Neighbourhood low income, income inequality and health in Toronto

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Abstract

Objectives
This study examines the association of neighbourhood low income and income inequality with individual health outcomes in Toronto, Canada's largest census metropolitan area.

Data sources
The data are from the cross-sectional component of Statistics Canada's 1996/97 National Population Health Survey (NPHS) and the 1996 Census of Population.

Analytical techniques
Individual records for Toronto residents aged 12 or older who responded to the 1996/97 NPHS were augmented with aggregated data from the 1996 Census to provide information on the average socio-economic characteristics of the respondents' neighbourhoods. Hierarchical linear models were used to estimate the effect of low income and income inequality at the neighbourhood level on selected health outcomes.

Main results
When individual low-income status and several other individual characteristics were taken into account, the neighbourhood low-income rate and income inequality were not associated with individuals' reported number of chronic conditions or distress. However, both low income and income inequality at the neighbourhood level remained significantly associated with poor self-perceived health.

Key words
poverty, low-income population, health status indicators

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A growing body of research in the United States and Europe has indicated that living in a low-income neighbourhood has a negative effect on an individual's health-related behaviours and health status.[1-13] Low-income neighbourhoods often have relatively few community resources, such as schools, recreational facilities, churches, public transportation, law enforcement, sanitation, and health and family services,[2,6,7] and unhealthy physical environments—pollution, crowding and inferior housing.[14] Stressful social conditions, including social isolation and high crime rates, may also exist in low-income neighbourhoods.[15-19] And, because people may conform to prevailing norms, low-income neighbourhoods are likely to have a high prevalence of unhealthy behaviours—smoking, heavy drinking and lack of physical activity—as well as passive attitudes toward health and health care.[2,20,21]

In addition to neighbourhood poverty, income inequality within neighbourhoods, which is an indicator of relative deprivation, has been viewed as a potential determinant of individual health.[22] Many ecological studies have found statistical associations between income inequality and

average health status at the population level, both between countries and between large areas within a country.[23-26] Income inequality may weaken social cohesion and have a detrimental psychological effect on individual health.[23,27,28]

Few studies have examined the association between income inequality and individual health at the local level.[29] The health effects of inequality are more apparent in large societies than in small geographic areas, where it is more difficult to compare social strata.[27] Theoretically, income inequality at the local level could have a positive effect on individual health. Income inequality within neighbourhoods reflects economic integration, low social isolation, and a high likelihood of sharing communal resources.[13] On the negative side, wide economic disparities among residents of a small area may heighten social comparisons, provoke distrust,

and create a sense of injustice and dissatisfaction among the disadvantaged.[16,31]

Most of Canada's major metropolitan areas have experienced neighbourhood concentration of low-income and growing income inequality in the last two decades.[32-34] Although some Canadian studies have examined the connection between socio-economic conditions and variations in population health at the neighbourhood level, they have not separated health differences due to neighbourhood socio-economic conditions from those due to individual characteristics.[35,36] Thus, such studies may have overestimated the effect of neighbourhood socio-economic conditions on health. For instance, a significant association between neighbourhood low income and poor health status could be because low-income neighbourhoods tend to have more low-income people, and people with lower incomes tend

Data sources

This analysis is based on cross-sectional household data from the 1996/97 National Population Health Survey (NPHS) and the 1996 Census tract profiles for the Toronto census metropolitan area (CMA).[30] Every two years, the National Population Health Survey (NPHS), which began in 1994/95, collects information about the health of Canadians. It covers household and institutional residents in all provinces and territories, except persons on Indian reserves, on Canadian Forces bases, and in some remote areas. The NPHS has both longitudinal and cross-sectional components.

The 1994/95 and 1996/97 (cycles 1 and 2) cross-sectional samples are made up of longitudinal respondents and other members of their households, as well as individuals selected as part of supplemental samples, or buy-ins, in some provinces. In 1994/95, the majority of interviews were conducted in person. Most of the 1996/97 interviews were conducted by telephone, and additional respondents for the buy-ins were chosen using the random digit dialing (RDD) technique.

NPHS data are stored in two files. The General file contains socio-demographic and some health information obtained for each member of participating households. The Health file contains in-depth health information, which was collected for one randomly selected household member, as well as the information in the General file pertaining to that individual.

In 1994/95, in each selected household, one knowledgeable person provided the socio-demographic and health information about all household members for the General file. As well, one household member, not necessarily the same person, was randomly selected to provide in-depth health information about himself or herself for the Health file.

Among individuals in the longitudinal component in 1996/97, the person providing in-depth health information about himself or herself for the Health file was the randomly selected person for the household in cycle 1 (1994/95), and was usually the person who provided information on all household members for the General file in cycle 2, if judged to be knowledgeable to do so. In households added to the 1996/97 cross-sectional sample (buy-ins), one knowledgeable household member—not necessarily the randomly selected respondent for the Health file—provided information for all household members for the General file.

In 1996/97, there were 81,804 respondents to the questions on the Health file. The 1996/97 cross-sectional response rates for the Health file were 93.1% for the longitudinal component and 75.8% for the RDD component, yielding an overall response rate of 79.0%. More detail on the NPHS is available in published reports.[37,38]

to have poor health. On the other hand, neighbourhood low income may create an unhealthy environment for all residents regardless of their personal income. A combination of both effects is also possible.

