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Socioeconomic inequalities in survival and provision of neonatal care: population based study of very preterm infants

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ABSTRACT

Objectives To assess socioeconomic inequalities in survival and provision of neonatal care among very preterm infants.

Design Prospective cohort study in a geographically defined population.

Setting Former Trent health region of the United Kingdom (covering about a twelfth of UK births).

Participants All infants born between 22+0 and 32+6 weeks' gestation from 1 January 1998 to 31 December 2007 who were alive at the onset of labour and followed until discharge from neonatal care.

Main outcome measures Survival to discharge from neonatal care per 1000 total births and per 1000 very preterm births. Neonatal care provision for very preterm infants surviving to discharge measured with length of stay, provision of ventilation, and respiratory support. Deprivation measured with the UK index of multiple deprivation 2004 score at super output area level.

Results 7449 very preterm singleton infants were born in the 10 year period. The incidence of very preterm birth was nearly twice as high in the most deprived areas compared with the least deprived areas. Consequently rates of mortality due to very preterm birth per 1000 total births were almost twice as high in the most deprived areas compared with the least deprived (incidence rate ratio 1.94, 95% confidence interval 1.62 to 2.32). Mortality rates per 1000 very preterm births, however, showed little variation across all deprivation fifths (incidence rate ratio for most deprived fifth versus least deprived 1.02, 0.86 to 1.20). For infants surviving to discharge from neonatal care, measures of length of stay and provision of ventilation and respiratory support were similar across all deprivation fifths.

Conclusions The burden of mortality and morbidity is greater among babies born to women from deprived areas because of increased rates of very preterm birth. After very preterm birth, however, survival rates and neonatal care provision is similar for infants from all areas.

INTRODUCTION

In developed countries such as the United States and the United Kingdom preterm birth is a major public health problem, with the incidence rising over the past 10 years.[1 2] Preterm birth is also the major cause of infant mortality in these countries. There are wide socioeconomic disparities in the incidence of spontaneous preterm birth, with substantially higher rates among women from more deprived areas both in the UK[1 3] and internationally.[4 5] Increases in the UK in the incidence of very preterm birth (before 33 weeks' gestation) over the past decade have affected all deprivation groups alike,[1] resulting in an increase in the absolute difference in numbers of very preterm births between affluent and deprived areas. Hence the burden of mortality in more deprived areas is increasing and might explain the widening inequalities in infant mortality seen in the UK.[6] The survival rates of very preterm births are well documented, as are the detrimental effect on survival of clinical factors such as early gestation and low birth weight.[7] Little is known, however, about how the survival of very preterm infants varies with deprivation.[8]

While improvements have been made in survival, very preterm infants who do survive are likely to have major health and disability problems.[9] Consequently these babies have long term need of health services and associated high costs of hospital inpatient services compared with babies born at later gestations.[10] Socioeconomic differences in the use and costs of hospital services have been explored in young children,[11] and higher costs are seen among disadvantaged children.[12] These differences might be partially explained by the increased proportion of very preterm and low birthweight infants in the more disadvantaged groups. Therefore it is of interest to assess whether very preterm infants who survive their first weeks of life have similar levels of service use or whether they vary by deprivation.

We explored inequalities in survival and provision of neonatal care in over 7000 very preterm births. We compared survival to discharge from neonatal care per 1000 total births and per 1000 very preterm births, allowing for differential incidence rates between areas. We assessed neonatal care provision for very

Table 1 | Incidence of very preterm birth, rate of death before discharge from neonatal care, and relative risk by deprivation fifth (95% confidence interval) in infants alive at onset of labour

	Deprivation fifth (1=least deprived, 5=most deprived)					
	1 (n=1026)	2 (n=1269)	3 (n=1416)	4 (n=1734)	5 (n=1957)	All (n=7402)
Incidence of very preterm birth:						
Per 1000 births*	9.5 (8.9 to 10.1)	11.7 (11.1 to 12.4)	13.1 (12.4 to 13.8)	16.0 (15.3 to 16.8)	18.1 (17.3 to 18.9)	13.7 (13.4 to 14.0)
Rate ratio	1	1.24 (1.14 to 1.34)	1.38 (1.27 to 1.49)	1.69 (1.57 to 1.82)	1.91 (1.77 to 2.06)	—
No of deaths before discharge	180	204	235	321	349	1289
Mortality rate of very preterm infants:						
Per 1000 births	1.67 (1.43 to 1.93)	1.89 (1.64 to 2.17)	2.17 (1.91 to 2.47)	2.97 (2.66 to 3.31)	3.23 (2.90 to 3.59)	2.39 (2.26 to 2.52)
Relative risk	1	1.13 (0.93 to 1.38)	1.31 (1.08 to 1.58)	1.78 (1.49 to 2.14)	1.94 (1.62 to 2.32)	
Per 1000 very preterm births	175 (153 to 200)	161 (141 to 182)	166 (147 to 186)	185 (167 to 204)	178 (162 to 196)	174 (166 to 183)
Unadjusted relative risk (P=0.42)	1	0.92 (0.76 to 1.10)	0.95 (0.79 to 1.13)	1.06 (0.89 to 1.24)	1.02 (0.86 to 1.20)	—
Adjusted relative risk† (P=0.25)	1	0.96 (0.79 to 1.16)	0.99 (0.82 to 1.20)	1.04 (0.83 to 1.31)	0.94 (0.74 to 1.18)	—

