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Effect of neighbourhood economic characteristics on the health of individuals

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Effect of neighbourhood economic characteristics on the health of individuals

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ABSTRACT

This multilevel study examined the influence of neighbourhood socioeconomic context on individual health as measured by self-rated health status and the Health Utilities Index (HUI) in urban neighbourhoods of the City of Ottawa and the combined cities of Ottawa and Gatineau. The samples were drawn from the respondents to the Canadian Community Health Survey 2000-2001 which included individuals 12 years of age and older. There were 1441 respondents within the 37 Ottawa neighbourhoods and 711 respondents within the 14 Gatineau neighbourhoods. The neighbourhood characteristics were derived from the 2001 Census.

In Ottawa there was significant variation in health at the neighbourhood level. In age-adjusted models the neighbourhood low income rate and the neighbourhood low education rate were significantly associated with self-rated health (OR=1.35, 95% CI 1.01-1.81; OR=1.03, 95% CI 1.00-1.06, respectively) and a HUI score <0.973 (OR=1.31, 95% CI 1.10-1.56; OR=1.27, 95% CI 1.07-1.52, respectively). However, adjustment for individual level factors reduced the influence of the neighbourhood level variables such that they were no longer statistically significant. Similar results were found for the analysis of the combined cities.

This study suggests that the differences in health between neighbourhoods of Ottawa and Ottawa-Gatineau can be attributed primarily to the compositional impact of the characteristics of individuals within the neighbourhoods.

In memory of my father for whom it was enough that I tried my best and whose confidence in me never wavered. He made me believe I could be anything I wanted to be.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

CCHS	Canadian Community Health Survey
CI	confidence interval
CMA	census metropolitan area
HUI	Health Utilities Index
LICO	low income cut off
MQL	marginal quasilikelihood
PQL	predictive quasilikelihood
RIGLS	restricted iterative generalized least squares
SD	standard deviation
SES	socioeconomic status
SPH/SRH	self perceived health / self-rated health

Chapter 1: Introduction

Evidence suggests that individual health is not just a function of individual characteristics, but is also influenced by the setting in which we live. The main focus of epidemiology in classic experiments was contextual and lead to improvements in environment which helped foster significant reductions in morbidity and mortality.[1] Subsequently, epidemiology turned its attention to the individual and individual risk factors for disease such as diet, blood pressure and exercise. The focus on the environment was significantly diminished. This shift was due partly to the revelation of the ecological fallacy* and the lack of techniques to deal with this issue.[2,3,4] In addition, it was thought that greater improvements in health could be gained by reducing individual risk factors given that the most significant environmental determinants such as sanitation, nutrition and overcrowding had been addressed, at least in the developed world.

More recently, there has been renewed interest in the effect of environment or context on health particularly with respect to the socioeconomic characteristics of people's areas of residence. The association between socioeconomic status and health has been well documented at both the individual level and in ecological studies.[5] Whether this association is entirely attributable to individual characteristics or whether there are socioeconomic features of the environment which independently affect health has been an area of debate.[6]

Over the past 30 years the move towards urbanization has resulted in an increased concentration of poverty within urban centres. Technological advances in communication and improved transportation have allowed for increased mobility and choice of location of

* Ecological fallacy is "the bias that may occur because an association observed between variables on an aggregate level does not necessarily represent the association that exists on an individual level".

residence. This has allowed for the distancing of the affluent from the poor within cities particularly through migration to suburbs. Where poverty is concentrated, so too are factors that are correlated with poverty such as crime, single parent families etc. This process is evident in US cities and to some extent in Canada. Political segmentation within cities helps force poor areas to pay for their own services from their low tax base while allowing the affluent to pay only for their services, thereby exacerbating the problem.[7]

Evidence suggests that the concentration of poverty within city neighbourhoods in the US and Britain has negative impacts on health over and above the individual impact of poverty.[8] As more and more people move into urban areas, the design of urban areas to benefit all of those living within them will become of foremost importance. Moves from the European Union to focus on the development of sustainable, healthy cities have resulted in initiatives such as the World Health Organization (WHO) Healthy Cities Project and the Aalborg Charter Sustainable Cities and Towns Campaign.[9] Canadian cities have also been part of the WHO Healthy cities project which has included such projects as the planning of a sustainable community in central Vancouver, the conversion of vacant lots into playgrounds, parks and community gardens in Winnipeg and Vancouver and the funding of neighbourhood action plans in Edmonton.[10] Even the United States is recognizing the need to address issues of segregation and the death of the central cores of their major cities which have had notoriously poor experiences in the past. Although Canadian cities do not approach the levels of segregation in the United States, they are becoming more segregated which leads to the question: Do the economic characteristics, including the level of poverty and the extent of income inequality, of neighbourhoods in Canadian cities impact individual health?

This study examines the impact of neighbourhood socioeconomic measures on individual health within the cities of Ottawa and Ottawa-Gatineau, Canada, between 2000 and 2001 using multilevel modeling techniques. The City of Ottawa has put in place an official city plan entitled Ottawa 2020, a major focus of which is to build "complete communities" which have a balance of facilities and services including schools, community facilities, parks, a variety of housing and places to work and shop. "The plan encourages investment in a dense, socially diverse City, focused around lively neighbourhoods."[11] Tools are provided that may be used to shape growth of local communities including community design plans and community-based assessments which encourage neighbourhood-level actions. The neighbourhood focus of the city plan makes the question of the impact of neighbourhood economics on health particularly relevant for Ottawa. The cities of Ottawa and Gatineau provide a unique opportunity to examine neighbourhood impacts on health as they possess a high level of integration created by proximity and shared employment base while being located in different provinces. The relative impact of individual and neighbourhood economics on health may be best examined by focusing simultaneously on both the individual and on their environment through the use of recent statistical techniques, such as multilevel modeling.

The rest of this thesis is organized as follows. Chapter 2 provides the background to the thesis. In section 2.1, the socioeconomic health literature, including the topics of income, income inequality and economic segregation with respect to their associations with health, is reviewed. A conceptual pathway for a relationship between economic segregation and health is proposed with a focus on the importance of neighbourhoods in section 2.2. In section 2.3 an introduction to multilevel modeling is presented. Chapter 3 consists of the methods of the study including a statement of the objectives in section 3.1

and a detailed explanation of the examined variables and the steps of the statistical analysis in section 3.2. The results are then presented in Chapter 4 with Chapter 5, a discussion of the findings including limitations, completing the report.

Chapter 2: Background

2.1 Literature Review

Interest in the association between socioeconomic status and health has grown over the past thirty years as evidenced by the increasing number of publications in this area. As insight into the topic increased, the research questions developed from an initial focus on the relationship between income and health, to a focus on the importance of relative income reflected in studies of income inequality. More recently, with the trend towards economic homogenization of urban neighbourhoods, investigation of the impact of area-based concentration of income has become an important research agenda. The following is a review of the progression of socioeconomic health research beginning with the literature focused on income and health, followed by income inequality and finally with respect to area-based income concentration.

2.1.1 Income and Health

Those who are wealthier generally have better health and live longer.[12,13] Some of the first studies in this area date back to the 1820s when Renè Villermè compared mortality rates and poverty across neighbourhoods of Paris.[14] More recent studies provide evidence that this relationship persists.

Strong support for differential mortality rates by socioeconomic status in the United States between 1930 and 1960 were demonstrated in a landmark study by Kitagawa and Hauser.[13] Those in the lower socioeconomic groups had higher mortality

rates for a number of major causes of death. Additionally, although mortality rates overall in the US declined between 1960 and 1986, the gradient in health by socioeconomic status persisted and the mortality gap between the richest and poorest widened.[15,16] Britain has an even longer tradition of social class† health research which was extensively reviewed by Marmot in 1987.[17,18,19] Even though the overall mortality rate declined for all social classes over the time period of the 1950's, 1960's and 1970's, the rate of decline was greater in the higher social classes thereby resulting in greater inequality in mortality rates between the classes by 1970. A more recent study covering the period from 1981 to 1997 in Britain found that the trend continued through these years.[20] In examining the importance of socioeconomic factors for health, the Black Report, which was commissioned by Britain's Labour government in 1977, concluded that although healthcare contributed to health and well-being, socioeconomic factors were of equal or greater importance.[21]

The gradient between health and socioeconomic characteristics has also been supported by Canadian studies.[22,23,24,25] A 20 year cohort study of 2000 Ontario males found that the adjusted relative risk of mortality was significantly lower for those in the highest 20% income group as compared with the lowest 20% income group.[26] When the cumulative effects of high income, high social relationships and being a non-smoker were considered, there was an approximately 18 fold decrease in the risk of mortality. Similarly, differential mortality between 49 counties within Ontario was found to be dependant on both educational attainment and low income rates.[27] Health status has also

† Social class is defined as a collection of people with similar position and is generally measured by education, occupation and income. The classification system within Britain is based solely on occupation with the understanding that there is a clear hierarchy of occupations within British society and concepts such as skill requirements and "standing within the community" are utilized in establishing the hierarchy.

been shown to be associated with socioeconomic status in Canada. In 1995 Roberge et al found an association between socioeconomic status (SES), as measured by income and education, and health status based on data from the Ontario Health Survey with those in the middle-age group being most affected.[28]

Support for a causal relationship between income and health has been provided in both longitudinal and life course studies. Longitudinal studies generally found that long-term income was most influential with respect to health, as opposed to current income. Controlling for initial health status attenuated, but did not eliminate the relationship between income and health thereby supporting a causal relationship.[29,30] Two additional studies found that the association between income and health was present throughout the life course, with exposures in childhood and early adulthood being strongly linked to survival and adult morbidity.[31,32]

Evidence suggests that this relationship persists not only when considering the extremes of the socioeconomic spectrum, but throughout the range. The Whitehall study which examined the relationship between socioeconomic factors and the health of employees of the British civil service found that job hierarchy correlated with health, even in this group of relatively healthy, middle class workers.[33] In general, studies that have attempted to elucidate the nature of the relationship between income and health have found that there is an approximately linear relationship between the logarithm of income and health, except in those with very high and those with very low incomes. This means that increases in income for those with low incomes have the most impact, with diminishing returns at higher levels of income.[34,35,36]

Although the association between income and life expectancy has been demonstrated both within countries and in comparisons between countries, Wilkinson

found that when focusing only on those countries with the highest GNP (approximately $4000 to $5000 US per capita in 1984) the relationship between wealth and life expectancy was no longer present.[37,38] Countries such as Sweden and Japan have higher life expectancies than the United States, even though the United States has a greater absolute standard of living.[39] Through his analysis Wilkinson found that income inequality correlated more strongly with life expectancy, once a certain ceiling with respect to GNP was reached.

2.1.2 Income Inequality

The importance of income inequality implies that it is an individual's relative position in socioeconomic terms rather than their absolute position which is a concern. It has been proposed that in situations of high income inequality, those who are poor may view themselves as "worse-off" as a result of their relative economic position in addition to the impact of absolute wealth.[40] This more negative view may lead to psychological stress and reduced social cohesion, contributing to increased morbidity. It may also lead to more unequal distributions of healthcare and other resources with more restricted access for the poor as has happened within the United States.[41]

The following is a review of studies which have examined the association between income inequality and health or mortality focusing first on those studies at an ecological level and secondly on multilevel analyses. Although the relationship appears quite consistent at the level of comparisons between countries, the evidence is more conflicting as the association is tested at smaller geographic areas.

2.1.2.1 Ecological Analysis

Ecological comparisons of the impact of income inequality between developed countries support the conclusion that those countries with greater levels of income

inequality generally have lower life expectancies.[37,42,43,44,45,46] On average Canada has both a lower magnitude of income inequality and a greater life expectancy than both the US and the UK. Although some studies have shown that the inclusion of additional countries within Wilkinson's analysis significantly reduces the association, a relationship between income inequality within countries and infant mortality persists in most comparisons between countries.[47,48]

It appears from studies within the United States and the UK that income inequality may also affect health within some countries. A number of studies have found an association between both income inequality and mortality and income equality and health when comparing states and counties.[49,50,51,52,53] Regression models adjusted for poverty rates and median income found that a one percent increase in inequality, as measured by the Robin Hood Index [54,‡], was associated with an excess mortality of 21.7 deaths per 100,000 (95% confidence interval (CI) 6.6-36.7) based on a comparison between states of the United States.[41] Longitudinal studies from Britain have also shown that as income inequality has increased, so have health inequalities.[55,56]

It has been suggested that the association between income inequality and health or mortality is merely a statistical artifact resulting from a true relationship between individual income and health and mortality, which is non-linear in nature.[57] However, subsequent evidence has shown that the strength of the relationship between state level inequality and mortality is in excess of that predicted by the application of the statistical artifact theory.[58] This analysis, in combination with the multilevel analyses discussed in

‡ The Robin Hood Index is equivalent to "the maximum vertical distance between the Lorenz curve and the line of equal incomes where the Lorenz curve is a graphical device for displaying the cumulative share of total income accruing to successive income groups."

the next section, provide evidence which is supportive of the importance of the relative income hypothesis in comparisons between countries, US states and British counties.

Studies focusing on smaller geographical areas such as cities or census tracts and those utilizing data from countries that have more redistributive taxing policies than the United States have provided less clear results regarding the potential association between income inequality and health or mortality. Ross et al compared US and Canadian provinces and states and metropolitan areas and found that income inequality was associated with mortality in the US, but not in Canada.[59] They put forward the explanation that in situations such as exist in Canada, where income inequality is less linked to investments in health-related public infrastructure, the relationship with income inequality may break down.[59,60] A second Canadian study also did not find a meaningful relationship between income inequality and mortality in an ecological study of the coastal communities of British Columbia.[61] Likewise, studies in other countries with similarly redistributive taxation policies such as Denmark and New Zealand also did not find an association between regional income inequality and mortality once adjustments for individual risk factors were made.[62,63]

With respect to smaller geographical areas within the United States, two studies, one by Lynch et al and one by Soobader et al found an association between income inequality and health at the county level in the US; whereas, a study in 1997 by Fiscella et al did not.[64,65,66] When looking at the level of the census tract, the study by Soobader found that percent poverty, median income and individual income, as opposed to income inequality, were dominant correlates with perceived health.

Given that all of the studies discussed thus far are ecological in nature, they are not able to distinguish whether the associations between income inequality and health are

truly a result of the area level income inequality or whether they are a consequence of areas of high income inequality having a greater number of poorer people. The multilevel studies discussed in the following section help to distinguish these effects.

2.1.2.2 Multilevel Analysis

As with the small-area ecological studies, the results of multilevel studies examining the effect of income inequality within countries have been mixed. Income inequality as measured by the GINI coefficient[§] was found to be associated with poorer self-perceived health in a multilevel study comparing US states.[67,68] Daly also found a significant association between state-level income inequality and mortality after adjustment for individual income, but only in individuals between the ages of 25 and 64.[51] Similarly, a more recent multilevel analysis found a significant association between state-level income inequality and mortality risk of 1.12 (95% CI =1.04-1.19) in states with high income inequality as compared to those with low income inequality after adjustment for individual income.[69] At the community level, Fiscella et al found a significant association between income inequality, as measured by the median share, and self-rated health but not with mortality after adjusting for individual level income. Furthermore, they found that the effects of income inequality were mediated in part through psychological distress but not through biomedical morbidity assessed by a physician.[70] With respect to Canada, a significant association between health region income inequality in Ontario and health as measured by self-perceived health and a health-related utility questionnaire was demonstrated, after adjusting for individual level variables, including individual income in a multilevel study.[71]

[§] The Gini coefficient is an overall measure quantifying the degree of income inequality of a particular income distribution and can be derived directly from the Lorenz curve. The Lorenz curve represents the cumulative distribution of households against the cumulative distribution of income.

At the city level Blakely et al found an association between the level of metropolitan-area income inequality in US cities and self-rated health with the odds of poor/fair health being 1.20 (95% CI 1.04-1.38) in areas of high income inequality as compared with low income inequality after adjusting for age, gender, race and individual level household income. However, when average metropolitan-area household income was taken into consideration the association between income inequality and health was no longer statistically significant (OR 1.10, 95% CI 0.95-1.28).[72] As we move to smaller and smaller geographic areas questions arise about the relevance of income inequality. With respect to inequality within neighbourhoods Wilkinson made the following comment:

"Inequality is important in areas large enough to contain the salient social heterogeneity, but in small residential neighbourhoods composed largely of one social stratum, mortality is related to the average income: income differences within such neighbourhoods matter much less because the comparisons between social strata are lost. At the other end of the scale, between whole societies average income does not matter, because the social comparisons are within them rather than between them. Income distribution within societies continues to matter because it measures the extent of relative deprivation between social strata within the society." [73]

In other words, in situations where there is a small degree of income inequality, there is little sorting into neighbourhoods of those that are poor and those that are affluent and therefore the poor will benefit in a more equitable fashion from the contributions of all members of the neighbourhood. However, in situations where there is a large degree of income inequality, there is greater sorting of the poor and the affluent into neighbourhoods resulting in more homogeneous neighbourhoods that are either primarily poor or primarily

affluent.[65] Consequently, in examining the impact of neighbourhood socioeconomic characteristics on health, it may be that the concentration of poverty or segregation of the poor within neighbourhoods is an important determinant of health.

2.1.3 Neighbourhood Economic Characteristics and Health

Paralleling the rise in income inequality throughout the world, there has been an increasing spatial concentration of the poor, specifically within urban areas. According to Douglas Massey in his 1996 address to the Population Association of America, "urbanization, rising income inequality and increasing class segregation have produced a geographic concentration of affluence and poverty throughout the world, creating a radical change in the geographic basis of society".[74] Between the years of 1970 and 1990 the percentage of urban poor living in non-poor neighbourhoods decreased from 45% to 31% and the percentage living in poor neighbourhoods increased from 38% to 41% within the United States.[74]

2.1.3.1 Ecological / Individual Level Studies

Comparisons have been made between cities in both the United States and Canada with respect to the association between community economic characteristics such as the degree of economic segregation and both mortality and health. Most studies have found that there is an impact of community-level socioeconomic indicators over and above the impact of individual and family level socioeconomic circumstances, although individual and family level indicators tended to be stronger predictors of individual health. Robert used ordinary least squares logistic regression to study a nationally representative sample of adults within the United States and found an association between some community level socioeconomic measures, specifically percent of households receiving public assistance, families with an annual income of less than $30,000, adult unemployment and

a community disadvantage index with two measures of morbidity, the number of chronic conditions and self-rated health.[75] One study looking at whether the association between income inequality and health in 276 metropolitan areas in the US was mediated by the effects of residential segregation found that there was a significant association between both income inequality and mortality and residential segregation as measured by the Jargowsky Sorting Index[**,76] and mortality within US urban areas. The effect of income inequality did not appear to be mediated through residential segregation as both determinants were independently associated with mortality.[77] Within Canada, Wilkins grouped urban census tract neighbourhoods into quintiles based on the percentage of economic families below the low income cut offs and found that there was a negative association between neighbourhood poverty and life expectancy.[78]

2.1.3.2 Multilevel Studies

Multilevel studies have been completed in an effort to better understand the importance of contextual neighbourhood and compositional individual socioeconomic characteristics on health. Some studies have focused on both urban and rural areas whereas others are solely concerned with urban environments. It is likely that there are quite different mechanisms acting within these two environments which should be kept in mind when examining this literature.

In 2001, a critical review of multilevel studies of the effects of neighbourhood socioeconomic context on health outcomes published in English before June 1998, was

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** "The Jargowsky Sorting Index is a measure of economic segregation which is equal to the standard deviation of the neighbourhood income distribution over standard deviation of the household income distribution. The neighbourhood distribution of incomes is the distribution of households by the mean household income of the neighbourhood in which they live -- each neighbourhood is weighted by the number of households it contains. The household distribution of income is the distribution of households by their own income."

completed. The outcomes measured in the 25 studies, which included studies of urban neighbourhoods and studies of urban and rural neighbourhoods, were mortality, morbidity and health behaviours. Overall, the majority, 23 of 25 studies, found a modest, but statistically significant, effect of neighbourhood SES on individual outcomes after accounting for individual level characteristics.[79] Additional studies supporting these finding have been published more recently. A Swedish study which examined both rural and urban neighbourhoods throughout Sweden found that the context of living in deprived neighbourhoods contributed to increased self-reported long-term illness, but not to mortality risk. This association persisted even after controlling for individual socioeconomic status, age, housing tenure, marital status and social networks.[80] Complementary results were found in a second Swedish study which found that neighbourhood socioeconomic environment (as measured by the Care Need Index and the Townsend score) was associated with self-reported poor health after adjustments for individual level covariates including education.[81] A six year study focusing on the 86 urban neighbourhoods of Eindhoven in the Netherlands found that there was a higher risk of death in more deprived neighbourhoods as measured by the percentage of people with only primary schooling, engaged in manual labour, unemployed or with severe financial problems for both individuals with high SES and those with low SES. After adjustments for the same covariates at the individual level, there was a trend towards neighbourhood impacts; however they were no longer significant.[82] In addition to cross sectional studies examining the association between area poverty and health, a 9 year cohort study also found that poverty area residence and a neighbourhood social environment index which incorporated socioeconomic status, commercial stores and environment/housing were associated with an increased risk of declining perceived health status and increased

mortality, respectively, even after adjusting for individual level covariates in the Alameda County Study.[83,84] Summary measures of segregation that incorporate a variety of dimensions of segregation within city neighbourhoods have also been used in between city comparisons.[77] Waitzman compared the association between the "p index" of poverty, which measures the average across tracts of the probability of within-tract encounters between residents above and below the poverty line, in five US cities. After adjusting for individual covariates including age, race, education and household income they found that there was a significant association between economic segregation and mortality.[85]

In attempting to explain the mechanisms through which neighbourhoods may affect health, some studies have focused on the association between neighbourhoods the prevalence of specific diseases. A study focused specifically on cardiovascular outcomes at four United States study sites (Forsyth County, North Carolina; Jackson, Mississippi; Suburbs of Minneapolis and Washington County) utilizing census block groups of approximately 1000 persons as proxies for neighbourhoods, found that living in a disadvantaged neighbourhood was associated with increased risk of coronary heart disease even after adjusting for individual income, education and occupation.[86] Another study which provided greater understanding of the possible mechanisms through which urban neighbourhoods may affect health, specifically of an older population (>55 years of age) found that neighbourhood problems such as excessive noise, inadequate lighting and heavy traffic were associated with loss of physical functioning over a period of a year.[87]

A search of the literature revealed six multilevel Canadian studies which have examined neighbourhood effects on health. The first two studies looked at whether there were differences between neighbourhoods with respect to health after adjustments for individual level covariates. Pampalon found that there was significant variation in self-

perceived health at the local (census tract) level in the province of Quebec, after adjustments for both individual and household characteristics including age, gender, lifestyle factors, socioeconomic conditions, marital status and social support.[88] However, there was no significant variation at the health region level. Similarly, based on the Ontario Health Survey 1990, Boyle also found significant variation in health outcomes at the local level (enumeration area), but not at the public health unit level after individual and family adjustments.[89] The enumeration level explained 4.8% of the variation in health problems, 2.5% of the variation in quality of life (Health Utilities Index (HUI)), 1.2% of general well-being and 0.8% of family dysfunction.

The final four studies examined not only the variation that was present at the neighbourhood level, but also to what extent various neighbourhood characteristics explained the variance in health. A study utilizing the health region as the area level found that the risk of reporting self-rated health as poor or fair varied by health region; however, the majority of this variation was explained by individual factors. The extent to which contextual socioeconomic factors influenced the reporting of poor or fair health was modest in comparison with individual factors.[90] In a study by Ross of Montreal neighbourhoods, defined both by census tract and as "natural" neighbourhoods, three percent of the variation in health status as measured by the Health Utilities Index was attributable to the neighbourhood; however, none of the neighbourhood level variables considered in the study, including percent of lone parents, low education, household income and percentage of recent immigrants, significantly explained this variability. With respect to the definition of neighbourhood boundaries, they did not find a significant difference in results between the use of census tracts and the use of "natural" neighbourhoods.[91] Hou and Chen utilized both the neighbourhood low-income rate and

the coefficient of variation in order to assess the relationship between neighbourhood income and individual health in a multilevel study of census tract neighbourhoods in Toronto.[92] This study utilized data from the National Population Health Survey 1996/1997 and examined three outcome measures, self-perceived health, distress and frequency of chronic conditions. Poor self-perceived health, but not distress and chronic conditions, was found to be associated with neighbourhood socioeconomic characteristics. Somewhat conflicting results were found in a study based on the Nova Scotia Nutrition Survey which was longitudinal in nature, conducted over a 9 year period.[93] Neighbourhood socioeconomic characteristics (neighbourhood income, educational level, unemployment rate) were not associated with mortality in multilevel models. Because of multicolinearity between neighbourhood income characteristics, to test for interactions between neighbourhood and individual income, they conducted a separate analysis for advantaged and disadvantaged neighbourhoods and compared the odds ratios for the effects of individual income within these two groups. They found that individual income had a significantly greater effect on mortality in advantaged neighbourhoods as compared with disadvantaged neighbourhoods.

Overall, most studies have demonstrated that there is variation in health by neighbourhood in cases where the neighbourhood is defined either through census geography as the enumeration area or census tract, or as natural neighbourhoods based on factors such as historical context, resident's perception and real estate maps. In considering the relative impact of individual versus neighbourhood characteristics, most studies have found that the majority of variation is explained at the individual level and that the variation at the neighbourhood level is relatively small in comparison. The

following section is a discussion of the relevance of neighbourhood and the rational for conducting research into its impact.

