 1).

The case of **diabetes** was used to discuss implications of this technology. The criteria of cost per number of patients reached in the community was proposed as a measure of effectiveness. As one participant stated, "What is the advantage of allowing the frontline

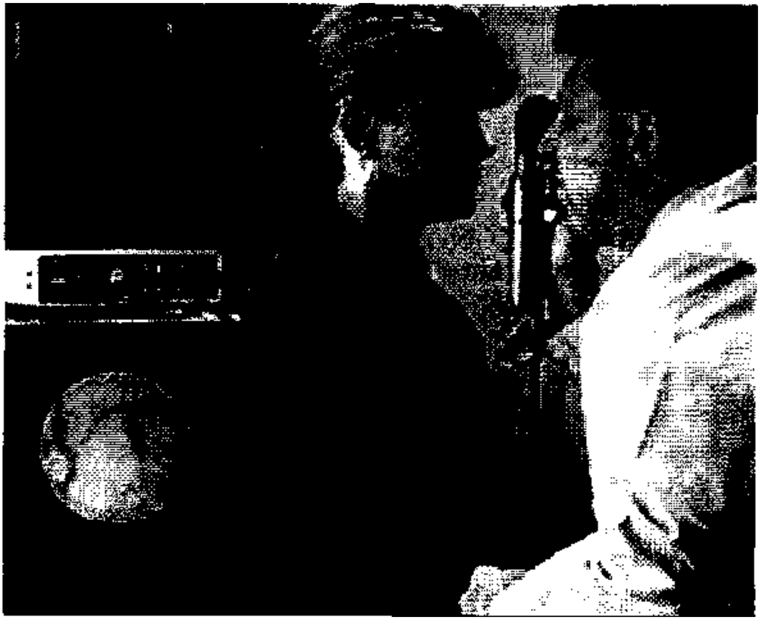

Figure 1. Video ophthalmoscope in use

physician to operate this system over the current systems of diabetic screening where a van travels round and takes annual pictures of the retina of diabetic patients living in a given area?" Some questions about the value of the technology were raised in discussion. Whilst mass screening for diabetic retinopathy may be best carried out using a still camera set-up in a van, many areas do not have such a system, particularly rural areas. Some patients (often those in greatest need for screening) slip through the net because they didn't bother attending for screening and needed to be picked up opportunistically within primary health care.[23] It is known that ophthalmologists are best at viewing and treating diabetic retinopathy.[24] The video ophthalmoscope allows a video sequence of the whole fundus to be stored and sent electronically to the ophthalmologist, a significant advance over current visualisation and recording methods.

It was pointed out however, that the ophthalmoscope was not used solely for the purposes of diabetic screening in primary care and had other applications such as assessment of the retina for macular degeneration, assessment of cupping of the optic disc in glaucoma or blurring the disc margins in papilledema or for changes in hypertensive retinopathy. If the general practitioner was unsure of the diagnosis in any of these areas, retinal images could be stored along with an electronic voice history and sent to the ophthalmologist electronically. Such an approach could act as a filter with patients only being seen in secondary care, if appropriate. Whilst the current video ophthalmoscope has a wider field of vision than a normal ophthalmoscope the field is still limited to about 25 degrees. In the near future we can look forward to a video ophthalmoscope which has a field of view extending to 45 degrees thereby enabling pathology at the back of the eye to be seen more rapidly and without the need for pupil dilation.

The Video Otoscope

It is now possible to store electronically the visual record of a patient's eardrum and ear canal (still or video sequence images) picking up pathology which the GP may not be able to diagnose (See Figure 2). It has been demonstrated that one of the most important factors in predicting diagnostic certainty for a diagnosis of otitis media is a satisfactory view of the ear drum.[25,26] These images may be combined with audiometric readings which can then be e-mailed with a history to an ENT specialist thereby obviating the need for an initial consultation for assessment.

