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# Understanding differences in infant mortality rates across local areas

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Hospital Episode Statistics data (year range 2015/16–2018/19).

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For further information and support, visit the [Baby Loss Awareness Alliance](#), which provides useful links and information on many organisations who can help people experiencing baby loss.

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# Key points

With general improvements in health care, in particular in midwifery and neonatal intensive care, infant mortality rates in England have decreased over the past four decades. But improvements in infant mortality rates have stalled since 2014 and there are socioeconomic and demographic inequalities and variation across the country.

This report examines how local authority characteristics are associated with different rates of infant mortality. Using an adjusted regression model, we observed that in 2017, infant mortality rates at the upper-tier local authority level in England were likely to be higher in areas where:

- there were fewer households with central heating and where households were more likely to be crowded
  - local authorities with the highest central heating deprivation had, on average, one more infant death per 1,000 live births than those with the lowest deprivation
  - local authorities with the lowest number of dwellings per person had, on average, 1.4 more infant deaths per 1,000 live births than those with the highest number of dwellings per person
- there was a greater proportion of the population who were severely obese
  - local authorities with the highest percentage of the population who were severely obese had, on average, 0.8 more infant deaths per 1,000 live births than those with the lowest percentage
- there was lower spend on early years provision and Sure Start
  - local authorities that had the lowest spend on early years provision and Sure Start had, on average, 0.7 more infant deaths per 1,000 live births than those with the highest spend.

The variety of local authority characteristics that were associated with infant mortality and the potential intersectionality between them – for example between deprivation and housing conditions, and between deprivation and obesity – highlight the complexity of the pathways that may lead to the death of a child in their first year of life.

National data showed that the rate of infant mortality was higher for babies from minority ethnic backgrounds compared with White British babies. Local authorities that had higher levels of deliveries among Pakistani mothers were associated with increased levels of infant mortality. We did not see similar associations for deliveries among women of other minority ethnicities, so these findings need to be treated with caution, and could be related to known issues with ethnicity coding in health care datasets.

The evidence presented in this report suggests that infant mortality should not be overlooked when developing and implementing policies, particularly those relating to the housing, obesity and children’s services, which tend to neglect to draw the links outlined above. In the following examples, consideration needs to be given to how they impact on infant mortality:

At a national level:

- the development and implementation of housing policies
- decisions about local government funding, particularly for the early years
- the development and implementation of policies to tackle obesity, and whether they work for women of childbearing age.

At a local level:

- the development and implementation of housing and planning decisions
- supporting women of childbearing age to help maintain a healthy weight
- providing targeted action for women and communities where there are particular risks.

# 1 Introduction

## What is infant mortality and what are the causes?

The death of an infant – defined as the death of a child under the age of one after a live birth – is a truly tragic event. It has profound negative impacts on parents, siblings and wider family members and is a loss of life with potential to contribute to future society.<sup>1,2,3,4,5</sup> Because of these impacts, infant mortality is used as an indicator of regional population health<sup>6</sup> and economic strength.<sup>7</sup>

There are many different causes of infant mortality and different risk factors for it, depending on the infant's age. In 2021, immaturity-related conditions\* were the most common reason for infant mortality in England and Wales, accounting for 40% of all infant deaths,<sup>8</sup> and of these, 91% were neonatal deaths.† Congenital anomalies‡ were the next most common reason, accounting for 33% of infant deaths. Most deaths resulting from congenital anomalies (74%) occur in the neonatal period, but congenital anomalies are also the leading cause of post-neonatal infant mortality, with 32% of post-neonatal deaths due to a congenital anomaly. Other causes include, but are not limited to, infections, asphyxia (deprivation of oxygen), trauma and sudden infant death syndrome (SIDS).

\* Immaturity-related conditions are those associated with babies who were born pre-term, such as respiratory and cardiac conditions.

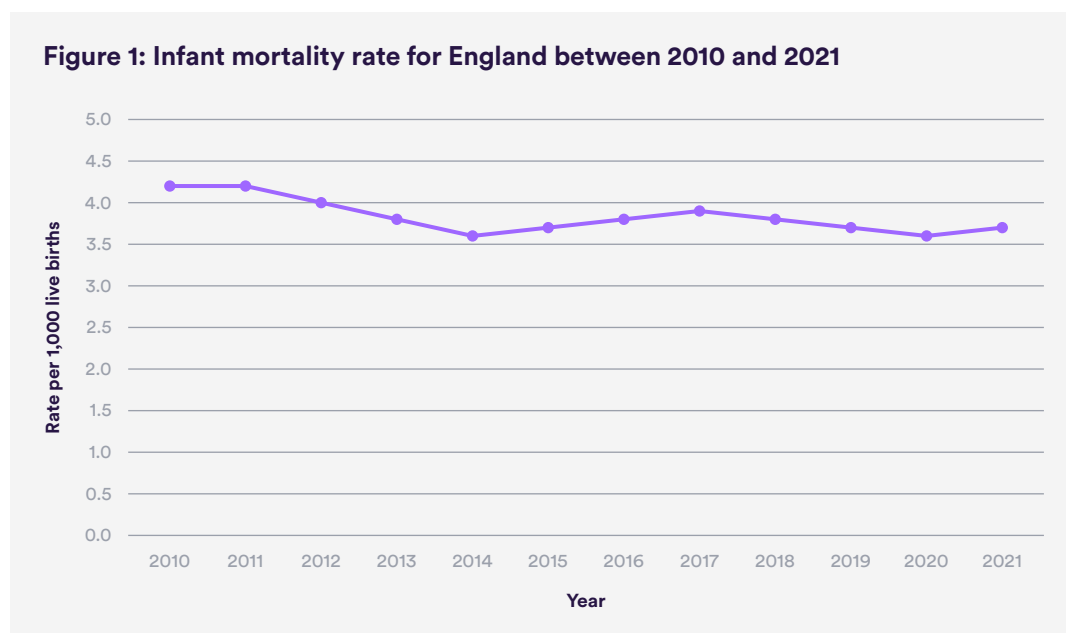
† The death of an infant aged under 28 days.

