Neighbourhood Family Income and Adverse Birth Outcomes Among Singleton Deliveries

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Abstract

Objective: To assess the association between neighbourhood family income and adverse birth outcomes.

Methods: We conducted a retrospective cohort study of 334 231 singleton births during 2004 and 2006 based on the Niday Perinatal Database from Ontario. Median neighbourhood family incomes from the 2001 Canadian census were linked with the Niday Perinatal Database by dissemination areas. Generalized estimating equations were applied to estimate the odds ratios of adverse birth outcomes associated with lower neighbourhood income, with adjustment for maternal confounding variables at the individual level.

Results: Compared with the highest neighbourhood income quintile, mothers from the lowest quintile were at increased risk of having small for gestational age neonates (OR 1.51; 95% CI 1.46 to 1.57), low birth weight (OR 1.43; 95% CI 1.36 to 1.50), preterm birth (OR 1.17; 95% CI 1.12 to 1.23), low Apgar score (< 7) at five minutes (OR 1.32; 95% CI 1.21 to 1.44), and stillbirth (OR 1.39; 95% CI 1.19 to 1.62). The risks of women from the lowest income quintiles delivering a macrosomic baby (OR 0.81; 95% CI 0.79 to 0.84) or
a large for gestational age baby (OR 0.82; 95% CI 0.80 to 0.85) were significantly decreased. No difference in risk of congenital anomaly was found among different income quintiles.

Conclusion: A lower level of neighbourhood income is associated with increased risks of small for gestational age babies, low birth weight, preterm birth, low Apgar score at five minutes, and stillbirth.

Résumé

Objectif : Évalué l'association entre le revenu familial du voisinage et les issues de naissance indésirables.

Méthodes : Nous avons mené une étude de cohorte rétrospective portant sur 334 231 grossesses monofœtales en 2004 et en 2006, en fonction de données issues de la *Niday Perinatal Database* d'Ontario. Les données quant aux revenus familiaux médians du voisinage issues du recensement canadien de 2001 ont été liées aux données issues de la *Niday Perinatal Database* par région de dissémination. Des équations d'estimation généralisées ont été mises en œuvre afin d'estimer les rapports de cotes des issues de naissance indésirables associées à un revenu de voisinage inférieur, l'effet des variables confusionnelles maternelles étant neutralisé au niveau personnel.

Résultats : Par comparaison avec le quintile de revenu de voisinage le plus élevé, les mères faisant partie du quintile le plus faible étaient exposées à un risque accru d'accoucher de nouveau-nés présentant une hypotrophie fœtale (RC, 1,51; IC à 95 %, 1,46 – 1,57), d'accoucher de nouveau-nés présentant un faible poids de naissance (RC, 1,43; IC à 95 %, 1,36 – 1,50), de connaître un accouchement préterme (RC, 1,17; IC à 95 %, 1,12 – 1,23), d'accoucher de nouveau-nés présentant un faible indice d'Apgar (< 7) à cinq minutes (RC, 1,32; IC à 95 %, 1,21 – 1,44) et de connaître une mortinaissance (RC, 1,39; IC à 95 %, 1,19 – 1,62). Les risques que couraient les femmes faisant partie des quintiles de revenu de voisinage les plus faibles d'accoucher d'un nouveau-né macrosomique (RC, 0,81; IC à 95 %, 0,79 – 0,84) ou présentant une hypertrophie fœtale (RC, 0,82; IC à 95 %, 0,80 – 0,85) connaissaient une baisse considérable. Aucune différence en matière de risque d'anomalie congénitale n'a été constatée entre les différents quintiles de revenu.

Conclusion : Un niveau inférieur de revenu de voisinage est associé à une hausse des risque d'accoucher de nouveau-nés présentant une hypotrophie fœtale, d'accoucher de nouveau-nés présentant un faible poids de naissance, de connaître un accouchement préterme, d'accoucher de nouveau-nés présentant un faible indice d'Apgar à cinq minutes et de connaître une mortinaissance.