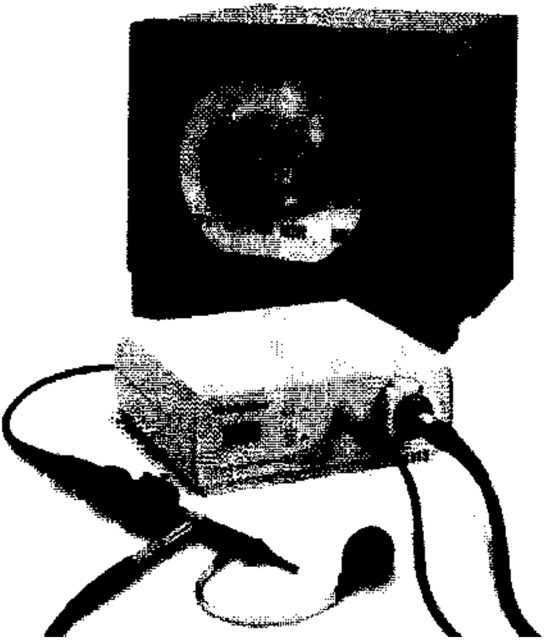

Figure 2. The video otoscope with a captured image of the eardrum

As evidence mounts for the increasing resistance of bacteria to antibiotics through inappropriate use,[27] clinicians are coming under pressure not to prescribe for conditions such as otitis media.[28-32] At the same time clinicians experience significant pressure from anxious parents[33] worried about their child's hearing, speech and language development.[34-35] Parents may be reassured that the child is coming to no harm through a wait and see approach, given a visual record of the eardrum, particularly when combined with evidence from audiometric testing within the surgery. There are two immediate benefits to the NHS; decreased prescribing costs and less pressure to refer children to expensive secondary care. The possibilities become more interesting when we consider this approach to ear care in combination with other new technologies on the horizon (see later - Combination Technologies).

The Video Dermatoscope (Episcope)

The video dermatoscope enables either still or video sequence images of skin lesions to be transmitted from one site to another by e-mail. The advantage of this tool is that, when combined with a high resolution microscope, lesions may be looked at from different angles and their size measured accurately. There is often difficulty in diagnosing possible melanomas and other skin cancers within primary care so many skin lesions are referred in case they are cancerous. Recent work carried out using telemedicine in dermatology within the primary/secondary care interface has demonstrated the practicality of this approach, saving on referral resources and helping patients in terms of convenience and improved outcome with consumer satisfaction.[36,37]

The Handheld Otoacoustic Emission Audiometer (see Figure 3)

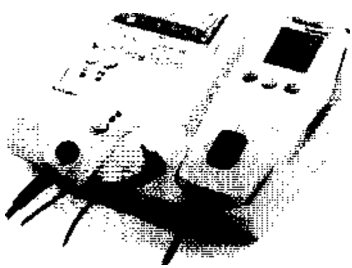

Figure 3. The Otoacoustic Emission Audiometer

Otoacoustic emissions (OAEs) are sounds generated within the inner ear (cochlea). Since OAEs are present in all normal ears it can be assumed that the absence of an emission is a sign of irregular cochlear function which could result in hearing loss. The test therefore provides a fast non invasive method for testing cochlea pathology (the sensorineural pathway). The method works by providing an acoustic stimulus from a speaker in the ear canal to the cochlea. The hair cells in the cochlear become excited by the stimulus and react by generating and emitting an acoustic response. This response then travels in the reverse direction from the cochlea back down the ear canal where it is detected by a microphone. This process requires no feedback from the patient and is therefore suitable for neonatal screening programmes (see figure 4) or to test for the effects of ototoxic drugs or for detecting early signs of noise exposure in musicians or factory workers.

It is also very good for testing the site of a lesion, i.e. cochlear or retrocochlear.[38-42] The test takes less than 30 seconds to perform in each ear and is much more sensitive and specific than the current test used by health visitors in children - the health visitor distraction test (HVDT).[31] Indeed a recent report in the Nursing Times suggested that OAE testing should be adopted across the UK for neonatal hearing screening making the HVDT obsolete.[43] Importantly, the OAE only requires one person to carry out the test, and not necessarily a highly skilled health visitor. (The current approach, HVDT, requires a health visitor and another person.) OAE audiometry is currently only available to 2 per cent of the nation's babies in the United Kingdom,[43] but very widely used in the United States. An additional benefit is that the health visitor is freed for other tasks.[44] A cost benefit analysis of this development using HTA guidelines is urgently required and the National Institute for Clinical Excellence (NICE) is due to report in Autumn

2000. There is however, no point in carrying out an OAE test if there is fluid in the middle ear and therefore, when combined with tyampanometery, measuring the ability of the eardrum to vibrate in response to an auditory stimulus forms a very powerful tool. So it is possible to record what the eardrum looks like, (video otoscope) and also differentiate between sensorineural and conductive deafness using objective tools within primary care. Such information is not only beneficial in terms of quick diagnosis but

Figure 4. Hearing screening of a neonate in progress

provides valuable information leading to more appropriate referral to secondary care.