2.2 Neighbourhoods

2.2.1 The Importance of Neighbourhoods

The focus of this research is not at a county, provincial or health region level, but rather at the level of the local neighbourhood in which people live and its impact on their health. Neighbourhoods are often the most immediate areas outside of an individual's household which may influence health. Particularly within larger cities, neighbourhoods continue to provide an important context of everyday life.[94,95] They influence people's feeling of safety and security through factors such as the local crime rate and occurrences of vandalism. They offer a social context in which people build friendships particularly through the provision of meeting places such as parks, community centres and cafés. The availability of bike paths and well kept sidewalks provide opportunities for exercise, while community newspapers and organizations act as avenues for political influence. In addition, people derive an understanding of their place in society through comparisons with their neighbours.

Given the context that neighbourhoods provide, it is not surprising that studies have demonstrated variability in health and healthcare usage between neighbourhoods.[96] Neighbourhoods with fewer resources are often deficient in many of the above mentioned characteristics which are important for both the physical and mental health of their residents.

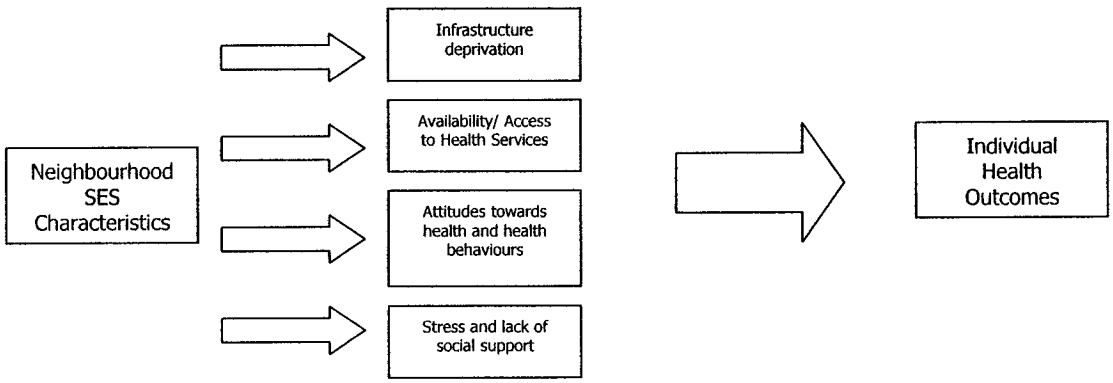
2.2.2 Proposed Mechanisms Through Which Neighbourhoods May Affect Health

Proposed mechanisms for an association between neighbourhoods and health may be divided into two general categories.[97] The first is material deprivation, which includes

lack of infrastructure and limited access to services and amenities. The second are psychosocial mechanisms including differences in attitudes towards health and health behaviors, stress and lack of social support and deficits of social capital (see Figure 2.1).

From a material standpoint, individuals in poorer neighbourhoods may be more deprived than those living in more affluent neighbourhoods. Poorer neighbourhoods generally have poorer housing, more polluted environments, fewer social amenities and

Figure 2.1: Conceptual Pathway[79,98,99,100]



worse working conditions.[101] The environment of poor neighbourhoods may also discourage healthy individual behaviours. Morland et al found that access to supermarkets selling healthy food was lower in poorer neighbourhoods.[102] There are often fewer facilities promoting health behaviors, including fewer gyms and exercise facilities, in poorer neighbourhoods.[103] Life opportunities may also be restricted in poor neighbourhoods which often contain low-performing schools whose school zone catchment areas are generally organized geographically.[104] These characteristics often encourage the flight of the middle and upper income families from poor neighbourhoods which further removes the tax base on which neighbourhood services rely. Furthermore, studies have shown that some characteristics of neighbourhood material deprivation have

negative impacts upon health. An analysis of 883 individuals in the Alameda County Study, a cohort study, found that certain characteristics of neighbourhood environments, specifically, excessive noise, inadequate lighting and heavy traffic, were associated with functional loss in elderly patients, over 55 years of age.[87]

Although the material deprivation theory may explain why the health of the poor is worse than that of the rich or middle class, it is difficult to rationalize the overall gradient in health based on this theory. The gradient persists when looking at middle, upper-middle and high income earners, with those with higher incomes generally being healthier than those in lower income groups. Yet, it is unlikely that poorer health in these situations is related solely to material deprivation, as those in the middle income brackets are not subject to the deprivations of those with the lowest income. Psychosocial processes have been proposed as an alternative or additional mechanism which is believed to be better able to explain differences in health due to relative measures of income, i.e. income inequality, throughout the income spectrum.

Psychosocial explanations for differences in health by neighbourhood socioeconomic status include increased frequency of stressful life events, poorer coping resources and lack of personal control over circumstances.[105] These factors may lead to increased incidence of depression and anxiety disorders. One study found that there was a higher prevalence of depression in poorer neighbourhoods with high concentrations of single female headed households as compared with more affluent neighbourhoods.[106] They also found that neighbourhood disadvantage was associated with adult depression after adjusting for individual characteristics, an association which was almost entirely mediated through perceived neighbourhood disorder. Faris and Dunham in a study of Chicago residents found that there were higher admission rates for schizophrenia the

closer to the inner city individuals lived.[107] They attributed the association to the higher levels of social isolation and disorganization producing higher rates of psychiatric illness in the inner city areas. These impacts may begin early in life as children growing up in neighbourhoods with high concentrations of poverty are often exposed to hostile environments which hold many temptations and few role models.[108] In an adolescent population, Aneshenel found that teenagers living in neighbourhoods in which they perceived greater ambient hazards, such as crime, violence, drug use and graffiti, had greater symptoms of anxiety, depression and deviant behavioral disorders.[109]

The majority of studies that have examined the potential for neighbourhood SES context to affect individual behavioural risk factors or attitudes have shown a significant impact.[110,111] Four of five studies examining smoking behaviour found an increased risk of smoking associated with low neighbourhood SES, with a relative risk of between 1.2 and 1.7. Studies have also found that communities differ with respect to seatbelt use, dietary fat consumption and alcohol consumption in either health behaviors or attitudes towards them.[8,112] Poorer neighbourhood conditions were associated with decreased intake of fish, vegetables and fruits and increased intake of meat in a study by Diez-Roux et al.[113] High neighbourhood rates of unemployment have also been shown to be associated with reduced physical activity in adolescent girls.[114] These finding support the potential importance of a contextual influence on health behaviours.

Recently a growing interest in the concept of social capital and its influence on health has developed. Social capital may be considered a psychosocial mechanism which is a resource of societies, distinct from the individual concept of social inclusion.[115] Social capital has been defined as "the resources available to individuals and society through social relationships" and includes "features of social organization, such as

networks, norms and trust that facilitate co-ordination and co-operation for mutual benefit.[3,40,116] Conceptually social capital includes aspects of the extent of trust people have in others, their level of social engagement in activities such as church, community projects and volunteer organizations and the scope of informal social engagement within a community through activities such as attending dinner parties or playing cards with neighbours. A large number of studies published recently have found that social capital is significantly associated with individual health (morbidity, mortality and violent crime).[117] Ross examined the association between sense of community belonging and self-perceived health as measured in the Canadian Community Health Survey 2000/2001 and found that there was an association with odds of 1.3 and 1.7 for reporting very good or excellent health in those with a somewhat strong and very strong sense of community as compared with those with a very weak sense of community.[118] There is also some evidence that the association between income inequality and mortality at the state level in the US may be mediated through divestments of social capital.[119]

This area of research has had its detractors. Pearce warned that too great a focus on social capital may lead to increased interventions directed at the community rather than the macrolevel social and economic processes that may be the overriding cause of the health inequalities resulting in the equivalent of "blaming the victim" at the community level and consequent community resentment and overloading of community resources.[120] Analysis thus far into the impact of social capital on health is still in its preliminary stages; however, if it does prove to be a significant determinant of health it is feasible to propose that economic segregation may work through influencing the stocks of social capital within a community.

It is unlikely that either material deprivation or psychosocial mechanisms independently explain the effects of neighbourhood income characteristics on health as they are not mutually exclusive but rather are likely to be acting together to differing extents in different neighbourhoods.

2.2.3 Definition of Neighbourhoods

One of the key issues in neighbourhood research is the definition of neighbourhoods. Neighbourhoods can be defined either spatially or socially.[121] Socially defined neighbourhoods are generally defined by the participants of a study based on their perceived social network. Retrospective studies generally do not have this option of defining neighbourhoods and therefore many studies utilize a spatial definition of neighbourhood. In considering a spatial definition of neighbourhoods one must take into account the neighbourhood processes that the study is attempting to capture while allowing for the limitations of the available data. The impact of segregation within a neighbourhood may be mediated through multiple pathways including economic, political, cultural and institutional processes, operating in the neighbourhood environment.[121] Small neighbourhoods maximize the potential for detecting differences between neighbourhoods given that the neighbourhoods themselves will be relatively homogeneous; however, they may not offer the heterogeneity that is required to measure the impact of segregation. Large neighbourhoods, on the other hand are better able to reflect the impacts of segregation; however, they tend to be more heterogeneous within the neighbourhood and therefore detecting neighbourhood effects is more difficult.

Due to the limitations of the methods of data collection, many previous studies have utilized census tracts as a proxy for neighbourhoods which is often the most convenient approach as it aligns with the data collection methods. In many cases census

tracts do not coincide with perceived neighbourhoods; however, they do represent relatively homogeneous populations which are in many cases divided by nature boundaries such as major roads, rivers or railroads. Reality is that no single definition of neighbourhood will satisfy the need for incorporating multiple neighbourhood processes. Whatever the size of the neighbourhood, defining neighbourhoods based on historical relevance and resident's perceptions is likely to produce neighbourhoods that are able to encompass the distinct culture histories and cultures present in urban neighbourhoods.

2.2.4 Neighbourhood Socioeconomic Measures

A number of neighbourhood socioeconomic measures have been proposed by Dolores Acevedo-Garcia and Kimberly Lochner in the book entitled "Neighborhoods and Health".[76] The majority provide overall summary measures for the dimensions of segregation for metropolitan areas thereby enabling comparisons between cities. When looking within cities at comparisons between neighbourhoods, it is less clear which economic characteristics of a neighbourhood may influence the health of residents. The most commonly used measures of socioeconomic status at the individual level are income, occupation and education. Income is a useful measure in assessing current socioeconomic conditions whereas education provides a more accurate view of long term socioeconomic exposures. Occupation is not used frequently outside of Britain as most countries do not have the well accepted occupational classification system of Britain.

Comparable measures have been developed for neighbourhood socioeconomic characterization which include the neighbourhood poverty rate and the extent of limited education. Although there is no established definition of poverty within Canada, Statistics Canada has established low income cut offs which are defined as the income level at which a family will tend to spend a significantly higher proportion of its income on food,

shelter and clothing than the average family and would therefore be considered to be in "straitened" circumstances. Therefore in Canada, the neighbourhood poverty rate is generally measured as the percentage of households below the low income cut off (LICO)[††].

The extent of limited education with a neighbourhood is generally defined as either the percentage of individuals who have not completed high school or the percentage who have completed high school, but have not gone further in their education, through enrolling in college or university. As many Canadians complete high school the latter of these two measures is used more commonly in Canada.

2.2.5 Changes in income characteristics in cities in Canada

The extent of economic segregation within Canadian neighbourhoods is significantly less than that seen in the United States; however, as in the US, it is growing. Evidence suggests that neighbourhoods in Canada's largest eight urban centres have increasing concentrations of poverty and there is an increase in the number of distressed neighbourhoods.[123] Myles et al examined the level and change in neighbourhood inequality and residential economic segregation in the eight largest Canadian cities over the 1980-1995 period.[124] They found that over this period income inequality rose in all cities as a result of declines in incomes in the poorest neighbourhoods (census tracts) and increased incomes in the richest neighbourhoods. Employment became increasingly concentrated in high income neighbourhoods. Economic segregation increased in five of eight cities and became a major factor by 1995 in four cities (Edmonton, Quebec City, Calgary and Winnipeg). Although social transfers had an impact on offsetting this trend, the effect was small, primarily because increases in transfers during the period were

[††] See page 47 for definition of LICO.

directed at seniors rather than low income families. The most recent study which examined the trends in neighbourhood poverty from 1986 through 1996 found that the majority of urban areas saw an increase in neighbourhood poverty with Saint John, Montreal, Quebec City and Winnipeg being the most severely affected. However, Ottawa-Hull, along with Hamilton and Saskatoon, were the next hardest hit with the sharpest increases being seen between 1991 and 1996 resulting in between 7-12% of neighbourhoods with greater than 40% poverty rates.[125,‡‡] This corresponded with an overall rise in poverty over the same period. A study which focused specifically on the variations in mortality by poverty level in the Quebec section of the Ottawa-Hull CMA, the Outaouais, in comparison with six other major urban centres within Quebec found that death rates were higher in urban census tracts in the Outaouais than in census tracts of comparable wealth in urban Quebec. The authors attributed this excess mortality to the relative poverty of the Outaouais section of the Ottawa-Hull CMA.[126]

2.3 Multilevel Analysis

Multilevel analysis allows for investigation of the determinants of health at various levels of aggregation and also for the examination of potential interactions between determinants at different levels. In many instances data are not independent, but are rather clustered or nested in groups or hierarchical in nature. For example, when looking at factors that may influence students test results, it may be important to take into consideration the hierarchical structure of the data. In this case, students may be considered to be nested within classrooms and classrooms within schools, etc. Similarly,

‡‡ The poverty rate is the percentage of the population who lives in poverty where poverty is defined as an economic family income below the Statistics Canada low income cut offs. Families spending 20 percentage points more than average on basic necessities would be below the low income cut offs. At the time of this study this included any family spending 56% of their gross income or more on basic necessities.

in analyzing the impact of socioeconomic environments on health, individuals may be considered to be nested within neighbourhoods, neighbourhoods within cities, cities within counties etc. Multilevel modeling is a statistical analysis technique which takes into consideration the hierarchical structure of the data and the fact that groupings of individuals often have commonalities with others within their group.

In many analyses it is the group or cluster of individuals which is of interest rather than, or in addition to, the individuals themselves. Historically, ecological analyses have been conducted which use the group as the unit of analysis rather than the individual; however, in some instances this has produced misleading conclusions due to the ecological fallacy. More recently, a new fallacy has been elucidated, namely the "atomistic fallacy". This results from the mistake of assuming that associations which are found at the individual level are also present at the group level.[127] For example, a positive association between income and health at an individual level may lead to the conclusion that at the contextual level of countries, those with higher mean incomes will have better health. However, at the contextual level there may be other factors which are characteristics of the groups that are modifying this relationship between income and health.[128] By taking into account the hierarchical structure of the data, multilevel modeling allows for a partitioning of the variation between the levels of analysis thereby allowing greater understanding of the impact of groups and individuals within them on the outcomes of interest.

A number of aspects relevant to the technique of multilevel modeling are discussed below, including: random intercept/random slope models, fixed and random effects, the hierarchical linear model, the hierarchical generalized linear model, intra-class correlation,

estimation methods, the test for extra-binomial variation, the Wald test statistic and the interpretation of ecological effects.

2.3.1 Random Intercept / Random Slope Models

There are two types of models which may be constructed in examining multilevel data. Depending on the hypothesis one is interested in testing, one may construct either a random intercept model or a random intercept / random slope model. The random intercept model assumes that the position of the regression line may differ from group to group; however, the relationship between the independent and dependent variables is consistent across groups. In the case of an analysis of the association between neighbourhood socioeconomic factors and individual health, the hypothesis that is being tested in this model is that the gradient in health between the rich and the poor is consistent across neighbourhoods; however, health is poorer in poorer neighbourhoods irrespective of individual wealth. On the other hand, in the random intercept / random slope model, both the position of the regression line and the relationship between the independent and dependent variables are permitted to vary between groups. This would be akin to a hypothesis that the gradient in health differs depending on the neighbourhood. For example it may be proposed that in wealthier neighbourhoods the difference in health between those who are poorer and those who are richer is smaller due to the beneficial impact of shared neighbourhood resources as compared with poorer neighbourhoods. In addition to considering the hypothesis to be tested, one must also consider the available sample size. There is a tendency for random intercept / random slope models to be unable to converge in situations where there is a limited sample size.

2.3.2 Fixed versus Random coefficients

In traditional regression analysis, the coefficients for the intercept and slope are assumed to be fixed and are estimated from the data. In multilevel modeling, on the other hand, one or both of the coefficients is assumed to be random at the first level (i.e. the micro-level) and therefore the coefficients for the level 2 effect vary randomly around an overall mean. The values of random coefficients are assumed to be distributed as a probability function. The random coefficient of the slope and intercept may be calculated in two parts. An overall coefficient is calculated which is estimated overall for all micro-level units, regardless of the group to which they belong. Secondly, a variance is calculated which represents the deviation of each group from the mean value of the slope or intercept. [127,129]

2.3.3 The Hierarchical Linear Model: [127,130]

For illustrative purposes the development of a model of a normally distributed continuous dependent variable and a single individual level and single group level independent variable is presented below.

At the first stage, a separate individual level regression which appears quite similar to the equation for simple linear regression, is defined for each group.

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + \varepsilon_{ij} \qquad \varepsilon_{ij} \approx \mathrm{N}(0, \sigma^2) \qquad \text{Equation 1}$$

where Y_{ij} is the outcome variable for the i^{th} individual in the j^{th} group
X_{ij} is the individual level independent variable for the i^{th} individual in the j^{th} group
β_{0j} is the group specific intercept
β_{1j} is the group specific slope.

With respect to the distribution of the individual errors it is assumed that they are independent, normally and identically distributed with a mean of zero and a variance

of σ^2. The presence of the j subscript for both the intercept and slope term indicates that these values are permitted to vary from group to group.

In the second stage, the group level regression coefficients for the slope (β_{1j}) and intercept (β_{0j}) are modeled as a function of group level independent variables.

$$\beta_{0j} = \gamma_{00} + \gamma_{01} Z_j + \delta_{0i} \qquad \delta_{0j} \approx \mathrm{N}\left(0, {\tau_{00}}^2\right) \qquad \text{Equation 2}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11} Z_j + \delta_{1i} \qquad \delta_{1j} \approx \mathrm{N}\left(0, {\tau_{11}}^2\right) \qquad \text{Equation 3}$$

where Z_j is a group level independent variable
γ_{00} is the common intercept for all of the groups
γ_{10} is the common slope for all of the groups
γ_{01} and γ_{11} are the effects of the group level independent variable on the group specific intercept and slope, respectively

The errors at the group level, δ_{0i} and δ_{1i}, are assumed to be normally distributed with a mean of zero and variances of ${\tau_{00}}^2$ and ${\tau_{11}}^2$, respectively. ${\tau_{01}}^2$ represents the covariance between the intercepts and slopes. The group-level error terms measure the unique deviation of each intercept and each slope for each group from the common intercept and slope after taking into account the effect of the independent group variable Z_j.

The overall model can be presented by substituting equations 2 and 3 into equation 1 as follows:

$$Y_{ij} = \gamma_{00} + \gamma_{01} Z_j + \gamma_{10} X_{ij} + \gamma_{11} Z_j X_{ij} + \delta_{0j} + \delta_{1j} X_{ij} + \varepsilon_{ij}$$

with the first four terms representing the fixed portion of the model and the last three representing the random portion.

2.3.4 Generalised Linear Model [131,132]

In the case where the dependent variable is a dichotomous variable, the assumptions of the linear model, specifically those regarding normality of the data and of homoscedastic error, are violated. Additionally, utilizing a normal regression equation may return values of greater than 1 or smaller than 0 which are impossible values for a proportion. An appropriate transformation which aims to achieve normality and reduce heteroscedasticity is the logit transformation:

$$f(X) = \ln(X/1-X)$$

where X is the probability of the outcome. The approach entitled the generalised linear model includes both the transformation of the data and the choice of the appropriate error distribution: binomial, in the case of proportions. These models may be defined by three components:

- the linear regression equation
- a specific error distribution
- a link function which is the transformation that links the predicted values for the dependent variable to the observed values.

Generalized linear models may be represented by the equation:

$$\Pi_{ij} = f(X_{ij}\beta_j)$$

where Π_{ij} is the probability of the outcome for the i-th individual in the j-th group, and f is the nonlinear function of the "linear predictor" $X_{ij}\beta_j$. For the logit link function the log odds have a normal distribution in the population of groups which may be represented by:

$$\text{logit}(P_j) = \gamma_0 + U_{oj}$$

where γ_0 is the population average of the transformed probabilities and U_{oj} are the random deviations from this average for each group which are assumed to be independent random variables with a normal distribution with mean of zero and variance τ_0^2. Unlike in the linear model, this model does not include a separate parameter for the level-one variance because the level-one residual variance follows directly from the success probability, as indicated by the equation:

$\text{var}(R_{ij}) = P_j(1 - P_j)$.

Also, in contrast to the linear regression where the level 1 residual variance is constant, the level 1 residual variance in the generalized linear model is interpreted as the average residual variance (i.e. the average of the residual variance in the population of all groups).

2.3.5 Intra-Class Correlation

In contrast to traditional regression models, multilevel modeling does not require the assumption that individuals are independent of each other but it takes into consideration the fact that individuals within groups may be more similar than those from separate groups. The degree of resemblance between micro-units (e.g. individuals) belonging to the same macro-unit (i.e. group) is represented by the intra-class correlation coefficient. It may be calculated in multilevel linear regression by dividing the population variance between macro-units by the total variance. In determining if there are significant differences between the macro-units of the analysis, one is testing the hypothesis that the intra-class correlation coefficient is zero.

2.3.6 Estimation Methods

Restricted iterative generalized least squares is the recommended estimation procedure for producing unbiased estimates in hierarchical generalized linear modeling in

cases where the sample size is small. Parameter estimation in hierarchical generalized linear models may utilize only the fixed parameters for the approximation in the case of MQL (marginal quasilikelihood) or it may use both the fixed and the random parameters in the case of PQL (predictive quasilikelihood). MQL is more stable; however, it tends to underestimate the values for both the fixed and random parameters. On the other hand, PQL produces more accurate fixed and random parameter estimates, even when the sample size is small. PQL has been shown to produce estimates close to the true value even in cases where the data set is very unbalanced (differing number of individuals per group) including the case where some level 2 units have only one level 1 observation.[131,132,133]

2.3.7 Test for Extra Binomial Variation [133]

When estimating multilevel generalized linear models, the level 1 random coefficient (error term) is defined with a zero mean and a variance which is constrained to equal 1. This implies that there is a binomial distribution. Any violation of this distribution can be tested by allowing for extra binomial variation in the model estimation procedure. Should the level 1 variance be significantly different from one when this procedure is used, it may indicate one of two problems with the model. Firstly, it may indicate that a level may have been eliminated which is an important cluster. For example, when more than one person is sampled from a household, leaving the household level out of the model may result in extrabinomial variation. Alternatively, it may indicate that an important level 1 variable has been left out of the model.

2.3.8 Wald Statistic

The Wald test statistic is used to determine if the parameter and variance estimates differ significantly from zero.[134]

$$W_j = \beta_j / SE(\beta_j)$$

Under the hypothesis that an individual coefficient is zero, these statistics will follow a standard normal distribution. In the case of the variance estimates, a one sided test is conducted given that the variance is not permitted to be negative.

2.3.9 Interpretation of Ecological Effects

Blakely suggests that there are three types of ecological effects which may be examined through multilevel modeling which include: cross-level effect modification, direct cross level effect and indirect cross level effect.[135]

In the case of cross-level effect modification, the ecological variable affects the relationship between the individual exposure and the individual health outcome. This may be tested by allowing for a random slope within the model and testing if the slopes differ between the level 2 groups. With respect to neighbourhood socioeconomic characteristics this would be equivalent to testing whether the impact of individual income is greater in poorer or more wealthy neighbourhoods. A significant sample size is required to examine the potential for cross-level effect modification.

A direct cross level effect is the result of the ecological variable directly affecting the individual outcome. In the multilevel model, the intercepts for the various groups would be significantly different; however, the slopes would not. In applying this to neighbourhood socioeconomic characteristics, this would imply that neighbourhood income characteristics directly affect individual health such that those in poorer neighbourhoods have poorer health than those in wealthier neighbourhoods, irrespective of their individual income.

Finally, in the case of an indirect cross level effect, adjusting for individual variables within the model will completely remove the significance of the ecological

variable indicating that the individual variables may be intermediary steps in the causal pathway between the ecological variable and the individual outcome.[136] Neighbourhood socioeconomic characteristics may affect individual health through impacting on individual exposures such as individual income and education or individual health behaviours.

Chapter 3: Study Design

3.1 Objectives of the Study

Primary Objective: The objectives of this study are:

- to examine the relative importance of neighbourhood concentration of poverty and individual risk factors on individual health within the urban portions of the City of Ottawa alone and the combined cities of Ottawa and Gatineau

Secondary Objective:

- to examine the importance of different measures of neighbourhood concentration of poverty, specifically low income and limited education, as determinants of health

Hypotheses:

- It is hypothesized that individuals living within neighbourhoods that have a high concentration of poverty will have poorer health than individuals living in neighbourhoods with a lower concentration of poverty

Implications:

Although Canadian metropolitan neighbourhoods remain less segregated than their US counterparts, evidence suggests that income segregation is increasing in most cities within Canada. Given this trend and the relative paucity of Canadian studies, the impact of economic residential segregation on the health of Canadians requires further study.

Should the concentration of poverty within cities be shown to negatively affect health, the results would provide further impetus to encourage development of integrated neighbourhoods in urban planning.

