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DOI
10.1136/jech.2008.080408

Publication date
2009

Document Version
Final published version

Published in
Journal of Epidemiology and Community Health

The effect of neighbourhood income and deprivation on pregnancy outcomes in Amsterdam, The Netherlands

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Accepted 7 April 2009

ABSTRACT

Background: Studies suggest that the neighbourhoods in which people live influence their health. The main objective of this study was to investigate the associations of neighbourhood-level income and unemployment/social security benefit on pregnancy outcomes: preterm delivery, small for gestational age (SGA), pregnancy-induced hypertension (PIH) and miscarriage/perinatal death in Amsterdam.

Methods: A random sample of 7883 from 82 neighbourhoods in Amsterdam. Individual-level data from the Amsterdam Born Children and their Development (ABCD) study were linked to data on neighbourhood-level factors. Multilevel logistic regression was used to estimate odds ratios and neighbourhood-level variance.

Results: After adjustment for individual-level factors, women living in low-income neighbourhoods (third, second and first quartiles) were more likely than women living in high-income neighbourhoods (fourth quartile) to have SGA births: OR 1.32 (95% CI 1.04 to 1.68), 1.42 (1.11 to 1.82) and 1.62 (1.25 to 2.08) respectively. Women living in the quartile of neighbourhoods with the highest unemployment/social security benefit were more likely than those living in the quartile with the lowest unemployment/social security benefit to have SGA births 1.36 (1.08 to 1.72). The neighbourhood-level variance was significant only for SGA births. No significant associations were found between neighbourhood-level factors and other pregnancy outcomes.

Conclusion: The findings suggest that neighbourhood income and deprivation are related to SGA births. More research is needed to explore possible mechanisms underlying poor neighbourhood environment and pregnancy outcomes, in particular through stress mechanisms. Such information might be necessary to help improve maternal and fetal health.

Growing attention is being paid to the impact of residential neighbourhood environment on health outcomes. A large body of literature,[1–6] suggests that the neighbourhood in which people live influences their health, although a few studies failed to confirm this.[7–9] Neighbourhood socioeconomic status (SES) and deprivation, for example, have been shown to be strongly related to several poor health outcomes.[1] It has been proposed that health inequalities are the result of different accumulation of exposures and experiences that have their roots in the material world.[10–12] The effects of socioeconomic inequalities on health are the consequence of a combination of negative exposures and a lack of individual economic resources associated with a systematic low investment in a whole series of human, physical, health and social infrastructure.[10] The unequal distribution of income is the consequence of historical, political, cultural and economic processes. These processes influence the availability of private resources to individuals and determine the nature of public infrastructure for health care services, food availability, education, transport, control of the environment, quality of housing and rules and regulations in the workplace.

The neighbourhood environmental effects on health could have important policy implications, given the possibility of designing interventions that could potentially affect the health of entire neighbourhoods.[13] Consequently, the interest in neighbourhood-level SES and deprivation on pregnancy and birth outcomes is increasing.[14–23] A historical analysis of socioeconomic inequalities in infant and perinatal mortality from 1954 to 1990 in Amsterdam, for example, shows that absolute differences in infant mortality decreased, but relative differences increased during the study period with deprived areas having relatively high rates compared to non-deprived areas.[16] However, information on the effect of neighbourhood-level SES and deprivation on some of the important pregnancy outcomes, such as pregnancy-induced hypertension (PIH) is still lacking. In addition, studies of neighbourhood-level SES on pregnancy outcomes have shown inconsistent results.[17 18] For example, Luo *et al.*[17] found a strong relationship between neighbourhood-level SES (as measured by neighbourhood median income) and preterm birth in Canada. Kaufman *et al.*,[18] however, found no relationship between neighbourhood income and preterm birth in white Americans in the USA. The effect of neighbourhood-level income on pregnancy outcomes has also been shown to vary between different settings.[14] Furthermore, many studies did not have information on important individual-level factors that have been shown to influence pregnancy and birth outcomes such as ethnicity, maternal SES, smoking and obesity.[24]

These inconsistent results and the lack of data on pertinent pregnancy outcomes such as PIH clearly indicate the need for more studies on this topic especially in Europe where information is very limited.