Vision Screening

A vision screener was presented which enables accurate measurement of refractive error, including astigmatism, in each eye within 30 seconds. This instrument is portable and can be used in one hand. (See Figure 5). It requires no feedback from the patient and therefore is particularly suitable for use with young children from the age of 3 months. (See Figure 6). It may also be a valuable tool in nursing homes and elderly patient homes or for patients who are housebound - these are all high risk groups for falls through visual impairment and appropriate visual aids may prevent such falls and improve quality of life.[45]

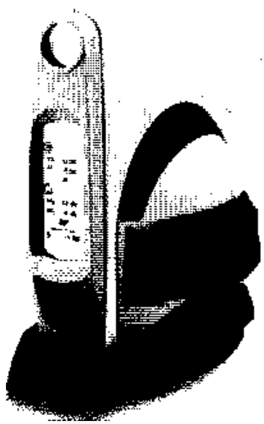

Figure 5. Vision screener

Figure 6. Vision screener in use with a child

In children, refractive error results in loss of vision in one eye (amblyopia) if this condition is not detected early and treated with appropriate correction.[46-48] The test is easy to carry out, giving an objective measure with a much higher specificity and sensitivity than the current visual acuity test carried out by health visitors. As in the case of hearing, this type of instrument might replace crude health visitor testing using reading charts, making screening both quicker and more accurate; however the instrument needs careful cost benefit analysis.

There is still considerable debate on the merits of vision screening for amblyopia as the treatment outcomes are often unsatisfactory.[49] The systematic review, however, stated that there is a lack of high quality research in this area. It would seem to be important that children with visual difficulty are identified early for the purposes of educational development so that disadvantage through visual handicap is minimised.

"Sniff" Technology

This is a new technology which is based on the property of both bacteria and viruses to give off an odour, the concentration of which can be measured using sensitive electronics (see Figure 7). Each virus or bacteria has its own signature smell and therefore it is possible to accurately detect not only the type of bacteria or virus but which antibacterial or antiviral agent would be most appropriate.

This technology may have an enormous impact on the prescribing of both antibiotics and antiviral drugs as it seems more promising than the current dry chemistry/immunology methods which have been tested[50]. There is a wealth of evidence on inappropriate prescribing of antibiotics for upper respiratory tract infections, as well as infections of the ear and throat within primary care.[51-53]

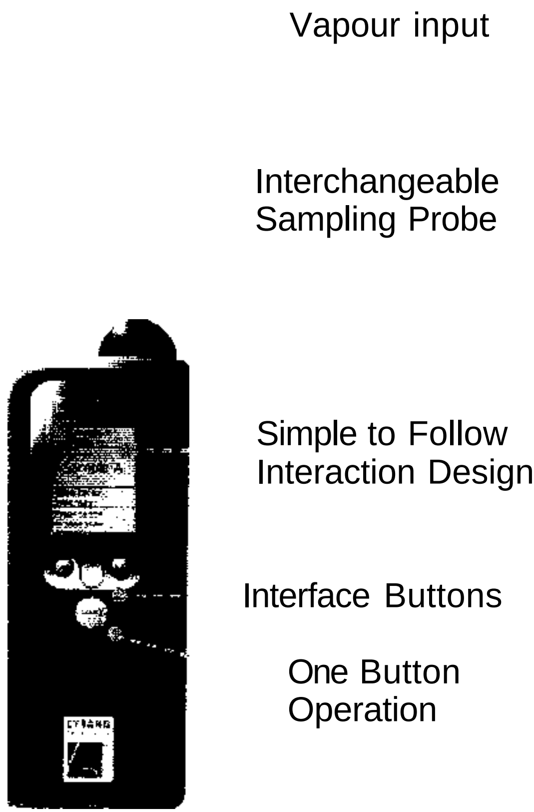

Figure 7. "Sniff" technology detector probe

Such prescribing has been socially harmful in terms of both cost and drug resistance. Patients have not benefited and indeed they have been subjected to unnecessary treatment with concomitant side effects.[54,55] In the near future it will be possible to introduce a probe to the back of the throat which will be able to detect the presence of bacterial or viral infection within seconds and an appropriate selection of antibiotics or antiviral agents within minutes. The current guesswork involved in treating illnesses which may be either bacterial or viral should be removed.