3.2 Materials and Methods

The focus of this chapter is to describe the materials and methods adopted to address the primary and secondary objectives of the thesis. In section 3.2.1, the study design and study population are described. In Section 3.2.2 information on the two sources for the data utilized in the analysis, the Canadian Community Health Survey 2000/2001 and the Census 2001 is provided. The dependant and explanatory variables at both the neighbourhood and individual level are described in section 3.2.3 and finally, section 3.2.4 details the methods of statistical analysis of the data.

3.2.1 Study Design

This study used multilevel modeling to examine the relative importance of the contextual effects of neighbourhood income characteristics and individual characteristics on individual health, as measured by self-perceived health and the Health Utilities Index score.

Health status = f (neighbourhood socioeconomic characteristics, age, gender, marital status, household income, education, immigrant status, physical activity, smoking, alcohol binge drinking)

Two analyses were completed, the first focused on urban neighbourhoods within the City of Ottawa and the second incorporated an expanded geography which included both urban neighbourhoods of the City of Ottawa and of the new City of Gatineau, both of which are contained within the Ottawa-Hull Census Metropolitan Area. Although the two cities are politically distinct at the municipal level, they are highly integrated, as a large proportion of people living in each city commutes to work in the other.

As discussed within the introduction, a key consideration in this analysis was the definition of neighbourhood. For the purpose of this analysis merged census tracts were used as a proxy for neighbourhoods. Census tracts are designed to be small, stable areas with relatively homogeneous socioeconomic characteristics, ranging in size from 2,500 to 8,000 people.[137] Identification of the boundaries of census tracts was initially conducted by a group of local specialists (e.g. planners, health and social workers, educators) in conjunction with Statistics Canada. The City of Ottawa has combined the census tracts to form 37 Ottawa City urban neighbourhoods that more closely reflect traditional perceptions of neighbourhoods within the city. These City of Ottawa neighbourhoods will be used for this analysis. With respect to Gatineau, neighbourhoods consisting of combined census tracts were created based on research into the structuring of the electoral districts, the real estate maps, and individual perceptions of neighbourhoods within this area. These neighbourhoods lined up closely with the boundaries of census tracts enabling appropriate grouping of the CCHS data.

Rural neighbourhoods were excluded from the analysis given that the concept of residential segregation and concentrated poverty are generally only applied to urban areas as their meaning with respect to rural areas is less clear.[138]

3.2.1.1 Sample Size

Establishing an appropriate sample size for a hierarchical model with random intercepts is challenging. It depends not only on the effect size but also on the level of intra-class correlation when the variance of the response variable is divided into within and between parts. Monte Carlo simulation methods have been used in some studies to evaluate the power of multilevel modeling. In a study by Bassiri which examined the required sample size to detect cross-level interactions, they found that at least 30 groups

Table 3.1: Ottawa and Gatineau City Neighbourhoods Showing Population and Sample Size in the Canadian Community Health Survey 2000-2001

Neighbourhood Name	Population	Sample Size
Ottawa		
Alta Vista	28966	60
Beaconhill	18478	53
Beaverbrook/Marchwood	11389	11
Blossom Park/ Windsor Park	16074	16
Bridlewood	16346	19
Carleton Heights	8974	43
Carlington	12593	57
Centretown	24779	56
Clementine	3929	15
Convent Glen	16634	16
Copeland	25094	42
Cyrville	15135	27
Dalhousie	12836	30
Glebe	11369	46
Glencairn	9085	20
Hunt Club East	29491	56
Hunt Club West	15267	14
Katimavik/ Hazeldean	14907	50
Lower Town	11134	29
Nepean Central	28637	46
Nepean East	34379	128
Nepean North	11904	9
Orleans East	40209	62
Orleans South	27852	66
Ottawa East	5865	30
Ottawa North East	20735	37
Ottawa South	8160	30
Ottawa South East	4249	6
Ottawa West	22476	83
Overbrook	9839	77
Pinecrest/ Queensway	34600	56
Riverside Park	5211	17
Riverview/ Hawthorne	15600	39
Rockcliffe Park	2028	6
Sandy Hill	13232	42
Vanier	17632	30
Westboro	7372	17
Total	**612460**	**1441**
Gatineau		
Aylmer	12815	9
Lucerne	12539	79
Deschenes	10731	34
Val Tetrea	14467	20
Wright-Montagne	12149	92
Oree-du-Parc	14723	33
St-Raymond-Vanier	16412	67
Hull	8495	49
Riverains	8217	66
Promenades	19381	67
Versant	13133	40
Bellevue	18061	12
Lac-Beauchamp	17578	78
Riviere-Blanc	11839	65
Total	**190540**	**711**

and 30 observations per group are needed.[139] If the number of groups is increased to, for example, 60, then fewer observations (i.e. 25) per group are needed. If, on the other hand, there are few observations per group, say 5 observations, then a larger number of groups (i.e. 150) would be required.[140]

The urban portion of the City of Ottawa consists of 37 neighbourhoods with the CCHS sample size per neighbourhood ranging from 6 to 128 with a mean of 40. The Gatineau region consists of 14 neighbourhoods with a sample size ranging from 9 to 92 with a mean of 51.

3.2.2 Sources of Data

3.2.2.1 Canadian Community Health Survey:

The source for the individual level health data was the Canadian Community Health Survey (CCHS) conducted in 2000/2001, which has been described in detail elsewhere.[141] Briefly, the primary objective of this survey, conducted by Statistics Canada, was to provide cross-sectional estimates of health determinants, health status and health system utilization at the health region level. The target population for the survey was household residents in all provinces and territories aged 12 years and older. In most cases one person per household was randomly selected for inclusion in the study. Two persons per household were selected from some households to allow over-sampling of youths, as planned. Populations on Indian Reserves, Canadian Forces Bases, persons in institutions and some remote areas were excluded from the survey. The survey covered approximately 98% of the Canadian population over the age of 12 years.[142] With respect to the Ottawa Carleton Health Region, 1728 individuals were included in the survey. Removal of the rural areas reduced the sample size available for analysis to 1441

individuals. The sample size from the Outaouais Health Region which includes the city of Gatineau was 1061, which reduced to a sample size of 711 after removal of rural areas.

3.2.2.1a Sample Selection

The sample allocation strategy for the CCHS consisted of three steps. In the first two steps, the sample was allocated among the provinces according to their respective populations and the number of Health Regions they contain. In the third step, each province's sample was allocated among its health regions in proportion to the square root of the estimated population in each health region.

Three sampling frames were used for the sample of households. The majority, eighty three percent, were selected from an area frame; however, random digit dialing (7% of sample) and a list frame of telephone numbers (10% of sample) were also used. For the area frame, a multistage stratified cluster design was implemented in which the province is first divided into three types of regions: major urban centres, cities and rural regions. For the urban centres, geographic or socioeconomic strata were then created within which, clusters were created by grouping 150-250 dwellings. In each strata six clusters or residential buildings were chosen by a random sampling method with probability proportional to size, where the size corresponds to the number of households. In the second stage, dwelling lists were prepared for each cluster and dwellings or households were selected from the lists. Respondents were then randomly selected from the sampled households.

3.2.2.1b Response Rate

The overall response rate for all of Canada was 85%. For the Ottawa-Carleton Health Region and the Outaouais Health Region the response rates were 88% and 84%, respectively.[143] A number of steps were taken in order to minimize non-response. These

included measures such as numerous call-backs to individuals were weren't home on the initial contact and written follow-up stressing the importance of the survey for those individuals who refused to participate. During the final months of data collection those who were non-respondents and those who refused to participate were again contacted and encouraged to participate in the survey.[144]

3.2.2.1c Sample Weighting

The probability sampling design used for the CCHS sample is based on the principle that each individual selected represents not only him or her self, but also a number of other individuals. The number of individuals represented by each sampled individual is adjusted for using the sample weights which are provided on the data file. Therefore to calculate population estimates from the data, the sampling weight must be used in the calculations.[145] Utilization of the weights takes into account the unequal probability of sampling thereby ensuring that the estimates produced are correct; however, they do not take into account the clustered sampling and therefore do not adjust for the design effect upon the variance.

3.2.2.1d Design Effect

The design effect is a factor which represents the multistage, clustered nature of the sample design. The design effects for both the Ottawa-Carleton and the Outaouais Health Regions are relatively small and are estimated at 1.49 and 1.45, respectively.[146]

3.2.2.1e Data Release

Statistics Canada Guidelines for release of data from the CCHS state that in order to ensure precision of estimates and confidentiality of individuals, estimates based on sample sizes of less than 30 should not be released. The lowest level of aggregation for which estimates are presented is the level of an aggregation of census tracts. Census tracts

range in size from 2,500 to 8,000 and therefore presentation of these data does not jeopardize individual confidentiality.

3.2.2.2 Census 2001

Area level information for neighbourhoods was sourced from the 2001 Census. The Census of Population provides information regarding demographic, social and economic characteristics for Canada, for each province and territory, and for smaller geographic units such as cities or districts within cities. The Canadian Census is conducted every five years. It aims to provide 100% coverage of the population with completion required by law. In 2001 80% of households received a short questionnaire containing seven questions and 20% of households were given the 59 question long form. Self-enumeration was completed in 98% of households and 2% were enumerated by interview, generally in remote areas and Indian reserves. Through audits, errors are identified and attempts are made to resolve them through contacting the respondent. Any errors or missing values that are not resolved by contacting the respondent are imputed using either a "deterministic" or "minimum change hot deck" approach via computer. Weights are then applied to the 20% sample in order to apply the sampled information to the entire population. From a data release perspective the lowest level of aggregation utilized in this analysis was the dissemination area, which is well above the minimal aggregation required to allow release of estimates while maintaining individual confidentiality.[147]

3.2.3 Dependant and Explanatory Variables

3.2.3.1 Dependant Variables: Health Status Measures

The two measures of health status studied in the analysis are self-perceived health and the Health Utilities Index (HUI). Exploration of data from Canadian health surveys revealed that these outcome measures were most significantly affected by income.

3.2.3.1a Self-perceived Health (SPH)

A person's self-perceived health is elicited by asking participants how they would rate their health, in general, at the time they are asked the question. The five possible ratings are excellent, very good, good, fair and poor. Unlike the HUI, which is focused to a large extent on functional capacity, SPH provides a more subjective assessment of health. It allows individuals to incorporate a judgment about their quality of life in their assessment and therefore may be highly influenced by a person's coping skills, their ability to adapt to their environment, the support they have and the people with whom they compare themselves. As a simple measure of health, it is not as reliable or valid as other more complex indices; however it is regarded as an adequate and powerful global health measure.[88] It has been shown to be closely linked to morbidity as reported in surveys and diagnosed in clinical examination and to restrictions in activities.[148,149,150,151,152] It captures not only a person's current health, but it has also been shown to be a strong predictor of mortality and utilization of health services. [151,153,154,155,156] The global nature of this measure is thought to reflect a holistic evaluation of health which is reflective of the World Health Organizations definition as a "complete state of physical, mental and social well-being".[156]

3.2.3.1b Health Utilities Index Mark 3

The Health Utilities Index (HUI) is a generic health index that is able to measure both health status and health-related quality of life.[157] The Mark 3 version of the index, developed at McMaster's University's Centre for Health Economics and Policy Analysis, provides a description of an individual's overall functional health, based on eight attributes: vision, hearing, speech, ambulation (ability to get around), dexterity (use of hands and fingers), cognition (memory and thinking), emotion (feelings), and pain. Each of the attributes has between 5 and 6 levels ranging from unrestricted to a highly disabled state.[157] Utility weights derived using both a visual analogue scale and standard gamble are then used to calculate a single utility measure for each individual ranging from –0.360 to 1, with 0 representing death and 1 representing perfect health. States worse than death have a negative utility value. The following multi-attribute utility function is used to combine the attribute scores:

$$HUI\ score = 1.371 * \prod_{i=1..6} u_i - 0.371$$

The scores reflect society's preferences for specific health states based on a random sample of 500 people from the City of Hamilton-Wentworth, Canada.

As a large portion of the population, approximately one third, has a HUI score of 1 representing full health, the distribution of HUI scores for the population is not normal. Therefore, for this analysis the HUI score was dichotomized into a category for those with scores less than 0.973 and those with scores equal to or greater than 0.973. The choice of this cut-off value was based upon the fact that most values between 0.973 and 1 are associated with vision-related problems which include wearing glasses and contact lenses. For example, a person who is nearsighted, yet fully healthy on all other attributes receives

a score of 0.973. Given that these health problems are almost uniformly resolved within Canadian society through the wearing of optical eyewear, it seems reasonable to dichotomize this variable at 0.973.[158]

3.2.3.2 Explanatory Variables:

3.2.3.2a Neighbourhood/Group Level

The main explanatory variable is the neighbourhood socioeconomic characteristics including both a neighbourhood low income measure and a neighbourhood low education measure. The low income measure used in the analysis was the percentage of economic families within a given neighbourhood with incomes below the Statistics Canada Low Income Cut Offs (LICOs). Neighbourhood income data was derived from the 2001 Census, with calculations based on post-transfer, pre-tax income. With respect to education, the percentage of individuals over 20 years of age completing up to a high school education was used as the neighbourhood measure. More details regarding these measures is provided in the following sections.

The impetus for this thesis comes from an interest in the impact on health of the trend towards concentration and separation of poverty and wealth within urban neighbourhoods. In establishing appropriate neighbourhood exposure measures a logical place to start is within the literature focused on economic segregation. Massey and Denton proposed five dimensions to characterize the degree of urban segregation including: dissimilarity, isolation, concentration, centralization and clustering.[159] There are a number of summary measures based on these dimensions that capture the extent of segregation within metropolitan areas such as the Jargowsky Neighbourhood Sorting

Index, the Dissimilarity Index[§§], the Isolation Index[***] etc.[76] These indices are useful in comparing the extent of segregation between cities. However, they have not been applied to comparisons between neighbourhoods within cities as this would involve examination of subregions within neighbourhoods which is unlikely to produce measures that are meaningful.[17,108] Alternative measures of neighbourhood socioeconomics which are meaningful in comparisons between neighbourhoods and which will be utilized within this thesis are the neighbourhood low income rate and the neighbourhood low education rate.[†††]

Neighbourhood Low Income

Given the hypothesis that the health of poor will be influenced by the concentration of poverty within their resident neighbourhood, the neighbourhood low income proportion was expected to provide the most direct measure by which to test this hypothesis. Neighbourhood low income is often defined as the proportion of economic families with each neighbourhood with a family income below Statistics Canada low income cut offs (LICOs).[160,161] Low income cut offs are a relative measure of socioeconomic status which are used to distinguish "low income" family units from "other" family units. "Low income" families are defined as those economic families or unattached individuals who spend 54.7% or more of their income, which is 20% more than average, on basic necessities of food, shelter and clothing.[162] The base value for the LICOs is derived from the 1992 Family Expenditure Survey, which showed that the average family spent 35% of its before-tax income on food, shelter and clothing.

[§§] "The dissimilarity index may be interpreted as the proportion of the minority economic group of interest that would need to move across sub-units in order to achieve an even distribution."

[***] "The isolation index measures the extent to which a member of a minority group (i.e. those in poverty) is likely to be in contact with members of this same group (as opposed to members of other groups)."

[†††] The neighbourhood low income rate and the neighbourhood low education rate are, in fact, proportions; however, the terminology of "rates" will be used within this thesis as it is the conventional terminology.

Therefore the threshold is set at 64%, which is the value at which it is expected that families would be considered "in strained circumstances". This value is then converted into a set of LICOs varying with family and community size. The adjustment for family size takes into account the economies of scale which result from reduced per person shelter costs with increasing family size. For example, it is expected that the per person shelter costs for a family of four would not be double the per person shelter costs of a family of two.[162]

Neighbourhood Low Education

Neighbourhood low education is defined as the percentage of individuals 20 years of age or older who completed no more than high school education. Extent of education greatly affects the types of jobs people obtain, the likelihood of being employed and the level of employment income. The 2001 Census showed that people with a bachelor's degree were more likely to have higher earnings than high school graduates.[163] In contrast to the neighbourhood low income measure which provides a reflection of the current socioeconomic status, neighbourhood low education provides a more long term view of socioeconomic status. This is due to the fact that educational attainment is generally determined in early adulthood; however, it influences an individuals socioeconomic status throughout their life.

3.2.3.2b Individual Level

Individual level variables which were incorporated in the model may be grouped into three categories, namely, demographic characteristics, behavioral characteristics and socioeconomic characteristics. The demographic characteristics included age, gender and marital status. The behavioral characteristics included smoking, physical activity and alcohol consumption. Lastly, the socioeconomic characteristics included household

income, education attainment and recent immigration. All of these variables have been shown in the past to be related to health outcomes. The treatment of the individual variables in the multilevel analysis was based upon a combination of a literature review and preliminary single level analysis. The literature review provided a perspective on how previous authors of papers within the same field of study had treated the covariates while the descriptive and logistic analysis provided evidence of the association between the individual level variables and the outcomes of interest.

All models were age adjusted with age being entered into the model as a categorical variable. The five categories which were created were age 12-19, 20-34, 35-49, 50-64 and 65 years or greater.

Information on household income was requested within the CCHS through a series of questions asking people to identify into which group their household income falls based on the income, before taxes and deductions, of all household members from all sources in the past 12 months. The household income was then grouped into categories of low, low-middle, upper-middle and upper income taking into consideration both the income and the number of members of the household. *(See table 3.2)*

Table 3.2: Household Income Categories, Canadian Community Health Survey 2000-2001

Income Category	Household Income by Number of Household Members
Lowest	< $15,000 if 1 or 2 people
	< $20,000 if 3 or 4 people
	< $30,000 if 5 or more people
Lower-middle	$15,000 - $29,999 if 1 or 2 people
	$20,000 - $39,999 if 3 or 4 people
	$30,000 - $59,999 if 5 or more people
Upper-middle	$30,000 - $59,999 if 1 or 2 people
	$40,000 - $79,999 if 3 or 4 people
	$60,000 - $79,999 if 5 or more people
Upper	≥$60,000 if 1 or 2 people
	≥$80,000 if 3 or more people

Respondents who were over the age of 20 were grouped with respect to education into three categories, one for those who had not completed high school, one for those who had completed their high school diploma, but had not pursued further study, and one for those who had pursued further post-secondary study. Those individuals less than 20 years of age were considered to be in the process of completing high school. Smokers included those individuals who reported smoking daily with all others being classified as non-smokers. Those who participated in daily physical activity of at least 15 minutes' duration were classified as active with all others classified as not active. Individuals were classified as heavy drinkers if they drank 5 or more alcohol drinks in a sitting on at least 12 occasions over the past year. All others were classified as non-binge drinkers. *(See Table 3.3 for listing of categories and sources of explanatory variables)*

3.2.4 Statistical Analysis

Two analyses were conducted, the first for the 37 urban neighbourhoods of the city of Ottawa and the second for the 51 urban neighbourhoods for the Ottawa-Hull Census Metropolitan Area. The primary ecological unit of analysis was the derived neighbourhoods based on groupings of census tracts which approximate residents' perceptions of neighbourhoods. The first step was to confirm that there is an income based gradient at the individual level for the two health outcome measures. Simple logistic regression was then utilized to evaluate the association between the outcome measures and the neighbourhood level variables while adjusting for individual level determinants. The final step was to conduct a multilevel analysis to examine the importance of the neighbourhood and individual level variables. Details of the analysis steps are presented below.

The following are the steps in the analysis:

1. Descriptive Analysis: The distribution of selected variables and respondent characteristics by the health outcomes was explored.

2. Age-Standardized Plots: Age-standardized prevalence of poor/fair self rated health and health utility scores less than 0.973 were plotted against the neighbourhood characteristics.

3. Logistic Regression: The neighbourhood level exposure variables were regressed against the outcome measures while adjusting for individual level demographic, socioeconomic and behavioural variables.

4. Multilevel Analysis: The software package, MLWin version 2.1a, was used for the multilevel analysis as it is able to accommodate the hierarchical structure of the data. Multilevel logistic regression models were utilized to examine the relationship between self-rated poor/fair health and the Health Utility Score (<0.973) and both neighbourhood socioeconomic characteristics and individual level characteristics. The method of estimation was restricted iterative generalized least squares (RIGLS). Joint two sided Wald tests were utilized to assess the significance of the fixed parts of the models. The significance of the random part was assessed utilizing a one-sided Wald test as the variance is by definition non-zero. A weighted analysis was conducted in order to incorporate the impact of unequal probability sampling. Standardized weights defined as the population weights divided by the average weights for responses from all subjects were utilized at the individual level, whereas neighbourhoods were weighted at unity.

Table 3.3: Categories and Source for Explanatory Variables

Variable	Data Source
Neighbourhood	
Low income	Census 2001 (20% sample)
Low education	Census 2001 (20% sample)
Individual	
Demographic	
Age	CCHS 2000/2001
10-19	
20-34	
35-49	
50-64	
≥65	
Gender	CCHS 2000/2001
Male	
Female	
Marital status	CCHS 2000/2001
Married/common-law/partner	
Single/widowed/separated/divorced	
Socioeconomic	
Income	CCHS 2000/2001
Low	
Low-middle	
Upper-middle	
Upper	
Education	CCHS 2000/2001
Less than high school	
High school graduate	
Post-secondary	
Immigrant status	CCHS 2000/2001
Immigrated <10 years ago	
Others	
Behavioral	
Smoking	CCHS 2000/2001
Daily smoker	
Others	
Physical activity	CCHS 2000/2001
Daily exercise	
Others	
Alcohol consumption	CCHS 2000/2001
Regular heavy drinker	
Others	

Modeling Strategy:

A four stage modeling strategy was utilized. The modeling strategy was designed to allow assessment of the importance of each of the neighbourhood SES and individual characteristics independently in addition to the relative importance of the combination of

individual characteristics versus the neighbourhood characteristics and finally the importance of both levels of characteristics within a single model.

Model 1: Empty Model – this model, which contains no explanatory variables, partitions the variance between the two levels (the individual and neighbourhood levels). This model provides information on the relative importance of individual versus neighbourhood characteristics in explaining the variance in outcomes. It is utilized as a baseline against which future models are compared in order to determine how much neighbourhood level variance is explained by the models.[164]

Model 2: Independent models for each of the explanatory variables were constructed. The neighbourhood level explanatory variables were examined in separate models; whereas the individual level variables were grouped into three categories and each of the categories was examined in separate models. The three categories of individual variables were socioeconomic which included income, education and immigrant status, behavioural, which included alcohol consumption, physical activity and smoking, and demographic which included gender and marital status. All models were age adjusted. The independent effect of each group of individual variables and each contextual level variable on the outcome can be assessed through this series of models.

Model 3: The groups of individual variables were incorporated in the models containing the contextual level variables. These models allow an assessment the relative importance of individual and neighbourhood level variables in addition to providing insight into pathways through which neighbourhood effects may be mediated.

Model 4: Both individual level and neighbourhood level variables are included in this final model. This model allows one to determine if after adjustment for individual level variables there is an independent effect of neighbourhood variables or if the

neighbourhood variability is explained through differences in the characteristics of individuals within the neighbourhoods. The results of the multilevel analysis were compared with the traditional single level logistic regression models.

The method utilized for parameter estimation was second order predictive quasi-likelihood (PQL). With this method, the approximation is around the fixed and random parts of the model.

Chapter 4: Results

The following section presents the results of the investigation. The results for the City of Ottawa alone are presented first followed by the combined analysis of the City of Ottawa and the City of Gatineau. The order of the presentation of the results for each region begins with the descriptive analysis of the sample followed by the regression analysis. Within the section focusing on the multilevel logistic regression, the neighbourhood low income analysis is presented, firstly with self-rated health as the outcome and secondly with the Health Utilities Index as an outcome, followed by the neighbourhood low education analysis with the same two outcomes. See Table 4.1 for description of models.

4.1 Ottawa

4.1.1 Description of Sample

The CCHS included 130,827 respondents, of whom 2096 were within the City of Ottawa. Exclusion of rural neighbourhoods left 1441 individuals and 37 neighbourhoods for inclusion in the Ottawa portion of the study. The sample sizes from the City of Ottawa neighbourhoods ranged from 6 to 128 with a mean of 39 (SD=25) which is in line with the required sample size for multilevel analysis.

4.1.2 Characteristics of Area-level Variables

The mean percentage of economic families below the LICO per Ottawa neighbourhood was 15% with a standard deviation of 9% and ranged from 3% to 36%. The mean percentage of individuals completing no more than high school education per Ottawa neighbourhood was 27% with a standard deviation of 10% and ranged from 9 to 47. The

neighbourhood percentage of households below the LICO was correlated with neighbourhood education (Pearson's correlation coefficient 0.64).

Table 4.1: Description of Multilevel Models

Model Title	Description
SRH/ LICO/ OTTAWA	This model uses self-rated health as the outcome measure and the neighbourhood low income rate as the neighbourhood exposure measure to analyse the urban neighbourhood of the City of Ottawa.
HUI/ LICO/ OTTAWA	This model uses the Health Utilities Index as the outcome measure and the neighbourhood low income rate as the neighbourhood exposure measure to analyse the urban neighbourhood of the City of Ottawa.
SRH/ EDUCATION/ OTTAWA	This model uses self-rated health as the outcome measure and the neighbourhood low education rate as the neighbourhood exposure measure to analyse the urban neighbourhood of the City of Ottawa.
HUI/ EDUCATION/ OTTAWA	This model uses the Health Utilities Index as the outcome measure and the neighbourhood low education rate as the neighbourhood exposure measure to analyse the urban neighbourhood of the City of Ottawa.
SRH/ LICO/ OTTAWA-GATINEAU	This model uses self-rated health as the outcome measure and the neighbourhood low income rate as the neighbourhood exposure measure to analyse the urban neighbourhood of the City of Ottawa and Gatineau combined.
HUI/ LICO/ OTTAWA-GATINEAU	This model uses the Health Utilities Index as the outcome measure and the neighbourhood low income rate as the neighbourhood exposure measure to analyse the urban neighbourhood of the City of Ottawa and Gatineau combined.
SRH/ EDUCATION/ OTTAWA-GATINEAU	This model uses self-rated health as the outcome measure and the neighbourhood low education rate as the neighbourhood exposure measure to analyse the urban neighbourhood of the City of Ottawa and Gatineau combined.
HUI/ EDUCATION/ OTTAWA-GATINEAU	This model uses the Health Utilities Index as the outcome measure and the neighbourhood low education rate as the neighbourhood exposure measure to analyse the urban neighbourhood of the City of Ottawa and Gatineau combined.

