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REGULAR ARTICLE

Risk of low Apgar score and socioeconomic position: a study of Swedish male births

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Abstract
Aim: The aim of this study was to investigate the association between maternal socioeconomic position and a persistent low Apgar score (a score of < 7 at 1 and 5 min following birth).
Methods: The research is based on a population cohort study of 183 637 males born in Sweden between 1973 and 1976. Data from the Medical Birth Register were linked to Population and Housing Censuses.
Results: There was evidence that mothers working in non-manual (Odds ratio (OR) 0.83 (0.72–0.97)) and self-employed (OR 0.64 (0.44–0.93)) occupations were less likely to have an infant with a low Apgar score, compared to manual workers. There was evidence that the risk of a low Apgar score decreased as the mother's level of education increased, if the infant was born by instrumental (OR 0.86 (0.74–0.99)) or caesarean section (OR 0.80 (0.68–0.93)) delivery, but not by unassisted vaginal delivery (OR 1.01 (0.92–1.10)).

Conclusion: There was a lower risk of poor birth condition in male infants born to more educated and non-manual/self-employed mothers. These differences may contribute to our understanding of socioeconomic differences in infant health and development although the results may not be applicable due to changes over the last 30 years.

INTRODUCTION

Sweden is considered to have a high standard of universal health care provision, including free antenatal care, and it might be expected that social gradients in health outcomes would be less important there than in countries with more socioeconomic inequalities (1). Occupational status and education are two measures of socioeconomic position that may have independent effects on health outcomes. Swedish mothers in manual work are more likely to deliver babies of low birth weight (2) when compared to mothers in non-manual work, while higher levels of maternal education have been shown to be associated with better infant health in Sweden and other Scandinavian countries (3). However, the impact of socioeconomic position on the infant's condition at birth, and the mechanisms through which any effect may occur is unclear.

The Apgar score is the most commonly used measure of newborn infant well-being. Devised in 1953 by Virginia Apgar (4), it is commonly measured at 1 and 5 min after birth. The score is calculated by rating newborns on a scale of zero to two points for each of five separate indices of well-being: (i) heart rate, (ii) colour, (iii) tone, (iv) breathing and (v) reflexes. The score is influenced by hypoxic insults and is a reliable measure of foetal condition at birth, with a score of seven or above considered normal, and a level of less than four considered severely low (5). The duration the score remains low is predictive of the likelihood of developing profound neurological injuries (6)and even transiently low scores may have impact on cognitive development (7).

The aim of this study was to investigate the associations between socioeconomic positions, as assessed by maternal occupation and education, and persistently low Apgar scores (a score of below seven at 1 and 5 min) as our indicator of poor condition at birth.

Abbreviations
SD, standard deviation; IQR, interquartile range; OR, odds ratio; CI, confidence interval.

PATIENTS AND METHODS

Study design

This study describes a cross-sectional analysis of a large cohort of Swedish male births. The outcome of interest is persistently low Apgar scores, defined as a score of less than seven at 1 min and 5 min following birth. The primary exposures are two measures of socioeconomic position, maternal educational level and occupation.

Swedish cohort database

The data set, initially assembled for other research, is based on the birth registry records of males born in Sweden between 1973 and 1976. The Swedish Medical Birth Registry provides data on 98–99% of Swedish births (8). Data, including Apgar scores, and neonatal and maternal diagnoses (coded using the International Classification of Disease, 8th revision) are recorded for all births on the register. This register was linked to the Population and Housing Censuses of 1970 and 1990 providing socioeconomic data on the mothers and fathers.

Occupation was categorised as manual, non-manual, self-employed or other (including unemployed and students). Education status was categorised as <9 years, 9–10 years, full secondary education or higher education. If the 1970 data were unavailable, the 1990 data were used. Maternal information was used as paternal data reflected the biological father, irrespective of the level of social contact he had with the mother during the pregnancy and delivery.

Infants who had achieved a normal Apgar score (seven or more) by 5 min of age were used as the reference group. Infants with a low 1 and 5 min Apgar score (below seven) were classified as having poor birth condition (5).