*Number of live and still births in each deprivation fifth=108 053 births.
†Adjusted for gestation at birth, weight for gestational age, and year of birth and correlation within neonatal intensive care unit.

preterm infants surviving to discharge using length of stay, provision of ventilation, and respiratory support.

METHODS

Participants

We included in the study all very preterm singleton infants (22+0 to 32+6 weeks' gestation inclusive) alive at the onset of labour, born 1 January 1998 to 31 December 2007, whose mothers resided in the former Trent health region. The Trent region is a geographically defined population of about 4.6 million people, with about 54 000 births a year, representing one in 12 UK births. The neonatal survey is a register of all infants born before 33 weeks' gestation and admitted for neonatal care.[13] It includes detailed information on the pregnancy, delivery, and provision of neonatal care. These data were combined with mortality data from the Confidential Enquiry into Maternal and Child Health (CEMACH),[14] formerly known as the Confidential Enquiry into Stillbirths and Deaths in Infancy (CESDI), to identify infants born at 22-32 weeks' gestation who died before admission to neonatal care and also the neonatal mortality (28 days) of infants discharged from neonatal care. Data were obtained on gestation, birth weight, sex, and postcode of residence for all infants. Infants small for gestational age were defined as those whose birth weight was below the 10th centile for gestational age and sex based on centile charts.[15] Because of variations in the perceptions of the viability of a very preterm infant and consequent differences in the reporting of live births in low gestation infants[16] we included all those infants with the potential to be live born—that is, infants alive at the onset of labour. Infants with missing data were excluded from the analyses.

Socioeconomic group was measured with the UK index of multiple deprivation for 2004,[17] a deprivation index at small area level designed for the UK government. It combines information on seven measures of deprivation (income; unemployment; health and disability; education, skills, and training; housing and services; living environment; crime) and is available at super output area level (about 1500 residents). All super output areas in the region were ranked by their deprivation score, and information on the number of live births (1998-2007) in each super output area was used to divide the areas into five groups (fifths) with equal populations of births (from 1 (least deprived) to 5 (most deprived)). Hence if the incidence rate was similar for all deprivation groups, the same number of incident cases of very preterm birth would be expected in each fifth. The distribution of the index of multiple deprivation across super output areas in the study region is similar to England as a whole, with a slight excess of more deprived areas (56% of the study region's super output areas are ranked in the most deprived half of English super output areas). Each very preterm infant was assigned to a super output area of residence based on their mother's postcode at the time of birth and allocated to the appropriate deprivation fifth.

The incidence of very preterm birth was calculated with denominator data from the Office for National Statistics (ONS) on all live births by super output area level of residence and data from the Confidential Enquiry into Maternal and Child Health on all stillbirths in the former Trent region for each year from 1998-2007. The number of stillbirths in each deprivation fifth was estimated as a fifth of the total stillbirths as this information was not available at super output area level. The number of stillbirths as a proportion of all births was so small (0.5%), however, that variations in the rate of stillbirths between deprivation fifths would not have a significant effect on the results.

Mortality

To measure deaths relating to prematurity, we defined mortality as a death before discharge from neonatal care but included planned early deaths at home (that is, within seven days) when this was part of a palliative care plan. This approach was used instead of mortality within an essentially arbitrary fixed time period (such as the first 28 days of life) to capture all early deaths relating to prematurity while excluding the majority of deaths relating to injuries and sudden unexplained deaths after discharge from care. We also carried out

Table 2 | Rates of low gestational age, low birth weight, and low birth weight for gestational age by deprivation fifth in very preterm births and relative risks (95% confidence intervals) comparing rates with those in least deprived fifth

