The influence of Social Determinants of Health on Child Physical Health in Greater Sudbury Neighbourhoods

by

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Abstract

There is increasing awareness that social determinants of health are associated with growing health inequities, or avoidable differences, among many populations. The City of Greater Sudbury is experiencing these health inequities, including inequities in child physical health and wellbeing. This study will examine the relationship between specific social determinants of health and child physical health and wellbeing in Greater Sudbury neighbourhoods. The goals of this research are 1) to explore the relationships between specific social determinants of health and child physical health and wellbeing in Greater Sudbury neighbourhoods, 2) explore the collective influence of social determinants of health on child physical health and wellbeing, and 3) examine unique relationships that may exist between the social determinants of health and children physical health in neighbourhoods for the City of Greater Sudbury.

The complexity, nature, and interactions of the social determinants of health within society makes observing them quantitatively difficult. This requires many different social determinants of health to be studied separately from one another, as well as together, in order to understand how they influence child physical health and wellbeing. In order to better understand these interactions, the social ecological model of health promotion presents an ideal theoretical framework for examining multiple variables and their correlations and, therefore, is used in this study. This study is an ecological cross-sectional study using secondary data analysis of the 2011 National Household Survey (Statistics Canada) and the Early Development Instrument which was developed by the Offord Centre for Child Studies.

This study involves a multi-variate analysis with the dependent variable of child physical health being represented by a composite measure of child physical health and wellbeing, and multiple independent variables including different measures of neighbourhood income, education, unemployment, lone-parent families and poverty. Child physical health and wellbeing is represented by the Early Development Instrument (EDI) - a questionnaire completed by the teacher or an Early Child Educator (ECE) when the child is in senior kindergarten. The EDI is a comprehensive measure of child physical health and wellbeing because it includes gross/fine motor skills, physical readiness for the school day, and physical independence. The social determinants of health are represented by the National Household Survey – a voluntary sample survey using a random sample collected by Statistics Canada, which the federal government uses to collect social and economic data about the Canadian population (Statistics Canada, 2011).

Descriptive statistics address the assumptions of linear regression as well as examine the nature and normalcy of the independent and dependent variables. Then the presence of outliers are tested using univariate, bivariate, and multivariate detection methods. Linear and multiple regression tests are then used to analyze the influences of the social determinants of health on child physical health and wellbeing. The results of this study demonstrate the challenges of exploring geographical differences in the health of a population, and how those differences in health may be socially produced. Furthermore, this study provides insight into better understanding how child physical health and wellbeing in Greater Sudbury neighbourhoods may be influenced by socially produced health disparities.

Key Words

Social determinants of health, health equity, child physical health, neighbourhood, social gradient, health trajectory, social ecological model.

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Chapter 1: Introduction

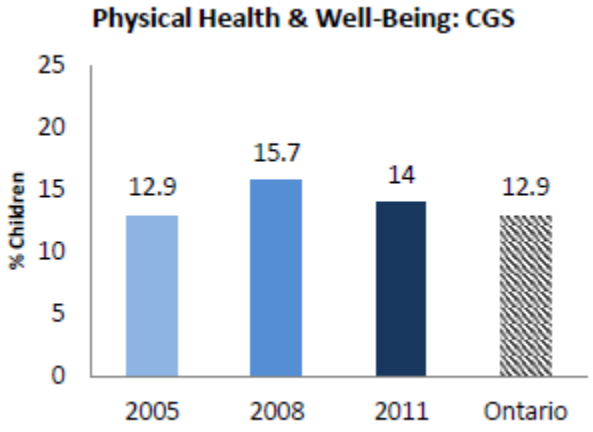
There are factors beyond an individual's biology and behaviour that influences their health behaviour. These are known as the social determinants of health (M Marmot, 2008). These social determinants of health are part of growing health inequities, or avoidable differences, in health among populations (M Marmot, 2008). It is important to note that child physical health and wellbeing is a health inequity in Greater Sudbury because there is an unequal distribution of poor child physical health, and poor child physical health is avoidable. Once a population (Greater Sudbury for example) is determined to have an unequal distribution of health, the reasons should be examined to determine whether these differences are socially produced, and therefore, avoidable (Ontario Agency for Health Protection and Promotion, 2013). The World Health Organization (WHO) Commission on Social Determinants of Health claims that the vast majority of inequalities in health are avoidable, however they are still experienced by all age groups including young people (Currie, Zanotti, Looze, Roberts, & Barnekow, 2012). Greater Sudbury is similar to other communities in that these health inequities are especially prevalent for residents living in poverty, lone-parent families, those without a high school certificate or diploma, who are unemployed, and those who struggle with obesity (Sudbury & District Health Unit, 2013). The report 'Opportunity for All' stresses the importance of understanding health inequities, such as the prevalence rate of obesity being two times higher in residents of the City of Greater Sudbury's (CGS) most deprived areas (Sudbury & District Health Unit, 2013). Understanding such inequities is needed in order to reduce health disparities for the people of Greater Sudbury (Sudbury & District Health Unit, 2013). This report demonstrates significant area level health inequities in the CGS, including a social gradient in health outcomes (Sudbury & District Health Unit, 2013). The social gradient implies that the higher an individual's social position, the more likely they are not experiencing poor health outcomes (Michael Marmot, 2010). Poor social and economic circumstances affect health throughout life. People further down the social ladder usually run at least twice the risk of serious illness and premature death as those near the top (Wilkinson & Marmot, 2003). For example, if everyone in the CGS experienced the same opportunities for wellbeing, there would be 38% fewer people who were obese in the City (Sudbury & District Health Unit, 2013). This is especially important because the global rise in obesity has manifested itself within the CGS as it is the second most obese city in Canada with 33.8 % of its residents identified as obese (Carroll, Navaneelan, Bryan, & Ogden, 2015). More specifically, if everyone in Greater Sudbury experienced the same opportunities for health, each year there would be 9,706 more people in the City who would rate their health as excellent or very good

(Sudbury & District Health Unit, 2013). The global rise in obesity is also a reality for children. The prevalence of obesity among children and adolescents aged 3–19 in Canada was 13% from 2009-2013, and for children between the ages of 3-6, the prevalence of obesity was 11.3 % (Carroll et al., 2015). Negative physical health in children is linked to adiposity, cardiovascular health, mental health, academic achievement, musculoskeletal health, cancer, asthma, and other chronic diseases associated with premature death (Janssen, 2007; Warburton, Nicol, & Bredin, 2006).

This social gradient is evident in spatial differences in child physical health and wellbeing. Neighbourhoods within Greater Sudbury are experiencing a gradient in vulnerability of children in terms of physical health and wellbeing. Analysis of the Early Development Instrument (EDI) has demonstrated that specific neighbourhoods within Greater Sudbury have disproportionate numbers of children not meeting expectations for physical health and wellbeing (Turchan, 2013). This means that specific neighbourhoods have a higher percentage of children who are considered 'vulnerable' when it comes to physical health. These children experience poor physical readiness (coming to school hungry or tired), poor physical independence (coordination, balance, handedness), and poor gross/fine motor skills (physical skills, energy levels) (Turchan, 2013). Therefore, social determinants of health have an important role in child physical health and wellbeing inequities that exist within the CGS.

Social determinants of health may also have a meaningful role in the poor state of child physical health and wellbeing for the CGS when compared to the rest of the province.

Figure 1.1 % of vulnerable children in CGS for Physical Health and Wellbeing



(Turchan, 2013)

Figure 1.1 shows that the CGS has been above the provincial average when it comes to the percentage of vulnerable children compared to the rest of the province. It is important to note that a lower

percentage is more desirable as it reflects a lower number of children who are deemed vulnerable. This demonstrates the importance of examining the relationship between specific social determinants of health and child physical health and wellbeing in the CGS neighbourhoods.

Data from the National Household Survey (NHS) including various measures of income, education, unemployment, lone-parent families, and measures of poverty are used to measure the social determinants of health, and the physical health and wellbeing of children will be represented by data from the EDI. This research also explores the area-level differences in CGS neighbourhoods. This will lead to a better understanding of the complex role that determinants of health are having in child development within CGS neighbourhoods and could, therefore, assist in policy formulation and the creation of programs targeted to improve child development for vulnerable populations.

Overall, this study highlights the importance of examining the influence of social determinants of health on child physical health and wellbeing by exploring the role the social determinants of health have in influencing child physical health. The rest of this thesis is comprised of several chapters. The literature review chapter examines the importance of the social determinants of health, the social gradient, child development and child physical health trajectories, the role of the social ecological model of health promotion, the relationship between poverty and health, and how neighbourhoods influence health and physical health. The literature review also includes a critical appraisal section which examines the challenges that come with examining the social determinants of health. The methodology chapter addresses the setting of this study, the data collection process, inclusion and exclusion criteria, how the variables in this study are measured, and the hypothesis and prediction of outcomes. The analysis chapter examines the influence of the social determinants on health on child physical health in CGS neighbourhoods by examining descriptive statistics for the dependent and independent variables including the data range and skewness, examining outlier neighbourhoods that have unique relationships between the independent and dependent variables, and analyzes the findings from the bivariate and multivariate analyses including linear, two variable, and three variable regression models. The final chapters discuss the findings of the analysis including the implications, key findings, limitations, and policy implications as well as knowledge dissemination.

Chapter 2: Literature Review

This literature review stresses the importance of improving health inequities by examining the nature of the social determinants of health, how these determinants influence child physical health at the neighbourhood level, and the challenges of studying the social determinants of health at the neighbourhood level. The following summarizes current literature relevant to the nature of the social determinants of health, the social gradient effect, the importance of improving child development and child physical health, the influence of poverty on physical health, the role of neighbourhoods, and the usefulness of the social ecological model of health promotion as a theoretical framework for this study. After reviewing the literature, the research questions that guide the rest of the thesis are presented.

2.1 The Social Determinants of Health

Social determinants of health are nonmedical, and non-lifestyle factors that impact health. There are multiple groups and organizations that have varying classification systems for these determinants including the Ottawa Charter for Health Promotion, the Canadian Institute for Advanced Research, and the World Health Organization (Raphael, 2003). Identified determinants include income, education, employment, working conditions, social support networks, healthy child development, environment, gender, and genetic endowment. Social determinants of health developed as researchers started to identify the specific mechanisms in different socioeconomic environments that cause people to experience varying degrees of health and illness (Raphael, 2006). There is indisputable evidence that the quality of social determinants of health an individual experiences explains the wide range of health disparities that exist among populations. The health impact of social determinants are supported by strong and widely observed associations between a wide range of health indicators and measures of individuals' socioeconomic resources or social position such as income or education (Braveman & Gottlier, 2014). For example, level of education in the United States influences life expectancy after the age of 25. This means for both men and women, the higher educational attainment an individual has, the longer they are expected to live (Braveman & Gottlier, 2014). Educational attainment is also related to infant mortality rate in the United States. This means the lower a mother's educational attainment, the more risk of infant mortality there is (Braveman & Gottlier, 2014). Another important association between social determinants of health and their impacts on health is family income and child health. The higher family income is, the likelier the health of children in those families will be rated as good or better (Braveman & Gottlier, 2014). Family income is also associated with activity limiting chronic diseases (Braveman & Gottlier, 2014).

One important aspect of the social determinants of health is that they have an accumulative effect. This means the likelihood of enduring negative health outcomes increases with the presence of multiple social disadvantages. Bauman et al. (2006) found that adding social disadvantages together increased risk of poor health outcomes in children. Specifically, poverty, low parent education, and single-parent family structure have additive negative health effects for children (Bauman, Silver, & Stein, 2006). This study examines the cumulative effect of neighbourhood income, education, unemployment, lone parent family prevalence, poverty, and how these social determinants of health influence child physical health and wellbeing.

2.1.1 Education

Education is a very important determinant of health and it exerts both a direct and indirect influence on health. This means educational attainment has a direct association with health outcomes, and education also influences other social determinants of health such as income, and education (Dubow, Boxer, & Rowell Huesmann, 2010; Ross & Mirowsky, 2011; Sanders, Federico, Klass, Abrams, & Dreyer, 2011). Education provides literacy, numeracy, and analytical and communication skills which increase a person's employability and ability to cope with a range of issues including health (Ministerial Taskforce on Health Inequalities, 2008). The World Health Organization (WHO) recognizes that obtaining good health involves reducing levels of educational failure (Wilkinson & Marmot, 2003). Life expectancy within a community is associated with the proportion of people with a postsecondary education (Shields & Tremblay, 2002). People living in large metropolitan areas and urban centres, where education levels are high, have the highest life expectancies in Canada (Shields & Tremblay, 2002). Education and health may be related for different reasons: poor health early in life may lead to less educational attainment; lower educational attainment may adversely affect subsequent health; or some third factor may affect education and health seeking behaviour (Cutler & Lleras-Muney, 2011). This is because those with a college education and relatively wealthy parents are more likely to have access to educational opportunities and to higher status, as well as well-paying careers (Cohen, Janicki-Deverts, Chen, & Matthews, 2010). Also, parental education level has an impact on child health. As poorly educated children age, the negative health effects of their parents' low educational attainment get worse. This is because an individual's own education is highly structured by their parents. This means that individuals from disadvantaged family backgrounds are likely to be disadvantaged themselves (Ross & Mirowsky, 2011). Level of education is highly correlated with other social determinants of health such as the level of income, employment security, and working conditions. This demonstrates that education gives

people resources and the ability to move up the socioeconomic ladder and have access to other societal and economic resources (Mikkonen & Raphael, 2010).

2.1.2 Income

It is very well known that income can positively or negatively influence health. It can be argued that it is the most important social determinant of health because of its ability to influence living conditions, higher levels of education, and health-related behaviours such as extent of physical activity, smoking and alcohol consumption (Lapointe, Ford, & Zumbo, 2007; Mikkonen & Raphael, 2010). Children experience the impact of income through the circumstances of their parent or guardian. In families with low income, deprivation can directly affect a child's material circumstances and, as a consequence, their health (Benzeval et al., 2014). This is because income and health have a bi-directional and inter-generational relationship. Parental income will impact child health, and child health can improve later income and wealth (Benzeval et al., 2014). Low parental income can have a negative impact on school readiness for children. Lapointe et al. (2007) found that low parent income is associated with poor physical health scores, less than a grade nine education, and poor school readiness outcomes in children (Lapointe et al., 2007). Also, people who are already most vulnerable to poor health outcomes due to their lower income and education are also the ones most likely to experience adverse working conditions. (Mikkonen & Raphael, 2010).

2.1.3 Unemployment

Unemployment, and the length of time spent unemployed, has a negative effect on health status. Unemployment implies lost earnings, which leads to a reduction in the ability to afford goods and services that positively influence health (Box, Haven, & Ranis, 2012). Unemployment is linked with lower life expectancy within a community (Shields & Tremblay, 2002), material deprivation (M Marmot, 2008), and chronic stress (Adler & Newman, 2002). Unemployment is also a significant negative predicator of cognitive development, communication skills, and general knowledge (Lapointe et al., 2007). Parent unemployment has a significant impact on child health and development. There is an increase in the number of young children being raised by working parents with inadequate earnings, therefore keeping their family in poverty (Shonkoff & Phillips, 2000). These parents work long non-standard hours, have few benefits, and this economic pressure can force an early return to work shortly after the birth of a child. The consequences of this change in parental employment structure for young children is likely to determine the parenting the child receives and the quality of the caregiving they experience when they are not with their parents (Shonkoff & Phillips, 2000). In order to improve the health of children, the consequences of parental employment conditions need to be better understood, and there needs to be

a focus on alleviating the long term vulnerability of children growing up in families with risks of unemployment and poor working conditions (Box et al., 2012).

2.1.4 Lone Parent Families

Parents and other regular caregivers in children's lives are crucial in influencing the health environment. Children grow and thrive in the context of close and dependable relationships that provide love, nurturing, security, responsive interaction, and encouragement for exploration. Without at least one such relationship, development is disrupted and the consequences can be severe and long-lasting (Shonkoff & Phillips, 2000). Single-parent family structures are not just an underlying social disadvantage, but have additive effects on the life chances of children (Bauman et al., 2006). Lone-parent families may have less income and access to health promoting resources, which means they are at greater risk for living in poverty; children who spend a significant amount of time in poverty will likely have poorer health and increased stress (Evans & Kim, 2007). Also, parents that have less income have been found to be at an increased risk for many forms of psychological distress including depression and lack of self-worth. This is due to greater exposure to negative life events and having fewer resources with which to cope with adverse life experiences (Shonkoff & Phillips, 2000).

2.1.5 Poverty

Measures of poverty can include combinations of different social determinants of health including the ones previously discussed. Poverty consists of compounding poor social and economic circumstances which have adverse health outcomes, especially for children. Social and economic resources influence early child development through different mechanisms including low levels of education and literacy which negatively impact the skill-base of children's parents (Irwin, Siddiqi, & Hertzman, 2007). Social risk factors such as growing up in poverty have been associated with poorer health outcomes for children because being exposed to multiple social and economic risk factors can have an accumulative effect on child health across physical and socioemotional domains (Larson, Russ, Crall, & Halfon, 2008). Bauman et al. (2006) found that children living in households below the poverty line compared with those above the poverty line are more likely to have a chronic health condition and more likely to have an activity restriction (Bauman et al., 2006). Poverty is a major risk factor for mental, emotional, and behavioral disorders, as well as other developmental challenges including physical health problems (Cushon, Vu, Janzen, & Muhajarine, 2011). An interesting mechanism by which poverty can negatively impact child health is through biological embedding of disease risk. There is a large body of evidence that suggests adult disease and risk factors for poor health can be biologically embedded in the brain and other organ systems during sensitive periods of child development. These biologically

embedded health risks can result in negative health outcomes that do not appear for years to decades after they are embedded (Centre on the Developing Child at Harvard University, 2010).

2.2 The Social Gradient

One important attribute of these determinants is the social gradient that highlights the nature of health inequities. The lower a person's social and economic position, the more likely it is they are unhealthy (Marmot, M 2010). Individuals further down the social gradient usually have double the risk of serious illness and premature death as individuals closer to the top. However, the effects of the social gradient are not just confined to the poor: it includes all social groups including middle class workers (Wilkinson & Marmot, 2003). The social gradient provides evidence for a widening gap in health equity. There is an unequal distribution and availability of resources such as income, education, and goods and services which contributes to disparities in health (Toivanen & Modin, 2011). This means that social groups with more access to health promoting resources have many advantages over groups of people towards the bottom of the social gradient (Ministerial Task Force on Health Inequalities, 2008). Gaining a better understanding of how social determinants of health may be influencing child physical health and wellbeing is necessary to help close the social gradient and help eliminate health inequities that exist in Greater Sudbury. The social gradient effect of early child development is a very powerful explanation for differences in children's well-being within societies, and these resources profoundly affect all other aspects of the family environment (Irwin et al., 2007). There is also a physical activity gradient where volume of physical activity is correlated with health outcomes. This means the more physically healthy and active an individual is, the lower the risk is for experiencing negative health outcomes. The less physically healthy an individual is, the more risk there is for developing negative health outcomes. (Warburton et al., 2006).