4.1.2.1 Self-reported Health: Association with Individual-level Variables

All of the 1441 respondents to the CCHS who resided in the urban Ottawa neighbourhoods provided responses to the question regarding self-reported health and

therefore all were included in the analysis. Table 4.2 presents the characteristics of the sample for Ottawa as well as the number and percentage of individuals who rated their health as fair or poor for each category.

Overall 12% of individuals (n=169) reported their health as fair or poor; whereas 88% reported their health as good, very good or excellent in Ottawa. As expected the percentage of people reporting fair or poor health increased with age. Poor or fair health was reported slightly more frequently by females as compared to males and by those who were married as compared with unmarried. Smokers, those who were inactive and regular heavy drinkers also reported poor/fair health more frequently. With respect to socioeconomic variables, people with lower incomes and those with lesser education were more likely to report poor/fair health. Lastly, immigrants were less likely to report poor/fair health.

4.1.2.2 Health Utility Index: Association with Individual-level Variables

Of the 1441 respondents to the CCHS within urban Ottawa neighbourhoods, 16 did not provide responses to the HUI and they were therefore excluded from the analysis. Of the 1425 individuals included in the analysis 53% rated their health as <0.973 on the HUI which represents individuals with less than perfect health not including those whose eyesight may be corrected by eyewear. *(see Table 4.3)*

As with self-rated health, smokers, females, inactive individuals, binge drinkers, those with lower individual incomes and those with lesser education were more likely to report lower HUI scores. Although those 65 years of age and older had lower HUI scores than younger ages, the age gradient was not as clear as it was for self-rated health. Unlike with self-rated health, single people reported low HUI scores more frequently than

married individuals. The frequency of reporting low HUI scores was slightly more frequent in immigrants in Ottawa compared with non-immigrants.

4.1.3 Missing Data

In cases where data for the outcome was missing, the individual was excluded from the analysis. For Ottawa there were no individuals missing the outcome of self-reported health; whereas there were 16 individuals missing information regarding the HUI. In cases where the values of the independent variables were missing, dummy variables were created and included in the analysis. A sensitivity analysis was also conducted which consisted of completing the analysis with all of the missing data coded as high risk and completing the analysis with all of the missing data coded as low risk to determine the influence of missing values on the results.

Of the 1441 individuals who responded to the question regarding self-rated health and the 1425 individuals who had HUI scores, 106 (7.4%) did not report their income. Of those who did not report their income, 19% of them reported poor or fair health and 61% reported a HUI score of less than 0.973. Older individuals were less likely to report their income and those with higher education (greater than high school) were more likely to report their income.

Activity and alcohol binge drinking were unknown for 109 and 341 individuals, respectively. A higher percentage of poor health was reported by those individuals who were missing full data. In the case of the other individual variables, marital status, education, immigrant status and smoking, fewer than 10 individuals were missing data. For all variables, except marital status and smoking, dummy variables were created in order to allow these variables to be kept within the multilevel model. Due to the low number of missing data for marital status and smoking and their skewed distribution the

Table 4.2: Prevalence of self-reported fair or poor health by various risk factors, Ottawa, Canadian Community Health Survey 2000-2001

	Number	Fair/poor	Percent
Overall	1441	169	12.01%
Individual-level Variables			
Age (years)			
10-19	198	8	4.04%
20-34	366	15	4.10%
35-49	390	37	9.49%
50-64	268	48	17.91%
≥65	219	59	26.94%
Gender			
Male	660	73	11.06%
Female	781	94	12.04%
Marital Status			
Married/common-law/partner	776	95	12.24%
Single/widowed/separated/divorced	664	71	10.69%
Missing	1	1	100.00%
Income			
Low	181	47	25.97%
Lower-Middle	221	36	16.29%
Upper-Middle	340	32	9.41%
Upper	593	32	5.40%
Missing	106	20	18.87%
Educational attainment			
Less than high school	167	57	34.13%
High school graduate	197	32	16.24%
Post-secondary	873	69	7.90%
In high school (≤19 years of age)	198	8	4.04%
Missing	6	1	16.67%
Immigrant			
Immigrated <10 years ago	125	10	8.00%
Others	1307	155	11.86%
Missing	9	2	22.22%
Smoking Status			
Daily smoker	242	56	23.14%
Others	1194	111	9.30%
Missing	5	0	0.00%
Activity			
Daily exercise	476	42	8.82%
Others	856	109	12.73%
Missing	109	16	14.68%
Alcohol			
Regular heavy drinker	219	25	11.42%
Others	881	82	9.31%
Missing	341	60	17.60%
Area-Level Variables			
Percent of individuals by neighbourhood low income rate			
0-10 %	326	17	5.21%
11-20 %	502	62	12.55%
21-30 %	369	40	10.64%
> 30 %	244	48	19.61%
Percent of individuals by neighbourhood low education rate			
0-10 %	52	6	11.56%
11-20 %	301	22	7.51%
21-30 %	622	64	10.29%
31-40 %	353	58	16.45%
41-50 %	113	17	15.04%

Regular heavy drinker: Consumed >5 drinks in single sitting > 12 times in previous year

Table 4.3: Prevalence (%) of people scoring <0.973 on the HUI by various risk factors, Ottawa, Canadian Community Health Survey 2000-2001

	Number	HUI<0.973	Percent
Overall	1425	750	52.63%
Individual-level Variables			
Age (years)			
10-19	198	104	52.52%
20-34	366	170	46.45%
35-49	390	195	50.00%
50-64	268	134	50.00%
≥65	219	147	67.12%
Gender			
Male	660	332	50.30%
Female	781	418	53.52%
Income			
Low	181	118	65.19%
Lower-Middle	221	141	63.80%
Upper-Middle	340	179	52.65%
Upper	593	249	41.99%
Missing	106	63	59.43%
Educational attainment			
Less than high school	164	110	67.01%
High school graduate	194	126	64.55%
Post-secondary	863	407	47.16%
In high school (≤19 years of age)	198	104	52.53%
Missing	3	3	100.00%
Marital Status			
Married/common-law/partner	664	310	46.69%
Single/widowed/separated/divorced	776	439	56.57%
Missing	1	1	100.00%
Immigrant			
Immigrated <10 years ago	125	67	53.60%
Others	1307	678	51.87%
Missing	9	5	55.56%
Smoking Status			
Daily smoker	242	158	65.29%
Others	1194	590	49.41%
Missing	5	2	40.00%
Activity			
Daily exercise	476	218	45.80%
Others	856	482	56.31%
Missing	109	50	45.87%
Alcohol			
Regular heavy drinker	219	121	55.25%
Others	881	429	48.69%
Missing	341	200	58.65%
Area-Level Variables			
Percent of households below LICO			
0-10 %	324	145	44.75%
11-20 %	496	261	52.62%
21-30 %	366	197	53.63%
> 30 %	239	147	61.51%
Percent of individuals with high school or less than high school education			
0-10 %	52	25	46.08%
11-20 %	299	131	45.61%
21-30 %	617	334	54.15%
31-40 %	384	199	51.62%
41-50 %	109	61	55.36%

models would not converge with dummy variables and therefore the missing individuals were coded as smokers and singles.

4.1.4 Correlations

4.1.4.1 Relationship between SRH and HUI

The relationship between self reported health and the health utility score is presented in Figures 4.1 and Table 4.4. As expected those who reported better health also had higher HUI scores. The median HUI scores were 0.368, 0.688, 0.905, 0.973 and 0.973 for those with poor, fair, good, very good and excellent self-reported health, respectively. There was a statistically significant correlation between the two measures with a Spearman correlation coefficient of 0.44 ($p<0.0001$).

The majority (88%) of those who self reported having poor or fair health also had scores lower than 0.973 for the HUI. On the other hand, a large proportion (81%) of those with HUI scores of less than 0.973 reported having good, very good or excellent self-reported health.

4.1.4.2 Relationship between NBHD Low Income and NBHD Low Education

Figure 4.3 presents the relationship between the two neighbourhood exposure measures, the percentage of economic families below the LICO and the percentage of individuals who completed up to a high school education. These two measures were moderately correlated, with a Pearson correlation coefficient of 0.64. The degree of correlation prohibits the inclusion of both variables within a single model due to issues of colinearity.

Table 4.4: Agreement between HUI scores and self-reported health status

Health Utilities Index	≥0.0973	<0.973
Self Rated Health		
Good/very good/excellent	656	611
Poor/fair	19	139

Figure 4.1: Median HUI Score by Self-Reported Health Status, Ottawa, Canadian Community Health Survey 2000-2001

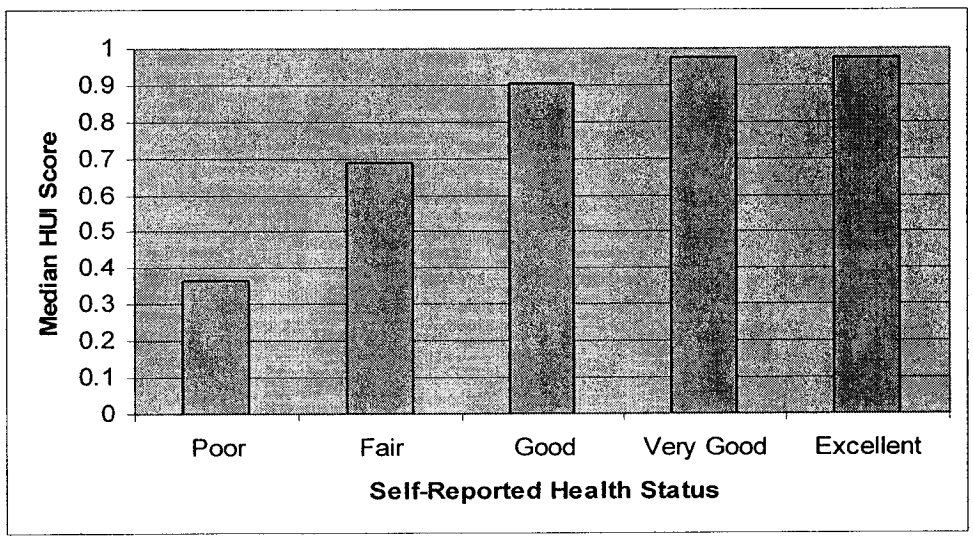
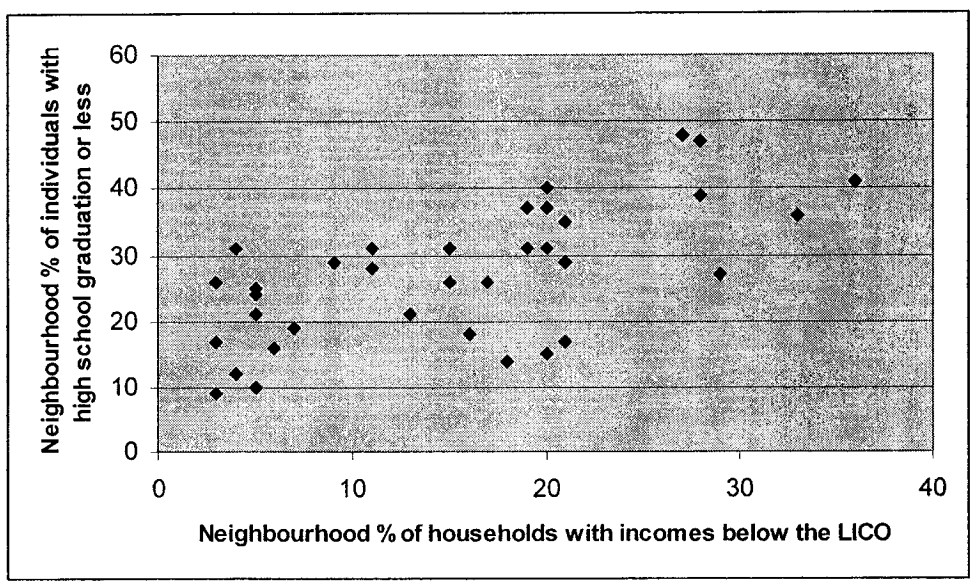


Figure 4.2: Neighbourhood Low Education by Neighbourhood Low Income



4.1.4.3 Relationship Between Neighbourhood Socioeconomic Measures and Health Outcomes

Figure 4.3 and 4.4 present the ecological correlation between the age-standardized percentage of individuals with poor/fair SRH and with low HUI scores and the neighbourhood low income rate for the 37 Ottawa neighbourhoods. The neighbourhood low income rate was modestly correlated with SRH, with a Pearson correlation coefficient of 0.29. The HUI, on the other hand, was slightly less correlated with the neighbourhood low income rate, with a correlation coefficient of 0.15. The health outcomes were age-standardized; however, adjustments for individual income and other individual variables were not incorporated.

In Figures 4.5 and 4.6 the ecological correlation between the age-standardized percentage of individuals with poor/fair SRH and low HUI scores and the neighbourhood low education rate for the 37 Ottawa neighbourhoods. The correlation coefficient of 0.40 for the relationship between SRH and the neighbourhood low education rate indicates a modest correlation. On the other hand the correlation between the HUI (< 0.973) and the neighbourhood low education rate was very weak (Pearson correlation coefficient=0.06).

4.1.5 Single level logistic regression for neighbourhood SES characteristics after adjusting for individual level covariates with SRH and HUI as an outcome.

The relationship between neighbourhood socioeconomic characteristics and the health outcomes, self-rated health and the Health Utilities Index were investigated via single-level logistic regression. The results, presented in Table 4.5, show that there is a significant relationship between the two neighbourhood socioeconomic variables and both of the health outcomes, supporting the need for further investigation into the nature of the relationship.

Figure 4.3 Age-Standardized Percentage of Poor/Fair SRH by Percentage of Families Below the LICO for 37 Ottawa Neighbourhoods

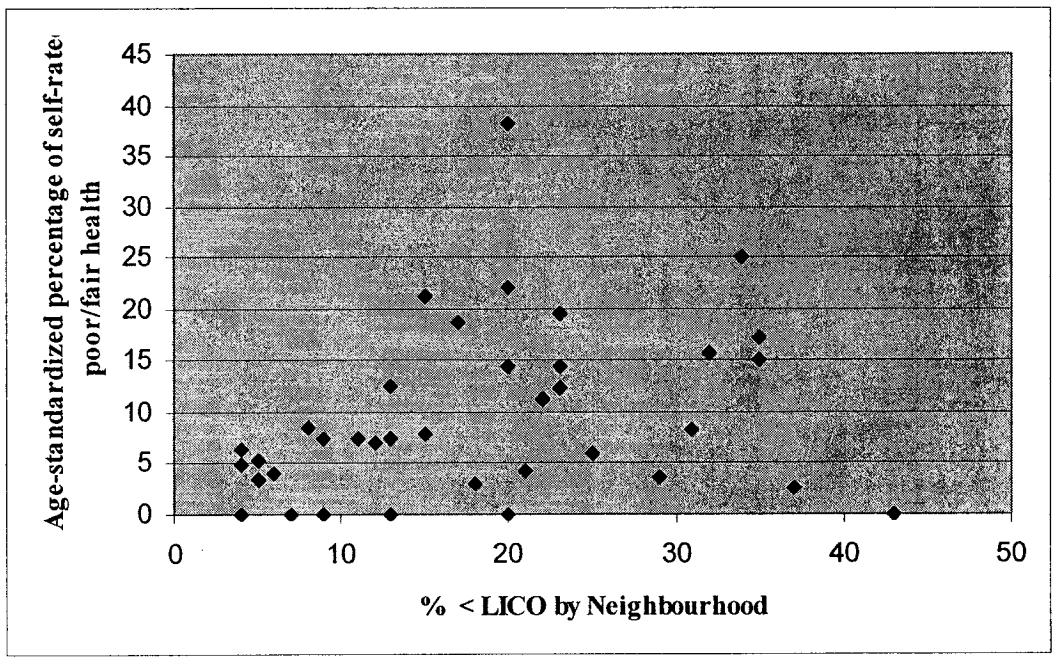


Figure 4.4 Age-Standardized Percentage of HUI scores <0.973 by Percentage of Families Below the LICO for 37 Ottawa Neighbourhoods

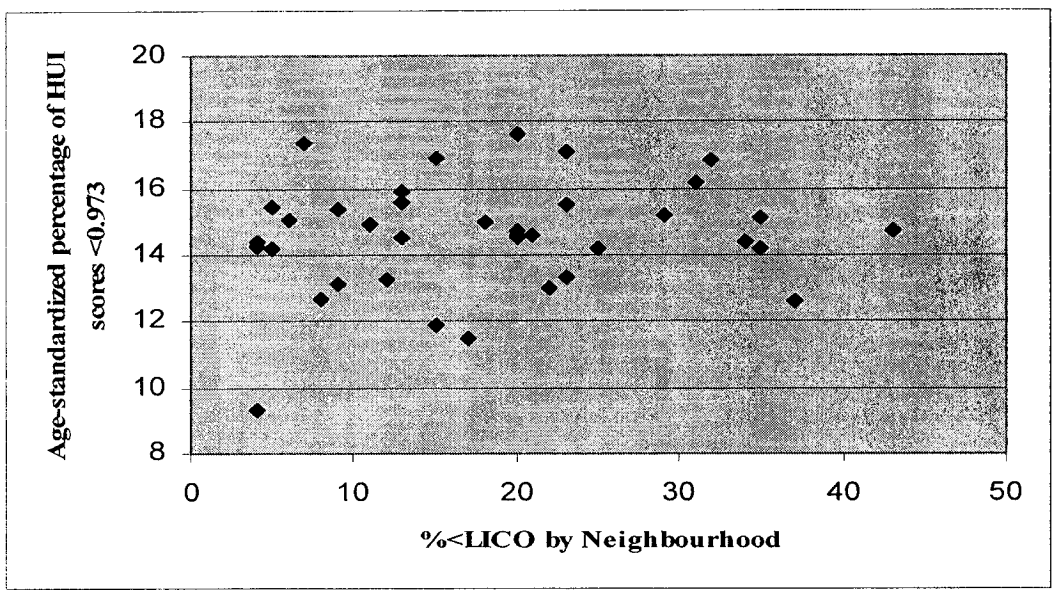


Figure 4.5 Age-Standardized Percentage of Poor/Fair SRH by Neighbourhood Low Education Rate for 37 Ottawa Neighbourhoods

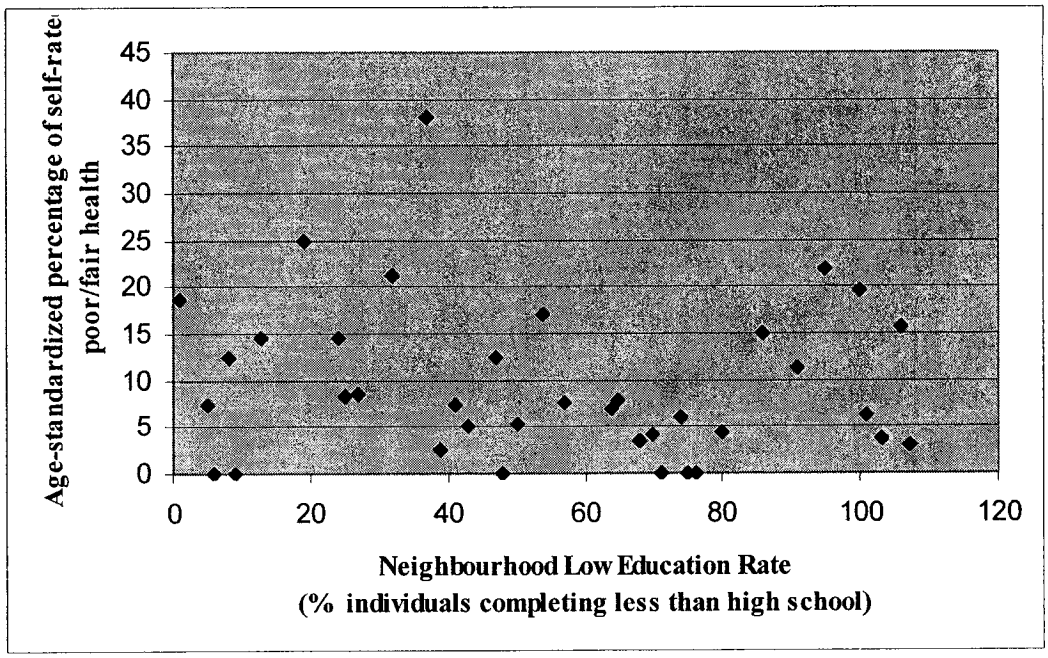


Figure 4.6 Age-Standardized Percentage of HUI scores <0.973 by Neighbourhood Low Education Rate for 37 Ottawa Neighbourhoods

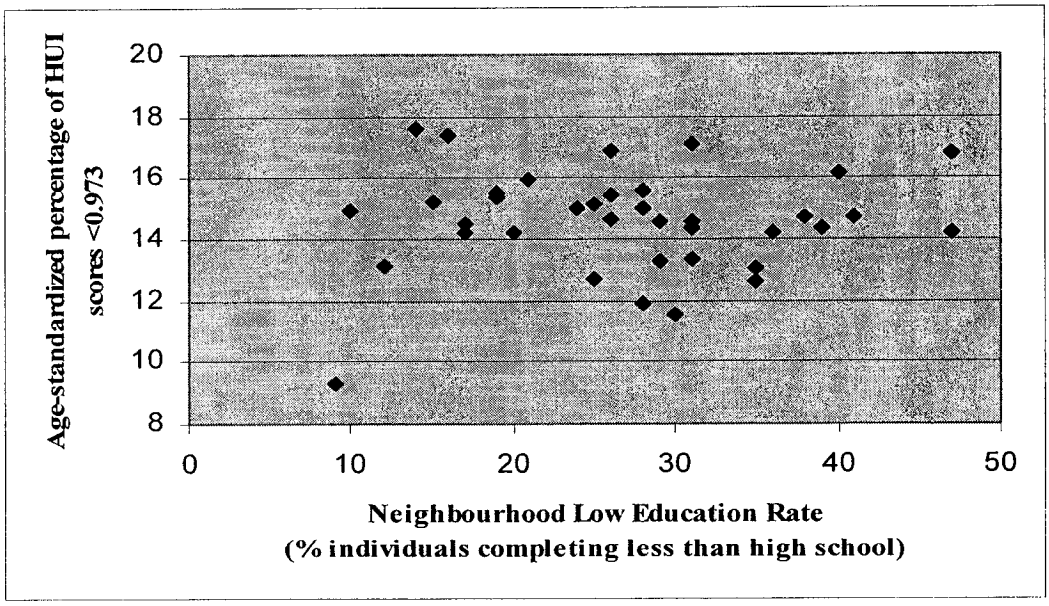


Table 4.5: Association between health outcomes and Ottawa neighbourhood socioeconomic characteristics, Canadian Community Health Survey 2000-2001: Single-level logistic regression*

Neighbourhood Variable	Health Outcome	Odds Ratio (10 % increase)	95% Confidence Interval
LICO	Poor/fair self-rated health	1.008	1.007-1.009
	Health Utility Index score	1.007	1.006-1.007
Education	Poor/fair self-rated health	1.038	1.025-1.051
	Health Utility Index score	1.009	1.009-1.010

* weighted analysis adjusted for individual factors including age, gender, marital status, individual income, education, immigrant status, alcohol consumption, smoking and physical activity.
(note: missing coded as dummy variables in SAS)

4.1.6 Multilevel Logistic Regression

The results of the multilevel logistic regression for Ottawa are presented in Tables 4.6 – 4.9, pages 75-82. The extent to which the neighbourhood variation in health, as measured by self-reported health and the Health Utilities Index, is explained by the neighbourhood percentage of economic families below the low income cut offs is presented first, followed by the models examining the neighbourhood low education rates.

4.1.6.1 SRH/ LICO/ OTTAWA

The empty model, which partitions the variance between the two levels, the neighbourhood and the individual, demonstrated statistically significant variation in self-rated health at the neighbourhood level. The Wald statistic was 2.40 ($p<0.05$) which is statistically significant based on a one sided test of significance, assuming a normal distribution.

Individual demographic, socioeconomic and behavioral factors were shown to be associated with self-rated health when added separately in blocks to the age adjusted models. In general, within all these models (models 2a-2c) the risk of poor or fair SRH

increased with age, with those in the 10-19 age range not differing statistically significantly from those in the 20-34 age range.

Neither of the demographic factors, gender or marital status, were statistically significantly associated with SRH, with females having an odds ratio for poor or fair SRH of 1.01 (95% CI 0.71-1.45) versus males and singles having an odds ratio of 1.45 (95% CI 0.98-2.12) as compared with married people.