‡ Congenital anomalies are defined as structural or functional anomalies that occur during pregnancy and describe numerous development disorders such as spina bifida and heart defects.

There are also several maternal risk factors that make it more likely that a live birth will result in the death of an infant, including maternal weight (underweight or overweight/obesity), maternal age (under 20 years of age or over 35 years of age) and whether they smoke, take drugs or drink alcohol during pregnancy (see Table 1 in Chapter 3).

## How well do England and the UK fare?

With general improvements in health care – specifically improvements in midwifery and neonatal intensive care<sup>9</sup> – national infant mortality rates in England have decreased over time. Figure 1 shows the recent trend in infant mortality rates for England between 2010 and 2021.



Source: Office for National Statistics, 2023, 'Child mortality (death cohort) tables in England and Wales'<sup>8</sup>

Infant death is a comparatively rare event – on average each year,\* out of more than 631,000 live births, one in 269 results in a death within one year of birth. In 2021, there were 3.7 infant deaths per 1,000 live births; of these, 2.7 deaths per 1,000 live births occurred in the neonatal period and one death per 1,000 live births occurred in the post-neonatal period.<sup>8</sup>

\* Calculated from the average between 2014 and 2021 inclusive.

Overall, the trend in infant mortality is a big improvement on historical rates in England – there were 540 fewer infant deaths per year in 2021 compared with a decade before, equating to more than 10 more infants surviving each week.<sup>8</sup> However, while the overall drop in rates across England is positive, it hides aspects of poorer performance.

Since 2014, improvements in infant mortality rates in England have stalled. Between 2014 and 2017 there were unprecedented year-on-year increases in the rates of infant mortality and since then they have not returned to the low in 2014.<sup>8</sup> The rates of infant mortality across the country in 2021 range from 0 per 1,000 live births in Rutland to 10.1 in Stoke on Trent.<sup>8</sup> There are also known socioeconomic and demographic inequalities in infant mortality in England:<sup>8,10</sup>

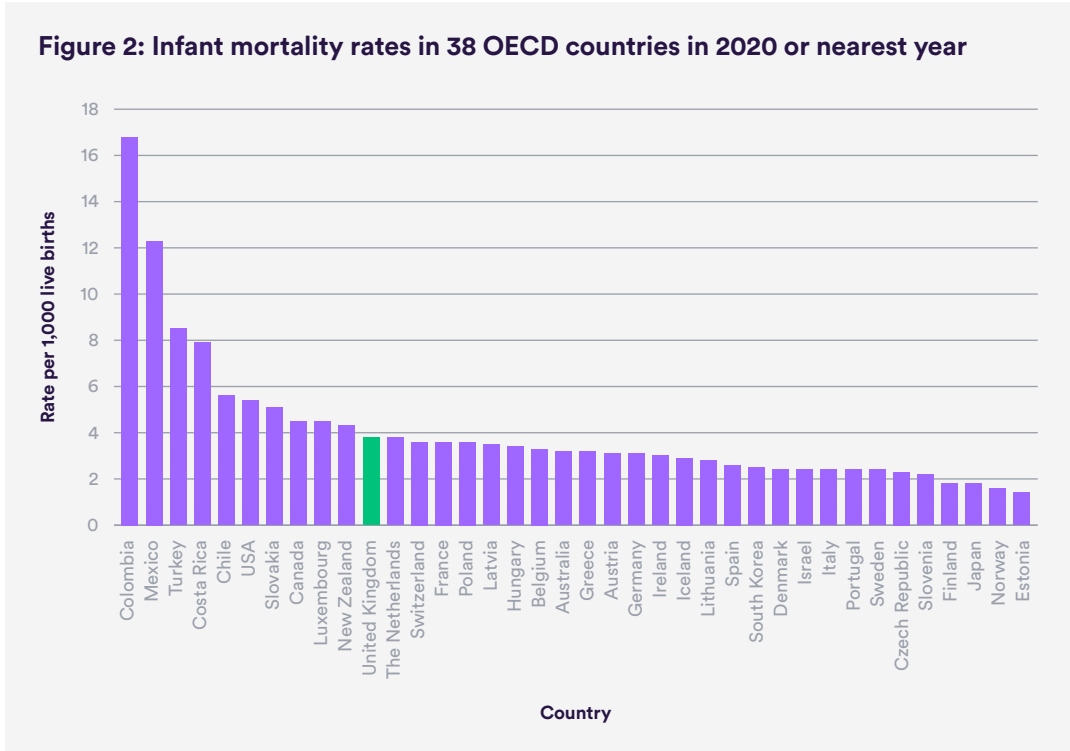
- In 2021, infant mortality rates were more than double for those from the most deprived areas than the least deprived.<sup>8</sup>
- In 2021, infant mortality rates for infants born to parents with routine and manual occupations were the highest, whereas those born to parents with managerial, administrative and professional occupations were the lowest.<sup>10</sup>
- In 2021, mortality rates for infants who were Asian or Black were higher compared with those for infants who were White. With Black African and Pakistani babies, rates were more than double.<sup>8</sup>

When comparing against other countries of the Organisation for Economic Co-operation and Development (OECD), the UK does not perform particularly well.<sup>11,\*</sup> Out of 38 OECD countries, the UK came 28th in 2020 or the nearest year (see Figure 2). If the UK had achieved the rate of the best-performing country in the comparator group (Estonia), more than 1,500 more infants would have survived per year in the UK.<sup>†</sup>

\* Based on 2020 data or the nearest year – New Zealand’s nearest year was 2018. The reference link provides the most up to date data at the time it is accessed, to access 2020 data toggle off the latest data and expand the time period to include these dates.

