Neighbourhood Contexts and Low Birthweight: Social Disconnection Heightens Single Parents Risks in Saskatoon

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ABSTRACT

Background: The majority of research to date on low birthweight (LBW) has emphasized maternal characteristics, and less so how maternal risk is shaped (via contextual factors). This study aims to understand how neighbourhood characteristics influence LBW, independently and in interaction with individual factors, in the context of community-defined neighbourhoods.

Method: All singleton births for a 3-year period (1992-1995; n=8504) to mothers resident in Saskatoon comprised the study population. Data included were child and mother's/father's characteristics and six neighbourhood characteristics: socio-economic disadvantage, social disconnection, physical condition, population density, availability and accessibility of local programs and services, and smoking prevalence. Multilevel modeling for a binary outcome (LBW) was employed; odds ratios and 95% confidence intervals for the final model were reported.

Results: Newborns in families receiving income assistance, with a mother over 40, and whose mother had previous stillbirths were at greater risk for LBW; however, mothers who had more than one previous live birth were less likely to have a LBW baby. Independent of individual-level risk factors, infants in socio-economically disadvantaged neighbourhoods were at increased risk for LBW (OR 1.34; 95% CI 1.07, 1.68). Most interestingly, the risk of LBW among infants born to single mothers was exacerbated by greater level of neighbourhood social disconnection. Neighbourhoods with low levels of social disconnection have a lower risk of LBW among single mothers (OR=0.89, 95% CI 0.72, 1.17) compared to those with high levels (OR=1.57, 95% CI 1.18, 1.93).

Conclusion: Neighbourhood contextual factors influence the risk of LBW directly, via independent effects, as well as through moderating the risk of individual factors. Studies that simultaneously examine both individual and contextual effects on LBW could provide a stronger evidentiary base for multiple points of interventions targeting individuals as well as settings.

Key words: Infant; low birth weight; neighbourhood characteristics; socioeconomic factors; pregnancy; small-area analysis

La traduction du résumé se trouve à la fin de l'article.

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Low birthweight (LBW) is a common and preventable public health concern that has been implicated in a range of negative infant and adult health outcomes.¹⁻⁵ Epidemiological and clinical studies have linked LBW with a variety of risk factors;^{1,6-8} however, most studies have focused on individual-level factors, predominantly maternal characteristics, which explain only a small proportion of the overall variation in birthweight. In order to more fully understand the determinants of LBW, we need to look beyond maternal characteristics and behaviours to aspects of the physical, social, and economic environment that may impact LBW, either by shaping prenatal behaviour or through other pathways.⁸ Elucidating the environmental or contextual factors that are related to LBW may also suggest new strategies for preventing this problem, consistent with health promotion's increasing focus on community-level interventions and policy approaches.⁹⁻¹¹

Studies examining both individual and contextual factors have found that community characteristics (such as economic hardship or social support) exert an impact on LBW in addition to the customary maternal characteristics.¹²⁻¹⁸ Important as these studies are, they generally fall short on three counts. First, research has tended to focus on socio-economic dimensions of communities, neglecting other characteristics such as physical environment, services, and social connectedness. Second, few studies have defined neighbourhoods or communities in ways that are meaningful to residents, relying instead on commonly available divisions, like census tracts or health regions. Third, few studies have examined the interaction between individual and contextual factors.

This study aims to understand how a range of neighbourhood characteristics influence LBW, independently and in interaction with individual factors, in the context of community-defined neighbourhoods.

METHODS

Source population and data extraction

The study employed a population sample of all singleton children born between April 1, 1992 and March 31, 1994 to mothers who lived and delivered in the city of Saskatoon, Canada. These 8,504 births were identified through the birth registry maintained by Saskatchewan's vital statistics branch. For each child, the neighbourhood in which the mother resided at the child's birth and whether she received income assistance were indicated. Data used

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to define neighbourhood characteristics were from Statistics Canada's 1991 Census as well as local sources such as the municipal planning department, and from purpose-built neighbourhood surveys.^{19,20} The neighbourhoods themselves are geographic and social entities that are meaningful to Saskatoon residents.²¹

Measurement

Individual-level Variables

The dependent variable, LBW, was defined as less than 2500 grams. Independent variables at the individual level were: mother's marital status (married/common-law, single parent, and unknown), mother's age (less than 20 years, 20-40, and over 40), father's age (same groupings as mother), Aboriginal status of child, child's sex, family income status (defined as 'low income' if income support had been received from the provincial/federal governments during the child's birth year), mother's history of stillbirth, and parity (one live birth, two or more).