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INTRODUCTION

Inequality in health, especially in neonatal health, caused by socioeconomic disparity has long been a concern for government, health professionals, and the public. Among the commonly used socioeconomic measures such as racial background, income, wealth, education, occupation, and social class, income has been recognized as one of the strongest predictors of health outcomes. However, most population-based surveillance databases, including perinatal surveillance databases,[1] do not contain information about socioeconomic status, which has restricted the ability

of investigators to explore the potential influence of socio-economic status on health outcomes. To fill this gap, 17 countries, including Canada,[2] have tried to link population health registries with national population censuses. Previous studies based on these linked data have demonstrated substantial disparities in mortality rates and cause-specific mortalities among people from different socioeconomic levels.[3–6]

In the perinatal health domain, previous studies have suggested that neighbourhood socioeconomic status is associated with adverse birth outcomes. Neighbourhood socioeconomic measures explored in previous studies include income,[7–10] economic deprivation,[11–13] education,[11,14,15] occupation,[11] ethnicity,[15–17] crime,[13–16] deterioration,[18] infrastructure deprivation (e.g., alcohol outlets, tobacco outlets, lack of grocery supermarkets selling healthy food),[18] and social support.[19] However, most previous studies have focused on single birth outcomes because of data limitation, and the majority of publications used data collected prior to 2000. Few studies have described the situation in recent years.

Although essential health care services such as physician services and hospital care in Canada are publicly funded, inequity in health due to socioeconomic disparity still exists.[2,20–22] The potential effects of socioeconomic status on health outcomes (including adverse birth outcomes) might be different in other industrialized countries with different health care systems, such as the United States. There have been few concrete strategies to reduce health disparities in Canada because of a lack of policy-relevant findings that could benefit policy development.[23] The possible effects of socioeconomic status on birth outcomes have not been clearly identified in Canada. Only a few studies have been published on this issue. Joseph et al.[24] explored the effect of individual socioeconomic status on birth outcomes based on data from Nova Scotia, and Luo and colleagues investigated the effects of neighbourhood economic factors on birth outcomes based on data from Quebec[8] and British Columbia.[10]

The objective of the present study was to examine the potential association between neighbourhood incomes and adverse birth outcomes.

MATERIALS AND METHODS

The study data were derived from the 2004–2006 Niday Perinatal Database, which is a regional, internet-based, timely perinatal surveillance system developed and maintained by Better Outcomes Registry & Network Ontario (BORN Ontario—previously the Ontario Perinatal Surveillance System) and hosted by the Criticall Ontario system. By 2006, there were 82 health sites participating in the system, including both hospitals and midwifery practice groups. Among them, 64 entered data directly into the database and the remaining 18 hospitals uploaded data from their own databases. A total of 359 747 births were registered in the database during these three years, accounting for over 95% of births in Ontario. To enhance data quality, an operating manual was developed to ensure consistency of definitions and understanding for each variable, formal training was provided on data entry and reporting capabilities for all sites using the database, an automatic system using "pop-up" messages or hideaway fields was created to ensure accurate data entry, and a thorough data check was used to identify errors by running all data in SPSS format (SPSS Inc, Chicago, IL). The available information in this database included maternal and prenatal characteristics, health service status, intrapartum interventions, and infant outcomes.

The median family income based on dissemination area was abstracted from 2001 Canadian census data. The dissemination area was a small, relatively stable geographic unit with a population of 400 to 700 persons of relatively homogenous socioeconomic status. We used automated geographic coding based on the Statistics Canada postal code conversion files[25] to link the Niday Perinatal Database to the 2001 Canadian census data for Ontario by geocoding maternal postal codes in the Niday dataset into dissemination areas used in the 2001 census. Altogether 348 369 births (96.84%) in the Niday dataset were successfully matched to the census data. We excluded births with missing information on gestational age, infant sex, and birth weight, leaving 346 233 births with complete information on basic birth outcomes. We then extracted all singleton births, 334 231 in total, for the final analysis.

All births were categorized into quintiles according to the median family income in their corresponding dissemination area. Dissemination areas in the lowest income quintile (Q1) represented the poorest neighbourhoods.

Maternal characteristics included in our analysis were maternal age at delivery (< 20, 20 to 34, and ≥ 35 years), parity (nulliparous or multiparous), initiation of prenatal care during the first trimester of pregnancy, smoking during pregnancy, and pre-existing maternal health problem. A pre-existing maternal health problem was defined as presenting chronic hypertension, diabetes, heart disease, thyroid disease, lupus, alcoholism, asthma, HIV, mental illness, hepatitis B, drug use, psychiatric disorders, depression, anxiety, or other diseases.