	Deprivation fifth (1=least deprived, 5=most deprived)					
	1 (n=1026)	2 (n=1269)	3 (n=1416)	4 (n=1734)	5 (n=1957)	All (n=7402)
Gestational age <29 weeks:						
No (%)	372 (36)	443 (35)	486 (34)	653 (38)	745 (38)	2699 (36)
Relative risk	1	0.96 (0.86 to 1.08)	0.95 (0.85 to 1.06)	1.04 (0.94 to 1.15)	1.05 (0.95 to 1.16)	P=0.12
Birth weight for gestational age <10th centile:						
No (%)	174 (17)	191 (15)	217 (15)	282 (16)	286 (15)	1150 (16)
Relative risk	1	0.89 (0.74 to 1.07)	0.90 (0.75 to 1.08)	0.96 (0.81 to 1.14)	0.86 (0.73 to 1.02)	P=0.43
Birth weight <1000 g:						
No (%)	284 (28)	349 (28)	390 (28)	506 (29)	590 (30)	2119 (29)
Relative risk	1	0.99 (0.87 to 1.14)	1.00 (0.87 to 1.13)	1.05 (0.93 to 1.19)	1.09 (0.97 to 1.23)	P=0.34

sensitivity analyses with stillbirth and neonatal death as the outcome to assess the impact of differential follow-up for infants.

We were interested in two aspects of mortality: whether the total burden of mortality because of very preterm birth varied with deprivation and whether, after very preterm birth, mortality varied by deprivation fifth. Firstly, we calculated the mortality of very preterm infants per 1000 total births for each deprivation fifth using the data from the Office for National Statistics and the Confidential Enquiry into Maternal and Child Health on all live births and stillbirths in the region as the denominator. Secondly, we calculated the mortality per 1000 very preterm births using the study data on all very preterm live and still births as a denominator, thus allowing for differences in the incidence of very preterm birth between deprivation fifths. Relative risks for mortality were calculated with the least deprived fifth as the comparison group. For mortality after very preterm birth, we adjusted relative risks for differences in gestation, year of birth, and birth weight with a Poisson regression model with robust standard error estimates.[18] To account for potential correlation of outcomes within neonatal intensive care centres, we used generalised estimating equations with exchangeable correlation. Of the 31 neonatal care units involved in the study, 16 units were in the study region and cared for 97.9% of infants. The 15 remaining units did not lie in the study region but cared for a small number of infants whose mothers lived in Trent. Deprivation fifth was treated as a categorical variable, but we also assessed tests for trend. To test whether the deprivation gap varied across the 10 year period and with gestational age, we tested the significance of the interaction terms between deprivation and year of birth and gestation.

Provision of neonatal care

Detailed information was available on provision of neonatal care until discharge for those babies admitted to the neonatal unit. Length of stay and provision of ventilation and respiratory support were chosen as widely accepted measures of hospital inpatient care that could be used to compare provision of neonatal care across the deprivation fifths. For length of stay, we used the median and interquartile range as indicators of the typical length of stay, and the mean (SD) provided a measure of overall costs of hospital stay for all infants in each deprivation fifth. Mechanical ventilation was used as a proxy for higher level intervention and was assessed by the percentage of infants receiving any ventilation and the mean (SD) number of days of ventilation. Provision of any respiratory support (days of ventilation, continuous positive airway pressure (CPAP), or oxygen) was used as a proxy for medium level intervention and again assessed by the percentage of infants provided with any respiratory support as well as the mean (SD) of the number of days of support provided.

RESULTS

Complete data were available on 7402 (99%) of the 7449 very preterm singleton births in the study period. There were 540 261 births (live and still born) in the 10 year period, giving an incidence rate of very preterm birth of 13.8 per 1000 total births. The incidence of very preterm singleton birth increased significantly with increasing deprivation, as has been shown previously,[1] with mothers from the most deprived fifth nearly twice as likely to have a very preterm infant as those from the least deprived areas (table 1). Follow-up time for those receiving neonatal care varied from 1 to 645 days with a median length of stay of 33 days (interquartile range 19-57). The prevalence of mortality risk factors showed little variation across all deprivation groups, with similar rates of extremely preterm birth (<29 weeks' gestation), low birth weight for gestational age (<10th centile), and low birth weight (<1000 g) (table 2).

