Neighbourhood immigrant concentration and hospitalization: A multilevel analysis of cardiovascular-related admissions in Ontario using linked data

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ABSTRACT

OBJECTIVE: To assess the influence of neighbourhood immigrant concentration on cardiovascular-disease-related hospitalizations in Canada (CVDH), while adjusting for individual-level immigrant status and socio-economic indicators at individual and neighbourhood levels.

METHODS: Data were from the 2006 Canadian Census linked to the hospital Discharge Abstract Data (DAD) for the province of Ontario. Adults ($n=1,459,950$) aged ≥ 18 years at baseline and grouped by place of birth (Canada, China, South Asia, Europe, and other) were followed between Census Day May 16, 2006 and March 31, 2008. Information on CVDH was obtained from the DAD, while that on immigration and socio-economic indicators was obtained from the Census. The analysis used multilevel logistic regression.

RESULTS: Unadjusted results showed that CVDH was significantly lower among people living in neighbourhoods with medium and high immigrant concentration. Neighbourhood immigrant concentration tended to have no independent effect on CVDH after adjustment for individual-level immigrant status. Immigrants were less likely to experience CVDH irrespective of their country of birth. However, cross-level interaction showed that neighbourhood immigrant concentration provided additional protection to individual-level immigrant status against CVDH for most female immigrant groups, but only for South Asian males.

CONCLUSION: This study resulted from the first-ever linkage of census data to hospitalization data in Canada. It is also the first Canadian study to report on neighbourhood variation and the effect of immigrant concentration on CVDH. The study shows that understanding immigrant health requires both individual and neighbourhood approaches, and a consideration of country of origin.

KEY WORDS: Hospitalization; immigrants; cardiovascular diseases; neighbourhoods; data linkage

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

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Although empirical studies generally show that compositional effects are relatively more important predictors of health, contextual effects (where people live) also matter.^{1,2} More importantly, unlike human behaviour that puts people at risk for cardiovascular disease (CVD) which is harder to change, places are far more modifiable and also have the potential to affect a greater number of people – both those at risk and those not currently at risk.^{2,3} For example, constructing bike lanes, foot trails or sidewalks affects everyone in the neighbourhood and could encourage more people to bike or go for walks. Although places could affect health positively and negatively, most studies view places as sites of 'deprivation amplification'.⁴ Accordingly, individual or household poverty is amplified by negative characteristics of the neighbourhood such as poor or unavailable public services; neighbourhood stressors like noise, pollutants, crime or disorder; and neighbourhood norms related to the support of deleterious health behaviour among others.

This is particularly true for CVD. The first prospective research on the relationship between neighbourhood disadvantage and CVD was the 2001 9-year follow-up study of 15,792 American adults age 45-64 by Diez-Roux and her colleagues.⁵ Using an index measure of neighbourhood socio-economic status (SES) comprising measures of income, wealth, education and occupation, they found that coronary heart disease (CHD) was

more likely to develop among people living in the most disadvantaged neighbourhoods than among those residing in the most advantaged ones. This relationship was independent of personal SES and CHD risk factors like smoking, physical activity, diabetes and hypertension. The body of work appearing since then generally shows that living in disadvantaged neighbourhoods is positively associated with both risk factors and incidence of CVDs.⁶⁻⁹

Canadian research has generally supported the notion of neighbourhood deprivation amplification,¹⁰⁻¹² but the gap between affluent and poor neighbourhoods is less stark than in the United States.^{13,14} In Canada, what may be a more relevant contextual indicator is the presence of a large immigrant population. Ecological studies that use summary measures of individual characteristics have largely focused on deprivation, but these have shown it to be of less importance in accounting for health differences in Canada.^{11,13} Immigration is increasingly

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changing Canada's demographic profile. The 2011 National Household Survey enumerated more than 6.8 million foreign-born individuals in Canada, representing 20.6% of the total population.¹⁵ This percentage is projected to grow to between 25% and 28% by 2031.¹⁶ It is therefore of theoretical and policy relevance to understand the health impacts of immigration, including health care utilization. Newcomers to Canada could bring with them diet or exercise norms that are perhaps more supportive of cardiovascular health than traditional North American practices. Immigrants might also shape the availability of foods in local neighbourhoods that are more supportive of cardiovascular health than North American foods; these benefits would be bestowed to immigrants and non-immigrants alike.