The 'Optical' Biopsy

Trials are already underway to explore a technology which uses multimodal fluorescence and reflectance spectroscopy with visible and UV light to diagnose abnormalities of tissue at cellular level **without** the need to take a tissue sample (see Figure 8).

Cervical cancer and other epithelial cancers provide an ideal target for diagnosis using both spectroscopic methods. Given the short path light energy must travel (less than 1mm) to fully penetrate the epithelium down to the germinative layer, it can undergo minimum absorption and scattering from non specific interactions. Since the germinative layer is a site for early disease, conventional screening

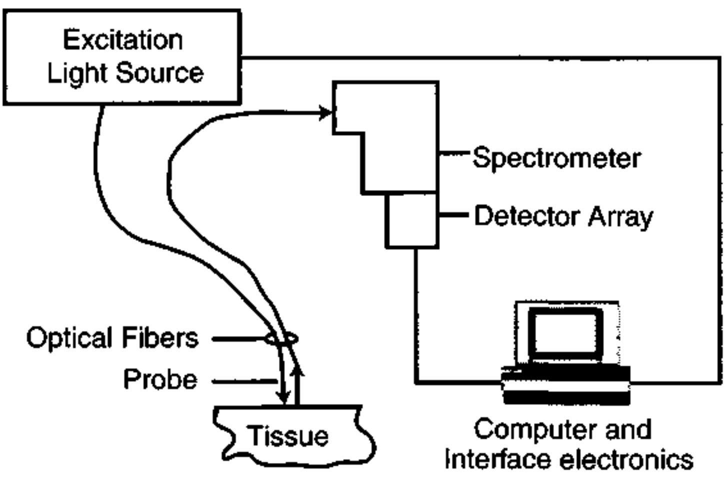

Figure 8. The concept of the optical biopsy

methods which rely on tissue surface visualisation and sample are unable to detect it. Such technology therefore enables the detection of pre-cancers.[56-58] This technology will be available to the primary care market within the next two to three years.

Often considerable anxiety is generated in the delay between a patient suspecting an abnormality and receiving the results following histological diagnosis. This technology will enable such anxieties to be addressed.

The technology will impact significantly on cervical and skin cancer diagnosis and treatment. Patients will be able to have a tissue diagnosis within minutes in the doctor's surgery and without the need for a painful biopsy. Appropriate treatments can therefore be started at the earliest possible stage and in some cases unnecessary further investigation involving hospital referral for colposcopy or skin biopsy, for example, may be avoided, together with the added cost of such procedures.

Early results on more than 250 patients examined for cervical abnormalities show that this optical biopsy method is more accurate in terms of sensitivity (Pap smear 70 per cent, optical biopsy 89 per cent) and specificity (Pap smear 72 per cent, optical biopsy 80 per cent) for picking up abnormalities than the current pap smear approach. These comparisons are made using histology as the gold standard.

How combinations of these new technologies may change the face of primary care: ear care as an illustration

We currently have the ability to visualise the eardrum, to measure the ability of the eardrum to move and to detect middle ear effusions (video otoscope and typanometry). We can also test the sensorineural hearing pathway (OAEs). In the near future we will have the ability to classify upper respiratory tract infections by determining whether they are bacterial or viral and if bacterial, to which antibiotic they might be sensitive ('sniff technology). All of these data - high resolution images, results linked to these images and a commentary from a referring GP can be transmitted electronically. This scenario describes how a primary care doctor may function as a gatekeeper and screener in the near future. Importantly it is possible to do all of this within a 10 minute consultation and the technical side doesn't necessarily need a doctor or a nurse.[59] Additional benefits would be an improved clinical outcome for the patient with improved patient satisfaction,[60,61] and cost savings through more appropriate prescribing and referrals to secondary and tertiary care centre.[62-64] What is crucially important is that the health service determines the cost/benefits of these new technologies, not only in isolation, but in combination with using HTA guidelines.[65] Indeed this may be one of the early challenges for the National Institute of Clinical Excellence.[3]

Other Considerations

However, new technologies cannot be considered in isolation. If we have the ability to detect disease at an early stage through more appropriate and accurate screening, would the secondary care system be able to cope with possible increased numbers of children being identified with hearing problems or visual deficit, or adults with tissue abnormalities requiring urgent treatment (eg, cancer of the cervix or skin)? The participants of this seminar in general rejected the argument against screening because of the consequent resource implications. Discussants drew on similar arguments in other disease areas such as diabetes where screening has been beneficial both to patients and, in the longer term, to health service costs through reduced morbidity.