Neighbourhood Context

We used six variables, each measuring an underlying contextual domain at the neighbourhood level. Four of the six variable domains were derived from principal component analysis of multiple items relating to neighbourhood context (socio-economic disadvantage, physical condition, social disconnection, and availability and accessibility of programs and services for children), and two domains consisted of single items (population density and smoking prevalence). The underlying constructs indicated by each variable domain are among the key contextual factors in neighbourhoods that have been theorized previously to influence children's growth and development.^{15,22,23} Appendix A presents the specific variable items comprising each neighbourhood domain. For example, social disconnection was measured by five items, with more disconnected neighbourhoods being those with lower levels of voter participation in recent civic and federal elections, greater transience, higher levels of ethnic diversity, and higher crime rates.

Statistical approach

Multilevel modeling for binary outcomes examined the independent effects of neighbourhood factors. Three hierarchical models were estimated using HLM software, each building on the previous model and thus increasing in complexity.²⁴ Step 1 included only the estimated neighbourhood-mean probability of LBW, which provides estimates of the variance in probability of LBW observed between and within neighbourhoods. Step 2 added all individual-level risk factors one at a time. If a significant variance component was observed, the variable was retained as a random effect; otherwise, the variable was constrained to be fixed across neighbourhoods. In step 3, six neighbourhood variables were added. The final model retains statistically significant individual- and neighbourhood-level variables.

RESULTS

The proportion of LBW babies was 4.7%, with 29% of the cohort born to single mothers, and 13% to families receiving income assistance. Other socio-demographic characteristics are given in Table 1.

Table 2 presents the steps in multilevel modeling and the variables included in the final model with the significant individual- and neighbourhood-level variance components associated with

Table 1. Characteristics of the Birth Cohort (1992-94) and Prevalence of Low Birthweight, Saskatoon (n=8504)

Variable		Number (%)
Birthweight	Low	399 (4.7)
	Normal	8105 (95.3)
Mother's Marital Status	Married/Common-law	5831 (68.6)
	Single parent	2480 (29.2)
	Unknown	193 (2.3)
Father's Age (years)	20-40	6951 (91.3)
	<20	251 (3.0)
	>40	413 (4.9)
Mother's Age (years)	20-40	7597 (89.3)
	<20	835 (9.8)
	>40	72 (0.9)
Child's Aboriginal Status	Non-Aboriginal	7543 (88.7)
	Aboriginal	961 (11.3)
Child's Sex	Male	4412 (51.9)
	Female	4092 (48.1)
Income Assistance Status during Child's Birth Year	Low income (received income assistance)	1192 (13.1)
	No income assistance	6604 (86.9)
History of Stillbirth	No prior stillbirth	8337 (98.0)
	At least one prior stillbirth	167 (2.0)
Parity	One live born baby	3541 (41.6)
	Two or more live born babies	4963 (58.4)

LBW. At the individual level, children born into households receiving income assistance, with a mother over 40, and whose mother had experienced one or more previous stillbirths were at greater risk for LBW. In contrast, children of mothers who had more than one previous live birth were less likely to be LBW.

At the neighbourhood level, two contextual variables were significantly associated with LBW over and above the effects of individual factors. Adjusted for all other individual- and neighbourhood-level variables, the likelihood of having a LBW baby among women living in the most socio-economically disadvantaged neighbourhoods was 1.34 times higher (95% CI 1.07, 1.68) than that among women living in relatively affluent neighbourhoods. Living in neighbourhoods with available and accessible child-related programs and services was associated with a lower risk of LBW (OR=0.98, 95% CI 0.96, 1.00).

Figure 1 maps the association between socio-economically disadvantaged neighbourhoods and the risk of LBW, adjusted for covariates in Table 2. Neighbourhood socio-economic disadvantage is shown in shaded polygons, each polygon representing a neighbourhood; the darker the shade, the higher the level of socio-economic disadvantage. The shaded polygons are overlaid with circles, which indicate adjusted LBW rates; the larger the circle, the higher the adjusted rate of LBW. The map shows that neighbourhoods with higher levels of socio-economic disadvantage are generally associated with higher rates of LBW.