† Based on 2020 data for both countries, with Estonia’s infant mortality rate of 1.4 infant deaths per 1,000 live births and UK’s infant mortality rate of 3.8.





Source: OECD, 2023, 'Infant mortality rates'<sup>11</sup>

## What does this research aim to achieve?

There are many different reasons why a child dies in infancy, and the pathways by which it transpires are complex. There are also several socioeconomic and demographic inequalities and variations across the country, as noted above. All of this means that it can be seen as an intractable problem, with disjointed responses to tackle it.

Many previous studies on risk factors for infant mortality have focused on data at an individual level, based on population sampling and following what the sample's outcomes were or auditing cases of infant mortality. But this hypothesis-generating piece of research covers the whole population. We looked at the relationship between the characteristics of local areas and their infant mortality rates by combining and analysing publicly available data in a novel way. Looking at influences at an area level means that policies and interventions can be developed at this level, but this also has benefits for individual-level interventions, for example those aimed at reducing health inequalities.<sup>12,13</sup>

The NHS Long Term Plan has a stated aim to improve maternity services and reduce neonatal deaths by half by 2025.<sup>14</sup> But there has been limited policy focus on infant mortality beyond maternity services, and perinatal and neonatal mortality, despite post-neonatal deaths driving more than a quarter of the overall infant mortality rate. Furthermore, the focus of the NHS Long Term Plan is about improving the delivery of health care services and interventions at an individual level, yet the plan itself acknowledges that ‘the health of children and young people is determined by far more than healthcare’.<sup>14</sup> Understanding the broader determinants of infant mortality will add value to the planned changes to reduce infant mortality.

Looking at an area level is also timely with the statutory formation of integrated care boards and integrated care systems in 2022.<sup>15,16</sup> Within integrated care boards, local organisations (the NHS, local government, education and other partners such as the voluntary and community sector) work in partnerships at ‘place’ level to the benefit of the population. Knowing what local authority factors may impact on infant mortality rates can help local areas to better understand the different contributions that each organisation can make to improve infant mortality and work together with a common aim.

Demonstrating which local authority characteristics show significant associations with infant mortality provides a focus for national and local policy makers, and practitioners, across a range of different agencies (not just health care) to target their efforts in tackling infant mortality.

This report also provides a focus for local areas to monitor their own data and a new methodology that can be applied locally, for better interrogation of locally held data that might not be available nationally. This will help to build area-specific evidence to support better local decision-making. Furthermore, where we identify any unknowns, it provides additional areas for further research.

## 2 What we did

### Literature review

We conducted a literature review to identify peer-reviewed publications and grey literature relating to infant mortality and to environmental factors such as the nature of an infant’s neighbourhood and community. We also identified literature that discussed conceptual models for early childhood development. From these, we identified themes of local area characteristics that either hypothetically influence, or have previously been shown to be associated with, infant mortality (for example, health care provision and the quality of the immediate environment). The literature also provided some potential measures for those themes. Further details of this literature review are available in the technical annex to this report.

### Statistical analysis

We sourced data at upper-tier local authority level in England\* to represent the themes and potential measures of the characteristics found in the literature. We included an additional theme in the statistical analysis, looking at socioeconomic and demographic measures, since there are known inequalities in infant mortality relating to deprivation and ethnicity. Details of all the local authority characteristics used are shown in Tables 5 and 6 of the technical annex.

We used data on the number of infant deaths per 1,000 live births in 2017† from the Office for National Statistics as the outcome measure.<sup>8</sup> These data were not normally distributed, so we used negative binomial regression

\* Where not already done so in the raw data, to deal with low numbers in these smaller local authorities, we combined data for the Isles of Scilly with Cornwall, and data for the City of London with Hackney, resulting in 150 upper-tier local authorities in England.

† 2017 was the year with the most up-to-date data at the time of the statistical analysis.

