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Neighbourhood socioeconomic disadvantage and the risk of preterm delivery

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ABSTRACT

Objective Preterm birth is a major cause of childhood mortality and morbidity, but the aetiology of preterm delivery remains incompletely understood. We sought to examine whether cumulative exposure to neighbourhood socioeconomic disadvantage is associated with preterm delivery risk.

Methods The association between neighbourhood socioeconomic disadvantage over the 20 years preceding delivery and risk of preterm delivery was assessed in a population-based cohort of 11 979 deliveries in Southwest Finland in 2008–2010. The statistical analyses were adjusted for a large number of potential individual-level confounding or mediating factors obtained from the national registry on parturients, deliveries and births.

Results Altogether 615/11 979 deliveries (5.1%) occurred before 37 weeks of gestation. The incidence of preterm delivery was 6.2% (95% CI 5.0% to 7.7%) in the women with the highest cumulative exposure to neighbourhood disadvantage as compared with 3.6% (95% CI 2.8% to 4.5%) in women who had lived in the most affluent neighbourhoods adjusted for the covariates; OR 1.74 (95% CI 1.26 to 2.40). Smoking during pregnancy, prepregnancy body mass index, gestational diabetes, pre-eclampsia and other medical problems during pregnancy explained 27.4% of this association. Shorter exposure to neighbourhood disadvantage was associated with lower excess risk of preterm births.

Conclusions Women with long-term exposure to neighbourhood socioeconomic disadvantage are at increased risk for preterm delivery in a dose-dependent fashion. Improving deprived neighbourhoods may offer means to reduce the risk of preterm birth and, consequently, the intergenerational transfer of health inequality.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Preterm birth is a major cause of child mortality and morbidity. In addition to several individual-level maternal and pregnancy characteristics, neighbourhood socioeconomic disadvantage has been found to be associated with increased risk of preterm delivery (PTB). However, it is unclear whether longitudinal cumulative exposure to neighbourhood-level disadvantage is linked to increased risk of PTB.

WHAT THIS STUDY ADDS

⇒ Cumulative exposure to neighbourhood socioeconomic disadvantage is associated with PTB risk in a dose-dependent fashion. The association is strongest in women with high individual level disadvantage.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Women with long-term history of living in socioeconomically disadvantaged neighbourhoods are at increased risk for PTB, suggesting that a significant proportion of the variation in PTB risk appears to be determined by the living environment.

⇒ Some but not all of the risk increase is attributable to factors including single parenthood, individual socioeconomic status, smoking during pregnancy, prepregnancy underweight or overweight, gestational diabetes, pre-eclampsia, other medical problems during pregnancy and previous spontaneous or medical abortions.

INTRODUCTION

Approximately 1 in 10 children is born preterm each year[1] and prematurity is globally the leading cause of death in children under the age of 5 years.[2] In addition to neonatal mortality and morbidity, preterm birth may lead to long-term health problems including impaired growth, neurodevelopmental, pulmonary and gastrointestinal issues, and increased risk of cardiovascular and metabolic disease in later life.[3] Accurate identification of high-risk pregnancies is instrumental in efforts attempting to reduce the burden of preterm birth and its adverse consequences.

Several individual-level maternal and pregnancy characteristics have been found to be associated with increased risk of preterm delivery.[3 4] These include socioeconomic status (SES) (as measured by education level, income or occupation), old or young age, obesity or underweight, previous preterm delivery, multiple pregnancy, smoking during pregnancy and underlying or pregnancy-related medical conditions. According to a

systematic review of epidemiological studies, neighbourhood socioeconomic disadvantage is also associated with increased risk of preterm birth.[4] However, most of the studies included in the meta-analysis were cross-sectional. It is unclear whether longitudinal cumulative exposure to neighbourhood-level disadvantage is linked to increased risk of preterm delivery.

We investigated the association between 20-year cumulative exposure to neighbourhood socioeconomic disadvantage and the risk of preterm delivery in a cohort of children born in Southwest Finland. High-resolution data allowed controlling for a wide range of potential risk factors.