Aly Rashid

A USER INTERFACE THAT AIDS HEALTHCARE PERSONNEL IN POPULATING THE ELECTRONIC HEALTH RECORD WITH CODED MEDICAL TERMS

Summary

The electronic health record is being implemented worldwide as an aid to increased efficiency and quality of health care. Successful implementation is dependent on healthcare personnel being able to enter coded medical terms into the patient record easily and quickly within the time constraints of clinics and surgeries. We describe a new method for entering coded terms which relies on word/image association in a graphical pointer driven environment.

Introduction

Implementing electronic health records (EHRs) has become a priority in industrialised nations as governments and health care organisations look for ways of improving the delivery and efficiency of care. In the United Kingdom the NHS Executive[2] has set a goal of a lifelong EHR for every person in the United Kingdom allowing round-the-clock access to patient records, seamless care across institutions and effective use of resources by providing health planners with the information they need. A European initiative[66] is seeking to establish good practice in data architectures for health records to allow the retention of meaning and structure in the storage and transfer of clinical records. In the United States Managed Care Organisations are driving the rapid development of EHR systems.[67.68]

Benefits of the EHR

The benefits of an EHR include:

- Reducing variations in use of clinical resources, outcomes, access to health care and quality.[69]

- Instantaneous availability of patients' medical history, treatment regimes, and current health status.[70.71]

- Easy transfer of the clinical record and administrative details between institutions and clinicians.

- Easier analysis of health trends.

- Easier audit and research and implementation of decision support tools.[72]

Coded terminologies and the EHR

A paper based health record contains written text which expresses medical concepts. A free text input into the EHR will do the same but the computer has no intrinsic understanding of the text and limited ability to interrogate it. Until computer systems are developed which have an understanding of natural language, medical terms which are entered in them must be assigned a code which signifies a concept and has a defined relationship with other concepts. Storage of the code rather than a text string (with its potential for mis-spelling or variations in expression) allows the record to be manipulated for patient and health service benefits. Various government, academic and commercial organisations world-wide have built comprehensive coded language thesauruses for use either to classify disease or to aid billing procedures. In the UK the NHS Centre for Coding and Classification developed Clinical Terms Version 3 (CT3) codes in a project involving many clinicians from different disciplines.[73] A program of creating a new thesaurus which combines CT3 and the American College of Pathologist's Systemised Nomenclature of Disease (SNOMED RT) will result in an international English language terminology thesaurus "SNOMED Clinical Terms.[74]

Barriers **to** Success

Barriers to the successful development of EHRs include software systems that do not share the same record architecture, concerns about security of data and user acceptance of changes in working practices. However, perhaps the greatest barrier to success for the EHR remains the difficulty of getting clinicians to enter data into computer-based patient record systems.[75] Entering clinical records on paper has the advantage of speed, ease of use, portability and flexibility in expression. Entering coded data into computer systems requires a familiarity with computer technology and understanding of a user interface that may be far from intuitive to the user. Keyboard skills may also be needed and the interface may lack flexibility in the methods and structuring of data input. A lack of easily accessible views and easy extraction of the medical data entered may be further disincentives.[76,77] As one observer has commented, "... the one remaining problem is the efficient capture of physician information in a coded form. Research is still needed to solve this last problem".[77]

Current methods of coded term entry into the EPR

A common method of finding coded clinical terms is a keyword search. The user then selects the desired term from the search result list. Refinements of this method exist which narrow the length of the search result list but the more comprehensive the thesaurus the longer the result list. The keyword search method requires keyboard skills and either a knowledge of which terms are available for selection or a guess as to what terms may be present within the thesaurus. This method is typically used to enter only one coded term in the consultation because of time constraints inherent in the method, resulting in an incomplete record.

Some systems use template forms on screen for particular disease conditions or clinics so that the user selects from a predefined selection of coded terms. This can be a rapid way of populating the record with coded terms but depends on a well defined circumstance for the consultation.

Interface solutions to aid medical personnel in entering coded clinical language into the EHR

Users will need a choice of methods of clinical term entry to suit circumstance and preferences. Accessing coded terms using image-word association is an alternative method to the standard key word search or template picklist method. This method is described in detail later.

