Socioeconomic inequalities in neonatal intensive care admission rates

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ABSTRACT

Objective: To examine socioeconomic inequalities in neonatal intensive care (NIC) admissions relating to preterm birth, intrauterine growth restriction (IUGR), multiple births and other conditions.

Methods: Retrospective review of all NIC admissions from 1996 to 2001 throughout a geographically defined region. Area deprivation indices were grouped into quintiles from least (1) to most (5) deprived. Admissions were classified by predefined hierarchical criteria.

Results: The rate of admissions was 31.4 per 1000 births. There was a J-shaped relation with socioeconomic group (28.1 NIC admissions per 1000 in quintile 1, 34.0 in quintile 5 and below 28 in the other quintiles). The most deprived areas had a rate 19% above the regional average. The relation with socioeconomic group differed significantly according to primary reason for admission. The rates of admissions with significant prematurity (34% of all admissions) and IUGR as primary reason were highest in quintile 5 (18% and 41% above the regional average, respectively). This contrasted with the rate of admission for multiple birth which was highest in quintile 1 (45% above average). These differences provided the main explanation for the J-shaped overall curve.

Conclusions: Measures to alleviate deprivation and to improve the preterm birth and IUGR rates in deprived groups would have the greatest potential to reduce inequality in need for NIC admission. Efforts to achieve targets for reduction in infant mortality need to take account of the different effects of socioeconomic inequalities for different conditions and groups of infants.

The 2007 report by the Comptroller and Auditor General “Caring for Vulnerable Babies: The Organisation of neonatal Services in England” highlighted the increasing numbers of newborn infants needing specialist care, and the correlation between high neonatal death rates and lower socioeconomic groups.1 Approximately 1 in 12 liveborn infants are admitted to a neonatal facility, with half of these receiving neonatal intensive care (NIC).2 Many of these infants have conditions such as congenital malformations, prematurity, intrauterine growth restriction (IUGR) or infection, which are known to be linked to socioeconomic deprivation.3 However, other risk factors for admission such as multiple birth and elective caesarean section may have a different association and even be linked to higher socioeconomic status through factors such as their links to maternal age, use of assisted reproductive technology and ability to pay for private care.

Previous work has demonstrated that social deprivation correlates with perinatal and neonatal mortality. The report of the Confidential Enquiry into Maternal and Child Health on Perinatal Mortality 2006 has reported rates of stillbirth and neonatal mortality for mothers resident in the most deprived areas (9.5) that were almost double those in the least deprived areas (5.5).4 A Department of Health review has also reported a widening from 15% (1997–1999) to 17% (2004–2006) in the relative gap between infant mortality rate in the routine and manual group and in the total population.5 Smith et al reported wide socioeconomic inequalities that persist over time and influence the incidence of very preterm birth.6 Social deprivation is also a risk factor for low birth weight and thus can be expected to influence the need for neonatal intensive care. Howell and Vert reported in 1993 that socioeconomic status was important in determining use of neonatal intensive care in both France and the United States.7 A more recent UK study also concluded that social deprivation correlates strongly with neonatal morbidity and the need for neonatal unit admission.8

In this paper, we use a population-based database of all NIC admissions throughout Northern Ireland to examine socioeconomic inequalities in admissions by primary reason for admission. This information is useful for appropriate distribution of resources, for understanding the socioeconomic profile of families receiving services and for predicting the effect of trends in risk factors for NIC admission on the development and planning of the service regionally and nationally. It is part of a larger study that has assessed...
socioeconomic inequalities in adverse pregnancy outcomes in Northern Ireland, which is a region of the UK with high levels of socioeconomic deprivation.8

METHODS

Since 1994 all neonatal intensive care units in Northern Ireland have prospectively collected and returned a range of socio-demographic, obstetric and neonatal intervention and outcome data items to a central NICORE database (Neonatal Intensive Care Outcomes Research & Evaluation). One proforma is completed by medical or nursing staff in accordance with agreed definitions for each infant admitted to any neonatal facility within the first four weeks of life. Each episode of care is then linked to create a single record for each infant.

For the purposes of this study a subset of NICORE data items were extracted for infants receiving level 1 and/or level 2 care (categorised by the British Association of Perinatal Medicine levels of care)9 during the period 1 January 1996 to 31 December 2001. These data variables included year of birth, postcode, birthplace, marital status of mother, age of mother, antenatal risk factors, birth weight, gestation, gender, mode of delivery, small for gestational age, number of fetuses this pregnancy, congenital malformations, diagnoses and final outcome.

