Risk of Low Apgar Scores and Socioeconomic Status over a 30 Year Period

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Short Title: Apgar's over 30 Years

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ABSTRACT

Objective: The aim of this study was to investigate the stability of associations between social factors, as assessed by maternal occupation and education, and poor birth condition (an Apgar score of below seven at one and five minutes) over a 30 year period in Sweden.

Methods: The dataset was based on infants born in Sweden between 1973 and 2002. Poor birth condition was defined as an Apgar score below 7 at 1 and 5 minutes. Logistic regression was used to investigate the association of between socioeconomic status and poor birth condition.

Results: In the adjusted model, mothers in non-manual occupations (OR 0.91 (0.88, 0.95)) or with higher educational status (OR 0.88 (0.84, 0.93)) were less likely to have an infant born in poor condition than the reference group. Limiting the analysis to the last decade showed less evidence for an association (OR 0.94 (0.86, 1.02) and OR 0.94 (0.82, 1.09) respectively).

Conclusions: While maternity, delivery and child healthcare are free of charge in Sweden, poor birth condition was more common among infants of mothers in manual occupations or low levels of education. However this association appeared to attenuate over the calendar period studied.

INTRODUCTION

The association between socioeconomic status and health outcomes has long been recognized.[1] In general men and women from lower socioeconomic groups tend to have higher rates of cancer, heart disease and shorter life spans.[2] Explanations for these associations are complex and multifactorial including lack of material resources, social patterning of health behaviours, the long term impact of early life adversity, poorer educational opportunities and lack of access to health care.

We have previously reported that infants born to mothers of lower socioeconomic status are at increased risk of poor condition at birth.[3] However the study was limited to male infants born over 30 years ago. The likely healthcare impact of these infants is still unclear, although may be substantial and we have shown that infants born in poor condition (even in the absence of significant neurological signs) have lower IQ scores[4] and function less successfully in society than other adults.[5] We speculate that reductions in socioeconomic inequalities in Sweden over the last 30 years have resulted in a narrowing in the socioeconomic disparities in adverse perinatal outcomes.

The aim of this study was to investigate the stability of associations between social factors, as assessed by maternal occupation and education, and poor birth condition (an Apgar score of below seven at one and five minutes) over a 30 year period in Sweden.

METHODS

The dataset was based on the birth registry records of infants born in Sweden between 1973 and 2002. This registry has previously been shown to have high validity,[6] was linked to the Multi-Generation Registry, the Population and Housing Censuses, the Registry of

Education and to the Cause of Death Registry. Poor birth condition was defined as an Apgar score below 7 at 1 and 5 minutes.

Two measures of socioeconomic status were used; maternal occupation and education. Occupation was categorised as manual, non-manual, self-employed or other (including unemployed and students). Education status was categorised as <9 years in full-time education, 9-10 years, full secondary education or higher education. 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.

In addition, other risk factors were included in the analyses as potential confounders. Covariates were selected as presumed confounders[7] *a-priori*, and categorised into 3 groups:

- Demographic Factors; Maternal age and maternal parity.
- Antenatal Factors (indicators of fetal growth); Birthweight, length and head circumference (as gestation and gender specific z-scores).
- Intrapartum Factors; Maternal/neonatal infection, mode of delivery (caesarean section, instrumental delivery (vacuum extraction or forceps) or unassisted vaginal delivery).

For maternal education the mother's educational record closest in time to their offspring's date of birth was used based on data recorded at Swedish censuses conducted in 1970 and 1990 and the Registry of Education from 1995. Likewise, the most recent data on occupation from 1970, 1980 or 1990 were used. Data recorded when the mother was less than 21 years of age were not used as she may not have completed education by that age or be in a job indicative of her future socioeconomic status.

The dataset contained information on 2,990,210 births. Infants from multiple births (n=68,763), those with cardiovascular, respiratory, neurological or multiple system congenital abnormalities (n=25,737) or born preterm (before 37 weeks gestation) (n=80,187) were removed leaving 2,815,523 singleton births for the study.

