Multiple Maternities and Neighborhood Income

Marcelo Luis Urquia,[1] John William Frank,[2] Richard Henry Glazier,[3] and Rahim Moineddin[4]

[1] *Centre for Research in Inner City Health, St. Michael's Hospital, Toronto, Canada*

[2] *Canadian Institutes of Health Research, Institute of Population and Public Health, University of Toronto, Toronto, Canada*

[3] *Institute for Clinical Evaluative Sciences, Toronto, Canada*

[4] *Department of Family and Community Medicine, University of Toronto, Toronto, Canada*

This study aimed to examine differences in multiple maternities by neighborhood-income levels in Toronto, Canada. Hospital records were used to perform secondary analysis of 144,731 maternities resulting in single or multiple infants live-born to mothers residing in the City of Toronto 1996 to 2001. The independent variable was neighborhood income, defined as mean household neighborhood-income quintiles. Multiple logistic regression analysis was used to compute adjusted odds ratios (AORs) and 95% confidence intervals (CIs). Differences by income levels were found in twin maternities but not in higher order maternities. Twin maternities were more likely to occur in the richest neighborhood-income quintile compared to the rest of the population (AOR: 1.25, 95% CI: 1.10-1.41), after adjustment for potential confounders. The positive association between high neighborhood income and twin maternities found in this study suggests that the richest neighborhoods select families whose characteristics pose them at increased risk of having twins. Further studies are needed to clarify the underlying mechanisms leading to socioeconomic differences in multiple births.

Multiple birth rates have been increasing steadily over the last three decades in industrialized countries (Blondel & Kaminski, 2002; Kaprio & Martilla, 2005; Kiely & Kiely, 2001; MacFarlane & Blondel, 2005; Umstad & Lancaster, 2005). Multiple births have a disproportionate impact on preterm delivery and low birthweight, which in turn leads to increased hospital costs due to intensive postnatal care, perinatal mortality, and adverse health outcomes later in life (Blondel et al., 2002; Tucker & McGuire, 2004). Multiple births are known to increase with higher maternal age and the use of fertility treatments, and have been positively associated with parity, maternal height, and African–American ethnicity (Bortolus et al., 1999; Campbell, 2005; Nylander, 1981). It has also been suggested that migration and interethnic mixing modify twinning rates (Campbell, 2005; Pollard, 1995). However, little is known about how multiple birth rates vary by socioeconomic position (Campbell, 2005). No clear pattern emerges from earlier studies assessing associations between multiple births and socioeconomic position (Colletto et al., 2003; Maher & Macfarlane, 2004; Murphy & Botting, 1989; Nylander, 1981).

The City of Toronto constitutes a distinctive research setting for the study of socioeconomic disparities in health outcomes, despite the existence of universal healthcare coverage. Although Toronto is richer on average than the province of Ontario and the country, it has a much greater prevalence of vulnerable populations (e.g., characterized by low income, renting, living alone, lone parents' families, immigrants with cultural and language barriers), suggesting a high degree of income-related spatial segregation. We conducted a retrospective cross-sectional study to identify differences in the occurrence of multiple births by neighborhood-income levels in the City of Toronto, Canada.

Materials and Methods

Study Population

The City of Toronto had a population of 2.48 million in 2001, about half being born in countries other than Canada. The Toronto area is the main destination of immigrants to Canada, receiving around half of all the immigrants to Canada every year (about 125,000 in 2001, from more than 100 countries). Nearly 30,000 births take place every year. In recent years, about 35% of all live-births were born to Canadian-born women, 30% were born to women who migrated to Toronto within the previous 5 years, and the remainder is accounted by longer-term immigrant mothers (Shah & Ohlsson, 2002). A study population of 154,295 infants live-born to women residing in the City of Toronto in 5 fiscal years from April 1, 1996 to March 31, 2001, was extracted from hospital discharge abstracts from the Canadian Institute for Health Information obtained through a comprehensive research agreement with the Ontario Ministry of Health and Long-Term Care. Hospital records account

Received 14 October, 2006; accepted 27 October, 2006.