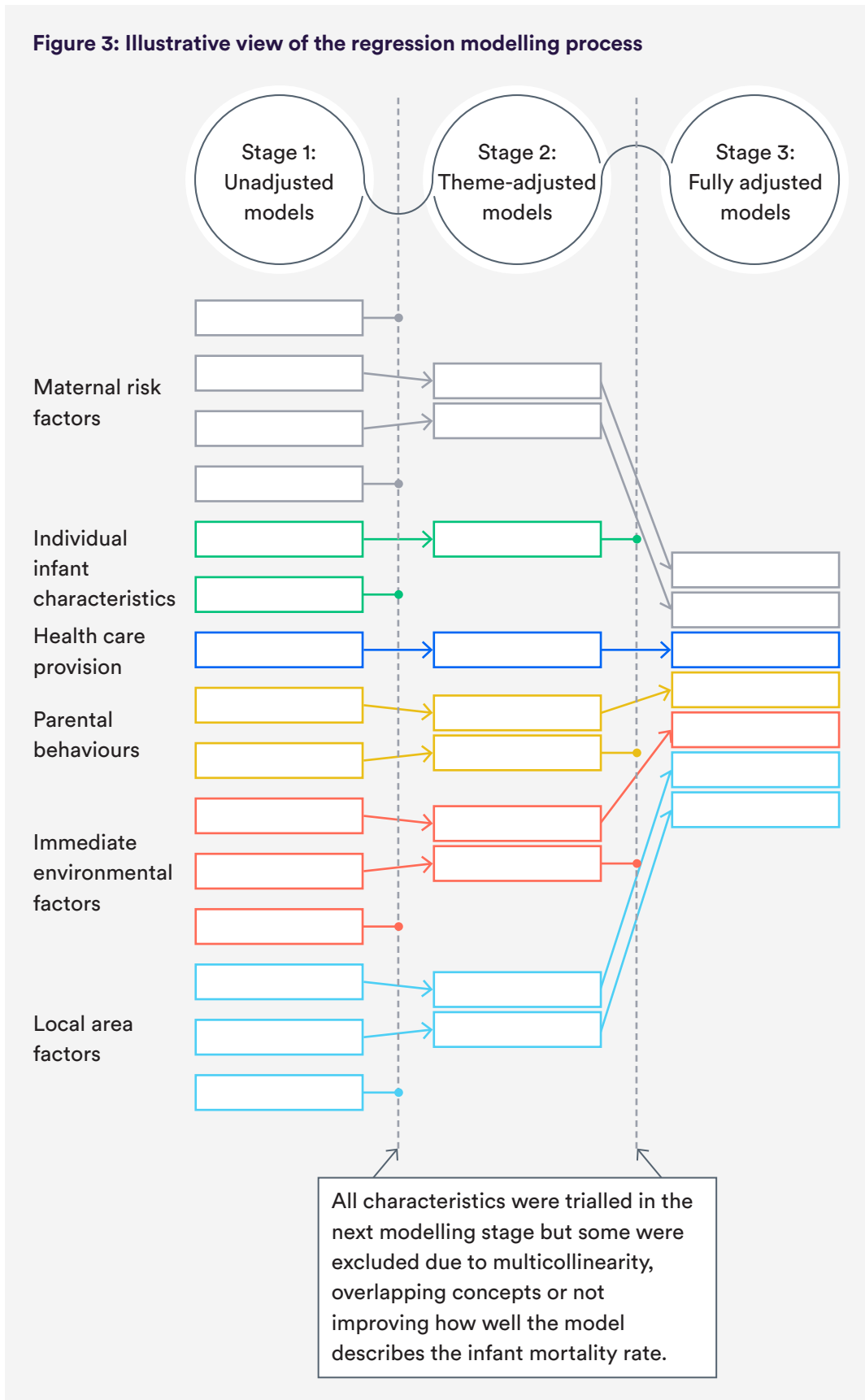
modelling to assess the level of association between the local authority characteristics identified and the infant mortality rate.

The statistical analysis involved three stages:

- 1 We ran simple regression models exploring the associations between each individual characteristic and the variation in the infant mortality rate observed across local authorities.
- 2 We grouped the characteristics from the simple associations according to the different themes and ran them as multiple regression models to identify the characteristics within each theme that best explained the variation in the infant mortality rate observed across local authorities.
- 3 We ran an overall regression model using the factors from the second stage that best explained – in statistical terms – the variation in the infant mortality rate observed across local authorities.

Figure 3 is an illustrative view of the regression modelling process, further details of which can be found in the technical annex.

Figure 3: Illustrative view of the regression modelling process



The next chapter details the results of the literature review and the statistical analyses we conducted. We discussed these with experts in childhood policy and practice to help understand the findings.

# 3 What we found

## Findings from the literature review

In total, 11 articles were included in a full-text review, covering a wide variety of issues related to infant mortality. Some common themes along with measures for each theme emerged, which we used to guide the sourcing of quantitative data (see Table 1). Further information on the review process can be found in the technical annex. Full details on the measures, data sources and years for which the data were available are shown in Tables 5 and 6 in the technical annex.

**Table 1: Themes and potential measures identified from the literature review**

Theme	Potential measures (shown in <i>italics</i> where no data source was identified)
Maternal risk factors	<ul style="list-style-type: none"> <li>• Weight (underweight or overweight/obesity)</li> <li>• Ethnicity</li> <li>• Maternal age (under 20 years of age or over 35 years of age)</li> <li>• Smoking</li> <li>• <i>Drug and alcohol misuse</i></li> <li>• <i>Educational attainment level</i></li> <li>• <i>Personal employment status</i></li> </ul>
Individual infant characteristics	<ul style="list-style-type: none"> <li>• Very low and low birth weight</li> <li>• Prematurity</li> <li>• <i>Congenital abnormalities</i></li> </ul>
Health care provision	<ul style="list-style-type: none"> <li>• Health care spending</li> <li>• Important health checks (0–5 years of age)</li> </ul>
Parental behaviours	<ul style="list-style-type: none"> <li>• Breastfeeding</li> <li>• Immunisations</li> <li>• <i>Safe sleeping</i></li> </ul>

Theme	Potential measures (shown in <i>italics</i> where no data source was identified)
Immediate environmental factors	<ul style="list-style-type: none"> <li>• Air pollution: fine particulate matter</li> <li>• Housing condition</li> <li>• Overcrowding</li> <li>• Residential and occupational pollution</li> </ul>
Local area factors	<ul style="list-style-type: none"> <li>• Commissioning for early years</li> <li>• Local priorities</li> </ul>
Wider societal factors	<ul style="list-style-type: none"> <li>• Child poverty</li> <li>• Deprivation</li> <li>• Population employment</li> </ul>

## Findings from the statistical data analysis

The statistical data analysis aimed to explain the variation in the infant mortality rate across local authorities in England, using local area characteristics associated with infant mortality as found in the literature.

The first stage of the analysis examined the association between infant mortality and each characteristic individually (for further details, see Table 7 in the technical annex). This revealed that while measures from almost all the themes explained some of the variation in infant mortality, there was no measure that alone explained more than 21% of the variation, which is relatively low.

While associations between single characteristics and infant mortality are interesting, we also wanted to know how well each of the themes explained the variation in infant mortality across local authorities. We found that the characteristics from the maternal risk factor theme explained the most variation in the local authority infant mortality rates (30%), followed by the socioeconomic/demographic theme (22%), as can be seen in Table 2.