A neighbourhood's potential influences on health are often called "contextual effects." These are "the aggregate effect of social, cultural and environmental characteristics of the neighbourhood, that is, similar types of individuals will have different

Analytical techniques

Census summary statistics about neighbourhood socio-economic conditions were matched to the records of each NPHS respondent, using Health PCCF+, a SAS program for automated geographic coding based on the Postal Code Conversion Files prepared by Statistics Canada.[39]

In this analysis, the census tract represents the basic neighbourhood unit. Census tracts are permanent small geo-statistical areas in large urban communities that are carefully established to be as similar as possible in terms of economic status and social conditions.[40] In 1996, Toronto had 808 census tracts. Four were deleted from this analysis because most of their census information was suppressed due to small population size. Another four with small populations (less than 500 people) were excluded to ensure the reliability of derived neighbourhood characteristics. Two more tracts were deleted because they contained no NPHS respondents. In the remaining 798 tracts, the total estimated population ranged from 554 to 25,437, with a mean of 5,333 (standard deviation: 2,372).

There were 9,002 NPHS respondents aged 12 or older residing in Toronto in 1996/97. Records for 121 individuals whose reported postal codes did not match any of the census tract codes were excluded. Another 19 respondents belonging to census tracts for which information was suppressed in the census profile or to tracts that had small populations were also excluded. Therefore, this analysis is based on 8,862 Toronto residents, weighted to represent an estimated 3.6 million Canadians. Compared with the selected weighted sample of these residents, the excluded weighted cases had a higher percentage of women than men (63% versus 51%) and reported poorer self-perceived health. However, there were no statistical differences between these two groups when weighted estimates for age, education, household income, level of distress, and number of chronic conditions were compared.

Using HLM5 (hierarchical linear models),[41,42] two models were fitted to the data in three stages (see Appendix Tables A, B, and C for complete models).

First, a random-effect one-way ANOVA (Model 1) was fitted to determine the total amount of variability in the health outcomes (number of chronic conditions, distress, and self-perceived health) within and between neighbourhoods. Next, a means-as-outcome model (Model 2) was used to regress the neighbourhood average of an individual health outcome on the neighbourhood low-income rate and income inequality at the neighbourhood level to examine the extent to which the between-neighbourhood variation in each of the selected health outcomes was associated with the extent of neighbourhood low income and income inequality. At this stage, individual characteristics were not considered.

Second, a one-way ANCOVA with random effects (Model 1) was used to estimate average health status of each neighbourhood, adjusting for individual low-income status. Then, a means-as-outcome regression (Model 2) was used to estimate the association between the neighbourhood average of the health outcome and the low-income rate and income inequality, adjusting for individuals' low-income status. The results indicate if neighbourhood low income and income inequality have an effect on individual health over and above the effect of low income at the individual level.

The third and final stage controlled for low-income status at the individual level, as well as age, sex, education, alcohol dependence, smoking, physical inactivity, and perceived emotional support (see *Definitions*). The analysis tested whether the effect of the extent of neighbourhood low income and income inequality on individual health remained statistically significant when the effects of the individual characteristics were taken into account.

In Models 1 and 2, at each step, the chi-square statistic indicates whether the neighbourhood component explains a significant amount of the variance in each selected outcome. If the variance is not significantly greater than zero, it would suggest that all neighbourhoods have the same average score on the selected health outcome. In Model 2, a significant coefficient indicates whether neighbourhood average scores of the selected health outcome estimated in Model 1 are associated with neighbourhood low-income level and income inequality.

The original NPHS sampling design relied on household selection through a multi-stage stratified cluster probability sampling procedure. Population weights were given to each respondent record to produce estimates representative of the Canadian population in 1996/97. In the individual-level analyses, population weights were rescaled to an average weight of 1 so the sum of the rescaled weights equalled the sample size. The rescaled weights were used to avoid underestimating standard errors, while maintaining the same distribution as those obtained when using the population weight.

Definitions

Three *health outcomes* were examined in this analysis: number of chronic conditions, distress, and self-perceived health.

National Population Health Survey (NPHS) respondents were asked if they had "any long-term health conditions that have lasted, or are expected to last, six months or more and that have been diagnosed by a health professional." A checklist of 22 conditions was read to them: food allergies, other allergies, asthma, arthritis or rheumatism, back problems (excluding arthritis), high blood pressure, migraine, chronic bronchitis or emphysema, sinusitis, diabetes, epilepsy, heart disease, cancer, stomach or intestinal ulcers, effects of a stroke, urinary incontinence, bowel disorder such as Crohn's disease or colitis, Alzheimer's disease or other dementia, cataracts, glaucoma, thyroid condition, and any other long-term condition that has been diagnosed by a health professional. The number of chronic conditions diagnosed within the last 12 months could range from 0 to a maximum of 13.

Distress level was derived from a subset of items from the Composite International Diagnostic Interview.[30] It was based on responses to six questions: "During the past month, about how often did you feel—so sad that nothing could cheer you up?; nervous? restless or fidgety? hopeless? worthless? that everything was an effort?" Each question was answered on a five-point scale, ranging from "none of the time" (score 0) to "all of the time" (score 4). Responses to all items were scored and summed; the possible range is 0 to 24, with high positive scores indicating greater distress (Cronbach's alpha = 0.79).