Infants with insufficient data to classify exposure or outcome (n=432,106) were removed. In addition 86,997 infants had missing data on a covariate or improbable weight, length or head circumference recorded (more than 5 standard deviations from the mean) leaving 2,316,502 subjects available for the analyses (82% of eligible subjects).

Subjects with and without missing data were compared. The distributions of potential confounders in the population were investigated. Logistic regression models were used to investigate the association of measures of a) maternal occupation, and b) education with poor birth condition. Initial adjustment was performed by adding maternal level of education to the models investigating associations with maternal occupation and vice versa. A final model was created after further adjustment for antenatal and intrapartum factors. The analyses were repeated, with the results stratified over 10 year periods (1973-1982, 1983-1992 and 1993-2002) and the impact of socioeconomic status was estimated by calculating the population attributable risk (PAR) for being born in poor condition due to maternal manual occupation or non-university educational status (split by the three time periods). Comparison of models and possible interaction was done using likelihood ratio tests.

Two further sensitivity analyses were performed, one using paternal measures of socioeconomic status as the exposure variables and a second using an imputed dataset. In this final analysis all missing data were imputed using a multiple imputation technique with chained equations.[8] For practical computational reasons only a random 3% of those infants born in good condition were included in this analysis. Further details of the multiple imputation technique used are available on request.

All analyses were conducted with Stata 10 software (Stata Corp, TX, USA). All data are presented as odds ratio (OR) ((95% confidence interval (95% CI)), mean (±1 standard deviation (SD)), mean difference (95% CI), median (interquartile range (IQR)), or number

(%). Ethical approval for the study was obtained from the National Research Ethics Committee (North East), UK.

RESULTS

The initial dataset contained data for 2,815,523 eligible subjects with a total of 499,021 (17%) infants having missing or improbable data on one or more covariates. The majority of infants excluded from the analysis for insufficient data had missing data on maternal socioeconomic status (n=432,106), and for the majority of cases this was because the mother was too young (<21 years) at the time of the sampling to have a reliable measure (n=320,962). Infants excluded due to missing socioeconomic status data were less likely to be born to non-manual working mothers (14.3% vs. 36.7%) and less likely to be university educated (24.4% vs. 26.7%). They had slightly higher risk of being born in poor condition (0.9% vs. 0.8%). Infants excluded due to missing covariate data (n=90,553) were slightly more likely to be born to mothers working in manual occupations (36.4% vs. 34.2%) but more likely to have university educated mothers (27.9% vs. 26.7%). They had markedly higher risk of being born in poor condition (5.1% vs. 0.8%). Due to the large sample sizes, statistical evidence for differences between groups was strong ($p<0.001$) even if the magnitude of such differences was small.

Table 1 shows the study population split by birth condition. 17,549 (0.8%) of infants were born with a low Apgar score. Infants born in poor condition were more likely to be male, have a lower birthweight, length and head circumference, be born by instrumental or caesarian section and develop sepsis. Their mothers were younger, more likely to have infection and have pre-eclampsia (all comparisons $p<0.001$). There was statistically strong evidence that maternal socioeconomic status and education were associated with birth condition; with mothers of infants in poor condition less likely to be non-manual workers or university educated, although actual differences were small.

TABLE 1

Initial associations between maternal socioeconomic status and birth condition suggest that mothers in non-manual socioeconomic status are less likely to have an infant born in poor condition compared to manual-working mothers (OR 0.93 (0.90, 0.96), Table 2) and this association persisted in the final (fully adjusted) analysis (OR 0.91 (0.88, 0.95)). Mothers who were self-employed had a slightly lower risk of delivering a baby in poor condition (OR 0.90 (0.81, 1.01)) and this association strengthened in the final analysis (OR 0.89 (0.80, 0.99)). Increasing maternal education was associated with a reduction in the risk of having a baby born in poor condition in all models (OR for each increase in educational level OR 0.93 (0.91, 0.95), $p<0.001$).