**Table 2: Theme-adjusted proportion of the variation in infant mortality explained by each theme**

Theme	Explained variation
Maternal risk factors	30%
Socioeconomic/demographic factors	22%
Individual infant characteristics	20%
Immediate environmental factors	19%
Wider societal factors	15%
Health care provision	7%
Local area factors	4%

Finally, we wanted to know which local authority characteristics were most important when looking at characteristics from across all the themes. Therefore, the final stage of the analysis brought together the remaining explanatory factors from each theme to find the best model to explain variations in infant mortality. This model included eight measures that explained 39% of the variation in infant mortality, of which seven were statistically significant (see Table 8 in the technical annex for detailed results). The model showed that, on average, local authorities with a higher infant mortality rate had:

- a higher local authority spend on public health
- a higher percentage of children under five years old living in areas with poor central heating availability
- a higher percentage of the population who were severely obese
- a higher percentage of deliveries among mothers from Pakistani ethnic backgrounds
- a lower spend on early years per child under five years old

- a lower percentage of children under five years old living in areas with poor housing affordability
- fewer numbers of dwellings per person (which could be a proxy for overcrowding).

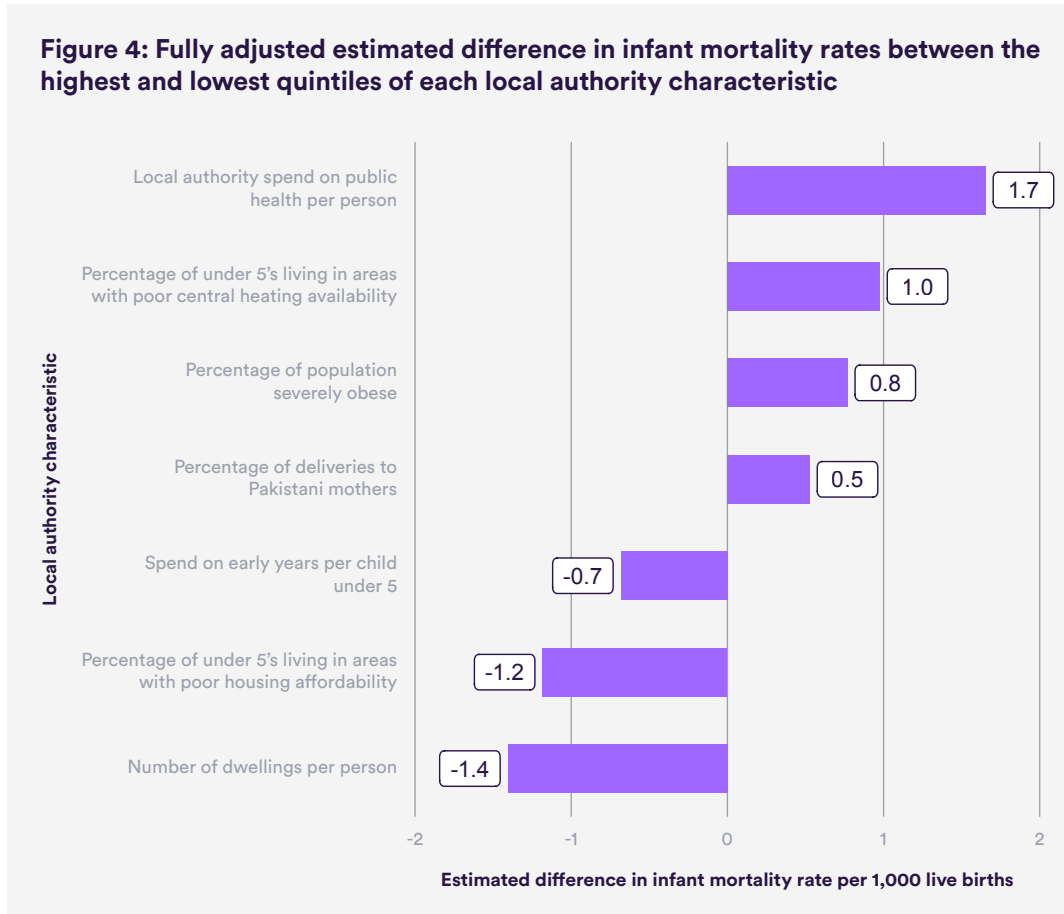
For example, all other things being equal, the model predicted that local authorities that were more likely to have overcrowded homes (that is, had fewer numbers of dwellings per person) had, on average, 1.4 more infant deaths per 1,000 live births than local authorities that were less likely to have overcrowded homes (that is, had higher numbers of dwellings per person) (see Figure 4).\*

Our analysis also shows that for many of the local authority characteristics that explained a proportion of the variation in the infant mortality rate in the fully adjusted models, there were stark differences between the worst- and best-performing local authorities.

For example, the average value from the fifth of local authorities with the highest percentage of children under five years old living in areas with poor central heating availability was 55%, compared with an average value of only 3% for the fifth of local authorities with the lowest percentage.

\* We calculated this by using the regression model to estimate the infant mortality rate when the average value from the fifth of local authorities with the lowest number of dwellings per person (0.38) is used, which leads to an estimated infant mortality rate of 4.6 deaths per 1,000 live births. This is compared to the estimated infant mortality rate when the average value from the fifth of local authorities with the highest number of dwellings per person is used (0.47), which gives an estimated infant mortality rate of 3.2 deaths per 1,000 live births. So the difference between the highest and lowest is an estimated 1.4 fewer infant deaths per 1,000 live births.

Table 10 in the technical annex gives an indication of the distributions for the local authority characteristics used in the fully adjusted regression models.



Source: Nuffield Trust analysis of ONS data

The results of these regression models need to be interpreted carefully, particularly from a policy point of view. Some local authority characteristics that are positively associated with lower levels of infant mortality – such as higher spend on early years – make intuitive sense, others need to be interpreted carefully, such as the association between higher public health spending and higher infant mortality rates. The next chapter unpicks these results further.