Results also indicated that the impact of single-parent status on LBW was attenuated by lower levels of neighbourhood social disconnection. As shown in Figure 2, in neighbourhoods with low levels of social disconnection (indicated, for example, by 10th percentile score), the risk of LBW among single mothers is lower (OR=0.89, 95% CI 0.72, 1.17) than in neighbourhoods with high levels of social disconnection (indicated by 90th percentile score) (OR=1.57, 95% CI 1.18, 1.93).

DISCUSSION

Using individual and contextual data in a defined population, we sought to understand the role of neighbourhood contexts in LBW.

Table 2. Estimated Coefficients and Odds Ratios (95% Confidence Intervals) from Multilevel Modeling: Individual and Neighbourhood Characteristics Regressed on Low Birthweight, Saskatoon (n=8504)

Variable (reference category in <i>italics</i>)	Intercept Only Model β (SE)	Individual Model β (SE)	Neighbourhood Model β (SE)	Odds Ratio (95% CI)
Intercept	-3.01 (0.06)	-3.09 (0.06)	-3.13 (0.06)	
Family income assistance status (low income vs. <i>no income assistance</i>)		0.57 (0.14)*	0.59 (0.15)*	1.80 (1.35, 2.42)
Child's sex (female vs. <i>male</i>)		0.08 (0.10)		
Parity (1 live born vs. <i>>1 live born</i>)		0.36 (0.15)*	0.41 (0.14)*	1.51 (1.14, 2.00)
Stillbirth (1 or more prior stillbirth vs. <i>no stillbirth</i>)		1.42 (0.21)*	1.38 (0.19)*	3.99 (2.74, 5.80)
Child's Aboriginal status (Aboriginal vs. <i>non-Aboriginal</i>)		-0.11 (0.27)		
Mother's marital status (single mother vs. <i>married/common law</i>)		0.39 (0.17)*	0.16 (0.15)	1.17 (0.88, 1.57)
Mother's age (<20 vs. <i>20-40 yrs</i>)		-0.12 (0.22)	-0.20 (0.20)	0.82 (0.55, 1.20)
Mother's age (>40 vs. <i>20-40</i>)		1.01 (0.40)*	1.20 (0.40)*	3.33 (1.55, 7.14)
Father's age (<20 vs. <i>20-40</i>)		-0.15 (0.35)		
Father's age (>40 vs. <i>20-40</i>)		0.26 (0.19)		
Neighbourhood socio-economic disadvantage			0.29 (0.11)*†	1.34 (1.07, 1.68)
Neighbourhood programs and services availability and accessibility			-0.02 (0.01)*‡	0.98 (0.96, 1.00)
Interaction between neighbourhood social disconnection and single mother status			0.23 (0.10)*	1.25 (1.02, 1.53)

* Significant variables ($p < 0.05$)

† Odds ratio correspond to '1-unit' change in the independent variable in a continuous scale; when contrasts are applied to the independent variable, the odds of low birthweight for neighbourhoods with highest socio-economic disadvantage (score at 90th percentile) is 1.34 compared to neighbourhoods with lowest socio-economic disadvantage (score at 10th percentile).

‡ Odds ratio for low birthweight for neighbourhoods with the most programs and services for children (90th percentile) is 0.98 compared to neighbourhoods with fewest programs and services (10th percentile).

Figure 1. Association between the adjusted low birthweight rate (quintiles) and neighbourhood socio-economic disadvantage score (quintiles), based on multilevel final model in Table 2

Controlling for individual risk factors, newborns in neighbourhoods with more available and accessible child-related programs and services were less likely to be LBW. In contrast, infants in socio-economically disadvantaged neighbourhoods were at increased risk for LBW. Most interestingly, the risk of LBW among infants born to single mothers was influenced by the level of social disconnection in their neighbourhood.

Neighbourhood socio-economic disadvantage in this study was defined as a high concentration of lower income families, education levels less than grade 9, unemployment, single parents, people of Aboriginal ancestry, and lower rates of home and car ownership. The independent association between neighbourhood socio-economic disadvantage and LBW found in this study is consistent with results of other studies.¹²⁻¹⁸ Previous studies have suggested that one pathway through which neighbourhood socio-economic status may influence residents' health status is the physical environment (e.g., housing quality, proximity to major thoroughfares, lack of parks).^{23,25} In this study, however, we accounted for the

Figure 2. Odds ratio and 95% confidence bars, based on multilevel final model in Table 2: level of neighbourhood social disconnection heightens effects of single mother on low birthweight

physical condition of neighbourhoods; thus the association between neighbourhood socio-economic disadvantage and LBW was independent of the effect of neighbourhood physical environment. This result indicates that interventions directed at increasing economic opportunities in disadvantaged neighbourhoods may contribute to enhanced maternal and child health.

