A Population-level Analysis of Birth Weight Indices in Peel Region, Ontario: The Impact of Ethnic Diversity

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ABSTRACT

Objectives: The purpose of this paper is to examine whether the elevated rate of low birth weight (LBW) in the Region of Peel, Ontario can be attributed to the high proportion of immigrants in the population. In addition, we examined how the infant birth weight distribution in Peel differs by maternal region of birth.

Methods: Provincial live birth registration data were used to compare rates of LBW, preterm birth and small-for-gestational-age (SGA) births in Peel and Ontario for the years 2002 through 2006 by maternal region of birth. Birth weight for gestational age curves were developed for singletons and were specific for infant sex and maternal region of birth using the lambda-mu-sigma (LMS) method. Quantile regression was used to examine whether the median birth weight at term (37 to 42 weeks) differed by maternal region of birth.

Results: The rate of LBW was higher in Peel than in Ontario (6.8% and 6.0%, respectively). This is the result of a higher SGA rate and not due to differences in rates of preterm birth. Infants of immigrant mothers had significantly lower median birth weights at all gestations, showing that the birth weight distribution among infants of immigrant mothers is shifted towards lower birth weights.

Conclusion: At the population level, the shifted birth weight distribution among singleton infants of immigrant mothers has significant impact on the LBW rate observed in Peel.

Key words: Birth weight; ethnic groups; infant, newborn; small for gestational age; infant, low birth weight

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The rate of low birth weight (LBW), defined as a birth weight of less than 2500 grams, is a common measure of a population's reproductive health. The two components of LBW are: preterm birth and intrauterine growth restriction (IUGR). Infants born at a birth weight below the sex-specific 10th percentile for their gestational age are termed small-for-gestational-age (SGA) and may have experienced IUGR. The risk factors associated with preterm birth and being SGA are different¹ and therefore each component must be examined separately to understand the causes of LBW in a population.

The ethnic origin and immigrant status of mothers impacts rates of preterm birth and SGA.²⁻⁷ At a population level, Caribbean women in England and Wales had a higher singleton preterm birth rate compared to white British women (9.7% vs. 6.1%).³ Infants of South Asian or East Asian mothers have lower birth weights than those of Canadian-born mothers and consequently have higher rates of SGA.^{2,5} These studies do not address whether these differences are attributable to ethnic-specific risk for certain conditions during pregnancy (e.g., pre-eclampsia), natural differences in stature and body composition, or other reasons.

The Regional Municipality of Peel, Ontario (which includes the municipalities of Caledon, Brampton and Mississauga) has an elevated rate of LBW compared to that of Ontario (6.8% vs. 6.0%), prompting concern among public health practitioners. The population of Peel is ethnically diverse, with almost half of residents being immigrants to Canada. The purpose of this paper is to exam-

ine whether the elevated rate of LBW in the Region of Peel, Ontario can be attributed to the high proportion of immigrants in the population. In addition, we examined how the infant birth weight distribution in Peel differs by maternal region of birth.

METHODS

Provincial birth registration data were used to examine LBW, preterm birth and SGA rates. Data were obtained for the five-year period of 2002 through 2006, which were the most recent years of data for which maternal region of birth was available. Infants born to mothers who reside in Peel were compared to all infants in the province. Preterm birth is defined as a gestational age less than 37 completed weeks. Singleton infants were defined as SGA if they had a birth weight below the sex-specific 10th percentile according to the Canadian standard developed by Kramer and colleagues in 2001 (valid for gestational ages between 22 and 43 weeks only).⁸ Multiple births were excluded from the SGA analysis.

Provincial birth registration records do not capture information regarding the ethnic origin of an infant. Therefore, the self-reported

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country of birth of the mother was used as a proxy measure for her ethnic origin. The country of birth was categorized into geographical regions based on categories utilized by Statistics Canada.⁹ The categories examined in this study were: Canada, South Asia, East Asia (includes both Eastern and Southeast Asian countries), Caribbean, African (excludes Northern Africa), other countries and unknown. Data regarding the mother's country of birth was missing for 0.1% of records, and therefore these records were excluded from the analysis. Mothers born in Canada were defined as "non-immigrants", whereas mothers born outside of Canada were defined as "immigrants". Although data are available regarding the country of birth for both parents, the maternal region of birth was selected for analysis as the data regarding the maternal and paternal country of birth were found to be highly correlated (80.5% agreement, kappa = 0.67).