MATERIALS AND METHODS

Study population

This study is based on the Southwest Finland Birth Cohort, which consists of all 14946 live births in the Hospital District of Southwest Finland during the years 2008–2010. For the present study, only the first delivery during the study period was included for each woman to ensure the independence of the deliveries. We excluded women with unknown identification codes or missing or incomplete information regarding the duration of gestation or neighbourhood socioeconomic disadvantage, and those with less than 5 years of residential history before delivery.

Altogether, 11979 live births were included in the analytic sample (figure 1).

Patient and public involvement

Patients and the public were not directly involved in the design, conduct, reporting or dissemination plans of this research.

Preterm delivery

The time of childbirth was extracted from the national register on parturients, deliveries and births maintained by the Finnish Institute for Health and Welfare. The duration of pregnancy was based on the last menstrual period and confirmed at routine ultrasonography examinations which are provided without cost to all pregnant women in Finland. The word delivery is used to refer to the events leading to the birth of a child with weight greater than or equal to 500 g or duration of pregnancy greater than or equal to 22 weeks. Preterm delivery was defined as delivery occurring before 37 weeks of gestation.

Maternal characteristics

We extracted data on age, marital status and individual SES (based on occupation and classified to higher grade non-manual, lower grade non-manual, manual, student, full-time mother or unknown) from the national register on parturients, deliveries and births. Race or ethnicity is not recorded in national registers in Finland and, consequently, information on the primary language of the mother was derived from the Population Register Centre as an indicator of immigrant background if the primary language was not Finnish or Swedish (the official languages spoken in the study area).

The behaviour-related potential risk factors included self-reported smoking during the third trimester of

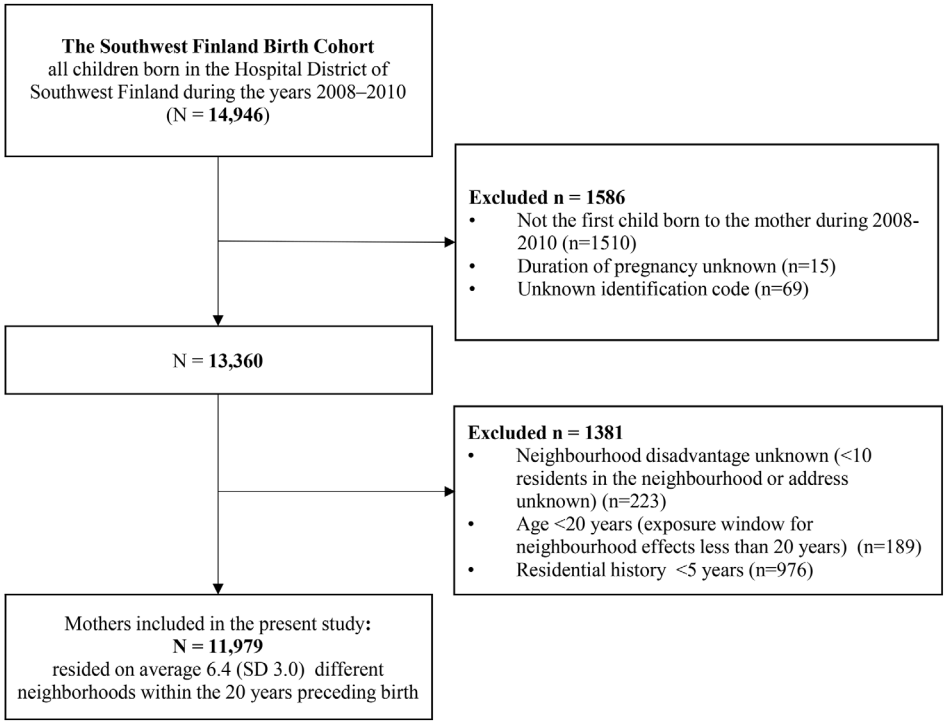

Figure 1 Flow chart of the women included from the Southwest Finland Birth Cohort study.

pregnancy (yes or no) and prepregnancy underweight (body mass index (BMI)<18.5) or obesity (BMI>30), based on maternal weight and height before pregnancy. The pregnancy-related potential risk factors included gestational diabetes mellitus (GDM, International statistical classification of diseases and related health problems, 10th revision (ICD-10) code E11 and O24) or pre-eclampsia (ICD-10 code O13–O16). The presence of medical conditions during pregnancy, such as mental and behavioural disorders (ICD-10 codes F00–F99), diseases of the circulatory (ICD-10 codes I00–I99), respiratory (ICD-10 codes J00–J99), digestive (ICD-10 codes K00–K93) or genitourinary systems (ICD-10 codes N00–N99) or multiple gestation (yes or no) was recorded. Data on earlier pregnancies included previous deliveries as well as spontaneous or medical abortions (yes or no).