Potential confounders

Other risk factors were included in the analyses as potential confounders or explanatory factors. Factors identified with a '*' were extracted from maternal or infant diagnoses coded in the birth register, as appropriate:

(a) Maternal parity (Number of viable previous pregnancies)
(b) Birth weight, length and head circumference (standardised for gestational age, and categorised into five groups based on the number of standard deviations (SD) their values were above or below the mean)
(c) Pre-eclampsia*
(d) Mode of delivery (caesarean section, instrumental delivery (vacuum extraction or forceps) or unassisted vaginal delivery)
(e) Maternal and neonatal infection*
(f) Year of birth
(g) Maternal age at the time of the subject's birth (under 20 years, 20 to 24 years, 25 to 29 years and 30 years and over)

Inclusion criteria

The data set contained information on 212 606 male infants. Infants from multiple births (n = 3428), those born before 36 weeks completed gestation (n = 11 155), and those diagnosed with cardiovascular, respiratory, neurological or multiple system congenital abnormalities (n = 1613) were removed. This left 196 410 eligible subjects for the study. Weights, lengths or head circumferences at birth more than five standard deviations (SD) from the mean (corrected for gestational age) were considered improbable, and the records with these values removed (n = 2139). Infants with insufficient data to assign to one of the two Apgar measures (n = 2759) or missing data on potential confounders (n = 15) or socioeconomic position (n = 7860) were removed. This left 183 637 subjects for the analyses (93.5% of eligible subjects).

Analysis strategy

Subjects with and without missing data were compared. The distribution of potential confounders was investigated. Multivariable logistic regression models were used to investigate the association of measures of maternal socioeconomic position with a persistently low Apgar score. The models used random effects to adjust for possible clustering of data within the family (using the mother's ID number), with 5% of infants sharing a mother with another infant in the study. Initial adjustment was performed by adding the other measure of socioeconomic position into the model. A subsequent model was created with the potential confounders added. Finally, paternal occupation and education status were added to assess the impact on any maternal effect seen. All variables were investigated to see if they modified any effect of socioeconomic position on the Apgar scores by fitting appropriate interaction terms to the models. Comparison of models was done using likelihood ratio tests.

All analyses were conducted with Stata 9 software (StataCorp LP, TX, USA). All data are presented as odds ratio (OR) (95% confidence interval (95% CI)), mean (standard deviation (±SD)), median (interquartile range (IQR)) or number (percent (%)). Ethical approval for the study was obtained from the London School of Hygiene and Tropical Medicine Ethics Committee, UK, and the Ethics Committee, Stockholm, Sweden.

RESULTS

Infants with incomplete data were more likely than those with complete data to have had persistently low Apgar scores (1.04% vs. 0.66%, $p < 0.001$), lower mean birth weight (3519 vs. 3604 gm, $p < 0.001$), birth length (50.7 vs. 51.1 cm, $p < 0.001$) and head circumference (34.7 vs. 34.9 cm, $p < 0.001$). Mothers of infants with incomplete data were more likely to be primipara (55.9% vs. 44.2%, $p < 0.001$), have maternal (1.8% vs. 1.2%, $p < 0.001$) or infant (0.3% vs. 0.2%, $p = 0.037$) infection and were more likely to be younger (25.3 vs. 26.8 years old, $p < 0.001$). There was no evidence of a difference between the two groups for the proportion of mothers with pre-eclampsia (8.19% vs. 8.73%, $p = 0.121$).

In the study population, 1217 (0.66%) infants had a low Apgar score at 1 and 5 min. Table 1 shows the distribution of the socioeconomic measures and potential confounders. The most common occupational category was non-manual employment (n = 89 263 (48.6%)). The most common education level was 'full secondary' (n = 79 990 (43.6%)).