TABLE 2

Temporal trends in maternal education and socioeconomic status are shown in figures 1 and 2 respectively. There was strong evidence that the association between social measures and birth condition differed by year of birth ($p_{interaction}<0.001$) (Table 3). The risk of poor birth condition was lower throughout the first two periods (1973-1982 and 1983-1992) for mothers in non-manual socioeconomic status, and reduced in the first period (1973-1982) for those mothers self-employed compared to mothers in manual occupations. The socioeconomic differences had diminished by 1993-2002. The association between maternal education and birth condition also attenuated through the 3 time periods. By the third time period only those infants with mothers in the lowest educational group had evidence of different birth condition to the reference group.

However is should be noted that the proportion of mothers in the lowest (<9 years) educational group has changed dramatically over the 30 year period, making interpretation difficult, as such women are likely to be very different from women who received lower levels of education in the 1970s.

FIGURES 1 & 2

TABLE 3

The proportion of infants born in poor condition that was attributable to manual working mothers was 1.7% (-1.2%, 1.6%) in 1973-1982, 2.6% (0.3%, 4.8%) in 1983-1992 and 1.5% (-1.5%, 4.3%) in 1993-2002. The proportion of infants born in poor condition that was attributable to non-university educated mothers was 6.0% (1.5%, 10.4%) in 1973-1982, 5.9% (1.0%, 10.5%) in 1983-1992 and 7.0% (2.2%, 11.4%) in 1993-2002.

Repeating the main analysis using paternal details (Supplementary Digital Content S1) showed similar results for paternal occupation to that of maternal occupation, except the association with 'other' occupational status persisted in the fully adjusted model. However there was less evidence that paternal education levels were associated with the risk of being born in poor birth condition, except in the those fathers in the highest educational group (compared to the reference group). Repeating the main analysis using an imputed dataset (Supplementary Digital Content S2) provided similar results.

DISCUSSION

We have found in a cohort of Swedish mothers and infants that the risk of having an infant born in poor condition appears to be lower if the mother is more educated or is self employed or employed in non-manual work (compared to manual workers). To our knowledge this is the first study to assess if there have been secular changes in these associations, and indeed, the association appears to have attenuated over time.

Over the three decades the women employed in different areas of work will have changed, while changing patterns of immigration etc. will also confound the associations seen. In general however the proportion of women with a University education over the study period (20% in 1973 to 1982 vs. 39% in 1993 to 2002) has increased, as has the proportion of women in non-manual positions (36% in 1973 to 1982 vs. 39% in 1993 to2002). The population impact has remained stable. There results suggest that important differences in birth condition remain for those women with lower levels of educational achievement.

However, generalising the results is problematical and the mechanisms through which socioeconomic status and health care outcomes are related are likely to be complex. Maternal socioeconomic status may have influenced birth condition through unmeasured factors such as existing maternal medical condition and poor nutrition. Some of these may not confound the relationship, but rather be part of the causal pathway through which these infants become compromised[2]. Unfortunately we were unable to take account of some important factors, in particular maternal smoking, although we were able to control for birthweight (one of the main consequences of *in-utero* smoke exposure).[9] Interestingly, the association with occupation appeared similar when using paternal measures, although paternal educational level appeared to be less strongly associated with birth condition than maternal education. It may be that the associations seen with maternal (and paternal) occupation relate to environmental and more pervasive social impacts such as diet and general health (and hence are shared by the mother and the father), whereas the educational level of the mother reflects more specific decisions and behaviors related to pregnancy and childbirth. These findings of associations between socioeconomic status and birth condition are in accordance with results by other groups.[10,11] However, direct comparison of findings is difficult due to the differences in healthcare systems and methodologies used.

Nevertheless, impacts on health may well be important from these relatively weak associations. Increasing evidence suggests that infants born in poor condition (even if this appears to be transient) are at increased risk of low cognitive skills,[4,12] psychiatric problems[13] and do less well in the employment and social arenas.[5]

A moderate proportion of missing values is a limitation, although mostly due to lack of (routine) data collection for periods during the study years. These infants did appear to differ from those with complete data, with a difference in the profile of socioeconomic status and an increased risk of being born in poor condition (although the effect was most pronounced in the smaller group with missing covariate data). However, the prevalence of low Apgar scores in the main analysis was similar to those seen in other publication[14,15] and a sensitivity analysis with imputed missing data produced similar results to the main analysis.