Neighbourhood socioeconomic disadvantage

Data on neighbourhood disadvantage were derived from a grid database established and maintained by Statistics Finland. The database contains socioeconomic information from each residence at a spatial resolution of 250 m by 250 m. The grid data were obtained with 5-year intervals between 1990 (the first time point available from Statistics Finland) and 2010. The socioeconomic composition for each grid comprised the average annual income of households, the mean number of years of education of residents over 18 years of age, and the proportion of unemployed adults in residents belonging to the labour force.[5] A score for neighbourhood disadvantage was then calculated by taking the mean value across the three z scores. Missing data (ie, areas with fewer than 10 residents in the neighbourhood) were replaced with the mean neighbourhood disadvantage score of the eight adjacent map squares. For each of the three variables, we derived a standardised z score based on the total Finnish population (mean=0, SD=1). Higher scores on the continuous index denote greater disadvantage. Corresponding relative measures of neighbourhood deprivation are, for example, the Townsend Index and the Netherlands Institute for Social Research Status Scores.[6 7] For the main analyses, the neighbourhood disadvantage score was further classified into four categories based on national means as follows: <−0.5 SD (lowest disadvantage), −0.5 to 0 SD, ≧0 to 0.5 SD and >0.5 SD (highest disadvantage).

High-quality residential mobility data, based on a complete history of the residential addresses with latitude and longitude coordinates, were obtained from the Population Register Centre for each mother. Using open-source Geographical Information Systems (http://www.qgis.org/en/site/), data on the residential neighbourhood disadvantage at each location of residence preceding the delivery were linked to the cohort participants' home addresses by the latitude and longitude coordinates. A time-dependent cumulative socioeconomic disadvantage score weighted by residential time at each location covering the 20-year exposure window preceding the delivery was calculated for each study subject.

Statistical analysis

To examine the associations of potential risk factors with preterm delivery, we used binary logistic regression models. Multinomial logistic regression models were used to study the associations of the 20-year cumulative neighbourhood disadvantage score with the risk factors. In the main analyses, we modelled the association between the categories of cumulative neighbourhood disadvantage and preterm delivery using logistic regression models. The results are expressed as risks (in percentages) and the corresponding ORs and their 95% CIs compared with delivery at full term. Linear trends in these associations were tested using the continuous disadvantage score. The models were adjusted for potential confounders (maternal age, immigrant background, multiple gestation and previous births). Age differences in the associations were tested in a model including the interaction term 'age*cumulative neighbourhood disadvantage'. In these data, excluding very young women, there was no interaction with age (p>0.20). Thus, we did not stratify the analyses based on age.

We examined the extent to which the association was explained by risk factors on the pathway between neighbourhood disadvantage and preterm delivery. A directed acyclic chart (DAG) depicting the mediation is shown in online supplemental figure 1. The mediators included risk factors that have previously been observed to be associated with neighbourhood disadvantage and, consequently, can potentially lay on the pathway linking disadvantage with preterm delivery. These included marital status, maternal SES, smoking during pregnancy, prepregnancy underweight or obesity, GDM, pre-eclampsia and other medical conditions the mother experienced during pregnancy, and earlier spontaneous or medical abortions. The baseline model examined the association between neighbourhood disadvantage and preterm delivery adjusted for the confounders. The mediation model examined the association between neighbourhood disadvantage and preterm delivery, adjusted for the confounders and a mediator. Mediation was assessed by the attenuation of the risk of preterm delivery (in percentages) in the mediation model compared with the baseline model using the following formula: (ORBaseline model − ORAdjusted model) / (ORBaseline model − 1) × 100.[8]

We examined whether the risk of preterm delivery was dependent on the duration of exposure to neighbourhood disadvantage. We calculated the association between the cumulative neighbourhood disadvantage and preterm delivery time using 20, 15, 10 and 5 years as exposure time as well as exposure at the time of delivery only.