Each record was reviewed by one of the authors (JJ) and a primary reason for admission was assigned according to the following hierarchical criteria:

- Congenital malformation (excluding mild conditions such as skin tags, talipes, hypospadias, mild dysmorphic features)
- Significant prematurity: gestational age \( \leq 32 \) weeks (no congenital malformation). This cut-off for gestation was chosen pragmatically as infants born at gestational ages between 33 weeks and 37 weeks are unlikely to require intensive care unless there is another complicating condition
- Small for gestational age (IUGR—birth weight less than 10th centile for gestational age) (>32 weeks’ gestation, no congenital malformations)
- Multiple birth (>32 weeks’ gestation, no congenital malformations, no IUGR)
- Elective caesarean section at 37 or 38 weeks’ gestational age (>32 weeks’ gestation, no congenital malformations, no IUGR, singleton pregnancy)
- Other (>32 weeks’ gestation, no congenital malformations, no IUGR, singleton pregnancy, not elective caesarean section at 37 or 38 weeks’ gestation).

A primary reason for admission to the NICU was not assigned when there was insufficient information to make an informed decision (57 cases). Area deprivation indices were allocated by linkage of post-coded data to wards. The socioeconomic index was the Northern Ireland Multiple Deprivation Measure 2001 (Noble index), using only its income domain for the 1991 census wards. The Registrar General birth data were used to provide the denominator for the number of live births in the population, similarly linked by postcode to wards to obtain deprivation quintiles. Indices were grouped into quintiles—that is, 20% of wards were in each quintile, from least deprived (1) to most deprived (5).

\( \chi^2 \) Tests were used to test for heterogeneity or trend of NIC admission rates across quintiles, and to test for an association between primary reason for admission and deprivation quintile.10 No attempt was made to correct for risk factors such as maternal age, since our aim was to describe the overall gradient, not to provide a causal model.

RESULTS

There were 4343 infants admitted to neonatal intensive care among 138,444 live births in 1996–2001, a rate of 31.4 per 1000 births (table 1). Of these 92% were discharged alive. The rate of admissions increased during the study period (from 27 per 1000 in 1996 to 33 in 2001).

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The socioeconomic quintile of residence could be determined for 90.2% (3919/4343) of NIC admissions and 98.9% of births. For those with known socioeconomic status, the NIC admission rate was 34.0 per 1000 in the most deprived quintile, 28.1 in the least deprived, and below 28 in the other quintiles (fig 1), a J-shaped relation. These differences were statistically significant (\( \chi^2 \) for trend = 21.2, \( p<0.0001 \)).

<table>
<thead>
<tr>
<th>Socioeconomic quintile</th>
<th>Number of births</th>
<th>NIC admissions</th>
<th>Admission rate/1000 births</th>
<th>95% Confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (least deprived)</td>
<td>29954</td>
<td>842</td>
<td>28.1</td>
<td>26.2 - 30.0</td>
</tr>
<tr>
<td>2</td>
<td>24469</td>
<td>617</td>
<td>25.2</td>
<td>23.2 - 27.2</td>
</tr>
<tr>
<td>3</td>
<td>23233</td>
<td>638</td>
<td>27.5</td>
<td>25.4 - 29.6</td>
</tr>
<tr>
<td>4</td>
<td>25020</td>
<td>661</td>
<td>26.4</td>
<td>24.4 - 28.4</td>
</tr>
<tr>
<td>5 (most deprived)</td>
<td>34182</td>
<td>1161</td>
<td>34.0</td>
<td>32.1 - 35.9</td>
</tr>
<tr>
<td>Missing</td>
<td>1586</td>
<td>424</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>138444</td>
<td>4343</td>
<td>31.4</td>
<td>30.5 - 32.3</td>
</tr>
<tr>
<td>Total where quintile known</td>
<td>136858</td>
<td>3919</td>
<td>28.6</td>
<td>27.7 - 29.5</td>
</tr>
</tbody>
</table>

Figure 1 Neonatal intensive care admission rates and 95% confidence intervals 1996–2001 by socioeconomic quintile.
The assigned primary reason for admission, as categorised above, was congenital malformations in 11%, significant prematurity 34%, small for gestational age 8%, multiple birth 5% and elective caesarean section at 37 or 38 weeks 4% (table 2). The proportion discharged alive was lowest for congenital malformation (81.5%) and significant prematurity (86.7%) with over 97.5% discharged alive in all other categories. The primary reason for admission was classified as other where this information was available but did not fall into any of the defined categories. This included infants with conditions such as respiratory illnesses, patent ductus arteriosus, infection, necrotising enterocolitis, seizures, etc, as the number of infants with each of these conditions was insufficient for meaningful separate analysis.