Only a few Canadian studies have examined the effect of immigration on health outcomes, especially on health care utilization. These studies show that areas with higher concentration of immigrants have better health outcomes, including lower hospitalization rates for circulatory diseases, heart conditions, and mental health and behavioural disorders,¹⁷ and lower mortality.¹⁸ However, it is unclear whether these differences are driven by contextual versus composition effects, given that individual-level studies also show better health outcomes among immigrants, including lower hospitalizations.¹⁹⁻²¹ To properly account for the effect of both compositional and contextual effects requires use of a multilevel analytical framework, which none of the previous Canadian studies on hospitalizations have employed, perhaps because of lack of appropriate data.^{17,19} However, if past Canadian multilevel research on risk factors is any indication, we would expect that a greater concentration of immigrants and individual-level immigrant status will be protective of hospitalizations.^{22,23}

This study used the linked 2006 Canadian Census and the Discharge Abstract Database (DAD) to examine the association between neighbourhood immigrant concentration and hospitalization with a CVD in the province of Ontario. CVDs are among the most prevalent diseases in Canada and the leading cause of hospitalization. In the 2011/2012 fiscal year, about 87,000 people were hospitalized for acute myocardial infarction and stroke, two of the leading cardiovascular conditions.²⁴ This study therefore addresses this information gap by analyzing neighbourhood-level differences in cardiovascular-disease-related hospitalizations (CVDH) and to determine whether the contextual effect of immigrant concentration on CVDH persists after controlling for compositional effect (individual-level immigrant status). Furthermore, it explores potential interactions between neighbourhood-level immigrant concentration and individual-level immigrant status to assess the hospitalization profile for immigrants and non-immigrants living in different immigrant concentration areas. Although the linkage was also done for the province of Manitoba, we focus on Ontario because most immigrants settle there.²⁵

METHODS

Data

The linked 2006 Canadian Census and DAD for Ontario is a cohort of 2006 Census respondents followed for hospitalization. The 2006 Census used two questionnaires to collect information

about Canada's population. First, Form 2A (short-form questionnaire) administered to the entire population collected basic demographic information, including birth date, sex and postal code of all household members. Second, Form 2B (long-form questionnaire) administered to one in five (~20%) randomly selected private households collected detailed information on all household members on issues like family composition, country of birth, and education.²⁶ The DAD contains demographic, administrative and clinical data on hospital discharges across Canada, excluding Quebec.²⁷ The linkage was approved by the Statistics Canada Policy Committee²⁸ and was governed by the Record Linkage Directive.^{28,29}

This is the first time in Canada that census data were linked to hospitalization data and it involved three steps. First, a probabilistic linkage to the Registered Persons Database (RPDB) was done using birth dates, postal codes, sexes, surnames and given names of Census Form 2A. The RPDB is a registry containing unduplicated records of all people who have ever acquired an Ontario health card and identified by unique health insurance numbers (HINs). By using the full census, there was also less chance of false links because both datasets represented 100% of all eligible records. Second, a concordance table containing the unique census identifier and matching HINs was used to deterministically link the census and DAD files (Ntarwi, unpublished internal documentation, Statistics Canada, 2013). The final step involved a direct linkage of the hospital record data to the 2006 Census 20% sample using census ID. Further details about the linking process and validation results are available elsewhere.³⁰ About 2.4 million household residents in Ontario completed the 2006 Census long form, and 89% of them were linked to the RPDB.