Both individual income and education were significantly associated with the risk of poor or fair SRH. Those in the low income category were more likely to rate their health as poor or fair as compared with those in the upper middle income bracket (OR= 2.70, 95% CI 1.16-4.97). There was an overall gradient, with a trend towards lower risk of poor or fair health with increasing income, although the lower-middle and upper income groups were not statistically significantly different from the upper-middle income group with odds ratios of 1.43 (95% CI 0.82-2.48) and 0.60 (95% CI 0.35-1.03), respectively. Similarly, lower education was also associated with a higher risk of poor or fair health with an odds ratio of 2.73 (95% CI 1.69-4.41) for those with less than high school education and 1.64 (95% CI 0.99-2.71) for those with high school education as compared with those with greater than high school education. On the other hand, those who immigrated less than 10 years ago did not have statistically significantly different odds of poor or fair health as compared with non-immigrants (OR = 0.88, 95% CI 0.43-1.81).

With respect to behavioral factors, smokers, heavy drinkers and those who are inactive all had higher risks of reporting poor or fair health. Of all of the individual factors smoking was associated with the highest odds ratio with smokers being 3.12 times more likely to report poor or fair health than non-smokers. Binge drinkers were more

likely to report being in poor or fair health versus non-binge drinkers (OR=1.92, 95% CI 1.10-3.32). Although those that were inactive were more likely to report poor or fair health, they did not differ significantly from those who were active as the 95% confidence interval includes zero (OR=1.44, 95% CI 0.93-2.22).

After the separate block addition of individual demographic, socioeconomic and behavioral factors to the models, statistically significant variation at the neighbourhood level remained with Wald statistics of 2.09, 1.71 and 1.87 (all $p<0.05$), respectively for the level 2 variation.

The socioeconomic characteristic of the neighbourhood as measured by the percentage of economic families below the low income cut offs was significantly associated with the reporting of poor or fair health as is evident in model 2d, in which the percentage of economic families below the LICO was added to the age adjusted model. There was approximately a 35% increase in the odds of reporting poor or fair health with each 10% increase in the percentage of families below the LICO (OR=1.35, 95% CI 1.01-1.81). However, even within this model, significant variation at the neighbourhood level remained with a Wald statistic for the level two variation of 1.87 ($p<0.05$).

Incorporation of all of the individual variables within a single model resulted in slightly reduced odds ratios compared with the separate models; however, those with statistically significant values remained significant. The addition of all individual variables reduced the variability at the neighbourhood level such that it remained just statistically significant with a Wald statistic of 1.67 ($p<0.05$).

The results of the separate block incorporation of the individual level variables to the age adjusted model containing the neighbourhood level variable are presented in models 3a through 3c. As expected given the lack of significance of the individual

demographic variables the percentage of economic families below the LICO remained statistically significant after addition of the demographic factors to the model (OR=1.31, 95% CI 1.01-1.69). On the other hand, addition of the individual socioeconomic variables and the behavioral variables reduced the odds ratio associated with the neighbourhood level variable such that it was no longer statistically significant. In the model containing the percentage of families below the LICO and individual SES variables the odds ratio associated with the neighbourhood LICO was 1.12 (95% CI 0.85-1.47) and it was 1.23 (95% CI 0.96-1.59) in the model containing the neighbourhood LICO and individual behavioral variables. In all of these models significant variation at the neighbourhood level remained with Wald statistics of 1.86 in the model containing neighbourhood LICO and individual demographic variables, 1.72 in the model containing neighbourhood LICO and individual socioeconomic variables and 1.79 in the neighbourhood LICO and individual behavioral variable model.

The neighbourhood variable of percentage of families below the LICO was also not statistically significantly associated with poor or fair health once all of the individual level variables were added to the model. In the final model there was approximately a 7% increase in the odds of reporting poor or fair health with each 10% increase in the percentage of families below the LICO (OR=1.07, 95% CI 0.82-1.41). Additionally, statistically significant variation at the neighbourhood level was no longer present once all of the variables were added to the model.

4.1.6.2 HUI/ LICO/ OTTAWA

The results of the analysis of the importance of neighbourhood percentage of families below the LICO in explaining neighbourhood variation in health as measured by the Health Utilities Index were similar to those for self-rated health. The empty model

demonstrated significant variation in health at the neighbourhood level with a Wald statistic of 2.61 ($p<0.05$). The block addition of the individual demographic, socioeconomic and behavioral variables in models 2a through 2c produced similar results as were found with self-rated health with the exception of the impact of marital status, education and alcohol binge drinking. With HUI as the outcome, singles had a significantly higher risk of reporting a low HUI score (less than 0.973) than married individuals (OR=1.64, 95% CI 1.27-2.10). As was the case with SRH, those with lower education reported poorer HUI scores than those with higher education; however, with the HUI as the outcome only those with high school education were statistically significantly different from those with greater than high school education (OR=1.46, 95% CI 1.01-2.13). Alcohol binge drinking did not result in a statistically significant risk with respect to reporting a low HUI score as compared with those who did not drink (OR=1.11, 95% CI 0.80-1.53). There was approximately a 31% increase in the odds of reporting an HUI score less than 0.973 with each 10% increase in the percentage of families below the LICO (OR=1.31, 95% CI 1.10-1.56) based on the model which included age and the percentage of families below the LICO (model 2d). Once all of the individual variables had been added to the model, significant variation at the neighbourhood level remained, with a Wald statistic of 2.61 ($p<0.05$).

The addition of the blocks of individual variables to the age adjusted models containing the neighbourhood percentage of families below the LICO resulted in a reduction in the odds ratio for the neighbourhood variable; however, it remained statistically significant in both the model containing the demographic factors and the model containing the behavioral factors. There was approximately a 27% increase in the odds of reporting poor health (HUI score <0.973) with each 10% increase in the

percentage of families below the LICO (OR=1.27, 95% CI 1.07-1.52) after adjustment for demographic factors and a 25% increase (OR=1.25, 95% CI 1.06-1.46) after adjustment for behavioral factors. Addition of individual socioeconomic factors reduced the neighbourhood level impact such that it was not significant with an odds ratio for a 10% increase in families below the LICO of 1.16 (95% CI 0.97-1.39). In the final model containing all of the individual variables and the neighbourhood variable, the neighbourhood level variable was not statistically significant, with a 10% increase in the percentage of families below the LICO being associated with an odds ratio for poor health of 1.13 (OR=1.13, 95% CI 0.94-1.34). Significant variation at the neighbourhood level remained even within this final model with a Wald statistic of 2.25 ($p<0.05$) indicating that there may be an alternative neighbourhood factor that could explain these neighbourhood differences better than the LICO. This lead to the investigation of neighbourhood low education as a level 2 explanatory variable. The results of this investigation are presented below.

4.1.6.3 SRH/ EDUCATION/ OTTAWA

As previously stated the empty model for self rated health confirmed that there was significant variation in SRH between neighbourhoods with a statistically significant Wald statistic of 2.40 ($p<0.05$).

The details of the block addition of the individual variables to the age adjusted models discussed previously in section 3.2.4. Briefly, increasing age was associated with an increased risk of poor or fair health as was lower socioeconomic status, lower education, smoking and binge drinking. Not being active and being single was associated with an increased risk of poor or fair health; however, the odds ratios did not reach statistical significance (OR=1.45, 95% CI 0.98-2.12 and 1.44, 95% CI 0.93-2.22,

respectively). Those who immigrated in the previous 10 years were at lower risk of poor or fair health although the difference compared to non-immigrants was also not significant (OR=0.88, 95% CI 0.43-1.80). Gender did not appear to impact the risk of poor or fair health (OR=1.01, 95% CI 0.71-1.45). Statistically significant variation at the neighbourhood level remained after the block addition of the individual level variables, with Wald statistics of 2.09, 1.71 and 1.87 (all $p<0.05$), respectively for the level 2 variation.

The addition of the neighbourhood low education variable to the age-adjusted model resulted in an odds ratio for the neighbourhood variable of 1.03 (95% CI 1.00-1.06). This indicates that a 10% increase in neighbourhood low education is associated with a 3% increase in the odds of poor or fair health, a much smaller increase in odds as compared with the 35% associated with neighbourhood percent of families below the LICO. Significant variation at the neighbourhood level remained with a Wald statistic for the level two variation of 1.99 ($p<0.05$).

The incorporation of all of the individual variables within a single model did not change the statistical significance of the odds ratios. However, the addition of all individual variables reduced the variability at the neighbourhood level such that it remained just statistically significant with a Wald statistic of 1.67 ($p<0.05$).

The results of the separate block incorporation of the individual level variables to the age adjusted model containing the neighbourhood level variable are presented in models 3a through 3c. As expected given the lack of significance of the individual demographic variables the neighbourhood low education variable remained statistically significant after addition of the demographic factors to the model (OR=1.35, 95% CI 1.01-1.81). On the other hand, addition of the individual socioeconomic variables and the

behavioral variables reduced the odds ratio associated with the neighbourhood level variable such that it was no longer statistically significant. In the model containing the neighbourhood low education and individual SES variables the odds ratio associated with the neighbourhood education was 1.08 (95% CI 0.87-1.45) and it was 1.22 (95% CI 0.91-1.64) in the model containing the neighbourhood education and individual behavioral variables. The Wald statistics for the age adjusted models containing neighbourhood education and demographic variables, neighbourhood education and socioeconomic variables and neighbourhood education and behavioural variables were 1.93, 1.76 and 1.87, respectively, indicating that significant variation at the neighbourhood level remained.

The neighbourhood variable of the percentage of people completing only high school education was also not statistically significantly associated with poor or fair health once all of the individual level variables were added to the model. A 10% increase in the percentage of people not completing at least a high school education was associated with a 4% increase the odds of poor or fair health, based on the final model which incorporated all the individual and the neighbourhood variables. Unlike in the case of the neighbourhood percentage below the LICO, statistically significant variation at the neighbourhood level remained even within this final model with a Wald statistic of 1.74 ($p<0.05$).

4.1.6.4 HUI/ EDUCATION/ OTTAWA

In comparison with the above analysis in which SRH was the outcome, in the following analysis, which utilized the HUI as the outcome, neighbourhood education was a more relevant explanatory variable. As previously stated, significant variation in the proportion of HUI scores lower than 0.973 was found at the neighbourhood level based on

the empty model with a Wald statistic of 2.61 ($p<0.05$). The block addition of the individual variables to the age-adjusted models was described in detail in section 3.2.4. Briefly, singles, those with lower incomes, those with lower education, smokers and those who aren't active all had a statistically significantly higher odds of HUI scores of less than 0.973. The age-adjusted model containing only neighbourhood education found that a 10% increase in the percentage of individuals completing only high school education was associated with a 27% increase in the odds of poor health (HUI<0.973). Significant variation at the neighbourhood level remained within this model with a Wald statistic of 2.29 ($p<0.05$). Significant variation at the neighbourhood level was also present within the model containing all of the individual variables (Wald statistic=2.61, $p<0.05$).

The addition of the blocks of individual variables to the age adjusted models containing the neighbourhood percent low education resulted in a reduction in the odds ratio for the neighbourhood variable; however, it remained statistically significant in only the model containing the demographic factors. A 10% increase in the number of individuals completing only a high school education was associated with a 26% increase in the odds of poor health (HUI score <0.973) (OR=1.26, 95% CI 1.05-1.50) after adjustment for demographic factors. Addition of individual socioeconomic factors and the addition of the behavioral factors reduced the neighbourhood level impact such that it was not significant with an odds ratio for a 10% increase those completing only high school of 1.14 (95% CI 0.94-1.38) and 1.20 (95% CI 1.00-1.43), respectively. In the final model containing all of the individual variables and the neighbourhood variable, the neighbourhood level variable was not statistically significant, with a 10% increase in the percentage of individuals completing only high school education being associated with a 12% increase in odds of poor health (OR=1.12, 95% CI 0.92-1.36). Significant variation

at the neighbourhood level remained even within this final model with a Wald statistic of 2.21 ($p<0.05$).

4.1.6.5 Neighbourhood Size

The neighbourhoods were constructed to mirror individual's perceptions of neighbourhoods, consequently there was some variation in neighbourhood size. The addition of neighbourhood size as a covariate within the model did not result in a significant coefficient indicating that neighbourhood size did not explain the variability between the neighbourhoods.

4.1.6.6 Missing Information

The sensitivity analysis which was conducted in order to determine if the missing data impacted the results revealed that the misclassification of the missing data did not significantly change the results and would not have influenced the conclusions.

Table 4.6: Odds Ratios (95% Confidence Intervals) for Poor/Fair Self-Rated Health with Percentage of Families below the LICO as the Neighbourhood Exposure Measure, Ottawa

	Empty Model: Model 1	Model 2a		Model 2b		Model 2c		Model 2d	
		Demog + age	CI	SES + age	CI	Behav + age	CI	LICO + age	CI
FIXED EFFECTS									
Area level variables									
% < LICO (10% increase)								1.35	1.01-1.81
Individual level variables									
Demographic									
Age									
10-19		1.18	0.44-3.18	0.91	0.31-2.67	1.16	0.42-3.17	1.38	0.52-3.66
20-34		1.00		1.00		1.00		1.00	
35-49		2.94	1.46-5.93	2.81	1.38-5.73	2.63	1.31-5.30	2.69	1.36-5.33
50-64		7.03	3.61-13.69	6.37	3.19-12.69	7.99	4.05-15.74	6.71	3.49-12.91
≥65		11.94	6.14-23.21	8.31	4.13-16.69	14.20	7.14-28.25	11.28	5.87-21.66
Gender									
Female		1.01	0.71-1.45						
Male		1.00							
Marital status									
Single etc.		1.45	0.98-2.12						
Married etc.		1.00							
SES									
Household income									
Low				2.70	1.46-4.97				
Low-mid				1.43	0.82-2.48				
Upper-mid				1.00					
Upper				0.60	0.35-1.03				
Missing				1.83	0.93-3.57				
Education									
< high school				2.73	1.69-4.41				
high school				1.64	0.99-2.71				
>high school				1.00					
missing				1.58	0.16-15.27				
Immigrant									
Immigrant				0.88	0.43-1.81				
Non-immigrant				1.00					
Missing				3.07	0.58-16.26				
Behavioral									
Smoking									
Current daily						3.12	2.03-4.78		
Others						1.00			
Physical activity									
Not active						1.44	0.93-2.22		
Active						1.00			
Missing						2.98	1.55-5.74		
Alcohol consumption									
Heavy drinker						1.92	1.10-3.32		
Other						1.00			
Missing						2.83	1.86-4.31		
RANDOM EFFECTS									
Level 2 variance (standard error)	0.42 (0.17)	0.31 (0.15)		0.22 (0.13)		0.26 (0.14)		0.25 (0.13)	
Wald Statistic	2.40	2.09		1.71		1.87		1.87	

Table 4.6 Continued: Odds Ratios (95% Confidence Intervals) for Poor/Fair Self-Rated Health with Neighbourhood Low Income as the Neighbourhood Exposure Measure, Ottawa

	Model 2e		Model 3a		Model 3b		Model 3c		Model 4	
	Individual Variables + Age	CI	LICO + age + demog	CI	LICO + SES + age	CI	LICO + behav + age	CI	All variables	CI
FIXED EFFECTS										
Area level variables										
% < LICO (10% increase)			1.31	1.01-1.69	1.12	0.85-1.47	1.23	0.96-1.59	1.07	0.82-1.41
Individual level variables										
Demographic										
Age										
10-19	1.00	0.32-3.08	1.22	0.45-3.27	0.92	0.32-2.69	1.19	0.43-3.25	1.02	0.33-3.14
20-34	1.00		1.00		1.00		1.00		1.00	
35-49	2.99	1.42-6.31	2.98	1.48-5.98	2.85	1.40-5.81	2.69	1.34-5.42	3.02	1.43-6.35
50-64	8.00	3.91-16.37	7.13	3.67-13.85	6.44	3.23-12.83	8.13	4.13-15.98	8.05	3.93-16.50
≥65	12.04	5.75-25.20	11.88	6.14-23.00	8.35	4.15-16.80	14.33	7.20-28.50	12.10	5.77-25.38
Gender										
Female	1.02	0.69-1.53	1.02	0.72-1.47					1.03	0.69-1.54
Male	1.00		1.00						1.00	
Marital status										
Single etc.	1.06	0.69-1.64	1.37	0.93-2.02					1.05	0.68-1.62
Married etc.	1.00		1.00						1.00	
SES										
Household income										
Low	2.34	1.22-4.46			2.58	1.39-4.80			2.28	1.19-4.39
Low-mid	1.29	0.72-2.29			1.39	0.80-2.43			1.26	0.71-2.26
Upper-mid	1.00				1.00				1.00	
Upper	0.66	0.38-1.15			0.61	0.35-1.06			0.67	0.38-1.17
Missing	1.65	0.82-3.32			1.85	0.95-3.63			1.66	0.83-3.35
Education										
< high school	2.05	1.24-3.39			2.74	1.69-4.42			2.06	1.24-3.40
high school	1.40	0.83-2.35			1.64	0.99-2.71			1.40	0.83-2.35
>high school	1.00				1.00				1.00	
missing	1.02	0.08-12.43			1.52	0.16-14.83			1.00	0.08-12.22
Immigrant										
Immigrant	0.94	0.44-1.99			0.87	0.43-1.79			0.93	0.44-1.98
Non-immigrant	1.00				1.00				1.00	
Missing	2.88	0.49-16.83			3.09	0.58-16.43			2.90	0.49-16.99
Behavioral										
Smoking										
Current daily	2.38	1.51-3.76					3.03	1.97-4.65	2.37	1.50-3.75
Others	1.00						1.00		1.00	
Physical activity										
Not active	1.37	0.88-2.15					1.45	0.94-2.24	1.38	0.88-2.17
Active	1.00						1.00		1.00	
Missing	2.86	1.44-5.67					2.99	1.55-5.75	2.88	1.45-5.70
Alcohol consumption										
Heavy drinker	1.97	1.09-3.58					1.91	1.10-3.32	1.99	1.09-3.61
Other	1.00						1.00		1.00	
Missing	1.95	1.24-3.05					2.76	1.81-4.21	1.94	1.24-3.04
RANDOM EFFECTS										
Level 2 variance (standard error)	0.22 (0.13)		0.24 (0.13)		0.22 (0.13)		0.23 (0.13)		0.22 (0.13)	
Wald Statistic	1.67		1.86		1.72		1.79		1.64	

Table 4.7: Odds Ratios (95% Confidence Intervals) for HUI Scores <0.973 with Neighbourhood Low Income as the Neighbourhood Exposure Measure, Ottawa

	Empty Model: Model 1	Model 2a		Model 2b		Model 2c		Model 2d	
		Demog + age	CI	SES + age	CI	Behav + age	CI	LICO + age	CI
FIXED EFFECTS									
Area level variables									
% < LICO (10% increase)								1.31	1.10-1.56
Individual level variables									
Demographic									
Age									
10-19		1.17	0.78-1.75	0.93	0.57-1.52	1.30	0.86-1.95	1.48	1.00-2.17
20-34		1.00		1.00		1.00		1.00	
35-49		1.45	1.07-1.97	1.25	0.93-1.68	1.18	0.87-1.58	1.25	0.94-1.67
50-64		1.20	0.87-1.65	1.09	0.79-1.52	1.09	0.79-1.51	1.10	0.80-1.52
≥65		2.97	2.04-4.33	2.26	1.53-3.34	2.70	1.85-3.94	2.68	1.85-3.88
Gender									
Female		1.03	0.83-1.28						
Male		1.00							
Marital status									
Single etc.		1.64	1.27-2.10						
Married etc.		1.00							
SES									
Household income									
Low				1.62	1.04-2.51				
Low-mid				1.46	1.01-2.13				
Upper-mid				1.00					
Upper				0.66	0.50-0.88				
Missing				1.15	0.72-1.83				
Education									
< high school				1.34	0.90-1.98				
high school				1.55	1.11-2.17				
>high school				1.00					
missing				1.07	0.21-5.55				
Immigrant									
Immigrant				1.23	0.84-1.81				
Non-immigrant				1.00					
Missing				2.34	0.58-9.50				
Behavioral									
Smoking									
Current daily						1.88	1.38-2.57		
Others						1.00			
Physical activity									
Not active						1.43	1.13-1.82		
Active						1.00			
Missing						1.18	0.77-1.82		
Alcohol consumption									
Heavy drinker						1.11	0.80-1.53		
Other						1.00			
Missing						1.70	1.27-2.27		
RANDOM EFFECTS									
Level 2 variance (standard error)	0.20 (0.08)	0.16 (0.07)		0.15 (0.06)		0.13 (0.06)		0.13 (0.06)	
Wald Statistic	2.61	2.41		2.31		2.25		2.24	

Table 4.7 Continued: Odds Ratios (95% Confidence Intervals) for HUI Scores <0.973 with Neighbourhood Low Income as the Neighbourhood Exposure Measure, Ottawa

	Model 2e		Model 3a		Model 3b		Model 3c		Model 4	
	Individual Variables + Age	CI	LICO + age + demog	CI	LICO + SES + age	CI	LICO + behav + age	CI	All variables	CI
FIXED EFFECTS										
Area level variables										
% < LICO (10% increase)			1.27	1.07-1.52	1.16	0.97-1.39	1.25	1.06-1.46	1.13	0.94-1.34
Individual level variables										
Demographic										
Age										
10-19	0.82	0.48-1.37	1.21	0.81-1.81	0.95	0.58-1.55	1.33	0.88-1.99	0.83	0.49-1.40
20-34	1.00		1.00		1.00		1.00		1.00	
35-49	1.37	1.00-1.88	1.47	1.08-1.99	1.26	0.94-1.70	1.21	0.90-1.62	1.38	1.00-1.89
50-64	1.21	0.86-1.71	1.21	0.88-1.68	1.10	0.79-1.54	1.11	0.80-1.54	1.22	0.87-1.72
≥65	2.61	1.74-3.93	2.91	2.00-4.24	2.24	1.52-3.32	2.66	1.83-3.89	2.57	1.72-3.86
Gender										
Female	0.94	0.74-1.18	1.04	0.83-1.28					0.94	0.75-1.19
Male	1.00		1.00						1.00	
Marital status										
Single etc.	1.43	1.09-1.87	1.57	1.22-2.02					1.41	1.07-1.84
Married etc.	1.00		1.00						1.00	
SES										
Household income										
Low	1.47	0.94-2.30			1.54	0.99-2.40			1.42	0.90-2.23
Low-mid	1.44	0.98-2.10			1.41	0.97-2.05			1.39	0.95-2.04
Upper-mid	1.00				1.00				1.00	
Upper	0.74	0.55-0.99			0.68	0.51-0.90			0.75	0.56-1.01
Missing	1.12	0.69-1.81			1.15	0.72-1.84			1.13	0.70-1.82
Education										
< high school	1.15	0.76-1.72			1.33	0.90-1.96			1.15	0.76-1.72
high school	1.43	1.01-2.01			1.55	1.11-2.16			1.43	1.01-2.01
>high school	1.00				1.00				1.00	
missing	1.25	0.23-6.72			1.05	0.20-5.50			1.22	0.23-6.60
Immigrant										
Immigrant	1.31	0.88-1.94			1.21	0.82-1.78			1.28	0.86-1.91
Non-immigrant	1.00				1.00				1.00	
Missing	2.30	0.55-9.56			2.35	0.58-9.51			2.30	0.55-9.58
Behavioral										
Smoking										
Current daily	1.60	1.16-2.21					1.82	1.33-2.49	1.57	1.14-2.17
Others	1.00						1.00		1.00	
Physical activity										
Not active	1.42	1.11-1.81					1.44	1.13-1.83	1.42	1.11-1.81
Active	1.00						1.00		1.00	
Missing	1.12	0.72-1.74					1.18	0.76-1.81	1.12	0.72-1.75
Alcohol consumption										
Heavy drinker	1.11	0.79-1.56					1.10	0.80-1.52	1.10	0.79-1.55
Other	1.00						1.00		1.00	
Missing	1.42	1.05-1.92					1.64	1.23-2.19	1.41	1.04-1.90
RANDOM EFFECTS										
Level 2 variance (standard error)	0.14 (0.06)		0.13 (0.06)		0.15 (0.06)		0.12 (0.06)		0.14 (0.06)	
Wald Statistic	2.19		2.22		2.29		2.07		2.25	

Table 4.8: Odds Ratios (95% Confidence Intervals) for Poor/Fair Self-Reported Health with Neighbourhood Low Education as the Neighbourhood Exposure Measure, Ottawa

	Empty Model: Model 1	Model 2a		Model 2b		Model 2c		Model 2d	
		Demog + age	CI	SES + age	CI	Behav + age	CI	Education + age	CI
FIXED EFFECTS									
Area level variables									
% low education (10% increase)								1.03	1.00-1.06
Individual level variables									
Demographic									
Age									
10-19		1.18	0.44-3.18	0.91	0.31-2.66	1.16	0.42-3.17	1.35	0.51-3.57
20-34		1.00		1.00		1.00		1.00	
35-49		2.94	1.46-5.93	2.81	1.38-5.73	2.63	1.30-5.29	2.60	1.31-5.15
50-64		7.03	3.61-13.69	6.37	3.19-12.69	7.99	4.05-15.74	6.37	3.31-12.25
≥65		11.94	6.14-23.21	8.31	4.13-16.69	14.20	7.13-28.25	11.02	5.73-21.21
Gender									
Female		1.01	0.71-1.45						
Male		1.00							
Marital status									
Single etc.		1.45	0.98-2.12						
Married etc.		1.00							
SES									
Household income									
Low				2.70	1.46-4.97				
Low-mid				1.43	0.82-2.48				
Upper-mid				1.00					
Upper				0.60	0.35-1.03				
Missing				1.83	0.93-3.57				
Education									
< high school				2.73	1.69-4.41				
high school				1.64	0.99-2.71				
>high school				1.00					
missing				1.58	0.16-15.27				
Immigrant									
Immigrant				0.88	0.43-1.80				
Non-immigrant				1.00					
Missing				3.07	0.58-16.26				
Behavioral									
Smoking									
Current daily						2.03	4.78-5.22		
Others						1.00			
Physical activity									
Not active						1.44	0.93-2.22		
Active						1.00			
Missing						2.07	1.15-3.73		
Alcohol consumption									
Heavy drinker									
Other									
Missing									
RANDOM EFFECTS									
Level 2 variance (standard error)	0.42 (0.18)	0.31 (0.15)		0.22 (0.13)		0.26 (0.14)		0.28 (0.14)	
Wald Statistic	2.38	2.09		1.71		1.88		1.99	