To examine the association with preterm delivery in groups with low or high individual and neighbourhood socioeconomic disadvantage, we dichotomised maternal

Table 1 Maternal and pregnancy characteristics

	All N (%)	Preterm delivery N (%)	OR	95% CI
	11 364 (94.9)	615 (5.1)		
Socioeconomic characteristics				
Maternal age at delivery (years)				
20–25	1855 (16.3)	92 (15.0)	1.00	
26–30	4015 (35.3)	199 (32.4)	1.00	0.78 to 1.29
31–35	3832 (33.7)	219 (35.6)	1.15	0.90 to 1.48
36–49	1662 (14.6)	105 (17.1)	1.27	0.96 to 1.70
Immigrant background*				
No	10 873 (95.7)	583 (94.8)	1.00	
Yes	491 (4.3)	32 (5.2)	1.22	0.85 to 1.76
Single parenthood at delivery				
No	10 731 (94.6)	570 (93.0)	1.00	
Yes	614 (5.4)	43 (7.0)	1.35	0.98 to 1.86
Socioeconomic status				
High-grade non-manual	2422 (21.3)	125 (20.3)	1.00	
Low-grade non-manual	2408 (21.2)	131 (21.3)	1.07	0.84 to 1.38
Manual	3436 (30.2)	205 (33.3)	1.22	0.96 to 1.54
Student	1100 (9.7)	47 (7.6)	0.90	0.63 to 1.29
Full-time mother	428 (3.8)	23 (3.7)	1.10	0.69 to 1.74
Missing	1570 (13.8)	84 (13.7)	1.09	0.81 to 1.45
Behaviour-related health risks				
Smoking during pregnancy				
No	10 108 (88.9)	525 (85.4)	1.00	
Yes	1256 (11.1)	90 (14.6)	1.46	1.15 to 1.84
Body mass index before pregnancy†				
<18.5 (underweight)	386 (3.4)	32 (5.2)	1.64	1.13 to 2.38
18.5–29.9	9622 (84.7)	503 (81.8)	1.00	
>30 (obese)	1356 (11.9)	80 (13.0)	1.13	0.89 to 1.44
Diseases during pregnancy				
Gestational diabetes mellitus				
No	9645 (84.9)	484 (78.7)	1.00	
Yes	1719 (15.1)	101 (21.3)	1.49	1.22 to 1.83
Pre-eclampsia				
No	10 781 (94.9)	514 (83.6)	1.00	
Yes	583 (5.1)	101 (16.4)	3.62	2.88 to 4.55
Other medical conditions‡				
No	11 062 (97.3)	568 (92.4)	1.00	
Yes	302 (2.7)	47 (7.6)	3.00	2.18 to 4.13
Birth and pregnancy related factors				
Multiple gestation				
No	11 260 (99.1)	525 (85.4)	1.00	
Yes	104 (0.9)	90 (14.6)	18.39	13.68 to 24.72
Previous births				
No	5369 (47.3)	357 (58.0)	1.00	
Yes	5995 (52.7)	258 (42.0)	0.59	0.50 to 0.70

Continued

Table 1 Continued

	All N (%)	Preterm delivery N (%)	OR	95% CI
Spontaneous abortions				
No	8957 (78.8)	446 (72.5)	1.00	
Yes	2407 (21.2)	169 (27.5)	1.38	1.15 to 1.66
Medical abortions				
No	9749 (85.8)	519 (84.4)	1.00	
Yes	1609 (14.2)	96 (15.6)	1.12	0.90 to 1.40

The OR and their 95% CI are adjusted for age.
*Primary language not Finnish, Swedish.
†Test of curvilinearity, p=0.0056.
‡Mental and behavioural disorders, diseases of the circulatory, respiratory, digestive or genitourinary systems.

individual SES to low SES (manual work or full-time mother) and high SES (all other statuses) and neighbourhood disadvantage score to high (20 year standardised national mean score >0 SD) or low (<0 SD) and divided the participants into four groups based on their individual disadvantage (low SES) and neighbourhood disadvantage: low/low, low/high, high/low and high/high disadvantage. We modelled the association between these combinations of disadvantage and preterm delivery using logistic regression models adjusted for confounders. All analyses were performed using the SAS software V.9.4 (SAS Institute).