Mortality

Of the 7402 infants alive at the onset of labour, 529 died before admission to neonatal care and 760 died before discharge from neonatal care. The rate of mortality before discharge among all births was 2.4 per 1000 total births—that is, out of every 10 000 infants, 24 died after being born very preterm. This increased with increasing deprivation, with women from the most deprived fifth almost twice as likely to have a pregnancy that resulted in the birth of a very preterm

Table 3 | Measures of provision of care by deprivation fifth for infants surviving to discharge after very preterm birth

	Deprivation fifth					
	1 (n=846)	2 (n=1065)	3 (n=1181)	4 (n=1413)	5 (n=1608)	All (n=6113)
Length of stay (days):						
No (%) staying ›28 days	579 (68)	713 (67)	794 (67)	1006 (71)	1097 (68)	4189 (69)
Median (IQR)	39.5 (26-65)	37 (25-60)	38 (25-61)	40 (27-62)	40 (25-67)	39 (26-63)
Mean (SD)	49.2 (33.1)	47.0 (32.4)	47.2 (31.4)	49.5 (33.7)	50.4 (37.1)	48.8 (33.9)
Ventilation:						
No (%) ventilated ≥1 day	424 (50)	490 (46)	531 (45)	667 (47)	781 (49)	2893 (47)
Mean (SD) time (days)	4.3 (9.3)	3.9 (9.0)	3.6 (8.9)	3.8 (9.8)	4.5 (10.8)	4.0 (9.7)
Any respiratory support:						
No (%) supported ≥1 day	670 (79)	822 (77)	906 (77)	1114 (79)	1283 (80)	4795 (78)
Mean (SD) time (days)	22.3 (35.6)	20.2 (34.7)	19.3 (33.9)	21.3 (35.5)	23.1 (37.3)	21.3 (35.6)

IQR=interquartile range.

baby who died before discharge, compared with a woman from the least deprived fifth (relative risk 1.94, 95% confidence interval 1.62 to 2.32) (table 1).

We then recalculated these rates using very preterm births as the denominator to allow for the differences in the incidence of very preterm birth. The mortality rate was 174 per 1000 very preterm births, hence out of 1000 very preterm infants alive at the onset of labour, 174 did not survive to discharge from neonatal care. There was little evidence of a significant variation in this mortality rate with deprivation fifth (table 1). Very preterm infants of mothers in the most deprived fifth were 2% more likely to die before discharge compared with infants of mothers from the least deprived fifth (incidence rate ratio 1.02, 0.86 to 1.20). Adjustment of the very preterm birth mortality rates for risk factors including low birth weight, gestational age, and year of birth as well as correlation within the neonatal care unit, led to little change (0.94, 0.74 to 1.18). Hence there was no evidence of significant inequalities in the mortality of very preterm infants after adjustment for the incidence of very preterm birth.

Analyses of alternative measures of mortality (stillbirth and neonatal mortality) showed qualitatively similar results with little evidence of significant socioeconomic inequalities in mortality after very preterm birth.

Provision of neonatal care

The measures of neonatal care provision in very preterm births were similar across all deprivation fifths (table 3). Around two thirds of very preterm infants who survived to discharge had a hospital stay of more than 28 days, with a median stay of 40 days. The mean stay of 49 days was similar for all fifths of deprivation, suggesting that average care costs per infant were similar across all deprivation groups. Investigation of ventilation used showed that around half of very preterm infants surviving to discharge needed ventilation at some point during their hospital stay, with an overall mean of about four days. As expected a higher number of infants required some form of respiratory support, with around 80% of surviving infants needing at least one day of support (mean 21 days). There was no evidence of a significant difference between fifths for measures of ventilation or respiratory support.

DISCUSSION

Survival to discharge in very preterm infants does not seem to vary with deprivation, although the overall burden of mortality is greater in more deprived areas because of the increased incidence rates of very preterm birth. A very preterm infant from a deprived area and one from an affluent area of the same gestational age and birth weight have similar levels of expected mortality and neonatal care. The prevalence of risk factors for mortality such as low birth weight and early gestation were comparable across all deprivation groups, and the similarity in the proportion of infants who were small for gestational age seems to confirm the view that the aetiology of very preterm birth is different from that of intrauterine growth retardation.

We found little socioeconomic variation in the provision of neonatal care. In other areas of health care, inequalities in access to care arise because of variations in service availability, organisational barriers to the provision of care, and individual and social barriers such as help seeking behaviour, financial resources, and cultural beliefs.[19] A recent systematic review of equity of access to care noted that the inequities seen in studies of adults are less common among children in primary care but that socioeconomic inequities existed in secondary care.[20] The UK neonatal service, as in many other countries, has been developed on the basis that specialist cots are not available in every community but instead arrangements are in place to move the baby to such facilities either in utero (when a high risk of premature delivery can be predicted) or after birth by using specialised transport equipment and personnel. Sometimes babies are moved long distances to find an appropriate cot but access to specialist care is not denied and indeed judgments about the appropriateness of babies being given access to such facilities based on any aspect of their background would be illegal in the UK. Therefore, in terms of individual and social barriers to care, as most women are in hospital when they give birth to very preterm infants, differences in help seeking behaviours, ability to pay to