The main objective of this present study was, therefore, to assess the effect of neighbourhood income and unemployment/social security benefit (deprivation) on pregnancy outcomes (preterm

delivery, small for gestational age (SGA), PIH and miscarriage/perinatal death) in Amsterdam, The Netherlands. It was hypothesised that low neighbourhood income and deprivation would be associated with poor pregnancy outcomes after adjustment for individual-level characteristics.

METHODS

The data for this study came from two different sources. The individual-level data were obtained from the Amsterdam Born Children and their Development (ABCD) study, and the neighbourhood-level data were from Statistics Netherlands.

Data collection at the individual level

The ABCD study was a community cohort investigation of pregnant women residing in Amsterdam, The Netherlands. The ABCD study (see www.abcd-study.nl) investigated differences in pregnancy outcomes with a focus on maternal lifestyle.[25 26]

Between January 2003 and March 2004, all pregnant women in Amsterdam were invited to participate at their first antenatal visit (median: 13 weeks; interquartile range: 3 weeks) with their obstetric caregiver. In addition to the routine prenatal care provided, a modular pregnancy questionnaire was distributed via mail 2 weeks later, to be returned in a prepaid envelope. This validated questionnaire was administered in four languages via a translator's service, and included information on women's sociodemographic characteristics, lifestyle and obstetric history. A reminder was sent 2 weeks later to women who had not returned the questionnaire. In total, 12 373 women were invited to participate, and 8266 women returned the questionnaire (response rate: 67%). For those women who gave permission for follow-up, additional data were obtained from the National Perinatal Register. Data on gestational age (based on ultrasound or, if unavailable, onset of most recent menstrual period), and birth weight were obtained from the Youth Health Care Registration of Amsterdam's Municipal Health Service. Multiple births (n = 131) were excluded from the analysis. The study protocol was approved by the medical ethical committees of all Amsterdam hospitals and the Municipal Privacy Protection Committee of Amsterdam. All participating women gave informed written consent.

Individual level variables

Outcome variables

Preterm births

Preterm birth was defined as gestational age of less than 37 weeks.

Small for gestational age (SGA)

Small for gestational age was defined as a birth weight below the 10th percentile for gestational age on the basis of gender and parity-specific standards.[27]

Pregnancy-induced hypertension (PIH)

Pregnancy-induced hypertension was based on all women who answered yes to the question "Did you have hypertension or use blood pressure medication during your pregnancy?" or who had, according to the national obstetric register, a high diastolic blood (≥90 mmHg) pressure during pregnancy (filled out by the health care professionals), or a diagnostic code for eclampsia, pre-eclampsia or PIH (optional fields). Women with a previous hypertension history before pregnancy or before 20 weeks gestational age (ie, chronic hypertension) were excluded from the analyses.

Miscarriage/fetal and neonatal death (miscarriage/perinatal death)

Miscarriage/perinatal death was determined from four overlapping sources: (1) the National Midwifery Registry, (2) the National Obstetric Registry, (3) the National Neonatal Registry and (4) self-reporting. Miscarriage was defined as death of the fetus occurring before 22 weeks of gestation. The miscarriage group excludes all those with induced abortion. Fetal death was defined as birth of a fetus weighing at least 500 g (or, where birth weight was unavailable, of at least 22 weeks gestation), which showed no signs of life, and neonatal death was defined as death of infants under 7 days according to existing standards.

Maternal explanatory variables were derived from women's questionnaire responses: age, parity, ethnicity, educational level (measured as years of education completed after primary school), smoking during pregnancy (yes/no) and pre-pregnancy body mass index (BMI). The ABCD study has no information on maternal income. Hence, maternal education has been used as a proxy for individual-level socioeconomic status. The ethnic groups were classified according to country of birth and/or country of birth of the parents in accordance with the definition of Statistics Netherlands.[28]