In conclusion, poor birth condition was more common to mothers in manual socioeconomic status or lower levels of education. While much of this disparity appears to have attenuated over time, some evidence remains even in the most recent data and measures of population impact remain similar. Further work is needed to identify the causal pathways and identify potential points of intervention.

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Declaration of interests

The authors report no declarations of interest

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Table 1.Characteristics of the study population according to birth condition (n=2,316,502)

Measure	Normal Apgar score (n=2,298,953)	Low Apgar Score (n=17,549)
Antenatal Factors		
Male	1,117,690 (51%)	9,981 (56.9%)
Birthweight (g)	3568 (497)	3467 (593)
Birth Length (cm)	50.6 (2.1)	50.7 (2.6)
Head Circumference (cm)	34.8 (1.5)	34.8 (1.7)
Maternal pre-eclampsia	113,987 (5.0%)	1,422 (8.1%)
Intrapartum Factors		
Maternal Infection	16,087 (0.7%)	196 (1.1%)
Neonatal Infection	8,023 (0.4%)	491 (2.8%)
Mode of Delivery		
Vaginal	1,939,889 (84.4%)	10,341 (58.9%)
Instrumental	137,002 (6.0%)	2,831 (16.1%)
Caesarian Section	222,062 (9.7%)	4,377 (24.9%)
Demographic factors		
Maternal Age	28.4 (5.1)	27.9 (5.3)
Primiparae	901,381 (39.2%)	9,623 (54.8%)
Maternal Occupation		
Manual	786,779 (34.2%)	6,037 (34.4%)
Non-manual	844,595 (36.7%)	6,030 (34.4%)
Self Employed	49,981 (2.2%)	347 (2.0%)
Other	617,598 (26.9%)	5,135 (29.3%)
Maternal Education Status		
<9 Years	147,911 (6.4%)	1,440 (8.2%)
9-10 Years	382,717 (16.7%)	3,140 (17.9%)
Full Secondary	1,153,076 (50.2%)	8,718 (49.7%)
Higher Education	615,249 (26.8%)	4,251 (24.2%)

Values are number (%) or mean (±SD) as appropriate.

All comparisons are p<0.001

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

Factor Measured	Adjusted for gender		Adjusted for gender and demographic factors†		Adjusted for gender, demographic factors† and other risk factors‡	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Maternal Occupation						
Manual (Reference)	1.00		1.00		1.00	
Non-manual	0.93 (0.90, 0.96)	<0.001	0.90 (0.87-0.94)	<0.001	0.91 (0.88, 0.95)	<0.001
Self Employed	0.90 (0.81, 1.01)	0.071	0.88 (0.78-0.98)	0.016	0.89 (0.80, 0.99)	0.034
Other	1.08 (1.04, 1.12)	<0.001	1.00 (0.96-1.04)	0.985	1.00 (0.97, 1.04)	<0.001
Maternal Education Status						
<9 Years	1.19 (1.11, 1.26)	<0.001	1.14 (1.07-1.22)	<0.001	1.13 (1.06, 1.20)	<0.001
9-10 Years (Reference)	1.00		1.00		1.00	
Full Secondary	0.92 (0.88, 0.96)	<0.001	0.93 (0.89-0.97)	0.001	0.95 (0.91, 0.99)	0.016
Higher Education	0.84 (0.80, 0.88)	<0.001	0.84 (0.79-0.88)	<0.001	0.88 (0.84, 0.93)	<0.001

Data are odds ratio (OR) (95% confidence interval) for persistent low Apgar scores

† Adjusted for maternal education/occupation, parity, maternal age and birth year

‡ Adjusted for birthweight, head circumference and length, infant and maternal infection, pre-eclampsia, mode of delivery, birth year, maternal age and parity.