Self-perceived health refers to an individual's global assessment of his or her health. Respondents were asked: "In general, would you say your health is excellent, very good, good, fair or poor?" Scores range from 1 to 5, with a higher score indicating poorer self-perceived health.

Although all three health outcomes were treated as continuous variables in this analysis, alternative analyses that treated chronic conditions and self-perceived health as categorical variables were also conducted (data not shown). Self-perceived health was coded as a dichotomous variable: poor (fair or poor) versus other (excellent, very good, good). Two ways of creating a dichotomous variable for chronic conditions were explored: one compared individuals with or without any chronic conditions; the other contrasted those with at least two chronic conditions versus "other" (one condition or none). These alternate analyses yielded the same significant associations between outcome and neighbourhood explanatory variables as the analyses that treated the outcome variables as continuous. Results of the models using continuous variables are presented in this article because this allowed the use of ANOVA and ANCOVA to decompose the variance in the dependent variables into between- and within-neighbourhood components (see *Analytical techniques).*

Two neighbourhood-level income variables were included in the analysis: neighbourhood low income and income inequality. *Neighbourhood low income* is defined as the proportion of the population in each census tract with an economic family income below Statistics Canada's low-income cut-offs (LICOs). An economic family is a group of two or more people who live in the same dwelling and who are related by blood, marriage, a common-law relationship, or adoption. LICOs take into account income and expenditure patterns in seven family-size categories and in five community-size groups. Compared with the average household, a family at or below the LICO spends 20 percentage points more of its income on food, clothing and shelter. In 1996 in Toronto, a family of four with a before-tax income below $32,328 would be classified as low income.[43] The neighbourhood low-income rate ranged from 2.1% to 76.5%.

Since the low-income rate is clustered toward the low end of the distribution (Appendix Table D) and the effect of neighbourhood economic condition on individuals' health may be nonlinear,[20,44,45] the *neighbourhood low-income rate* was used as a categorical variable: lowest (2.1% to 9.9%), lower-middle (10.0% to 19.9%), upper-middle (20.0% to 39.8%) and highest (40.0% to 76.5%). Census tracts with a low-income rate of at least 40% are usually identified as high-poverty neighbourhoods.[46,47]

Neighbourhood income inequality was measured by the coefficient of variation (CV), based on economic family income from the 1996 Census. To calculate the CV, economic family incomes were adjusted for the economies of scale associated with family size.[48] The CVs ranged from 0.44 (the standard deviation is less than one half of the mean) to 3.69 (the standard deviation is 3.69 times larger than the mean), but were clustered toward the low end of the distribution. In multivariate analyses, CVs were grouped into four quartiles: least inequality (0.44 to 0.61), lower-middle inequality (0.61 to 0.70), upper-middle inequality (0.70 to 0.84), and greatest inequality (0.84 to 3.69). (Appendix Table D). The ratio between the 90th and 10th percentiles of the family income distribution was also used as an alternative measure of neighbourhood income inequality. This ratio for the Toronto CMA is 7.2 (that is, the top 10% of families have income about 7.2 times higher than the bottom 10% of families). Among the census tracts for the Toronto CMA, such ratios ranged from 2.8 to 48.0. This ratio was above the CMA average (7.2) in about 31% of the census tracts, and over 10 in about 12% of the tracts. The two measures of income inequality produced similar results in multivariate analysis. Results were presented using the coefficient of variation only because it was not significantly correlated with the neighbourhood low-income rate, while the ratio of 90th over 10th percentile was correlated.

Individual low-income status was measured using a two-category measure of income adequacy that considers household income and household size.[30] Respondents with an annual income of less than $15,000 and a household size of 1 to 2 people, or less than $20,000 and a household size of 3 or 4, or less than $30,000 and a household size of 5 or more were coded as 1, or "yes," low income. Others with information on income were coded as 0, or "no," and constituted the reference group. About 8.7% of respondents had low-income status, and about 61.5% did not (Appendix Table D). Since a large percentage (29.8%) of respondents did not report their income, another dichotomous variable (income missing = 1, others = 0) was created to incorporate them into the analyses.

Several other variables were included for analysis at the individual level: sex, age, education, smoking, alcohol dependence, physical inactivity and perceived emotional support. These variables were used primarily to further control for compositional differences in population characteristics among neighbourhoods that are likely related to both individual low income and health outcomes.

Age, a continuous variable coded by single year, ranged from 12 to 99. *Sex,* a dichotomous variable, was coded as female = 1, male = 0. *Education* was coded as less than high school graduation = 0 or high school graduation or more = 1.

Two categories were coded for *smoking*: daily smoker = 1, no = 0.

The NPHS uses the full range of nine questions developed by Kessler et al.,[49] based on a subset of items from the Composite International Diagnostic Interview, to derive the measure of *alcohol dependence*. The questions use Criterion A and Criterion B of the DSM-III-R diagnosis of "psychoactive substance use disorder," and they were asked only of respondents who reported that they had consumed five or more drinks on one occasion, at least once a month, during the past 12 months. For those who were not asked these questions, the score was coded as zero. Scores range from 0 to 7, with a higher score indicating a stronger risk of alcohol dependence.

Physical activity was coded as active = 1, moderate = 2, and inactive = 3.