RESULTS

Altogether, 615 (5.1%) of the 11 979 pregnant women in the study delivered preterm. The baseline and pregnancy characteristics of the women are presented in table 1. Smoking during pregnancy, GDM, pre-eclampsia, other medical conditions during pregnancy, multiple gestation, primiparity and previous spontaneous abortions were associated with increased risk of preterm delivery.

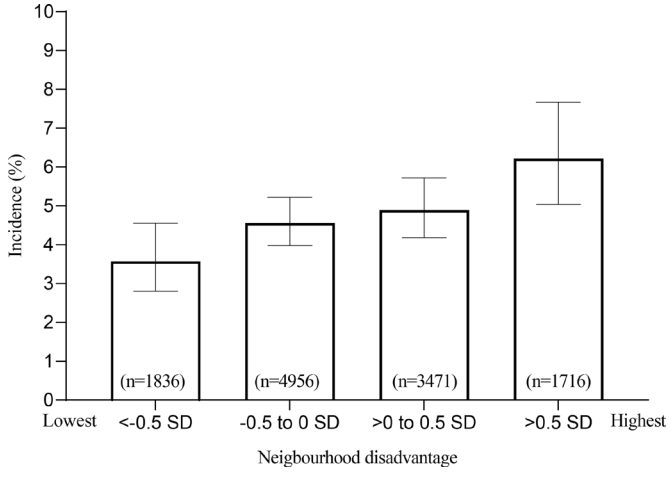

Figure 2 Incidence of preterm delivery by the level of neighbourhood disadvantage. The analyses were adjusted for age, immigrant background, multiple gestation and previous deliveries. OR for trend across categories of neighbourhood disadvantage 1.32 (95% CI 1.11 to 1.56).

During the 20-year period before the delivery, the participants had lived on average in 6.4 (SD 3.0) different residential neighbourhoods (range 1–40). Altogether, 1836 (15.3%) of the women in the cohort were exposed to high cumulative neighbourhood socioeconomic disadvantage, whereas 1716 (14.3%) had lived in the most affluent neighbourhoods. Several risk factors for preterm delivery, including young age, immigrant background, single parenthood at the time of childbirth, low maternal SES, smoking during pregnancy, obesity, GDM and history of spontaneous or medical abortions were associated with high cumulative neighbourhood disadvantage (online supplemental table 1).

Cumulative exposure to neighbourhood socioeconomic disadvantage was associated with increased occurrence of preterm delivery (figure 2, table 2). After adjustment for confounding factors, the incidence of preterm delivery was 6.2% (95% CI 5.0% to 7.7%) in the women with the highest cumulative exposure to neighbourhood disadvantage as compared with 3.6% (95% CI 2.8% to 4.5%) in the women who had lived in the most affluent neighbourhoods; OR 1.74 (95% CI 1.26 to 2.40). The association was linear, with a trend for increased risk of preterm delivery; OR 1.32 (95% CI 1.11 to 1.56).

The contribution of the potential mediators to the risk of preterm delivery associated with neighbourhood disadvantage is presented in online supplemental table 2. Smoking during pregnancy and individual SES were the most prominent mediators. Single parenthood, medical conditions during pregnancy and history of spontaneous or medical abortions all contributed to a smaller extent to the risk of preterm delivery. Smoking, BMI and diseases in combination explained 27.4% of the risk for preterm delivery and all mediators in combination explained 37.5% of the risk. Adjusted for all confounders and mediators, the odds of preterm delivery were 1.47-fold (95% CI 1.05 to 2.05) in women with the highest cumulative exposure to neighbourhood disadvantage as compared with those with the lowest exposure (table 2).