In the univariable model, using manual workers as the reference category, offspring of mothers in self-employed (OR 0.94 (0.81–1.09)) or non-manual work (OR 0.97 (0.83–1.15)) had similar risks of low Apgar scores to the reference group (Table 2). There was evidence that mothers working in positions categorised as 'other' (OR 0.76 (0.60–0.96)) were less likely to have an infant born with low Apgar scores. However, after adjusting for maternal education and other

Table 1 Measures of maternal social economic position and other risk factors (n = 183 637)

Measure	Summary value
Maternal occupation	
Manual	52 238 (28.5%)
Non-manual	89 263 (48.6%)
Self-employed	7135 (3.9%)
Other	35 001 (19.1%)
Maternal education status	
<9 years	35 694 (19.4%)
9—10 years	49 391 (26.9%)
Full secondary	79 990 (43.6%)
Higher education	18 562 (10.1%)
Parity	0 (0–1)
Pre-eclampsia	16 019 (8.7%)
Birth weight (g)	3604 (±491)
Birth length (cm)	51.1 (±2.1)
Head circumference (cm)	34.9 (±1.5)
Maternal infection	2209 (1.20%)
Neonatal infection	358 (0.19%)
Delivery	
Unassisted vaginal delivery	157 458 (85.7%)
Instrumental delivery	14 284 (7.8%)
Caesarean section	11 895 (6.5%)
Year of birth	
1973	46 680 (25.4%)
1974	48 532 (26.4%)
1975	45 354 (24.7%)
1976	43 071 (23.5%)
Maternal age (years)	26.8 (±4.8)

Data are mean (±SD), median (IQR) or n (%) as appropriate.

potential confounders infants of mothers who were self-employed (OR 0.61 (0.43–0.88)) or in non-manual work (OR 0.82 (0.71–0.94)) appeared to have lower risks of poor birth condition. Adjusting for paternal socioeconomic factors did not appear to substantially attenuate the effect size, and there remained strong evidence that the risk of persistently low Apgar scores was associated with maternal occupation (p = 0.012). There was no evidence that paternal occupation was associated with poor condition at birth (p = 0.413). There was no evidence that the association of maternal occupation with Apgar score differed across different levels of any of the possible confounding factors investigated.

In the univariable model there was only weak evidence that maternal education was associated with persistently low Apgar scores (p = 0.046). After adjusting for both maternal occupation and potential confounders (Table 2) evidence of a trend remained (p = 0.046). Controlling for paternal socioeconomic factors had little impact on the effect estimates. Paternal education did not appear to substantially improve the fit of the model (p = 0.332). There was evidence that the association between maternal education and low Apgar scores differed by the mode of delivery (test for interaction, p = 0.027). Consequently the stratum-specific OR from the final model are shown in Table 3.

When looking at the results stratified by the mode of delivery, there was no evidence that increasing levels of maternal education were associated with a risk of a low Apgar score for infants born by unassisted vaginal delivery (OR 1.01 (0.92–1.10)). However, there was evidence for a trend in the risk of persistently low Apgar scores decreased as the mothers level of education increased, if the infant was born by instrumental (OR 0.86 (0.74–0.99)) or caesarean section (OR 0.80 (0.68–0.93)) delivery.

To further help investigate this interaction, the association between maternal education status and unassisted vaginal delivery was also estimated, unadjusted and corrected for maternal age and parity. While the unadjusted OR suggests that women with higher levels of education are less likely to have a unassisted vaginal delivery (OR for each increase in maternal education category OR 0.92 (0.91–0.94),

Table 2 Associations of maternal social factors and infants born with persistent low Apgar scores

	Unadjusted		Adjusted for other maternal social factor*		Adjusted for other maternal social factor* and other risk factors†		Adjusted for other social factor*, other risk factors† and paternal data‡	
Factor measured	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Maternal SES								
Manual	1.00		1.00		1.00		1.00	
Non-manual	0.97 (0.83–1.15)		0.86 (0.75–1.00)		0.82 (0.71–0.94)		0.83 (0.72–0.97)	
Self-employed	0.94 (0.81–1.09)	<0.001	0.62 (0.44–0.89)	0.005	0.61 (0.43–0.88)	0.003	0.64 (0.44–0.93)	0.012
Other	0.76 (0.60–0.96)		1.03 (0.87–1.21)		0.95 (0.80–1.12)		0.96 (0.81–1.14)	
Maternal education status								
<9 years	1.00		1.00		1.00		1.00	
9–10 years	0.97 (0.83–1.15)		0.91 (0.76–1.08)		0.85 (0.71–1.02)		0.84 (0.70–1.01)	
Full secondary	0.94 (0.81–1.09)	0.046§	0.94 (0.80–1.10)	0.226§	0.86 (0.73–1.02)	0.046§	0.85 (0.72–1.01)	0.058§
Higher education	0.76 (0.60–0.96)		0.82 (0.64–1.04)		0.76 (0.59–0.97)		0.76 (0.59–0.99)	