Neighbourhood-level variable

The neighbourhood income data were obtained "from the basic statistics for districts and neighbourhoods" registered by Statistics Netherlands. The neighbourhood income was based on the percentage of median income of people aged between 15 and 64 years in 2003 for each Amsterdam neighbourhood. The neighbourhood unemployment/social security benefit was based on the percentage of people aged between 15 and 64 years who were unemployed or received social security benefit for each Amsterdam neighbourhood. Nine neighbourhoods had small sample sizes (<10 subjects/neighbourhood) and were therefore excluded from the analyses. Data were analysed for 7883 women from 82 neighbourhoods. The average number of participants per neighbourhood was 96, ranging from 12 to 386. In The Netherlands, neighbourhoods are areas with a similar type of buildings, often delineated by natural boundaries. As a result of these natural boundaries, they are a socioculturally homogeneous group.[29]

Data analysis

Individual-level data were linked to neighbourhood-level data via participants' postcodes, creating a multilevel design for data analysis. The data were analysed using multilevel logistic regression. First, models were adjusted for age and parity (ie physiological characteristics), and then sociodemographic and lifestyle factors (education, ethnicity, smoking and body mass index) were added to determine independent associations between neighbourhood-level factors and pregnancy outcomes. Maternal socioeconomic status, ethnicity, smoking and obesity have all been shown to influence pregnancy and birth outcomes.[24–26 30 31]

In addition, the intraclass correlation (ICC) was calculated to estimate the proportion of total variation in pregnancy outcomes that occurred at the neighbourhood level, using the latent variable method.[32] Furthermore, the median odds ratio (MOR) was calculated, which has a consistent and intuitive interpretation.[33 34] Median odds ratio quantifies cluster variance in terms of odds ratios. It is therefore comparable to the fixed effects

Table 1 Maternal characteristics by neighbourhood income and unemployment/social security benefit quartiles in Amsterdam

	Median income				Unemployment/social security benefit			
	Q1 (poorest) (n = 2043)	Q2 (n = 1947)	Q3 (n = 2103)	Q4 (richest) (n = 1790)	Q1 (lowest) (n = 1881)	Q2 (n = 1869)	Q3 (n = 1975)	Q4 (highest) (n = 2158)
Age (years)								
<20	4.8	3.5	1.0	0.4	1.0	2.4	2.5	3.8
20–9	51.6	39.9	23.3	16.6	21.1	32.6	36.2	41.5
30–9	40.5	53.2	72.7	79.4	74.5	62.0	58.5	50.9
40–9	3.1	3.4	3.1	3.5	3.4	3.0	2.8	3.8
Education (years)*								
0–5	44.5	28.4	11.4	7.3	11.4	20.8	26.0	33.0
6–10	40.1	41.3	37.5	32.9	39.0	37.5	38.3	37.5
>10	15.4	30.3	51.1	59.8	49.6	41.7	35.7	29.5
Ethnicity (%)								
Dutch	34.7	59.3	77.0	79.1	76.7	65.5	60.8	47.7
Suriname	11.8	7.9	2.1	0.9	1.6	3.1	6.8	10.1
Turks	8.8	5.3	1.8	0.4	1.5	5.0	4.8	5.3
Moroccan	16.4	8.4	3.2	1.2	2.7	8.7	8.5	9.6
Other	28.3	19.8	15.8	18.4	17.5	17.7	19.1	27.3
Parity (%)								
Primiparous	47.5	54.2	61.3	56.9	52.7	55.7	55.8	55.5
Multiparous	52.5	45.8	38.7	43.1	47.3	44.3	44.2	44.5
Current smoking, yes (%)	10.6	12.2	9.6	5.2	6.9	9.7	11.4	9.9
Pre-pregnancy BMI								
BMI ⩽25 kg/m^2	63.6	72.2	84.3	85.4	81.4	78.0	74.9	71.6
BMI ⩾25 kg/m^2	25.0	20.5	12.4	11.2	14.5	16.5	18.3	19.9
BMI ⩾30 kg/m^2	11.4	7.3	3.3	3.4	4.0	5.5	6.8	8.6

*After primary school.

odds ratio, which is the most widely used measure of effect for dichotomous outcomes. Statistical analyses were performed using Stata version 9.0 (Stata Corp., College Station, Texas, USA).