The *perceived emotional support* scale consists of four items that reflect whether respondents feel they have someone they can confide in, count on, who can give them advice, and who makes them feel loved. Scores range from 0 to 4, with a high score indicating a high degree of perceived emotional support.[30]

…health status in different types of neighborhoods."[5] By comparison, "compositional effects" are "the aggregate of all individual characteristics in a neighborhood, that is, similar types of persons will have similar illness experiences no matter where they live."[5]

The 1996/97 National Population Health Survey (NPHS) offers a large sample, as well as a variety of health measures and socio-economic attributes of individuals. Augmenting the individual NPHS records with aggregated data from the 1996 Census of Population provides reliable information on the average socio-economic characteristics of the individuals' immediate neighbourhoods. This article uses multi-level modelling to examine the association of neighbourhood low income and income inequality with three individual health outcomes— number of chronic conditions, level of distress, and self-perceived health—in Toronto, Ontario (see *Data sources, Analytical techniques, Definitions* and *Limitations*).

Although a few Canadian studies have investigated the contextual effects of geographic areas using multi-level modelling,[50-52] none has focussed on the contextual effect of neighbourhood low income and income inequality at the census tract level within a major metropolitan area.

The Toronto CMA
Toronto is Canada's largest census metropolitan area (CMA), and it has the highest level of neighbourhood income inequality among CMAs.[33] Therefore, if neighbourhood low income and income inequality have detrimental effects on individual health status, such effects are likely to be apparent in Toronto.

In 1996, Toronto contained about 15% of Canada's total population. Neighbourhood (census tract) low-income rates differed drastically. In the CMA's most affluent neighbourhood, only 1 person out of 50 was in a low-income family in 1995 (the year for which income was reported). By contrast, in the neighbourhood with the highest low-income rate, 8 out of 10 people lived in low-income families.

There were also large income disparities in many neighbourhoods. In about 12% of Toronto's census tracts, the highest income families (the top 10%) had incomes more than 10 times higher than the lowest income families (the bottom 10%).

Chronic conditions
No consistent pattern emerged between low income and income inequality at the neighbourhood level in Toronto and the average number of chronic conditions reported by individuals (Table 1, Appendix Table A). Neighbourhoods with the highest income inequality had higher average numbers of chronic conditions than neighbourhoods with the lowest income inequality, even after controlling for individual low-income status. But this relationship was no longer present when individuals' age was included in the model, because neighbourhoods with the lowest income inequality had the youngest population, and being younger was associated with fewer chronic problems. Individual low-income status, however, was associated with having more chronic conditions.

Several other individual characteristics were significantly related to the number of chronic conditions. People with at least high school graduation had fewer chronic conditions than those with less education. Women had more chronic health problems than did men, and older people had more chronic conditions than did younger ones. Alcohol dependence was associated with an increased number of chronic conditions, as was daily smoking. People with relatively strong emotional support tended to have fewer chronic conditions.

Level of distress
Level of distress was assessed by asking people about their feelings in the past month (see *Definitions*), including how often they felt so sad nothing could cheer them up, and how often they felt nervous, hopeless or worthless.

The average level of distress tended to be higher in low-income neighbourhoods (those with the highest low-income rates), compared with neighbourhoods where low-income rates were lowest (Table 1, Appendix Table B). When individual low income was taken into account, however, the difference was no longer statistically significant. Additional adjustments to consider other

individual characteristics reduced the difference even further, indicating that the association between the extent of neighbourhood low income and individuals' reported levels of distress is likely attributable to a compositional effect.

Neighbourhoods with the widest income inequality tended to have a lower average level of distress than did neighbourhoods with the least income inequality, even after controlling for individual low-income status. This association, however, did not remain statistically significant when individuals' age was included in the model, because neighbourhoods with the greatest income inequality had the oldest populations, and older age was associated with lower levels of distress.

Low-income is a significant predictor of an individual's distress level, and people with low-income status are more likely to live in low-income neighbourhoods. Being younger, a female, having

less than high school graduation, a stronger dependence on alcohol, daily smoking and lower emotional support were all associated with higher levels of distress.

Neighbourhood low income, income inequality associated with poor self-perceived health

NPHS respondents were asked to rate their own health as excellent, very good, good, fair, or poor, with scores ranging from 1 to 5, respectively, and higher scores indicating poorer health (see *Definitions*). Average scores for self-perceived health differed significantly from one Toronto neighbourhood to another (Table 1, Appendix Table C). Further, the neighbourhood variation in average self-perceived health was associated with the neighbourhood low-income rate and the highest level of income inequality. Low-income

Table 1

Average number/scores on selected health outcomes, by neighbourhood low-income rate, adjusted for neighbourhood income inequality, Toronto census metropolitan area, 1996/97

	Adjusted for neighbourhood income inequality only	Adjusted for neighbourhood income inequality and:	
		Individual low-income status	Individual low-income status, age, sex, education, alcohol dependence, smoking, physical inactivity, support
Average number of chronic conditions†			
Neighbourhood low-income rate			
Lowest (2.1%-9.9%)	1.04	1.07	1.14
Lower-middle (10.0%-19.9%)	1.03	1.04	1.14
Upper-middle (20.0%-39.8%)	1.03	1.02	1.11
Highest (40.0%-76.5%)	1.02	0.98	1.14
Average distress level‡			
Neighbourhood low-income rate			
Lowest (2.1%-9.9%)	2.21	2.28	2.28
Lower-middle (10.0%-19.9%)	2.38	2.43	2.41
Upper-middle (20.0%-39.8%)	2.46*	2.45	2.36
Highest (40.0%-76.5%)	2.61*	2.50	2.29
Average self-perceived health§			
Neighbourhood low-income rate			
Lowest (2.1%-9.9%)	2.11	2.13	2.16
Lower-middle (10.0%-19.9%)	2.20**	2.21*	2.24 **
Upper-middle (20.0%-39.8%)	2.30***	2.29***	2.30***
Highest (40.0%-76.5%)	2.38***	2.35***	2.38***