LBW, preterm birth and SGA rates for infants in Peel and all of Ontario were calculated and compared using SPSS Version 19.0 (IBM Company Inc, USA) and EpiInfo 6.04d (Centers for Disease Control and Prevention, Atlanta, GA). All p-values were two-sided, and significance was set at a value of 0.05.

To examine whether the differences in rates observed were the result of a shift in the underlying birth weight distribution of infants of immigrant mothers, birth weight for gestational age curves which were specific for infant sex and maternal region of birth were developed. These curves were developed for all singleton births in Peel from 2002 to 2006 using lmsChartMaker Light (Medical Research Council, UK). Weight percentile curves were derived using the lambda-mu-sigma (LMS) method.¹⁰ The L (skewness), M (median) and S (dispersion) parameters were estimated, smoothed using the penalized likelihood method, and fitted as cubic splines by nonlinear regression. The penalized likelihood, with the roughness penalties incorporated with the likelihood, makes the smoothing of the three curves become an integral part of the likelihood maximization. Maximizing the penalized likelihood strikes a balance between fidelity to the data and smoothness of the L, M and S curves. Data for 50th percentile (median) among male and female infants are presented here. Data corresponding to other percentile values can be obtained from the authors, upon request. Using the smoothed curve data, we conducted quantile regression to examine whether the percentiles of birth weight among term infants (gestational age between 37 and 42 weeks) differed by the region of birth of the mother. Quantile regression models the relation between a set of predictor variables and specific percentiles (or quantiles) of the response variable. It specifies changes in the quantiles of the response. For example, a median regression of infant birth weight on mothers' characteristics (e.g., region of birth) specifies the changes in the median birth weight as a function of the predictors.

RESULTS

Table 1 shows the maternal and infant characteristics of the live births in Peel (N=74,836) and Ontario (N=659,802) for the time period 2002 through 2006. Live births in Peel accounted for slightly more than 10% of all live births in the province in each year. The average age of mothers was similar between Peel (30.2 years) and Ontario (29.9 years). In Peel, 38% of mothers were born in Canada (non-immigrants), in comparison to 64% of all Ontario mothers who were born in Canada. Among mothers in Peel,

Table 1. Maternal and Infant Characteristics

	Peel		Ontario	
	n	% of Live Births 2002-2006	n	% of Live Births 2002-2006
Year of birth				
2002	13,488	18.0	128,202	19.4
2003	14,438	19.3	130,603	19.8
2004	15,190	20.3	132,221	20.0
2005	15,738	21.0	133,485	20.2
2006	15,982	21.4	135,291	20.5
2002-2006	74,836	100.0	659,802	100.0
Maternal age (years)				
Mean	30.2		29.9	
Median	30.0		30.0	
Range	12-52		12-55	
Type of birth				
Singleton	72,419	96.8	638,758	96.8
Multiple	2,417	3.2	21,044	3.2
Maternal region of birth				
Canada	28,495	38.1	420,529	63.7
South Asia	19,661	26.3	56,223	8.5
East Asia	6,838	9.1	51,216	7.8
Caribbean	3,988	5.3	16,636	2.5
Africa	2,122	2.8	16,713	2.5
Other	13,663	18.3	97,749	14.8
Low birth weight	5,126	6.8	39,791	6.0
Preterm birth	5,608	7.5	49,442	7.5
SGA*	7,826	10.8	55,703	8.7

* SGA rate calculated for singleton births between 22 and 43 weeks gestation only.

26% were born in South Asia (42% of all mothers born outside of Canada).

The LBW rate in Peel was significantly higher than that in Ontario (6.8% vs. 6.0%, $p < 0.001$). There was no difference in the preterm birth rate comparing Peel to Ontario, whereas the SGA rate in Peel was significantly higher than that in Ontario (10.8% vs. 8.7%, $p < 0.001$) (Table 1).