RESULTS

Table 1 shows the characteristics of the study population. Mothers living in low-income or deprived neighbourhoods were younger, less educated, and were more likely to smoke, and to be obese than their counterparts living in high-income neighbourhoods. Ethnic minority mothers were more likely than Dutch mothers to live in low-income or deprived neighbourhoods.

Table 2 shows the distribution of the adverse pregnancy outcomes by neighbourhood factors whilst table 3 shows the associations between neighbourhood factors and pregnancy outcomes. Pregnant women living in low-income neighbourhoods were significantly more likely than those living in high-income neighbourhoods to have preterm births, SGA births and miscarriage/perinatal deaths. After further adjustment for educational level, ethnicity, smoking and obesity, however, only SGA births differences persisted. Women living in the quartile of neighbourhoods with the highest percentage of people on unemployment/social security benefit were significantly more likely than those living in the quartile with the lowest percentage on unemployment/social security benefit to have SGA births. The difference persisted after further adjustment for educational level, ethnicity, smoking and obesity: OR 1.36 (95% CI 108 to 1.72). Women living in the quartile of neighbourhoods with the highest unemployment/social security benefit were also significantly more likely to have a miscarriage/perinatal death than those living in the quartile with the lowest unemployment/social security benefit. The differences were no longer statistically significant after further adjustment for education, ethnicity, smoking and obesity. There were no statistically significant associations between neighbourhood income, unemployment/social security benefit and other adverse birth outcomes.

Only the neighbourhood variation in SGA births (ie the random intercept in the empty model) was statistically significant (neighbourhood variance (standard error) was 0.092 (0.028), ICC was 0.022, and median OR was 1.34 (95% CI 1.20 to 1.44). The variance between neighbourhoods attenuated but still remained significant after adjustment for all the individual level factors (neighbourhood variance was 0.035 (0.017), ICC was 0.011 and median odds ratio was 1.20 (95% CI 1.04 to 1.28). Further adjustment for neighbourhood-level factors removed the significant variation between neighbourhoods and reduced neighbourhood variance to 0.011 (0.015).

Table 2 Adverse birth outcomes by neighbourhood income and unemployment/social security benefit quartiles in Amsterdam

	Preterm births	SGA births	PIH	Miscarriage/ perinatal death
Income quartiles				
Q1 (poorest)	6.8	16.6	7.7	1.2
Q3	6.9	13.6	8.5	1.2
Q2	5.9	11.2	9.1	0.7
Q4 (richest)	5.4	8.4	9.2	0.6
p Values for trend	0.037	0.001	0.071	0.015
Unemployment/SSB quartiles				
Q1 (lowest)	5.8	9.8	9.6	0.5
Q2	5.8	11.6	9.2	1.1
Q3	6.7	12.6	8.3	1.1
Q4 (highest)	6.7	15.9	7.3	1.1
P-values for trend	0.113	<0.001	0.005	0.073

SGA, small for gestational age; PIH, pregnancy-induced hypertension

Table 3 Odds ratios (95% CI) of adverse birth outcomes and neighbourhood income and unemployment/social security benefit quartiles

	Preterm births		Small for gestation age births		Pregnancy-induced hypertension		Miscarriage/perinatal death	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Median income								
Q4 (richest)	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Q3	1.07 (0.79 to 1.44)	1.02 (0.78 to 1.35)	1.40 (1.08 to 1.81)**	1.32 (1.04 to 1.68)*	1.00 (0.74 to 1.34)	1.00 (0.74 to 1.34)	1.30 (0.58 to 2.96)	1.22 (0.55 to 2.74)
Q2	1.35 (1.00 to 1.81)*	1.12 (0.84 to 1.49)	1.63 (1.26 to 2.11)***	1.42 (1.11 to 1.82)**	1.05 (0.77 to 1.42)	1.04 (0.76 to 1.42)	2.35 (1.09 to 5.07)*	1.81 (0.83 to 3.96)
Q1 (poorest)	1.36 (1.00 to 1.85)*	1.03 (0.76 to 1.40)	1.93 (1.48 to 2.50)***	1.62 (1.25 to 2.08)***	1.04 (0.75 to 1.45)	1.07 (0.76 to 1.51)	2.30 (1.05 to 5.07)*	1.64 (0.72 to 3.74)
Unemployment/SSB								
Q1 (lowest)	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Q2	1.01 (0.74 to 1.36)	0.95 (0.74 to 1.28)	1.15 (0.88 to 1.49)	1.10 (0.86 to 1.39)	0.95 (0.72 to 1.26)	1.00 (0.75 to 1.33)	2.35 (1.03 to 5.39)*	2.04 (0.92 to 4.52)
Q3	1.18 (0.88 to 1.59)	1.04 (0.80 to 1.37)	1.29 (0.99 to 1.68)	1.15 (0.91 to 1.45)	0.86 (0.65 to 1.14)	0.88 (0.66 to 1.18)	2.31 (1.01 to 5.28)*	1.95 (0.88 to 4.33)
Q4 (highest)	1.16 (0.89 to 1.55)	0.97 (0.84 to 1.52)	1.49 (0.1.15 to 1.93)**	1.36 (1.08 to 1.72)**	0.76 (0.57 to 1.01)	0.79 (0.59 to 1.07)	2.28 (1.00 to 5.18)*	1.78 (0.80 to 3.99)

