
Determinants of high birth weight by geographic region in Canada

Lise Dubois, Manon Girard and Fabiola Tatone-Tokuda

Abstract

This study aims to analyze the determinants of high birth weight (> 4000 grams) by various geographic regions of Canada. Analyses were performed using the data from cycles 1 to 4 (1994-2001; N=20,002 children) of the Canadian National Longitudinal Survey of Children and Youth (NLSCY). Children were grouped into five geographic residential area categories: the Atlantic provinces, Quebec, Ontario, the Prairie provinces and British Columbia. Determinants analyzed in the study include sex, gestational age and birth rank of children; maternal age and education; maternal smoking during pregnancy; family type; family socioeconomic status (SES) and maternal health (postpartum depression; hypertension and prescription drug use during pregnancy). In comparison to Quebec, the odds of giving birth to a high-birth-weight child were 25% higher in Ontario, 41% higher in the Atlantic provinces and 53% higher in British Columbia. In Quebec, non-smoking mothers of higher SES had increased odds of delivering a baby weighing more than 4000 grams, while in British Columbia, the odds of having a birth weight greater than 4000 grams doubled for children of non-smoking mothers from the lowest SES quintiles. The relationship between social disparities and macrosomia was found to vary by geographic region.

Key words: birth weight, geographical determinants, demographic factors, socioeconomic factors, Canada

Introduction

A birth weight of more than 4000 g has been implicated as a risk factor for many immediate and long-term health concerns, including complications with childbirth, childhood and adult morbidity, and obesity at different ages.¹⁻⁷ High birth weight has also been associated with increased rates of cesarean delivery; obstetrical brachial plexus palsy (OBPP); childhood brain tumours (astrocytomas); childhood leukemia (acute lymphoblastic leukemia and acute myeloid leukemia); Wilms tumour (nephroblastoma); type 2 diabetes; diabetes-associated mortality; childhood asthma; prostate cancer; increased fat mass in adolescence; and overweight and obesity from childhood through adulthood.^{2,4,8-22}

Despite this evidence, mean birth weight and the proportion of infants weighing more than 4000 g at birth is on the rise in Canada and in many other developed and developing countries, including Sweden, the United Kingdom and Denmark.²³⁻³¹ For Canada (with the exclusion of Newfoundland and Labrador, due to data unavailability), Wen et al. reported that the proportion of infants weighing more than 4000 g at birth rose from 10.57% for the period 1981-1983 to 12.11% for the period 1995-1997.³¹ More recent statistics demonstrate a mean of 12.8% Canadian babies who were born weighing 4000 g or more between 2002 and 2004 (a mean of 12.5% of babies were born weighing \geq 4000 g, when excluding Newfoundland and Labrador for comparability pur-

poses).³²⁻³⁴ A similar increase in birth weight was found in Denmark from 1990 to 1999, where mean birth weights rose by 45 g for all infants and 62 g for those born at term, and the percentage of infants with a high birth weight (> 4000 g) rose from 16.7% to 20.0% over the ten years observed.²⁷

Certain maternal, infant and lifestyle characteristics have been suggested as determinants to the increasing trend in mean birth weight evident in various countries over the years. In particular, higher birth weights have been associated with higher maternal age and level of education; non-smoking mothers; low caffeine intake; high prepregnancy weight and height; high pregnancy weight gain; increased maternal body mass index (BMI); multiparity; gestational age greater than 40-42 weeks; gestational diabetes; male infants; higher family SES; maternal ethnic origin; and married status.^{1,3,5,7,20,26,30,35-39} However, not all these factors have been shown to consistently maintain a significant association with high birth weight across all regions and populations observed. In a study from Sweden, socioeconomic indicators were no longer significantly related to variations in birth weight after controlling for smoking habits.³⁹ Xu et al. also reported no significant relations to maternal age, education and occupation in a study from China.⁴⁰ With conflicting findings such as these, it is unclear whether determinants typically associated with increased rates of macrosomia can be generalized to all regions. Even though antenatal health care practices vary by region, few studies have controlled for geographic differences

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in their analyses. In fact, a majority of studies on high birth weight have been localized to a particular hospital or region and do not assess for geographic variations.