Address for correspondence: Marcelo Luis Urquia, Centre for Research in Inner City Health, St Michael's Hospital, 70 Richmond St E., 4th floor, Toronto, ON M5C 1N8 Canada. E-mail: marcelo.urquia@utoronto.ca

https://doi.org/10.1375/twin.10.2.400 Published online by Cambridge University Press

for approximately 99% of all live-births in Toronto, with the exception of home-births. After excluding still-births and newborns weighing less than 500 grams and more than 6000 grams, missing links to mothers, records with implausible or missing information on key maternal characteristics, such as maternal age and place of residence, and records to which census information could not be assigned, the sample was reduced to 146,686 infants (95.1% of the original records), corresponding to 122,839 mothers. Multiple births were defined by counting the number of live-births per delivery episode. The unit of analysis for this study was defined as any maternity of a woman in the study period, which could result in a single or a multiple live-birth. The dependent variable was defined as a maternity resulting in multiple live-births.

Neighborhood Income

Socioeconomic position was assessed by neighborhood mean household-income quintiles, at the census tract level, using 1996 and 2001 Canadian censuses. Census tracts are relatively stable geographic urban areas with a population of 2500 to 8000. The use of area-based measures to assess health status is common in social epidemiology and the methodological implications of their use have been discussed elsewhere (Krieger et al., 2003; Mustard et al., 1999; Spencer et al., 1999). The mean household income of each census tract was assigned to each individual record, according to the mother's place of residence at the time of delivery, and then ranked and grouped into quintiles of newborns. Variations in income over the study period were taken into account by interpolating a linear trend for the years in between censuses.

Maternal Characteristics

Maternal age was categorized into the following age groups: less than 20, 20 to 24, 25 to 29, 30 to 34, 35 to 39, and 40 years and more.

Since lifelong parity was not available in hospital records for the study period, information on previous hospitalizations back to 1991 were used to define 'recent parity' as having a live-birth during the 5 years preceding the delivery of interest.

In order to obtain information on recent immigration, hospital data were linked to the Registered Persons Database, which is Ontario's universal healthcare insurance registry. First-time registration of a woman within 5 years prior to the delivery of interest was used as a proxy for recent immigration, based on estimates from the 2001 census that at least 84% of 'new registrants' are foreign rather than domestic migrants.

Statistical Analyses

Descriptive analysis was performed to characterize the population in relation to neighborhood income. We used chi-square and the Cochran-Armitage trend tests to identify differences in multiple births across income quintiles. Regression analyses were restricted to twin maternities, since higher order maternities were not associated with income levels. Thus, the final dataset used for multivariate analyses included 144,671 maternities from 122,781 mothers. We estimated odds ratios (OR) to assess trends across neighborhood-income quintiles, using income quintile as a continuous variable in logistic regression. Multiple logistic regression analysis was used to model delivery episodes resulting in twin live-births and produce OR with 95% confidence intervals. Specific procedures were carried out to take into account the clustered nature of the data. First, it is possible for a woman to have more than one delivery in the 5-year study period, and it is reasonable to expect that these deliveries are more similar to one another than those of different women, due to same factors operating at the maternal level. To adjust for such a clustering that violates the assumption of independence of observations in regression analysis; standard errors were multiplied by the design effect (Donner & Klar, 2000). The design effect is a measure that quantifies the loss of sampling effectiveness by the use of clustered observations, instead of independent observations, and is a function of the intraclass correlation coefficient (ICC) and the average cluster size. Second, generalized estimating equation (GEE) methods were used to adjust for any potential correlation of responses within census tracts, but as the correlations in all models were very low (less than .01), results were virtually identical and therefore ordinary estimates are reported (Diggle et al., 2002). Fiscal year was included as a covariate in order to control for any possible trend over time. All analyses were performed using SAS 9.1 (SAS Institute, Cary, NC) for UNIX.

The study was approved by Research Ethics Boards at the University of Toronto, St. Michael's Hospital and Sunnybrook Health Sciences Centre, all in Toronto.