Hospitalizations occurring between the Census Day May 16, 2006 and March 31, 2008 were selected. This was done to ensure sufficient hospitalizations for the analysis and that individual characteristics were closer to the hospitalization event. To create the analytic file for this analysis, we first recreated an individual-oriented file from all reported hospitalizations associated with a person. During the follow-up period, 308,861 hospitalizations occurred among 210,718 individuals. People not living in Census Metropolitan Areas (CMA) and Census Agglomerations (CA) ($n=482,020$) were excluded because census tracts (CTs), our measure of neighbourhoods, are only created for CMAs and CAs.³¹ People living in CTs whose information was suppressed for confidentiality were excluded ($n=1,431$). Further, people <18 years of age ($n=431,957$), foreign-born, non-permanent residents ($n=19,037$), and people identified as non-immigrants but whose country of birth was not Canada ($n=3,662$), were excluded. The study comprised 1,459,953 persons, residing in 2,116 neighbourhoods. Regression models used unrounded data, but all frequency output was randomly rounded to the base of five in accordance with Statistics Canada disclosure rules.

Definition of variables

Outcome Variable

The outcome measure is inpatient hospital discharges in which CVD was the most responsible or secondary diagnosis. These included hospitalizations with ICD 10 codes I00-I99.³²

Table 1. Characteristics of the 2006 Census-DAD cohort, Ontario province, 2006 to 2008

Characteristic	Total (N=1,459,950)		Immigrants (n=571,430)		Non-immigrants (n=888,520)	
	Count	%	Count	%	Count	%
CVD hospitalization	42,600	2.9	18,100	3.2	24,500	2.8
Immigration by country/continent of origin						
South Asian	78,430	5.4	78,430	13.7		
Chinese	60,120	4.1	60,120	10.5		
European	220,500	15.1	220,500	38.6		
Other	212,380	14.6	212,380	37.2		
Age group (years)						
18-29	292,510	20.0	76,220	13.2	216,290	24.3
30-39	268,040	18.4	101,100	17.7	166,940	18.8
40-49	319,360	21.9	124,920	21.9	194,440	21.9
50-59	254,680	17.4	109,480	19.2	145,200	16.3
60-69	157,510	10.8	78,250	13.7	79,260	8.9
70-79	110,430	7.6	54,930	9.6	55,500	6.3
≥80	57,420	3.9	26,530	4.6	30,890	3.5
Female	759,880	52.1	301,050	52.7	458,830	51.6
Marital status						
Married/Common-law	803,940	55.1	373,600	65.4	430,340	48.4
Widowed	83,690	5.7	39,740	7.0	43,950	5.0
Divorced/Separated	158,190	10.8	55,160	9.7	103,030	11.6
Never married	414,130	28.4	102,930	18.0	311,200	35.0
Living arrangements						
Married couple without children	362,520	24.8	138,330	24.2	224,190	25.2
Married couple with children	679,680	46.6	287,050	50.2	392,630	44.2
Lone-parent household	141,300	9.7	52,530	9.2	88,770	10.0
Other	276,450	18.9	93,520	16.4	182,930	20.6
Education level						
Less than high school	249,890	17.1	112,390	19.7	137,500	15.5
High school graduate	399,340	27.3	134,760	23.6	264,580	29.8
Post-secondary non-university	460,850	31.6	173,520	30.4	287,330	32.3
University degree	349,870	24.0	150,760	26.4	199,110	22.4
Income quantile						
Lowest income quantile	268,350	18.4	124,020	21.7	144,320	16.2
Low-middle income quantile	278,550	19.0	122,900	21.5	155,640	17.5
Middle income quantile	288,970	19.8	114,850	20.1	174,130	19.6
Upper-middle income quantile	303,420	20.8	109,030	19.1	194,390	21.9
Highest income quantile	320,660	22.0	100,630	17.6	220,040	24.8
Employment status						
Currently employed	949,060	65.0	339,840	59.6	609,220	68.6
Unemployed/never worked	143,870	9.9	74,840	13.1	69,030	7.8
Not in labour force	367,020	25.1	156,750	27.4	210,270	23.7
No knowledge of English or French	39,140	2.7	38,650	6.8	490	0.1
Rural residents	95,400	6.5	15,000	2.6	80,400	9.1
Residence five years ago						
Different city in Canada or overseas	269,020	18.4	127,780	22.4	141,240	15.9
Same address	851,040	58.3	311,480	55.5	539,560	60.7
Same city, but different address	339,890	23.3	132,170	23.1	207,720	23.4