From a population health perspective, it is important to have a thorough understanding of the determinants involved across geographic regions in order to develop effective public health strategies to counter the trend of higher birth weight prevalence in certain population subsets.

Thus, the aim of this study is to analyze how characteristics including sex, gestational age and birth rank of children; maternal age and education; maternal smoking during pregnancy; family type; family SES; and maternal health (postpartum depression; hypertension and prescription drug use during pregnancy) function as population determinants of high birth weight. Another aim is to assess how these characteristics may vary in their influence on high birth weight across the geographic regions of Canada.

Methods

The analyses were performed using the data from the four cycles of the Canadian National Longitudinal Survey of Children and Youth (NLSCY) (cycle 1 in 1994-95; cycle 2 in 1996-97; cycle 3 in 1998-99; and cycle 4 in 2000-01). The NLSCY is a survey conducted by Statistics Canada and Human Resources Development Canada (HRDC) to monitor the development of Canadian children from birth to adulthood. The survey began in 1994, collecting data on a representative sample of about 25,000 Canadian children between birth and 11 years of age. Follow-up data collection every two years thereafter and through adulthood focussed on factors influencing children's social, emotional, behavioural and physical development. Cross-sectional samples were added in cycles 2, 3 and 4 to provide representative sample estimates.

Information for the NLSCY was collected via telephone interviews from the mothers of children under study. Data collected was weighted by a factor based on the inverse of the selection probability, the

probability of a non-response and both the post-stratification and attrition rates to ensure that the data was longitudinally representative of same-age children in the total population.

Using the first four cycles of the NLSCY, the present study performed statistical analyses on data of children between birth and three years of age for whom birth data was available. Analyses were based on individuals with no missing values for any of the studied variables. Of the 20,798 singleton babies having a reported birth weight, the data of 20,002 (96%) were analyzed. The impact of missing data was analyzed by conducting with-and-without analyses. Missing data were excluded from the analyses since they had no impact on the results.

Reported birth weight, adjusted for gestational age, was used to analyze factors related to birth weights over 4000 g (high birth weight) across various geographic regions of Canada. Although several definitions and cutoff points have been used to classify high birth weight (macroscopic) infants, using the 4000 g marker has shown merits in the prediction of parturition-associated and fetal morbidity, whereas using the 90th centile to classify Large-for-Gestational-Age (LGA) infants is a better marker for investigating underlying causes and outcomes related to gestational age.⁴¹ In an assessment of adverse outcomes associated with various macrosomic birth weight categories, Boulet et al. also demonstrate that grade 1 macrosomia (> 4000 g) is most useful to identify increased risks associated with labor and newborn complications, whereas grade 2 (> 4500 g) and grade 3 macrosomia (> 5000 g) are better predictors of increased risks of neonatal morbidity and infant mortality, respectively.¹ The criteria chosen by experts to distinguish high birth weight infants has also differed depending on whether it is used in epidemiological research or in decision making for care in a clinical practice setting.⁴² Given the present study's aim to observe associations in a population, the 4000 g marker was deemed appropriate in order to include all levels of risk associated with high birth weight.

Information about birth weight and gestational age were obtained from mothers' responses to the following questions from the NLSCY: 1) "Was he/she born before or after the due date?"; 2) "How many days or weeks before or after the due date was he/she born?"; and 3) "What was his/her birth weight in kilograms and grams or pounds and ounces?"

The proportions of high birth weight infants by maternal, family and child characteristics and by geographic region are presented in Table 1. The children belong to one of five areas of residence categories: the Atlantic provinces (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador), Quebec, Ontario, the Prairie provinces (Manitoba, Saskatchewan, Alberta) and British Columbia. Territories (Yukon Territory, Northwest Territories and Nunavut) were not included in the analyses.

Factors analyzed in relation to high birth weight for children in the sample included sex and birth rank of the child; maternal age and education; maternal smoking during pregnancy; family type; family SES; and maternal health (postpartum depression; during pregnancy, hypertension and consumption of prescription drugs). These characteristics were selected in accordance with previous associations with high birth weight from the literature.