South Asian, Caribbean and African mothers had significantly higher rates of LBW than Canadian-born mothers (Table 2). Caribbean mothers had the highest rate of preterm births (10.7%). South Asian and East Asian mothers had significantly lower preterm birth rates compared to Canadian-born mothers. Immigrant mothers had higher SGA rates than non-immigrant mothers, regardless of where they were born, with South Asian mothers having the highest rate.

Table 3 includes the birth weight values associated with the 50th percentile (median) for male and female Peel infants at each gestational age (between 31 to 42 weeks) for each maternal region of birth. Infants born to immigrant mothers had lower median birth weights than those born to non-immigrant mothers across most gestational ages. At the earliest gestational ages (before 34 weeks), this pattern is not consistent among infants of East Asian-born and Caribbean-born mothers. However, this may be due to the small number of infants in these categories leading to variability in the median values or to fetal fat accumulation during the last weeks of pregnancy.

Infants of all immigrant mothers born at term have lower median birth weight compared to infants of non-immigrant mothers (Table 4). The largest difference in birth weight at term was observed between infants born to South Asian-born and those born to Canadian-born mothers. For example, infants of South Asian-born mothers had a significantly lower median birth weight at term compared to infants of Canadian-born mothers (220-gram difference among male infants and 189-gram difference among female infants).

Table 2. Birth Outcomes by Maternal Region of Birth, Peel Region, 2002-2006

Maternal Region of Birth	Low Birth Weight		Preterm Birth		Small-for-gestational-age	
	n	%	n	%	n	%
Canada	1790	6.3	2256	7.9	2128	7.8
South Asia	1594	8.1†	1385	7.0†	2972	15.5†
East Asia	385	5.6‡	450	6.6†	761	11.3†
Caribbean	388	9.7†	425	10.7†	516	13.4†
Africa	168	7.9†	179	8.4	232	11.3†
Other	789	5.8‡	898	6.6†	1208	9.1†
Total	5126	6.8	5608	7.5	7826	10.8

* SGA rate calculated for singleton births between 22 and 43 weeks gestation only.

† Difference in proportions significant at p<0.01 level (compared to Canada reference).

‡ Difference in proportions significant at p<0.05 level (compared to Canada reference).

Table 3. Birth Weight at the 50th Percentile by Sex, Gestational Age and Maternal Region of Birth

Infant Sex	Gestational Age (weeks)	Maternal Region of Birth					
		Canada (grams)	South Asia (grams)	East Asia (grams)	Caribbean (grams)	Africa (grams)	Other (grams)
Female	31	1495.3	1489.8	1667.2	1551.8	1767.8	1554.9
	32	1766.1	1718.5	1841.7	1755.4	1891.9	1795.8
	33	2035.3	1945.7	2032.5	1968.7	2024.5	2037.0
	34	2298.5	2177.1	2240.1	2205.9	2199.3	2278.8
	35	2553.5	2415.2	2459.6	2463.0	2428.9	2523.6
	36	2797.6	2651.0	2688.1	2720.2	2714.5	2763.7
	37	3022.9	2873.9	2917.4	2944.1	2993.5	2988.5
	38	3219.9	3059.8	3120.6	3118.1	3187.6	3181.1
	39	3382.2	3209.3	3256.2	3262.5	3314.4	3325.0
	40	3515.3	3334.1	3382.2	3395.4	3403.2	3466.9
	41	3632.0	3426.3	3500.3	3501.1	3484.1	3602.3
	42	3743.0	3511.1	3604.2	3598.8	3572.6	3729.5
Male	31	1697.2	1520.7	1582.3	1580.3	1468.3	1576.2
	32	1937.5	1758.3	1814.4	1800.8	1742.4	1818.4
	33	2174.4	1997.3	2049.3	2017.1	2021.3	2062.9
	34	2406.9	2234.3	2290.4	2244.4	2296.4	2316.2
	35	2644.5	2471.0	2540.8	2487.1	2561.8	2580.5
	36	2894.2	2713.2	2792.7	2742.4	2809.0	2844.8
	37	3143.8	2956.3	3026.3	2994.5	3039.7	3094.6
	38	3358.7	3171.6	3221.9	3201.2	3237.8	3303.0
	39	3520.1	3328.8	3364.4	3369.3	3390.6	3469.3
	40	3660.9	3455.6	3481.3	3498.5	3535.8	3617.2
	41	3783.5	3580.1	3602.5	3620.1	3677.7	3732.9
	42	3899.7	3703.0	3720.9	3735.4	3811.9	3832.5