ABBREVIATIONS

LBW	low birth weight
LGA	large for gestational age
SES	socioeconomic status
SGA	small for gestational age

Adverse birth outcomes included in the present study were low birth weight (live-born infant < 2500 g at birth), very low birth weight (live-born infant < 1500 g at birth), macrosomia (live-born infant > 4000 g at birth), preterm birth (live infant delivered before 37 weeks of gestation), very preterm birth (live infant delivered before 32 weeks of gestation), severe preterm birth (live infant delivered before 28 weeks of gestation), SGA birth (live-born infant with birth weight below the 10th percentile for a specific gestational age and sex based on the latest Canadian fetal growth standard[26]), severe SGA birth (below the 3rd percentile), LGA birth (live-born infant with birth weight above the 90th percentile for a specific gestational age and sex based on the latest Canadian fetal growth standard), low Apgar score at five minutes (< 7), very low Apgar score at five minutes (< 4), low umbilical artery pH value (< 7.0), stillbirth (≥ 20 weeks), and congenital anomaly (presenting anencephaly and similar anomalies, cleft lip, cleft palate, Down syndrome, neural tube defects and other central nerve system anomalies, gastrointestinal, renal, respiratory, cardiovascular, musculoskeletal, or other anomalies).

We first described the distribution of maternal age, parity, tobacco use during pregnancy, time of initiation of prenatal care, and pre-existing maternal health problem by neighbourhood income levels. Percentages of adverse birth outcomes were then calculated by neighbourhood income quintiles, and the Cochran-Armitage test was applied to explore whether the trend of birth outcomes was significantly associated with neighbourhood incomes. Finally, with infants born to mothers from the highest income quintile (Q5) as reference, the adjusted odds ratios and their 95% confidence intervals for adverse birth outcomes associated with different lower income quintiles were computed, using generalized estimating equations with adjustment for potential confounders at the individual level. Confounding variables included in generalized estimating equations models were maternal age, parity, whether prenatal care was initiated during the first trimester, smoking during pregnancy, and pre-existing maternal health problem.

To reduce loss of samples in the regression analysis, missing values exceeding 10% in independent variables were coded as a separate category in generalized estimating equations models. To evaluate the possible impacts of including those subjects with missing information on confounding variables, we performed a sensitivity analysis by using records without any incomplete information in any field. All data were analyzed using SAS version 9.1 (SAS Institute Inc., Cary NC).

The study was approved by the Research Ethics Board at The Ottawa Hospital Research Institute.

RESULTS

Higher neighbourhood income was associated with a lower proportion of teenage mothers and a higher proportion of mothers aged 35 years or more. As neighbourhood income increased, the proportion of women who initiated prenatal care in the first trimester increased and the proportion of women smoking cigarettes during pregnancy decreased. The percentage of women with a pre-existing maternal health problem was slightly higher among women in lower neighbourhood income quintiles (Table 1).

With respect to adverse birth outcomes, there were clear trends of the percentages of low birth weight, very low birth weight, preterm birth, very preterm birth, severe preterm birth, SGA birth, severe SGA birth, low Apgar score and very low Apgar score at five minutes, and stillbirth all decreasing significantly with increasing neighbourhood family income (Table 2). Conversely, LGA and macrosomia showed a positive correlation with neighbourhood income. No difference was found in umbilical artery pH values or the incidence of congenital anomalies among different neighbourhood income levels.

After adjustment for confounding factors, lower neighbourhood income was significantly associated with an increased risk of low birth weight, very low birth weight, preterm birth, very preterm birth, severe preterm birth, SGA birth, severe SGA birth, low Apgar score, very low Apgar score, and stillbirth (Table 3). The risk of macrosomia and LGA was decreased in lower neighbourhood income quintiles. No significant association was found between the risks of low umbilical artery pH or congenital anomalies and neighbourhood income. Supplemental analysis excluding mothers with any missing information on confounding variables yielded similar results (data not shown).

DISCUSSION

Our population-based study demonstrated that lower neighbourhood family income was associated with an increased risk of multiple adverse birth outcomes, including low birth weight, preterm birth, SGA birth, low Apgar score, and stillbirth. Such associations were much more evident in severe adverse birth outcomes such as very low birth weight (< 1500 g), very preterm birth (< 32 weeks), severe preterm birth (< 28 weeks), severe SGA birth (< 3rd percentile), and very low Apgar score at five minutes (< 4). Conversely, higher levels of neighbourhood income were associated with a higher risk of LGA (> 90th percentile) and macrosomia (> 4000 g).