Table 3. Associations of maternal social factors with persistent low Apgar scores, split by time period

Factor Measured	**Year of Birth**					
	1973-1982		**1983-1992**		**1993-2002**	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**P**
Maternal Occupation ($p_{interaction}$ <0.001)						
Manual (Reference)	1.00		1.00		1.00	
Non-manual	0.88 (0.93, 0.93)	<0.001	0.92 (0.87, 0.98)	0.009	0.94 (0.86-1.02)	0.136
Self Employed	0.82 (0.71, 0.96)	0.011	0.96 (0.81, 1.16)	0.697	0.94 (0.67-1.32)	0.727
Other	1.07 (1.02, 1.13)	0.010	0.97 (0.90, 1.04)	0.335	1.02 (0.93-1.12)	0.666
Maternal Education Status ($p_{interaction}$<0.001)						
<9 Years	1.12 (1.03, 1.20)	0.005	1.04 (0.89, 1.21)	0.611	1.56 (1.15, 2.14)	0.004
9-10 Years (Reference)	1.00		1.00		1.00	
Full Secondary	0.95 (0.90, 1.00)	0.070	0.95 (0.88, 1.02)	0.130	1.00 (0.87, 1.15)	0.968
Higher Education	0.88 (0.82, 0.94)	<0.001	0.91 (0.83, 0.99)	0.024	0.94 (0.82, 1.09)	0.425

Data are odds ratio (OR) (95% confidence interval) for persistent low Apgar scores.

Adjusted for maternal education/occupation, gender, birthweight, head circumference and length, parity, infant and maternal infection, pre-eclampsia, year of birth, maternal age.

Supplementary Digital Content S1. Associations of paternal social factors and infants born with persistent low Apgar scores

Factor Measured	Adjusted for gender		Adjusted for gender and demographic factors†		Adjusted for gender, demographic factors† and other risk factors‡	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Paternal Occupation						
Manual (Reference)	1.00		1.00		1.00	
Non-manual	0.90 (0.86, 0.94)	<0.001	0.92 (0.88, 0.97)	0.001	0.94 (0.89, 0.99)	0.014
Self Employed	0.93 (0.87, 1.00)	0.061	0.93 (0.87, 1.00)	0.050	0.95 (0.88, 1.02)	0.188
Other	1.13 (1.07, 1.21)	<0.001	1.16 (1.09, 1.24)	<0.001	1.17 (1.09, 1.24)	<0.001
Paternal Education Status						
<9 Years	1.01 (0.95, 1.07)	0.757	1.01 (0.95, 1.08)	0.725	1.00 (0.94, 1.07)	0.942
9-10 Years (Reference)	1.00		1.00		1.00	
Full Secondary	0.97 (0.92, 1.02)	0.189	0.97 (0.92, 1.02)	0.257	0.98 (0.93, 1.04)	0.496
Higher Education	0.87 (0.82, 0.92)	<0.001	0.88 (0.82, 0.94)	<0.001	0.91 (0.85, 0.97)	0.005

Data are odds ratio (OR) (95% confidence interval) for persistent low Apgar scores

† Adjusted for paternal education/occupation, parity, maternal age and birth year

‡ Adjusted for birthweight, head circumference and length, infant and maternal infection, pre-eclampsia, mode of delivery, birth year, maternal age and parity.

Supplementary Digital Content S2. Associations of maternal social factors and infants born with persistent low Apgar scores (Fully Imputed Dataset)

Factor Measured	Adjusted for gender		Adjusted for gender and demographic factors†		Adjusted for gender, demographic factors† and other risk factors‡	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Maternal SES						
Manual (Reference)	1.00		1.00		1.00	
Non-manual	0.95 (0.92, 0.98)	0.002	0.92 (0.89, 0.96)	<0.001	0.93 (0.90, 0.97)	0.001
Self Employed	0.92 (0.84, 1.01)	0.093	0.89 (0.81, 0.98)	0.023	0.88 (0.80, 0.98)	0.017
Other	1.06 (1.02, 1.10)	0.004	1.04 (1.00, 1.08)	0.023	1.03 (0.99, 1.07)	0.201
Maternal Education Status						
<9 Years	1.16 (1.07, 1.25)	<0.001	1.12 (1.04, 1.22)	0.004	1.12 (1.03, 1.21)	0.010
9-10 Years (Reference)	1.00		1.00		1.00	
Full Secondary	0.92 (0.88, 0.96)	<0.001	0.89 (0.85, 0.93)	<0.001	0.90 (0.86, 0.95)	<0.001
Higher Education	0.86 (0.82, 0.90)	<0.001	0.79 (0.75, 0.83)	<0.001	0.82 (0.78, 0.87)	<0.001