Table 4. Median Birth Weight for Male and Female Term* Infants by Maternal Region of Birth

Maternal Region of Birth	Males		Females	
	50 th Percentile Birth Weight (grams)	Difference at 50 th Percentile (95% CI)	50 th Percentile Birth Weight (grams)	Difference at 50 th Percentile (95% CI)
Canada	3555	Reference	3415	Reference
South Asia	3335	-220g† (-241g, -199g)	3226	-189g† (-207g, -171g)
East Asia	3345	-210g† (-230g, -190g)	3260	-155g† (-175g, -135g)
Caribbean	3373	-182g† (-206g, -158g)	3271	-143g† (-171g, -116g)
Africa	3430	-125g† (-165g, -85g)	3316	-99g† (-135g, -61g)
Other	3514	-41g † (-59g, -23g)	3370	-45g† (-63g, -27g)

* Term infants are between 37 and 42 completed weeks of gestation at birth.

† Difference significant at p<0.001 level.

DISCUSSION

Our findings use population data to show that the elevated rate of LBW in Peel is a result of higher rates of SGA and not due to differences in rates of preterm birth. Moreover, infants born to immigrant mothers have lower birth weight at all gestations and consequently higher SGA rates than infants born to non-immigrant mothers. The median birth weight for infants of immigrant mothers was lower than that for infants of non-immigrant mothers, showing that the underlying birth weight distribution for infants of immigrant mothers is shifted towards lower values compared to that for infants of Canadian-born mothers. The high proportion of immigrants of childbearing age in Peel and the shifted birth weight distribution results in the elevated LBW rate observed for Peel.

Compared to the province of Ontario, Peel's population has a high proportion of immigrants, which is reflected among the

cohort of infants born each year. The majority of births in Peel occur to immigrant mothers, with a large proportion occurring among immigrant mothers from South Asia, East Asia and the Caribbean. As evidenced here, for geographic areas with a high proportion of immigrants, the difference in birth weight distribution will have an important impact on common reproductive health measures such as LBW and SGA rates.

Given that newborns of immigrant mothers have a lighter birth weight distribution across all gestational ages, using the Canadian fetal growth standard developed by Kramer and colleagues (2001) to assess the appropriateness of the birth weight of an infant born to an immigrant mother will potentially result in misclassification. Ray and colleagues reported that 111 per 1,000 male and 88 per 1,000 female newborns of South Asian origin may be misclassified as SGA using the Canadian standard compared to the ethnic-

specific standard derived based on hospital data.⁵ Misclassifying infants of immigrant mothers as small-for-gestational-age when they may have an appropriate birth weight for their gestational age and ethnicity may lead to unnecessary additional health care costs and parental stress. Ethnic-specific fetal growth standards developed using population birth data from British Columbia were shown to be more congruent with observed perinatal mortality than the single growth standard (i.e., not ethnic-specific), leading the authors to conclude that the differences in birth weight by ethnic group represent a physiologic rather than a pathologic process.²

At term, infants of immigrant mothers had lower median birth weight values compared to infants of non-immigrant mothers. At a population level, these observed differences are significant and it follows that a higher proportion of infants born to immigrant mothers would be expected to fall below 2500 grams and, therefore, meet the criteria for LBW, as seen in Peel.

This paper does not provide guidance regarding the clinical assessment of individual infants, but rather provides a description of trends in birth weight indices at the population level in Peel. Clinical decisions and follow-up regarding LBW infants must be determined by health care providers based on factors relevant to each individual infant.

There are limitations to the analysis presented in this paper that may have an impact on the applicability of the results. It was not possible to analyze ethnic origin of the infant's mother and therefore the country of birth of the mother was used as a proxy. The regions included for analysis are geographically large and diverse and therefore will include mothers with a range of cultural and ethnic backgrounds (including the Canadian-born mothers).¹¹ Data from the 2007/2008 Canadian Community Health Survey show that 10% of non-immigrants in Peel self-identified as South Asian and 3% as East or Southeast Asian. The inclusion of mothers of South and East Asian ethnic origins in the non-immigrant category would lower the birth weight distribution observed in this category. Therefore our findings may be considered as a conservative estimate of difference in birth weight distributions between ethnicities.