The SES measure was based on Willms and Shields' indicator.⁴³ It is a complex measure derived from a composite score of family income, parents' level of education and the occupational prestige scale of the parents.

Maternal hypertension during pregnancy was documented through a "yes/no" response to the following question from the NLSCY: "During the pregnancy with ___, did you suffer from: ... high blood pressure?" Likewise, information about maternal prescription drug usage during pregnancy and maternal depression was obtained through "yes/no" responses to the questions "Did you take any prescription medications during pregnancy with ___?" and "After ___'s delivery, did

you/her/his mother suffer from: ... postpartum depression?"

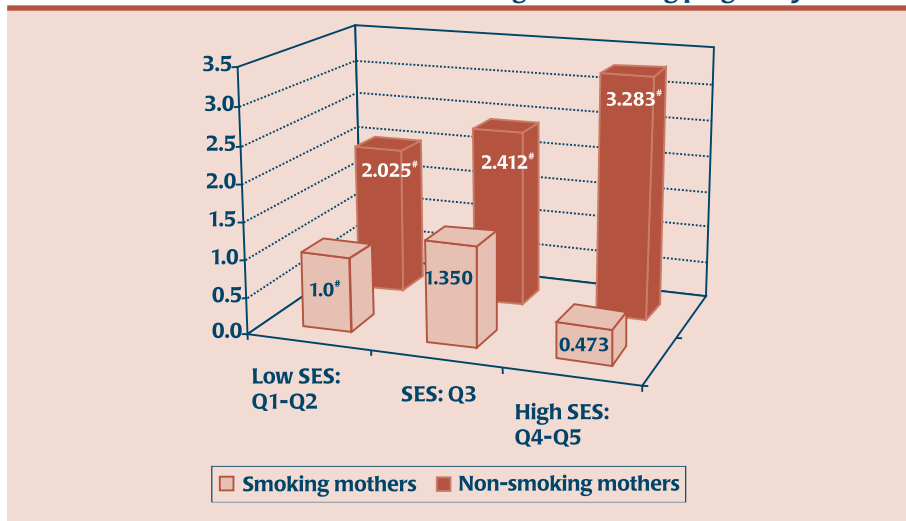
Statistical analyses were performed on weighted data using SAS (version 8.2). Data from each cycle was regrouped. Cross-sectional weights for each dataset were used. This procedure may have resulted in an underestimation of the variances. Consequently, the statistical significance level was established at 0.01. All variables were treated as categorical variables. Preliminary associations between the independent variables and birth weight were verified through a chi-square test on contingency tables. Independent variables found to be significantly associated with birth weight were included in multivariate analyses. Adjustments for potential confounders and odds ratios (OR) estimates, as well as their confidence intervals, were made with logistic regressions. The logistic regression was first assessed without any interactions; then all possible interactions between the studied independent variables were further examined by province and for Canada as a whole.

Results

Univariate analysis (Table 1) pointed to various factors associated with high birth weight in Canada. Provincial differences were observed. The prevalence of high birth weight was highest in British Columbia and lowest in Quebec. Boys, second- or later-born children, children born to older, more educated and non-smoking mothers, children from two-parent families or those from higher SES families were more likely to have a high birth weight. Maternal health was also related to high birth weight (e.g., not suffering from postpartum depression; during pregnancy, not having hypertension nor taking prescription drugs).

When analyzing these variables by Canadian region, each of the variables examined in the present study were found to associate with high birth weight in the provinces of Quebec and Ontario. In Quebec, the prevalence of high birth weight was higher for mothers aged 30 to

FIGURE 1
Adjusted^a odds ratios^b of high birth weight (> 4000 g) of infants born in Quebec, by socioeconomic status strata (SES - in quintiles), for the interaction observed between SES and maternal smoking status during pregnancy



^a Adjusted for gestational age, birth rank and sex of baby, mother's age group and maternal health.

^b Reference group for the dependant variable is 3000-4000 g.