Results

The average household income differences across neighborhood-income quintiles (Table 1) do not surpass CAN $10,000 between adjacent quintiles, with the exception of the highest income quintile, which surpasses quintile 4 by more than CAN $40,000. From a total of 1894 multiple deliveries, 1834 resulted in twins, 59 in triplets, and one in quadruplets. The larger proportion of multiple births in the richest quintile is composed mainly of twins. The Cochran-Armitage trend test indicates the presence of a trend across income quintiles for twin deliveries ($p < .0001$) but its absence for higher order multiple deliveries ($p = .50$). Therefore, 60 deliveries resulting in triplets and quadruplets were excluded from regression analyses, giving a final sample of 144,671 deliveries.

Table 2 shows how maternal characteristics are distributed across neighborhood-income quintiles and provides a summary measure of trends for each characteristic across income quintiles, as estimated by the OR per change in income quintile. The proportion of

https://doi.org/10.1375/twin.10.2.400 Published online by Cambridge University Press

Table 1

Mean Household Income, Mothers, Maternities and Live-Births by Neighborhood-Income Quintile, Toronto, Canada, 1996/97–2000/01

Neighborhood-income quintile	Mean household income*	Mothers	Maternities	Number of maternities resulting in *N* live-borns			Twin maternities	Total live-borns
				1	2†	≥ 3‡		
Quintile 1 (lowest income)	40,400	24,548	28,999	28,664	323	12	1.11	29,346
Quintile 2	50,100	24,863	29,016	28,651	355	10	1.22	29,391
Quintile 3	57,100	24,711	29,087	28,734	343	10	1.18	29,450
Quintile 4	65,900	24,696	28,737	28,372	350	15	1.22	29,118
Quintile 5 (highest income)	108,700	24,021	28,892	28,416	463	13	1.60	29,381
Total	59,200	122,839	144,731	142,837	1834	60	1.27	146,686

Note: *In 2000 Canadian dollars, rounded to the nearest hundreds

†*p* for trend: < .0001

‡*p* for trend: .50

young mothers (aged up to 29 years) decreases with increasing neighborhood income, and mothers aged 30 years and more are more common as neighborhood income increases. There seems to be a weak trend among mothers who had at least one delivery in the previous 5 years but this trend is of borderline significance. The proportion of recent registrants drops markedly as neighborhood income increases.

Table 3 shows the results of the logistic regression analyses. In order to account for the clustering of twin deliveries within mothers (ICC = .65), standard errors were multiplied by the design effect (DE = 1.12). Model 1 compares the richest neighborhood-income quintile with each of the remaining quintiles. Although adjustment for potential confounders reduced the magnitude of the estimates, they are still significant. As the proportions of twin maternities in the income quintiles Q1, Q2, Q3, and Q4 were not statistically different from each other, as assessed by chi-square tests (not shown); therefore these categories were collapsed to allow a comparison between the richest quintile and the rest of the population in Model 2. Again, these results show that women in the richest quintile were 25% more likely to have twins, compared to the rest of the population, after controlling for maternal age, recent parity, recent immigration, and fiscal year.

Discussion

Unlike the rather monotonic dose-response gradient usually observed between income and many health outcomes, the socioeconomic pattern of twin maternities in the City of Toronto only shows a clear excess in the richest quintile. Although part of this difference is explained by differences in maternal age, recent parity, and recent immigration, the association is still significant after controlling for these characteristics.

Strengths of this population-based research are its large sample size and that practically all women in Toronto who gave birth during the study period were taken into account. Our results are not affected by the choice of the unit of analysis. Sensitivity analyses using both the first delivery episode of a woman in the study period and all live-born infants, produced estimates of the same direction, and similar magnitude and statistical significance (not reported here).

Our findings should be interpreted with caution. Since we restricted our examination to pregnancies resulting in live-born infants, our findings are not applicable to multiple pregnancies that did not carry to viable gestational age. One limitation of this study is the imperfect measurement of the independent variables, which could result in some degree of residual confounding. The use of neighborhood-based measures of socioeconomic status is usually expected to produce attenuated and therefore conservative effect estimates, but this is not always the case (Mustard et al., 1999; Spencer et al., 1999). Parity could only be measured during a limited time period and was therefore underestimated in some women. It is unlikely that underestimation of parity seriously affects our results, since the available evidence portrays parity as a weak confounder (Campbell, 2005; Nylander, 1981). The use of recent registration, as a proxy for recent immigration, overestimates the number of true foreign migrants, since some new registrants may be internal migrants rather than external migrants. According to census data, 84% of people new to Ontario between 1996 and 2001 arrived directly from other countries, but many of the remainder may also be recent immigrants to Canada who arrived to Ontario via other provinces.