2.3 Child Physical Health Trajectory

The health of the Canadian population, and populations globally, are dependent on the health of children as they grow up and become functional members of society. Health in the earliest years, even starting with the mother's health before she becomes pregnant can impact the health trajectory of that child. When developing biological systems are strengthened by positive early experiences, healthy children are more likely to grow into healthy adults (Centre on the Developing Child at Harvard University, 2010). This critical time period of development is also when young children develop behavioral routines and patterns that influence long-term health trajectories. These healthy behaviours span across multiple health domains including hygiene, screen time, routine levels of physical activity,

nutritional habits, and even the suppression or promotion of risk taking behaviours (Centre on the Developing Child at Harvard University, 2010). Scientific progress has produced a better appreciation for the importance of early life experiences, the influences of genetics and environment on human behaviour, and the role of support in early relationships in reducing or increasing health risks (Karoly, Kilburn, & Cannin, 2005; Shonkoff & Phillips, 2000). Children with multiple risks (low parental education, single parent, and low income) will likely have limited skills and lower educational attainment themselves, which increases the likelihood of undesirable outcomes in adulthood (Karoly et al., 2005).

An important aspect of child health development is that childhood socioeconomic status and health are correlated. This means that there is a greater likelihood of enduring negative health outcomes as an adult if an individual experienced lower socio economic status in childhood.

Negative and positive health experiences during child development affect many domains, and among them is physical health and wellbeing. Exposure to risk or protective factors in early life impacts physical behavioural capacities which affects development across the life course (Centre on the Developing Child at Harvard University, 2010). Negative physical health in children is linked to adiposity, cardiovascular health, mental health, academic achievement, musculoskeletal health, cancer, asthma, and other chronic diseases associated with premature death (Janssen, 2007; Warburton et al., 2006).

Overall, children growing up in impoverished environments with more health risks and fewer protective factors are more likely to have a poorer health trajectory than those children growing up in environments where risks are fewer and there are more protective factors (Halfon, Larson, Lu, Tullis, & Russ, 2014). This means a focus on health promotion during child development in order to improve the trajectory of children's health will reduce the social and economic burdens of illness throughout the life course (Centre on the Developing Child at Harvard University, 2010).

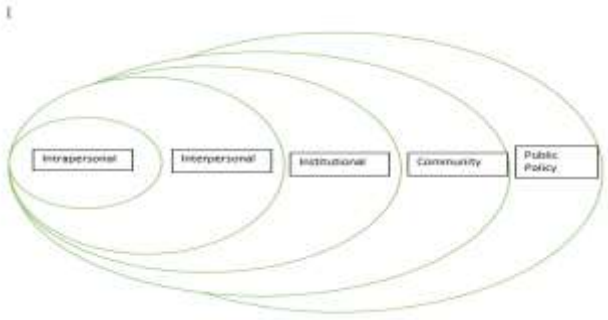
2.4 Theoretical Framework: The Social Ecological Model of Health Promotion

In the past two decades, there has been a dramatic increase and interest in, and application of, ecological models in research and practice (Glanz, Rimer, & Viswanath, 2008; Sallis et al., 2006). This is due to their ability to guide comprehensive population-wide approaches to changing behaviours that will reduce serious and prevalent health problems. Also, ecological models can be used to develop comprehensive interventions that systematically target mechanisms of change at each level of society (Fisher et al., 2005; Cohen, Scribner, & Farley, 2000; Glanz, Sallis, Saelens, & Frank, 2005). This is due to

the ability of the models to represent the complex mechanisms that influence human behaviour within society which, in turn, allows for the analysis of the dynamic relationships of the social determinants of health. Social ecological models emphasize individual characteristics, proximal social influences including family, also considers broader community, organizational, and policy influences on health behaviour (Glanz et al., 2008). This model creates an excellent framework that is adaptable to many different public health issues because it considers many variables that influence health behaviours.

This study uses one specific adaptation of the social ecological model which was adapted from Bronfenbrenner's ecology of human development (Bronfenbrenner, 1977). This particular version of the social ecological model has been adapted to help analyze various public health issues. In this adaptation model, the outcome of interest is patterned behaviour determined by the following five domains: intrapersonal, interpersonal, institutional, community, and public policy (see figure 2.1) (McLeroy, Bibeau, Steckler, & Glanz, 1988).

Figure 2.1 Social Ecological Model for Health Promotion



(adapted from McLeroy, et al., 1988).

These five domains are individually influencing health behaviour as well as influencing each other by interacting at different levels within society. Intrapersonal factors focus on the characteristics of the individual, interpersonal factors include social support networks such as friends and family, institutional factors include the influence of institutions and organizations that have the ability to impact health policy, community factors include relationships among individuals, the institutions and organizations, and public policy involves local, provincial, and national laws and policies (McLeroy et al., 1988). This is important because the social determinants of health examined in this study have similar characteristics: they also influence health behaviour across different dimensions within society both simultaneously and

separately. Table 2.1 demonstrates how the social determinants of health examined in this study fit within the framework of the social ecological model for health promotion.

Table 2.1 Social Ecological Model for Health Promotion and Social Determinants of Health

Variable	Intrapersonal	Interpersonal	Institutional	Community	Public Policy
Income	Developmental history, skills, knowledge, attitudes towards work, personality	Social networks/connection, support systems, resources	Social institutions, job stability and security, labor force status	Relationships among organizations, job market	Laws and policies for wages, support
Education	Knowledge, motivation, skills, attitude	Support from friends/family, teachers, resources	Influence of schools, teachers	Quality of schools/learning environments, access/availability	Ministry of Education policies, curriculum
Unemployment	Motivation, skills and knowledge, attitude, developmental history	Social support systems, workplace networks	Workplaces - job security, training, job stability, labor force status, related organizations	Connectedness, job opportunities, ability to network, skill building	Service Canada policies,
Lone-parent families	Values, beliefs, knowledge, attitudes	Social support systems, social networks, family support, friend network	Rules and regulations, support institutions	Societal norms, cultural norms, divorce rate, access to support	Compen-sation, divorce laws

Each variable is independently influenced by the different domains within the model. For example, income can be influenced by intrapersonal factors such as knowledge and skills, by interpersonal factors such as social networks and connections, by institutional factors such as job security/stability, by community factors such as the job market and relationships among organizations, and by public policy such as laws pertaining to salary, wages, and job support. These relationships also exist for the other variables in this study, which makes the social ecological model for health promotion, adapted from McLeory et al., 1988, the most appropriate model for this study.

2.4.1 Strengths and Limitations of the Social Ecological Model

The social ecological model is very broad, which makes it difficult to identify specific variables and how they influence specific behaviours (Glanz et al., 2008). The interactions of variables at personal,

community, social, and political levels that influence health behaviour form a complex web (see figure 2), which makes it difficult to isolate and manipulate variables. Also, there are many adaptations of social ecological models, so it is important that the selection of the proper ecological model relates to the nature of the research question and on the data being used (Chatzinikolaou, 2012). It is also difficult to find a balance between minimizing complexity, and including sufficient scope to ensure the predictions are valid and relevant (Chatzinikolaou, 2012).

However, the strengths of this model make it suitable for this research. A key strength of ecological models is their focus on multiple levels of influence that broadens options for interventions. Policy and environmental changes are designed and promoted with the desire to affect many, if not all, individuals in a population, in contrast to interventions that only reach individuals who choose to participate (Glanz and Mullis, 1988). Also, ecological models can enhance human dignity by moving beyond explanations that hold individuals responsible for, and even blame them for, harmful behaviours (Glanz et al, 2008). For this study, there are many possible factors that are influencing child physical health in Greater Sudbury neighbourhoods. The social ecological model is not only an effective way to demonstrate what factors within society are influencing child physical health, but it also is an effective tool for developing intervention strategies in order to improve the health of populations including children.

2.5 Neighbourhoods: Place and Health

Studying neighbourhood differences in child physical health and wellbeing is important for many reasons. The neighbourhood as a unit of analysis may itself be influencing child physical health and wellbeing. Many aspects of the physical environment have the ability to harm young people's development. Unsafe physical environments can not only negatively impact child health in the present, but also their future health and development. Some negative threats within neighborhoods include easy access to alcohol and increased drinking problems, injuries, and violence, the types of food available in the neighborhood which affect people's nutrition and health, and neighborhoods often can have many physical toxins (e.g., air or soil pollution) that directly affect health and behavior (Centre on the Developing Child at Harvard University, 2010). Families experiencing poverty are limited in their choice of home, area of residence, and even choice of schools for children. Low income and socioeconomic status may also lead to social disorganization (crime, many unemployed adults, neighbors who do not monitor the behavior of adolescents), and few resources for child development such as playgrounds, child care, health-care facilities, parks, and after-school programs (Duncan & Brooks-Gunn, 2000). A

study done by Cushon, et al. in 2011 found that there is a significant relationship between a neighborhood poverty index and declining scores for physical health and well-being in Saskatoon, Canada. The physical health and well-being domain was more sensitive to a measure of neighborhood-level socioeconomic disadvantage than other domains. Neighborhood poverty was significantly related to declines in the domain of physical health and well-being, suggesting neighborhood effects in patterning school readiness outcomes in children over time. This means there is a clear need for policy and program implementation addressing poor physical health and wellbeing at the neighbourhood level (Cushon et al., 2011).

On the contrary, neighbourhoods with access to safe places to be active, are more walkable, offer healthier food options, are likely to lead to good health and therefore help avoid negative health trajectories (Sallis & Glanz, 2006). This is because physical health is promoted in certain areas more than others. Other elements of land use such as buildings, transportation, community design, and recreational facilities all influence physical health and physical activity (Sallis & Glanz, 2006). Access to facilities depends on proximity of children's homes or schools, how costly they are to use, and how easily they can be reached. Therefore it is likely that many built environment variables have a cumulative effect on physical activity and child obesity, rather than any single variable (Sallis & Glanz, 2006). Evidence also suggests that transitioning from high poverty to lower poverty neighbourhoods enhances physical health of children (Shonkoff & Phillips, 2000). Overall, studying area–level differences in child physical health is important in understanding health inequities. This is because neighborhoods themselves have the ability to influence health behaviours, and also because examining area-level differences is an effective way to identify where health inequities may exist.

2.6 Critical Appraisal of the Literature

There is indisputable evidence that the quality of social determinants of health an individual experiences explains the wide range of health disparities that exist among populations (Braveman & Gottlier, 2014). It is well established in the literature that social factors such as education, income, employment, lone-parent families, and overall poverty have the ability to influence health, specifically the health of children (Bauman et al., 2006; Benzeval et al., 2014; Box et al., 2012; Cohen et al., 2010; Cushon et al., 2011; Evans & Kim, 2007; Lapointe et al., 2007; Mikkonen & Raphael, 2010; Shields & Tremblay, 2002; Shonkoff & Phillips, 2000). It is also clear that these social determinants are responsible for health inequities (avoidable differences) between groups of people (Braveman, Cubbin, Egerter, Williams, & Pamuk, 2010; Braveman & Gottlier, 2014; Marmot, 2008; Marmot, 2010; Sudbury & District

Health Unit, 2013). However, there is still much to understand about how these social determinants operate, interact, and the pathways through which they influence health inequities.

Understanding of the social determinants of health has seen a shift in approach from a biomedical orientation to a more social orientation (Potvin, Gendron, Bilodeau, & Chabot, 2005). This has evolved the realm of public health research from an epidemiological approach to an approach that recognizes the complexity and interaction of the multiple domains within society that influence our health (Potvin et al., 2005). Yet the theoretical underpinnings of public health research are still rooted in a biomedical foundation, and this has lead to a lack of social theory within public health that recognizes the complex interactions of the social determinants of health (Potvin et al., 2005). Potvin et al., (2005) argues for a renewal of the knowledge base within public health practice to include contemporary social theory in order to strengthen the understanding of the social determinants of health (Potvin et al., 2005). Therefore, a major challenge within the social determinants of health literature is the gap between disciplinary approaches.

Approaches to studying the social determinants of health alters depending on the disciplinary background of the researcher. There is a large professional difference when addressing the issues of health and illness (Raphael, 2006). One end of the spectrum is defined by biomedical research that includes an epidemiological perspective focused on identifying individual behavioral risk factors associated with disease (Raphael, 2006). The other end of the spectrum is defined by socio-environmental approaches to understanding health and illness. The concept of the social determinants of health falls within the socio-environmental paradigm which uses political and economic environments as lenses to view public health issues (Raphael, 2006). There is a large rift between the two approaches to health and illness, and this has prevented the social determinants of health from permeating into the traditional health sciences literature (Raphael, 2006). Due to the friction between the two approaches, there is a gap in the literature where biomedical and behavioural risk factors could combine with socio-environmental approaches to develop a more encompassing approach to understanding the influences of the social determinants of health and negative health outcomes.

Stemming from the issue of disciplinary approaches, there is debate over the extent of influence that genetic factors play versus social factors. There is an emerging awareness of how genes interact with the environment, which makes determining the causes of disease include both social and genetic factors simultaneously. It is known that genetic endowment is not unalterable because certain genes may only be expressed in the presence of triggers within various social and physical environments

(Braveman & Gottlier, 2014). Therefore, determining the health effects of social determinants accurately without considering genetic factors makes examining the role of social determinants of health even more complicated.

Another challenge within the social determinants of health literature is the ability to identify pathways through which each social determinant works with specificity and accuracy. Social gradients in health are well documented within the literature, but more research is needed to determine the underlying pathways and the attributable risk that is indicated by the social gradients in health (Braveman, Egerter, & Williams, 2011). Social factors that influence health are complex and impact populations over long periods of time, which makes it difficult to pin-point the specific pathways through which specific social determinants shape health (Braveman et al., 2011). Attempting to document and quantify the effects of a select determinant on a specific health outcome in a single study represents an important obstacle to understanding how social factors influence health. For example, if an individual living in neighbourhood A is exposed to a certain level of poverty for X amount of years, then the negative health outcomes are Y and Z. This level of specificity regarding the pathways through which social factors influence health is currently not present in the literature. This is because current measures of the social determinants do not have the ability to identify the distinct effects of relevant aspects of income, education, employment, or the presence/absence of wealth (Braveman et al., 2011). This dilemma highlights another challenge within public health research – the lack of life-course research and longitudinal studies.

There is a deficiency of life-course research linking the social determinants of health to population health outcomes, including longitudinal studies (Braveman et al., 2011). An increase in longitudinal studies would improve the ability of researchers to understand the complex pathways through which the social determinants of health influence health (Braveman et al., 2011). Improving this deficiency requires improving public-use databases with more comprehensive information. Data collected over longer-time frames spanning generations would make identifying health consequences of early childhood experiences more efficient (Braveman et al., 2011). Braveman et al., (2011) state there needs to be an increased linkage between research of adult health and how child health trajectories are influenced by social disadvantage across the life course (Braveman et al., 2011).

This thesis uses neighbourhoods as a unit of analysis to explore health inequities that may exist within Greater Sudbury. Examining socioeconomic status between and within neighbourhoods presents challenges as well. Socioeconomic status within neighbourhoods may interact with unforeseen variables

not included in a given study. Therefore, there may be a moderating and mediating influence of other key variables other than SES that can influence health. This is because neighbourhoods can influence health through their physical characteristics such as air and water quality, the quality of dwelling infrastructure, as well as access to community services that either promote or hinder health promoting behaviours (Braveman et al., 2011). However, they can also influence health through social relationships due to the positive effects that strong social relationships have on reducing social disorganization (Braveman et al., 2011). Using neighbourhoods as a unit of analysis to study the social determinants of health presents additional challenges.

These challenges stem from the nature of conceptualizing neighbourhoods. There is no universal definition of 'neighbourhood' that can be applied across cities and countries. The concept of 'neighbourhood' is subjective and depends entirely on the context for which the definition is derived. The concept of 'neighbourhood' for preschool aged children differs from what an adolescent or adult would consider to be a neighbourhood (Muhajarine, Vu, & Labonte, 2006). When exploring how neighbourhoods influence the health of kindergarten children it is important to consider the family and caregiver environments as well as the immediate neighborhood in which the child resides. For elementary school children, the focus shifts away from the home environment and shifts more towards the school and other neighborhood places where children develop social networks (Muhajarine et al., 2006). This means that depending on the age of an individual, there will be different factors within a given neighbourhood that influence health more directly than other factors. Muhajarine, Vu, and Labonte (2006) argue that previous research exploring area-level differences in child health rely on an incorrect concept of neighbourhood.

Research using the spatial concept of neighbourhoods and children's health has shown mixed results, with the statistical significance of the findings and magnitude of effect being generally small (Cushon et al., 2011; Ellaway, Benzeval, Green, Leyland, & MacIntyre, 2012; Lapointe et al., 2007; Pickett et al., 2001; Sallis & Glanz, 2006; Simen-Kapeu, Kuhle, & Veugelers, 2010). This thesis explores contextual neighbourhood effects on child health, and relies on census tracts (which is an available spatial unit consisting of local geographical boundaries). Spatial units are commonly used in geographically based studies such as this thesis. Lapointe et al., 2007 point out that research on neighbourhood effects that rely on census tracts is criticized because census tracts may not be a meaningful unit of analysis (Lapointe et al., 2007). This is because census tracts may be too large and heterogeneous, therefore masking the effects of place that can be found in smaller units of analysis

(Lapointe et al., 2007). Muhajarine, Vu, and Labonte (2006) argue that these spatial units have no saliency or meaning as a place of residence or identity for those living within them. They recommend forming 'real' neighbourhoods using information on variables of theoretical importance such as agency, perceptions, social interactions within the neighborhood, and engaged community based organizations in the research (Muhajarine et al., 2006). This means that using census tracts instead of deriving a more comprehensive definition of neighbourhood results in a sacrifice of intricacies at the level of the child, the family, and the neighborhood (Muhajarine et al., 2006). Another challenge when using neighbourhoods as a unit of analysis presented in the literature is the concept of ecological fallacy.

This thesis is an ecological study as it is studying groups of individuals who are represented within neighbourhoods. This thesis also attempts to explain the relationship between poor child physical health and deprivation within the social determinants of health. When ecological data are used to make inferences about individuals, those inferences may be misleading and this is referred to as an ecological fallacy (Wakefield, 2004). Ecological studies use data that is collected for general purposes, which can produce greater variations at the individual-level within the data (Wakefield, 2004). The larger the geographical area from which the data is collected, the more potential there is for bias to arise within the data at the individual level (Wakefield, 2004). Therefore, drawing inferences about individuals within this study creates a bias known as an ecological fallacy. This is because there is variation between individuals within a neighbourhood, as well as variations between neighbourhoods. Therefore, if a relationship is found at the neighbourhood level between variables, that relationship may not exist at the individual level within the neighbourhood. This means there is a strong presence of bias when inference of neighbourhood-level correlations are made at the individual level. There are other interactions within neighbourhoods that make identifying causal relationships difficult.