Table 2 Cumulative neighbourhood disadvantage and the risk of preterm delivery compared with delivery at full term

Disadvantage↓	Cases N (%)	Crude		Confounders*		Confounders and mediators†	
	615 (5.1)	OR	95% CI	OR	95% CI	OR	95% CI
<−0.5 (lowest)	75 (4.1)	1.00		1.00		1.00	
>−0.5 to 0	254 (5.1)	1.27	0.97 to 1.65	1.28	0.97 to 1.67	1.22	0.93 to 1.60
>0 to 0.5	180 (5.2)	1.28	0.98 to 1.69	1.37	1.03 to 1.82	1.25	0.94 to 1.67
>0.5 (highest)	106 (6.2)	1.55	1.14 to 2.09	1.74	1.26 to 2.40	1.47	1.05 to 2.05
Linear trend‡		1.22	1.04 to 1.42	1.32	1.11 to 1.56	1.20	1.00 to 1.43

*Age, immigrant background, multiple gestation, previous births.
†Single parenthood, maternal socioeconomic status, spontaneous abortions, medical abortions, smoking during pregnancy, BMI category, gestational diabetes mellitus, pre-eclampsia and maternal mental and behavioural disorders, diseases of the circulatory, respiratory, digestive or genitourinary systems.
‡Continuous score.
BMI, body mass index.

The neighbourhood disadvantage at the time of delivery was not correlated with the frequency of preterm delivery (table 3), but the increased risk became apparent after a 10-year cumulative exposure to disadvantaged neighbourhoods. The association was most marked for the full 20-year cumulative exposure, and the results were similar in a subsample where the same participants were included in all the analyses.

Table 3 Risk of preterm birth in relation to the time frame of preceding exposure to neighbourhood disadvantage

		All participants (n=11 979)		Subpopulation† (n=10 333)	
Cumulative exposure (years)	Disadvantage	OR*	95% CI	OR*	95% CI
0 (at birth)	≤−0.5 (lowest)	1.00		1.00	
	>−0.5 to 0	0.97	0.77 to 1.21	1.02	0.80 to 1.30
	>0 to 0.5	0.89	0.68 to 1.17	0.92	0.69 to 1.24
	>0.5 (highest)	1.10	0.84 to 1.42	1.14	0.86 to 1.51
	Linear trend	1.07	0.95 to 1.20	1.09	0.96 to 1.23
1–5 years	≤−0.5 (lowest)	1.00		1.00	
	>−0.5 to 0	0.89	0.70 to 1.12	0.90	0.70 to 1.16
	>0 to 0.5	1.01	0.78 to 1.30	1.01	0.77 to 1.32
	>0.5 (highest)	1.04	0.77 to 1.39	1.03	0.75 to 1.43
	Linear trend	1.06	0.91 to 1.25	1.06	0.91 to 1.25
5–10 years	≤−0.5 (lowest)	1.00		1.00	
	>−0.5 to 0	0.82	0.63 to 1.06	0.85	0.65 to 1.11
	>0 to 0.5	0.97	0.74 to 1.26	0.95	0.71 to 1.26
	>0.5 (highest)	1.17	0.86 to 1.58	1.11	0.79 to 1.54
	Linear trend	1.19	1.01 to 1.40	1.14	0.96 to 1.37
10–15 years	≤−0.5 (lowest)	1.00		1.00	
	>−0.5 to 0	1.20	0.91 to 1.57	1.25	0.94 to 1.66
	>0 to 0.5	1.27	0.95 to 1.69	1.26	0.93 to 1.70
	>0.5 (highest)	1.42	1.03 to 1.98	1.33	0.93 to 1.90
	Linear trend	1.26	1.07 to 1.49	1.22	1.01 to 1.46
15–20 years	≤−0.5 (lowest)	1.00		1.00	
	>−0.5 to 0	1.28	0.97 to 1.67	1.36	1.02 to 1.81
	>0 to 0.5	1.37	1.03 to 1.82	1.38	1.02 to 1.87
	>0.5 (highest)	1.74	1.26 to 2.40	1.72	1.22 to 2.43
	Linear trend	1.32	1.11 to 1.56	1.30	1.08 to 1.56

*ORs adjusted for confounders (age, immigrant background, multiple gestations, previous births).
†Disadvantage data covers >15 years before birth.

