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Association between socioeconomic status with pregnancy and neonatal outcomes: An international multicenter cohort

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Abstract

Introduction: Previous evidence examining the association between socioeconomic status and pregnancy complications are conflicted and often limited to using area-based measures of socioeconomic status. In this study, we aimed to examine the association between individual-level socioeconomic factors and a wide range of adverse pregnancy and neonatal outcomes using data from the IMPROvED birth cohort conducted in Sweden, the Netherlands and Republic of Ireland.

Material and methods: The study cohort consisted of women who participated in the IMPROvED birth cohort between 2013 and 2017. Data on socioeconomic factors were self-reported and obtained at 15 weeks' gestation, and included level of education, employment status, relationship status, and income. Data on pregnancy and neonatal outcomes included gestational hypertension, pre-eclampsia, gestational diabetes mellitus, emergency cesarean section, preterm birth, post term delivery, small for gestational age and Apgar score at 1 min. These data were obtained within 72 h following delivery and confirmed using medical records. Multivariable logistic regression examined the association between each socioeconomic variable and each outcome separately adjusting for maternal age, maternal body mass index, maternal smoking, maternal alcohol consumption and cohort center. We also examined the effect of exposure to any ≥2 risk factors compared to none.

Results: A total of 2879 participants were included. Adjusted results suggested that those with less than third level of education had an increased odds of gestational hypertension (OR: 1.74, 95% CI: 1.23–2.46), while those on a middle level of income had a reduced odds of emergency cesarean section (OR: 0.59, 95% CI: 0.42–0.84). No significant associations were observed between socioeconomic variables and neonatal outcomes. Exposure to any ≥2 socioeconomic risk factors was associated with an increased risk of preterm birth (OR: 1.75, 95% CI: 1.06–2.89).

Abbreviations: BMI, body mass index; CI, confidence interval; IMPROvED, improved pregnancy outcomes via early detection; OR, odds ratio; SES, socioeconomic status.

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Conclusions: We did not find strong evidence of associations between individual-level socioeconomic factors and pregnancy and neonatal outcomes in high-income settings overall, with only few significant associations observed among pregnancy outcomes.

KEYWORDS

emergency cesarean section, gestational hypertension, neonatal outcomes, pregnancy outcomes, preterm birth, socioeconomic status

1 | INTRODUCTION

Socioeconomic inequalities can have repercussions across the life course. They are associated with an increased risk of chronic disease and reduced life expectancy potentially due to poorer nutrition, housing insecurity, financial stress, and reduced access to healthcare services.[1–4] Low socioeconomic indicators including lower education attainment, unemployment and low household income have also been linked to pregnancy complications resulting in harmful consequences for the mother and newborn.[5] For example, previous studies have suggested that low socioeconomic indicators were associated with adverse pregnancy outcomes such as low birthweight and preterm birth.[6,7] Furthermore, associations with poor outcomes have been shown to persist despite access to a universal healthcare system, suggesting the associations observed may not be attributable to type of prenatal care received.[8,9]

Conversely, other studies suggest that socioeconomic status (SES) has little impact on adverse birth outcomes.[10,11] A Canadian study using neighborhood-level SES variables suggested there was little to no association with low birthweight and preterm birth.[10] In a separate study, Clayborne and colleagues suggested that associations between neighborhood SES and birth outcomes may be mediated by maternal body mass index (BMI),[11] highlighting the need to take account of factors such as maternal BMI as well as other lifestyle factors linked to both deprivation and adverse pregnancy outcomes.[5,10]

In addition, a recent systematic review has emphasized the need to examine individual-level socioeconomic factors on pregnancy outcomes such as gestational diabetes, hypertensive disorders of pregnancy and measures of newborn health (eg Apgar scores) as there is less evidence examining the impact of SES on these outcomes.[5] Individual-level factors may provide a better understanding of the relative importance of specific socioeconomic factors over area-based measures.[5]

Therefore, this study aimed to examine the association between individual-level socioeconomic factors (including education, employment, relationship status and income) and adverse pregnancy and neonatal outcomes (including gestational hypertension, pre-eclampsia, gestational diabetes mellitus, emergency cesarean section, preterm birth, post term delivery, small for gestational age and Apgar score) using data from Sweden, the Netherlands, and Republic of Ireland.