2.7 Summary

By examining the influence of social determinants of health including measures of income, education, unemployment, lone-parent families, and poverty on child physical health and wellbeing, this study may lead to the improvement of child development and the health trajectories of children. By examining the area-level differences in health inequities related to social determinants of health and child physical health, there is potential to level off the social gradient and close the widening gap of health inequities. The social ecological model helps explain the complex relationship between social determinants of health and how they influence health behaviour, as well as demonstrates the need to better understand the influence of these determinants. The literature establishes certainty that social

factors are important influencers of health, however it also establishes uncertainty of the pathways through which these social factors operate. There is also caution when using neighbourhoods as a unit of analysis – this will be addressed in the methodology section. Inferences of this thesis will be made with caution due to the nature of the ecological fallacy and the subjective nature of neighbourhoods.

2.7 Research Questions

This research attempts to answer the question: How is child physical health being influenced by the social determinants of health within CGS neighbourhoods? This is answered by a breakdown into sub questions: How does each social determinants of health independently influence different measures of child physical health; do the social determinants of health have a cumulative effect on child physical health as the literature states; and are there influential outliers with unique relationships between the social determinants of health and child physical health? The social determinants of health in this study are represented by average neighbourhood measures of income, government assistance, unemployment, education, lone-parent families, and select measures of neighbourhood poverty. Child physical health in this study is defined by the Early Development Instrument and consists of multiple variables. These domains include the percentage of children who are not on track for child physical health, as well as the percentage of children who are meeting few/no developmental expectations for physical readiness for the school day, physical independence, and gross/fine motor skills.

Chapter 3: Methodology

3.1 Setting of Study

The population studied in this research are the residents of Greater Sudbury. Within this population, the sample consists of individuals aged 15 and older who filled out the 2011 National Household Survey, as well as kindergarten children who have been included in the Early Development Instrument data collection process throughout Greater Sudbury in 2011. Area-level differences will be examined between the established neighbourhoods of Greater Sudbury. Neighbourhoods in this study are established based on Statistics Canada census tracts, as well as neighbourhoods used by the EDI analysts. This population has been chosen for this research for two main reasons. The primary investigator is a resident of Greater Sudbury and has resided in the City of Greater Sudbury (CGS) for over a decade and therefore, he has formed a working understanding of the socio-economic background of the CGS in general and is familiar with various city neighbourhoods. There is also evidence of health inequities at the neighbourhood level in CGS, which includes socioeconomic inequities as well as child physical health inequities (Sudbury & District Health Unit, 2013; Turchan, 2013).

3.2 Study Design

This research is a cross-sectional ecological study involving secondary data analysis. It uses data collected on individual characteristics to describe a subgroup within a population with respect to an outcome and a set of risk factors (Levin, 2006). This research is examining possible geographical correlations between exposure to selected social determinants of health and rates of poor child physical health. This study involves a multi-variate analysis with selected dependent variables and multiple independent variables. The nature of this research requires a quantitative approach. This is because examining the interaction of social determinants of health and how they influence our health behaviour requires observation at a large scale. This is accomplished by reducing the social determinants of health to measured variables in order to understand large scale patterns of health behaviour.

3.3 Secondary Data Collection

The data used in this study was collected by different organizations. The social determinants of health data was collected by Statistics Canada using the National Household Survey. The child physical health data was collected by the Offord Centre for Child Studies using the Early Development Instrument.

3.3.1 The National Household Survey

Between May and August 2011, Statistics Canada conducted the National Household Survey (NHS) for the first time. The federal government switched from the mandatory long form census to the voluntary National Household Survey in 2011 (Statistics Canada, 2011). The NHS is designed to collect social and economic data about the Canadian population. The objective of the NHS is to provide data for small geographic areas and small population groups. The NHS is a sample survey using a random sample of 4.5 million dwellings, which is slightly less than one-third of all private dwellings in Canada in 2011. Statistics Canada encouraged the sampled households to participate in the NHS by outlining the survey's objectives, giving examples of how the data are used, and describing the benefits for their community. Ontario had a 76.3 % response rate, and Canada had an overall response rate of 77.2 %. NHS non-response follow-up was planned in such a way as to maximize the survey's response rate and control potential non-response bias due to the survey's voluntary nature. The nearest-neighbour method was used to impute NHS data. This method is widely used in the treatment of non-response. It replaces missing, invalid or inconsistent information about one respondent with values from another, 'similar' respondent (Statistics Canada, 2011). The NHS has a number of quality indicators. Various indicators are analyzed so the quality of NHS estimates can be assessed. This includes non-response rates, indicators of response quality, global non-response rate, indicators of non-response bias, coefficients of variation, and certification of final estimates follows (Statistics Canada, 2011). The NHS data is in Excel format with census tracts as the unit of analysis.

3.3.1.1 2011 NHS vs. 2006 Long Form Census

Mentioned above, Statistics Canada switched from the mandatory long form census to the voluntary National Household Survey in 2011. This has been seen as a controversial attempt to make census data collecting less intrusive (The Globe and Mail, 2013). Experts believe that the voluntary nature of the NHS has resulted in less detailed, more unreliable data than what Statistics Canada has generated in the past (The Globe and Mail, 2013). This is because when there is a change in the methods of a survey, it can impact the comparability of data over time (Statistics Canada, 2011). Table 3.1 below demonstrates differences between selected measurements of data for both the 2011 NHS and the 2006 census. It is important to note that other variables used in this study were not selected for demonstration in this table for an important reason. The 2006 mandatory long form census measures selected household characteristics by median statistics, whereas this study uses average statistics from the NHS. Therefore, a comparison of other variables of interest is not useful due to different measurement techniques.

Table 3.1 Comparing 2011 NHS data to 2006 census data in Greater Sudbury

Census Categories	2011 NHS Data	2006 Long-Form Census
Population	158,260	158,258
No certificate, diploma, or degree	28,240	33,400
Participation Rate	63.1	63
Unemployment Rate	7.8	7.8
Number of Lone Parent Families	7900	7820
Government Transfer Payments (% of income)	14.6	12.6

(Statistics Canada, 2007, 2013).

Table 3.1 demonstrates that census categories measured by percentages including unemployment, participation in the labor force, and government transfer payments are almost identical. The overall population of Greater Sudbury is very similar, as well as the number of lone parent families included in each survey, demonstrating accuracy at the census metropolitan area level. There is a discrepancy for the number of individuals without a certificate, diploma, or degree. However, this discrepancy should not be an issue in this study. This may be because of self-report bias: the NHS is a voluntary survey, so individuals may be less likely to report a lack of education if they are not legally obligated. Also, area-level differences will still exist between neighbourhoods in Greater Sudbury, despite the total number of some measurements having a discrepancy.

In summary, statisticians recommend using the 2006 long form census data as a benchmark to cross-check the NHS data (Statistics Canada, 2011), and doing so has demonstrated little discrepancy in measurements of interest for this study. Statistics Canada is confident that the NHS has produced useful data which can be used for many purposes, even though it has not produced the same level quality as a mandatory long form census would have. Caution will be used when interpreting the results of this study.

3.3.2 The Early Development Instrument (EDI)

This study uses the Early Development Instrument as its data source for child physical health, which is managed by the Offord Centre for Child Studies. The EDI is a questionnaire designed to collect data on children's readiness to learn by assessing their school readiness, or a child's ability to meet the demands of school (Janus et al., 2007). The EDI is completed by the teacher or an Early Child Educator (ECE) for every individual in a given class, generally in the second half of the senior kindergarten year. This allows teachers time to get to know the children and allows children time to adjust. It can be used for children from the ages of 4 to 7 and includes 104 core items, with several additional questions available as appropriate to local or community needs (Janus et al., 2007). The EDI was refined through

extensive preliminary testing in the 1998-99 school year for validation purposes and cultural validity before being introduced in all kindergarten classes in the Metro Toronto and North York sections of the Toronto District School Board, as well as in several other communities across Canada (Janus et al., 2007). Macro-level aggregations of EDI scores are useful data in association with other societal indicators. For example, EDI data on school readiness could be studied in relation to: city statistics on education levels, school enrollment, and income, longer-term outcome including older children's environmental or geographic statistics, and population-level health variables (Janus, 2006).

3.3.2.1 Validity and Reliability of the EDI

Three types of validity (concurrent, external, and predictive) have been established for the EDI. For concurrent validity, the EDI was compared with other tests of school readiness. The EDI's external validity was determined through parent interviews in which interviewers asked parents questions which corresponded with the EDI domains, and the parents' responses were correlated with the children's EDI scores (Janus, 2006). For external validity, individual correlations within the Physical Health and Well-being domain ranged from 0.15 to 0.34. For all EDI measures, all correlations were in the expected direction, and 16 out of 24 (66%) were statistically significant (Janus et al., 2007). The EDI's predictive validity was determined using three direct tests 3 years after the EDI was first implemented (Janus, 2006). In terms of reliability, the internal consistency of the EDI varies from 0.84 to 0.96, indicating a high internal consistency. Test-retest reliability correlations are also high. For physical health and wellbeing, internal reliability is 0.84, and test-retest reliability is 0.82 (Janus et al., 2007). Overall, The EDI is a useful population health tool. It allows for data comparison from uniform, consistent indicators of children's status at broad neighbourhood and community levels. Results can be used to identify the need for community resources that can contribute to school readiness (Janus et al., 2007).The EDI data is in SPSS format and uses neighbourhoods as the unit of analysis. Permission has been given by the Offord Centre for Child Studies to use EDI data at the neighbourhood level.

There are some possible limitations with the EDI. Teacher judgement is subjective when reporting on child school-readiness because when teachers make judgements on individual children in their classrooms, the strengths of their social assumptions may affect their judgment and make assessment less objective (Keating, 2007). Because the EDI is primarily about understanding the social patterning of school readiness, it is possible that false correlations between EDI neighbourhood characteristics could arise (Keating, 2007).

3.4 Creation of the Data File for Analysis

The following section explains the process of how the two data sources were synthesized to form one data file. This includes the process of neighbourhood selection, and how the data was aggregated to meet the inclusion criteria set for this study.

3.4.1 Neighbourhood Selection

The data that is collected by both Statistics Canada and the EDI are organized into geographic areas. The neighbourhoods included in this study are determined by the geographic boundaries of Statistics Canada's census tracts. Census tracts are small, relatively stable geographic areas that usually have a population between 2,500 and 8,000. They are located in census metropolitan areas and in census agglomerations with a core population of 50,000 or more in the previous census (Statistics Canada, 2012). A committee of local specialists, for example, planners, health and social workers, and educators initially create census tracts in concurrence with Statistics Canada (Statistics Canada, 2012). The EDI organizes its data by neighbourhood using the geographic boundaries recognized by Greater Sudbury's census tracts (see figure A in appendix) (Statistics Canada, 2012). The EDI forms 35 neighbourhoods based on the 42 census tracts established for the CGS by Statistics Canada. This is because the EDI amalgamates selected census tracts and forms larger neighbourhoods to increase the number of valid children that can be included in the EDI data (see figure B in the appendix) (Turchan, 2013).

In order for a neighbourhood to be included in this study, it had to meet multiple requirements. First, there needs to be a minimum of 25 valid children for each EDI neighbourhood. This meets the confidentiality concerns of the Offord Centre for Child Studies. Second, the population of a given census tract needs to be a minimum of 2000 people. Third, the census tract boundaries for Statistics Canada and the EDI neighbourhood boundaries have to match. And fourth, a neighbourhood was excluded if there was any suppressed data within either data set (NHS or EDI). Out of all possible Statistics Canada census tracts, five of them did not meet the inclusion criteria: Lockerby, Godfrey, Montrose, Dowling/Rural Onaping/Levack, and Rural Rayside Balfour. Table 3.2 provides a detailed list of the exclusion criteria.

Table 3.2 Excluded Neighbourhoods and Exclusion Criteria

Neighbourhood	# of valid children	Population	Suppressed Data	Boundary Issues
Lockerby	18	2835	No	No
Godfrey	X	395	Yes	No

Montrose	10	2015	No	No
Dowling/Rural Onaping-Levack	18 + 23	4845	No	Yes
Rural Rayside Balfour	X	4195	Yes	No

3.4.2 Neighbourhood Aggregation

In order to maximize the number of valid children included in the data analysis, as well as maximize the number of neighbourhoods that can be analyzed, some neighbourhoods were aggregated together to form larger neighbourhoods. Neighbourhoods were aggregated together to ensure the number of valid children included was 25 or greater, and they were only aggregated together if they shared a geographic boundary. Also, aggregation only occurred if the EDI results and the NHS data for each neighbourhood were very similar. The process of neighbourhood amalgamation also included a discussion with the primary investigator and supervisors. This resulted in deciding which neighbourhoods should be included, which ones should be excluded, and setting the criteria discussed in this section. Table 3.3 lists the aggregated neighbourhoods used in the analysis and the census tracts that make up each neighbourhood. Table 3.3 also lists the number of valid children for the EDI in each neighbourhood as a result of the aggregation. Column one lists the names of the census tracts as defined by Statistics Canada, followed by the census tract codes in column two, and then the name of the neighbourhood for this study in column three.

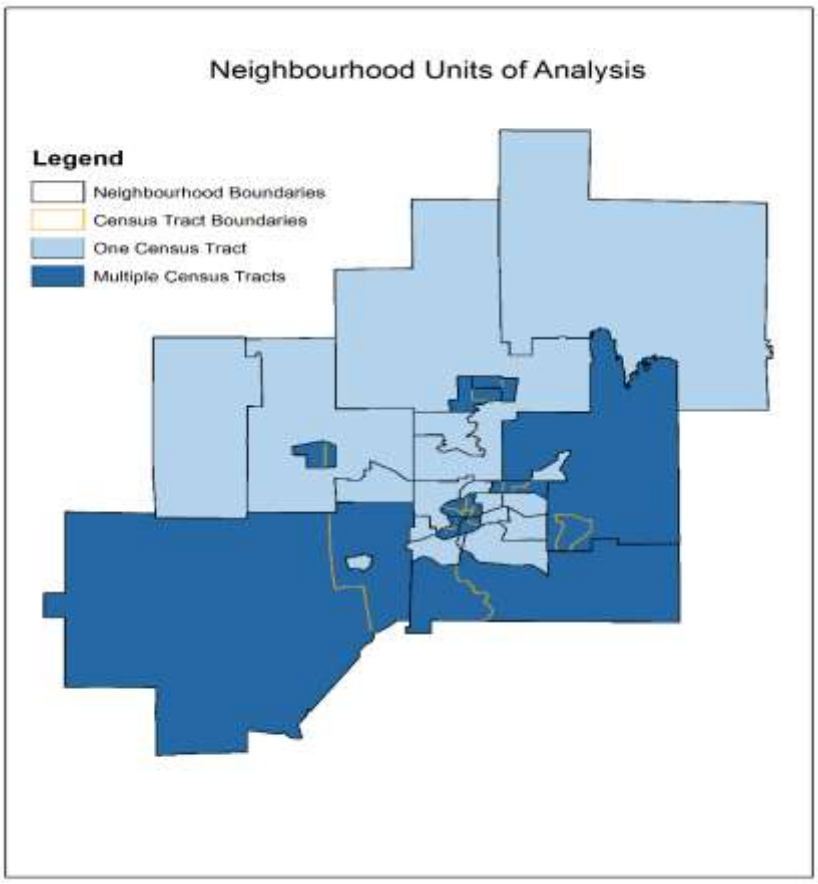
Table 3.3 Aggregated Census Tracts Forming Neighbourhoods

Census Tract Names	Census Tract Codes	Aggregated Neighbourhood Name	# of valid children
Algonguin/Wanup Long Lake	0001.03 0001.05	Algonguin/Wanup-Long Lake	49
Gatchell Elm West	0002.00 0003.00	Gatchell-Elm West	67
Downtown/Bell Park Downtown/Bell Park	0004.00 0005.00	Downtown-Bell Park	53
Flour Mill Flour Mill Flour Mill/Donovan Donovan Flour Mill	0010.00 0011.00 0012.00 0014.00 0015.00	Flour Mill-Donovan	100
Woodbine Cambrian Lebel	0016.02 0017.01 0017.02	Woobine-Cambrian-Lebel	90
Coniston/Falconbridge & Rural Nickel Centre	0100.00	Falconbridge, Rural Nickel Centre and Coniston	45

Falconbridge/Rural Nickel Centre/Wahnapitae	0102.00		
Worthington/Whitefish/Naughton/Whitefish Lake FN/Rural Walden Worthington/Whitefish/Naughton/Whitefish Lake FN/Rural Walden	0131.00 0132.00	Rural Walden	74
Val Therese Val Therese	0192.00 0193.03	Val Therese	100
Hanmer Hanmer	0193.01 0193.02	Hanmer	70

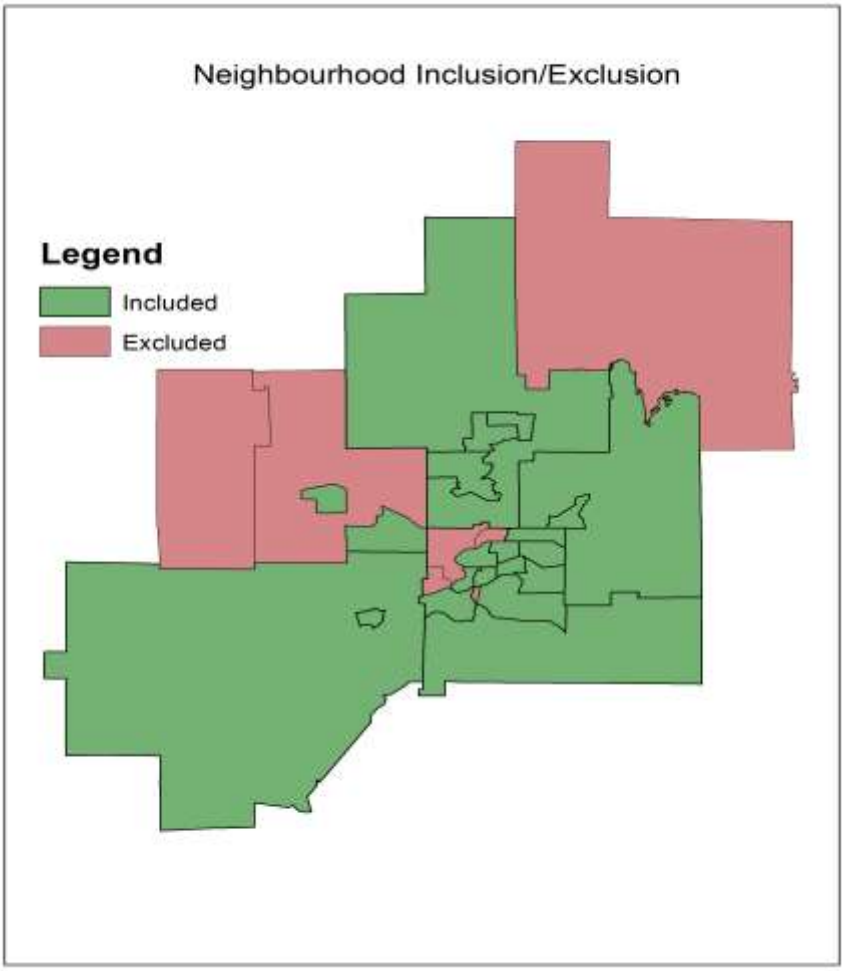
This table demonstrates that there are nine neighbourhoods that have been aggregated for this study to ensure a larger sample size, and they consist of data from 22 census tracts. Figure 3.1 below is a visual representation of this process. It displays the 28 neighbourhoods that were formed as a result of the aggregation process.