Independent Variables

There were two classes of independent variables in this study, neighbourhood- and individual-level factors. Neighbourhood-level factors include immigrant concentration, education, income, and unemployment rate. Immigrants were defined as foreign-born persons who were not Canadian citizens at birth, but who have been granted the right to live in Canada permanently by Canadian immigration authorities. Because of a large variation in the distribution percentage of people in the neighbourhoods who were immigrants in 2006 (ranged from 0% to 81.8%), immigrant concentration was categorized into terciles. The derivation of this measure follows an earlier approach by Carriere and colleagues.¹⁷

Quintiles of neighbourhood population ranked by income adequacy were constructed based on total average household income of all private households and total single person equivalents (IPPE). Details on calculation of the income quintiles are available elsewhere.³³ Similarly, measures of education and unemployment were quintiles of neighbourhood population aged 15 and over with less than high school education and unemployed.

Table 1 lists the individual-level factors included in the analysis. Because of differences in CVD morbidity and mortality

by ethnicity,^{34,35} country of birth was used as indicator of immigrant status at the individual level, namely, Canada (non-immigrants), and South Asia, China, Europe, and other country (immigrants).

Analytical techniques

We used multilevel logistic regression analysis. First, we fitted a random-intercept unconditional regression model or *null-model* (Model 1) to quantify the amount of variance in CVDH attributable to geographic variation. Four additional models were estimated. Model 2 included neighbourhood immigrant concentration, Model 3 added individual-level immigrant status and age, while Model 4 included all selected individual- and neighbourhood-level characteristics. Model 5 tested the effect of an interaction term between neighbourhood immigrant concentration and individual-level immigrant status. These estimates are, however, not directly interpretable as all the terms involved in the interaction have to be considered. A product involving a sum of the interaction term and the main effect of immigrant concentration and country of birth was used to derive probabilities of CVDH.

The intra-class correlation coefficient (ICC) and median odds ratio (MOR) were calculated to quantify heterogeneity between

Table 2. Characteristics of neighbourhoods by immigrant concentration tercile, Ontario province, 2006

Characteristic	Neighbourhood immigrant concentration		
	Lowest <i>n</i> =1333	Medium <i>n</i> =485	Highest <i>n</i> =300
CVD hospitalization, Rate (95% CI)*	75.8 (75.1, 76.5)	69.4 (68.3, 70.5)	63.2 (61.9, 64.5)
Neighbourhood characteristics			
Income			
Lowest income quantile	18.1	19.0	47.7
Low-middle income quantile	16.3	23.1	25.0
Middle income quantile	19.7	22.5	17.0
Upper-middle income quantile	19.8	22.7	6.7
Highest income quantile	26.1	12.9	3.7
Education†			
Lowest education quantile	32.1	33.0	25.7
Low-middle education quantile	20.4	20.6	22.0
Middle education quantile	18.0	15.9	17.3
Upper-middle education quantile	16.4	16.7	15.0
Highest education quantile	13.1	13.8	20.0
Unemployment			
Lowest unemployment quantile	38.4	23.3	7.7
Low-middle unemployment quantile	23.0	23.5	12.3
Middle unemployment quantile	16.1	24.5	18.0
Upper-middle unemployment quantile	12.5	15.3	31.0
Highest unemployment quantile	10.1	13.4	31.0
Individual-level characteristics			
Immigration by country/continent of birth‡			
Canadian (<i>n</i> =888,520)	74.8	18.9	6.3
South Asian (<i>n</i> =78,430)	13.7	34.2	52.1
Chinese (<i>n</i> =60,120)	14.6	25.4	60.0
European (<i>n</i> =220,500)	51.2	32.9	15.9
Other (<i>n</i> =212,380)	29.8	36.1	34.2
Census Metropolitan Area (CMA)			
Greater Toronto Area	21.1	86.0	100.0
Other CMA	78.9	14.0	0.0

* Age-/sex-standardized rates per 10,000.