Natural language processing and "autocoding" are promising techniques under development. Advances in speech recognition wi'l allow free text input by voice although the text will still require coding. Free text input can be "autocoded" by comparing the free text entry with terms in the coded thesaurus and applying language rules to allow the system to pick the correct concept code. This technology is some years away.

The "Galen-in-use" project[78] has created language independent concept representation to separate the medical concepts from the syntax used to describe the concepts. This may result in easier to use interfaces as limitations imposed by the requirements of directly accessing coded terminology are overcome.

A graphical interface using image-word association

1. Description of navigation method

Most medical concepts and clinical terms are associated with an anatomical site or system. The Visual Read anatomical interface (VR) allows the user to navigate between anatomical images to find terms that have been attached to 'hotspots' on those images. Navigation from image to image is achieved by pointing the cursor at the body region of interest and then drilling into the region by selecting from a choice of up to two thumbnail images that appear beside die main image. The thumbnail images represent greater anatomical detail or a drilldown into a deeper structure. Sites on the images which are associated with medical terms display a picklist of terms when the user points at them with the cursor. Selection of terms for entry into the patient record is by a single cursor click on the term.

2. *Term selection*

The medical terms are taken from the CT3 code set although the system can be populated with any coded thesaurus. There are currently over 80,000 CT3 terms in the browser. An initial image of a man and woman allows the user to select any of 12 body regions with 117 images and 1100 hotspots in total within the graphical interface. Apart from body regions the terms have been divided between six "consultation stages": history taking (symptoms), physical examination findings, investigations, diagnosis, planning (management) and procedures. Where terms are associated with multiple sites or consultation stages they will appear in multiple places.

The system therefore uses knowledge (of anatomy and of how consultations are structured), which the user has already acquired in clinical training, as the "headings" (anatomy and consulting stages) under which the user can find terms. The thesaurus has in effect been broken up into many small picklists by a method that the user finds easy to understand and use.

Decision making process for the user in finding a term

Terms in the picklists have been pre-sorted to display the six most commonly used terms for immediate access. The terms list can be