* Reference group for the characteristic.

* $p \leq 0.0001$

Source: National Longitudinal Survey of Children and Youth, Cycles 1-4, 1994-2001.

34 years and lower for mothers comparatively older or younger. In Ontario, a greater proportion of mothers with, during pregnancy, neither hypertension nor prescription drug use delivered high-birth-weight infants. In the Atlantic provinces, three variables (sex of baby, maternal non-smoking status during pregnancy and two-parent family) were associated with high-birth-weight deliveries. In the Prairie provinces, sex and birth rank of baby, maternal non-smoking during pregnancy and maternal non-hypertension were all related to high birth weight. In British Columbia, sex and birth rank of baby, mothers' education, maternal non-smoking during pregnancy and family SES, as well as maternal hypertension during pregnancy, were related to high birth weight. These results indicate that not all the factors associated with birth weight inequalities in some provinces feature in the results from the Atlantic and Prairie provinces.

A multivariate analysis was performed, taking all these factors into simultaneous consideration (Table 2). Thus, in Canada,

the odds of giving birth to a high-birth-weight child were 25% higher in Ontario, 41% higher in the Atlantic provinces and 53% higher in British Columbia, when compared to Quebec. Within Quebec, being born into the highest socioeconomic quintiles increased the odds of having a high birth weight by 51%, in comparison to children born there into the lowest SES quintiles. In British Columbia, however, being born in the middle SES quintile lowered the odds by 45%. In these two provinces, maternal health remained related to high birth weight, and a non-smoking status during pregnancy was not related to high birth weight in British Columbia when all other factors were taken into simultaneous consideration.

The interaction between family SES and maternal smoking during pregnancy was examined for the provinces of Quebec (Figure 1) and British Columbia (Figure 2), taking into consideration all other variables in the multivariate model. In Quebec, in comparison to children born to smoking mothers from the lowest SES quintiles, the odds of a high birth weight

TABLE 1
Proportion of infants weighing over 4000 g^a at birth in Canada, by maternal, family and infant characteristics, and by region of residence

Characteristic	Categories	%	Canada	Atlantic provinces	Quebec	Ontario	Prairie provinces	British Columbia
Region of residence	Atlantic provinces	7.3	15.2***	15.2	—	—	—	—
	Quebec	23.1	10.6	—	10.6	—	—	—
	Ontario	38.8	13.6	—	—	13.6	—	—
	Prairie provinces	18.4	12.4	—	—	—	12.4	—
	British Columbia	12.4	17.4	—	—	—	—	17.4
Sex of infant	Male	51.4	16.7***	18.4***	13.0***	17.1***	16.7***	21.7***
	Female	46.6	9.6	11.8	7.9	9.9	8.0	12.9
Birth rank of infant	First	40.7	10.4***	13.2	9.0*	9.7***	10.1***	13.7***
	Second	38.8	15.3	16.9	11.5	16.4	14.5	18.6
	Third or later	20.5	16.1	17.8	11.3	16.7	14.7	25.1
Age group of mother (years)	< 25	19.6	11.3***	11.6	9.8***	11.1***	12.0	13.4
	25 - 29	32.8	13.3	15.7	9.9	14.2	12.2	18.3
	30 - 34	32.8	14.3	17.5	13.3	13.9	13.0	17.4
	≥ 35	15.3	13.6	15.8	7.5	14.3	12.5	20.0
Mother's highest educational level	No high school dipl.	14.2	10.4***	12.4	8.1***	9.2***	11.9	16.8**
	High school dipl.	38.3	13.4	13.9	9.9	13.2	13.7	18.9
	College	27.6	14.5	17.4	12.1	15.8	12.1	16.9
	University	19.5	13.6	17.0	11.9	14.3	11.4	15.5
Maternal smoking during pregnancy	Non-smoker	79.2	15.2***	18.1***	11.7***	15.5***	14.2***	19.6***
	Smoker	20.8	6.7	7.6	5.6	5.9	7.8	9.5
Family type	Two parent	88.4	13.5***	15.9***	10.8***	13.8***	12.7	17.6
	Single parent	11.6	11.3	11.1	8.4	12.1	9.7	15.6
Family socioeconomic status	Quintile 1	21.2	11.2***	12.6	8.6***	11.0***	10.7	17.9***
	Quintile 2	19.8	11.5	14.5	8.1	11.0	13.3	15.4
	Quintile 3	19.5	13.5	15.7	11.5	13.4	13.5	15.8
	Quintile 4	19.7	14.2	17.8	11.5	14.9	11.4	17.5
	Quintile 5	19.7	15.4	17.1	13.7	15.8	14.6	17.6
Maternal postpartum depression	No	90.6	13.4***	15.4	10.7*	14.1***	12.3	17.3
	Yes	9.4	10.9	11.7	9.0	8.6	13.3	15.5
Maternal hypertension during pregnancy	No	90.0	13.3***	15.4	9.9***	13.9***	12.8**	17.4***
	Yes	10.0	14.7	15.7	14.1	13.0	12.2	23.8
Maternal use of prescription drugs during pregnancy	No	73.4	13.2***	15.2	9.2***	14.1***	12.5	17.3
	Yes	26.6	14.0	15.9	12.7	12.9	13.4	20.8
Mean		—	13.26	15.2	10.6	13.6	12.4	17.4