† Population with less than high school education.

‡ The frequency distribution is done within the category of birth country/continent.

neighbourhoods. The ICC measures the amount of variation shared by members of the same neighbourhood. The MOR quantifies heterogeneity between neighbourhoods by comparing two persons with identical characteristics, but from two randomly selected neighbourhoods. The MOR is always greater or equal to 1; a value of 1 indicates a lack of variation across neighbourhoods.³⁶ The proportional change in the variance (PCV), expressed as the proportion of variance explained from the variance initially estimated in the model with no covariates (null model), was calculated at each stage of the modelling. The models were estimated using MLwiN version 2.08 (Centre for Multilevel Modelling, University of Bristol, UK).

RESULTS

Descriptive statistics

Approximately 42,600 people, comprising about 3% of the cohort members, were hospitalized with a CVD over the two years of follow-up (Table 1). Slightly more immigrants than non-immigrants were hospitalized with CVD, 3.2% versus 2.8%. Most of the immigrants were from Europe (15.1%) and other countries (14.6%). Whereas almost half of non-immigrants were living in households in the upper-middle or highest income quintile, a similar proportion of immigrants were living in households in the lowest or lower-middle income quintile.

The rate for CVDH was highest in the neighbourhoods with the lowest immigrant concentration and lowest in those with the highest immigrant concentration, 76 versus 63 per 10,000 people (Table 2). The richest neighbourhoods appear to be those with the lowest immigrant concentration and the poorest

neighbourhoods those with the highest; 26.1% of the population living in low immigrant neighbourhoods were in the highest income quantile, while 48% of the population living in high immigrant neighbourhoods were in the lowest income quantile. Most of the South Asian and Chinese immigrants live in the highest immigrant areas, 52.1% and 60.0% respectively.

Multilevel regression results

In null-models, there was modest yet significant neighbourhood variation in CVDH among both men and women (Tables 3 and 4). Both measures of heterogeneity indicated significant variation in CVDH across neighbourhoods, with an estimated MOR of 1.57 and 1.43 for females and males respectively. The variation declined in subsequent models, but it remained significant. The estimated MOR in Model 5 is 1.23 and 1.18 for females and males respectively. For both females and males, the highest PVC was attained in the model including both individual- and neighbourhood-level factors; 79.1% and 79.4% respectively.

There was a gradient associated with neighbourhood immigrant concentration among both females and males (Model 2). Relative to people living in areas with the lowest concentration of immigrants, those living in both medium- and highest-immigrant concentration neighbourhoods were less likely to experience CVDH. This relationship, however, became statistically non-significant with adjustment for individual-level immigrant status (Model 3). Although all immigrants were less likely to experience CVDH irrespective of their birth country, the odds for Chinese immigrants are substantially lower. These differences remained largely unchanged in Model 4 which adjusted for all the selected factors. The conditional effect of

Table 3. Odds ratio of CVD hospitalization by immigration concentration and country/continent of origin, Ontario province, 2006-2008, Census-DAD database, females ($n=759,875$)