Data sources: 1996/97 National Population Health Survey, cross-sectional sample, Health file; 1996 Census of Population
Note: For complete models, see Appendix Tables A, B, and C.
* p ≤ 0.05; significantly different from neighbourhoods with lowest low-income rates
** p ≤ 0.01; significantly different from neighbourhoods with lowest low-income rates
*** p ≤ 0.001; significantly different from neighbourhoods with lowest low-income rates
† Range 0 to 13
‡ Scale 0 to 24
§ Scale 1 to 5, with higher scores indicating poorer self-perceived health

neighbourhoods tended to have a lower average level of self-perceived health.

Even when controlling for individuals' low-income status, average self-perceived health scores among neighbourhoods remained associated with the neighbourhood low-income rate and income inequality, although the strength of the relationship was attenuated. And when other individual characteristics were taken into account, the association between average self-perceived health and neighbourhood low-income rate and income inequality still remained statistically significant.

The average difference in self-perceived health between people living in neighbourhoods with the highest low-income rates (40.0% to 76.5%) and those in neighbourhoods with the lowest low-income rates (2.1% to 9.9%) is about 0.22, or one-fifth of the standard deviation of the self-perceived health variable (0.99, Appendix Table D), when other factors were held constant. This difference was

Limitations

Although the overall sample used for this analysis is quite large, on average, each census tract had just 11 National Population Health Survey (NPHS) respondents, and half (405) had less than 10. This small sample size at the neighbourhood level should not affect estimates of the effects of individual variables such as sex, age, education, smoking, alcohol dependence or physical inactivity, because hierarchical linear modelling permits reliable estimates of the regression model for a particular tract with a small sample by using a weighted composite of the information from that tract and the relations that exist in the overall sample.[41] However, average neighbourhood health status based on such a small number of observations may be much less reliable and may therefore lead to underestimating the correlation between neighbourhood low income, income inequality and neighbourhood average health status.

To determine if the limited sample size biases the estimate of the effects of neighbourhood low income and income inequality, a larger "neighbourhood" unit was derived by combining census tracts with similar low-income rates. The 798 tracts were grouped into percentiles based on their low-income rates. The tracts were then combined within each percentile into a single aggregated neighbourhood. The aggregated neighbourhoods had an average of 89 NPHS respondents, ranging from 50 to 190. The analyses were repeated for aggregated neighbourhoods rather than census tracts (data not shown). The estimates of the coefficients and standard errors for all individual characteristics remained essentially the same, but the association between neighbourhood low income and neighbourhood average of self-perceived health was much stronger when aggregated neighbourhoods were used.

Based on aggregated neighbourhoods, the neighbourhood low-income rate explained 19.8% of the neighbourhood variation in average self-perceived health scores when all the selected individual variables were taken into account; based on non-aggregated census tracts, the neighbourhood low-income rate explained only 8.3%. This difference suggests that small sample size at the neighbourhood level may lead to an underestimation of the neighbourhood effect.

The associations of neighbourhood economic conditions with chronic conditions and distress were also examined based on aggregated neighbourhoods, but no significant associations were found when the individual characteristics were taken into account.

The data used in this analysis do not contain variables that might explain the mechanisms through which neighbourhood economic conditions affect individual health. Indicators of neighbourhood socialization of unhealthy lifestyles, social networks, communal resources, and physical environment would help researchers understand if the effect of neighbourhood low income and income inequality is independent of or conditioned by other neighbourhood characteristics.

To test whether the health effects of neighbourhood low income and income inequality are affected by another potentially important neighbourhood characteristic, the percentages of recent immigrants (in Canada for 10 years or less) and visible minorities in the neighbourhoods were included in the hierarchical models. The results did not yield different conclusions (data not shown).

The NPHS does not contain information on how long respondents have lived in a specific neighbourhood; therefore, it is not possible to determine if the contextual effect of neighbourhood low income depends on length of exposure. Furthermore, a neighbourhood's socio-economic status may change over time, so even long-term residents may not always be exposed to the same type of environment.

The use of census tracts as "neighbourhoods" may attenuate the true association between neighbourhood socio-economic status and health. Although census tracts have similar population characteristics and economic conditions, they may not coincide with residents' perception of neighbourhoods.[6,7] In fact, many census tracts are not homogeneous in family income. However, because of limited sample size, it was not possible to conduct the analyses using smaller geographic units (enumeration areas, for example).

slightly smaller than the coefficient of individual-level low-income (0.329). Although the magnitude of the difference appears small, it is due to the limited range (1 to 5) in the outcome.

People in neighbourhoods with the greatest income inequality tended to have better average self-perceived health than those in neighbourhoods with the least income inequality even when all the selected individual-level variables were considered.