Data are odds ratio (OR) (95% confidence interval) for persistent low Apgar scores

† Adjusted for maternal education/occupation, parity, maternal age and birth year

‡ Adjusted for birthweight, head circumference and length, infant and maternal infection, pre-eclampsia, mode of delivery, birth year, maternal age and parity.

Figure 1. Maternal educational level, split by year of childbirth

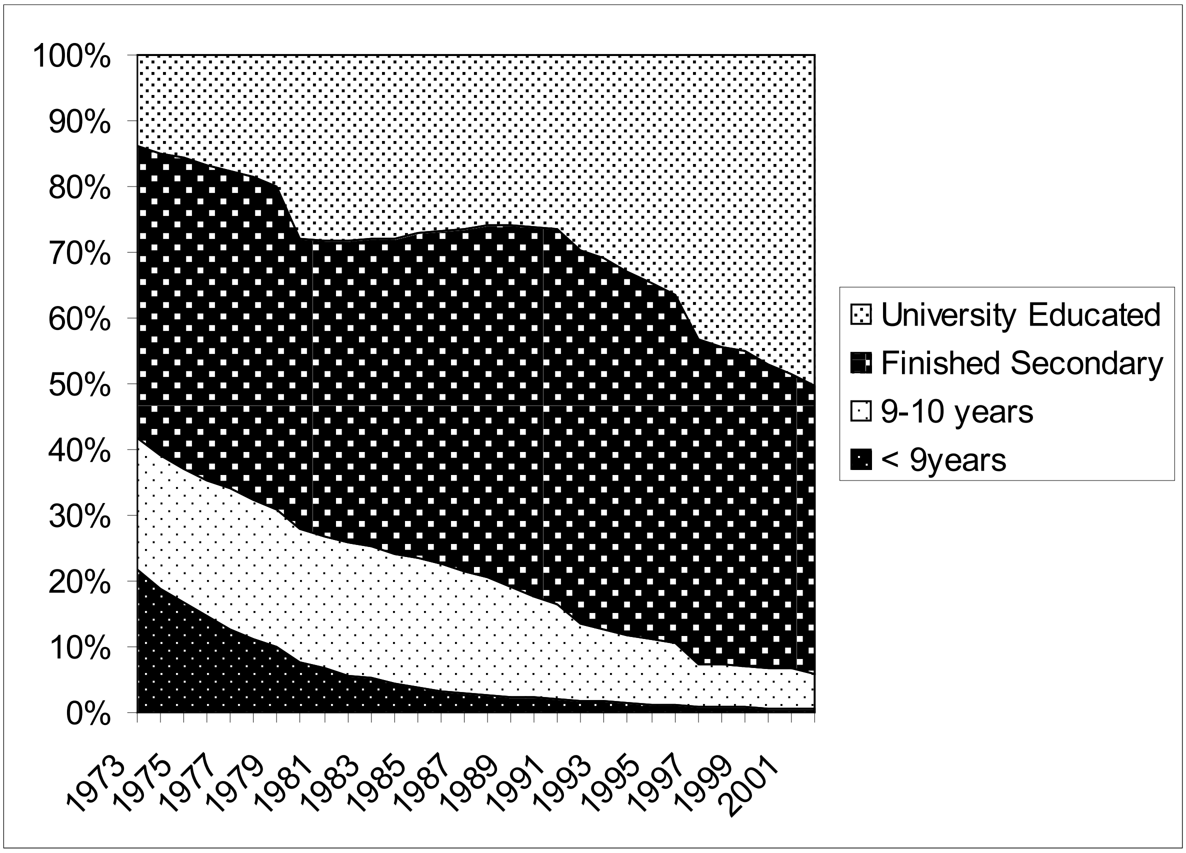

Figure 2. Maternal occupation, split by year of childbirth