Characteristic	Model 1 OR (95% CI)	Model 2* OR (95% CI)	Model 3† OR (95% CI)	Model 4‡ OR (95% CI)	Model 5§ OR (95% CI)
Fixed effects					
Neighbourhood immigrant concentration tercile					
Lowest		1.00	1.00	1.00	1.00
Medium		0.83 (0.78, 0.88)	0.99 (0.95, 1.04)	0.92 (0.87, 0.98)	0.98 (0.91, 1.05)
Highest		0.73 (0.68, 0.79)	1.00 (0.94, 1.06)	0.86 (0.79, 0.93)	0.95 (0.86, 1.06)
Country/continent of origin					
Canada			1.00	1.00	1.00
South Asia			0.82 (0.75, 0.90)	0.79 (0.72, 0.87)	0.92 (0.75, 1.14)
China			0.43 (0.39, 0.48)	0.43 (0.38, 0.48)	0.49 (0.37, 0.65)
Europe			0.88 (0.85, 0.91)	0.86 (0.82, 0.89)	0.90 (0.86, 0.94)
Other			0.80 (0.76, 0.84)	0.80 (0.76, 0.84)	0.84 (0.78, 0.92)
Interaction					
South Asian					
Medium immigrant concentration					0.76 (0.59, 0.99)
Highest immigrant concentration					0.79 (0.61, 1.02)
Chinese					
Medium immigrant concentration					0.77 (0.54, 1.09)
Highest immigrant concentration					0.80 (0.59, 1.10)
European					
Medium immigrant concentration					0.89 (0.81, 0.97)
Highest immigrant concentration					0.82 (0.73, 0.93)
Other country					
Medium immigrant concentration					0.89 (0.79, 1.01)
Highest immigrant concentration					0.85 (0.74, 0.97)
Random effects					
Variance intercept	0.23 (0.01)	0.22 (0.01)	0.08 (0.01)	0.05 (0.01)	0.05 (0.01)
Intra-class correlation coefficient	6.51	6.13	2.32	1.44	1.41
Median odds ratio	1.57	1.55	1.30	1.23	1.23
Proportional change in variance		6.1	65.9	79.1	79.4

* Model 2 included only immigrant concentration quantiles.

† Model 3 added individual-level immigrant status delineated by country/continent of origin and age to Model 2.

‡ Model 4 added all individual-level controls to Model 3 and other CT-level variables.

§ Model 5 added an interaction between neighbourhood immigrant concentration and individual-level immigrant status to Model 4.

|| Standard error in parentheses.

Table 4. Odds ratio of CVD hospitalization by immigration concentration and country/continent of birth, Ontario province, 2006-2008, Census-DAD database, males ($n=700,078$)

Characteristic	Model 1 OR (95% CI)	Model 2* OR (95% CI)	Model 3† OR (95% CI)	Model 4‡ OR (95% CI)	Model 5§ OR (95% CI)
Fixed effects					
Neighbourhood immigrant concentration tercile					
Lowest		1.00	1.00	1.00	1.00
Medium		0.86 (0.81, 0.90)	1.00 (0.96, 1.05)	0.96 (0.91, 1.01)	0.97 (0.92, 1.03)
Highest		0.79 (0.74, 0.84)	1.03 (0.98, 1.08)	0.94 (0.88, 1.01)	0.93 (0.85, 1.01)
Country/continent of origin					
Canada			1.00	1.00	1.00
South Asia			0.85 (0.78, 0.91)	0.91 (0.84, 0.98)	1.19 (1.03, 1.39)
China			0.42 (0.38, 0.47)	0.44 (0.40, 0.49)	0.40 (0.30, 0.53)
Europe			0.93 (0.90, 0.96)	0.91 (0.88, 0.94)	0.91 (0.87, 0.95)
Other			0.79 (0.75, 0.83)	0.81 (0.77, 0.86)	0.81 (0.75, 0.88)
Interaction					
South Asian					
Medium immigrant concentration					0.72 (0.59, 0.88)
Highest immigrant concentration					0.71 (0.58, 0.87)
Chinese					
Medium immigrant concentration					1.12 (0.80, 1.56)
Highest immigrant concentration					1.14 (0.83, 1.56)
European					
Medium immigrant concentration					0.99 (0.91, 1.07)
Highest immigrant concentration					1.05 (0.94, 1.18)
Other country					
Medium immigrant concentration					0.97 (0.86, 1.10)
Highest immigrant concentration					1.05 (0.92, 1.21)
Random effects					
Variance intercept	0.14 (0.01)	0.13 (0.01)	0.04 (0.00)	0.03 (0.00)	0.03 (0.00)
Intra-class correlation coefficient	4.11	3.86	1.17	0.87	0.87
Median odds ratio	1.43	1.41	1.21	1.18	1.18
Proportional change in variance		6.4	72.3	79.4	79.4

* Model 2 included only immigrant concentration quantiles.