## 4 What does this mean?

The sheer number of significant unadjusted associations we found between infant mortality rates and local authority characteristics supports existing evidence that pathways resulting in infant mortality are likely to be complex. This means that there is unlikely to be a silver bullet when looking to improve these outcomes and many things will need to be considered and acted on. Because of this, those who can bring about change may see it as something that is too difficult to tackle, not knowing where best to focus activity or who is best placed to act.

However, the results of our adjusted models, which considered the effects of the eight local authority measures that made it into this final model, show that there are a few local authority characteristics that best explain the variation in these outcomes across England. This provides a focus, highlighting those that might be the most useful to further explore, research and target.

In this chapter we discuss the specific local authority characteristics found to be significant in our analysis, looking at why the associations may exist.

### Maternal risk factors

#### **Overweight/obese – percentage of adults aged 18 and over classified as severely obese**

Our analysis provides evidence that, when considering other local authority characteristics, where there are higher levels of the population who are severely obese, this is associated with increased levels of infant mortality. While there were no routinely published measures on obesity in pregnancy at a local authority level that we could use in this analysis, it is likely that these areas have higher levels of obesity in women of a childbearing age.

Although this analysis does not determine causality, obesity in pregnancy is linked to a number of conditions that increase the risk of infant mortality, such as diabetes and preeclampsia.<sup>17</sup> It may also be a proxy for other factors such as older maternal age<sup>18</sup> or deprivation,<sup>19</sup> which are associated with increased risk of infant mortality.

Tackling obesity across the population, not just for women of childbearing age, including childhood obesity, is important in relation to obesity in pregnancy. Obese children are more likely to be obese adults<sup>20</sup> and obese mothers are more likely to have obese children, perpetuating the cycle.<sup>21</sup>

We have looked at childhood obesity and its associations with local authority characteristics in a similar report to this one.<sup>22</sup> There we discuss what the current strategy is for tackling obesity and its strengths and weaknesses. Evaluation on progress against the strategy, including for women of a childbearing age, should inform how the strategy develops.

As well as national initiatives, local government can play a part in supporting individuals to maintain a healthy weight, such as managing fast-food outlets<sup>23</sup> and providing more opportunities for physical exercise.<sup>22</sup>

For the NHS there are guidelines from the National Institute for Health and Care Excellence (NICE) on weight management before, during and after pregnancy.<sup>24</sup> All clinicians, not just those in maternity services, can be supported, through training, to help women with obesity. However, there needs to be a recognition that it can be difficult for clinicians to raise what is a sensitive issue.<sup>25,26</sup> The NICE guidelines indicate *what* they should discuss and offer but they do not provide guidance on *how*.<sup>24</sup> Midwives and other clinicians consistently report a lack confidence, knowledge and skills in discussing the issue of weight with women and a lack of knowledge about guidelines on raising the topic.<sup>25,26</sup>

Another potential means of supporting women to maintain a healthy weight is the Healthy Start scheme, which provides additional financial support to pregnant women under the age of 18, lower-income pregnant women and

families with children under four years old so that they can improve their diet.\* Previous similar grants have been shown to increase birthweights, particularly for some vulnerable babies.<sup>27</sup> However, there have been relatively low levels of awareness about the Healthy Start scheme among the general population,<sup>28</sup> and in May 2023, 35% of eligible families in England had not taken up the scheme.<sup>29</sup>

## Ethnicity

There are known persistent inequalities in pregnancy outcomes for people from minority ethnic backgrounds. Therefore, we included measures of maternal ethnicity to take that into account in our analysis, to see if additional environmental factors can explain the variation in infant mortality rates across local authorities.

In doing so, the analysis indicates that where local authorities have higher levels of deliveries among Pakistani mothers, this is associated with increased levels of infant mortality.

However, this association does not mean that the higher infant mortality rates are solely down to high levels of mortality of Pakistani infants – associations that may exist at an individual level between infant mortality and other minority ethnicities may not have been detected in our model.

In fact, national statistics show that, where there is a recorded ethnicity, rates of infant mortality are higher for infants who are from minority ethnic backgrounds compared with infants who are White British, and highest for babies who are Black Other, Black African or Pakistani, which are double the rate of babies who are White British.<sup>8</sup>

A possible explanation for why we did not see associations for other ethnicities could be due to issues in the quality of ethnicity recording in the dataset that we used to construct the measures, as there are known issues with ethnicity coding in English health service datasets.<sup>30</sup> In addition, any statistical

\* This scheme covers England, Wales and Northern Ireland (see GOV.UK, 2021, 'Healthy Start' [www.gov.uk/healthy-start](http://www.gov.uk/healthy-start), accessed 2 January 2024).

association between variables at local authority level will be stronger where there is more variation in ethnicity between local authorities.

We reviewed some of the evidence\* that might explain these inequalities. We mainly looked at the evidence for women of Black ethnicities and Pakistani women, due to their much higher infant mortality rates. Where the evidence did not break down ethnicities into their more granular categories, we have included it here if relevant.

#### Health care use

After controlling for individual health, Pakistani women are more likely to have fewer GP consultations than White British women,<sup>31</sup> and Black women are much less likely to rely on GPs or health care professionals for women’s health than all other ethnic groups.<sup>32</sup> This could mean that these populations have fewer opportunities to discuss preconception health.

Once a woman is pregnant, timely access to good-quality antenatal care has been shown to be associated with lower occurrence of adverse maternal outcomes, including perinatal and neonatal mortality.<sup>33,34,35</sup> Women from minority ethnic backgrounds face many challenges accessing good-quality maternity services, including structural and cultural biases, with previous life experiences – such as racist attitudes, microaggressions, dismissal of concerns or a breakdown of trust – affecting interactions between these populations and pre-conception and maternity health care services.<sup>36,37,38</sup>

Some evidence indicates that Pakistani women are more likely to be underrepresented in early bookings for a scan (a scan booked by 12 weeks of gestation or fewer<sup>†</sup>),<sup>39</sup> the likelihood of late booking is higher for Black women and the relative risk of extremely late initiation is highest for Black African mothers specifically.<sup>40,41,42,43</sup> Other evidence suggests that women

\* There may be other relevant factors. For example, for Pakistani communities, there are several other reasons why congenital anomalies may occur, but these are not discussed here as they are out of scope of this report.