Table 4.8 Continued: Odds Ratios (95% Confidence Intervals) for Poor/Fair Self-Reported Health with Neighbourhood Low Education as the Neighbourhood Exposure Measure, Ottawa

	Model 2e		Model 3a		Model 3b		Model 3c		Model 4	
	Individual Variables + Age	CI	Education + age + demog	CI	Education + SES + age	CI	Education + behav + age	CI	All variables	CI
FIXED EFFECTS										
Area level variables			1.35	1.01-1.81	1.08	0.87-1.45	1.22	0.91-1.64	1.04	0.78-1.40
% low education (10% increase)										
Individual level variables										
Demographic										
Age										
10-19	1.00	0.32-3.08	1.17	0.43-3.15	0.92	0.31-2.68	1.15	0.42-3.14	1.00	0.32-3.10
20-34	1.00		1.00		1.00		1.00		1.00	
35-49	2.99	1.42-6.31	2.92	1.45-5.89	2.82	1.38-5.76	2.62	1.30-5.28	3.00	1.42-6.33
50-64	8.00	3.91-16.37	6.85	3.52-13.33	6.34	3.18-12.64	7.83	3.97-15.43	8.00	3.90-16.38
≥65	12.04	5.75-25.20	11.72	6.03-22.77	8.34	4.14-16.79	14.03	7.05-27.91	12.08	5.76-25.35
Gender										
Female	1.02	0.69-1.53	1.01	0.70-1.44					1.03	0.69-1.53
Male	1.00		1.00						1.00	
Marital status										
Single etc.	1.06	0.69-1.64	1.43	0.97-2.09					1.06	0.69-1.64
Married etc.	1.00		1.00						1.00	
SES										
Household income										
Low	2.34	1.22-4.46			2.67	1.45-4.94			2.33	1.22-4.46
Low-mid	1.29	0.72-2.29			1.42	0.81-2.47			1.28	
Upper-mid	1.00				1.00				1.00	0.72-2.28
Upper	0.66	0.38-1.15			0.61	0.35-1.05			0.66	0.38-1.16
Missing	1.65	0.82-3.32			1.84	0.94-3.60			1.65	0.82-3.33
Education										
< high school	2.05	1.24-3.39			2.69	1.65-4.36			2.04	1.23-3.39
high school	1.40	0.83-2.35			1.62	0.98-2.68			1.39	0.83-2.34
>high school	1.00				1.00				1.00	
missing	1.02	0.08-12.43			1.56	0.16-15.10			1.03	0.08-12.47
Immigrant										
Immigrant	0.94	0.44-1.99			0.88	0.43-1.81			0.94	0.44-1.99
Non-immigrant	1.00				1.00				1.00	
Missing	2.88	0.49-16.83			3.06	0.58-16.25			2.89	0.49-16.94
Behavioral										
Smoking										
Current daily	2.38	1.51-3.76					3.02	1.96-4.64	2.37	1.50-3.76
Others	1.00						1.00		1.00	
Physical activity										
Not active	0.73	0.46-1.14					1.45	0.99-2.24	1.37	0.38-2.16
Active	1.00						1.00		1.00	
Missing	2.08	1.12-3.87					2.05	1.14-3.70	2.09	1.12-3.88
Alcohol consumption										
Heavy drinker	1.97	1.09-3.58					1.90	1.10-3.31	1.98	1.09-3.60
Other	1.00						1.00		1.00	
Missing	1.95	1.24-3.05					2.79	1.83-4.25	1.94	1.24-3.05
RANDOM EFFECTS										
Level 2 variance (standard error)	0.22 (0.13)		0.26 (0.14)		0.23 (0.13)		0.26 (0.14)		0.24 (0.14)	
Wald Statistic	1.67		1.93		1.76		1.87		1.74	

Table 4.9: Odds Ratios (95% Confidence Intervals) for HUI Scores <0.973 with Neighbourhood Low Education as the Neighbourhood Exposure Measure, Ottawa

	Empty Model: Model 1	Model 2a		Model 2b		Model 2c		Model 2d	
		Demog + age	CI	SES + age	CI	Behav + age	CI	Education + age	CI
FIXED EFFECTS									
Area level variables									
% low education (10% increase)								1.27	1.07-1.52
Individual level variables									
Demographic									
Age									
10-19		1.17	0.78-1.75	0.93	0.57-1.52	1.30	0.86-1.95	1.43	0.97-2.10
20-34		1.00		1.00		1.00		1.00	
35-49		1.45	1.07-1.97	1.25	0.93-1.68	1.18	0.87-1.58	1.21	0.91-1.62
50-64		1.20	0.87-1.65	1.09	0.78-1.52	1.09	0.79-1.51	1.06	0.77-1.45
≥65		2.97	2.04-4.33	2.26	1.53-3.34	2.70	1.85-3.94	2.63	1.82-3.82
Gender									
Female		1.03	0.83-1.28						
Male		1.00							
Marital status									
Single etc.		1.64	1.27-2.10						
Married etc.		1.00							
SES									
Household income									
Low				1.62	1.04-2.51				
Low-mid				1.46	1.01-2.13				
Upper-mid				1.00					
Upper				0.66	0.50-0.88				
Missing				1.15	0.72-1.83				
Education									
< high school				1.34	0.90-1.98				
high school				1.55	1.11-2.17				
>high school				1.00					
missing				1.07	0.21-5.55				
Immigrant									
Immigrant				1.23	0.84-1.81				
Non-immigrant				1.00					
Missing				2.34	0.57-9.50				
Behavioral									
Smoking									
Current daily						1.88	1.38-2.57		
Others						1.00			
Physical activity									
Not active						1.43	1.13-1.82		
Active						1.00			
Missing						1.18	0.77-1.82		
Alcohol consumption									
Heavy drinker						1.11	0.80-1.53		
Other						1.00			
Missing						1.70	1.27-2.27		
RANDOM EFFECTS									
Level 2 variance (standard error)	0.20 (0.08)	0.16 (0.07)		0.15 (0.06)		0.13 (0.06)		0.14 (0.06)	
Wald Statistic	2.61	2.41		2.31		2.25		2.29	

Table 4.9 Continued: Odds Ratios (95% Confidence Intervals) for HUI Scores <0.973 with Neighbourhood Low Education as the Neighbourhood Exposure Measure, Ottawa

	Model 2e		Model 3a		Model 3b		Model 3c		Model 4	
	Individual Variables + Age	CI	Education + age + demog	CI	Education + SES + age	CI	Education + behav + age	CI	All variables	CI
FIXED EFFECTS										
Area level variables			1.26	1.05-1.50	1.14	0.94-1.38	1.20	1.00-1.43	1.12	0.92-1.36
% low education (10% increase)										
Individual level variables										
Demographic										
Age										
10-19	0.82	0.48-1.37	1.16	0.78-1.73	0.94	0.58-1.53	1.29	0.86-1.93	0.82	0.49-1.38
20-34	1.00		1.00		1.00		1.00		1.00	
35-49	1.37	1.00-1.88	1.44	1.06-1.95	1.24	0.92-1.67	1.17	0.87-1.58	1.37	1.00-1.87
50-64	1.21	0.86-1.71	1.17	0.85-1.62	1.08	0.78-1.51	1.07	0.78-1.48	1.21	0.85-1.70
≥65	2.61	1.74-3.93	2.89	0.99-4.20	2.24	1.51-3.32	2.63	1.80-3.84	2.59	1.72-3.88
Gender										
Female	0.94	0.74-1.18	1.03	0.83-1.28					0.94	0.75-1.88
Male	1.00		1.00						1.00	
Marital status										
Single etc.	1.43	1.09-1.87	1.62	1.26-2.08					1.42	1.09-1.86
Married etc.	1.00		1.00						1.00	
SES										
Household income										
Low	1.47	0.94-2.30			1.59	1.02-2.47			1.45	0.92-2.27
Low-mid	1.44	0.98-2.10			1.44	0.99-2.10			1.42	0.97-2.07
Upper-mid	1.00				1.00				1.00	
Upper	0.74	0.55-0.99			0.68	0.51-0.90			0.75	0.56-1.01
Missing	1.12	0.69-1.81			1.15	0.72-1.84			1.12	0.70-1.81
Education										
< high school	1.15	0.76-1.72			1.30	0.88-1.92			1.12	0.75-1.68
high school	1.43	1.01-2.01			1.53	1.09-2.13			1.41	1.00-1.98
>high school	1.00				1.00				1.00	
missing	1.25	0.23-6.72			1.05	0.20-5.45			1.22	0.23-6.57
Immigrant										
Immigrant					1.23	0.84-1.81			1.31	0.88-1.94
Non-immigrant					1.00				1.00	
Missing					2.31	0.57-9.38			2.28	0.55-9.47
Behavioral										
Smoking										
Current daily							1.81	1.33-2.48	1.57	1.13-2.17
Others							1.00		1.00	
Physical activity										
Not active							1.43	1.13-1.82	1.42	1.11-1.81
Active							1.00		1.00	
Missing							1.17	0.76-1.80	1.12	0.72-1.74
Alcohol consumption										
Heavy drinker							1.11	0.80-1.53	1.11	0.79-1.56
Other							1.00		1.00	
Missing							1.66	1.24-2.21	1.41	1.04-1.90
RANDOM EFFECTS										
Level 2 variance (standard error)	0.14 (0.06)		0.13 (0.06)		0.15 (0.06)		0.12 (0.06)		0.14 (0.06)	
Wald Statistic	2.19		2.22		2.32		2.15		2.21	

4.2 Combined Analysis for the Cities of Ottawa and Gatineau

The Ottawa analysis was limited with respect to the number of neighbourhoods and the number of individuals per neighbourhoods. The limited extent of neighbourhood variation that remained after all the individual variables were added to the model may be due, in part, to the limited sample size. To ensure that the limited sample size was not the determining factor in the Ottawa results, an analysis of the combined Ottawa and Gatineau data was completed. This ensured that there were a more substantial number of neighbourhood which compensates for the fact that some of the neighbourhoods had fewer than 30 individuals per neighbourhood.

4.2.1 Description of Sample

As stated previously, 3117 of the 130,827 respondents to the CCHS were residents of the Ottawa-Hull census metropolitan area. Exclusion of rural neighbourhoods left 1441 individuals within the City of Ottawa and 711 individuals within the Gatineau portion resulting in a total sample size of 2152 individuals within 51 neighbourhoods for the combined analysis of Ottawa and Gatineau.

The sample sizes from the City of Ottawa neighbourhoods ranged from 6 to 128 with a mean of 39 (SD=25) and for Ottawa-Gatineau they also ranged from 6 to 128 with a mean of 42 (SD=26).

4.2.2 Characteristics of Area-level Variables

In Gatineau neighbourhoods the mean percentage of economic families below the LICO was 21.29% with a standard deviation of 10.54 and ranged from 5% to 40%. Overall, when Ottawa and Gatineau were combined, the mean percentage of economic families below the LICO was 16.80% with a standard deviation of 9.85.

The mean percentage of individuals completing up to high school education per Gatineau neighbourhood was 42.14% with a standard deviation of 12.18% and ranged from 21% to 63%. Overall, for Ottawa and Gatineau combined, the mean percentage of individuals completing up to high school education was 31.08% with a standard deviation of 12.43.

4.2.2.1 Self-reported Health: Association with Individual-level Variables

Similarly to the reporting for Ottawa, for Ottawa and Gatineau combined, there were no individuals who did not respond to the self-rated health question and therefore all 2152 CCHS respondents were included in the analysis. Table 4.10 presents the characteristics of the sample for Ottawa/Gatineau, as well as the number and percentage of individuals who rated their health as fair or poor for each category.

In Ottawa/Gatineau 12.59% (n=271) rated their health as fair or poor. The same variables were associated with reporting poor or fair health in Ottawa/Gatineau as were associated with reporting poor/fair health in Ottawa.

4.2.2.2 Health Utilities Index: Association with Individual-level Variables

In Ottawa/Gatineau 17 individuals were missing HUI scores and were therefore excluded from the analysis. Of the 2135 individuals included in the analysis 51.19% had HUI scores of less than 0.973.

The same variables were associated with more frequent reports of HUI scores of less than 0.973 in Ottawa/Gatineau as in Ottawa except for the fact that the frequency of reporting low HUI scores was almost equivalent in immigrants and non-immigrants in Ottawa/Gatineau whereas it was slightly more in immigrants in Ottawa.

4.2.3 Missing Data

As with the Ottawa analysis, in cases where data for the outcome was missing, the individual was excluded from the analysis. For Ottawa/Gatineau, there were no individuals missing the outcome of self-reported health; whereas there were 17 individuals missing information regarding the HUI in Ottawa/Gatineau, one more than was missing within the Ottawa data. In cases where the values of the independent variables were missing, dummy variables were created and included in the analysis. A sensitivity analysis was also conducted which consisted of completing the analysis with all of the missing data coded as high risk and completing the analysis with all of the missing data coded as low risk.

The characteristics of those who were missing data for independent variables were reviewed in detail in section 4.1.3 within the Ottawa analysis. Of the 2152 individuals who responded to the question regarding self-rated health, 195 (9%) did not report their income. Of those who did not report their income, 15% of them reported poor or fair health and 51% reported a HUI score of less than 0.973. People at the age extremes were less likely to report their income and those with higher education (greater than high school) were more likely to report their income.

Activity and alcohol binge drinking were unknown for 114 and 477 individuals, respectively. Individuals who were missing data had higher percentages of poor health as compared with those with full data. In the case of the other individual variables, marital status, education, immigrant status and smoking, 15 or fewer individuals were missing data. For all variables, except marital status and smoking, dummy variables were created in order to allow these variables to be kept within the multilevel model. Due to the low

Table 4.10: Prevalence (%) of poor or fair self-reported health by various risk factors, Ottawa-Gatineau, Canadian Community Health Survey 2000-2001

	Number	Fair/poor	Percent
Overall	2152	271	12.59%
Individual-level Variables			
Age (years)			
10-19	292	18	6.16%
20-34	537	28	5.21%
35-49	606	55	9.08%
50-64	411	86	20.92%
≥65	306	84	27.45%
Gender			
Male	977	119	12.18%
Female	1175	152	12.94%
Marital Status			
Married/common-law/partner	1160	161	13.88%
Single/widowed/separated/divorced	109	109	11.00%
Missing	1	1	100.00%
Income			
Low	284	86	30.28%
Lower-Middle	365	60	16.44%
Upper-Middle	566	54	9.54%
Upper	742	41	5.53%
Missing	195	30	15.38%
Educational attainment			
Less than high school	340	108	31.76%
High school graduate	291	43	14.72%
Post-secondary	1222	101	8.27%
In high school (≤19 years of age)	292	18	6.16%
Missing	7	1	15.29%
Immigrant			
Immigrated <10 years ago	144	11	7.64%
Others	1993	257	12.90%
Missing	15	3	20.00%
Smoking Status			
Daily smoker	475	98	20.63%
Others	1672	173	10.35%
Missing	5	0	0.00%
Activity			
Daily exercise	682	64	9.38%
Others	1356	190	14.01%
Missing	114	17	14.91%
Alcohol			
Regular heavy drinker	307	37	12.05%
Others	1368	143	10.45%
Missing	477	91	19.08%
Area-Level Variables			
Percent of households below LICO			
0-10 %	546	36	6.59%
11-20 %	833	102	12.24%
21-30 %	555	93	16.76%
31-40 %	218	40	18.35%
Percent of individuals with high school or less than high school education			
0-10 %	52	6	11.54%
11-20 %	301	22	7.31%
21-30 %	709	74	10.45%
31-40 %	453	68	15.01%
41-50 %	377	56	14.85%
51-60 %	194	29	14.95%

Regular heavy drinker: Consumed >5 drinks in single sitting > 12 times in previous year

Table 4.11: Prevalence (%) of people scoring <0.973 on the HUI by various risk factors, Ottawa-Gatineau, Canadian Community Health Survey 2000-2001

	Number	HUI<0.973	Percent
Overall	2135	1093	51.19%
Individual-level Variables			
Age (years)			
10-19	292	144	49.32%
20-34	537	237	44.13%
35-49	606	290	47.85%
50-64	411	212	51.58%
≥65	306	210	68.63%
Gender			
Male	977	477	48.82%
Female	1175	616	52.43%
Marital Status			
Married/common-law/partner	991	455	45.91%
Single/widowed/separated/divorced	1160	637	54.91%
Missing	1	1	100.00%
Income			
Low	284	179	63.03%
Lower-Middle	365	223	61.10%
Upper-Middle	566	282	49.82%
Upper	742	310	41.78%
Missing	195	99	50.77%
Educational attainment			
Less than high school	340	217	63.82%
High school graduate	291	173	59.45%
Post-secondary	1222	556	45.50%
In high school (≤19 years of age)	292	144	49.52%
Missing	7	3	42.86%
Immigrant			
Immigrated <10 years ago	144	73	50.69%
Others	1993	1011	50.73%
Missing	15	9	60.00%
Smoking Status			
Daily smoker	475	276	58.11%
Others	1672	815	48.74%
Missing	5	2	40.00%
Activity			
Daily exercise	682	301	44.13%
Others	1356	740	54.57%
Missing	114	52	45.61%
Alcohol			
Regular heavy drinker	307	160	52.12%
Others	1368	659	48.17%
Missing	477	274	57.44%
Area-Level Variables			
Percent of households below LICO			
0-10 %	541	264	48.80%
11-20 %	828	417	50.36%
21-30 %	550	297	54.00%
31-40 %	216	115	53.24%
Percent of individuals with high school or less than high school education			
0-10 %	52	25	48.08%
11-20 %	299	131	43.81%
21-30 %	704	384	54.54%
31-40 %	448	248	55.36%
41-50 %	373	178	47.72%
51-60 %	194	92	47.42%

number of missing for marital status and smoking and their skewed distribution the models would not converge with dummy variables and therefore the missing individuals were coded as smokers and singles.

4.2.4 Multilevel Logistic Regression

The combined analysis of the cities of Ottawa and Gatineau provided a larger sample size thereby improving the accuracy of the estimates. The results of this combined analysis are presented in Tables 4.12 – 4.15, page 98-105. As with the Ottawa analysis the extent to which the neighbourhood variation in health, as measured by self-reported health and the Health Utilities Index, is explained by the neighbourhood percentage of economic families below the low income cut offs is presented first, followed by the models examining the neighbourhood low education rates.

4.2.4.1 SRH/ LICO/ OTTAWA-GATINEAU

The empty model demonstrated statistically significant variation in self-rated health at the neighbourhood level. The Wald statistic was 2.66 ($p<0.05$) which is statistically significant based on a one sided test of significance assuming a normal distribution.

Individual demographic, socioeconomic and behavioral factors were shown to be associated with self-rated health when added separately in blocks to the age adjusted models. In general, within all these models (models 2a-2c) the risk of poor or fair SRH increased with age, with those in the 10-19 age range not differing statistically significantly from those in the 20-34 age range. With respect to demographic factors, gender was not significantly associated with SRH (OR=1.06 for females versus males,

95% CI 0.79-1.41); whereas, those who were single had a higher risk of poor or fair SRH than those who were married (OR=1.57, 95% CI 1.16-2.14).

Both individual income and education were significantly associated with the risk of poor or fair SRH. Those in the low income category were more likely to rate their health as poor or fair as compared with those in the upper-middle income bracket (OR=3.25, 95% CI 2.05-5.14). There was an overall gradient, with a trend towards lower risk of poor or fair health with increasing income, although the lower-middle and upper income groups were not statistically significantly different from the upper-middle income group with odds ratios of 1.33 (95% CI 0.87-2.04) and 0.65 (95% CI 0.42-1.02), respectively. Similarly, lower education was also associated with a higher risk of poor or fair health with an odds ratio of 2.45 (95% CI 1.69-3.55) for those with less than high school education and 1.57 (95% CI 1.03-2.40) for those with high school education as compared with those with greater than high school education. On the other hand, those who immigrated less than 10 years ago did not have statistically significantly different odds of poor or fair health as compared with non-immigrants (OR = 0.77, 95% CI 0.40-1.47).

With respect to behavioral factors, smokers, heavy drinkers and those who are not active all had higher risks of reporting poor or fair health. Of all of the individual behavioral factors smoking was associated with the highest odds ratio with smokers being 2.20 times more likely to report poor or fair health than non-smokers (OR=2.20, 95% CI 1.60-3.04). Binge drinkers were more likely to report being in poor or fair health versus non-binge drinkers (OR=1.69, 95% CI 1.10-2.62). Although those that were not active were more likely to report poor or fair health, they did not differ significantly from those

who were active as the 95% confidence interval includes zero (OR=1.39, 95% CI 0.99-1.95).

After the separate block addition of individual demographic, socioeconomic and behavioral factors to the models, statistically significant variation at the neighbourhood level remained with Wald statistics of 2.25, 1.74 and 2.07 (all $p<0.05$), respectively for the level 2 variation.

The socioeconomic characteristic of the neighbourhood as measured by the percentage of economic families below the low income cut offs was significantly associated with the reporting of poor or fair health as is evident in model 2d, in which the percentage of economic families below the LICO was added to the age adjusted model. A 10% increase in the percentage of economic families below the LICO was associated with a 34% increase in the odds of reporting poor or fair health (OR=1.34, 95% CI 1.10-1.63). However, even within this model, significant variation at the neighbourhood level remained with a Wald statistic for the level two variation of 1.86 ($p<0.05$).

The addition of all of the individual level variables within a single model produced similar results to what was found within the separate models; however, the odds ratio for those who were single (OR=1.20, 95% CI 0.86-1.68) and those with a high school education (OR=1.44, 95% CI 0.94-2.21) were no longer statistically significant. The addition of all individual variables reduced the variability at the neighbourhood level; however, it remained statistically significant with a Wald statistic of 1.77 ($p<0.05$).

The results of the separate block incorporation of the individual level variables to the age adjusted model containing the neighbourhood level variable are presented in models 3a through 3c. As expected given the lack of significance of the individual

demographic variables, the coefficient for the percentage of economic families below the LICO remained statistically significant after addition of the demographic factors to the model (OR=1.26, 95% CI 1.03-1.53). On the other hand, addition of the individual socioeconomic variables and the behavioral variables reduced the odds ratio associated with the neighbourhood level variable such that it was no longer statistically significant. In the model containing the percentage of families below the LICO and individual SES variables the odds ratio associated with the neighbourhood LICO was 1.04 (95% CI 0.86-1.27) and it was 1.22 (95% CI 1.00-1.49) in the model containing the neighbourhood LICO and individual behavioral variables. In all of these models significant variation at the neighbourhood level remained with Wald statistics of 1.90 in the model containing neighbourhood LICO and individual demographic variables, 1.77 in the model containing neighbourhood LICO and individual socioeconomic variables and 1.84 in the neighbourhood LICO and individual behavioral variable model.

The neighbourhood variable of percentage of families below the LICO was also not statistically significantly associated with poor or fair health once all of the individual level variables were added to the model. In the final model a 10% increase in the percentage of families below the LICO was associated with an odds ratio of 1.03 (95% CI 0.85-1.25). Significant variation at the neighbourhood level was present within this full model (Wald statistic 1.79, $p<0.05$).

4.2.4.2 HUI/ LICO/ OTTAWA-GATINEAU

The results of the analysis of the importance of neighbourhood percentage of families below the LICO in explaining neighbourhood variation in health as measured by the Health Utilities Index were similar to those for self-rated health. The empty model

demonstrated significant variation in health at the neighbourhood level with a Wald statistic of 2.98 ($p<0.05$). The block addition of the individual demographic, socioeconomic and behavioral variables in models 2a through 2c produced similar results as were found with self-rated health with the exception of the impact of education, physical activity and alcohol binge drinking. As was the case with SRH, those with lower education reported poorer HUI scores than those with higher education; however, with the HUI as the outcome only those with high school education were statistically significantly different from those with greater than high school education (OR=1.46, 95% CI 1.12-1.91). With HUI as the outcome, the impact of not being active was statistically significant with those who are non-active reporting poor or fair health more frequently than those who are active (OR=1.49, 95% CI 1.22-1.81). Alcohol binge drinking did not result in a statistically significant risk with respect to reporting a low HUI score as compared with those who did not drink (OR=1.13, 95% CI 0.87-1.46). A 10% increase in the percentage of families below the LICO in a neighbourhood was associated with a 14% increased odds of reporting an HUI score less than 0.973 (95% CI 0.99-1.31) based on the model which included age and the percentage of families below the LICO (model 2d).

Once all of the individual variables had been added to the model, significant variation at the neighbourhood level remained, with a Wald statistic of 2.75 ($p<0.05$).