Data are odds ratio (OR) (95% confidence interval) for persistent low Apgar scores.
*Adjusted for maternal education/occupation.
†Adjusted for birth weight, head circumference and length, parity, infant and maternal infection, pre-eclampsia, mode of delivery, year of birth, maternal age.
‡Adjusted for paternal education and occupation.
§p for trend.

Table 3 Associations of maternal education with persistent low Apgar scores, split by mode of delivery

	Infants delivered by unassisted vaginal delivery		Infants delivered by instrumental delivery		Infants delivered by caesarian section	
Maternal education status	OR (95% CI)*	p for trend	OR (95% CI)*	p for trend	OR (95% CI)*	p for trend
Maternal education						
<9 years	1.00	–	1.00	–	1.00	–
9–10 years	1.03 (0.82–1.29)	–	0.64 (0.44–0.94)	–	0.59 (0.40–0.87)	–
Full secondary	1.02 (0.83–1.27)	0.895	0.72 (0.51–1.02)	0.041	0.58 (0.41–0.82)	0.003
Higher education	1.01 (0.73–1.39)	–	0.48 (0.27–0.84)	–	0.51 (0.29–0.90)	–

Data are odds ratio (OR) (95% confidence interval) for persistent low Apgar scores.
*Adjusted for birth weight, head circumference and length, parity, infant and maternal infection, pre-eclampsia, mode of delivery, maternal occupation, year of birth, maternal age and paternal education and occupation.

$p < 0.001$) after adjusting for maternal age and parity (categorised as above) the trend was reversed, with women with higher education more likely to have a unassisted vaginal delivery than those with less education (OR for each increase in maternal education status, 1.03 (1.01–1.05), $p < 0.001$).

DISCUSSION

Principal findings

Despite universal health care provision in Sweden, the risk of delivering an infant in poor condition varied between socioeconomic groups. Manual working mothers were more likely than non-manual or self-employed mothers to have an infant with persistently low Apgar scores. This association remained after adjusting for maternal education and other risk factors. Similarly, there was evidence of a gradient of risk, which decreased as the mother's education level increased. However, the association of maternal education with Apgar score differed with the infant's mode of delivery. The beneficial effect of being a more educated mother was only seen for instrumental and caesarean section deliveries. However, the data for this study dates from the 1970s and may not be valid today due to social and medical changes in the intervening years.

Possible causal pathways

The underlying causal mechanism for these findings is unclear. It is possible that important differences in the health behaviour of the mothers or medical management by the hospitals differ between the socioeconomic groups. Adjustment for other risk factors allowed investigation of the mechanisms through which socioeconomic positions may affect these outcomes. It is interesting to note that the strength of the association between both higher education and non-manual occupation status appeared to increase after adjustments, suggesting an influence of socioeconomic status, over and above the effect of socially patterned clinical risk factors assessed (e.g. birth weight or pre-eclampsia). Socioeconomic position may, therefore, have influenced birth condition through other, unmeasured factors, such as nutrition and co-existing maternal medical conditions. In particular, we were unable to adjust for maternal smoking, a strongly socially patterned behaviour. However, birth weight, one of the main consequences of in-utero smoke exposure, did not confound the relationship seen. The association between maternal education and condition at birth was only found in women with instrumental or caesarean section deliveries. More educated women may be more likely to have elective caesarean section deliveries (9), while emergency caesarean sections are associated with poorer outcomes for the infant (10). However, while we did not have information on the indication for the instrumental/caesarean deliveries, in our data more educated women were less likely to have an instrumental or caesarean delivery (after adjusting for parity and maternal age).

A possible explanation for our observations is that obstetricians, when in doubt about foetal well-being, may intervene more readily to achieve rapid delivery when dealing with more educated women, and this might translate into a reduction in poor birth condition.