Figure 3.1 Neighbourhood Aggregation



The neighbourhoods that consist of multiple census tracts are in dark blue. Each of these aggregated neighbourhoods have an orange line demonstrating the initial census tract boundaries. The light blue neighbourhoods represent un-aggregated census tracts. Once the neighbourhood aggregation process was complete, the inclusion and exclusion criteria discussed above was applied to the newly formed neighbourhoods. Figure 3.2 below displays the final 21 neighbourhoods that are included in the analysis and the neighbourhoods that were excluded after aggregation.

Figure 3.2 Neighbourhood Inclusion/Exclusion



3.4.3 Data Aggregation

For each neighbourhood that was aggregated together from multiple census tracts, the data for each census tract also had to be aggregated. Statistics Canada organizes the data for the social determinants of health in this study into the 42 census tracts of Greater Sudbury. This means that if two or more census tracts were geographically aggregated together to form a larger neighbourhood, the

data also has to be aggregated together. If the data for a given variable represents the total number of individuals in a census tract (total number of people with a high school diploma), than that total is converted into a percentage. This is done by aggregating the data for each variable separately, then deriving a percentage from the newly formed neighbourhood. Table 3.4 illustrates this process for the aggregated neighbourhood Gatchell and Elm West.

Table 3.4 Data Aggregation Process

Census Tract	Total people with a postsecondary degree	Population of Census Tract	Aggregated Percentage
Gatchell	1805	3745	3655/7130
Elm West	1850	3385	=.512
Gatchell and Elm West	**3655**	**7130**	**51.2%**

The aggregated percentage represents the percentage of individuals in the neighbourhood of Gatchell and Elm West that have a postsecondary degree of some kind. For variables that are already represented as percentages (average income), then the percentages of each census tract are added together and divided by the number of census tracts.

Note: the physical health and wellbeing data were aggregated by the Offord Centre for Child Studies based on the aggregated neighbourhood boundaries required by this study. The desired neighbourhood boundaries were sent to the Offord Centre for Child Studies team, and then the EDI data was aggregated into the desired neighbourhoods.

3.5 Variables

3.5.1 Independent Variable Classification: Social Determinants of Health

The independent variables in this study are the social determinants of health. These are represented by Statistics Canada data collected by the National Household Survey. Table 3.5 lists the independent variables examined in this study, and the definition for each variable.

Table 3.5 Independent Variable Definitions

Social Determinant	Variable	Statistics Canada Definition
Income	Average after tax family income	Sum of the after-tax incomes of all members of that family.
Income	Average after tax household income	Sum of total incomes in 2010 of households divided by the total number of households.
Income	Average after tax lone-parent family income	Average income of lone parent families by census tract after tax.

Education	No certificate, diploma, or degree	Total population (TP) over 15 with no education / TP over 15 by highest certificate.
Education	High school diploma or equivalent	The person has completed a secondary school diploma or the equivalent, no matter what other certificates, diplomas or degrees he or she has.
Education	Postsecondary diploma or degree	Different types of postsecondary education and training completed, including combinations of trades, college and university.
Unemployment	Unemployment rate	The unemployed in a group, expressed as a percentage of the labour force in that group.
Unemployment	Participation rate	The total labour force in that group, expressed as a percentage of the total population in that group.
Lone Parent Families	% of lone-parent family households	Mothers or fathers, with no married spouse or common-law partner present, living in a dwelling.
Poverty	Bottom half decile income	The population in private households is sorted according to its adjusted after-tax family income and then divided into 10 equal groups each containing 10% of the population. This variable includes the people in the bottom 5 deciles.
Poverty	Bottom 2nd decile income	Population in private households is sorted according to its adjusted after-tax family income and then divided into 10 equal groups each containing 10% of the population. This variable includes the people in the bottom 2 deciles.
Poverty	% of rented homes	Refers to the percentage of people with monthly cash rent paid by tenant households.
Poverty	% of people making less than $20,000 after taxes annually	Add total people between $0-$19,999 / total population by after-tax income.
Poverty	Shelter costs above 30% of income	Percentage of a household's average total monthly income which is spent on shelter-related expenses.
Poverty	Employment insurance	Total Employment Insurance benefits received during 2010, before income tax deductions. It includes benefits for unemployment, sickness, maternity, parental, adoption, compassionate care and benefits.

Poverty	Child benefits	Payments received under the Canada Child Tax Benefit program during 2010 by parents with dependent children under 18 years of age. Included with the Canada Child Tax Benefit is the National Child Benefit Supplement (NCBS) for low-income families with children.
Poverty	Government transfer payments	All cash benefits received from federal, provincial, territorial or municipal governments during 2010 (old age security pension, Canada pension plan benefits, employment insurance, child benefits, other income from government sources).
Poverty	Low Income Measure After-Tax (LIMAT)	Fixed percentage (50%) of median adjusted after-tax income of households observed at the person level, where 'adjusted' indicates that a household's needs are taken into account.

*Definitions are referenced from the National Household Survey Dictionary (Statistics Canada, 2011).

3.5.2. Dependent Variable: Child Physical Health and Wellbeing

The EDI measures child physical health and wellbeing by breaking it down into three sub-domains: physical readiness for the school day, physical independence, and gross and fine motor skills. Each child is given a rating of 1, 2, or 3. A rating of 1 means the child has met few/none of the expectations for the given sub-domain. A rating of 2 means they have met some of the expectations for the given sub-domain, and a rating of 3 means they are at/above the expectations for the given sub-domain (see Appendix: Figure C - EDI Questionnaire for Physical Health and Wellbeing).

Table 3.6 demonstrates how the EDI measures physical health and wellbeing as well as provides examples.

Table 3.6 EDI Subdomains and Examples

EDI Domains	Subdomains	Example items
Physical Health and Well-being	Physical readiness for school day	arrives at school hungry
	Physical independence	has well-coordinated movements
	Gross and fine motor skills	is able to manipulate objects

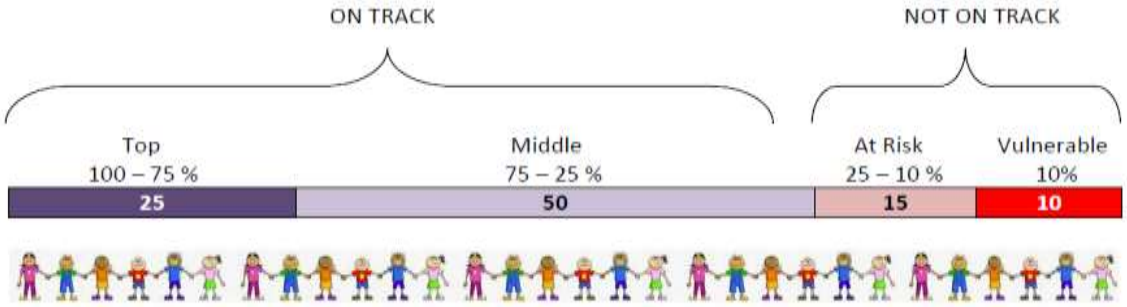
(Janus et al., 2007).

3.5.2.1. Children Not on Track: The bottom 25th Percentile

The average EDI scores for each domain (physical health and wellbeing) are organized by the highest scores to the lowest scores in the community. These scores fall within percentile boundaries that represent various levels of school readiness (see figure 3.4 below) (Turchan, 2013). Above the 90th percentile, a child is physically ready to tackle a new day at school, is generally independent, and has

excellent motor skills. Below the 10th percentile, a child has inadequate fine and gross motor skills, is sometimes tired or hungry, is usually clumsy, and may have flagging energy levels (Janus, 2006). 'Vulnerable' children experience poor physical readiness (coming to school late, hungry, or tired), poor physical independence (handedness, coordination), and poor gross/fine motor skills (energy levels and physical skills) (Turchan, 2013). This study examines the children who are in the bottom 25th percentile for physical health and wellbeing, or the 'not on track' children.

Figure 3.4 EDI Percentile Boundaries



(Turchan, 2013).

3.5.2.2. Subdomain 1: Physical Readiness for the School Day

As mentioned above, physical health and wellbeing is broken down into different sub-domains. This study examines the overall children who are not on track (the bottom 25th percentile), but it also examines each sub-domain independently. One subdomain that is examined in this study is the percentage of children meeting few/no developmental expectations in physical readiness for the school day. This is calculated by dividing the total number of children meeting few/no developmental expectations by the total number of valid children in a given neighbourhood. These children have at least sometimes experienced coming unprepared for the school day by being dressed inappropriately, and/or coming to school late, hungry, or tired (Turchan, 2013).

3.5.2.3. Subdomain 2: Physical Independence

Another subdomain that measures child physical health and wellbeing is physical independence. This study calculates physical independence by dividing the total number of children who are meeting few/no developmental expectations for physical independence by the total number of valid children in a given neighbourhood. These children vary from those who have not developed one of the three skills (independence, handedness, coordination) and/or suck a thumb (Turchan, 2013).

3.5.2.4 Subdomain 3: Gross and Fine Motor Skills

The third subdomain that measures child physical health and wellbeing is gross/fine motor skills. This study examines the percentage of children meeting few-no developmental expectations for gross/fine motor skills. This is calculated by dividing the total number of children meeting few/no developmental expectations by the total number of valid children in a given neighbourhood. These children range from those who have an average ability to perform skills requiring gross and fine motor competence and good or average overall energy levels, to those who have poor fine and gross motor skills, poor overall energy levels and physical skills (Turchan, 2013).

3.6 Statistical Analysis Plan

This study uses a number of statistical tests to examine the influence of the social determinants of health on child physical health in the CGS neighbourhoods. The univariate analysis examines the descriptive statistics of all variables including the range and the distribution of the data. The bivariate analysis explores the one directional relationships of each independent variable and dependent variable measure. The multivariate analysis examines the influence of multiple independent variables (social determinants of health) on the measures of the dependent variable (child physical health and wellbeing) by using linear regression and multiple regression tests for the social determinants of health and the dependent variable measures (the bottom 25th percentile, physical readiness for the school day and physical independence). The relationships between the social determinants of health and each dependent variable measure is examined by a linear regression, two variable regression, and three variable regression analysis. It is important to note that only independent variables that have strong and significant relationships with child physical health measures in the bivariate analysis are included in the multivariate analysis.

3.7 Hypothesis and Prediction of Outcomes

The null hypothesis for this study is there will be no relationship between the independent variables (income, education, government assistance, unemployment, lone-parent families, and poverty) and child physical health and wellbeing scores in Greater Sudbury neighbourhoods. The research hypothesis for this study is there will be a two tailed relationship between the independent variables (income, education, unemployment, lone-parent families, and poverty) and the multiple measures of child physical health and wellbeing scores in the CGS neighbourhoods. This research has multiple predictions of outcomes. Prediction one is that each social determinant of health will have an independent influence on child physical health. Prediction two is that the social determinants of health

will have a cumulative effect on child physical health. Prediction three is there will be outlier neighbourhoods that have unique relationships between the independent and dependent variable measures. The level of risk associated with the null hypothesis is $p < .05$.

Chapter 4: Data Analysis

Analyzing the influence of the social determinants on health on child physical health in CGS neighbourhoods in this study involves examining descriptive statistics for the dependent and independent variables including the data range and skewness. An important part of this analysis is to examine outlier neighbourhoods that have unique relationships between the independent and dependent variables. The chapter finishes with the findings from the bivariate and multivariate analyses including linear, two variable, and three variable regression models.

4.1 Descriptive Statistics for Child Physical Health

This section examines descriptive statistics including the mean, range, and skewness for child physical health measures. These measures demonstrate unique characteristics of child physical health in the CGS neighbourhoods. Table 4.1 demonstrates the descriptive statistics for measures of the dependent variable.

Table 4.1 Descriptive Statistics for Child Physical Health

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Percentage of children not on track	21	28.70	6.30	35.00	16.3238	7.44721	1.171	.501
Subdomain: physical readiness	21	17.00	.00	17.00	4.4579	3.96437	1.956	.501
Subdomain: physical independence	21	28.34	.00	28.34	7.6844	6.72685	1.801	.501
Subdomains gross & fine motor skills	21	31.43	.00	31.43	12.7718	7.75167	.901	.501

There are 21 CGS neighbourhoods included in this study. The range demonstrates that there is quite a wide difference of scores for each measure. The percentage of children not on track has a range of 28.70

%. Physical readiness for the school day has the smallest range of scores (17.0%), and gross & fine motor skills has the widest range of score (31.43%). This shows that child physical health scores in the CGS neighbourhoods have significant variance, with some neighbourhoods having a very low percentage of children not on track as well as some neighbourhoods with a very high percentage of children not on track. Figure 4.1 provides a visual representation of the varying scores for the percentage of children not on track by neighbourhood.

Figure 4.1 Percentage of Children Not on Track by Neighbourhood

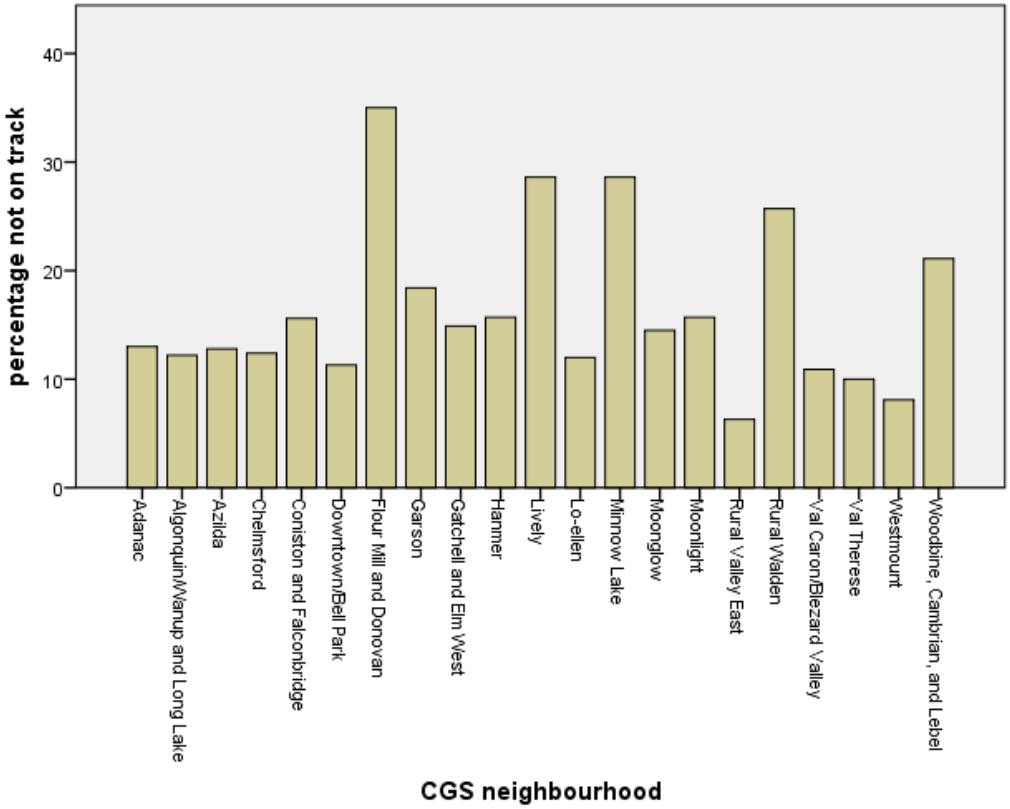


Figure 4.1 illustrates the differences between neighbourhoods in terms of children who are not on track for physical health. The Flour Mill and Donovan have the highest percentage of at risk children (35%), and Rural Valley East has the lowest (6.30%). This demonstrates a child physical health gradient because there is a select few neighbourhoods with much higher percentages of children who are not on track. When the subdomains are examined in terms of the distribution of at risk children, there are differences between the sub-domains. Figure 4.2 and 4.3 show differences in the distribution of scores between the sub-domains of child physical health. Figure 4.2 shows the distribution of scores for children meeting few/no developmental expectations for physical readiness for the school day, and

figure 4.3 shows the distribution of scores for children meeting few/no developmental expectations for gross/fine motor skills.