While low-income status, being older or female, having a stronger dependence on alcohol and being physically inactive were associated with poorer self-perceived health, higher emotional support and having at least high school graduation were associated with better self-perceived health.

Concluding remarks

Whether neighbourhood economic conditions make a difference in individual health status over and above the effect of individual income depends on the health outcome. Self-perceived health was significantly associated with neighbourhood low income and income inequality, even when individual low-income status and other individual characteristics were taken into account. However, the association between the neighbourhood low-income rate and distress was not statistically significant when individual low-income status was considered. And the number of chronic conditions reported was not significantly associated with the neighbourhood low-income rate, even without controlling for individual characteristics. The association of neighbourhood income inequality with distress and number of chronic conditions lost statistical significance when individual age was considered.

It may be that self-perceived health is a more global measure of health status than the other two outcomes. As suggested in previous research, self-perceived health may capture "the full array of illness a person had and possibly even symptoms of disease as yet undiagnosed but present in preclinical or prodromal stages."[53] American and European studies have demonstrated that self-perceived health is an important predictor of the onset of disability and mortality, independent of other medical conditions and psychosocial states.[53,54]

Self-perceived health is also subjective, reflecting individual perceptions of quality of life.[5] By contrast, reports of chronic conditions may be more objective, given that they do not consider the severity of illness. Respondents were asked if the condition(s) had been diagnosed by a health professional. Similarly, distress was measured on a scale using six specific, highly correlated questions.

Further analyses revealed that the interaction between neighbourhood low income and individual-level income was not significant in influencing individuals' self-perceived health (data not shown). This suggests that individuals' low-income status is detrimental to their general health regardless of where they live—in low-income or more affluent neighbourhoods. Thus, low-income people living in low-income neighbourhoods would be subject not only to the effect of individual low income, but also to the contextual effect of neighbourhood low income.

The relatively weak health effects of neighbourhood low income that emerged in this analysis may partly reflect the use of census tracts to represent neighbourhoods. Nonetheless, the findings are consistent with conclusions from previous Canadian studies on the effect of geographic area.[50-52] The results also complement those of a recent Canadian study on the relation between summary indexes of economic segregation and mortality across metropolitan areas.[55]

Other reasons may also partly explain the weak health effect of neighbourhood low income in Toronto. The low-income rate at the census tract level varies with business cycles, so even long-term residents of a certain neighbourhood may not have been exposed to the same economic conditions over time. Also, a large proportion of people in the low-income neighbourhoods were new residents (based on analysis of census mobility data), and had therefore been exposed to the conditions in those neighbourhoods for a short time. The high mobility of residents of these low-income neighbourhoods may have diluted the contextual effect of neighbourhood on individual health.

Although weak, the significant relationship between neighbourhood low income and self-perceived health suggests that the geographic concentration of low-income status and its potential detrimental impact on individual health is not negligible in Toronto. Although this finding cannot be generalized to all Canadian CMAs, it does highlight the need to further monitor and examine the impact of neighbourhood socio-economic context on population health.

This study also found that neighbourhoods with substantial income inequality had better average self-perceived health than neighbourhoods with relatively little income inequality. These results seem to suggest that income inequality at the local level has different social and health implications from income inequality in large societies. Income inequality in large societies is associated with a social environment that undermines individual confidence and trust.[27] By comparison, income inequality at the neighbourhood level may reflect economic heterogeneity and low class segregation.[56] ●

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Appendix

Table A

Hierarchical linear models for number of diagnosed chronic conditions, Toronto census metropolitan area, 1996/97

Step 1 (unadjusted)	Model 1: One-way ANOVA			Model 2: Means-as-outcome		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	1.096***	0.019	57.8	1.043***	0.044	24.0
Lower-middle low income	...	...	...	-0.016	0.047	-0.3
Upper-middle low income	...	...	...	-0.015	0.050	-0.3
Highest low income	...	...	...	-0.024	0.089	-0.3
Lower-middle income inequality	...	...	...	0.035	0.049	0.7
Upper-middle income inequality	...	...	...	0.107	0.056	1.9
Greatest income inequality	...	...	...	0.122*	0.055	2.2
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.077	796	1141.2***	0.076	790	1131.3***
Individual level	1.958	...	...	1.957	...	...

Step 2 (adjusted for individual low-income status)	Model 1: One-way ANCOVA			Model 2: Means-as-outcome		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	1.100***	0.019	58.1	1.067***	0.044	24.5
Lower-middle low income	...	...	...	-0.023	0.047	-0.5
Upper-middle low income	...	...	...	-0.044	0.049	-0.9
Highest low income	...	...	...	-0.084	0.088	-1.0
Lower-middle income inequality	...	...	...	0.033	0.049	0.7
Upper-middle income inequality	...	...	...	0.105	0.056	1.9
Greatest income inequality	...	...	...	0.116*	0.055	2.1
Individual characteristics						
Low-income status	0.383***	0.086	4.4	0.385***	0.086	4.5
Income not reported	-0.108**	0.039	-2.8	-0.107**	0.039	-2.7
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.077	796	1141.3***	0.077	790	1132.4***
Individual level	1.943	...	...	1.942	...	...