Strengths and limitations of this study

This study was an analysis of a large birth registry linked with census data. The data set was constructed for a study of conscripted males (compulsory service), and consequently, we were only able to investigate associations in male infants. There were only small amounts of missing data, although infants with missing data differed from those with complete data. The prevalence of low Apgar scores found in this data set are similar to those seen in previous publications of other populations (11,12), and supports the validity of the data when compared to other similar studies. The frequencies of clinical risk factors seen in our data are consistent with the published literature, for example the whole population risk for neonatal septicaemia/meningitis (2.3/1000) is similar to comparable studies (2.8/1000) (13).

The Apgar score is a semi-objective measure of the infant's well-being and some loss of power is likely due to measurement error. Another limitation of the data is the timing of the census information. Maternal socioeconomic factors were measured in 1970 or 1990, and were not actually known at the time of birth (1973–1976). This could have lead to a certain degree of misclassification. For example, education status could have increased between the census measures and the year of giving birth, underestimating the duration of education. However, this misclassification is unlikely to be differential by Apgar status, and the overall effect would be to attenuate any true association if it existed, rather than suggest a spurious association when none existed.

Additionally, only certain data on the mode of delivery were available, limiting interpretation. Caesarean section is often sub-divided into elective and emergency procedures, with elective caesarean sections associated with lower risk of birth asphyxia and emergency ones associated with more (10). However, even among women undergoing elective caesarean sections the distinction between those done or before labour is likely to have importance (10).

Finally, we recognise that it is more than 30 years since the study births occurred. It is important to consider how much demographic and social change there has been in Sweden since then, and whether the findings of this study are still useful. Among women giving birth to a baby in 1970, 46% were manual workers compared to 45% in 1990. In contrast, 53% of women giving birth in 1970 had $\leq$9 years of education compared to 11% in 2003 (14). The mean maternal age of the first child has increased (28.7 years in 2006 vs. 26.6 years in 1970), and the fertility rate has dropped (1.85 in 2006 vs. 1.94 in 1970) (15). In addition, important changes in health behaviour have also occurred over this time. In particular, a decline in antenatal smoking from 30% in 1983 to 10% in 2003 (16), and substantial improvements in medical care, with a corresponding fall in infant mortality (2.8/1000 births in 2006 vs. 11.5/1000 births in 1970) (15). However, variations in socioeconomic and educational levels still exist in Sweden, while inequalities in child health outcomes have persisted (2). While it is difficult to anticipate the effect these changes may have had on any association seen in this study, we believe that, even though these data are historic, the findings of this study contribute to the general understanding of the social and economic determinants of obstetric and perinatal health.

Comparisons with other studies

Previously published studies have also reported an association between poor birth condition and socioeconomic gradient (17,18), although the association has often become attenuated after adjusting for other maternal risk factors (17). In our study, the measure of effect became stronger after adjusting for a number of other risk factors. However, direct comparison with other research is difficult as different maternal risk factors were controlled for in these earlier studies. Furthermore, differences in perinatal outcome may be more likely to be dependent on social position in countries where universal health care is not provided.

Clinical implications and conclusions

While antenatal and delivery care is free of charges to access in Sweden, and neonatal outcomes are similar throughout the country (19), self-employed mothers had around a 35% lower risk of delivering an infant in poor condition compared to mothers in manual work. Similar relative risks were seen in other comparisons made, and while the study was limited to male infants, these differences may contribute to socioeconomic differences in infant mortality.

Some of the effects may be due to differing rates of elective caesarean sections in educated mothers with low-risk labours. In addition, the pathway to health care is likely to be influenced by knowledge of options and attitudes towards them, while obstetric practice may differ for women of higher socioeconomic status. The effect seen was not explained by the distribution of other risk factors in the data set, including paternal socioeconomic position. Importantly, this data is based on infants born in the 1970s and may not be valid today due to medical and social changes, although discrepancies in infant morbidity still exist (2,3). Further research, perhaps with more recent data, looking at the relative frequencies and impact of emergency caesarean sections between women of different socioeconomic position may help clarify the mechanisms underlying these associations.

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