The magnitude of association between neighbourhood income and adverse birth outcomes observed in this study was moderate, consistent with previous North American

Table 1. Maternal characteristics by neighbourhood family income

	Births by neighbourhood family income quintiles*					
Maternal characteristics	Q1 (poorest)	Q2	Q3	Q4	Q5 (richest)	Total
Subjects, n	66 836	66 866	66 759	66 924	66 846	334 231
Maternal age, %						
< 20	5.93	4.45	3.09	2.03	1.25	3.35
20 to 34	77.10	78.55	77.66	76.34	69.78	75.89
≥ 35	16.97	16.99	19.25	21.63	28.98	20.76
Parity, %						
Nulliparous	44.29	46.52	45.64	44.99	43.16	44.92
Multiparous	55.71	53.48	54.36	55.01	56.84	55.08
1st trimester prenatal care visit, n	27 899	29 577	30 831	32 760	28 815	149 882
Yes, %	73.43	80.69	83.62	85.25	85.78	81.94
No, %	26.57	19.31	16.38	14.75	14.22	18.06
Smoking during pregnancy, n	56 374	57 659	57 835	58 064	58 188	288 120
Yes, %	16.48	14.54	11.42	7.86	5.18	11.06
No, %	83.52	85.46	88.58	92.14	94.82	88.94
Maternal health problems, n†	45 095	46 488	45 356	44 686	43 524	225 149
Yes, %	14.87	15.89	14.80	13.38	13.02	14.39
No, %	85.13	84.11	85.20	86.62	86.98	85.61

*Statistical differences among income quintiles were found in all characteristics.

†Maternal health problems: chronic hypertension, diabetes, heart disease, thyroid disease, lupus, alcoholism, asthma, HIV, mental illness, hepatitis B, drug use, psychiatric disorders, depression, anxiety, and other diseases.

studies.[12,27] The most commonly examined birth outcomes in previous studies in the United States were preterm birth and low birth weight.[7,9,11–13,15–19] A study in four states reported the crude odds ratios of preterm birth for the highest neighbourhood deprivation quintile were 1.64 to 2.79 among non-Hispanic white women, and 0.86 to 1.37 among non-Hispanic black women, compared to the lowest neighbourhood deprivation quintiles.[12] Another study in the United States comparing the lowest neighbourhood income quintile to the highest reported an OR for low birth weight of 2.06 (95% CI 1.93 to 2.19).[27]

Two Canadian studies have explored the effect of neighbourhood income quintiles on birth outcomes. Luo et al.[10] used birth registry data in British Columbia to examine the trend of effects of neighbourhood income between 1985 and 2000. They found persistent disparities in birth outcomes over time, with the crude odds ratios for preterm birth (lowest vs. highest neighbourhood income quintiles) ranging from 1.13 to 1.25, for SGA from 1.38 to 1.44, and for stillbirth from 1.06 to 1.17. In another study based on Quebec birth registration data from 1991 to 2000, comparing lowest to highest neighbourhood income quintiles, the reported crude OR for preterm birth was 1.23 (95% CI 1.20 to 1.26) and for stillbirth was 1.44 (95% CI 1.29 to 1.62), findings which are comparable to ours. However, the OR for SGA (1.40; 95% CI 1.37 to 1.43) was smaller than in the present study.[8] A study in Nova Scotia exploring the association between individual income quintile and perinatal outcomes (preterm birth, SGA, and post-neonatal death between 1988 and 1995) also had similar findings.[24] As Canadian governments have attempted to provide equality in health care for all citizens in all provinces and territories over the last three decades, we should not expect large differences in the provision of health care between provinces.

A strength of the present study is the large amount of information included in the Niday Database, allowing an examination of multiple birth outcomes while controlling for various confounding variables. In our analysis, we adjusted for the status of prenatal care (first trimester visit), maternal smoking, and pre-existing maternal health.

Our study does have some limitations. Some non-mandatory fields in this administrative dataset had missing values, although no major difference in the distribution of missing values was observed among different neighbourhood income levels. We conducted a sensitivity analysis by including only study subjects with all information on independent variables and found essentially the