Key message

We examined individual-level socioeconomic factors and a wide range of adverse pregnancy and neonatal outcomes using data from Sweden, The Netherlands, and Republic of Ireland's IMPROvED birth cohort. We did not find strong evidence of associations in these high-income settings.

2 | MATERIAL AND METHODS

2.1 | Study population

The improved pregnancy outcomes via early detection (IMPROvED) consortium was initially set up to develop a clinically useful screening test for pre-eclampsia to assist clinicians in offering targeted surveillance or preventative strategies. The IMPROvED cohort study is a registered clinical trial, ClinicalTrials.gov with identifier: NCT01891240. Inclusion criteria included females aged 16 or older, primiparous, singleton pregnancy, and signed informed consent. Full exclusion criteria have been published previously,[12] including (but not limited to) essential hypertension treated prepregnancy, and moderate–severe hypertension at booking (>160/100 mmHg), as well as comorbidities such as diabetes mellitus, renal disease, systemic lupus erythematosus, antiphospholipid syndrome, sickle cell disease, and HIV positive.

The current study is a secondary analysis using data from the IMPROvED cohort from three of the four countries belonging to the IMPROvED consortium project. These included Karolinska Institutet (KI), Sweden ($N = 614$); Erasmus Medical Center (EMC), the Netherlands ($N = 802$); and University College Cork (UCC), Republic of Ireland ($N = 1474$). Recruitment took place between 9 + 0–16 + 6 weeks' gestation. Details of the numbers registered for inclusion and final numbers enrolled in the study can be found in Table S1. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies was used for the current study.

2.2 | Exposures

At the 15-week study visit (14+0 to 16+6 weeks'), participants were interviewed by research midwives on demographics, current pregnancy details, and smoking and alcohol habits. These data were entered directly into the study database. Measures of SES included level of education, employment status, relationship status, and income. Details of exposures are as follows: Level of education: categorized as third level and less than third level education. Employment status: categorized as full-time work, part-time work, student, homemaker, unemployed and sickness beneficiary. Those in full-time or part-time work were categorized as being "in paid employment", while those recorded as student, homemaker, unemployed and sickness beneficiary were categorized as "not in paid employment". Relationship status: recorded as: married", "stable relationship but not married", "single" or "separated or divorced". Married and stable relationship were grouped as "married/stable relationship" and single and separated or divorced were grouped as "single/separated/divorced". Income: recorded as the sum of the participant's and their partner's income per annum. This was classified into seven categories in the IMPROvED dataset. We recategorized the two highest and lowest categories of income as high- and low-income levels, respectively, while the three middle categories of income were recategorized as middle-income level. This ensured an adequate number of participants for analysis in each category, while it also ensured the median level of household income in the Republic of Ireland in 2022 (i.e., €46 999) was captured in the middle-income level category.[13] Therefore, low level of income was classified as <€42 000/387000 SEK (Swedish kronor), middle was classified as €42 000–€105 000 k/387000–945 000 SEK, and high was classified as >€105 000 k/954000 SEK.

2.3 | Outcomes

Within 72 h following delivery, information about the pregnancy, delivery and the baby were obtained through interview with a research midwife. If possible, the baby's measurements were taken at this time. If not, these were obtained from the medical records. All information was confirmed by reviewing the medical records and entered onto the research study database.[12]

2.3.1 | Pregnancy outcomes

Pregnancy outcomes of interest included gestational hypertension, pre-eclampsia, gestational diabetes mellitus and emergency cesarean section. Gestational hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg on at least two occasions 4 h apart after 20 weeks' gestation. Pre-eclampsia was defined as gestational hypertension with proteinuria (≥300 mg/24 h or spot urine protein: creatinine ratio ≥ 30 mg/mmol creatinine, or urine dipstick protein >=++).[12] Gestational diabetes mellitus was defined as glucose intolerance with onset or first recognition during pregnancy. Emergency cesarean section was defined as a cesarean section occurring due to one or more adverse events.