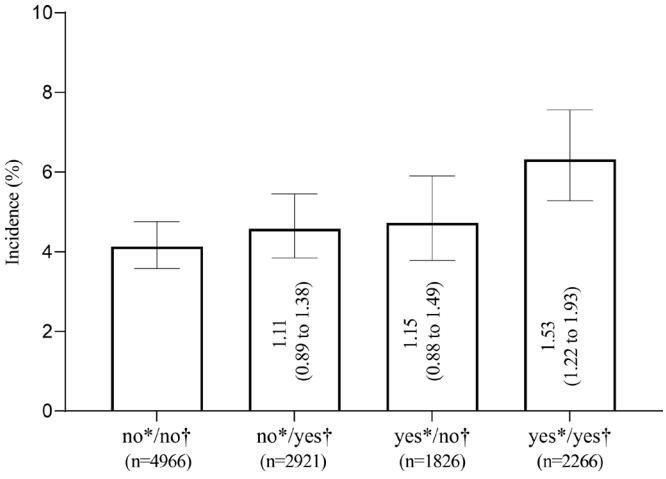

Figure 3 Incidence of preterm delivery by individual* and neighbourhood disadvantage†. Incidence estimate and 95% CIs are adjusted for age, immigrant background, multiple gestation and previous deliveries. *Low socioeconomic status (ie, manual work or full-time mother) versus intermediate or high socioeconomic status of the mother. †Above versus below or at the national mean of neighbourhood disadvantage.

In analysis of the combination of individual low SES (yes or no) and neighbourhood disadvantage (mean score >0 SD or not) and after adjustment for confounding factors, the incidence of preterm delivery was 6.3% (95% CI 5.3 to 7.6) in the women with both high individual and high neighbourhood disadvantage as compared with 4.1% (95% CI 3.6% to 4.4%) in the women with neither disadvantage; OR 1.53 (95% CI 1.22 to 1.93) (figure 3). In women with individual disadvantage only, the corresponding incidence was 4.6% (95% CI 3.8% to 5.4%) and in women with high neighbourhood disadvantage only 4.7% (95% CI 3.8% to 5.9%).

DISCUSSION

We found a robust association between cumulative exposure to neighbourhood socioeconomic disadvantage and the risk of preterm delivery in a population-based birth cohort after adjusting for individual-level risk factors. Single parenthood, maternal SES, smoking during pregnancy, prepregnancy BMI, GDM, pre-eclampsia, other medical problems during pregnancy and previous spontaneous or medical abortions partially but not completely explained this association. The increased risk became apparent after a 10-year cumulative exposure to disadvantaged neighbourhoods and was most marked for the full 20-year cumulative exposure.

The results from previous studies assessing the association between neighbourhood SES and the occurrence of preterm delivery have been inconsistent[4 9] and almost exclusively relied on cross-sectional assessment of neighbourhood disadvantage at the time of delivery. We are aware of only one study investigating the association between longitudinal neighbourhood SES measures and preterm birth. Burgos Ochoa *et al* linked individual-level data on 2 334 036 singleton births from the Dutch perinatal registry to the Netherlands Institute for Social Research neighbourhood SES scores calculated for areas corresponding to four-digit postcodes with 4-year intervals.[7] They used two consecutive cross-sectional SES measures to categorise the neighbourhoods before the births. They found that women living in stable low-SES neighbourhoods and those living in areas declining to low SES had 1.12 times higher odds of preterm birth than those in high SES areas. In the present study, long-term maternal cumulative exposure to neighbourhood disadvantage was associated with the risk of preterm delivery in a dose-dependent manner, but the level of neighbourhood disadvantage solely at the time of delivery was not. The risk was most obvious among mothers who also had low individual SES. As more than one third of the association was attributable to risk factors on the pathway linking neighbourhood disadvantage to preterm delivery, our results suggest that the risk of preterm delivery depends on the duration and severity of the exposure.

The impact of the living environment disadvantage on pregnancy outcomes has previously been investigated in the context of racial or ethnic disparities and discriminatory policies such as redlining.[10–12] Based on systematic reviews and meta-analyses, the associations between neighbourhood disadvantage and preterm delivery risk may differ by race,[4 13] but this might be explained by both accumulation of risk factors and neighbourhood economic contexts.[14 15] The proportion of women with an immigrant background identified by primary language in our cohort was 4.4%, which corresponds to national statistics according to which the prevalence of immigrant background defined as having both parents or the only known parent born in a country other than Finland varied between 4.2% and 4.7% in the study area during the study years 2008–2010.[16] While immigrant background was strongly associated with living in a disadvantaged neighbourhood, it did not explain the association between neighbourhood socioeconomic disadvantage and preterm delivery. Focusing on not only individual but also neighbourhood-level characteristics may aid in identifying high-risk pregnancies. Policies including financial and childcare assistance, housing and community development, and public health measures such as improving antenatal care access and quality in low-resource settings have been associated with reduced risk of preterm delivery.[17–19] In addition, more targeted interventions such as those promoting smoking cessation during pregnancy not only reduce smoking but also diminish preterm birth risk.[20] Improving the health and well-being of women in deprived neighbourhoods may therefore directly reduce adverse outcomes related to preterm delivery.