† The 12-week scan is an ultrasound that not only dates the gestation but also investigates foetal development and can help to determine whether the pregnancy is a high-risk one or not.

from minority ethnic backgrounds have fewer antenatal visits throughout their pregnancy.<sup>44</sup>

### Weight and diabetes

This reduced access to pre-conception and maternity care is particularly concerning for these groups of women due to several risk factors that can result in an infant dying within the first year of life – Pakistani, Black African and Black Caribbean women are more likely to be overweight or obese,<sup>45,46</sup> which is a risk factor for infant mortality, as previously discussed. South Asians and individuals of Black ethnicities are also more likely to have an increased risk or a high risk of developing diabetes, or to actually have diabetes,<sup>45,47</sup> which is a risk factor for developing congenital anomalies.

The risk that weight poses to people from minority ethnic backgrounds developing type 2 diabetes could be underestimated. The equivalent age- and sex-adjusted incidence of type 2 diabetes is greater at lower body mass indexes (BMIs) for people of minority ethnic backgrounds.<sup>48</sup> There is some evidence that this also applies to pregnant Pakistani women.<sup>40,41</sup> This suggests that current BMI thresholds are likely to be ineffective for diabetes screening and may miss high risk-pregnancies, particularly in Pakistani women.

### Folic acid and congenital anomalies

There is not much evidence on red blood cell folate levels between people of different ethnicities in England. A Public Health England survey found that 75% of all women of childbearing age had a red blood cell folate concentration lower than needed to avoid folate-sensitive foetal neural-tube defects, which cause some congenital anomalies,<sup>49</sup> but it does not mean that this is equally distributed across all ethnic backgrounds.

Some studies from the United States do suggest, however, that people from minority ethnic backgrounds in the general population are more likely to have lower levels of folate<sup>50</sup> and in women of childbearing age even after fortification of food with folic acid.<sup>51,52</sup> In some cases, lower understanding of and use of folic acid, a protective measure for this, among women from a minority ethnic background, and assumptions by health care professionals around knowledge and use, may compound this risk.<sup>53,54</sup>



### Socioeconomic factors

In addition to health and health care use there are also socioeconomic factors that increase the risks of infant mortality in births to Black and Pakistani women. For example, a high percentage of births of Pakistani, Black Caribbean and Black African babies occurs to parents in National Statistics Socio-economic Classification (NS-SEC) groups that are linked to poorer maternal health.<sup>55</sup> Similarly, deprivation is linked to infant mortality – nearly a third (31%) of people of Pakistani ethnicity and a fifth (20%) of people of Black ethnicity live in areas with higher deprivation compared with less than one in ten (9%) for those who are White.<sup>56</sup> So, these groups of women have a higher percentage of their babies born in socioeconomic populations where there is a higher risk of infant mortality.

### Reducing risks

The risks presented here could be better mitigated against by providing a better means of serving this population. For example, preliminary analysis of culturally adapted interventions for Pakistani women has shown benefits in outcomes for maternal mental health and for preventative behaviours for type 2 diabetes.<sup>57,58</sup> However, a systematic review found that few maternal policies have a focus on addressing maternity care inequalities and were not very well evaluated for their impact.<sup>59</sup>

## Health care provision

### Health care spending – net public health expenditure per 1,000 population

Our analysis indicates that where local authorities have higher levels of spending on public health, this is associated with higher rates of infant mortality. At first glance this could seem counterintuitive, as the hypothesis would be that higher levels of spending would have a positive impact on the health of the population, including pre-conception and maternal health, which would then translate to improved infant mortality rates.

However, as previously highlighted, infant mortality rates are considered an important indicator of overall population health.<sup>6,60</sup> Therefore, those areas that have higher infant mortality rates possibly also have higher population

health needs and require greater spending on public health services relative to the size of the population.

## Immediate environmental factors

### Housing quality and overcrowding – housing central heating deprivation, and dwellings per person

In our fully adjusted regression model, there is an association between higher housing central heating deprivation\* and higher rates of infant mortality, and an association between a lower number of dwellings per person (that is, overcrowding) and higher rates of infant mortality.

The links between poor housing conditions and overcrowding with child health and development have long been known.<sup>61,62</sup> Poor housing conditions have been shown to be associated with a range of adverse birth and infant outcomes, including those that are risk factors for infant mortality.<sup>63,64</sup> The potential influence on infant mortality may be direct or indirect.

Potential *direct* influences include restricted physical space, which may lead to difficulties in employing safe sleeping practices – a risk factor in sudden infant death syndrome (SIDS).<sup>65</sup> Poor housing conditions also increase the risk of infectious diseases and exacerbate respiratory illness and other conditions<sup>62</sup> as well as increasing the risk of unintentional injuries, particularly burns and falls.<sup>62,66</sup>

Potential *indirect* influences are reduced access to good-quality antenatal and maternity care and the impacts it has on maternal mental ill health, which is a risk factor for infant mortality.<sup>67,68,69</sup>

Poor housing conditions may be one of the mechanisms by which deprivation drives infant mortality inequalities as income-poor children are particularly likely to live in housing in a poor state of repair.<sup>70</sup> They may also be a contributory factor to the risk for babies of mothers who are under 20 years

\* Measured as the proportion of homes that do not have central heating. As well as being a specific measure in its own right, it is likely to be a proxy for poor housing conditions.

old,<sup>68</sup> as teenage mothers are more likely than older mothers to live in poor housing.<sup>71,72</sup> Finally, poor housing conditions may be a factor for those of Pakistani ethnicity: Pakistani people make up the largest proportion of people living in the most deprived areas for living environment, which includes the indoor living environment.<sup>56</sup> Black African and Pakistani groups represent the third and fourth most overcrowded households by ethnicity. Some 16% of Black African households are overcrowded and 13.5% of Pakistani households are overcrowded.<sup>73</sup>

The extent to which children experience poor housing conditions, for sustained periods of time, is not insignificant and the true numbers of those affected are unknown, as many children are effectively hidden and not represented in official datasets.<sup>74,75</sup> Past estimates have suggested that more than 3.5 million children\* live in ‘bad’ housing<sup>76,†</sup> and 1.6 million live in overcrowded accommodation.<sup>77</sup> Addressing poor housing conditions and overcrowding may present an opportunity to reduce infant mortality.