Table 2 shows the numbers and rates of admissions by primary reason in each socioeconomic quintile. There was a significant association between primary reason and quintile (fig 2; $\chi^2$ for heterogeneity $= 70.4$, $p < 0.0001$). Admissions associated with congenital malformation (overall admission rate 3.2 per 1000) showed differences across quintiles, but not a consistent gradient, though the lowest rate of malformation associated admissions was in the least deprived quintile. Significant prematurity (overall rate 9.7) showed a gradient of increasing frequency with increasing deprivation, from 8.6 in the least deprived quintile to 11.5 in the most deprived. Small for gestational age (overall rate 2.4) showed a J-shaped association with socioeconomic deprivation, with the highest rate of 3.4 in the most deprived quintile. Multiple births (overall rate 1.4) showed an inverse association with socioeconomic deprivation, with higher rates of 2.1 and 1.8 in the least deprived quintiles. Elective caesarean section showed a shallow U-shaped relation, with slightly higher rates in the least and most deprived quintiles. The differences in admission rate by quintile were statistically significant for each primary reason ($p < 0.01$) except for caesarean section ($p = 0.76$). Separate analysis of the periods 1996 to 1998 and 1999 to 2001 demonstrated no significant difference in the shape of the overall curve.

DISCUSSION
We found a trend of increase in the overall rate of NIC admissions. Numbers are too small for precise analysis, but contributory factors could be an increasing incidence of low birth weight, a rise in multiple births and rise in maternal age. Initial analysis of our larger study has shown a trend of increase in the overall percentage of live births that were multiple (from 2.76 in 1996 to 3.18 in 2001), <2500 g (5.64 in 1996 to 5.97 in 2001) and <32 weeks' gestation (1.01 in 1996 to 1.14 in 2001). It has also found that in Northern Ireland, small for gestational age is highly associated with socioeconomic deprivation and prematurity less so. Our previous work has demonstrated an increase from 19% in 1994–6 to 26% in 1999–2000 in the percentage of infants admitted to the NIC with birth weight <1.5 kg, and from 7% to 11% for those <1.0 kg.

The highest rates of NIC admissions related to the most deprived areas of residence, which had 19% more admissions than the average for Northern Ireland. This was particularly marked where the primary reason for admission was small for gestational age (41% more than average), significant prematurity (18%) or “other” (21%). Together these explain 42% of neonatal intensive care admissions, and it is clear therefore that...
Table 3  Neonatal intensive care admissions 1996–2001 by socioeconomic quintile and primary reason for admission (as defined by hierarchical criteria)

<table>
<thead>
<tr>
<th>Socioeconomic quintile</th>
<th>Congenital malformation</th>
<th>Significant prematurity</th>
<th>Small for gestational age</th>
<th>Multiple birth</th>
<th>Elective caesarean section</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Rate</td>
<td>No</td>
<td>Rate</td>
<td>No</td>
<td>Rate</td>
</tr>
<tr>
<td>1 (least deprived)</td>
<td>73</td>
<td>2.4</td>
<td>256</td>
<td>8.6</td>
<td>78</td>
<td>2.6</td>
</tr>
<tr>
<td>2</td>
<td>72</td>
<td>2.9</td>
<td>186</td>
<td>7.6</td>
<td>54</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>94</td>
<td>4.1</td>
<td>243</td>
<td>10.5</td>
<td>36</td>
<td>1.6</td>
</tr>
<tr>
<td>4</td>
<td>72</td>
<td>2.9</td>
<td>254</td>
<td>10.2</td>
<td>45</td>
<td>1.8</td>
</tr>
<tr>
<td>5 (most deprived)</td>
<td>119</td>
<td>3.5</td>
<td>392</td>
<td>11.5</td>
<td>116</td>
<td>3.4</td>
</tr>
<tr>
<td>Total</td>
<td>431</td>
<td>3.2</td>
<td>1331</td>
<td>9.7</td>
<td>329</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Attempts to reduce socioeconomic deprivation have the potential to reduce NIC rates and their associated costs to the infant, family and health service.

Multiple births explain 5% of NIC admissions when not associated with significant prematurity or IUGR, or 17% when all multiple births are considered. The least deprived quintile had a 45% greater admission rate for multiple birth as a primary reason than the Northern Ireland average. Multiple births have been rising in frequency in Northern Ireland related to increasing maternal age and use of assisted reproductive technology, and both these factors are associated with higher socioeconomic status. Multiple birth, whether as a primary reason for admission or as the underlying reason for preterm birth and IUGR, was the main explanation for the small but consistent tendency for babies from the least deprived areas to have higher NIC admission rates than those from the middle quintiles. Maternal age over 40, also shown in the larger study to be more common in less deprived areas and associated with higher preterm births and IUGR rates, would also have contributed to slightly elevated NIC admission rates in the least deprived areas. Paradoxically, the increase in multiple births has led to a slight narrowing of overall socioeconomic inequality in NIC admission. Measures to reduce the rate of multiple births, while of overall benefit, would initially increase inequalities, unless accompanied by measures to reduce the multiple birth rate.