The measure of neighbourhood programs and services in this study reflects not just the existence but also the accessibility (e.g., transportation assistance, cost, operating hours) of the following types of programs and services: early education, parenting, parent relief, family support, birth/prenatal support, nutrition, child care, support for special needs children, and sports and recreational activities for children. Although programs enumerated in this study were allocated to a neighbourhood based on their physical location, many programs serve a population from a wider geographical area. However, not all residents have the means to access resources in other neighbourhoods (i.e., if they do not own a vehicle and public transportation is inadequate). Systematic evaluation is, of

Appendix A Summary of six neighbourhood characteristics included in the analysis

Neighbourhood Domain	Item Description	Data Source
Socio-economic environment (Cronbach alpha=0.94)	Proportion of population with Aboriginal ancestry Proportion of families below low-income cutoff Proportion of population with education level below grade 9 Proportion of population who own their homes Average number of cars per person Proportion of families headed by single parent Proportion of population employed	Census 1991, Statistics Canada
Physical condition (Cronbach alpha=0.73)	Condition of neighbourhood, proportion of housing in need of major repair, street width, road condition, appearance, noise level, number of stoplights and crosswalks	Neighbourhood observation survey, 2001 ²⁰
Social disconnection (Cronbach alpha=0.84)	Proportion of voter participation in most recent civic elections Proportion of voter participation in most recent federal elections Proportion of population who moved in the past year Ethnic diversity index: Calculated by comparing the neighbourhood population of a given ethnic group to the population of that ethnic group across the whole city, and summing up these proportions across all ethnic groups. The ethnic diversity index shows the intensity of the presence of ethnic groups in that neighbourhood; the higher the sum, the more diversified the population Crime incidence: Created from Saskatoon City data; takes into account reported property crimes (break and entry), vandalism, arson, etc.	City of Saskatoon ¹⁹ Census 1991, Statistics Canada City of Saskatoon ¹⁹
Availability and accessibility of programs and services	Type of programs and services: early education, parenting, counseling, birth/prenatal, nutrition, child care, sport and recreation	Neighbourhood Programs and Services Survey, ²⁰ Understanding the Early Years, Saskatoon, 2001
Population density	Average number of persons per household in neighbourhoods	Census 1991, Statistics Canada
Unhealthy lifestyle "norm"	Proportion of current smokers in neighbourhoods	Tobacco Use Survey, Saskatoon Health Region

course, essential to assess the impact of specific programs and services on the rate of LBW and other birth outcomes.

Neighbourhood social disconnection moderated the association between single parent status and LBW. The measure of neighbourhood social disconnection in this study is conceptually related to constructs of social capital²⁶ and collective efficacy.²⁷ Previous studies have found neighbourhood support to be associated with infant birthweight,¹⁶ but to our knowledge this is the first study reporting moderating effects of neighbourhood social disconnection within a high-risk group such as single mothers. This finding adds to the growing evidence that social processes that enhance neighbourhood connectedness, trust and efficacy have a significant positive effect on health. Further studies are necessary to delve deeply not only into how social processes positively affect health outcomes, but also into how they may interact with individual-level factors to mitigate negative impact on health.^{17,18}

Our measure of neighbourhood social disconnection, however, has some limitations. It was constructed for the purpose of this study from available indicators. While the selection of these indicators was based on research and theory, the measure would have been strengthened by a direct assessment of residents' sense of connection to their neighbourhood. Moreover, as a new measure, it would benefit from further testing of its validity.