2.3.2 | Neonatal outcomes

Neonatal outcomes included preterm birth, post term delivery, small for gestational age, and Apgar score at 1 min. Preterm birth was defined as delivery at <37+0 weeks' gestation. Post term delivery was defined as delivery at >42 weeks' gestation. Small for gestational age was defined as birthweight <third customized centile. Apgar scores were measured at 1 min after birth with appearance, pulse, grimace, activity, and respiration each scored on a scale of 0–2 (with 2 being the best score). A score of 7–10 was considered a high Apgar score, while 0–6 was considered low/intermediate.

2.4 | Potential confounders

We controlled for the following potential confounders: maternal age, maternal BMI, maternal smoking, maternal alcohol consumption and cohort center, all of which were recorded at the 15-week study visit (14+0 to 16+6 weeks) by research midwives. A description of potential confounders is as follows: Maternal age: defined as mother's age (in years) at the beginning of the IMPROvED consortium project and recategorized as ≤20 years, 21–25 years, 26–30 years, 31–35 years and >35 years. Maternal BMI: maternal height (cm) and weight (kg) were recorded at the first study visit (or at the second study visit if not measured at the first visit) and were used to calculate maternal BMI. This was recategorized as underweight <18.5, normal weight ≥ 18.5 to ≤24.9, overweight ≥25 to ≤29.9 and obese ≥30. As only 27 participants were classified as underweight, we combined underweight and normal weight to maximize the number of participants that remained in our adjusted logistic regression models. Maternal smoking before or during pregnancy: participants were asked about the number of cigarettes they smoked prepregnancy and during their first trimester of pregnancy. This was recategorized as "non-smoker", "quit before first trimester" and "smoked at first trimester". Maternal alcohol consumption before or during pregnancy: participants were asked about their alcohol habits before pregnancy or during the first trimester of pregnancy. This was recategorized "non-drinker", "quit before first trimester" and "drank alcohol at first trimester". Cohort center: categorized as KI, EMC and UCC. Where a variable had missing data, the data were added as a separate category using the missing data indicator method.[14]

2.5 | Statistical analyses

Statistical analysis was performed using Stata MP 14.2. We excluded stillbirths due to the small number of cases. For example, there were no exposed cases of stillbirth among those classified as single/separated/divorced, while there were only two exposed cases of stillbirth among those classified as having less than third level education, those classified as not being in paid employment and those on low level of income.

First, univariable and multivariable binary logistic regression models examined the association between each socioeconomic variable and each outcome separately. Second, we examined the effect of exposure to any ≥2 risk factors compared to none (with "less than third level of education", "not in paid employment", "single/separated/divorced" and "low level of income" considered as risk factors). For example, if a participant had "less than third level of education", were "not in paid employment", were "single/separated/divorced" and had "low level of income", they were considered exposed to ≥2 risk factors. Finally, where the data allowed, we examined interaction terms for level of education and employment status; level of education and relationship status; level of education and income; employment status and relationship status; employment status and income, and relationship status and income, with each outcome. Multivariable models were adjusted for maternal age, maternal BMI, maternal smoking, maternal alcohol consumption and cohort center.

2.6 | Ethics statement

All three centers obtained ethical approval for the IMPROvED consortium project from their respective ethic committees (ECM 3(uuu) on January 31, 2023 & ECM5(3)06/08/13 & ECM3(t) on March 28, 2023). Informed consent was signed at the first study visit (11 + 0 to 13 + 6 weeks' gestation).

3 | RESULTS

After removal of stillbirths ($n = 11$), the current study comprised 2879 participants. Baseline characteristics and variables reflecting socioeconomic factors are presented in Table 1. Briefly, 35.5% had less than third level education; 10.7% were not in paid employment; 5.1% of participants were single/separated/divorced and 21.5% had a low level of income.