^aAdjusted for gestational age

Chi-square test of association between the characteristic and the dependant variable: * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

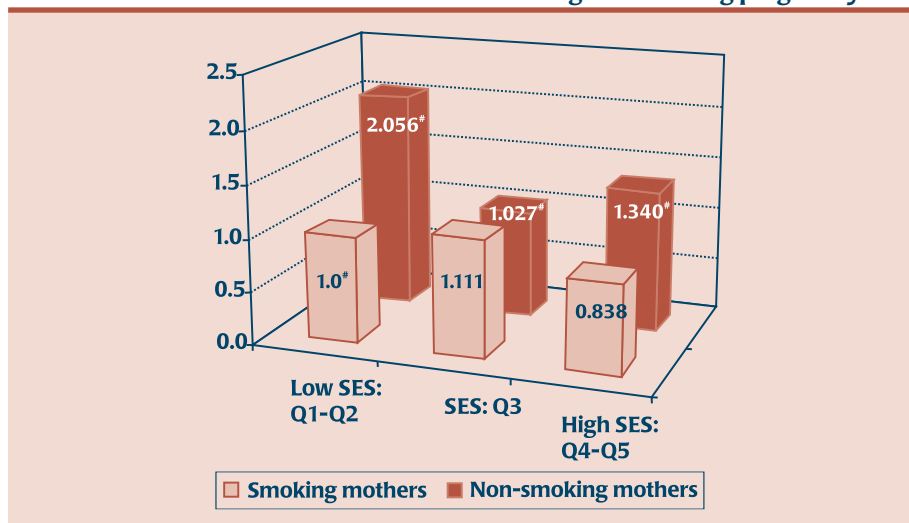
Source: National Longitudinal Survey of Children and Youth, Cycles 1-4, 1994-2001.

increased with higher SES quintiles for children born to non-smoking mothers. While in British Columbia, the odds of a high birth weight doubled for children of

non-smoking mothers from the lowest SES, but high birth weight was not associated with the middle (3) nor higher (4-5) SES quintiles. In other Canadian provinces,

there was no significant interaction between high birth weight and maternal smoking during pregnancy (data not shown).

FIGURE 2
Adjusted^a odds of high birth weight (> 4000 g) of infants born in British Columbia, by socioeconomic status strata (SES - in quintiles), for the interaction observed between SES and maternal smoking status during pregnancy



Discussion

In a developed country such as Canada, where the standard of living is high and antenatal care is freely available to all pregnant women, what are the main determinants of high birth weight? The analyses indicate that high birth weight varies geographically, even when maternal, family and child characteristics are taken into consideration. British Columbia was

^a Adjusted for gestational age, birth rank and sex of baby, mother's age group and maternal health.

^b Reference group for the dependant variable is 3000-4000 g.

[#] Reference group for the characteristic.