Step 3 (adjusted for individual low-income status, age, sex, education, alcohol dependence, smoking, physical inactivity, emotional support)	Model 1: One-way ANCOVA			Model 2: Means-as-outcome		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	1.147***	0.018	63.1	1.140***	0.041	27.6
Lower-middle low income	...	...	...	-0.000	0.045	-0.0
Upper-middle low income	...	...	...	-0.029	0.047	-0.6
Highest low income	...	...	...	-0.004	0.079	-0.0
Lower-middle income inequality	...	...	...	-0.008	0.046	-0.2
Upper-middle income inequality	...	...	...	0.041	0.052	0.8
Greatest income inequality	...	...	...	0.043	0.052	0.8
Individual characteristics						
Low-income status	0.328***	0.054	6.0	0.329***	0.075	4.4
Income not reported	-0.089*	0.033	-2.7	-0.089*	0.036	-2.4
Age	0.028***	0.001	25.5	0.028***	0.001	25.3
Female	0.350***	0.033	10.8	0.350***	0.033	10.8
High school graduation or more	-0.164***	0.039	-4.2	-0.167***	0.039	-4.3
Alcohol dependence	0.099**	0.032	3.1	0.098**	0.032	3.1
Daily smoker	0.089*	0.045	2.0	0.089*	0.045	2.0
Physical inactivity	-0.026	0.021	-1.2	-0.024	0.021	-1.1
Perceived emotional support	-0.096***	0.030	-3.2	-0.095**	0.031	-3.1
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.065	796	1143.8***	0.066	790	1140.4***
Individual level	1.687	...	...	1.687	...	...

Data sources: *1996/97 National Population Health Survey, cross-sectional sample, Health file; 1996 Census of Population*
* $p \leq 0.05$
** $p \leq 0.01$
*** $p \leq 0.001$

Table B
Hierarchical linear models for individual level of distress, Toronto census metropolitan area, 1996/97

Step 1 (unadjusted)	Model 1: One-way ANOVA			Model 2: Means-as-outcome		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	2.236***	0.041	55.2	2.214***	0.100	22.1
Lower-middle low income	...	...	...	0.169	0.103	1.6
Upper-middle low income	...	...	...	0.251*	0.113	2.2
Highest low income	...	...	...	0.393*	0.163	2.4
Lower-middle income inequality	...	...	...	-0.141	0.119	-1.2
Upper-middle income inequality	...	...	...	-0.162	0.126	-1.3
Greatest income inequality	...	...	...	-0.318*	0.119	-2.7
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.369	796	1143.8***	0.352	790	1122.2***
Individual level	8.783	...	...	8.783	...	...
Step 2 (adjusted for individual low-income status)	**Model 1: One-way ANCOVA**			**Model 2: Means-as-outcome**		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	2.245***	0.040	55.7	2.283***	0.101	22.5
Lower-middle low income	...	...	...	0.143	0.103	1.4
Upper-middle low income	...	...	...	0.162	0.112	1.4
Highest low income	...	...	...	0.218	0.160	1.4
Lower-middle income inequality	...	...	...	-0.145	0.119	-1.2
Upper-middle income inequality	...	...	...	-0.168	0.126	-1.3
Greatest income inequality	...	...	...	-0.334*	0.119	-2.8
Individual characteristics						
Low-income status	1.156***	0.187	6.2	1.146***	0.188	6.1
Income not reported	-0.158	0.087	-1.8	-0.161	0.087	-1.9
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.366	796	1146.9***	0.354	790	1128.1***
Individual level	8.671	...	...	8.672	...	...
Step 3 (adjusted for individual low-income status, age, sex, education, alcohol dependence, smoking, physical inactivity, emotional support)	**Model 1: One-way ANCOVA**			**Model 2: Means-as-outcome**		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	2.230***	0.038	58.05	2.281***	0.097	23.6
Lower-middle low income	...	...	...	0.125	0.099	1.3
Upper-middle low income	...	...	...	0.078	0.107	0.7
Highest low income	...	...	...	0.012	0.155	0.1
Lower-middle income inequality	...	...	...	-0.094	0.114	-0.8
Upper-middle income inequality	...	...	...	-0.180	0.121	-1.5
Greatest income inequality	...	...	...	-0.217	0.114	-1.9
Individual characteristics						
Low-income status	0.861***	0.182	4.7	0.872***	0.183	4.8
Income not reported	-0.203*	0.084	-2.4	-0.205*	0.084	-2.4
Age	-0.019***	0.002	-8.2	-0.019***	0.002	-8.1
Female	0.657***	0.076	8.7	0.659***	0.076	8.7
High school graduation or more	-0.288**	0.100	-2.9	-0.281**	0.100	-2.8
Alcohol dependence	0.431***	0.096	4.5	0.433***	0.096	4.5
Daily smoker	0.584***	0.113	5.2	0.583***	0.112	5.2
Physical inactivity	0.050	0.047	1.1	0.047	0.047	1.0
Perceived emotional support	-0.654***	0.082	-7.9	-0.656***	0.082	-8.0
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.314	796	1114.8***	0.311	790	1103.7***
Individual level	8.222	...	...	8.224	...	...