3.1 | Logistic regression models

3.1.1 | Pregnancy outcomes

Adjusted results suggested that those with less than third level of education had an almost 75% increase in odds of gestational hypertension (odds ratio [OR]: 1.74, 95% confidence interval (CI): 1.23–2.46), while those on a middle level of income had a reduced odds of emergency cesarean section compared to those on a high level of income (OR: 0.59, 95% CI: 0.42–0.84) (Table 2).

TABLE 1 Baseline characteristics of study participants and maternal and neonatal outcomes of low-risk first time mothers recruited to three centers in the IMPROvED Consortium ($N = 2879$).

	N (%)
Maternal age	
≤20 years	61 (2.0)
21–25 years	364 (13)
26–30 years	1074 (37)
31–35 years	1106 (38)
>35 years	274 (10)
Maternal body mass index	
Underweight/normal weight	1736 (61)
Overweight	835 (29)
Obese	291 (10)
Maternal smoking before/during pregnancy	
Non-smoker	2223 (77)
Quit before first trimester	519 (18)
Smoked at first trimester	137 (5.0)
Maternal alcohol consumption before/during pregnancy	
Nondrinker	546 (19)
Quit before first trimester	2280 (79)
Drank alcohol at first trimester	53 (2.0)
Education	
Third level	1856 (65)
Less than third level	1023 (35)
Employment status	
In paid employment	2570 (89)
Not in paid employment	309 (11)
Relationship status	
Married/stable relationship	2733 (95)
Single/separated/divorced	146 (5.0)
Income	
High	240 (8.0)
Middle	1691 (59)
Low	619 (22)
Missing	329 (11)
Gestational hypertension	
No	2708 (94)
Yes	171 (6.0)
Pre-eclampsia	
No	2788 (97)
Yes	91 (3.0)
Gestational diabetes	
No	2769 (96)
Yes	110 (4.0)
Emergency cesarean section	
No	2387 (83)
Yes	492 (17)

TABLE 1 (Continued)

	N (%)
Preterm birth (<37 weeks' gestation)	
No	2721 (95)
Yes	144 (5.0)
Post-term delivery (>42 weeks' gestation)	
No	2795 (98)
Yes	70 (2.0)
Small for gestational age (<3rd percentile)	
No	2758 (97)
Yes	95 (3.0)
Apgar score 1 min	
7–10 (high)	2623 (92)
0–6 (low/intermediate)	219 (8.0)

Note: If missing data >5%, number (%) of missing data reported.

While all other results examining the association between socioeconomic variables and pregnancy outcomes were not statistically significant, some of the effect estimates are worth noting. For example, the OR examining the relationship between those not in paid employment and gestational diabetes mellitus was 1.52 (95% CI: 0.86–2.68) compared to those in paid employment. Additionally, the OR examining level of income-gestational diabetes mellitus relationship was 1.56 (95% CI: 0.54–4.49) for those with a middle level of income and 2.35 (95% CI: 0.78–7.02) for those with a low level of income, compared to a high level of income (Table 2).

3.1.2 | Neonatal outcomes

No significant associations were observed between socioeconomic variables and neonatal outcomes in the adjusted analyses. However, there were some effects estimates of note, particularly for post term delivery. For example, the OR for the association between not being in paid employment and post term delivery was 1.61 (95% CI: 0.74–3.49) compared to those in paid employment, while the OR among those classified as single/separated/divorced and post term delivery was 2.03 (95% CI: 0.72–5.72) compared to those classified as married/in a stable relationship. Furthermore, the OR for the association between low level of income and post term delivery was 2.45 (95% CI: 0.86–6.97) compared to those with a high level of income (Table 3).

3.1.3 | Exposure to ≥2 risk factors

Those exposed to any ≥2 socioeconomic risk factors were over twice as likely to be diagnosed with gestational diabetes mellitus in the crude analysis (OR: 2.18, 95% CI: 1.34–3.54). However, this result attenuated in the adjusted model (OR: 1.44, 95% CI: 0.83–2.52). Similarly, those exposed to any ≥2 risk factors were over twice as likely to have a baby born preterm (OR: 2.05, 95% CI: 1.34–3.14) with this result attenuating slightly in the adjusted model (OR: 1.75, 95% CI: 1.06–2.89) (Table 4).