† Model 3 added individual-level immigrant status delineated by country/continent of birth and age to Model 2.

‡ Model 4 added all individual-level controls to Model 3 and other CT-level variables.

§ Model 5 added an interaction between neighbourhood immigrant concentration and individual-level immigrant status to Model 4.

|| Standard error in parentheses.

Table 5. Predicted probabilities of CVDH from the product of the interaction of immigrant concentration and immigrant country/continent of origin ($n=1,459,953$)

Country/continent of origin	Neighbourhood immigrant concentration					
	Low		Medium		High	
	M	F	M	F	M	F
Canada	0.50	0.50	0.49	0.49	0.48	0.49
South Asia	0.50	0.50	0.41	0.43	0.40	0.43
China	0.50	0.50	0.53	0.43	0.53	0.43
Europe	0.50	0.50	0.50	0.46	0.51	0.44
Other	0.50	0.50	0.49	0.47	0.51	0.45

M=male; F=female.

immigrant concentration in Model 4 was significant for females, but not for males.

Table 5 presents predicted probabilities of CVDH by immigrant concentration and country of birth from Model 5 (Tables 3 and 4). Recall that the derivation of these estimates involved the product of a sum of the interaction term for birth country and the main effect of neighbourhood immigrant concentration and birth country. A probability of 0.50 (median effective level) indicates that both hospitalization and no hospitalization are equally likely. Overall, neighbourhood immigrant concentration amplified the advantage for the individual-level immigrant effect among females, except those from China. For male South Asian immigrants, living in a low immigrant area is significantly deleterious for CVDH. For other male immigrants, there seems to be no benefit to living in higher immigrant areas.

DISCUSSION

This study resulted from the first-ever linkage of census data to hospitalization data in Canada. To our knowledge, it is the first Canadian study to report on neighbourhood variation and the effect of immigrant concentration on CVDH. There was modest yet significant between-neighbourhood variation in CVDH. The variation declined with adjustment of the selected individual- and neighbourhood-level factors, but it remained significant. The estimate of neighbourhood variation in hospitalization is consistent with previous Canadian studies on place effects in health.^{1,12,22} The results of this study, however, showed that differences between neighbourhoods in CVDH were largely explained by individual-level immigrant status.

There was a significant unadjusted gradient in the association between neighbourhood immigrant concentration and CVDH. However, neighbourhood immigrant concentration tended to have no independent effect on CVDH with adjustment for individual-level immigrant status. Immigrants overall were at a lower risk of CVDH irrespective of where they lived, but there were differences by birth country. The risk of CVDH for South Asian and European immigrants was closer to that of non-immigrants, but that of Chinese immigrants was substantially lower. Immigrants had a lower risk of hospitalization in spite of the fact that most of them were living in relatively lower income households, and despite neighbourhoods with higher immigrant concentration being poorer as measured by income and unemployment (Table 2). The results are consistent with previous studies showing that immigrants have relatively better health than non-immigrants, despite poorer socio-economic status. This is attributed to health selection and cultural differences in health behaviours.^{37,38}

Cross-level interaction showed that CVDH was dependent on neighbourhood immigrant concentration for all females except

those from China, but only for those from South Asia for males. The result for South Asian males indicates that the protective effect of high immigrant concentration neighbourhoods is not available for those living in the lowest immigrant concentration neighbourhoods. Although this result is consistent with the higher risk of CVD among South Asians,³⁹ the reasons behind the disparity in CVDH with their counterparts living in medium and high immigrant concentration neighbourhoods deserve further study. In contrast, the results for females from South Asia, Europe and those from 'other' countries demonstrate the importance to health of living among and being connected to similar others in the neighbourhood. This connectedness (demonstrated by strong family ties and social support within the immigrant culture) contributes to the lowering of stress and fosters healthy behaviours in the new country.^{38,40}

A major strength of this study was the large sample size, even for a single province. It allowed the analysis by gender and by immigrant population by select birth countries, and the use of multilevel regression. Using a linked dataset of census and hospital administrative data also permitted adjustment for a wide range of individual and neighbourhood characteristics. This was not possible in previous studies using only population health surveys or administrative data.