We had no information on tobacco smoking and alcohol consumption but this is not necessarily a limitation, since the available evidence does not support their causal role in multiple births (Bortolus et al., 1999; Campbell, 2005). However, it is a subject of debate whether these two factors should be controlled for anyway, since they may also be mediating actual socioeconomic effects on birth outcomes (Kramer et

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Table 2

Maternal Characteristics by Neighborhood-Income Quintile in Toronto, 1996/97–2000/01*

Characteristic	Neighborhood-income quintile					OR† for trends (95% CI)
	Q1 (Lowest)	Q2	Q3	Q4	Q5 (Highest)	
Maternities (n = 144671)	(n = 28,987)	(n = 29,006)	(n = 29,077)	(n = 28,722)	(n = 28,879)	
Twin maternities	1.11	1.22	1.18	1.22	1.60	1.08 (1.05–1.12)
Maternal age < 20	4.98	4.39	4.05	3.07	1.76	0.80 (0.78–0.81)
Maternal age 20–24	18.56	15.91	14.41	12.01	5.89	0.77 (0.76–0.78)
Maternal age 25–29	30.53	29.76	28.58	27.22	20.41	0.89 (0.88–0.90)
Maternal age 30–34	29.32	31.41	32.85	35.79	42.05	1.14 (1.13–1.15)
Maternal age 35–39	13.83	15.56	17.01	18.61	24.93	1.19 (1.18–1.20)
Maternal age 40 ≥	2.78	2.98	3.11	3.30	4.96	1.15 (1.13–1.18)
Recent parity (≤ 5 years)	34.06	32.15	32.91	32.44	35.42	1.01 (1.01–1.02)
Recent registrants (≤ 5 years)	43.27	35.64	32.45	29.49	19.16	0.77 (0.77–0.78)

Note: *Results are per cent unless indicated.

†Odds ratio per change in neighborhood-income quintile.

al., 2000). In the same vein, maternal height is more likely to be a mediator in the relationship between income and multiple births, since lifelong high income leads to higher maternal height, which in turn has been shown to be positively associated with multiple births (Bortolus et al., 1999; Nylander, 1981).

No clear pattern emerges from earlier studies assessing the relationship between multiple births and socioeconomic status (Colletto et al., 2003; Maher & Macfarlane, 2004; Murphy & Botting, 1989; Nylander, 1981). This may be attributed to different populations, secular trends, study periods, and methods. Higher age-standardized twinning rates have been observed in the manual group compared to the nonmanual group in Great Britain from 1974 to 1985, although the difference was not statistically significant (Murphy & Botting, 1989). Multiple birth rates became higher in the nonmanual groups since the late 1980s (Maher & Macfarlane, 2004), and no association was found in a study of social class and twinning rates in Scotland (Nylander, 1981). The latter two studies were descriptive in nature, providing unadjusted effect estimates. Our main finding is in agreement with a more recent Brazilian study that found higher multiple birth rates in hospitals caring for clients of high socioeconomic level (Colletto et al., 2003).

There are two potential mechanisms, not mutually exclusive, that could explain our main finding.

First, it is possible that the higher proportion of twin deliveries in the richest neighborhood-income quintile is driven by its ethnic composition. The richest neighborhoods in Toronto are characterized by the highest proportions of white Canadian-born population and by the lowest proportions of visible minorities, such as Africans and Asians. A report based on Toronto's Vital Statistics data showed that Canadian-born women, who were responsible for 35.7% of all births in 1997, had the highest crude rate of multiple births (2.8%), followed closely by women of African origin (2.7%), and women of Asian origins had the lowest rate (1.7%; Shah & Ohlsson, 2002). Although we had no information about the recent registrant mothers' country of origin, it is known from the 2001 census that Toronto immigrants' top five countries of origin from 1996 to 2001 were China, India, Pakistan, Philippines, and Sri Lanka, accounting for 43.7% of all immigrants in the period. Asian immigrants to Toronto have median incomes lower than the median income of the city as a whole.