3.1.4 | Interaction terms

Those not in paid employment and on a low level of income were 3.68 times more likely to be diagnosed with gestational diabetes mellitus compared to those in paid employment with high level of income (OR: 3.68, 95% CI: 1.04–12.95, p for interaction: 0.04). No other interaction term was statistically significant for pregnancy or neonatal outcomes. However, it is important to note that the number of exposed cases were small in most instances (Table S2).

4 | DISCUSSION

This study examined the association between socioeconomic factors including education, employment, relationship status and income and adverse pregnancy and neonatal outcomes using data from Sweden, the Netherlands, and Republic of Ireland. These analyses have yielded three principal findings. First, we did not find strong evidence of associations between individual-level socioeconomic factors and pregnancy and neonatal outcomes, with only few significant associations observed. For example, lower level of education was associated with an increased risk of gestational hypertension, while a reduced odds of emergency cesarean section was observed among those with a middle-income level compared to high-income level. However, it is not possible to rule out the role of chance here, especially considering the lack of consistent results across the various analyses. Second, exposure to more than one socioeconomic risk factor was associated with an increased odds of preterm birth and gestational diabetes mellitus, although the latter no longer reached statistical significance after controlling for potential confounders. Third, results of our interaction terms suggested that those who were classified as not being in paid employment and low level of household income were 3.68 times more likely to be diagnosed with gestational diabetes mellitus compared to those in paid employment with a high level of income. However, as the number of exposed cases were often small in our interaction analysis, future studies using larger sample sizes should be conducted to further examine the interaction effects of socioeconomic factors on pregnancy and neonatal outcomes.

Previous evidence conducted in a large maternity hospital in the Republic of Ireland suggested that mothers who are not in paid employment are at an increased risk of adverse pregnancy outcomes including preterm birth and small for gestational age.[15] While the effect estimates observed by Reynolds et al.[15] are similar to those of the current study, we did not reach statistical significance in our analysis examining employment status and preterm birth and small for gestational age. In a separate study, Kim and colleagues found higher rates of cesarean delivery and pre-eclampsia among those on

TABLE 2 Association between socioeconomic status and pregnancy outcomes in an international multicenter cohort.

Characteristic	No. of exposed cases	GH unadjusted OR (95% CI)	No. of exposed cases	Pre-eclampsia unadjusted OR (95% CI)	No. of exposed cases	GDM unadjusted OR (95% CI)	No. of exposed cases	Emergency CS Unadjusted OR (95% CI)
Education								
Third level	92	Reference	55	Reference	59	Reference	315	Reference
Less than third level	79	**1.60 (1.18–2.19)**	36	1.19 (0.78–1.83)	51	**1.60 (1.09–2.34)**	177	1.02 (0.84–1.25)
Employment status								
In paid employment	155	Reference	82	Reference	91	Reference	437	Reference
Not in paid employment	16	0.85 (0.50–1.44)	9	0.91 (0.45–1.83)	19	**1.78 (1.07–2.97)**	55	1.06 (0.78–1.44)
Relationship status								
Married/stable relationship	158	Reference	86	Reference	103	Reference	466	Reference
Single/separated/divorced	13	1.59 (0.88–2.88)	5	1.09 (0.44–2.73)	7	1.29 (0.59–2.81)	26	1.05 (0.68–1.63)
Income								
High	15	Reference	9	Reference	4	Reference	53	Reference
Middle	102	0.96 (0.55–1.68)	49	0.77 (0.37–1.58)	48	1.72 (0.62–4.82)	276	**0.68 (0.49–0.96)**
Low	42	1.09 (0.59–2.00)	22	0.95 (0.43–2.08)	33	**3.32 (1.16–9.48)**	123	0.87 (0.61–1.25)
Characteristic	**No. of exposed cases**	**GHAdjusted[a]OR (95% CI)**	**No. of exposed cases**	**Pre-eclampsia Adjusted[a]OR (95% CI)**	**No. of exposed cases**	**GDMAdjusted[a] OR (95% CI)**	**No. of exposed cases**	**Emergency CS Adjusted[a] OR (95% CI)**
Education								
Third level	92	Reference	55	Reference	59	Reference	315	Reference
Less than third level	79	**1.74 (1.23–2.46)**	36	1.06 (0.66–1.70)	51	1.03 (0.66–1.61)	177	1.14 (0.91–1.43)
Employment status								
In paid employment	155	Reference	82	Reference	91	Reference	437	Reference
Not in paid employment	16	0.75 (0.42–1.33)	9	0.86 (0.41–1.80)	19	1.52 (0.86–2.68)	55	1.17 (0.83–1.63)
Relationship status								
Married/stable relationship	158	Reference	86	Reference	103	Reference	466	Reference
Single/separated/divorced	13	1.30 (0.69–2.45)	5	0.91 (0.35–2.35)	7	1.16 (0.50–2.71)	26	0.97 (0.61–1.53)
Income								
High	15	Reference	9	Reference	4	Reference	53	Reference
Middle	102	0.75 (0.42–1.33)	49	0.65 (0.31–1.36)	48	1.56 (0.54–4.49)	276	**0.59 (0.42–0.84)**
Low	42	0.64 (0.33–1.26)	22	0.66 (0.28–1.57)	33	2.35 (0.78–7.02)	123	0.73 (0.49–1.10)