The accumulation of risk factors for preterm delivery in certain individuals is well-established[13 21] and it is therefore essential to consider exposures, which might confound or mediate the link between neighbourhood

disadvantage and preterm delivery risk in future research. In the present study, the observed association remained evident after adjusting for factors potentially affecting the likelihood of residential selection to disadvantaged neighbourhoods, including maternal age, immigrant background and previous deliveries. Individual-level maternal exposures may also lie on the pathway linking neighbourhood disadvantage and preterm delivery risk. Living in disadvantaged neighbourhoods is reportedly associated with increased risk of incident medical conditions such as diabetes mellitus and mood disorders, poisoning and self-harm, as well as the development of behaviour-related risk factors including weight gain and obesity, smoking and physical inactivity.[5 22–26] Our data indicate that single parenthood, maternal SES, smoking during pregnancy, prepregnancy BMI, GDM and maternal history of spontaneous or medical abortions explained more than one third of the increased risk of preterm delivery among mothers exposed to neighbourhood disadvantage. Moreover, the risk was particularly high among mothers who also exhibited low individual SES when pregnant. Living in a disadvantaged environment may be accompanied by socioeconomic insecurity, reduced access to healthy food and leisure activities, and increased exposure to crime and intimate partner abuse, all of which may contribute to anxiety, depression and stress during pregnancy. In line with this notion, neighbourhood deprivation is known to be associated with both maternal anxiety and depression and the risk of preterm delivery.[27] The impact of anxiety and depression on preterm delivery risk is reportedly most pronounced in women living in deprived neighbourhoods.[27] Further exploration of these complex interactions is essential for developing interventions to reduce the risk of preterm delivery.

Strengths and limitations

The validity of our study is supported by the use of an unselected, population-based cohort of all pregnant women whose residential history was known and who delivered in the same hospitals in a single geographical area over a 3-year period. The comprehensive national register data regarding maternal and pregnancy characteristics had been collected prospectively and were therefore free from recall bias. The rate of preterm delivery observed in our cohort (5.1%) corresponds to the national preterm delivery rate at the time of the study in Finland (5.2% in 2010). The assessment of maternal cumulative exposure to neighbourhood socioeconomic disadvantage was based on 20-year residential history obtained from geographically precise and regularly updated temporospatial information. The reliability of the residential data is high since residential addresses with dates of moves are recorded in the national population register in Finland. The classification of neighbourhoods by the level of socioeconomic disadvantage was performed with high geographical resolution using objective measures of average household annual income, level of education and unemployment.[28]

The limitations of this study should be considered when interpreting the results. Controlling for immigrant background diminishes the problems related to lack of data on race or ethnicity but may include misclassification. No information on maternal history of previous preterm deliveries or paternal characteristics was available. We were not able to differentiate between spontaneous and iatrogenic preterm deliveries, which may have different risk factors. The study was conducted in Finland, a country with small socioeconomic differences and a low rate of preterm delivery, limiting the generalisability of our findings. On the other hand, this highlights the significance of neighbourhood disadvantage even in an affluent society.

Conclusions

Our results suggest that long-term exposure to neighbourhood socioeconomic disadvantage is a risk factor for preterm delivery. The increased risk is most pronounced in women with low individual-level SES. Our findings suggest that social policies aiming to reduce socioeconomic disadvantage on the neighbourhood level might offer means to reduce the risk of preterm birth on the population level. Furthermore, improving the health and well-being of women in deprived neighbourhoods may reduce the risk of preterm delivery and its detrimental consequences on the child and, consequently, the intergenerational transfer of health inequality.

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