Figure 4.2 Physical Readiness for the School Day by Neighbourhood

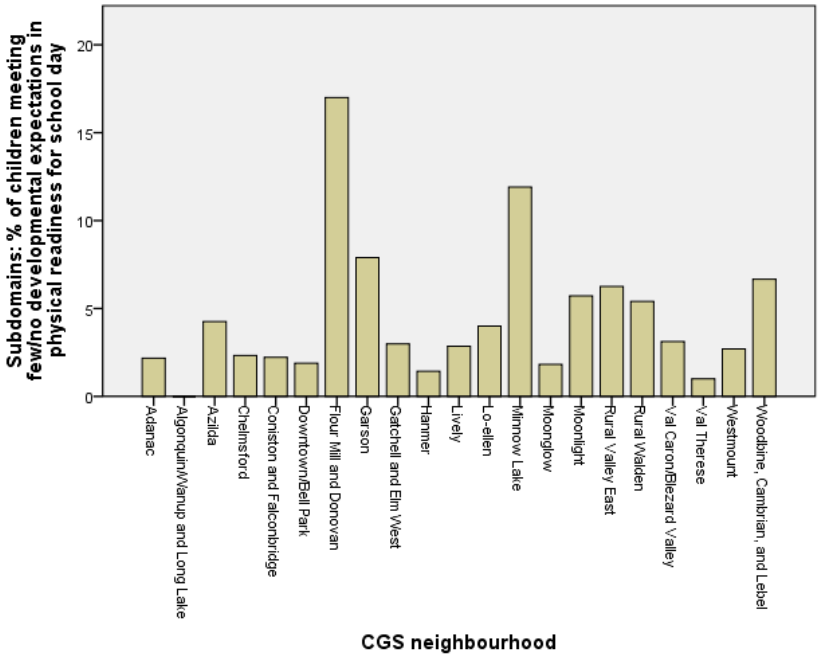


Figure 4.3 Gross and Fine Motor Skills Scores by Neighbourhood

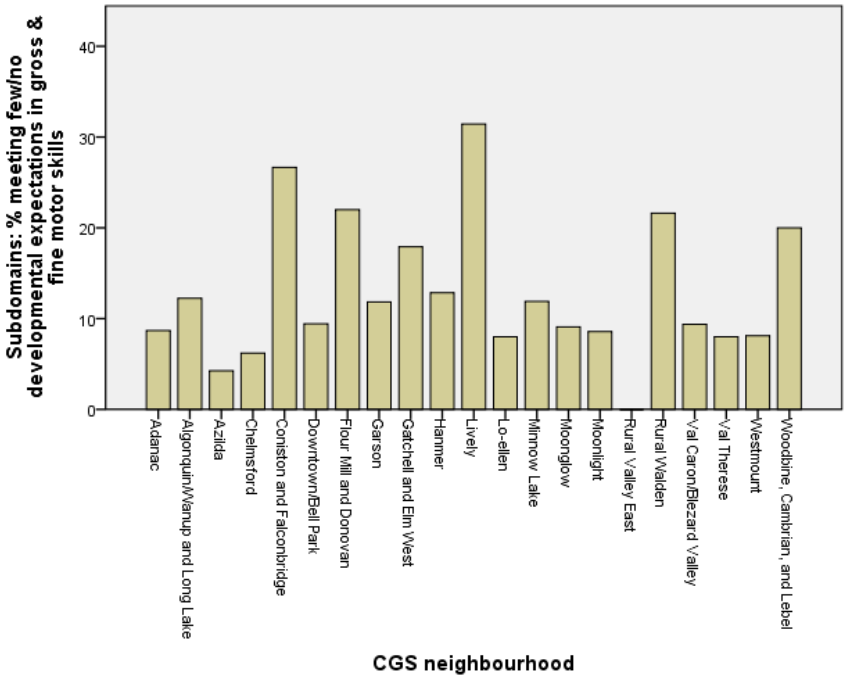


Figure 4.2 shows how there are major differences in scores by neighbourhood for physical readiness for the school day. Flour Mill and Donovan is has the highest percentage (17.0%), followed by Minnow Lake

(11.9%). For this sub-domain, there are more neighbourhoods with low percentages, with a select few neighbourhoods who have a significantly higher concentration of children not meeting the developmental expectations for physical readiness for the school day. Figure 4.3 also demonstrates the wide range of scores between CGS neighbourhoods. However, the distribution of scores do not follow the same pattern. This means neighbourhoods experiencing high percentages of children not meeting developmental expectations for gross/fine motor skills are not the same neighbourhoods experiencing high percentages in other domains. For gross/fine motor skills, Lively has the highest percentage of children meeting few/no developmental expectations (31.43%) followed by Coniston and Falconbridge (26.56%). This indicates that 1) there is a wide range of scores for child physical health in CGS neighbourhoods, and 2) the distribution of child physical health scores in the CGS neighbourhoods varies depending on what the measurement is. This is important because the same children who are at risk for physical readiness for the school day may not be the same children who are at risk for gross and fine motor skills. This indicates that each domain of child physical health needs to be analyzed separately even though all three domains compromise the total percentage of children who are in the bottom 25th percentile of scores. If neighbourhoods are experiencing different levels of risk for different measures, then there are different variables within those neighbourhoods that are increasing the risk of poor child physical health and wellbeing.

4.1.1 Neighbourhood Skewness

Besides the large and varying ranges, there is also skewness in the distribution of scores by neighbourhood. The subdomains physical readiness and physical independence demonstrate a large skewness. Figure 4.4 illustrates how the physical readiness scores are positively skewed.

Figure 4.4 Distribution of Physical Readiness Scores

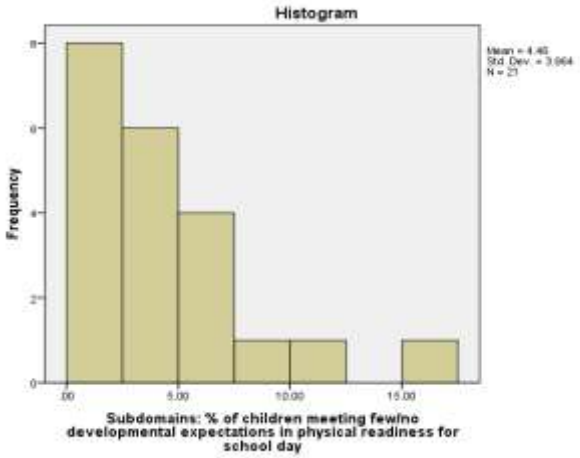


Figure 4.4 demonstrates there is a large number of neighbourhoods with the same value of scores. The mean scores for physical readiness is low (4.45 %). This means the average percentage of children meeting few/no developmental expectations for physical readiness is relatively low, but there are select neighbourhoods with a much higher percentage. The distribution of scores for this domain clusters towards the bottom of the distribution. This has implications for the bivariate and multivariate analyses. Table 4.2 summarizes how the dependent variables are distributed including the range of scores, the skewness and kurtosis of the distribution, and the Shapiro-Wilk test which measures the normality of the distribution (or lack thereof). A Shapiro-Wilk test score of $p<.05$ means that the cases have a statistically significant (not random) distribution and violates the assumption that the data is normally distributed (Hair, Black, Babin, Anerson, & Tatham, 2006).

Table 4.2 Dependent Variable Distribution Scores

Dependent Variable	Range	Skewness	Kurtosis	Shapiro-Wilk Test
% of at risk children	28.70%	1.171	.758	.014
Physical readiness	17.00%	1.956	4.36	.001
Physical independence	28.34%	1.801	3.68	.001
Gross/Fine Motor Skills	31.43%	.901	.448	.062

Table 4.2 demonstrates that all of the dependent variable measures have a varying range, are negatively skewed, are outside of the expected range of skewness and kurtosis (except for gross/fine motor skills) and the Shapiro-Wilk test demonstrates the data is not normally distributed due to the skewness and kurtosis. Due to the fact that the dependent variables measured in this study are not normally distributed, the data analysis will include results that are adjusted for non-normalcy.

4.2 Descriptive Statistics for the Independent Variables

The following section examines the descriptive statistics for the independent variables in this study: the social determinants of health. Table 4.3 displays the same descriptive statistics used to analyze the dependent variables.

Table 4.3 Descriptive Statistics for the Independent Variables

Independent Variable	Range	Minimum	Maximum	Mean	Skewness
Income less than %20,000	17.70	26.70	44.40	32.03	1.473
Employment Insurance %	2.40	.80	3.20	1.99	.011
Bottom half decile adjusted after-tax family income %	43.79	27.89	71.68	43.30	.875

Bottom two deciles adjusted after-tax family income	35.51	5.99	41.51	16.01	1.635
Spending 30% or more of household income on shelter costs	71.74	12.93	84.67	31.43	1.778
Prevalence of low income (2010) based on LIMAT %	30.52	4.50	35.02	12.27	1.717
Child benefits as a % of total income	2.00	.60	2.60	1.26	1.162
Government transfer payments as a % of total income	18.19	7.85	26.04	14.98	.738
% of rented dwellings	58.24	4.45	62.70	27.20	.722
% no certificate, diploma, or degree	13.88	14.76	28.64	20.64	.464
% with a postsecondary education	20.45	44.49	64.95	55.14	.057
Average after-tax household income	$57,957	$39,893	$97,850	$67,781	.088
Average after-tax family income	$68,020	$51,995	$120,016	$78,881	1.039
Average after-tax lone-parent family income	$29,167	$34,595	$63,763	$51,031	-.593
Unemployment rate %	9.60	4.00	13.60	7.36	1.239
Participation Rate %	17.42	54.18	71.60	63.90	-.327
% of lone-parent family households	22.94	9.08	32.02	16.59	1.221

The descriptive statistics in table 4.3 shows a wide variance amongst the independent variables. Examining income demonstrates a wide range among the neighbourhood income measures included. Low minimum and high maximum average income measures shows a large discrepancy in wealth between Greater Sudbury neighbourhoods. For example, when examining the percentage of families in the bottom two deciles of after tax income, the bottom neighbourhood only has 5.99% of its families in the bottom two deciles, whereas the highest neighbourhood has 41.51 percent (almost half) of its families in the bottom two deciles of average after tax income. This can have profound impacts on the health of neighbourhood residents due to the uneven distribution of family income across the CGS. This uneven income distribution also exists for average after tax family, household, and lone-parent family income. The wide range of scores is also prevalent in government assistance measures. The minimum for the percentage of neighbourhood government transfer payments is 7.85%, whereas the maximum is 26.04%. This indicates that some neighbourhoods are receiving much more government transfer payments than others. There is also a wide range of scores for the percentage of lone-parent family households. The bottom neighbourhood has only 9.08% of households being lone-parent families (Lively), whereas the highest neighbourhood has 32.02% of households being lone-parent families (Minnow Lake). This uneven distribution of lone-parent households is important because lone-parent

families generally have lower average incomes. Mean after tax lone-parent family income in Greater Sudbury $51,031, and for non-lone-parent families the mean after tax income in $78,881 (see table 4.3).Overall, measures of neighbourhood income, government assistance, education, unemployment, lone-parent families, and poverty in the CGS are unevenly distributed similar to how child physical health has an uneven distribution of at risk children. Not only is the distribution of these social determinants of health uneven, but the range demonstrates that some neighbourhoods have a high amount of health promoting resources, while others have a very low amount of health promoting resources.

Skewness is also present in select independent variables. Table 4.4 below includes measures of range, skewness, kurtosis, and the Shapiro Wilk test.

Table 4.4 Independent Variable Distribution Scores

Independent Variable	Range	Skewness	Kurtosis	Shapiro Wilk Test
Income less than %20,000	17.70	1.473	2.41	.011
Employment Insurance %	2.40	.011	-.05	.995
% Bottom half decile adjusted after-tax family income %	43.79	.875	.801	.096
% Bottom two deciles adjusted after-tax family income	35.51	1.635	2.10	.001
% Spending 30% or more of household income on shelter costs	71.74	1.778	2.85	.000
Prevalence of low income (2010) based on LIMAT %	30.52	1.717	2.72	.001
Child benefits as a % of total income	2.00	1.162	2.19	
Government transfer payments as a % of total income	18.19	.738	.065	.593
% of rented dwellings	58.24	.722	.977	.055
% no certificate, diploma, or degree	13.88	.464	-.692	.430
% with a postsecondary education	20.45	.057	-.816	.554
Average after-tax household income	$57,957	.088	.026	.942
Average after-tax family income	$68,020	1.039	2.24	.037
Average after-tax lone-parent family income	$29,167	-.593	.460	.565
Unemployment rate %	9.60	1.239	3.13	.071
Participation Rate %	17.42	-.327	-.127	.558
% of lone-parent family households	22.94	1.221	1.94	.032

Besides the ranges, various independent variables are strongly skewed and have a high kurtosis. There are also variables that have a significant Shapiro Wilk test score. This means that certain variables are not normally distributed including neighbourhood income less than $20,000, bottom half and bottom

two deciles of income, spending 30 % of income or more on shelter costs, prevalence of low income after taxes (LIMAT), average after tax family income, and the percentage of lone-parent family households. Because some of the independent variable measures in this study are not normally distributed, there are a select few neighbourhoods which have a much lower amount of health promoting resources than most within the CGS.

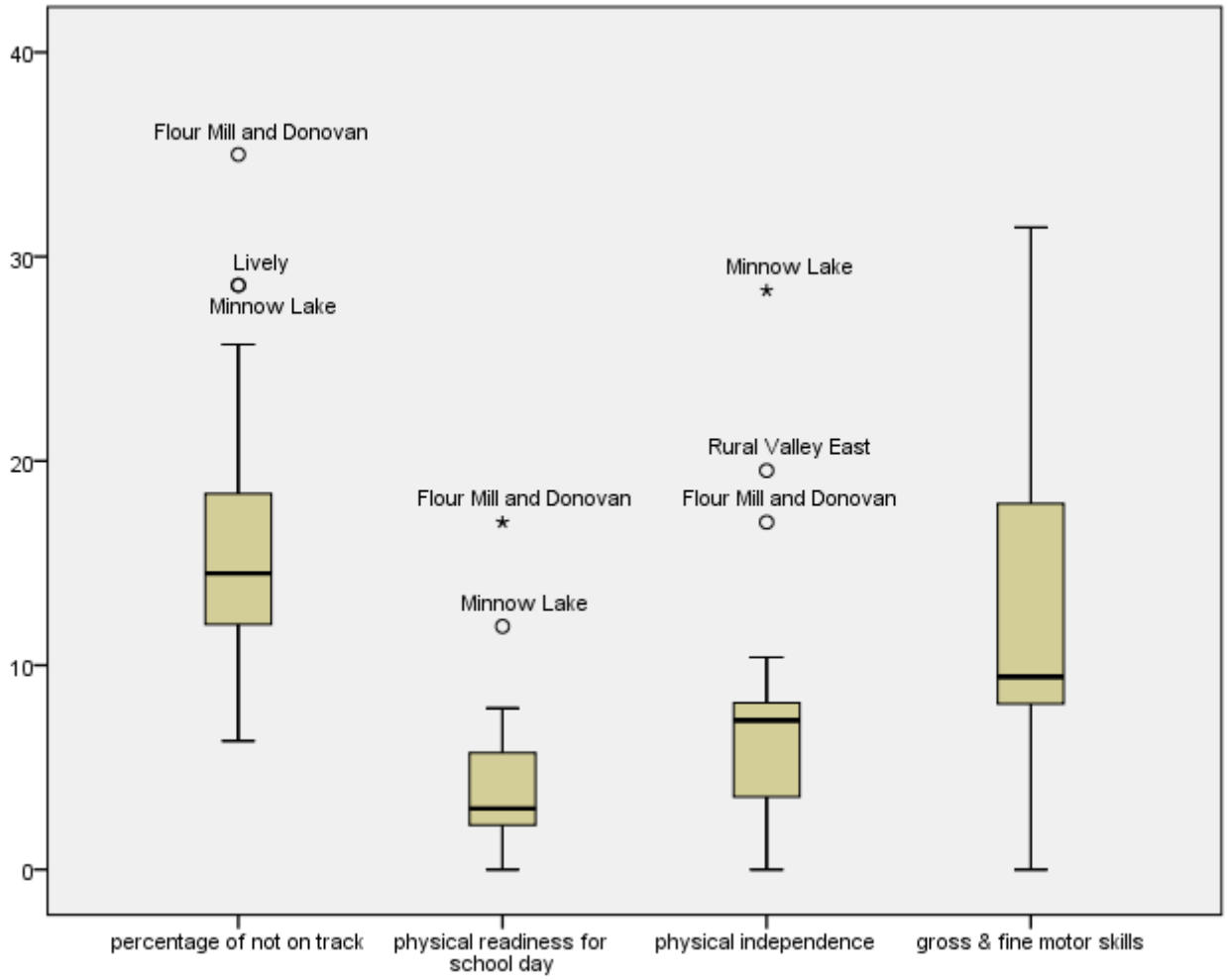
4.3 Outlier Analysis

It becomes clear in the descriptive analysis that there are specific CGS neighbourhoods with a wide range of scores for child physical health and for the social determinants of health. Before the relationships between child physical health and the social determinants of health are examined using bivariate and multivariate analysis, this section examines neighbourhoods that don't fit the normal distribution of scores, and are therefore outliers. The following section identifies outliers using univariate, bivariate, and multivariate analysis. The purpose of this section is to identify observations that do not properly represent the population, and that are distinct from either the dependent or independent variables values. Once the outliers are determined, further analysis will be done to determine if they are influential observations and/or leverage points. The goal is to determine if the identified outliers have a disproportionate effect on the regression coefficients and therefore account for most of the observed relationships between variables.

4.3.1 Univariate Detection of Outliers

Univariate detection of outliers is done by examining cases falling on the outer ranges of the distribution of scores. Figure 4.5 displays outliers determined by box plots for the dependent variables in this study.

Figure 4.5 Box Plots for the Dependent Variables



If a neighbourhood falls outside of the whiskers, then it is considered an outlier because it falls outside of the normal range of scores. Figure 4.5 shows outliers for three out of the four dependent variables.. The subdomain concerned with gross/fine motor skills does not have any outliers, but the skewness of the box plot shows that the mean for this subdomain is on the lower end, meaning a lower percentage of children meeting few/no developmental expectations. The Flour Mill and Donovan and Minnow Lake are classified as outliers for the other measures, and fall outside of the maximum value excluding outliers. This means they are outliers because of a much higher percentage of children not meeting developmental expectations than the other neighbourhoods in the CGS. Lively is an outlier for the percentage of children not on track, and Rural Valley East is an outlier for the physical independence measure.

Box plots for the independent variables also display similar outlier patterns. Figures D, E, and F in the appendix display the boxplots for the independent variables. Figure D shows outliers for the low

income measures in this study, figure E shows outliers for measures of poverty, and figure F displays the outliers for neighbourhood income measures (see appendix). There are independent variable measures that do not have outliers identified by box plots and they include employment insurance, government transfer payments, education measures, and percentage of rented dwellings. Table 4.5 lists the outliers for each variable included in this study.

Table 4.5 Univariate Outliers Determined by Box Plots

Variable	Case Outliers
Percentage not on track	Flour Mill and Donovan Minnow Lake Lively
Physical readiness for the school day	Flour Mill and Donovan, Minnow Lake
Physical independence	Minnow Lake, Flour Mill and Donovan, Rural Valley East
Gross/fine motor skills	No Outliers
Percentage of individual income >$20,000	Flour Mill and Donovan, Downtown/Bell Park
Employment Insurance as a % of total income	No outliers
Bottom half decile adjusted after-tax family income	Flour Mill and Donovan, Minnow Lake, Gatchell and Elm West
Bottom two deciles adjusted after-tax family income	Flour Mill and Donovan, *Minnow Lake, Downtown/Bell Park, Gatchell and Elm West
Spending 30% or more of income on shelter costs	Flour Mill and Donovan, *Downtown/Bell Park Gatchell and Elm West, Minnow Lake
Low income measure after taxes	Flour Mill and Donovan, Downtown/Bell Park, Minnow Lake
Child benefits as a % of total income	Minnow Lake
Government transfer payments as a % of total income	No Outliers
% no certificate, diploma or degree	No Outliers
% rented dwellings	No Outliers
Unemployment rate	Flour Mill and Donovan
Average after-tax household income	Algonquin/Wanup-Long Lake, Lo-ellen, Flour Mill and Donovan
Average after-tax family income	Lo-ellen, Algonquin/Wanup-Long Lake, Moonglow, Minnow Lake, Flour Mill and Donovan
Average after-tax lone-parent family income	Minnow Lake, Flour Mill and Donovan
% of lone-parent family households	Minnow Lake, Flour Mill and Donovan

Along with figures D, E, and F in the appendix, table 4.5 demonstrates that outliers for each variable are consistently similar. The Flour Mill and Donovan is a consistent outlier across every variable, followed by Minnow Lake, Downtown/Bell Park, and Gatchell and Elm West. This means there are select few neighbourhoods in the CGS which consistently fall outside of the normal distribution of cases regardless of what social determinant of health is measured. The same neighbourhoods that are outliers for low

income measures are also outliers for average neighbourhood income measures, percentage of lone-parent families, and unemployment rates. This indicates that there are specific neighbourhoods that have substantially less health promoting resources than the rest of the neighbourhoods in the CGS. The same neighbourhoods which are outliers for the independent variables also have much higher percentages of children not meeting physical health expectations. However, the neighbourhood of Lively is an outlier for percentage of children not on track for physical health, but falls within the expected values for every independent variable measure. This will be analyzed further in the discussion section. The next section examines which neighbourhoods are outliers using bivariate analysis.