Table 2. Adverse birth outcomes by quintiles of neighbourhood family income

	Adverse birth outcomes by neighbourhood family income quintile (%)					
Birth outcomes	Q1 (poorest)	Q2	Q3	Q4	Q5 (richest)	*P**
Low birth weight (< 2500 g)	6.64	5.87	5.36	4.99	4.47	< 0.001
Very low birth weight (< 1500 g)	1.51	1.38	1.27	1.17	1.02	< 0.001
Macrosomia (> 4000 g)	9.80	11.10	11.82	11.79	12.27	< 0.001
Preterm birth (< 37 weeks)	7.52	7.23	7.02	6.74	6.27	< 0.001
Very preterm birth (< 32 weeks)	1.57	1.41	1.26	1.20	1.04	< 0.001
Severe preterm birth (< 28 weeks)	0.79	0.67	0.65	0.61	0.53	< 0.001
SGA (< 10th percentile)	11.55	10.09	9.07	8.61	7.55	< 0.001
Severe SGA(< 3rd percentile)	3.58	2.94	2.68	2.35	2.04	< 0.001
LGA (> 90th percentile)	9.18	10.32	10.97	10.97	11.49	< 0.001
Apgar score < 7 at 5 minutes	2.03	1.82	1.87	1.58	1.47	< 0.001
Apgar score < 4 at 5 minutes	0.97	0.85	0.87	0.74	0.65	< 0.001
Umbilical artery pH < 7.0	0.45	0.46	0.47	0.43	0.38	0.1892
Stillbirth (≥ 20 weeks)	0.65	0.55	0.56	0.48	0.45	< 0.001
Congenital anomalies†	2.21	1.97	1.95	2.12	2.14	0.9488

SGA: small for gestational age; LGA: large for gestational age

*Results from Cochran-Armitage test for trend

†Congenital anomalies: anencephaly and similar anomalies; cleft lip, cleft palate; Down syndrome, neural tube defects, other central nerve system anomaly; gastrointestinal, renal, respiratory, cardiovascular, musculoskeletal, and other anomalies.

same results. Another limitation of this study is that information about some important maternal characteristics (such as ethnicity, education, and marital status) was unavailable, making it difficult to distinguish how much of the effect of neighbourhood income could be explained by individual differences and how much could be attributed to a crude neighbourhood effect. A further limitation is the absence of information on the duration of residence in the indicated neighbourhood, which might lead to misclassification of neighbourhood income quintile if some women had moved before delivery. If so, the neighbourhood to which they were assigned might not have influenced their birth outcomes.

The mechanisms by which neighbourhood income may contribute to the increased risk of adverse birth outcomes were complicated and unclear, and our study was not designed to explore these mechanisms. We speculate that the median neighbourhood family income based on dissemination areas, the smallest census geographic units of people with relatively homogenous socioeconomic status, could serve as a reliable surrogate for individual socioeconomic markers (such as individual income, education, and occupation) that could strongly affect birth outcomes.[7,28,29]

The findings that poorer neighbourhoods were more likely to have low birth weight and SGA babies, while macrosomia and LGA were more frequent among affluent neighbourhoods, suggest that nutrition status before and during pregnancy in women from different neighbourhood income groups might be different. This could be partly a result of limited family income, and partly a result of maternal behaviour. The variations in maternal smoking and prenatal health care among neighbourhood income levels may also explain some of the observed associations. Other lifestyle factors such as alcohol use, physical exercise, and nutrition intake may also vary by neighbourhood income.[30]

Presumably because of the public funding of health care in Canada, socioeconomic status was not found in a previous study to affect Canadian women's utilization of obstetric care services such as induction of labour and Caesarean section.[31] It appears reasonable to conclude that the difference in prenatal care among women from different neighbourhood income quintiles reflects their attitudes and behaviour towards maternity care rather than inequality in access to health care. A lower neighbourhood income level might be associated with a lower standard of living, including a higher crime rate, exposure to noise and industrial waste, inconvenience in gaining access to health care,

Table 3. Odds ratios of adverse birth outcomes in different quintiles of neighbourhood family income*