Bold values indicates significance level at p-value < 0.05.

Abbreviations: 95% CI, 95% confidence interval; CS, cesarean section; GDM, gestational diabetes mellitus; GH, gestational hypertension; OR, odds ratio.

[a]Adjusted for maternal age, maternal body mass index, maternal smoking, maternal alcohol consumption and cohort center.

TABLE 3 Association between socioeconomic status and neonatal outcomes in an international multicenter cohort.

Characteristic	No. of exposed cases	PTB Unadjusted OR (95% CI)	No. of exposed cases	Post term delivery Unadjusted OR (95% CI)	No. of exposed cases	SGA Unadjusted OR (95% CI)	No. of exposed cases	Apgar 1 min Unadjusted OR (95% CI)
Education								
Third level	76	Reference	50	Reference	53	Reference	128	Reference
Less than third level	68	**1.68 (1.20–2.35)**	20	0.72 (0.43–1.22)	42	1.46 (0.98–2.20)	91	1.33 (1.00–1.76)
Employment status								
In paid employment	123	Reference	61	Reference	81	Reference	199	Reference
Not in paid employment	21	1.46 (0.91–2.36)	9	1.25 (0.61–2.53)	14	1.47 (0.82–2.63)	20	0.83 (0.52–1.34)
Relationship status								
Married/stable relationship	113	Reference	65	Reference	89	Reference	202	Reference
Single/separated/divorced	11	1.61 (0.85–3.05)	5	1.47 (0.58–3.71)	6	1.29 (0.55–3.00)	17	1.65 (0.98–2.80)
Income								
High	11	Reference	7	Reference	9	Reference	14	Reference
Middle	74	0.95 (0.50–1.82)	45	0.91 (0.41–2.04)	52	0.82 (0.40–1.68)	124	1.28 (0.72–2.26)
Low	42	1.53 (0.78–3.03)	14	0.78 (0.31–1.95)	22	0.97 (0.44–2.13)	52	1.50 (0.81–3.08)
Characteristic	**No. of exposed cases**	**PTB Adjusted[a] OR (95% CI)**	**No. of exposed cases**	**Post term delivery Adjusted[a] OR (95% CI)**	**No. of exposed cases**	**SGA Adjusted[a] OR (95% CI)**	**No. of exposed cases**	**Apgar 1 min Adjusted[a] OR (95% CI)**
Education								
Third level	76	Reference	50	Reference	53	Reference	128	Reference
Less than third level	68	1.41 (0.96–2.06)	20	1.00 (0.54–1.84)	42	1.35 (0.85–2.15)	91	1.37 (1.00–1.87)
Employment status								
In paid employment	123	Reference	61	Reference	81	Reference	199	Reference
Not in paid employment	21	1.20 (0.71–2.02)	9	1.61 (0.74–3.49)	14	1.36 (0.73–2.52)	20	0.75 (0.45–1.24)
Relationship status								
Married/stable relationship	113	Reference	65	Reference	89	Reference	202	Reference
Single/separated/divorced	11	1.38 (0.70–2.71)	5	2.03 (0.72–5.72)	6	1.04 (0.43–2.52)	17	1.42 (0.81–2.48)
Income								
High	11	Reference	7	Reference	9	Reference	14	Reference
Middle	74	0.96 (0.50–1.85)	45	1.23 (0.53–2.84)	52	0.74 (0.35–1.55)	124	1.10 (0.62–1.96)
Low	42	1.30 (0.62–2.73)	14	2.45 (0.86–6.97)	22	0.82 (0.34–1.98)	52	1.11 (0.58–2.14)