Due to the limited number of variables available within the provincial birth registration dataset, we were unable to adjust for known risk factors for fetal growth restriction or preterm birth (e.g., smoking during pregnancy, diabetes and hypertension, the length of time since arrival in Canada, mental health issues, inadequate prenatal care) which may have an important impact on perinatal outcomes.^{6,7,12} Census data show that Peel has a young, highly educated population with a median income similar to the rest of the province of Ontario. Five percent of Peel mothers in 2008 reported smoking during pregnancy. The prevalence of diabetes and hypertension among Ontario mothers was 6% and 5% in 2006/2007, respectively.¹³ It is difficult to know how much of an effect these unmeasured confounders might have on our findings because recent immigrants tend to have fewer risk factors than non-immigrants or long-term immigrants.

Last, there are a number of widely recognized data quality issues with the Ontario birth registration data, including under-registration of births, missing birth registration data for infants who have died, and inaccurate gestational age recorded for births between 1991 and 1998.^{8,14-17} Birth registration data are collected both from parents/guardians and the health care provider present at the birth.

Parent-reported data are subject to recall bias and may not align with data reported by the health care provider. For the time period examined in this paper, information about the infant was obtained from the data provided by the health care provider (e.g., gestational age). The mother's country of birth is collected from the parent-report data and cannot be verified. In addition, examination of the 2006 data revealed that the birth weight values unnaturally cluster at values that correspond to a converted number of even pounds and ounces. Although this conversion leads to imprecision of birth weight, there is no reason to believe that the direction of the error would lead to significant bias.

The observed difference in LBW rates between Peel and Ontario can be explained by the higher proportion of infants born to immigrant mothers in Peel. Rates of preterm birth were similar between Peel and Ontario, whereas the SGA rate was significantly higher in Peel and highest among infants born to immigrant mothers. This higher SGA rate reflects the shift towards lower birth weights across gestation among infants of immigrant mothers. Further analysis may be able to determine whether the lower birth weight among infants of immigrant mothers leads to higher rates of mortality or morbidity compared to infants of non-immigrant mothers.

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RÉSUMÉ

Objectifs : Déterminer si le taux élevé d'insuffisance de poids à la naissance (IPN) dans la région de Peel, en Ontario, peut être attribué à la forte proportion d'immigrants dans la population. En outre, nous avons voulu déterminer en quoi la distribution du poids de naissance des nourrissons à Peel diffère selon la région de naissance de la mère.

Méthode : Les données provinciales d'enregistrement des naissances vivantes ont servi à comparer les taux d'IPN, de naissance avant terme et de naissance de nourrissons petits pour l'âge de gestation (PAG) à Peel et dans l'ensemble de l'Ontario pour les années 2002 à 2006 selon la région de naissance de la mère. Des courbes de poids de naissance selon l'âge gestationnel ont été dessinées pour les accouchements simples, et précisées selon le sexe du nourrisson et la région de naissance de la mère grâce à la méthode Lambda-Mu-Sigma (LMS). Au moyen d'une régression par quantile, nous avons déterminé si le poids de naissance moyen à terme (37 à 42 semaines) différait selon la région de naissance de la mère.

Résultats : Le taux d'IPN de Peel était supérieur à celui de l'Ontario (6,8 % et 6,0 %, respectivement). Cela s'explique par le taux plus élevé de PAG et non par des écarts dans les taux de naissance avant terme. Les nourrissons de mères immigrantes avaient un poids de naissance moyen significativement plus faible à tous les âges de gestation, ce qui montre que la distribution des poids de naissance des nourrissons de mères immigrantes tend vers un poids de naissance inférieur.

Conclusion : À l'échelle de la population, la distribution déplacée des poids de naissance chez les nourrissons de mères immigrantes (accouchements simples seulement) a un impact significatif sur le taux d'IPN observé à Peel.

Mots clés : poids de naissance; groupes ethniques; nourrisson, nouveau-né; nourrisson petit pour âge gestation; nourrisson à faible poids naissance