The addition of the blocks of individual variables to the age adjusted models containing the neighbourhood percentage of families below the LICO resulted in a reduction in the odds ratio for the neighbourhood variable such that it was not statistically significant in any of the three models. A 10% increase in the percentage of families

below the LICO was associated with a 10% increase in odds of poor health (HUI score <0.973) (OR=1.10, 95% CI 0.96-1.27) after adjustment for demographic factors, a 1% increase in odds (OR=1.01, 95% CI 0.86-1.18) after adjustment for socioeconomic factors, and a 9% increase in odds (OR=1.09, 95% CI 0.95-1.25) after adjustment for behavioral factors. In the final model containing all of the individual variables and the neighbourhood variable, the neighbourhood level variable was not statistically significant, with an odds ratio of 0.99 (95% CI 0.85-1.16). Significant variation at the neighbourhood level remained even within this final model with a Wald statistic of 2.69 ($p<0.05$) indicating that there may be an alternative neighbourhood factor that could explain these neighbourhood differences better than the percent of families below the LICO. This lead to the investigation of neighbourhood low education as a level 2 explanatory variable. The results of this investigation are presented below.

4.2.4.3 SRH/ EDUCATION/ OTTAWA-GATINEAU

As previously stated the empty model for self rated health confirmed that there was significant variation in SRH between neighbourhoods with a statistically significant Wald statistic of 2.66 ($p<0.05$).

The details of the block addition of the individual variables to the age adjusted models discussed previously in section 3.2.4. Briefly, increasing age was associated with an increased risk of poor or fair health as was lower socioeconomic status, lower education, smoking, being single and binge drinking. Not being active was associated with an increased risk of poor or fair health; however, the odds ratio did not reach statistical significance (OR=1.39, 95% CI 0.99-1.95). Those who immigrated in the previous 10 years were at lower risk of poor or fair health although the difference was

non-immigrants was also not significant (OR=0.77, 95% CI 0.40-1.47). Gender did not appear to impact the risk of poor or fair health (OR=1.06, 95% CI 0.79-1.41). Statistically significant variation at the neighbourhood level remained after the block addition of the individual level variables, with Wald statistics of 2.25, 1.74 and 2.07 (all $p<0.05$), respectively for the level 2 variation.

The addition of the neighbourhood low education variable to the age-adjusted model resulted in an odds ratio for the neighbourhood variable of 1.25 (95% CI 1.06-1.46). This indicates that a 10% increase in neighbourhood low education is associated with a 25% increase in the odds of poor or fair health. Significant variation at the neighbourhood level remained with a Wald statistic for the level two variation of 1.96 ($p<0.05$).

Addition of all of the individual variables within model 2e generally reduced the odds ratios; however, the direction of the odds ratios did not change and those that were statistically significant remained significant with the exception of marital status (OR= 1.20 for single versus married, 95% CI 0.86-1.68) and high school education (OR=1.44 versus greater than high school education, 95% CI 0.94-2.21). The addition of all individual variables reduced the variability at the neighbourhood level; however, it remained statistically significant with a Wald statistic of 1.77 ($p<0.05$).

The results of the separate block incorporation of the individual level variables to the age adjusted model containing the neighbourhood level variable are presented in models 3a through 3c. The addition of the individual demographic and behavioral variables reduced the odds ratio for the neighbourhood low education to 1.21 (95% CI 1.03-1.42) and 1.17 (95% CI 1.02-1.35), respectively. On the other hand, addition of the

individual socioeconomic variables reduced the odds ratio associated with the neighbourhood level variable such that it was no longer statistically significant. In the model containing the neighbourhood low education and individual SES variables the odds ratio associated with the neighbourhood education was 1.02 (95% CI 0.87-1.19). The Wald statistics for the age adjusted models containing neighbourhood education and demographic variables and neighbourhood education and socioeconomic variables were 1.89 and 1.68, respectively, indicating that significant variation at the neighbourhood level remained. However, in the model containing the behavioral level variables there was not statistically significant at the second level with a Wald statistic of 1.63 ($p<0.05$).

The neighbourhood variable of the percentage of people completing only high school education was also not statistically significantly associated with poor or fair health once all of the individual level variables were added to the model. A 10% increase in the percentage of people not completing at least a high school education was associated with a 2% increase the risk of poor or fair health, based on the final model which incorporated all the individual and the neighbourhood variables (OR=1.02, 95% CI 0.87-1.19). Unlike in the case of the neighbourhood percentage below the LICO, statistically significant variation at the neighbourhood level did not remain within this final model with a Wald statistic of 1.63 ($p<0.05$).

4.2.4.4 HUI/ EDUCATION/ OTTAWA-GATINEAU

The results of the analysis which utilized HUI as the health outcome and neighbourhood educational attainment as the neighbourhood exposure variable are presented below. As previously stated, significant variation in the proportion of HUI scores lower than 0.973 was found at the neighbourhood level based on the empty model

with a Wald statistic of 2.98 ($p<0.05$). The block addition of the individual variables to the age-adjusted models was described in detail in section 3.2.4. Briefly, singles, those with lower incomes, those with lower education, smokers and those who aren't active all had a statistically significantly higher risk of HUI scores of less than 0.973. The age-adjusted model containing only neighbourhood education found that a 10% increase in the percentage of individuals completing only high school education was associated with a 2% increase in odds of poor health (HUI<0.973). Significant variation at the neighbourhood level remained within this model with a Wald statistic of 2.80 ($p<0.05$). Significant variation at the neighbourhood level was also present within the model containing all of the individual variables (Wald statistic=2.69, $p<0.05$).

The addition of the blocks of individual variables to the age adjusted models containing the neighbourhood percent low education resulted in a reduction in the odds ratio for the neighbourhood variable, which remained generally not significantly different from one. A 10% increase in the number of individuals completing only a high school education was associated with a 1% increase in odds of poor health (HUI score <0.973) (OR=1.01, 95% CI 0.91-1.15) after adjustment for demographic factors. Addition of individual socioeconomic factors and the addition of the behavioral factors reduced the neighbourhood level impact such that it was not significant with an odds ratio for a 10% increase those completing only high school of 0.93 (95% CI 0.83-1.05) and 0.99 (95% CI 0.88-1.11), respectively. In the final model containing all of the individual variables and the neighbourhood variable, the neighbourhood level variable was not statistically significant, with a 10% increase in the percentage of individuals completing only high school education being associated with an odds ratio of 0.93 (95% CI 0.83-1.05).

Significant variation at the neighbourhood level remained even within this final model with a Wald statistic of 2.59 ($p<0.05$).

4.2.4.5 City Influence

The fact that the combined analysis only drew from two cities, Ottawa and Gatineau, a third city level could not be added to the model as the sample was not sufficient. To determine the impact of drawing the sample from two cities, a city covariate was added to the final models. The added covariate did not significantly alter the results and did not influence the conclusions.

4.2.4.6 Missing Information

The sensitivity analysis which was conducted in order to determine if the missing data impacted the results revealed that the misclassification of the missing data did not significantly change the results and would not have influenced the conclusions.

Table 4.12: Odds Ratios (95% Confidence Intervals) for Poor/Fair Self-Rated Health with Percentage of Families below the LICO as the Neighbourhood Exposure Measure, Ottawa-Gatineau

	Empty Model: Model 1	Model 2a		Model 2b		Model 2c		Model 2d	
		Demographic + age	CI	SES + age	CI	Behavioral + age	CI	LICO + age	CI
FIXED EFFECTS									
Area level variables									
% < LICO (10% increase)								1.34	1.10-1.63
Individual level variables									
Demographic									
Age									
10-19		1.23	0.62-2.41	1.04	0.49-2.20	1.34	0.68-2.65	1.45	0.75-2.81
20-34		1.00		1.00		1.00		1.00	
35-49		1.94	1.16-3.26	1.67	1.00-2.81	1.61	0.97-2.68	1.82	1.11-2.99
50-64		5.54	3.40-9.02	4.60	2.80-7.56	5.32	3.27-8.65	5.21	3.25-8.33
≥65		8.99	5.48-14.73	6.10	3.64-10.21	9.16	5.55-15.13	8.09	5.02-13.06
Gender									
Female		1.06	0.79-1.41						
Male		1.00							
Marital status									
Single etc.		1.57	1.16-2.14						
Married etc.		1.00							
SES									
Household income									
Low				3.25	2.05-5.14				
Low-mid				1.33	0.87-2.04				
Upper-mid				1.00					
Upper				0.65	0.42-1.02				
Missing				1.41	0.83-2.38				
Education									
< high school				2.45	1.69-3.55				
high school				1.57	1.03-2.40				
>high school				1.00					
missing				1.46	0.15-14.26				
Immigrant									
Immigrant				0.77	0.40-1.47				
Non-immigrant				1.00					
Missing				2.53	0.71-8.99				
Behavioral									
Smoking									
Current daily						2.20	1.60-3.04		
Others						1.00			
Physical activity									
Not active						1.39	0.99-1.95		
Active						1.00			
Missing						2.83	1.55-5.17		
Alcohol consumption									
Heavy drinker						1.69	1.10-2.62		
Other						1.00			
Missing						2.13	1.53-2.95		
RANDOM EFFECTS									
Level 2 variance (standard error)	0.31 (0.12)	0.23 (0.10)		0.15 (0.08)		0.19 (0.09)		0.15 (0.08)	
Wald Statistic	2.66	2.25		1.74		2.07		1.86	

Table 4.12 Continued: Odds Ratios (95% Confidence Intervals) for Poor/Fair Self-Rated Health with Percentage of Families below the LICO as the Neighbourhood Exposure Measure, Ottawa-Gatineau

	Model 2e		Model 3a		Model 3b		Model 3c		Model 4	
	Individual Variables + Age	CI	LICO + age + demog	CI	LICO + SES + age	CI	LICO + behav + age	CI	All variables	CI
FIXED EFFECTS										
Area level variables										
% < LICO (10% increase)			1.26	1.03-1.53	1.04	0.86-1.27	1.22	1.00-1.49	1.03	0.85-1.25
Individual level variables										
Demographic										
Age										
10-19	1.06	0.48-2.33	1.25	0.64-2.43	1.04	0.49-2.19	1.36	0.70-2.66	1.07	0.49-2.31
20-34	1.00		1.00		1.00		1.00		1.00	
35-49	1.77	1.04-3.03	1.95	1.18-3.23	1.67	1.00-2.78	1.63	0.99-2.69	1.77	1.04-2.99
50-64	5.41	3.24-9.04	5.48	3.40-8.84	5.54	2.79-7.40	5.28	3.27-8.52	5.32	3.21-8.82
≥65	7.74	4.51-13.30	8.69	5.35-14.10	5.98	3.60-9.94	8.92	5.44-14.61	7.58	4.44-12.94
Gender										
Female	1.12	0.82-1.52	1.06	0.80-1.40					1.12	0.82-1.52
Male	1.00		1.00						1.00	
Marital status										
Single etc.	1.20	0.86-1.68	1.52	1.12-2.06					1.20	0.86-1.66
Married etc.	1.00		1.00						1.00	
SES										
Household income										
Low	2.87	1.78-4.63			3.16	2.00-5.01			2.81	1.75-4.53
Low-mid	1.22	0.79-1.89			1.32	0.86-2.02			1.21	0.78-1.87
Upper-mid	1.00				1.00				1.00	
Upper	0.72	0.46-1.14			0.66	0.43-1.03			0.73	0.46-1.14
Missing	1.31	0.77-2.25			1.41	0.83-2.37			1.31	0.77-2.23
Education										
< high school	2.15	1.47-3.15			2.41	1.66-3.48			2.12	1.45-3.10
high school	1.44	0.94-2.21			1.56	1.03-2.37			1.43	0.94-2.19
>high school	1.00				1.00				1.00	
missing	1.03	0.10-2.21			1.44	0.15-13.90			1.02	0.10-10.78
Immigrant										
Immigrant	0.79	0.40-1.56			0.77	0.40-1.46			0.79	0.40-1.54
Non-immigrant	1.00				1.00				1.00	
Missing	2.53	0.70-9.16			2.52	0.72-8.88			2.52	0.70-9.02
Behavioral										
Smoking										
Current daily	1.69	1.20-2.38					2.10	1.53-2.89	1.67	1.19-2.35
Others	1.00						1.00		1.00	
Physical activity										
Not active	1.34	0.95-1.91					1.40	1.00-1.95	1.34	0.95-1.90
Active	1.00						1.00		1.00	
Missing	2.95	1.57-5.56					2.81	1.55-5.11	2.92	1.56-5.47
Alcohol consumption										
Heavy drinker	1.81	1.14-2.88					1.71	1.11-2.63	1.80	1.14-2.86
Other	1.00						1.00		1.00	
Missing	1.56	1.10-2.21					2.07	1.50-2.87	1.55	1.10-2.19
RANDOM EFFECTS										
Level 2 variance (standard error)	0.15 (0.09)		0.16 (0.08)		0.14 (0.08)		0.15 (0.08)		0.15 (0.09)	
Wald Statistic	1.77		1.90		1.77		1.84		1.79	

Table 4.13: Odds Ratios (95% Confidence Intervals) for HUI Scores <0.973 with Neighbourhood Low Income as the Neighbourhood Exposure Measure, Ottawa-Gatineau

	Empty Model: Model 1	Model 2a		Model 2b		Model 2c		Model 2d	
		Demographic + age	CI	SES + age	CI	Behavioral + age	CI	LICO + age *	CI
FIXED EFFECTS									
Area level variables									
% < LICO (10% increase)								1.14	0.99-1.31
Individual level variables									
Demographic									
Age									
10-19		1.12	0.81-1.55	0.94	0.64-1.40	1.27	0.92-1.75	1.36	0.99-1.86
20-34		1.00		1.00		1.00		1.00	
35-49		1.37	1.07-1.75	1.14	0.90-1.45	1.12	0.88-1.42	1.18	0.94-1.49
50-64		1.43	1.09-1.86	1.24	0.95-1.63	1.26	0.97-1.64	1.28	0.99-1.66
≥65		3.32	2.42-4.56	2.56	1.84-3.56	2.94	2.13-4.04	2.95	2.16-4.03
Gender									
Female		1.05	0.88-1.26						
Male		1.00							
Marital status									
Single etc.		1.58	1.29-1.94						
Married etc.		1.00							
SES									
Household income									
Low				1.62	1.15-2.27				
Low-mid				1.34	1.01-1.78				
Upper-mid				1.00					
Upper				0.72	0.57-0.91				
Missing				0.91	0.65-1.28				
Education									
< high school				1.28	0.97-1.70				
high school				1.46	1.12-1.91				
>high school				1.00					
missing				1.03	0.21-5.00				
Immigrant									
Immigrant				1.14	0.80-1.61				
Non-immigrant				1.00					
Missing				2.80	0.97-8.08				
Behavioral									
Smoking									
Current daily						1.41	1.13-1.76		
Others						1.00			
Physical activity									
Not active						1.49	1.22-1.81		
Active						1.00			
Missing						1.23	0.82-1.85		
Alcohol consumption									
Heavy drinker						1.13	0.87-1.46		
Other						1.00			
Missing						1.56	1.24-1.97		
RANDOM EFFECTS									
Level 2 variance (standard error)	0.16 (0.05)	0.12 (0.05)		0.14 (0.05)		0.13 (0.05)		0.13 (0.05)	
Wald Statistic	2.98	2.65		2.74		2.67		2.75	

Table 4.13 Continued: Odds Ratios (95% Confidence Intervals) for HUI Scores <0.973 with Neighbourhood Low Income as the Neighbourhood Exposure Measure, Ottawa-Gatineau

	Model 2e		Model 3a		Model 3b		Model 3c		Model 4	
	Individual Variables + Age	CI	LICO + demographic + age	CI	LICO + SES + age	CI	LICO + behavioral+ age	CI	All variables	CI
FIXED EFFECTS										
Area level variables										
% < LICO (10% increase)			1.10	0.96-1.27	1.01	0.86-1.18	1.09	0.95-1.25	0.99	0.85-1.16
Individual level variables										
Demographic										
Age										
10-19	0.82	0.54-1.24	1.13	0.82-1.56	0.95	0.64-1.40	1.27	0.92-1.76	0.82	0.54-1.24
20-34	1.00		1.00		1.00		1.00		1.00	
35-49	1.24	0.97-1.60	1.37	1.07-1.75	1.14	0.90-1.45	1.12	0.88-1.43	1.24	0.96-1.60
50-64	1.37	1.03-1.80	1.43	1.09-1.86	1.24	0.95-1.62	1.26	0.97-1.65	1.36	1.03-1.80
≥65	2.89	2.05-4.06	3.25	2.37-4.47	2.53	1.82-3.52	2.89	2.10-3.98	2.85	2.02-4.00
Gender										
Female	0.99	0.82-1.19	1.05	0.88-1.25					0.99	0.83-1.19
Male	1.00		1.00						1.00	
Marital status										
Single etc.	1.45	1.19-1.77	1.56	1.27-1.91					1.44	1.17-1.79
Married etc.	1.00		1.00						1.00	
SES										
Household income										
Low	1.48	1.05-2.10			1.60	1.14-2.26			1.48	1.04-2.09
Low-mid	1.31	0.98-1.75			1.33	1.00-1.77			1.31	0.98-1.75
Upper-mid	1.00				1.00				1.00	
Upper	0.80	0.63-1.01			0.72	0.57-0.92			0.80	0.63-1.02
Missing	0.89	0.63-1.26			0.91	0.65-1.29			0.89	0.63-1.26
Education										
< high school	1.89	0.89-1.59			1.28	0.97-1.70			1.19	0.89-1.59
high school	1.40	1.07-1.85			1.45	1.11-1.90			1.40	1.06-1.84
>high school	1.00				1.00				1.00	
missing	1.16	0.23-5.79			1.03	0.21-4.99			1.16	0.23-5.77
Immigrant										
Immigrant	1.19	0.83-1.70			1.14	0.80-1.61			1.19	0.83-1.70
Non-immigrant	1.00				1.00				1.00	
Missing	2.65	0.91-7.71			2.77	0.96-7.98			2.61	0.90-7.60
0ehavioral										
Smoking										
Current daily	1.24	0.98-1.56					1.39	1.11-1.73	1.23	0.98-1.55
Others	1.00						1.00		1.00	
Physical activity										
Not active	1.46	1.20-1.78					1.48	1.22-1.81	1.45	1.19-1.77
Active	1.00						1.00		1.00	
Missing	1.22	0.80-1.85					1.24	0.82-1.86	1.21	0.80-1.84
Alcohol consumption										
Heavy drinker	1.12	0.85-1.47					1.13	0.87-1.47	1.12	0.85-1.47
Other	1.00						1.00		1.00	
Missing	1.35	1.06-1.72					1.54	1.22-1.95	1.35	1.06-1.71
RANDOM EFFECTS										
Level 2 variance (standard error)	0.13 (0.05)		0.13(0.05)		0.14(0.05)		0.13 (0.05)		0.13 (0.05)	
Wald Statistic	2.69		2.68		2.74		2.71		2.69	

Table 4.14: Odds Ratios (95% Confidence Intervals) for Poor/Fair Self-Reported Health with Neighbourhood Low Education as the Neighbourhood Exposure Measure, Ottawa-Gatineau

	Empty Model: Model 1	Model 2a		Model 2b		Model 2c		Model 2d	
		Demographic + age	CI	SES + age	CI	Behavioral + age	CI	Education + age	CI
FIXED EFFECTS									
Area level variables									
% low education (10% increase)								1.25	1.06-1.46
Individual level variables									
Demographic									
Age									
10-19		1.23	0.62-2.41	1.04	0.49-2.20	1.34	0.68-2.65	1.20	0.64-2.24
20-34		1.00		1.00		1.00		1.00	
35-49		1.94	1.16-3.26	1.67	1.00-2.81	1.61	0.97-2.68	1.82	1.12-2.94
50-64		5.54	3.40-9.02	4.60	2.80-7.56	5.32	3.27-8.65	4.79	3.02-7.60
≥65		8.99	5.48-14.73	6.10	3.64-10.21	9.16	5.55-15.13	6.65	4.16-10.65
Gender									
Female		1.06	0.79-1.41						
Male		1.00							
Marital status									
Single etc.		1.57	1.16-2.14						
Married etc.		1.00							
SES									
Household income									
Low				3.25	2.05-5.14				
Low-mid				1.33	0.87-2.04				
Upper-mid				1.00					
Upper				0.65	0.42-1.02				
Missing				1.41	0.83-2.38				
Education									
< high school				2.45	1.69-3.55				
high school				1.57	1.03-2.40				
>high school				1.00					
missing				1.46	0.15-14.26				
Immigrant									
Immigrant				0.77	0.40-1.47				
Non-immigrant				1.00					
Missing				2.53	0.71-8.99				
Behavioral									
Smoking									
Current daily						2.20	1.60-3.04		
Others						1.00			
Physical activity									
Not active						1.39	0.99-1.95		
Active						1.00			
Missing						2.83	1.55-5.17		
Alcohol consumption									
Heavy drinker						1.69	1.10-2.62		
Other						1.00			
Missing						2.13	1.53-2.95		
RANDOM EFFECTS									
Level 2 variance (standard error)	0.31 (0.12)	0.23 (0.10)		0.15 (0.08)		0.19 (0.09)		0.16 (0.08)	
Wald Statistic	2.66	2.25		1.74		2.07		1.96	

Table 4.14 Continued: Odds Ratios (95% Confidence Intervals) for Poor/Fair Self-Reported Health with Neighbourhood Low Education as the Neighbourhood Exposure Measure, Ottawa-Gatineau

	Model 2e		Model 3a		Model 3b		Model 3c		Model 4	
	Individual Variables + Age	CI	Education+ demographic + age	CI	Education + SES + age	CI	Education + behavioral + age	CI	All variables	CI
FIXED EFFECTS										
Area level variables										
% low education (10% increase)			1.21	1.03-1.42	1.02	0.87-1.19	1.17	1.02-1.35	1.02	0.87-1.19
Individual level variables										
Demographic										
Age										
10-19	1.06	0.48-2.33	1.20	0.61-2.36	1.01	0.48-2.15	1.13	0.60-2.15	1.02	0.47-2.23
20-34	1.00		1.00		1.00		1.00		1.00	
35-49	1.77	1.04-3.03	2.05	1.23-3.41	1.80	1.08-3.00	1.75	1.07-2.85	1.90	1.12-3.22
50-64	5.41	3.24-9.04	5.63	3.48-9.12	4.79	2.93-7.84	5.00	3.13-8.01	5.51	3.31-9.15
≥65	7.74	4.51-13.30	8.86	5.43-14.47	6.15	3.69-10.26	7.33	4.51-11.92	7.63	4.47-13.03
Gender										
Female	1.12	0.82-1.52	1.04	0.78-1.37					1.09	0.80-1.48
Male	1.00		1.00						1.00	
Marital status										
Single etc.	1.20	0.86-1.68	1.57	1.16-2.12					1.19	0.86-1.65
Married etc.	1.00		1.00						1.00	
SES										
Household income										
Low	2.87	1.78-4.63			3.42	2.18-5.39			3.03	1.89-4.85
Low-mid	1.22	0.79-1.89			1.36	0.89-2.08			1.25	0.81-1.93
Upper-mid	1.00				1.00				1.00	
Upper	0.72	0.46-1.14			0.65	0.42-1.01			0.71	0.45-1.11
Missing	1.31	0.77-2.25			1.57	0.94-2.62			1.46	0.87-2.44
Education										
< high school	2.15	1.47-3.15			2.35	1.62-3.40			2.08	1.43-3.03
high school	1.44	0.94-2.21			1.57	1.04-2.37			1.45	0.95-2.20
>high school	1.00				1.00				1.00	
missing	1.03	0.10-11.07			1.33	0.14-12.95			0.94	0.09-9.99
Immigrant										
Immigrant	0.79	0.40-1.56			0.71	0.37-1.36			0.72	0.36-1.41
Non-immigrant	1.00				1.00				1.00	
Missing	2.53	0.70-9.16			2.37	0.67-8.39			2.32	0.64-8.39
Behavioral										
Smoking										
Current daily	1.69	1.20-2.38					2.23	1.64-3.05	1.64	1.17-2.31
Others	1.00						1.00		1.00	
Physical activity										
Not active	1.34	0.95-1.91					1.44	1.05-2.00	1.34	0.95-1.89
Active	1.00						1.00		1.00	
Missing	2.95	1.57-5.56					2.21	1.18-4.15	2.82	1.53-5.19
Alcohol consumption										
Heavy drinker	1.81	1.14-2.88					1.46	0.96-2.24	1.72	1.08-2.72
Other	1.00						1.00		1.00	
Missing	1.56	1.10-2.21					1.96	1.43-2.69	1.56	1.11-2.20
RANDOM EFFECTS										
Level 2 variance (standard error)	0.15 (0.09)		0.16 (0.08)		0.13 (0.08)		0.12 (0.07)		0.13 (0.08)	
Wald Statistic	1.77		1.89		1.68		1.63		1.63	

Table 4.15: Odds Ratios (95% Confidence Intervals) for HUI Scores <0.973 with Neighbourhood Low Education as the Neighbourhood Exposure Measure, Ottawa-Gatineau