4.3.2 Bivariate Detection of Outliers

Research question 1 of this study addresses the individual relationships between each social determinant of health and child physical health. One way to accomplish this is a bivariate detection of outliers. Bivariate detection of outliers involves using a visual of the bivariate relationships to identify cases that are considered isolated points. This study includes many variables, so displaying every relationship visually is not an effective strategy. Therefore, select variables that were identified as outliers in the univariate analysis will be examined in this section. The goal of detecting outliers using a bivariate analysis is to classify them into different categories. An isolated point that occurs in the expected direction of the relationship is an influential point and/or leverage point. An isolated point that falls outside of the cluster of scores in an unexpected area is classified as an unexplained observation. Influential points, leverage points, and unexplained observations that are discovered in the bivariate analysis are explored. Figure 4.6 displays a scatter plot for the bivariate relationship between the percentage of children not on track and a low income measure.

Figure 4.6 Scatter Plot for the Percentage of Children Not on Track

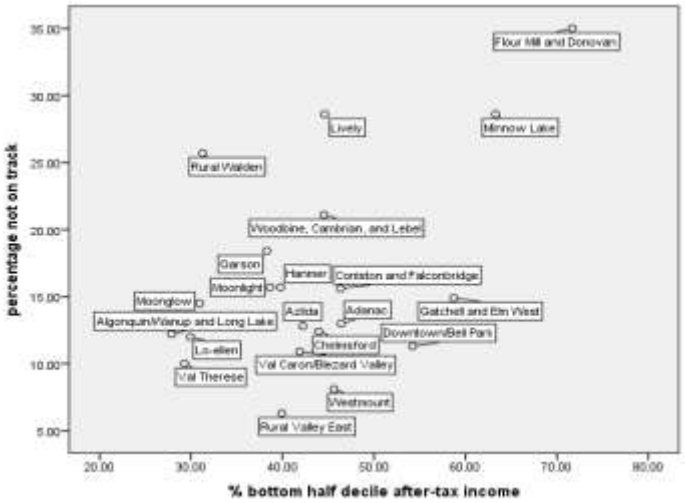
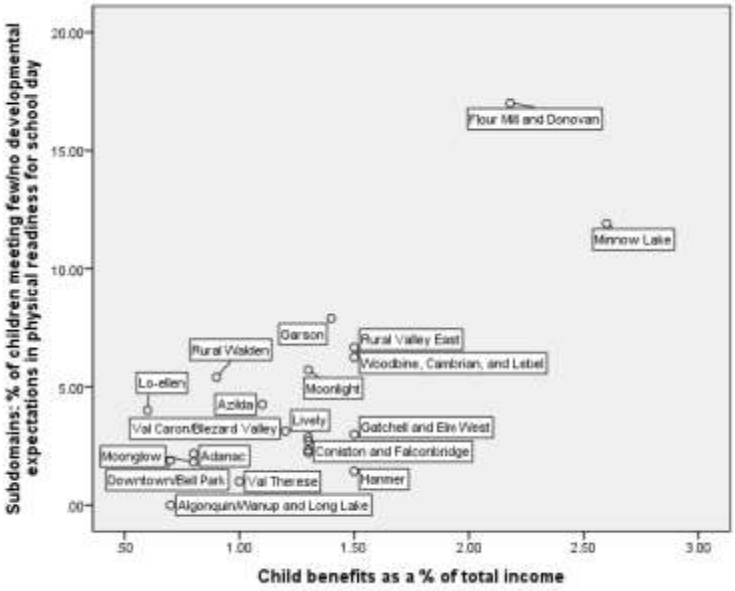


Figure 4.6 identifies Flour Mill and Donovan, Minnow Lake, Lively as isolated points for this bivariate relationship. The location of these points is outside the cluster of neighbourhoods. The location of these points demonstrates that neighborhoods with a very high percentage of children who are not on track for physical health also have a very high percentage of individuals in the bottom half decile of after-tax income. Figure 4.7 displays a scatter plot for the relationship between physical readiness for the school day and child benefits as a percentage of total income.

Figure 4.7 Scatter Plot for Physical Readiness for the School Day and Child Benefits



For figure 4.7, a similar pattern emerges compared to figure 4.6. There are two obvious isolated points on the scatter plot, and they are the Flour Mill and Donovan and Minnow Lake. This means that the relationship between these two variables in those neighbourhoods is far more extreme than what is found in the other neighbourhoods. Table 4.6 below identifies isolated points similar to figure 4.7 found on scatter plots for selected bivariate relationships. Each dependent variable measure is examined with different independent variables.

Table 4.6 Relationships with Isolated Points

Dependent Variable	Independent Variable	Isolated Cases
% Not on track	Bottom half decile of income Shelter costs above 30% Low income measure after-tax Average household income	Flour Mill and Donovan Minnow Lake Lively* Rural Walden
Physical readiness	Bottom 2 deciles of income Child Benefits	Flour Mill and Donovan Minnow Lake

	Unemployment rate	Flour Mill and Donovan Minnow Lake Lively*
	Average family income	Flour Mill Minnow Lake Lo-ellen
Physical Independence	Government transfer payments Unemployment rate % no certificate, diploma, or degree Average lone-parent family income	Flour Mill and Donovan Minnow Lake Rural Valley East
Gross/Fine Motor Skills	Employment insurance	Lively*
	% making <20,000	Lively* Flour Mill and Donovan
	% rented dwelling	Lively* Rural Valley East Flour Mill and Donovan
	% lone parent family households	Lively* Rural Valley East Flour Mill and Donovan Minnow Lake

*= off diagonal neighbourhood: high percentage of not meeting developmental expectations despite low percentages of poverty, income, government assistance, education, and high percentages of income.

Visually examining the bivariate relationships for isolated points validates the univariate results. The Flour Mill and Donovan and Minnow Lake are consistently isolated for almost every bivariate relationship examined in a scatter plot. These neighbourhoods are also bivariate outliers across all dependent variable domains. However, Lively is a neighbourhood that is consistently an isolated point, but it is different in the location on the scatter plot from other outliers. While the Flour Mill and Donovan are located in the expected direction of the relationship, Lively is not located in the expected direction. Especially for gross/fine motor skills, Lively has a high percentage of children not meeting developmental expectations, but this is not explained by presence of the independent variables. Rural Valley East as an outlier for bivariate relationships validates the differences between the dependent variable measures. This means the presence of outliers changes based on what dependent variable measure is examined. Therefore, physical readiness for the school day as a measure of child physical health has different outliers than physical independent and gross/fine motor skills. Rural Valley East falls at the bottom end of the expected direction for gross/fine motor skills, meaning they have very few children not meeting developmental expectations, while consistently having lower rates of poverty, low income, and higher rates of education and family income.

4.3.3 Multivariate Detection of Outliers

Research question 2 examines the collective influence of the social determinants of health on child physical health in the CGS neighbourhoods. This can be done by examining the outliers in multivariate relationships to see if multiple social determinants of health have a simultaneous influence on child physical health within specific neighbourhoods (Hair, Black, Babin, Anerson, & Tatham, 2006). Multivariate detection of outliers involves using the mahalanobis D^2 (MD) which is an analysis that evaluates the position of each observation compared with the centre of all observations in a set of variables. A mahalanobis D^2 of 2.5 (standard deviations) or higher from the mean of all observations in a distribution means it can be considered an outlier. The higher the standard deviation score, the further it is from the mean of all scores in the distribution. MD is calculated using multivariate regression analysis which examines the relationship between multiple independent variables and the dependent variable. Table 4.7 below includes the neighbourhoods that have high MDs in select multiple regression equations. The independent variable combinations were selected for this table based on high R^2 adjusted scores and statistically significant relationships ($P<.05$) with the dependent variable measures. Neighbourhoods with a MD score above 5.00 are included in the table.

Table 4.7 Mahalanobis D^2 Results for Multivariate Outliers

Dependent Variable	Independent Variables in Multiple Regression Equations	Neighbourhood MD
% not on track	Low income measure after taxes Child Benefits Government transfer payments	Downtown/Bell Park – 10.03 Flour Mill and Donovan – 8.65 Minnow Lake – 7.92 Adanac - 6.79
Physical readiness	Bottom 2 deciles for income Average family income after tax % of lone parent family households	Lo-ellen - 12.56 Minnow Lake – 8.27 Flour Mill and Donovan – 8.50
Physical Independence	Employment Insurance Average lone parent family income Child benefits	Minnow Lake – 8.37 Flour Mill and Donovan – 7.25 Downtown/Bell Park - 5.25 Chelmsford – 5.37
Gross/Fine Motor Skills	% no certificate, diploma, degree Shelter costs above 30 % of income Bottom half decile of income	Minnow Lake – 9.53 Flour Mill and Donovan – 9.41

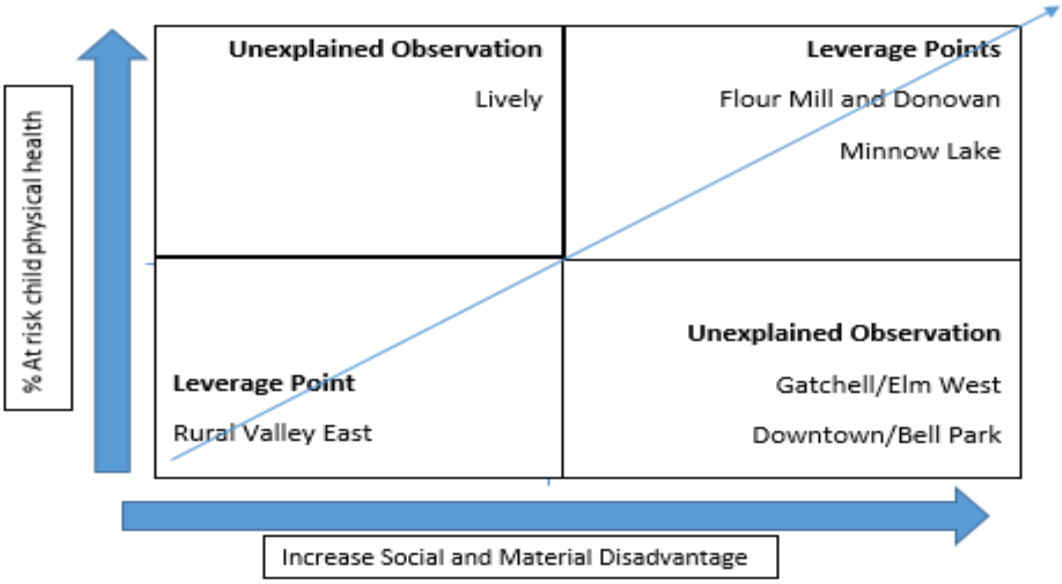
The MD scores in table 4.7 display very similar outlier neighbourhoods compared to the other outlier detection methods used in this study. When the collective influence of the social determinants of health on child physical health are examined, the outliers generally remain the same. For every child physical health measure, Flour Mill and Donovan and Minnow Lake have very high standard deviations. This

indicates that these neighbourhoods are consistently outside of the distribution of scores regardless of what variable is being measured. There is some variation between the child physical health measures. For example, Adanac has a very high MD score for the percentage of children not on track, Loellen has the highest MD score of any relationship when physical readiness for the school day is examined, and Chelmsford has a relatively high MD score for physical independence. Interestingly, Chelmsford is not classified as an outlier in the bivariate detection section. The presence of Loellen occurs when examining average neighbourhood income measures due to a substantially higher average income than any other neighbourhood.

4.3.4 Summary of Outliers

The goal of this section is to identify outliers that can be classified as influential data points, unexplainable observations, leverage points, and if the outliers are unique individually and in combination. Figure 4.8 below visually demonstrates the outlier neighbourhood patterns found in the bivariate and multivariate outlier detection sections.

Figure 4.8 Outlier Neighbourhoods



Two neighbourhoods that are classified as an outlier in every method used in this study are Flour Mill and Donovan and Minnow Lake. For child physical health, these neighbourhoods are identified as outliers for every measure except gross/fine motor skills. For the social determinants of health, these two neighbourhoods are consistently found to be outliers in both low income measures and lone-parent family measures. These two outlying neighbourhoods are influential points because they reinforce the general pattern of the data and account for most of the observed relationship. They have very high percentages of children meeting few/no developmental expectations for physical health combined with very high rates of low income and poverty. Another neighbourhood that is identified as an outlier is Rural Valley East. The univariate analysis identified Rural Valley Easy as an outlier for physical independence with a very low percentage of children not meeting developmental expectations. The bivariate analysis shows Rural Valley East is an outlier when gross/fine motor skills is combined with the social determinants of health. Unlike the case of the Flour Mill and Donovan/Minnow Lake, Rural Valley East has very low percentages of children not meeting developmental expectations combined with very low rates of low income and poverty measures. This indicates that Rural Valley East is an influential

point because it is found on the bottom end of the expected direction of the relationship, whereas the Flour Mill and Donovan and Minnow Lake are at the top end of the expected relationship. Loellen is classified as an outlier in the univariate analysis when measures of average family income are examined. It is also identified by bivariate and multivariate analysis when physical readiness is examined with measures of family income, which makes it an influential point for select relationships. In the case of Loellen, there are very low percentages of children meeting few/no developmental expectations for physical readiness are combined with a very high percentage of average neighbourhood income.

Besides the neighbourhoods that have an influential impact on the direction of the expected relationships, there are neighbourhoods that are identified as outliers but do not fit the criteria for being an influential point. Downtown/Bell Park and Gatchell/Elm West are identified as outliers for the independent variables, specifically low income measures and percentage of income dedicated to shelter costs. Despite having high rates of low income, the child physical health scores are in the middle of the distribution of scores. This means that child physical health appears to be resilient in these neighbourhoods despite having high percentages of residents having a low income. This means that these neighbourhoods are classified as unexplainable observations. Another neighbourhood that is an outlier but does not follow the expected direction of the relationships is Lively. For child physical health, Lively is an outlier due to a high percentage of children not on track and not meeting developmental expectations for gross/fine motor skills. However, Lively has relatively low rates of low income, and poverty. In Fact, Lively is not identified as an outlier for any measure of the social determinants of health. This means that Lively's poor child physical health scores cannot be explained by any independent variable measure included in this study. Therefore, Lively is classified as an unexplainable observation.

Overall, the outlier analysis has identified specific neighbourhoods that support the hypothesis and prediction of outcomes for this study. The social determinants of health may be influencing child physical health in specific CGS neighbourhoods. The bivariate outlier analysis demonstrates that the social determinants of health are independently influencing child physical health, and the multivariate outlier analysis demonstrates that the social determinants of health are collectively influencing child physical health within specific CGS neighbourhoods. However, there are some outlier neighbourhoods that do not support the hypothesis and prediction of outcomes, and will be analyzed further in the following sections.

4.4 Bivariate Analysis

The following section is a bivariate analysis of the relationship between child physical health and the social determinants of health for every neighbourhood in the CGS. Pearson's correlation coefficient and statistical significance of each dependent variable measure and independent variable are examined to determine correlation. Once correlation is established, the outliers identified in the outlier analysis will be removed from the analysis to determine how much influence they are having on the overall relationships. This will determine if these outliers are leverage points and how much influence these outliers have on the overall relationship. It is important to note that Pearson's correlation coefficient, and the statistical significance and effect size of each relationship is poorly estimated. The data for the following variables are not normally distributed, and therefore violates an assumption of linear regression. There are observations within the data set that are classified as leverage points (see table 4.6). Therefore, the correlation strength of the overall relationships displayed below are mostly accounted for by two select observations. The following section further demonstrates the presence of leverage points.

Table 4.8 includes Pearson's correlation coefficient and the statistical significance of the relationships between the independent variables and the percentage of children who are in the bottom 25th percentile for physical health and wellbeing. The first two columns include all of the neighbourhoods in this study, and the last two columns are the bivariate results with two outlier neighbourhoods removed: Four Mill and Donovan and Minnow Lake.

Table 4.8 Bivariate Results for the Bottom 25th Percentile

Independent Variables	**R**	**P**	**R***	**P***
Income less than %20,000	.361	.108	-.131	.593
Employment Insurance %	.267	.242	-.050	.839
% Bottom half decile adjusted after-tax family income %	.501	.021*	-.010	.969
% Bottom two deciles adjusted after-tax family income	.491	.024*	-.094	.702
Spending 30% or more of income on shelter costs	.439	.046*	-.117	.633
Prevalence of low income (2010) based on LIMAT %	.517	.016*	-.041	.869
Child benefits as a % of total income	.582	.006**	.141	.566
Government transfer payments as a % of total income	.466	.033*	-.068	.782
% of rented dwellings	.318	.161	-.147	.547
% no certificate, diploma, or degree	.198	.390	-.009	.970
% with a postsecondary education	-.174	.452	.088	.720
Average after-tax household income	-.423	.056	-.018	.941
Average after-tax family income	-.421	.058	-.074	.762

Average after-tax lone-parent family income	-.433	.050*	.098	.689
Unemployment rate %	.352	.118	-.094	.701
Participation Rate %	-.328	.147	-.116	.637
% of lone-parent family households	.540	.012*	.050	.837

Due to the presence of leverage points within the data set, the strength and significant correlations between the dependent variable and independent variables is poorly estimated. However, the presence of leverage points is still demonstrated. When Flour Mill and Donovan and Minnow Lake are removed from the equation, the strength of the correlations completely dissipate. When two influential outliers are removed, there is no correlation or significant relationships. This means that these two outliers are influential data points because they have a very large impact on the observed relationship. Child physical health and the social determinants of health are strongly related within the outlier neighbourhoods, but the same relationships do not exist within the other 19 neighbourhoods. Therefore, the generalizability of the results is changed by simply removing them.

A similar effect is found when physical readiness for the school day is examined. Table G and H in the appendix includes Pearson's correlation coefficient and the statistical significance of the relationships between the independent variables and the percentage of children who are meeting few/no developmental expectations for physical readiness for the school day, as well as physical independence. The first two columns include all of the neighbourhoods in this study, and the last two columns are the bivariate results with two outlier neighbourhoods removed: Four Mill and Donovan and Minnow Lake. When the influential outliers are removed, the correlations disappear. Without the Flour Mill and Donovan and Minnow Lake, there are no correlations or significant relationships. The presence of strong correlations with these outliers and the disappearance of these correlations without them indicates that these outliers are leveraging the data due to their impact on the observed relationships.