	Adjusted OR† (95% CI)			
Birth outcomes	Q1	Q2	Q3	Q4
Low birth weight (< 2500 g)	1.43 (1.36 to 1.50)	1.27 (1.20 to 1.33)	1.18 (1.13 to 1.25)	1.14 (1.09 to 1.20)
Very low birth weight(< 1500 g)	1.43 (1.30 to 1.58)	1.33 (1.20 to 1.47)	1.26 (1.14 to 1.40)	1.22 (1.10 to 1.35)
Macrosomia (> 4000 g)	0.81 (0.79 to 0.84)	0.93 (0.90 to 0.96)	0.98 (0.95 to 1.01)	0.96 (0.93 to 0.99)
Preterm birth (< 37 weeks)	1.17 (1.12 to 1.23)	1.13 (1.08 to 1.18)	1.12 (1.07 to 1.17)	1.10 (1.06 to 1.15)
Very preterm birth (< 32 weeks)	1.44 (1.30 to 1.59)	1.32 (1.19 to 1.46)	1.22 (1.01 to 1.35)	1.22 (1.10 to 1.36)
Severe preterm birth (< 28 weeks)	1.45 (1.26 to 1.66)	1.25 (1.09 to 1.44)	1.26 (1.10 to 1.46)	1.22 (1.05 to 1.41)
SGA (< 10th percentile)	1.51 (1.46 to 1.57)	1.31 (1.26 to 1.36)	1.18 (1.14 to 1.23)	1.14 (1.10 to 1.19)
Severe SGA (< 3rd percentile)	1.65 (1.54 to 1.77)	1.36 (1.27 to 1.46)	1.27 (1.18 to 1.36)	1.14 (1.06 to 1.23)
LGA (> 90th percentile)	0.82 (0.80 to 0.85)	0.93 (0.90 to 0.97)	0.98 (0.95 to 1.02)	0.97 (0.93 to 0.99)
Apgar score < 7 at 5 minutes	1.32 (1.21 to 1.44)	1.20 (1.10 to 1.31)	1.26 (1.16 to 1.37)	1.09 (0.99 to 1.19)
Apgar score < 4 at five minutes	1.44 (1.27 to 1.63)	1.28 (1.13 to 1.46)	1.34 (1.18 to 1.52)	1.17 (1.02 to 1.33)
Umbilical artery pH < 7.0	1.24 (0.96 to 1.58)	1.25 (0.98 to 1.60)	1.28 (1.01 to 1.63)	1.17 (0.92 to 1.49)
Stillbirth (≤ 20 weeks)	1.39 (1.19 to 1.62)	1.20 (1.03 to 1.40)	1.26 (1.08 to 1.47)	1.11 (0.95 to 1.30)
Congenital anomaly‡	1.01 (0.90 to 1.12)	0.92 (0.83 to 1.03)	0.91 (0.81 to 1.02)	0.96 (0.86 to 1.08)

*All ORs are calculated with pregnant women from the highest (Q5) quintile of neighbourhood family income as the reference.
†Adjusted ORs from generalized estimating equations included the following variables: maternal age, parity, smoking during pregnancy, maternal health problems, and initiating prenatal care in the first trimester.
‡n = 169 399

limited access to healthy food, and less social support or services in the neighbourhood, all of which may contribute to an increased risk of adverse birth outcomes.[13,19,30]

Although previous studies have suggested that most neighbourhood effects on health outcomes must ultimately be mediated through individual psychosocial factors and behaviour,[16] and that neighbourhood influences on health tend to be reduced as more individual variables are included,[32] other studies have suggested that neighbourhood influences are independent of individual variables.[7–9,18,19,33,34] The influence of such broader neighbourhood factors as the level of pollution, safety, culture, racial segregation, living facilities, and social support on birth outcomes could not be entirely explained by factors acting at an individual level. A study in Québec showed that, in pregnant women with the same education level, living in proximity to a highway was associated with preterm birth and low birth weight.[34] Other studies have indicated that neighbourhood social support is independently associated with infant birth weight among white mothers,[19] and neighbourhood satisfaction is a stronger predictor of individual health than annual household income.[35] Neighbourhood income might reflect an amalgamation effect of both individual and neighbourhood contexts.[36] Contextual level factors may help explain how socioeconomic status correlates with birth outcomes.[7]

Our study reveals the range of adverse birth outcomes at least partly related to neighbourhood disadvantage after controlling for some individual level factors. However, to what extent the different outcomes can be attributed to neighbourhood influences rather than individual influences deserves further study. Such individual-level influences may include demographic factors, medical issues, health care, social and psychological stress, and behavioural factors,[37] and contextual correlations should include neighbourhood environment, economic conditions, public services, safety, and social support.[38] Any future study should also try to explore which factors are most important in affecting birth outcomes at these two levels in order to set priorities in implementing effective interventions.

Because our study shows findings similar to studies based on Canadian data collected prior to 2000,[8,10] it appears that the disparity in birth outcomes associated with socioeconomic status has persisted in recent years. Universal access to health care is essential to, but cannot guarantee, equality in health outcomes. Interventions highlighting improvements in neighbourhood environments, advocacy of a healthy life style and prenatal care, and implementation of support systems including social support and counselling for nutrition and stress reduction will presumably be needed to improve perinatal outcome in areas of low neighbourhood socioeconomic status.

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