	Empty Model: Model 1	Model 2a		Model 2b		Model 2c		Model 2d	
		Demographic + age	CI	SES + age	CI	Behavioral + age	CI	Education + age	CI
FIXED EFFECTS									
Area level variables									
% low education (10% increase)								1.02	0.91-1.15
Individual level variables									
Demographic									
Age									
10-19		1.12	0.81-1.55	0.94	0.64-1.40	1.27	0.92-1.75	1.35	0.99-1.85
20-34		1.00		1.00		1.00		1.00	
35-49		1.37	1.07-1.75	1.14	0.90-1.45	1.12	0.88-1.42	1.17	0.93-1.48
50-64		1.43	1.09-1.86	1.24	0.95-1.63	1.26	0.97-1.64	1.27	0.98-1.65
≥65		3.32	2.42-4.56	2.56	1.84-3.56	2.94	2.13-4.04	2.96	2.17-4.04
Gender									
Female		1.05	0.88-1.26						
Male		1.00							
Marital status									
Single etc.		1.58	1.29-1.94						
Married etc.		1.00							
SES									
Household income									
Low				1.62	1.15-2.27				
Low-mid				1.34	1.01-1.78				
Upper-mid				1.00					
Upper				0.72	0.57-0.91				
Missing				0.91	0.65-1.28				
Education									
< high school				1.28	0.97-1.70				
high school				1.46	1.12-1.91				
>high school				1.00					
missing				1.03	0.21-5.00				
Immigrant									
Immigrant				1.14	0.80-1.61				
Non-immigrant				1.00					
Missing				2.80	0.97-8.08				
Behavioral									
Smoking									
Current daily						1.41	1.13-1.76		
Others						1.00			
Physical activity									
Not active						1.49	1.22-1.81		
Active						1.00			
Missing						1.23	0.82-1.85		
Alcohol consumption									
Heavy drinker						1.13	0.87-1.46		
Other						1.00			
Missing						1.56	1.24-1.97		
RANDOM EFFECTS									
Level 2 variance (standard error)	0.16 (0.05)	0.12 (0.05)		0.14 (0.05)		0.13 (0.05)		0.14 (0.05)	
Wald Statistic	2.98	2.65		2.74		2.67		2.80	

Table 4.15 Continued: Odds Ratios (95% Confidence Intervals) for HUI Scores <0.973 with Neighbourhood Low Education as the Neighbourhood Exposure Measure, Ottawa-Gatineau

	Model 2e		Model 3a		Model 3b		Model 3c		Model 4	
	Individual Variables + Age	CI	Education + demographic + age	CI	Education + SES + age	CI	Education + behavioral + age	CI	All variables	CI
FIXED EFFECTS										
Area level variables										
% low education (10% increase)			1.02	0.91-1.15	0.93	0.83-1.05	0.99	0.88-1.11	0.93	0.83-1.05
Individual level variables										
Demographic										
Age										
10-19	0.82	0.54-1.24	1.12	0.81-1.55	0.94	0.63-1.39	1.26	0.92-1.70	0.82	0.54-1.24
20-34	1.00		1.00		1.00		1.00		1.00	
35-49	1.24	0.97-1.60	1.36	1.07-1.74	1.14	0.90-1.45	1.15	0.90-1.46	1.24	0.96-1.60
50-64	1.37	1.03-1.80	1.42	1.09-1.85	1.24	0.95-1.62	1.41	1.08-1.85	1.36	1.03-1.80
≥65	2.89	2.05-4.06	3.27	2.38-4.49	2.52	1.81-3.50	2.93	2.14-4.02	2.84	2.02-3.99
Gender										
Female	0.99	0.82-1.19	1.05	0.88-1.26					0.99	0.82-1.19
Male	1.00		1.00						1.00	
Marital status										
Single etc.	1.45	1.17-1.80	1.57	1.28-1.93					1.44	1.17-1.78
Married etc.	1.00		1.00						1.00	
SES										
Household income										
Low	1.48	1.05-2.10			1.61	1.15-2.27			1.48	1.05-2.09
Low-mid	1.31	0.98-1.75			1.34	1.01-1.78			1.32	0.99-1.76
Upper-mid	1.00				1.00				1.00	
Upper	0.80	0.63-1.01			0.71	0.56-0.90			0.79	0.62-1.00
Missing	0.89	0.63-1.26			0.91	0.65-1.29			0.89	0.63-1.26
Education										
< high school	1.19	0.89-1.59			1.30	0.98-1.73			1.20	0.90-1.61
high school	1.40	1.07-1.85			1.47	1.12-1.92			1.41	1.07-1.85
>high school	1.00				1.00				1.00	
missing	1.16	0.23-5.79			1.03	0.21-4.99			1.16	0.23-5.80
Immigrant										
Immigrant	1.19	0.83-1.70			1.12	0.79-1.59			1.17	0.82-1.68
Non-immigrant	1.00				1.00				1.00	
Missing	2.65	0.91-7.71			2.74	0.95-7.88			2.58	0.89-7.49
Behavioral										
Smoking										
Current daily	1.24	0.98-1.56					1.46	1.17-1.83	1.25	0.99-1.57
Others	1.00						1.00		1.00	
Physical activity										
Not active	1.46	1.20-1.78					1.51	1.24-1.83	1.45	1.19-1.77
Active	1.00						1.00		1.00	
Missing	1.22	0.80-1.85					1.18	0.77-1.80	1.20	0.79-1.82
Alcohol consumption										
Heavy drinker	1.12	0.85-1.47					1.21	0.93-1.57	1.11	0.85-1.46
Other	1.00						1.00		1.00	
Missing	1.35	1.06-1.72					1.33	1.06-1.68	1.35	1.06-1.71
RANDOM EFFECTS										
Level 2 variance (standard error)	0.13 (0.05)		0.13 (0.05)		0.13 (0.05)		0.13 (0.05)		0. 12 (0.05)	
Wald Statistic	2.69		2.70		2.62		2.75		2.59	

Chapter 5: Discussion

5.1 Summary and Discussion of Findings

These cross-sectional analyses of the City of Ottawa alone and in combination with the City of Gatineau demonstrated that poor neighbourhood socioeconomic conditions are significantly associated with poor self-reported health (as measured by SRH or the HUI). However, the neighbourhood socioeconomic conditions were no longer significant after controlling for individual-level demographic, socioeconomic and behavioral factors. Additionally, the impact of neighbourhood level variables was modest, in comparison with individual characteristics.

Two possible explanations for these findings are, first, that the effects of the neighbourhood socioeconomic characteristics on individual health are the result of the composition of the neighbourhood. In other words, neighbourhoods that are poor have a high concentration of poor individuals and as it has been shown that poor individuals have poorer health, so too do poor neighbourhoods.

Alternatively, the effect of neighbourhood poverty on individual health may be mediated through individual socioeconomic and behavioral factors. From a behavioral perspective, poorer neighbourhoods provide conditions which are not conducive to healthy behaviors. For example, they may have fewer parks, fewer healthy food choices within grocery stores, greater numbers of stores selling cigarettes, and/or more bars, all of which may create environments in which people are more likely to participate in behaviors that are harmful to health. Similarly, poor neighbourhoods may create economic and social environments that negatively influence individual socioeconomic status. Disadvantaged neighbourhoods may have poorer schools with lower parental

involvement. They may also have more limited employment opportunities. As neighbourhoods become more disadvantaged, those who have the means to leave the neighbourhood often move elsewhere and it is typically the most disadvantaged individuals that are unable to leave. Consequently, through these mechanisms poor socioeconomic neighbourhoods may influence individual socioeconomic status thereby leading to poorer health. In both of these cases the fact that the neighbourhood characteristics are influencing health by working through individual characteristics means that adjustment for individual characteristics will reduce the neighbourhood characteristics such that they are no longer significant.

5.2 Interpretation of Findings in Context of Existing Literature

5.2.1 Association between Neighbourhood Socioeconomic Factors and Health

This study demonstrated that there is significant variation in health between neighbourhoods both within the City of Ottawa and Gatineau. It also showed that there was a significant association between the percentage of families below the LICO within the neighbourhood and the number of individuals not completing high school and self reported health. However, the significance of the neighbourhood socioeconomic characteristics disappeared upon adjustment for individual level factors. This being said in most cases significant variation in health at the neighbourhood level remained when only the individual variables were added to the model indicated that there may be an alternative neighbourhood variable or combination of variables that could explain this neighbourhood variability.

Previous studies within this area have produced conflicting results. Similar to our study a six year study focusing on 86 urban neighbourhoods of Eindhoven in the Netherlands found that there was a higher risk of death in more deprived neighbourhoods;

however, the significance of the neighbourhood effects was lost after adjustment for individual level covariates. Similarly, a Canadian study of Montreal neighbourhoods by Ross et al found that there was significant variation between neighbourhoods in health; however, none of the neighbourhood variables were significant determinants after adjustment for individual level variables. There are, however, a number of studies which found significant neighbourhood effects that persisted after adjustment for individual level variables. Hou and Chen found that neighbourhood socioeconomic conditions within Toronto neighbourhoods were significantly associated with poor self-perceived health after adjustment for individual level variables. Similarly, a Swedish study also found that residence in deprived neighbourhoods contributed to increased self reported long-term illness, but not to mortality risk, even after adjustment for individual socioeconomic status, age, housing tenure, marital status and social networks.[80]

There are a number of possible explanations that may account for the difference in the findings of our study in comparison with some of the published literature. First, there are differences with respect to the definition of neighbourhood from one study to another. Most studies utilized census geography and defined their neighbourhoods as either enumeration areas or census tracts. This study differed in that neighbourhoods were defined to be in keeping with individual's perceptions of neighbourhoods. This generally resulted in neighbourhoods that were larger than a single census tract. Although census tracts often do not reflect true neighbourhoods, in this type of analysis they are more likely to demonstrate significant neighbourhood effects, due to the fact that they are, by definition, relatively homogeneous socioeconomic areas. As a result, the within neighbourhood variation is diminished and the between neighbourhood variation

exploited. However, the hypothesized mechanisms for neighbourhood effects that this analysis was attempting to test support the choice of neighbourhoods defined as closely as possible by individual perception.

Another difference with respect to geographical considerations is with respect to the inclusion or exclusion of rural areas. Some of the previous studies included both rural and urban areas; whereas, only urban neighbourhoods were included within this analysis. (see page 14) It is likely that the impact of area socioeconomics differs in rural areas versus urban areas. Within rural areas the definition of neighbourhood is unlikely to be relevant given the distance between neighbours. Additionally, the concept of economic segregation is particularly relevant within urban areas; whereas, it is unclear how and if it can be applied to rural areas. Therefore, area effects within rural areas are likely to involved distinct mechanisms which may produce different results.

Another possible explanation for the differing results is the use of different health outcome measures. It is evident from the published literature that the significance of the neighbourhood variation and the importance of neighbourhood socioeconomics is dependent upon the chosen health outcome.

Finally, the nature of the two cities under consideration in this analysis may also have influenced the results. Although significant variation in health between neighbourhoods was demonstrated within Ottawa, it is only a moderately large city and therefore it does not have a large number of neighbourhoods with high levels of economic disadvantage. This limits the ability to demonstrate significant impacts of neighbourhood economics. The inclusion of Gatineau within the analysis increased the

number of neighbourhoods; however, the association may have been weakened by the fact that Gatineau does not have as established a neighbourhood structure as Ottawa.

5.2.2 Relationship between Self-Perceived Health and the Health Utilities Index

In this analysis both self-rated health and the Health Utilities Index were utilized as outcome measures in order to allow for a comparison between the two. In general those who rated their health as poor or fair based on the self-rated health question also had HUI scores of less than 0.973. However, more than 80% of those with HUI scores of less than 0.973 rated their health based on the self report as good, very good or excellent. One reason for this difference may be the fact that the HUI is focused primarily on functionality and therefore if those with decreased functionality are able to adapt to their limitations they may feel that their overall health is not compromised by their functional limitation.

In the multilevel analysis focusing on LICO, which appeared to be the more relevant neighbourhood measure, self-rated health demonstrated a stronger association with this neighbourhood measure as compared with the HUI within both the Ottawa and the combined Ottawa-Gatineau analysis. These differences in results may be due in part to the choice of cut point for the HUI. However, they may also be due to the fact that the HUI and SRH are measuring different things. SRH is a subjective measure of health and may therefore be influenced by a person's situation. For example, those in poorer situations may be more inclined to rate their health as poorer as compared with those in more equitable situations. With respect to the HUI, as stated above, it focuses primarily on functionality and may therefore also be affected by an individual's situation. For example, higher incomes may allow individuals to pay for services or equipment which

improve there functionality whereas those with lower incomes may not have this opportunity.

5.3 Limitations of Study

A number of factors should be considered in the interpretation of the results of this study.

1. The cross sectional nature of the Canadian Community Health Survey limits the ability to make inferences regarding causality. In cross sectional analyses the relationship between the exposure and the outcome may be bi-directional. In this case, living in a poor neighbourhood may negatively affect an individual's health, or alternatively, ill health may lead to loss of income encouraging movement into or preventing movement out of poor neighbourhoods that provide affordable housing alternatives.

Another drawback of cross sectional data is that it does not allow for examination of effects of exposure over time. It is likely that any neighbourhood effect on individual health will take a number of years to manifest itself. The people who were in the current survey may have only recently moved to the neighbourhood and therefore there would be little time for the neighbourhood environment to influence health. Duration of residence information was not collected as part of the CCHS and therefore this could not be included in the analysis.

Lastly, a cross sectional view of a neighbourhood provides only a static view of the neighbourhood at one point in time. Neighbourhoods evolve over time through economic cycles, changes in industries and businesses, demographic shifts and migration and these changes are not taken into consideration in cross-sectional analyses.[121]

2. Possible Measurement Error: There are a number of potential sources of measurement error, the two most important being the measurement of household income within the CCHS and the definition of neighbourhoods. In this study, adjustments for household income were made based on data provided in the CCHS. The question within the CCHS which asks respondents to provide their household income is categorical, allowing respondents to choose the bracket into which their household income falls. This may result in some residual confounding by household income; however, previous studies have shown that this is unlikely to materially affect the results.[69,165] Additionally, for both the household income variable and in the calculations of the neighbourhood low income percent, income is not adjusted for taxes. As taxes tend to act to reduce income inequality, use of unadjusted numbers may overestimate the proportion of households in the low income categories resulting in a slight over-adjustment for individual income.

A choice was made to use neighbourhoods which most closely approximate individual's perceptions of city neighbourhoods for Ottawa and Gatineau within this analysis. However, given the nature of the available data, approximations of perceived neighbourhoods were built from existing census tracts. This may lead to some misclassification with respect to the exposure; however, provided this misclassification is non-differential, it will bias the results toward the null thereby underestimating the impact of the exposure.[166]

3. Contextual versus Compositional effects: Multilevel modeling was utilized within this study in an attempt to separate the contextual effects of neighbourhood socioeconomics from the composition effects of the sum of individual socioeconomic characteristics. It is, however, very difficult to separate the two, particularly when

utilizing cross sectional data. Compositional effects on health are the result of the aggregation of individual health, meaning that similar types of people will have similar illnesses no matter where they live. Contextual effects, on the other hand, imply that individuals with similar characteristics will have different health status in different neighbourhoods.[75,80] Complicating this distinction is a number of factors. The first is that although some families select themselves into communities on the basis of the characteristics of the community, other families are selected into communities or remain in communities because they do not have the means to leave.[109] The second is that individuals are not distinct from their communities.[167] Individuals actions change and shape the nature of communities. For example, studies have shown that poor individuals often have poorer diets. This has been linked to the fact that grocery stores in poor neighbourhoods stock less healthy food than in more affluent neighbourhoods. The question that remains is, do poor people eat a poorer diet because poor food is stocked at the grocery stores of poor areas or do grocery stores in these neighbourhoods stock unhealthy food because it is the type of food that is in demand by poor individuals?[2] According to Massey and Denton 1993 neighbourhoods change in response to the characteristics and actions of their residents: "The isolated action of one actor affects the subsequent actions of others thereby creating a powerful feedback loop between individual and collective behavior."[159] It is therefore very difficult to separate the importance of individual versus ecological factors in determining individual health particularly utilizing cross sectional data. Future research based on longitudinal data and intervention studies may help to further clarify the importance of these two factors.

4. Consideration of Sample Design: A methodological limitation of this study is that the complex survey design was only partially taken into account. The probability of sampling was taken into account through utilization of weights within the analysis; however, the cluster nature of the sample selection was not taken into account. The sample weights reflect the number of individuals within the population that the sampled individual represents and therefore take into consideration the probability of being sampled. The cluster effects within neighbourhoods at the level of the census tract, enumeration area and household were not included within the analysis. This may lead to a slight underestimation of the standard errors. [168]

5. Outcome Measures: Both of the outcome measures rely upon a self report of health by the participant and although some people may consider the subjective nature of the report a limitation, health is in fact inherently subjective. The Health Utilities Index is likely to provide a slightly more objective measure of health as it includes questions from eight attributes which are focused on functionality i.e. the ability to perform specified activities. Self-reported health, on the other hand, allows people to provide an overall assessment of health which incorporates such factors as their ability to cope with limitations, comparisons with others and the impact of their environment on their health. One factor that is of particular importance with this study is the possibility that neighbourhood of residence may impact on how people rate their health. For example, people living within poor areas may have lower expectations with respect to health and therefore may rate their health higher than similar people living in more affluent areas. As mentioned previously this would tend to influence the rating of SRH rather than the

HUI and therefore may explain some of the differences in results between the two outcome measures.

6. Combination of Ottawa and Gatineau Data: The City of Ottawa was analysed independently first and then in combination with the City of Gatineau. It is proposed that the combined analysis is reasonable given the high degree of integration between the two cities. That being said, the two cities do reside within separate provinces which could impact a number of measures within this analysis. Although both healthcare systems are governed by the Canada Health Act , healthcare is under the jurisdiction of the provincial government and therefore the provinces differ with respect to the extent of investment in various segments of the healthcare system. Additionally, the cultural differences of the two cities may influence how health is rated.[169] A study by Kopec showed that Quebecer's may rate their health differently than the rest of Canada.[158] These differences were adjusted for through the addition of the province as a covariate within the multilevel analysis.

An additional limitation of combining the Ottawa and Gatineau data is that although the City of Ottawa has defined neighbourhoods which are compatible with resident's perceived neighbourhoods, Gatineau has not undergone this task. As a result the electoral districts in Gatineau were utilized as proxy neighbourhoods for this analysis. The size of these neighbourhoods was consistent with the size of the Ottawa neighbourhoods; however there may have been a greater degree of misclassification within Gatineau which is likely to be non-differential and therefore would be expected to bias the results towards the null.[124]

7. Healthy survivor bias: Given an interest in the impact of neighbourhood on the health of all members of the community, all age groups sampled in the CCHS were included within the analysis. In addition, sample size requirements did not permit the limiting of the study to selected age brackets. A number of previous studies have limited their population to those between the ages of 25 and 65. The rationale given for this limitation is generally two fold.

Firstly, it is suggested that it is within this age range that premature mortality is expected to be affected by access to healthcare and health behaviors which are most likely to be impacted by socioeconomic status.[65] In a study by Roos which found no association between socioeconomic factors and healthy aging the authors suggest this may be due to the fact the poor people die earlier or that government transfers may more effectively reduce income inequality in this group.[170] However, another multilevel study did show a significant impact of neighbourhood characteristics on the health of the elderly.[87] Based on this evidence, the elderly were retained in the study population.

The second argument for excluding the elderly is that there is a healthy survivor effect and given that those who are poorer are generally less healthy and have greater premature mortality elderly people in poor neighbourhoods may appear healthier than expected. This would result in a bias in the results towards the null.

8. Overadjustment of income: The question of whether or not to adjust for individual income when examining the impact of environmental socioeconomic characteristics on health has been extensively debated in the literature. Adjustments are made in an attempt to separate the effect of the environment from that of the individual. The drawback of adjusting for individual SES arises from the fact that, to a certain extent, individual SES

is determined by the environment. Policies on wages, investments and taxes help determine the extent of unequal income distribution across the population, and this distribution then influences individual income. The statistical adjustment for individual income thereby reveals an important pathway linking ecological economic conditions and individual health. At the same time, it may also encourage underestimation of the overall population effects of unequal income distribution.[171] Another pathway through which neighbourhood income may influence the apparent health of its residents stems from the fact that the neighbourhood economic conditions influence who moves in and out of neighbourhoods. If people move based on both the individual level variable and the ecological level variable (i.e. if old people move to areas of high poverty and/or young people move out of areas of high poverty) controlling for individual income will result in over-controlling and an underestimation of the neighbourhood effects.[63]

9. Power: As stated previously, the determination of adequate sample size in multilevel studies is a complicated issue. In this study, the City of Ottawa sample was just sufficient to meet the recommendations based on simulation studies. This may have contributed to the non-significant results; however, a similar size study by Yen and Kaplan found significant results in with 996 participants and 228 deaths.[83,84] The sample size of the combined Ottawa and Gatineau analysis was in excess of the minimal recommendations.

5.4 Implications for Policy and Future Research

5.4.1 Implications for Policy

The reduction of health inequalities requires policies which act to more equitably distribute wealth and opportunity within society. These policies may act to improve the situations of individuals or may be aimed at groups within society. The results of this study add to previous published literature which support the conclusion that individual

differences in socioeconomic status are responsible for the majority of the differences in health outcomes as opposed to neighbourhood socioeconomics.[172] This suggests that policies that are aimed at improving disadvantaged individual's situations throughout society, rather than targeting specific neighbourhoods may be more effective in reducing health inequalities. Consideration should however be given to the fact that although neighbourhood socioeconomic conditions may not have a large impact currently, economic segregation within Canadian cities is on the rise and therefore it may become a more significant factor in the future should policies not be put in place to reverse this trend.

It is evident from the degree of segregation and concentration of poverty within the United States that policies which are prominent within US cities have served to shore up racial and economic segregation. Zoning policies, the layout of federally funded freeways, school district manipulation and the suburbs' autonomy from central-city governments maintain the social isolation of African-Americans and the poor in the US cities.[173]

In contrast to the United States, policies of more socially democratic countries have been shown to be successful in minimizing inequalities, infant mortality and poverty. Navarro compared social democracies, Christian democracies, former fascist dictatorships and liberal countries and found that the social democracies were the most effective in reducing health inequalities. These countries had strong labour movements, invested heavily in social services and support services for families (children and the elderly), provided universal healthcare and strong welfare states. Furthermore, although it is often argued that policies such as these which are favorable to health, are not

economically sound, Navarro also found that these countries had stronger growth than the Christian democratic and liberal countries and that the reduction of inequalities was a precondition for economic efficiency and economic growth.[174]

An often cited example of these types of policies is that of Kerala India, which in contrast to most other Indian states and despite low individual income, enjoys a rate of infant mortality, maternal mortality, childhood mortality and overall mortality which approaches levels in richer, industrialized countries. Kerala also differs from other Indian states in the extent of its redistributive actions, its promotion of greater gender equality, education and its general public investment in human resources.[171]

As health inequalities are undeniably linked to socioeconomic inequalities, policies which serve to reduce socioeconomic inequalities will also act to reduce health inequalities.[175] These policies may include not only economic efforts such as progressive taxation directed at redistribution of wealth, but may also include education, labour, health, and social services policies which act to reduce socioeconomic inequalities thereby reducing health inequalities.[53,176]

From an educational standpoint, private school tuition tax credits and voucher systems within the US have served to encourage moves to private schools which have been shown to perform better, rather than focusing on improving the public school system. These types of programs did not work because poorer children remain in the public school system and the issue lies with the challenges of educating poorer children who bring fewer resources with them and therefore require more time and effort to teach.[173] Policies aimed at improving the public school system thereby ensuring equal

access to high quality schooling rather than shifting students from one school to another may help to reduce socioeconomic inequalities.

Regulation of the labour market also aids in reducing inequalities within society. Policies such as a minimum wage, strengthening of collective bargaining, unemployment insurance and investments in skills building programs have all been shown to be effective.[177] With respect to social policies, those which create a strong welfare state such as extended maternity leave benefits and universal day care are particularly important in the lives of families.

Specifically regarding health policy, universal healthcare is an essential base on which to build and equitable health system with equal opportunity for access. Evidence supports that the universal healthcare system has reduced insurance related barriers to healthcare. A study by Katz showed that low-income persons in Canada receive more health services than low-income persons in the United States.[178]

Canada has attempted many of these policies in the past, but has been moving away from them in recent years as demands for lower taxes have become more prominent.

5.4.2 Future Research

1. Longitudinal studies in combination with analysis techniques such as structural equation modeling and pathways analysis may help to further clarify the pathways through which neighbourhood differences in socioeconomics affect health. They would be particularly helpful in discerning to what extent neighbourhood characteristics work through influencing individual characteristics.
2. To date limited focus has been placed on investigating the potential mechanisms behind neighbourhood influences on health. Qualitative analysis could provide more

detailed information behind the processes at work within neighbourhoods and aid in the definition of relevant neighbourhoods. In addition, interventional studies would be useful in establishing cause and effect and in evaluating the effectiveness of policies.

3. There would be value in comparing the policies of various countries in order to better understand the impact of policies on health and to attempt to understand the mechanisms behinds the differences between countries such as Canada and the United States. This may provide insight into which policies have the most impact in altering the associations between income and health at the community level.

4. There may be particularly critical periods within the life cycle that are crucially important where social policies that increase equality may have particularly positive impacts or vice versa. Investigation utilizing life course techniques may be useful in these cases for informing policy.[179]

5. Although geographic neighbourhoods provide the context in which we live, people spend a great deal of time today in the context of other neighbourhoods which may be more relevant than geographic neighbourhoods. The influence of "work neighbourhoods" and possibly, in the future, "cyber neighbourhoods" may provide more important contexts for life potentially affecting health.

6. Given that individual socioeconomic factors appear to have a more significant impact on health than compositional factors, further research into the effectiveness of policies directed at all of those in need would be justified.

5.5 Conclusion

Our study demonstrated that there is a significant relationship between neighbourhood socioeconomic conditions, as measured by the percentage of families

below the LICO and by the percentage of individuals completing up to high school education, and individual health within Ottawa and Ottawa-Gatineau. However, adjustment for individual demographic, socioeconomic and behavioral factors resulted in a reduction in the importance of neighbourhood factors such that they were no longer statistically significant. Individual factors played a much more crucial role in influencing individual health as compared with neighbourhood socioeconomic factors. This suggests that policies directed at improving the socioeconomic status of all in need individuals may be more successful in reducing health inequalities as compared with targeting specific neighbourhoods.

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