Model 1 (adjusted for age and parity); model 2 (plus educational level and ethnicity, smoking and BMI); SSB, social security benefit; *$p<0.05$, **$p<0.01$, ***$p<0.001$

DISCUSSION

Key findings

The main objective of this study was to assess the effect of neighbourhood income and deprivation on pregnancy outcomes in Amsterdam, The Netherlands. The present study findings indicate that neighbourhood income and deprivation are related to SGA births. Neighbourhood variation in SGA births were also observed, and neighbourhood-level factors contributed to the variation between neighbourhoods. There were no significant associations between neighbourhood income, deprivation and other pregnancy outcomes.

Strengths and limitations

One of the main strengths of the present study is that it included several individual level factors pertinent to birth outcomes as compared to previous studies.[14 17 18 21 23] The current study is also one of the few studies to assess the effect of neighbourhood income and deprivation on several pregnancy outcomes. The neighbourhoods considered in the present study were socioculturally homogeneous communities. It has been emphasised that contextual or area-bound factors such as low income may have a greater impact on health if a neighbourhood relates to a socioculturally homogeneous community.[29] The present study also has limitations. Due to small numbers, miscarriage, fetal and neonatal deaths were combined. Future studies should assess the possible differences in the effect of neighbourhood income and deprivation on each of these outcomes. In addition, the inclusion of the pregnant women occurred during their first prenatal visit, which was on average at 12th (inter quartile range 9–14) week gestational age. This indicates that women were missed who had their miscarriage before the first visit.

Discussion of the key findings

The present finding of associations between neighbourhood income, deprivation and SGA births is consistent with a previous study,[14] and supports the importance of the effect of neighbourhood factors on pregnancy outcomes. Socioeconomic factors can have profound effects on individuals' health as well as the health of populations, and the perinatal domain is particularly prone to such influences.[30] The principal pathways by which SES affects perinatal health include those that operate through lifestyle and behavioural factors such as smoking and obesity.[30]

Small for gestational age is often used as a proxy for intra-uterine growth restriction (IUGR).[24 31] Intra-uterine growth restriction is believed to be related to poor fetal nutrition and/or reduced fetal oxygenation.[35] The mechanism underlying the effect of poor neighbourhoods on SGA is unclear. Neighbourhood-level determinants, such as low income or deprivation, are, however, considered as antecedent to individual-level exposures and behaviours,[24] which may increase the risk of poor pregnancy outcomes. For example, it has been shown that poor maternal nutrition especially around the time of conception is associated with an increased risk of SGA births.[36] Pregnant women's dietary choices may be influenced by the availability of food stores and food service places in their neighbourhoods. Neighbourhoods that share socioeconomic characteristics also tend to share physical (eg pollution and availability of nutritious food), social (eg crime and behavioural norms) and service (eg transportation and health care) environments and these environments could influence health above and beyond the health effects of the socioeconomic characteristics of

What is already known on this subject

- Neighbourhood in which people live influences their health.
- Information on the effect of neighbourhood-level SES and deprivation on pregnancy outcomes is limited and inconsistent.