WHAT IS ALREADY KNOWN ON THIS TOPIC

Areas of high deprivation have high rates of neonatal and infant mortality

Women from deprived areas have an increased risk of delivering a baby very preterm (that is, before 32 weeks' gestation)

Costs of hospital inpatient services seem higher in young infants from more deprived areas compared with less deprived areas

WHAT THIS STUDY ADDS

Very preterm infants from a deprived area and those from an affluent area of the same gestational age and birth weight have similar levels of expected mortality and neonatal care

The higher burden of mortality and increased neonatal care costs for very preterm infants in deprived areas is probably because of higher incidence rates and not differences in their individual severity of condition

Deprivation does not seem to be a barrier to accessing and receiving neonatal care

access care, and cultural beliefs have virtually no impact on access to neonatal care. This is supported by our findings that the prevalence of risk factors for mortality of infants was similar for all deprivation fifths—that is, the professional threshold for admitting and discharging infants to and from neonatal intensive care did not seem to vary with deprivation.

Limitations

We did not have access to individual level measures of deprivation, which might show inequalities in survival, risk profiles, or provision of neonatal care not seen by using area level measures. Factors such as cigarette smoking, ethnicity, and history of previous preterm birth might also have an impact, but we were not able to explore these here. Future prospective studies at the individual level would allow more accurate investigation of inequalities in survival and neonatal care provision in very preterm births. Obtaining individual level data, however, is more time consuming and costly. As discharge mortality, neonatal mortality, and rates of stillbirth showed similar patterns we believe that this adds strength to our findings based on area level data. Our methods using area level measures are relatively straightforward to undertake and allow constant monitoring of services for health service planners.

The use of length of stay and ventilation and respiratory support reflect the major components of inpatient provision of neonatal care but clearly do not represent a detailed cost analysis. As risk profiles were similar across deprivation fifths we believe it is unlikely that measurement error in provision of neonatal care would vary with deprivation and hence would not affect our comparisons.

Implications

Infant mortality is known to be related to socioeconomic status,[6] though there is little information on survival within specific causes. The wide inequalities in the incidence of very preterm birth might partially explain inequalities in infant mortality. Here we show that the wellbeing of very preterm infants at birth and their short term survival do not seem to differ with deprivation and that provision of neonatal care is equitable. Further follow-up work is needed to assess the impact of deprivation on morbidity, mortality, and provision of care as these infants grow older. Petrou et al found that the impact of social class was strongest between the ages of 3 and 10 compared with the first two years,[12] but this finding needs to be confirmed among very preterm infants.

As risk profiles were similar across deprivation groups, we would expect that the average costs of neonatal care for a very preterm infant would be comparable for infants from all areas, irrespective of their level of exposure to deprivation. This information is key for health service decision makers when planning care provision for very preterm babies. It is vital to remember, however, that the total costs of care in the most deprived areas will be substantially higher as the incidence rate of very preterm birth in these areas is about twice that seen in the least deprived areas.

The mechanistic link underlying the deprivation gradient in the incidence of very preterm birth remains elusive. What has actually happened, almost inadvertently, is that the capacity of neonatal care services has been increased to deal with increasing numbers of very preterm infants. While this has, in many ways, been successful, preterm babies often have long term complications that require ongoing heathcare support. We believe that understanding the link between deprivation and risk of preterm birth should be a major research priority. It seems highly likely that such work could lead to public health strategies that would reduce the costs not only of neonatal care but also those attached to the long term health problems suffered by some of these babies.

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Contributors: All authors developed the idea for the paper and designed the study. LKS performed the statistical analysis, and LKS, ESD, BNM, and DJF interpreted the results. LKS drafted the paper and all authors revised the paper critically and approved the final manuscript. LKS is the guarantor.

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Competing interests: None declared.

Ethical approval: This study was approved by the local research ethics committees for each of the centres at the beginning of the Trent Neonatal Survey. In 2004 approval was obtained from the Trent multicentre research ethics committee. The neonatal survey obtained section 60 approval under the Health and Social Care Act for its programmes in 2002. The Patient Information Advisory Group also gave approval for collection of data without consent.

Data sharing: Requests for data should be made to the corresponding author at lks1@leicester.ac.uk. Requests must be accompanied by a proposal, including an outline protocol and a description of data security measures, as required by original ethics approval.

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