Bold values indicates significance level at p-value < 0.05.

Abbreviations: 95% CI, 95% confidence interval; OR, odds ratio; PTB, preterm birth; SGA, small for gestational age.

[a]Adjusted for maternal age, maternal body mass index, maternal smoking, maternal alcohol consumption and cohort center.

TABLE 4 Association between socioeconomic status and pregnancy and neonatal outcomes in an international multicenter cohort.

No. of exposures	No. of exposed cases	GH Unadjusted OR (95% CI)	No. of exposed cases	Pre-eclampsia Unadjusted OR (95% CI)	No. of exposed cases	GDM Unadjusted OR (95% CI)	No. of exposed cases	Emergency CS Unadjusted OR (95% CI)
None	70	Reference	47	Reference	42	Reference	248	Reference
≥2 exposures	33	1.47 (0.96–2.56)	18	1.18 (0.68–2.04)	29	**2.18 (1.34–3.54)**	94	1.20 (0.92–1.55)
No. of exposures	**No. of exposed cases**	**GHAdjusted[a]OR (95% CI)**	**No. of exposed cases**	**Pre-eclampsia Adjusted[a] OR (95% CI)**	**No. of exposed cases**	**GDMA djusted[a] OR (95% CI)**	**No. of exposed cases**	**Emergency CSA djusted[a] OR (95% CI)**
None	70	Reference	47	Reference	42	Reference	248	Reference
≥2 exposures	33	1.25 (0.76–2.05)	18	0.91 (0.48–1.71)	29	1.44 (0.83–2.52)	94	1.26 (0.92–1.71)
No. of exposures	**No. of exposed cases**	**PTBUnadjustedOR (95% CI)**	**No. of exposed cases**	**Post term deliveryUnadjustedOR (95% CI)**	**No. of exposed cases**	**SGAUnadjustedOR (95% CI)**	**No. of exposed cases**	**Apgar 1 minUnadjustedOR (95% CI)**
None	58	Reference	38	Reference	44	Reference	102	Reference
≥2 exposures	37	**2.05 (1.34–3.14)**	9	0.73 (0.35–1.51)	20	1.43 (0.76–1.95)	41	1.27 (0.87–1.85)
No. of exposures	**No. of exposed cases**	**PTB Adjusted[a] OR (95% CI)**	**No. of exposed cases**	**Post term delivery Adjusted[a] OR (95% CI)**	**No. of exposed cases**	**SGA Adjusted[a] OR (95% CI)**	**No. of exposed cases**	**Apgar 1 min Adjusted[a] OR (95% CI)**
None	58	Reference	38	Reference	44	Reference	102	Reference
≥2 exposures	37	**1.75 (1.06–2.89)**	9	1.51 (0.62–3.70)	20	1.24 (0.65–2.34)	41	1.11 (0.71–1.72)

Bold values indicates significance level at p-value < 0.05.

Note: "Less than third level of education", "not being in paid employment", "single/separated/divorced" and "low level of income" were considered as risk factors. For example, if a participant had "less than third level of education", were "not in paid employment", were "single/separated/divorced" and had "low level of income", they were considered exposed to ≥2 risk factors.

Abbreviations: 95% CI, 95% confidence interval; CS, cesarean section; GDM, gestational diabetes mellitus; GH, gestational hypertension; OR, odds ratio; PTB, preterm birth; SGA, small for gestational age.