Another potential limitation of the study is the time gap between the data collected for the measure of availability and accessibility to neighbourhood programs (2001) and the birth cohort itself. While it would have been ideal to have the birth cohort (1992-1994) and the assessment of programs match in time, it is unlikely that this discrepancy led to spurious results. Most neighbourhood programs that were enumerated were of the type that would have existed throughout the 1990s. This decade saw no major changes to the type of services directed at children and families in Saskatoon.²⁸

One of the challenges of conducting this kind of multilevel research is deciding which individual-level factors to include in the analysis.²⁹ While it is important to control for potential confounders, there is also the risk of including factors that are part of

the causal pathway through which neighbourhoods influence health outcomes, thereby leading to an underestimation of the role that neighbourhoods play.^{30,31} In this study, the individual-level factors are ones which are generally related to LBW (mother's age, marital status, parity, previous birth outcomes), but are not likely to be influenced by the neighbourhood environment, unlike, for example, maternal smoking, poor diet or inadequate prenatal care. In studies involving multilevel variables, it is critical to carefully conceptualize mechanisms or causal pathways through which contextual factors affect individual outcomes, for these mechanisms need to inform the selection of variables, statistical modeling and interpretation of findings.²⁹⁻³²

In conclusion, we found neighbourhood contextual factors to be important determinants of LBW, over and above individual socio-economic characteristics and mothers' previous birth outcomes. Two neighbourhood dimensions were independently related with a higher risk of LBW: socio-economic disadvantage and lower levels of program availability and accessibility. Furthermore, an interesting interaction was found between factors at the neighbourhood and individual level: single mothers living in socially connected neighbourhoods were less likely to have a LBW infant than those living in more disconnected areas. These findings suggest that interventions aimed at reducing LBW would be enhanced by targeting high-risk neighbourhoods as well as high-risk individuals in order to eventually reduce maternal and child health disparities.

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RÉSUMÉ

Contexte : À ce jour, la majorité des travaux de recherche portant sur le faible poids à la naissance s'intéresse davantage aux caractéristiques des mères, et moins à la façon dont se profile le risque lié à la mère (par le biais des facteurs contextuels). Cette étude vise à comprendre la façon dont les caractéristiques du milieu influent sur le faible poids à la naissance, de manière indépendante et en interaction avec des facteurs individuels, dans le contexte de milieux définis par la collectivité.

Méthode : La population étudiée comprenait toutes les naissances d'enfants uniques issus de mères résidant à Saskatoon; la période à l'étude était de trois ans (1992-1995; n=8504). Les données considérées étaient les caractéristiques de la mère/du père de l'enfant ainsi que six caractéristiques du milieu : désavantage socioéconomique, rupture sociale, condition physique, densité de la population, disponibilité et accessibilité des programmes et des services locaux et la prévalence du tabagisme. Une modélisation à niveaux multiples pour des résultats exprimés de façon binaire (faible poids à la naissance) a été utilisée; des rapports de cotes ainsi que des intervalles de confiance à 95 % se rapportant au modèle final ont été signalés.

Résultats : Les nouveaux-nés des familles bénéficiaires de l'aide sociale, issus d'une mère âgée de plus de 40 ans dont la mère a fait des fausses couches, étaient plus susceptibles d'avoir un faible poids à la naissance; cependant, les mères ayant eu plus d'une naissance d'enfant vivant étaient moins susceptibles d'avoir un enfant de faible poids à la naissance. Indépendamment des facteurs de risque individuels, les nourrissons se trouvant en milieu désavantagé sur le plan socioéconomique étaient plus susceptibles d'avoir un faible poids à la naissance (r.c. 1,34; i.c. 95 % 1,07; 1,68). Fait intéressant, le risque d'un faible poids à la naissance chez les nourrissons nés de mères seules était exacerbé par un degré plus élevé de rupture sociale du milieu. Les milieux comportant un faible degré de rupture sociale représentent un moindre risque de faible poids à la naissance pour les mères seules (r.c.=0,89; i.c. 95 % 0,72; 1,17) en les comparant aux milieux comportant un degré élevé de rupture sociale (r.c.=1,57; i.c. 95 % 1,18; 1,93).

Conclusion : Les facteurs contextuels du milieu influent directement sur le risque de faible poids à la naissance par des effets indépendants, de même qu'en atténuant le risque des facteurs individuels. Des études examinant simultanément les effets individuels et contextuels sur le poids à la naissance pourraient fournir un fondement plus solide à l'appui des points d'intervention multiples visant des personnes, de même que des milieux.

Mots clés : nourrisson; faible poids à la naissance; caractéristiques du lieu de résidence; facteurs socioéconomiques; grossesse; analyse régionale