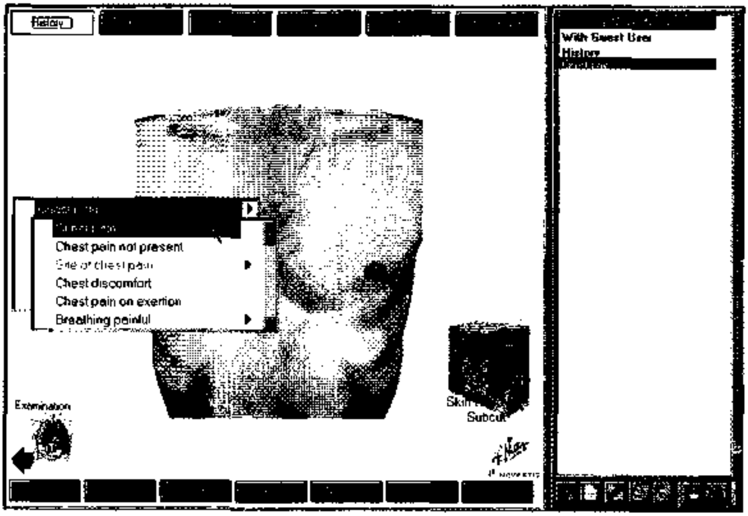

Figure 9. Region and presenting complaint identified in the history

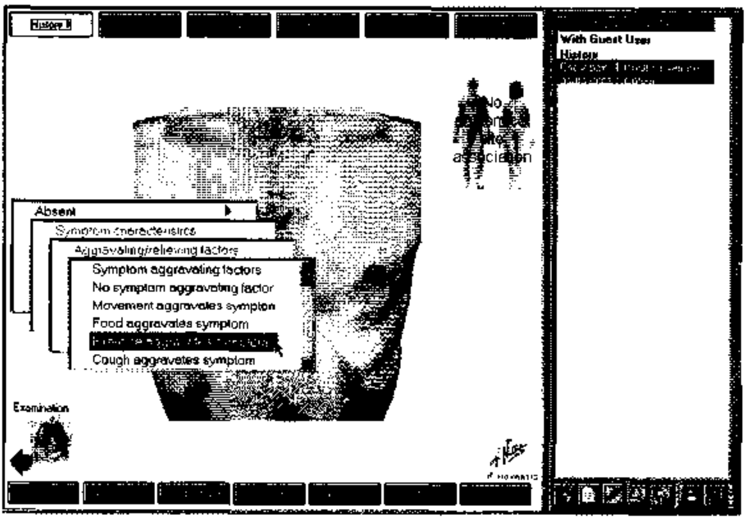

Figure 10. Additional history of symptom characteristics identified

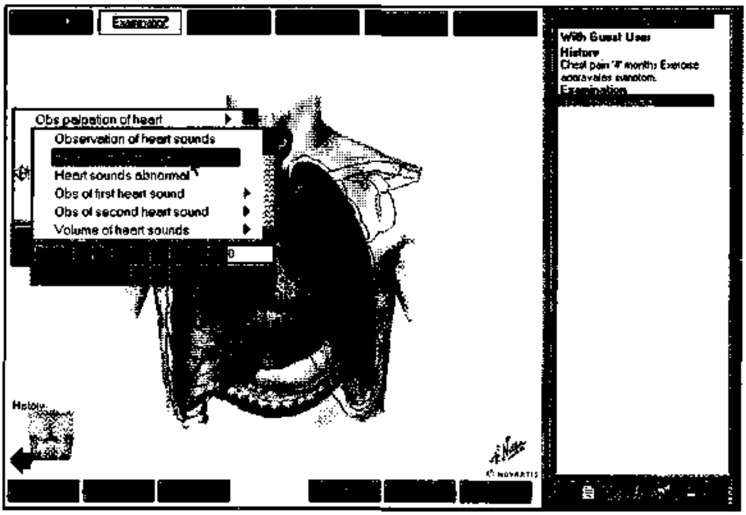

Figure 11. Findings of physical examination entered

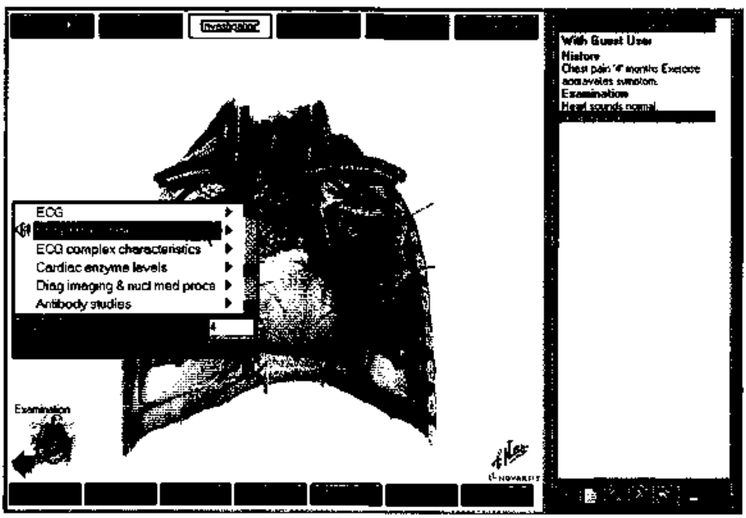

Figure 12. Results of investigations entered

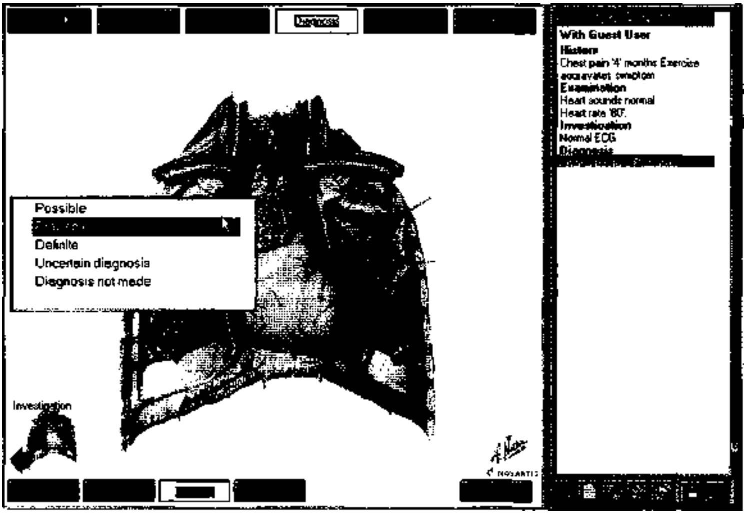

Figure 13. Diagnosis and diagnostic probabilities entered

defaulted to "self sort" so that the list order is dependent on how many times the user selects terms.