[a]Adjusted for maternal age, maternal body mass index, maternal smoking, maternal alcohol consumption and cohort center.

low-income compared to middle/high income in South Korea, which is in contrast to our study. Authors used a proxy indicator to measure income, classifying participants who received Korean Medical Aid as low SES, and those enrolled in the National Health Insurance system as middle/high SES which may explain some of the differences observed with the current study. Furthermore, they did not differentiate between emergency and elective cesarean delivery which may further explain the differences in effect estimates with our study.[8] However, they also observed a positive association for preterm delivery and gestational diabetes among those on low-income, which is consistent with our findings.[8] In a Swedish cohort study of children born between 1973 and 2002, it was reported that infants born to women with a lower level of education had an increased risk of low Apgar score, similar to our findings.[16] Unlike our findings however, a study conducted in the Netherlands using maternal educational level as an indicator of SES found that while low educational levels were associated with an increased risk of gestational hypertension, this association attenuated after controlling for maternal BMI.[17] Adjusted results from a Puerto Rican study did not suggest a positive association between employment, relationship status and income level and post term delivery. This is in contrast to our study results that demonstrated a positive, yet not significant relationship, with differences potentially due to varying definitions of post term delivery between studies.[18]

This study had several limitations that should be noted. First, information on socioeconomic factors and potential confounders were self-reported, which may have introduced recall bias. Furthermore, using face-to-face interviews for data collection may have influenced participant's responses, resulting in social desirability bias and potentially biasing results.[19,20] However, all data were collected in a standardized manner by trained research midwives in an attempt to limit these biases. Furthermore, latest data reported by the Organization for Economic Co-operation and Development show similar employment rates and numbers with a tertiary education in Sweden, the Netherlands and the Republic of Ireland as those reported in the current study.[21] Second, the number of exposed cases in the current study were sometimes small, in particular when examining interaction terms, which may have reduced the statistical power of our analysis. Third, we cannot rule out the presence of residual confounding or confounding due to unmeasured factors. However, we controlled for several potential confounding factors including maternal age, maternal BMI, maternal smoking, maternal alcohol consumption and cohort center. Furthermore, as our study population was restricted to low-risk first time mothers, this allowed us to further control for parity and several comorbidities, but limits the generalisability of our findings.[12] Finally, while we did include common socioeconomic indicators to measure SES, such as occupation and education,[22] use of a validated questionnaire in future research would further enable reproducibility of results. The socioeconomic status short-form questionnaire (SES-SQ) is one such instrument that could potentially be used when examining the association between SES and adverse pregnancy and neonatal outcomes in future studies. This encompasses six items including education, job position, number of rooms in the house, traveling abroad during last year, car ownership and use of notebook, laptop or tablet in the house.[23]

This study also had several strengths. First, we used data from three European cohorts, including Sweden, the Netherlands, and Republic of Ireland with a sample size of 2879 participants included in our analyses. Second, outcome data were recorded within 72 h following delivery by a trained research midwife and confirmed by reviewing medical records. This may have improved reliability and completeness of information through the use of a combination of sources.[24] Third, we used several individual-level socioeconomic factors to measure SES. This may provide a greater understanding of the direct impact of SES on adverse pregnancy and neonatal outcomes compared to aggregate area-based measures.[5]

5 | CONCLUSION

We did not find strong evidence of associations between individual-level socioeconomic factors and pregnancy and neonatal outcomes overall. However, few positive associations were observed including an increased likelihood of gestational hypertension among those with a lower level of education and an increased risk of preterm birth among those exposed to any two or more socioeconomic risk factors. Future studies should further explore the interaction effects of socioeconomic factors on pregnancy and neonatal outcomes.

AUTHOR CONTRIBUTIONS

KK contributed to study conception. All authors contributed to study planning and interpretation of the results. GMM undertook the statistical analysis and wrote the first draft of the manuscript. All authors contributed to and approved the final manuscript. All authors agreed with the content and gave explicit consent to submit manuscript for publication.

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CONFLICT OF INTEREST STATEMENT

None.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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