When the percentage of children meeting few/no developmental expectations for gross/fine motor skills is examined, there are no correlations or significant relationships. This includes the outlier neighbourhoods. Therefore, removing the outlier neighbourhoods does not result in any leverage or influence on the observed relationships. This may be due to the unexplained observations for the outlier neighbourhood of Lively for gross/fine motor skills. Table I in the appendix displays Pearson's correlation coefficient and the statistical significance of the relationships between the independent variables and the percentage of children who are meeting few/no developmental expectations for gross and fine motor skills.

4.4.1 Summary of Bivariate Analysis

The distribution of observations within the data set presented in the bivariate and outlier analysis shows that there are influential data points within the data set than are accounting for the majority of the observed relationships. For the equations that include all 21 neighbourhoods, the correlation and statistical significance of each relationship is poorly estimated, and therefore cannot be trusted. However, the presence of influential observations is further demonstrated when the outliers identified as influential points in the outlier analysis section are removed. By removing the Flour Mill and Donovan and Minnow Lake from the bivariate analysis, it becomes clear that these two outliers leverage the overall relationships and account for most of the observed relationship. Without these two outliers, no real pattern in the data emerges. The bivariate analysis results confirms what was found in the outlier analysis section by demonstrating the influence of the Flour Mill and Donovan and Minnow Lake.

4.5 Multivariate Analysis

The following section examines the collective influence of the social determinants of health on the measures of child physical health by exploring linear regression and multiple regression results. The multivariate analysis compares the regression equations with all neighbourhoods included, as well as examines those equations with outlier neighbourhoods removed. The goal of this section is to 1) determine the collective influence of the social determinants of health on child physical health and 2) determine the influence of outliers on the observed relationships. The influence of outliers is determined by comparing the strongest linear, two variable, and three variable regression results with them included and excluded. Similar to the bivariate analysis, it is important to note that the data for this study is not normally distributed and contains the presence of outliers that have been identified via univariate, bivariate, and multi-variate methods. Therefore, the nature of the data violates multiple linear regression assumptions: The presence of outliers demonstrates little linearity within the data, the data is not normally distributed (see tables 4.2 and 4.3), and there is multicollinearity due to the high correlations between the independent variables. The following multivariate analysis uses the linear and multiple regression results, despite the violation of linear regression assumptions, to further demonstrate the presence of outliers; however the results should be viewed with caution given the violation of assumptions.

4.5.1 Percentage of Children Not on Track

This section examines the strongest linear and multiple regression results for the percentage of children falling in the bottom 25th percentile for physical health (children who are 'not on track') and measures of neighbourhood income, poverty, government assistance, and lone-parent family households in the CGS. Then, the strongest relationships are examined with the outliers removed in order to understand the influence of these outliers on the observed relationship.

The linear regression analysis examines the variance in child physical health and wellbeing scores that can be explained by each social determinant of health independently. Table J in the appendix displays the linear regression analysis for each independent variable and the percentage of children who fall in the bottom 25th percentile for physical health. Table 4.13 displays Pearson's R, R^2, R^2 adjusted, the standard error, and the significance level which is set at $P<.05$. As demonstrated in the bivariate analysis, when the outlier cases are removed from the equations, the presence of any correlation disappears (see table 4.9 below).

Table 4.9 Linear Regression Outlier Comparison

Independent Variable	R	R^2	R^2 adjusted	SE	P<.05
Child Benefits (all cases)	.582	.339	.304	6.21	.006**
Child Benefits (outliers removed)	.141	.020	-.038	5.67	.566

The regression coefficients show no correlation and the equation is not statistically significant. When Flour Mill and Donovan and Minnow Lake are removed, the regression equation is R^2 adj=-.038, p=.566. This means the variance with all cases included was caused mostly by these two outliers. Table K in the appendix displays the significant two variable relationships for the percentage of children not on track. When the outlier cases are removed from the two variable regression, the results also become insignificant (see table 4.10 below).

Table 4.10 Two Variable Regression Outlier Comparison

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
Child Benefits (all cases) LIMAT (all cases)	.628	.395	.327	6.10	.011*	1.427
Child Benefits (outliers removed) LIMAT (outliers removed)	.147	.022	-.101	5.48	.839	1.00

The regression coefficients show no correlation and the equation is not statistically significant. When Flour Mill and Donovan and Minnow Lake are removed, the regression equation is R^2 adj=-.101, p=.839. The three variable regression results in table L in the appendix consists of the significant two variable regression combinations with an additional third variable added. When the outlier cases are removed from the three variable regression, the results again become insignificant (see table 4.11 below).

Table 4.11 Three Variable Regression Outlier Comparison

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
Child Benefits (all cases) LIMAT (all cases) Gov. transfer payments (all cases)	.635	.403	.298	6.24	.029*	2.48 1.93 3.36
Child Benefits (outliers removed) LIMAT (outliers removed) Gov. transfer payments (outliers removed)	.197	.039	-.154	5.98	.894	1.43 1.24 1.69

When the Flour Mill and Donovan and Minnow Lake are removed, there is no significant relationship and the independent variables account for no variance in child physical health. This further demonstrates the leverage that these outliers have on the overall observed relationship. They severely

impact the estimation of the regression coefficients when they are included in the equation. When they are removed, it is clear that they account for most of the observed relationship. Without these outliers in the equation, no real pattern emerges and the generalizability of the results are nullified.

4.5.2 Physical Readiness for the School Day

Table M in the appendix displays the linear regression analysis for each independent variable included and the percentage of children who are meeting few/no developmental expectations for physical readiness for the school day. Table 4.12 shows the strength of the relationship between child benefits as a percentage of total income and physical readiness for the school day (R^2 adj(19)=..549, p=.000).

Table 4.12 Linear Regression Outlier Comparison

Independent Variable	R	R^2	R^2 adjusted	SE	P<.05
Child Benefits (all cases)	.756	.572	.549	6.21	.000**
Child Benefits (outliers removed)	.420	.176	.128	1.97	.074

When the Flour Mill and Donovan and Minnow Lake are removed, there is no significant relationship for child benefits as a percentage of total income and physical readiness for the school day. Child benefits does not account for any variance in physical readiness for the school day. This demonstrates the leverage that these two outliers have on the observed relationships. The two variable regression results in Table N in the appendix displays the significant two variable relationships for physical readiness for the school day. When the outlier neighbourhoods are removed, there is no significant relationship between child benefits, low income measure after taxes, and physical readiness for the school day (see table 4.13 below)

Table 4.13 Two Variable Regression Outlier Comparison

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
Child Benefits (all cases) LIMAT (all cases)	**.811**	**.658**	**.620**	**2.44**	**.000**	**1.427**
Child Benefits (outliers removed) LIMAT (outliers removed)	.420	.176	.073	2.03	.212	1.00

The same leverage and influence that the outliers have in the linear and two variable regression is also found in the three variable regression for physical readiness for the school day. Table O in the appendix displays the three variable regression equations for physical readiness for the school day.

Table 4.14 Three Variable Regression Outlier Comparison

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
Child Benefits (all cases) LIMAT (all cases) Average household income (all cases)	.840	.705	.653	2.33	.000	2.3 1.8 2.8
Child Benefits (outliers removed) LIMAT (outliers removed) Average household income (outliers removed)	.488	.238	.085	2.02	.241	1.7 1.4 2.1

When the outliers are removed, the regression coefficients become insignificant and no variance in physical readiness for the school day is accounted for by the independent variables. This further demonstrates how much leverage the outlier variables have on estimating the regression coefficients.

4.5.3 Physical Independence

This section examines the presence of outliers using linear/multiple regression for the percentage of children meeting few/no developmental expectations for physical independence, and measures of neighbourhood income, government assistance, poverty, and lone-parent family households.

This linear regression analysis examines the variance in physical independence scores that can be explained by each social determinant of health. Table P in the appendix displays the linear regression results for each independent variable and the percentage of children who are meeting few/no developmental expectations for physical independence. The removal of outliers from the regression equations results in a change in the regression coefficients (see table 4.15 below).

Table 4.15 Linear Regression Outlier Comparison

Independent Variable	R	R^2	R^2 adjusted	SE	P<.05
Child Benefits (all cases)	.752	.565	.542	4.55	.000**
Child Benefits (outliers removed)	.362	.131	.080	4.19	.128

When the outliers are removed, the regression coefficients become insignificant and no variance in physical independence is accounted for by child benefits. The two variable regression results in table Q in the appendix displays the two variable relationships for physical independence. The removal of the Flour Mill and Donovan and Minnow Lake cause the regression coefficients to decrease and the overall model becomes insignificant (see table 4.16 below).

Table 4.16 Two Variable Regression Outlier Comparison

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
Child Benefits (all cases) Average family income (all cases)	.773	.597	.553	4.49	.000	2.223
Child Benefits (outliers removed) Average family income (outliers removed)	.399	.159	.054	4.25	.250	1.716

The outliers have the same effect on the strongest three variable regression models for physical independence. Table R in the appendix displays the three variable regression equations for physical independence. Table 4.17 below demonstrates what happens to this equation when the outliers are removed.

Table 4.17 Three Variable Regression Outlier Comparison

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
Child Benefits (all cases) Average family income (all cases) % lone-parent family homes (all cases)	.785	.617	.549	4.51	.001	2.8 2.3 2.1
Child Benefits (outliers removed) Average family income (outliers removed) % lone-parent family homes (outliers removed)	.400	.160	-.008	4.39	.441	1.71 1.99 1.24

Consistent with other models that exclude outliers from the equation, the regression coefficients become insignificant. This clearly demonstrates that the observed relationships between physical independence and the independent variables are extremely leveraged by the Flour Mill and Donovan and Minnow Lake. With these two neighbourhoods removed from the model, there is no correlation between physical independence and the social determinants of health.

4.5.4 Multivariate Analysis Summary

The first goal of this analysis is to determine the collective influence of the social determinants of health on child physical health. Due to the violation of linear regression assumptions and the nature of the data, the strength of the correlations and statistical significance are nullified. Based on this, the null hypothesis is not rejected and there is no overall relationship between the social determinants of health and child physical health in Greater Sudbury neighbourhoods. The second goal of this analysis is to determine the influence of outliers on the observed relationships. When the outliers are removed from the regression models, the relationships between child physical health and the social determinants of health are nullified. This indicates that the Flour Mill and Donovan and Minnow Lake are influential observations. Influential observations account for most of the observed relationship and there is no real

pattern in the data without them. The generalizability of the results for each model is changed by removing those two neighbourhoods. They are classified as influential points because there is a possible explanation for their effect on the models which will be discussion in the implications section. These outliers are also considered leverage points because they affect the estimation of the regression coefficients for every model they are removed from. This means they are distinct from the remaining neighbourhoods because the values these neighbourhoods contain are vastly different from the remaining neighbourhoods. Therefore they have a disproportionate effect on the regression results. Overall, by comparing multivariate correlations with and without outliers, it is clear that the Flour Mill and Donovan and Minnow Lake can be classified as influential points and account for most of the variance between child physical health and the social determinants of health within the CGS neighbourhoods.

4.6 Data Analysis Summary

This data analysis set out to answer research questions. One question is how are the social determinants of health independently influencing different measures of child physical health? It is clear that within the CGS, there is a large variance child physical health scores. There are neighbourhoods that have substantially more children at risk and not meeting developmental expectations for physical health and wellbeing, according to the EDI. These neighbourhoods change depending on what child physical health domain is measured. For the percentage of children not on track in all domains, the Flour Mill and Donovan and Minnow Lake have much higher percentages. This is also the case for physical readiness for the school day and physical independence. When gross/fine motor skills is measured, Lively has a much higher percentage of not meeting developmental expectations. There are also neighbourhoods that have substantially more material, economic, and social deprivation. For most of the social determinants of health, the neighbourhoods experiencing the most disadvantage are also neighbourhoods experiencing the highest percentage of children not meeting developmental expectations for physical health/wellbeing. Specific outliers do demonstrate individual relationships between child physical health and the social determinants of health, which is worth exploring further. Due to the violations of linear and multiple regression assumptions, the correlations and statistical significance of the linear and multiple regression models are nullified, and the null hypothesis cannot be rejected for research question 2. Therefore, there is no collective influence of the social determinants of health on child physical health in Greater Sudbury neighbourhoods. However, the bivariate and multivariate analysis demonstrates there are select neighbourhoods, specifically the Flour Mill and

Donovan and Minnow Lake, which demonstrate a cumulative effect of the social determinants of health on child physical health. By comparing multivariate correlations with and without outliers, it is clear that the Flour Mill and Donovan and Minnow Lake can be classified as influential points and account for most of the variance between child physical health and the social determinants of health within the CGS neighbourhoods. The third research question asks if there are unique relationships between the social determinants of health and child physical health. The descriptive statistic measures demonstrated that the CGS has a wide range of child physical health scores and social determinants of health, which indicates a large variance of health promoting resources within certain neighbourhoods. There are neighbourhoods that are outliers for both child physical health and for the social determinants of health. There are outliers that support this hypothesis because they are found in the expected direction of the observed relationships (Flour Mill and Donovan, Minnow Lake, and Rural Valley East), and there are outlying neighbourhoods for which the observed relationships cannot be explained (Downtown/Bell Park, Gatchell/Elm West, and Lively) because they do not follow the expected relationships.

Chapter 5: Findings

The null hypothesis for this study is there will be no relationship between the independent variables (income, education, government assistance, unemployment, lone-parent families, and poverty) and child physical health and wellbeing scores in Greater Sudbury neighbourhoods. Due to violations of linear regression assumptions including the presence of outliers, a lack of linearity, non-normal distribution, and multicollinearity, the regression coefficients and statistical significance of the linear and multiple regression models cannot be accepted. The null hypothesis cannot be rejected – there is no relationship between the social determinants of health and child physical health in Greater Sudbury neighbourhoods.

Tables 4.2 and 4.4 demonstrate that all of the dependent variable measures are negatively skewed, and are outside of the expected range of skewness and kurtosis (except for gross/fine motor skills), and most independent variables are strongly skewed and have a high kurtosis as well as a significant Shapiro Wilk test score. This means that certain variables are not normally distributed including neighbourhood income less than $20,000, bottom half and bottom two deciles of income, spending 30 % of income or more on shelter costs, prevalence of low income after taxes (LIMAT), average after tax family income, and the percentage of lone-parent family households.

Referring to table 4.6, a visual examination of the relationship between variables reveals isolated points that can be classified as leverage points. These leverage points account for most of the observed relationship between variables and suggests non-linearity for the overall models. In fact, child physical health and the social determinants of health are so correlated within these leverage points (neighbourhoods) that the generalizability of the results is changed by simply removing them. The presence of strong correlations with these outliers and the disappearance of these correlations without them indicates that these outliers are leveraging the data due to their impact on the observed relationships. For example, when the Flour Mill and Donovan and Minnow Lake are removed from linear and multiple regression equations, there is no significant relationship and the independent variables account for no variance in child physical health.

Prediction one of this study is that each social determinant of health will have an independent influence on child physical health. Prediction two is that the social determinants of health will have a cumulative effect on child physical health. Both of these predictions are incorrect due to the aforementioned violation of linear and multiple regression assumptions. Prediction three states there will be outlier neighbourhoods that have unique relationships between the independent and dependent

variable measures. The findings suggest that specific neighbourhoods do share unique relationships with the dependent and independent variables. Examination of the outliers reveals unique and important relationships between child physical health and social determinants of health within specific neighbourhoods due to influential observations and leverage points.

Univariate detection of outliers revealed specific neighbourhoods that consistently fall outside of the normal distribution of cases regardless of what social determinant of health is measured. These neighbourhoods are the Flour Mill and Donovan, and Minnow Lake. For child physical health, these neighbourhoods are identified as outliers for every measure except gross/fine motor skills. For the social determinants of health, these two neighbourhoods are consistently found to be outliers including low income measures and lone-parent family measures. They have very high percentages of children meeting few/no developmental expectations for physical health combined with substantial economic and social disadvantage. The bivariate relationships of the outliers validates the univariate results demonstrating an uneven distribution of both child physical health and the social determinants of health. The mahalanobis distance scores further prove that the outliers generally remain the same. For every child physical health measure, Flour Mill and Donovan and Minnow Lake have very high standard deviations. This indicates that these neighbourhoods are consistently outside of the normal distribution of scores regardless of what combination of social determinants of health are examined. The same neighbourhoods that are outliers for low income measures are also outliers for average neighbourhood income measures, percentage of lone-parent families, and unemployment rates. This indicates that there are specific neighbourhoods who have substantially less health promoting resources than the rest of the neighbourhoods in the CGS.

However, there are specific neighbourhoods (Gatchell and Elm West, Downtown/Bell Park) experiencing low risk for poor child physical health despite experiencing economic and social disadvantage. This indicates that there are mechanisms not examined in this study positively influencing children going to school physically ready to learn despite experiencing poor neighbourhood economic and social disadvantage. Interestingly, the opposite is also occurring within Lively: there are high rates of children not meeting developmental expectations for gross/fine motor skills despite having relatively low economic and social disadvantage. This also suggests there are mechanisms not examined in this study negatively influencing the gross/fine motor skills of children in Lively.

Overall this study found that children living in neighbourhoods with the most economic and social disadvantage are also simultaneously the most at risk for not meeting physical health and

wellbeing developmental expectations including physical readiness for the school day, physical independence, and gross/fine motor skills. This indicates that children living in these neighbourhoods are at the most risk for going to school not physically ready to learn due to showing up hungry, poorly dressed, sleep deprived, having poor energy levels, being poorly coordinated, and having poor physical independence. Despite the unique relationships observed in the outlier analysis, the results indicate a failure to reject the null hypothesis for this study. Therefore, there is no statistically significant relationship between the social determinants of health and child physical health within Greater Sudbury neighbourhoods.

Chapter 6: Discussion

This chapter addresses the literature relevant to the results of this study. This includes how the nature of the data reflects the challenges that are present when examining the social determinants of health and their influence on health outcomes, the shortcomings of cross-sectional studies, the exclusion of intra/interpersonal factors from the analysis, the lack of fusion between biomedical research and the social determinant of health literature, the subjectivity of using neighbourhoods as a unit of analysis, the identification of a social gradient within greater Sudbury for the social determinants as well as child physical health, and the importance of considering child physical health trajectories. This is followed by a discussion of possible implications as a result of this study.

6.1 Revisiting the Literature

The nature of the data in this thesis including its skewness, distribution, non-linearity, and multicollinearity, has resulted in failing to reject the null hypothesis. The findings align with other neighbourhood level studies examining the impacts of the SDOH and health outcomes. It is important to realize that the findings of this study do not necessarily mean that SDOH are unrelated to child physical health measures but may be an artefact of a small sample size and data aggregation. The complexity of how social factors interact within society makes it incredibly difficult to analyze them statistically. The distribution of observations within this study supports the social gradient literature which states that the lower a person's social and economic position, the more likely it is they are unhealthy (Marmot, M 2010). Due to the fact that the data is not normally distributed, a violation of linear regression occurs and the regression models cannot be accepted as accurate.