Using the System

Figures 9-13 illustrate how a coded record is built within the visual read system using the example of chest pain as a presenting complaint.

Where a term has no obvious anatomical site association (for example: "tired all the time" or "weight loss") they are assigned to a "not automatically site associated" image. Access to this image is from a "hotspot" in the white space around any anatomical image.

Psychiatric or psychologically associated terms have been assigned to a brain image with the terms divided up between labelled hotspots on the brain.

Anatomical terms such as "femur" are available from any image and can be used to build up a compound coded phrase; for example, "tenderness", "right iliac fossa". Qualifiers and attributes are available in every screen from buttons at the bottom of the screen which bring up a picklist of terms.

Managing updates and changes

All coded terminologies are dynamic reflecting changes in the use and meaning of medical concepts over time. Interfaces to coded terminologies must, therefore, also be dynamic. An editing suite allows alterations to the navigation, images and picklist ordering to be made in response to user feedback.

Future development

The VR system is currently undergoing validation, but early feedback from users suggests the method is typically six times faster than current keyword search methods when entering multiple coded medical terms in a consultation, and user rates in finding terms was also superior.

Methods of improving the interface include intelligent picklists that anticipate the doctor's next choice dependent on what has been entered already.

The ability to enter coded symptoms and examination related terms opens the possibility of powerful support tools to aid decision making in the consultation.

Terms can only be interpreted accurately by reference to the context in which they are placed by the user. The ability to send multiple coded medical terms into the EHR raises many issues regarding structuring the context of each term and associating terms together.

Audit and EHR

The advantages of electronic audit over the conventional paper audit are well documented.[79] However the use of electronic health records (EHR) and data to generate audits have themselves been associated with significant problems.[80-83]

The central feature to allowing computer-facilitated audit is the provision of reliably coded clinical data.[66;84;85]

With the advent of the EHR, the key feature of this must be the storage of the majority of the data in a coded format, rather than free-text. The storage of coded data is a key proviso to the use of computers in audit. The hindrance to storing information as coded data has two aspects. Firstly there is the lack of flexibility of the Read 2 codes, this however will be resolved with the possible adoption of Clinical Terms version 3 (CT3)[73] or the new hybrid of CT3 and SNOMED once released in 2001.[74] Secondly the user interfaces to access the coded term have often been poor and difficult to use. Until this becomes "invisible" to the user, as in Visual Read, or totally intuitive, this will remain the most significant obstacle to the health care provider entering real time coded information into the EHR.

The main impediment to electronic audit is the fundamental issue of data quality. For coded data to be auditable there needs to be reproducible high quality coded information. This means that appropriate diagnostic codes must be religiously entered into the computerised record. Even in paperless practices the quantity of the health record that is coded is often not comprehensive, usually resulting in just the main diagnosis being coded.[83]

At present the extractable data is limited to what has been appropriately coded, this is often rudimentary diagnostic related data together with other simple stored data. Examples are templates for chronic disease management and associated prescribing information.

The advances in computer facilitated audit have been demonstrated in the Collection of Health Data in General Practice Project (CHDGP), which has now been running for 4 years.[80] This has used a custom produced "Health Query Language" (HQL) which is based on Structured Query Language (SQL) a standard language used to manage and interrogate databases. A software package called MIQUEST has been produced which enables queries to be produced easily without needing specific programming knowledge.[80] The extracted data can be examined in any database, spreadsheet or statistic package. It is now a requirement for RFA4 approval (the standards that General Medical Services (GMS) software must meet to be accredited for use in primary care) that all software is MIQUEST compliant.

The need to obtain such data is one of the cornerstones of Clinical Governance, allowing standards of care, the level of implementation of NICE guidelines and the performance against National Service Frameworks to be monitored within each Primary Care Group/Trust.

The role of electronic audit is going to be ever more prevalent and significant. The future will see more user friendly graphical interfaces to allow practitioners to design and carry out an audit with ease, allowing reproducible audit cycles to be carried out with minimal staff time and effort. Eventually when the national EHR is in place, standard national audit templates will be able to be invisibly executed allowing a true picture of countrywide performance to be obtained.[2]

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