Second, the observed association between twin maternities and rich neighborhoods might be also explained by the use of assisted reproductive technologies (ART). There is indirect evidence suggesting that the association between high socioeconomic status and higher multiple births rates is mediated by the socioeconomic gradient in the use of ART (Heitman, 1995; Jenkins, 2005). Although infertility is more common among low income and African-origin groups in North America, women of greater material resources can more easily afford the cost of infertility therapies, even in settings with universal access to medically indicated infertility treatments (Jain & Hornstein, 2005).

In the province of Ontario, the universal healthcare insurance plan only covers in vitro fertilization (IVF) treatment if there is bilateral tubal occlusion. Otherwise, the couple has to pay the costs of the infertility treatment. It was calculated that the average cost of one IVF cycle in Canada in 1995 was CAN $5700. However, due to low success rates, the marginal cost of a single additional live-birth with early IVF treatment was estimated in CAN $89,427, which in 2002 was equivalent to approximately US $79,472 (Collins, 2002). Such a sum well surpasses the average neighborhood household income of the 80% of the Toronto mothers in this study but is below that of the 20% of

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Table 3

Odds Ratios of Twin Maternities Between the Richest Neighborhood-Income Quintile (Q5) and Each of the Remaining Quintiles (Model 1), and Between Q5 and the Rest of the Population (Model 2), Toronto, 1996/97–2000/01

Model		OR (95% CI)	
		Unadjusted	Adjusted*
Model 1	Q5 versus Q1	1.45 (1.23–1.70)	1.28 (1.08–1.51)
	Q5 versus Q2	1.31 (1.13–1.54)	1.20 (1.02–1.41)
	Q5 versus Q3	1.36 (1.17–1.60)	1.26 (1.08–1.48)
	Q5 versus Q4	1.32 (1.13–1.54)	1.25 (1.07–1.47)
Model 2	Q5 versus Q1+ Q2+ Q3 +Q4	1.36 (1.21–1.51)	1.25 (1.10–1.41)

Note: *Adjusted for maternal age, recent parity, recent registrants and fiscal year.

families living in the richest neighborhoods. Further studies would be needed to test such a hypothesis. It is of course the case that these families are also in a better position to cope with the care and education of their higher share of twins.

It is possible that adjustment for maternal age in this study could have accounted for part of the socioeconomic gradient in ART use, given the strong correlation between maternal age and the proportion of twin births attributable to ART. A population-based United States study found a trend in maternal age for twin births attributable to ART in 2000, from 0.8% among women aged 20 to 24 to 65% among women aged 45 and more (Reynolds et al., 2003).

Our findings suggest that, as a result of the income-related spatial segregation in the City of Toronto, the richest neighborhoods select families whose characteristics lead to higher rates of multiple maternities. In this sense ethnicity and ART use are not seen as potential confounders but as mediators in the association between neighborhood income and multiple maternities. The lack of data on ethnicity and ART use in this study prevent us from testing such pathways.

From an equity perspective, the investigation of social disparities in multiple births may shed light on disparities in reproductive health, such as limitations of access to fertility treatments and adverse pregnancy and birth outcomes and their long-term consequences.

More research is needed to clarify the mechanisms by which income differences in multiple births arise. Our findings suggest that future studies on this question should address the interplay between use of fertility treatments, socioeconomic status, ethnicity, and migration patterns.

Acknowledgments

Supported by the Institute for Clinical Evaluative Sciences, Toronto, Ontario, Canada, and the Ontario Ministry of Health and Long-Term Care. The opinions, results, and conclusions are those of the authors and no endorsement by the Ministry is intended or should be inferred.

ML Urquia was supported by the Institute of Population and Public Health of the Canadian Institutes of Health Research.

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