Data sources: *1996/97 National Population Health Survey, cross-sectional sample, Health file; 1996 Census of Population*
* $p \leq 0.05$
** $p \leq 0.01$
*** $p \leq 0.001$

Table C
Hierarchical linear models for individual self-perceived health, Toronto census metropolitan area, 1996/97

Step 1 (unadjusted)	Model 1: One-way ANOVA			Model 2: Means-as-outcome		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	2.182***	0.013	165.3	2.109***	0.027	77.6
Lower-middle low income	...	...	...	0.086**	0.029	2.9
Upper-middle low income	...	...	...	0.187***	0.033	5.7
Highest low income	...	...	...	0.275***	0.056	4.9
Lower-middle income inequality	...	...	...	-0.017	0.035	-0.5
Upper-middle income inequality	...	...	...	-0.054	0.040	-1.4
Greatest income inequality	...	...	...	-0.112**	0.036	-3.1
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.042	796	1190.9***	0.037	790	1126.3***
Individual level	0.893	...	...	0.891	...	...

Step 2 (adjusted for individual low-income status)	Model 1: One-way ANCOVA			Model 2: Means-as-outcome		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	2.183***	0.013	166.8	2.133***	0.027	77.9
Lower-middle low income	...	...	...	0.074*	0.029	2.5
Upper-middle low income	...	...	...	0.154***	0.033	4.7
Highest low income	...	...	...	0.216***	0.056	3.9
Lower-middle income inequality	...	...	...	-0.018	0.035	-0.5
Upper-middle income inequality	...	...	...	-0.056	0.040	-1.4
Greatest income inequality	...	...	...	-0.117**	0.037	-3.2
Individual characteristics						
Low-income status	0.415***	0.057	7.3	0.394***	0.058	6.8
Income not reported	-0.030	0.029	1.0	0.026	0.029	0.9
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.041	796	1183.1***	0.037	790	1136.4***
Individual level	0.882	...	...	0.881	...	...

Step 3 (adjusted for individual low-income status, age, sex, education, alcohol dependence, smoking, physical inactivity, emotional support)	Model 1: One-way ANCOVA			Model 2: Means-as-outcome		
Fixed effect	**Coefficient**	**Standard error**	**t-ratio**	**Coefficient**	**Standard error**	**t-ratio**
Neighbourhood means						
Intercept	2.198***	0.013	175.0	2.164***	0.027	80.0
Lower-middle low income	...	...	...	0.076**	0.029	2.6
Upper-middle low income	...	...	...	0.138***	0.032	4.4
Highest low income	...	...	...	0.220***	0.052	4.2
Lower-middle income inequality	...	...	...	-0.035	0.033	-1.1
Upper-middle income inequality	...	...	...	-0.076	0.039	-2.0
Greatest income inequality	...	...	...	-0.124**	0.035	-3.5
Individual characteristics						
Low-income status	0.346***	0.053	6.5	0.329***	0.054	6.1
Income not reported	0.016	0.028	0.6	0.014	0.028	0.5
Age	0.012***	0.001	16.2	0.012***	0.001	16.5
Female	0.065**	0.026	2.5	0.064*	0.026	2.5
High school graduation or more	-0.252***	0.030	-8.4	-0.246***	0.030	-8.1
Alcohol dependence	0.085***	0.025	3.4	0.088**	0.025	3.5
Daily smoker	0.164***	0.033	4.9	0.161***	0.033	4.9
Physical inactivity	0.133***	0.015	9.0	0.129***	0.015	8.7
Perceived emotional support	-0.070**	0.023	-3.1	-0.065**	0.023	-2.9
Random effect	**Variance component**	**Degrees of freedom**	**Chi-squared**	**Variance component**	**Degrees of freedom**	**Chi-squared**
Neighbourhood mean	0.036	796	1183.2***	0.033	790	1141.5***
Individual level	0.813	...	...	0.812	...	...

Data sources: *1996/97 National Population Health Survey, cross-sectional sample, Health file; 1996 Census of Population*
* $p \leq 0.05$
** $p \leq 0.01$
*** $p \leq 0.001$

Table D
Selected characteristics, Toronto census metropolitan area, 1996/97

Variables	Sample size	Weighted frequency distribution or mean (standard deviation)
Neighbourhood		
Neighbourhood low-income rate		
Lowest (2.1%-9.9%)	181	22.7%
Lower-middle (10.0%-19.9%)	258	32.3%
Upper-middle (20.0%-39.8%)	294	36.8%
Highest (40.0%-76.5%)	65	8.2%
Coefficient of variation, family income		
Least inequality (CV=0.44-0.61)	199	24.9%
Lower-middle inequality (CV=0.61-0.70)	200	25.1%
Upper-middle inequality (CV=0.70-0.84)	199	24.9%
Greatest inequality (CV=0.84-3.69)	200	25.1%
Individual		
Number of chronic conditions	8,617	1.11 (1.44)
Distress	8,308	2.25 (3.03)
Self-perceived health	8,682	2.22 (0.99)
Low-income status		
Yes	796	8.7%
No	5,480	61.5%
Income not reported	2,406	29.8%
Age	8,682	40.80 (17.86)
Sex		
Male	4,092	49.0%
Female	4,590	51.0%
Education		
Less than high school	1,834	24.7%
High school graduation or more	6,741	75.3%
Alcohol dependence	8,682	0.10 (0.51)
Daily smoker		
Yes	7,045	17.3%
No	1,637	82.8%
Physical inactivity	8,473	2.40 (0.78)
Perceived emotional support	8,682	3.80 (0.66)

Data source: *1996/97 National Population Health Survey, cross-sectional sample, Health file; 1996 Census of Population*