What this study adds

Neighbourhood-level income and deprivation are associated with SGA births but not preterm birth, child loss and PIH in Amsterdam, The Netherlands.

residents living within them.[37 38] It is therefore possible that pregnant women living in poor or deprived neighbourhoods may have limited access to essential services such as access to healthy food, which may affect fetal nutrition and/or oxygenation, and subsequently increase the risk of SGA. Studies from the USA and the UK, for example, suggest that because of unequal geographical distribution, people with low income have fewer choices and less access to healthy food than their high-income counterparts.[39 40]

The associations between neighbourhood income, deprivation and SGA remained after further adjustments for individual-level factors, which suggest that other factors may also play a role. For example, both neighbourhood-level and individual-level psychosocial factors have been shown to be related to an increased risk of SGA births.[41 42] Pregnant women with low SES experience more stressful life events during their pregnancy than women with high SES.[43] It has been shown that chronic stressors are embedded within and accrued from the environment of women with low SES.[44] More studies are needed to explore the role of other neighbourhood factors, such as psychosocial stressors,[45 46] on pregnancy outcomes.

The neighbourhood median income differences in preterm births and miscarriage/perinatal death disappeared after adjustments for individual-level factors. This finding on miscarriage/perinatal death is consistent with previous studies.[14 16 17] However, the lack of relationship between neighbourhood income, deprivation and preterm births after adjustments for individual-level factors contrasts with other studies.[14 17] The relationship between neighbourhood income, deprivation and preterm births remains inconsistent.[14 17 18 21 23] Canadian studies,[14 17] for example, found a strong relationship between neighbourhood income and preterm births after further adjustment for individual-level factors. Some USA studies,[18 21] however, found neighbourhood income to be associated with preterm births but only in African–Americans. One recent study from the USA,[21] by contrast, found weaker associations among African–Americans compared with white Americans. The explanations for these inconsistent results are unclear. However, differences in study design, neighbourhood context, and the different definitions of neighbourhood deprivation may contribute to these observed differences.

As far as the authors are aware, this is the first study to assess the effect of neighbourhood-level deprivation on PIH. No association was found between neighbourhood deprivation and PIH. However, there was a significant age- and parity-adjusted association between neighbourhood median income (ie first quartile and fourth quartile) and chronic hypertension 1.41 (95% CI 1.00 to 1.99). This suggests that women in deprived neighbourhoods, especially ethnic minority women, might still be at an increased risk of hypertension-related problems in pregnancy, despite the lack of differences in PIH. Hypertension is highly prevalent among some ethnic minority women in The Netherlands.[47 48] In the SUNSET study, for example, African–Surinamese women were nearly four times and Hindustani–Surinamese women were nearly three times more likely than Dutch women to be hypertensive.[47]

The present study findings may have public health and clinical implications. Small for gestational infants are more likely to have problems with perinatal asphyxia, and are at increased risk of long-term growth deficits and early infant mortality.[49] They also have an increased long-term risk of developing metabolic and cardiovascular diseases (Barker hypothesis).[50] Prevention of SGA is therefore of clinical and public health importance. The present findings clearly indicate the need for further studies to unravel the possible mechanism underlying the effect of poor neighbourhood environment on pregnancy outcomes.

In conclusion, the present findings suggest that neighbourhood income and deprivation are related to SGA births and that more clinical attention may be needed during pregnancy for women from low income or deprived neighbourhoods. More work is needed to explore possible mechanisms underlying poor neighbourhood environment and pregnancy outcomes. Such information might be necessary to help improve maternal and fetal health.

Acknowledgements: We thank Dr A. de Jonge (TNO, Leiden) and Mrs Margot Witvliet for providing useful comments on an earlier draft.

Funding: C. Agyemang was supported by a VENI fellowship (grant number 916.76.130) awarded by the Board of the Council for Earth and Life Sciences (ALW) of The Netherlands Organisation for Scientific Research (NWO).

Competing interests: None.

Ethics approval: The study protocol was approved by the medical ethical committees of all Amsterdam hospitals and the Municipal Privacy Protection Committee of Amsterdam.

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