* $p \leq 0.0001$

Source: National Longitudinal Survey of Children and Youth, Cycles 1-4, 1994-2001.

TABLE 2
Adjusted^a odds ratio^{b,c} for high birth weight (> 4000 g) of infants born in Canada, by region of residence

Description	Category	Canada	Atlantic provinces	Quebec	Ontario	Prairie provinces	British Columbia
Region of residence	Atlantic provinces	1.411 (1.053-1.891)					
	Quebec	1					
	Ontario	1.250 (1.025-1.524)					
	Prairie provinces	1.132 (0.898-1.428)					
	British Columbia	1.526 (1.195-1.950)					
Sex of infant	Male	1.947 (1.684-2.251)	1.829 (1.118-2.992)	1.810 (1.289-2.542)	1.897 (1.505-2.390)	2.343 (1.666-3.324)	1.929 (1.313-2.883)
	Female [#]	1	1	1	1	1	1
Birth rank of infant	First*	1	1	1	1	1	1
	Second	1.620 (1.370-1.914)	1.368 (0.772-2.424)	1.580 (1.071-2.331)	1.773 (1.359-2.313)	1.607 (1.072-2.408)	1.424 (0.921-2.200)
	Third or later	1.801 (1.473-2.202)	1.701 (0.859-3.369)	1.603 (1.001-2.580)	1.924 (1.390-2.663)	1.633 (1.029-2.591)	2.172 (1.265-3.729)
Maternal smoking during pregnancy	Non-smoker	2.332 (1.859-2.926)	2.977 (1.421-6.236)	2.311 (1.394-3.832)	2.582 (1.735-3.843)	2.027 (1.251-3.286)	1.705 (0.931-3.125)
	Smoker [#]	1	1	1	1	1	1
Family socio-economic status	Q1 + Q2 [#]	1	1	1	1	1	1
	Q3	0.913 (0.746-1.118)	0.900 (0.445-1.824)	1.187 (0.747-1.886)	0.886 (0.629-1.249)	1.079 (0.692-1.684)	0.551 (0.327-0.929)
	Q4 + Q5	1.026 (0.860-1.224)	0.926 (0.508-1.685)	1.507 (1.002-2.265)	1.079 (0.815-1.429)	0.896 (0.581-1.382)	0.677 (0.420-1.091)
Maternal postpartum depression	No	1.152 (0.888-1.495)	1.207 (0.519-2.811)	1.022 (0.529-1.976)	1.203 (0.780-1.857)	0.880 (0.511-1.516)	1.748 (0.877-3.482)
	Yes [#]	1	1	1	1	1	1
Maternal hypertension during pregnancy	No [#]	1	1	1	1	1	1
	Yes	1.469 (1.166-1.851)	1.223 (0.618-2.419)	1.722 (0.944-3.143)	1.399 (0.954-2.051)	1.087 (0.616-1.918)	2.204 (1.244-3.907)
Maternal use of prescription drugs during pregnancy	No [#]	1	1	1	1	1	1
	Yes	1.180 (1.006-1.383)	1.192 (0.711-1.998)	1.571 (1.102-2.241)	0.950 (0.732-1.232)	1.122 (0.774-1.626)	1.742 (1.118-2.713)

^aAdjusted for gestational age, mother's age and all other factors in the model

^bOdds ratios are presented with their 99% confidence intervals ()

^cReference group for the dependant variable is 3000-4000 g

[#]Reference group for the characteristic

Source: National Longitudinal Survey of Children and Youth, Cycles 1-4, 1994-2001.

observed to have the highest level of high birth weight, whereas Quebec had the lowest. This finding is interesting as, although high birth weight is associated with parental obesity,³ in Canada, Quebec and British Columbia are among the provinces with the lowest prevalence of adult obesity.⁴⁴ High birth weight did not follow this same pattern across geographic areas.

Overall, the odds of high birth weight were found to be higher for non-smoking women than for women who reported smoking during pregnancy, as smoking restricts growth *in utero*. This association is consistent with prior research findings in this area.^{1,5,24,26,30} Furthermore, the results indicate that in smoking women, high birth weight does not vary by socioeconomic status; this is true for both Canada as a whole and for each region considered independently.