Many organisations have produced detailed information laying out the roles of different agencies in relation to housing.<sup>74,78,79,80</sup> However, integrated care boards and integrated care systems offer an opportunity to strengthen the importance of housing for health, for example including housing in women’s multi-agency support teams and strengthening the links between housing and the public health roles of midwives and maternity support workers.<sup>81</sup>

\* There are no estimates specifically for infants.

† The authors say: ‘Any definition of bad housing needs to encompass a range of factors. The obvious ones are physical conditions: housing may be deemed to be bad if it is damp, infested, cold, or in a bad state of repair. Housing may also be bad if it is unable to adequately accommodate the number of people inhabiting... The environment in which the housing is located is also important... Security of tenure, the status people attach to housing and the levels of community safety and cohesion in an area are all important features.’

## Housing affordability deprivation

Higher housing affordability deprivation\* was associated with higher rates of infant mortality in our unadjusted model, but when accounting for all other factors in the fully adjusted model, this relationship reversed, and lower housing affordability deprivation was associated with higher rates of infant mortality.

These ambiguous results suggest that in the unadjusted model this measure of deprivation is acting as a proxy for overall deprivation – a risk factor in infant mortality. Yet when other factors are taken to account – when it is easier to afford to enter into owner occupation or the private rental market – it increases the exposure of individuals to the risks associated with poor housing conditions and overcrowding (that is, where it is easier to access housing, this is because the housing conditions are poor). More is needed to determine how these factors interact with each other.

## Local authority factors

### Commissioning for early years – net expenditure on early years and Sure Start per child under five years old

Early years spending supports families with young children in a variety of ways. Sure Start centres are an initiative that gives help and advice on child and family health, parenting, money, training and employment.

In our analysis we found an association between higher net expenditure on early years and Sure Start per child under five years old and lower rates of infant mortality, although the effect size was not large. However, given that infant mortality is a relatively rare event, it was still significant. Plus, with the significant consequences following an infant death, as previously described, as well as the interplay between infant mortality rates and economic growth,<sup>7</sup>

\* This is expressed as the inability to afford to enter owner occupation or the private rental market (see Department for Communities and Local Government, 2015, *The English Indices of Deprivation 2015*, GOV.UK, [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/464597/English\\_Indices\\_of\\_Deprivation\\_2015\\_-\\_Research\\_Report.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/464597/English_Indices_of_Deprivation_2015_-_Research_Report.pdf)).

if there was a causal factor involved, could this return on investment be good enough? Since there are no current estimates of the total cost or economic impact of infant mortality at a regional or national level, it is impossible to tell.

Sure Start services also add benefits in other ways, including lower BMIs and better physical health (including reduced hospitalisation) and development in children, better maternal outcomes and reduced inequalities.<sup>82,83,84,85</sup> A simple cost-benefit analysis shows that the benefits of Sure Start are able to offset approximately 31% of the programme costs.<sup>8,33</sup> Additionally, in 2017, a briefing paper to parliament, looking at the current evidence at the time, concluded that Sure Start ‘provide[s] overall value for money’.<sup>86</sup> Combining our findings on infant mortality will only positively contribute to the cost-benefit analysis of early years spend and Sure Start.

## 5 Concluding remarks

The majority of previous studies on risk factors for infant mortality have looked at associations between local factors and infant mortality at an individual level, based on population sampling or auditing cases. Our research used readily available public data, covering the whole population, to see if we could find associations between local authority and population characteristics and infant mortality. Using a novel methodology, we have been able to look comprehensively at the associations in relation to each other rather than just simple associations.

In doing so, we have provided a focus, by highlighting areas that should be a priority for further research or where interventions may be best targeted. Our methodology can be applied locally for better interrogation of locally held data, to build area-specific evidence to support better local decision-making.

It should be noted that even if we did not find an association, it does not mean it does not exist, just that our models were not able to pick it up; further research is needed to assess what the current evidence is in such cases in the literature. Plus, some of our local area characteristics were proxies for things identified as important factors in the literature, such as population obesity levels as a proxy for obesity levels in women of a childbearing age. To further interrogate factors involved in infant mortality, we need better data collection and better data-sharing between agencies.

Ultimately, the number and variety of factors we found associated with infant mortality further highlight its complexity. This emphasises the need to address multiple factors to reduce infant mortality rates. Approaches that are driven both nationally and locally are needed and this requires collaborative thinking and integrated implementation. Universal policies and offers are also required, accompanied by targeted interventions where there is greater need/risk.

Additionally, this report has drawn out where associations with infant mortality may interact with each other, such as housing and ethnicity, and ethnicity and obesity. However, we do not know enough about the nature of these interactions, including the accumulation of risk across multiple factors, and ultimately how these lead to inequalities in infant mortality. Tackling multiple determinants might mean the impacts are additive and greater than the sum of their parts.

Although the death of an infant is relatively rare, it is a tragic event that has far-reaching consequences for those involved, and at a cost to society. Any means of reducing infant mortality rates should be a priority for the nation.

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