The study does, however, have some limitations. First, the follow-up period of about two years is relatively short. A longer follow-up period will be able to capture more CVD-related hospitalizations. Extending the follow-up period, however, increases the chance that explanatory characteristics would not be directly related to the event. Second, the study did not adjust for duration in Canada, which could explain the differences by immigrant birth country. Close to 50% of immigrants who had been in Canada longer than 10 years were from Europe, while recent immigrants (10 years in Canada) were from South Asia and China (not shown). Results by duration will therefore not be substantially different from those reported here. Last, the study used immigrant birth country as an indirect measure of ethnicity, but a measure of neighbourhood ethnic concentration would be a better indicator of shared culture, diet and lifestyle. However, the proportions of the leading ethnic groups in the population are relatively small to derive stable measures of neighbourhood ethnic concentration.

This study demonstrated that there was significant neighbourhood variation in the risk of hospitalization with CVDH even though it was of a small magnitude. Neighbourhood immigrant concentration was important for CVDH, but its effect was accounted for by individual-level immigrant status. Similar to previous studies, immigrants had a health advantage compared to non-immigrants, which was further amplified by

neighbourhood immigrant concentration. Linking administrative hospitalization data to censuses ensures that individual- and area-level characteristics from the census, unavailable in administrative data, can be used to assess health care utilization. Additionally, the sample sizes are large enough to allow analysis by relatively small groups in the population, like immigrants delineated by country of birth, and also by rare hospitalization events.

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RÉSUMÉ

OBJECTIF : Évaluer l'influence de la concentration d'immigrants au niveau des quartiers sur les hospitalisations liées aux maladies cardiovasculaires (HLMCV) au Canada, tout en tenant compte du statut d'immigrant au niveau individuel et des indicateurs socioéconomiques aux niveaux individuel et du quartier.

MÉTHODE : Les données du Recensement du Canada 2006 ont été liées à celles du registre des sorties des hôpitaux (RSH) de la province de l'Ontario. Les adultes ($n=1\ 459\ 950$) de ≥ 18 ans au départ, regroupés selon leur lieu de naissance (Canada, Chine, Asie du Sud, Europe et autre), ont été suivis entre le jour du recensement (le 16 mai 2006) et le 31 mars 2008. L'information sur les HLMCV provient du RSH, tandis que celle sur l'immigration et les indicateurs socioéconomiques provient du Recensement. Les données ont été analysées par régression logistique multiniveau.

RÉSULTATS : Les résultats avant ajustement montrent que les HLMCV étaient significativement plus faibles chez les personnes vivant dans des quartiers à concentrations moyennes et élevées d'immigrants. La concentration d'immigrants dans les quartiers avait tendance à n'avoir aucun effet indépendant sur les HLMCV une fois pris en compte le statut d'immigrant individuel. Les immigrants étaient moins susceptibles de subir des HLMCV, peu importe leur pays de naissance. Toutefois, l'interaction transversale a montré que la concentration d'immigrants

dans les quartiers offrait une protection supplémentaire contre les HLMCV à la plupart des groupes de femmes immigrantes, mais chez les hommes, seulement aux immigrants d'Asie du Sud.

CONCLUSION : Cette étude est le résultat du tout premier maillage entre les données du Recensement et des données sur les hospitalisations au Canada. C'est aussi la première étude canadienne à aborder les écarts par quartier et l'effet de la concentration d'immigrants sur les HLMCV. L'étude montre que pour comprendre la santé des immigrants, il faut allier l'approche individuelle et l'approche par quartier et tenir compte du pays d'origine.

MOTS CLÉS : hospitalisation; immigrants; maladies cardiovasculaires; quartiers; maillage de données