Consistent with Nordstrom and Cnattingius's³⁹ findings, socioeconomic differences were no longer found to play a significant role as determinants of high birth weight in the Atlantic and Prairie provinces when all factors were taken into consideration at the multivariate level. However, in Quebec and British Columbia, social disparities did exert an influence on the prevalence of high birth weight in *non-smoking* women. For non-smoking women in Quebec, socioeconomic status was positively associated with increased odds of delivering a high-birth-weight infant, where the odds of this increased for women of higher socioeconomic status. By contrast, the influence of socioeconomic status was negative for non-smoking mothers of British Columbia, where the odds of delivering a high-birth-weight infant were greater for women of low socioeconomic status. This finding emphasizes the need for future studies and a greater understanding of these self-reported data in their relation to high birth weight. Additionally, given this observation, the findings suggest a need to develop health interventions that are region specific in their efforts to prevent macrosomic births, addressing the key determinants particular to each region. For

example, interventions to prevent high-birth-weight deliveries in non-smoking mothers should target those of low socioeconomic status in British Columbia and mothers of high socioeconomic status in Quebec.

Another interesting finding of the present study is the positive association between maternal hypertension and the increased odds of having a high-birth-weight infant. Boulet et al.¹ also report this association. However, a large body of literature also demonstrates an association between maternal hypertension and increased risks of small-for-gestational-age (SGA) infants, especially emphasized for particular ethnic groups.⁴⁵⁻⁴⁶ In their studies from northern and central Alberta (Canada) and a study from China, Xiong et al. support this U-shaped association between maternal hypertension and increased risks of both low birth weight-SGA infants and high birth weight-LGA infants.⁴⁷⁻⁴⁹ They further demonstrate that the effect of gestational hypertension varies by gestational age: Gestational hypertension associates with decreased birth weight in pre-term infants. Yet in babies born at term, gestational hypertension does not significantly associate with birth weight.⁴⁸ Given our analyses' adjustments for gestational age and other determinants of high birth weight, the finding that hypertension was only associated with high birth weight in British Columbia at the multivariate level emphasizes the need for further studies to investigate other potential moderators of this association within geographic regions.

The authors acknowledge the limitations of this study, specifically its inability to explain the mechanisms underlying these regional variations in the determinants of high birth weight. Other determinants not available in the present study may merit consideration in future analyses. For example, research has shown that characteristics such as maternal height, weight, BMI, ethnicity, gestational diabetes and pregnancy weight gain also relate to high birth weight.^{5,20,24,26,30,35,37,50} Certain studies also reveal that some ethnic groups have higher rates of infants born with high birth

weights, despite lower SES.^{35,51} Maternal diet may also warrant further consideration in future analyses of geographical variations in macrosomia. For example, maternal fish intake during pregnancy has been found to associate with an increased rate of fetal growth and birth weight.⁵²⁻⁵³ Future studies may consider monitoring whether the geographic variances in the influence of SES on high birth weight persist with the inclusion of these additional factors.

As a potential limitation, a mention must be made regarding the possibility of recall error in the indicator used to assess infant birth weight, though there is no reason to suspect *a priori* any geographic differences in distribution in this regard.

No other population-based studies to our knowledge have examined nationwide variances in the determinants of high birth weight by geographic region. Although the prevalence of high birth weight must be addressed nationwide, findings of the present study emphasize that certain geographic regions in Canada require special attention for their higher prevalence of high-birth-weight babies.

From a theoretical perspective, the results of the present study emphasize the need to re-examine possible causal pathways driving the differences in associations of high birth weight between geographic regions, taking into consideration individual, social and environmental variables. Practical implications would be to ensure that health practitioners remain aware of possible regional variances in groups most at risk for delivering high-birth-weight infants. Naïvely implementing a nationwide health promotion strategy, rather than a strategy specific to each region, may unintentionally neglect true high-risk populations particular to each region, thereby decreasing the effectiveness of health promotion efforts.

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