Elective caesarean section carries with it a risk of complications leading to NIC admission, and was found to account for 4% of admissions in this population. It did not show a strong relation with socioeconomic status in our data, although it is known to be more prevalent among more affluent mothers.

The results of this study confirm previous findings that social deprivation correlates with the need for admission to neonatal intensive care, with different relative impacts depending on the diagnosis and reason for admission. Manning et al reported a strong correlation between social deprivation and admission for all indications except jaundice and feeding problems in all admissions for special and intensive care in a single centre. They suggested that this association reflected a pervasive effect of socially determined factors on placental function and fetal nutrition, in addition to a range of respiratory conditions. However, special care admission, not included in our study, is also influenced by other factors than need, including cot availability. In contrast, neonatal intensive care is accessed on the basis of need only, and over this time period no babies needing NIC admission were unable to access it.

The study was limited by the need to retrospectively assign a primary reason for admission to each episode based on the list of diagnoses recorded at discharge. However this was undertaken by a single individual so any bias is likely to affect the whole dataset to a similar extent. A strength of the study is that the dataset included all live births and NIC admissions in the entire population of the region with very little transfer out of mothers or infants.

The UK government has recognised that although death rates in the first year of life have fallen in recent decades this trend has diminished in recent years, and the UK compares unfavourably with other countries in similar economic situations. The importance of this issue has led to development of an NHS target “by 2010 to reduce inequalities in health outcomes by 10% as measured by infant mortality and life expectancy at birth”. However, a review revealed that the infant mortality rate among the routine and manual group remained 17% higher than in the total population in 2004–6, compared with 18% higher than in the total population in 2003–5 and 19% higher than in the total population in 2002–4. This compares with 13% higher in the baseline period of 1997–9. The Department of Health is quoted in the report of the House of Commons Committee of Public Accounts as “redoubling its efforts including issuing a practical guide for Primary Care Trusts and health communities, and reviewing its health inequalities strategy”. The review of the Health Inequalities Infant Mortality Public Service Agreement (PSA) Target concluded that “the evidence about the effectiveness of interventions to reduce infant mortality is weak”, and recommended improvement of data quality and strengthening of the evidence base. To make progress towards achieving published UK targets attention should be given to the potential for alleviation of deprivation and targeted improvement of pregnancy outcomes among the more deprived groups to reduce NIC admissions with their considerable impact on babies, families and health service costs. Efforts to achieve targets for reduction in infant mortality also need to take account of the different effects of socioeconomic inequalities for different conditions and groups of infants. Routine analysis and reporting of NIC admissions for defined populations is an important part of monitoring progress towards this objective.

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REFERENCES

Severe bilateral intracranial haemorrhage due to alloimmune thrombozytopenia in a premature infant

A boy weighing 1310 g was born by caesarean section at 30 2/7 weeks’ gestation due to premature contractions. Fetal ultrasound 24 hours prior to delivery was normal. Postnatal cardio-pulmonary adaptation was poor and petechiae were noted. Thrombocytopenia (7.000/μl) and anaemia (7 g/dl) were present requiring transfusion of thrombocytes and packed red blood cells. Following detection of intracranial haemorrhage by ultrasound (fig 1), cranial MRI was done at 8 h of age on a 1.5T MR scanner (Philips, Best, the Netherlands), under mechanical ventilation using an MR-compatible incubator (Lammers, Lübeck, Germany) (fig 2). Due to the thus-confirmed extra-axial nature of the haemorrhage and following clinical stabilisation, the boy was operated on the third day. After 6 weeks, most of the haemorrhage was resorbed but severe parenchymal lesions were present. No further episodes of low platelet counts were observed. Clinically, he improved over time and was discharged in good condition on the 51st day of life.

Confirming the diagnosis of neonatal alloimmune thrombozytopenia, the mother was typed as HPA-1bb and the father as HPA-1aa, and maternal anti-HPA-1a could be detected (being the most common such antibody9). Screening programmes have been suggested but are not yet routinely implemented. Prenatal intracranial bleeding is rare in this condition but, if present, is more common in the third trimester. Intracranial haemorrhage is present in up to 20% of cases, but such severe extra-axial bleeding is unusual. Neither the full extent nor the extra-axial nature of the bleeding was fully appreciated in cranial ultrasound. The usefulness of early MR imaging guiding intervention, even in very small preterm babies, is confirmed.9

Figure 1 Cranial ultrasound examination on the first day of life; shown are four coronal slices from anterior (A) to posterior (D). Note, clear demonstration of bleeding and mass effect on the ventricles, but unclear delineation of the full extent of the haemorrhage, its intra-axial or extra-axial nature, or the size of the parenchymal lesions.