A challenge with studying these social determinants of health stems from the inability to identify pathways through which each social determinant works with specificity and accuracy (Braveman et al., 2011). This level of specificity regarding the pathways through which social factors influence health is currently not present in the literature. This is because current measures of the social determinants do not have the ability to identify the distinct effects of relevant aspects of income, education, employment, or the presence/absence of wealth (Braveman et al., 2011). The measures of the social determinants of health in this study are highly correlated with each other, resulting in issues of multicollinearity. This violates another linear regression assumption, which makes it difficult to identify the distinct effects that the social determinants of health are having on a specific health outcome (child physical health).

Another explanation for failing to reject the null hypothesis is the limitations of ecological cross-sectional studies. Attempting to document and quantify the effects of a select determinant on a specific health outcome in a single study represents an important obstacle to understanding how social factors influence health. Social determinants of health are complex and impact populations over long periods of time, which makes it difficult to pin-point the effects of these social determinants at a single point in time. (Braveman et al., 2011).

The lack of statistical significance in this study can also be explained by examining the social ecological model (SEM) of health promotion. The theoretical model used in this study, adapted from McLeroy et al., (1988) includes five domains that individually influence health behaviour as well as influence each other by interacting at different levels within society (see figure 2.1). Firstly, the many pathways that can influence health identified in this model, combined with the complex interaction of these pathways, demonstrates the true difficulty of statistically identifying correlations between social factors and health outcomes. Secondly, this thesis uses variables that reside within the larger domains of this model: community factors and public policy factors. The independent variables measured in this study such as measures of neighbourhood income, comprehensive poverty measures, neighbourhood education percentages, and the reliance on government assistance, operate within the larger domains of the social ecological model. Factors that influence health at the intrapersonal and interpersonal levels such as values, beliefs, personal knowledge, and social support networks such as friends and family were not measured in this study. By focusing on broader domains of the SEM and excluding more intra/interpersonal factors, there are unmeasured variables within the neighbourhoods of this study that may be influencing child physical health.

The lack of variables included in this study that fall within intra/interpersonal domains reflects a larger issue within the social determinants of health literature. The researcher of this thesis falls into the socio-environmental background of health research, and therefore did not include possible bio-medical variables. This can be explained by the rift between biomedical and socio-environmental approaches to solving public health problems. Approaches to studying the social determinants of health alters depending on the disciplinary background of the researcher (Raphael, 2006). Biomedical research involves an epidemiological perspective focused on identifying individual behavioral risk factors, whereas socio-environmental approaches to understanding health and illness are rooted in political and economic environments (Raphael, 2006). Due to the friction between the two approaches, there is a gap in the literature where biomedical and behavioural risk factors could combine with socio-environmental

approaches. Therefore this study is a testament to the need for a more encompassing approach to understanding the influences of the social determinants of health and negative health outcomes.

Another possible explanation for the results of this study stems from the literature regarding the use of neighbourhoods as a unit of analysis. Census tracts were used to define neighbourhoods used in this study. The boundaries for the census tracts used in this study were defined previous to the study, therefore the neighbourhoods used are not tailor-made. Lapointe et al., 2007 point out that research on neighbourhood effects that rely on census tracts is criticized because census tracts may not be a meaningful unit of analysis (Lapointe et al., 2007). This is because census tracts may be too large and heterogeneous, therefore masking the effects of place that can be found in smaller units of analysis (Lapointe et al., 2007). Lapointe et al., 2007 examined variables representing neighbourhood characteristics and found eight of these variables were significant predictors of EDI outcomes for physical health and wellbeing. However, the authors do point out that their findings are constrained by the conceptualization of 'neighbourhood' used in their study (Lapointe et al., 2007). The neighborhood boundaries that Lapointe et al., 2007 developed were determined through consultation with local early childhood development coalition representatives which identified natural boundaries by considering census tract boundaries, socioeconomic divisions, and natural or other physical boundaries (Lapointe et al., 2007). Muhajarine, Vu, and Labonte (2006) argue that these spatial units have no saliency or meaning as a place of residence or identity for those living within them (Muhajarine et al., 2006). This means that using census tracts instead of deriving a more comprehensive definition of neighbourhood may result in a sacrifice of intricacies at the level of the child, the family, and the neighborhood (Muhajarine et al., 2006). Despite the shortcomings of the challenges highlighted in the literature, select findings of this study are echoed within the literature. Cushon et al., 2011 examined socioeconomic disadvantage at the neighborhood level and its influence in the EDI domain of physical health and wellbeing and found statistically significant results using hierarchical linear regression: neighbourhood SES was significantly associated with declining physical health scores (Cushon et al., 2011). The findings of Cushon et al. 2011 are similar to this study because the decrease in physical health and well-being scores was not uniform across all neighborhoods, indicating a significant neighborhood influence in the patterning of these outcomes. The average change in physical health and well-being EDI scores over the three time points ranged from a low of 1% to 47% depending on which neighbourhood is examined (Cushon et al., 2011). The authors of this study also found a significant relationship between a derived neighborhood poverty index and declining EDI scores for physical health and well-being (Cushon et al., 2011). Overall, it is evident that neighbourhood differences in child physical health and wellbeing can be

explained by different measures of the SDOH including poverty indexes. It is also evident that these differences are not uniform: there are many contextual factors that need to be taken into consideration when using the concept of 'neighbourhood' as a unit of analysis.

Other literature examining the effects of the SDOH on health outcomes at the neighbourhood level have mixed results. Franzini et al., 2009 suggest that social environments are more influential on child physical health than physical environments (Franzini et al., 2009). After the authors controlled for SES factors, they found that a favorable social environment was positively associated with several measures of physical activity and that physical activity was negatively associated with obesity in these children (Franzini et al., 2009). However, physical environment was not significantly associated with physical activity, which suggests that neighborhood social factors as well as the physical environment should be considered in the development of health policy (Franzini et al., 2009). This is important because it highlights the challenges of conceptualizing what a 'neighbourhood' is and what factors within a conceived 'neighbourhood' are influencing health outcomes. This challenge is further emphasized when examining rural vs. urban neighbourhoods. Simen-Kapeu et al., 2010 examined physical activity in urban schools versus rural schools and found that those attending schools in towns and rural areas reported more physical activity despite perceiving less access to playgrounds/parks and recreational programs ($p<0.01$). These latter students further reported poorer diets and purchasing more energy-dense foods and snacks at their schools ($p<0.01$) (Simen-Kapeu et al., 2010). Other studies which examine this relationship have mixed findings, however the findings of Simen-Kapeu et al., 2010 do confirm the existence of geographic differences in health outcomes and possible underlying causes.

The CGS has been above the provincial average when it comes to the percentage of vulnerable children for physical health and wellbeing compared to the rest of the province (See figure 1.1). The analysis demonstrates there are select few neighbourhoods in which the percentage of children not meeting developmental expectations is exceptionally higher. The neighbourhoods that have highest percentages of children who are not on track for physical health are also high risk environments due to poorer social and economic circumstances related to the social determinants of health. These high risk environments include low protective factors from the social determinants of health such as lower average incomes, higher amounts of low income families, receiving more government assistance, and lower rates of education. This is consistent with the social determinants of health literature as the social determinants of health are specific mechanisms in different socioeconomic environments that cause people to experience varying degrees of health and illness (Raphael, 2006). This study supports the

evidence that the quality of social determinants of health a group of people experience can be accompanied by a wide range of health disparities that exist within that population. The associations between high percentages of children not on track for physical health and the social determinants of health within specific CGS neighbourhoods supports the widely observed associations between a wide range of health indicators and measures of individuals' socioeconomic resources or social position such as income or education (Braveman & Gottlier, 2014).

The results of this study demonstrate large neighbourhood-level differences in both child physical health as well as the social determinants of health. This implies that families and children within certain neighbourhoods are experiencing substantially more material, economic, and social disadvantage while simultaneously experiencing higher rates of poor child physical health. This indicates a very strong presence of a social gradient within the CGS. A social gradient indicates the nature of health inequities in a given population. The social gradient literature states that the lower a person's social and economic position, the more likely it is they are unhealthy (Marmot, M 2010). The presence of a social gradient provides evidence for a wide gap in health inequity because there is an unequal distribution and availability of resources such as income, education, and goods and services which contributes to disparities in health (Toivanen & Modin, 2011).

Another element within the health literature relevant to this study is the importance of health trajectories. The different environments children experience can have profound impacts on their immediate health as well as their future health. If a child in kindergarten is currently not on track for physical health than they are more likely to have a poorer health trajectory over time. Children growing up in impoverished environments with more health risks and fewer protective factors are more likely to have a poorer health trajectory than those children growing up in environments where risks are fewer and there are more protective factors (Halfon et al., 2014). This means a focus on health promotion during child development is crucial to improving the trajectory of child health and reducing the social and economic burdens of illness throughout the life course (Centre on the Developing Child at Harvard University, 2010).

6.2 Implications

The results of this study identify specific neighbourhoods where the residents are experiencing substantially more material and economic disadvantage than others, while simultaneously experiencing the highest rates of children who are not on track for physical health and wellbeing. This indicates that children living in neighbourhoods with the poorest social and economic circumstances are also at the

most risk for not meeting physical health developmental expectations. Better understanding of how to improve protective factors and decrease risk factors in these neighbourhoods will help level the social gradient and eliminate health inequities within the CGS. Also, this study identifies neighbourhoods experiencing unexpected relationships. This includes neighbourhoods that have lower rates of children who are not on track for physical health despite experiencing material, social, and economic disadvantage, and the opposite: neighbourhoods that have very high rates of children who are not on track for physical health despite experiencing relatively low social, economic and material deprivation. This indicates that there may be other mechanisms not examined in this study influencing positive child physical health in higher risk environments as well as influencing poor child physical health in lower risk environments.

Alleviating the health inequities experienced by these high risk neighbourhoods and decreasing the severity of the social gradient may result in healthier adults due to positively influencing the physical health trajectories of current children. This could lead to the growing promotion and protection of the overall health of Greater Sudbury citizens and prevent avoidable health problems for the children of future generations. On a larger scale, this research reflects the challenges of identifying the specific pathways through which social factors influence health outcomes, as well as the complexity of using census tracts as neighbourhoods for units of analysis. The results of this study, combined with the SEM of health promotion, helps illustrate the importance of encompassing biomedical and epidemiological factors with social, political, and economic factors when studying the social determinants of health.

The intentions of this study do align with the research carried out by the Sudbury & District Health Unit examining the local link between health outcomes and the social and economic environments in Greater Sudbury (Sudbury & District Health Unit, 2013). More broadly, this research aligns with the Sudbury & District Health Unit's health equity vision and its mandate to promote and protect health. This is accomplished by reducing avoidable health differences, narrowing the gap in health, and ensuring all citizens have the opportunity for good health and wellbeing through access to high quality public health programs and services (Sudbury & District Health Unit, 2013). The results of this study are pertinent to the current political and institutional environments within the CGS that are concerned with improving public health because it identifies specific areas where health inequities are the most prevalent and how it is impacting child physical health and wellbeing. There are many different community organizations that are key stakeholders in improving child physical health and wellbeing. The municipal government, educational institutions, the Social Planning Council of Sudbury, the Sudbury &

District Health Unit, Best Start Hubs and other daycare services are examples of key stakeholders that can directly benefit from the findings of this research.

6.3 Limitations of the study

There are multiple limitations of this study. One limitation involves using neighbourhoods as a unit of analysis. People are influenced by many factors when it comes to choosing to live where they live. Push and pull factors can influence the location and relocation of individuals and families. People have different priorities and preferences when it comes to selecting a neighbourhood to live in, whether its employment opportunity, economic climate, proximity and access to certain services, access to transportation, employment conditions, and more. Therefore, selection bias is a challenge when conducting neighbourhood-level research (Sampson, Morenoff, & Gannon-Rowley, 2002). This means there may be unforeseen variables that can account for neighborhood differences other than what is being measured in this study. However, regardless of the decisions leading to living in high risk environments with lower protective factors, people living in these environments do experience negative health outcomes, including child physical health as demonstrated in the literature and in this study.

An additional limitation related to the study of neighbourhoods is the ecological fallacy. Explaining the relationship between poor child physical health and deprivation within the social determinants of health requires the use of ecological data. When ecological data are used to make inferences about individuals, those inferences may be misleading and referred to as an ecological fallacy (Wakefield, 2004). The larger the geographical area from which the data is collected, the more potential there is for bias to arise when interpreting the data at the individual level (Wakefield, 2004). Therefore, drawing inferences about individuals within this study creates a bias due to the variation between individuals within a neighbourhood. Therefore, if a relationship is found at the neighbourhood level between variables, that relationship may not exist at the individual level within the neighbourhood. This implies that within the high risk neighbourhoods of the CGS, there are individuals that may not be experiencing the same amount of material and social deprivation as others.

Another limitation of this study is the nature of sample size and statistical analysis. Conducting linear and multiple regression with a small sample size can lead to misinterpreting regression coefficients. This is combated by including the adjusted regression coefficient which accounts for a small sample size. This is also combated by a thorough outlier analysis which satisfies a condition of regression analysis. The regression analyses for all of the cases included was compared to the regression analyses with the outliers removed, and the differences between the models are taken into consideration. It is

probable that a larger sample size (more neighbourhoods) may have improved the statistical significance and effect size.

The source of the data for the social determinants of health is also a limitation of this study. Statistics Canada eliminated the long-form census in 2006 and replaced it with the voluntary National Household Survey in 2011. This is a limitation because voluntary surveys have a higher non-response rate compared to the long form census. Therefore, the information in the NHS potentially may not be as accurate as the long form census in the past. This has been seen as a controversial attempt to make census data collecting less intrusive (The Globe and Mail, 2013). Experts believe that the voluntary nature of the NHS has resulted in less detailed, more unreliable data than what Statistics Canada has generated in the past (The Globe and Mail, 2013). This is because when there is a change in the methods of a survey, it can impact the comparability of data over time (Statistics Canada, 2011). This is addressed in the methodology chapter (see table 3.1) by examining the variables in this study and how they compare to results from the 2006 long-form census. Statisticians recommend using the 2006 long form census data as a benchmark to cross-check the NHS data (Statistics Canada, 2011), and doing so has demonstrated little discrepancy in measurements of interest for this study.

The process of neighbourhood aggregation, and therefore data aggregation, may be a limitation to this study. In order for a neighbourhood to be included in this study, it had to meet multiple requirements including sample size (number of neighbourhoods and number of kindergarteners) and no data suppression. In order to maximize the number of neighbourhoods that could be analyzed, some neighbourhoods were aggregated together to form larger neighbourhoods. The process of neighbourhood aggregation included the data for each census tract that was combined with another census tract (see table 3.3). The process of neighbourhood amalgamation included a discussion with the primary investigator and supervisors and careful scrutiny of the SDOH data. This resulted in deciding which neighbourhoods should be included, which ones should be excluded, and setting the criteria. Therefore, some individuality may have been lost for certain neighbourhoods because of the amalgamation of data. It is important to note that neighbourhoods were only aggregated if they shared a geographic boundary and very similar socioeconomic data for the independent variables.

6.4 Suggested Areas of Future Study

The challenges experienced throughout this thesis hopefully can provide new opportunities to explore and understand health inequities. Firstly, applying the methodology of this thesis to more populated areas with more neighbourhoods will lead to less data aggregation, more units of analysis,

and therefore create a stronger statistical analysis. Other data sources should be considered in order to ensure less suppressed data and therefore, a stronger statistical analysis. Future studies exploring health inequities at the neighbourhood level also need to consider a comprehensive 'neighbourhood' as a unit of analysis including what factors were used to determine the geographic boundaries of the given neighbourhoods. Also, the results of the outlier analysis revealed specific neighbourhoods within Greater Sudbury which should be analyzed further to examine contextual factors contributing to health inequities. Lastly, studies using a similar methodology to this thesis should consider other domains outside of the physical health and wellbeing domain of the EDI, as well as other health measures other than the Early Development Instrument in order to better understand how the SDOH are influencing health inequities at the neighbourhood level.

Chapter 7: Conclusion

The concluding chapter highlights key results that need to be considered, and possible policy implications of the results of this study. This includes policy interventions that may help alleviate the health inequities experienced within certain Greater Sudbury neighbourhoods.

7.1 Highlighting Key Results: Equity vs. Equality

The Sudbury & District Health Unit has developed a health equity vision for 2020 that plans to improve the overall health equity of citizens so that avoidable health disparities are reduced and all citizens have equal opportunities for good health (Sudbury & District Health Unit, 2013). This study shows that there may be avoidable health disparities for citizens residing in specific neighbourhoods. The citizens in these high risk neighbourhoods may be experiencing health disparities for the social determinants of health, and also for child physical health and wellbeing. This study demonstrates that children living in the areas with the most health disparities are at the most risk for not being physically ready to learn. In order to eliminate health inequities, the citizens experiencing the poorest health in the CGS need to have access to more health promoting resources than they currently have. The allocation of health promoting resources needs to focus on the greatest areas of need. This will result in citizens within specific neighbourhoods receiving more government assistance, more access to healthy and affordable food, cheaper education, and more overall health promoting resources than others. In order to improve health inequalities and the overall health of CGS citizens, there needs to be an allocation of health promoting resources to the people who need them the most. This may not achieve health equality, but it will likely lead to improving health equity within the CGS.

7.2 Knowledge Mobilization

The findings of this study can contribute to improving the health of citizens who are experiencing health inequities within the CGS, and therefore reduce the risk of children experiencing poor physical health including physical readiness to learn, physical independence, and gross/fine motor skills. Health equity research has become an important focus of public health research, and this provides an opportunity for the findings of this study to influence policy decisions and improve health inequities. Therefore, it is important that these findings of this study are shared with key stakeholders in order to provide more effective health services and strengthen the health of the CGS citizens. Key stakeholders may be individuals or organizations that will benefit from, and can help achieve, improving child physical health and reducing health inequities. Therefore, the results of this study will be disseminated to school boards, the Sudbury & District Health Unit, day care centres including Best Start Hubs, the Social

Planning Council of Sudbury, Child & Community Resources, and other key stakeholders within the community. These stakeholders have the ability to utilize the findings of this study and provide direction for where to allocate various health promoting resources. This can be done by the allocation of various community resources that can be tailored to meet the needs of each neighbourhood, therefore improving health inequities.

The timing of this research not only aligns with the health equity vision of the Sudbury & District Health Unit, but it also aligns with Ontario's Ministry of Health and Long-Term Care. The Ministry of Health and Long-Term Care (MOHLTC) has funded 45 communities across Ontario for three years (2015-2018) to participate in The Healthy Kids Community Challenge (HKCC). The aim of this program is to reduce poor child physical health by working with communities and local partners to develop and implement community based solutions (Ontario Agency for Health Protection and Promotion, 2015). The findings of this study can contribute to the HKCC by providing direction on implementation of health promoting resources and assist with identifying specific opportunities and challenges neighbourhoods are facing. An additional contribution is to help those involved in HKCC programs and initiatives to understand the complexity of the pathways influencing child physical health in the CGS.

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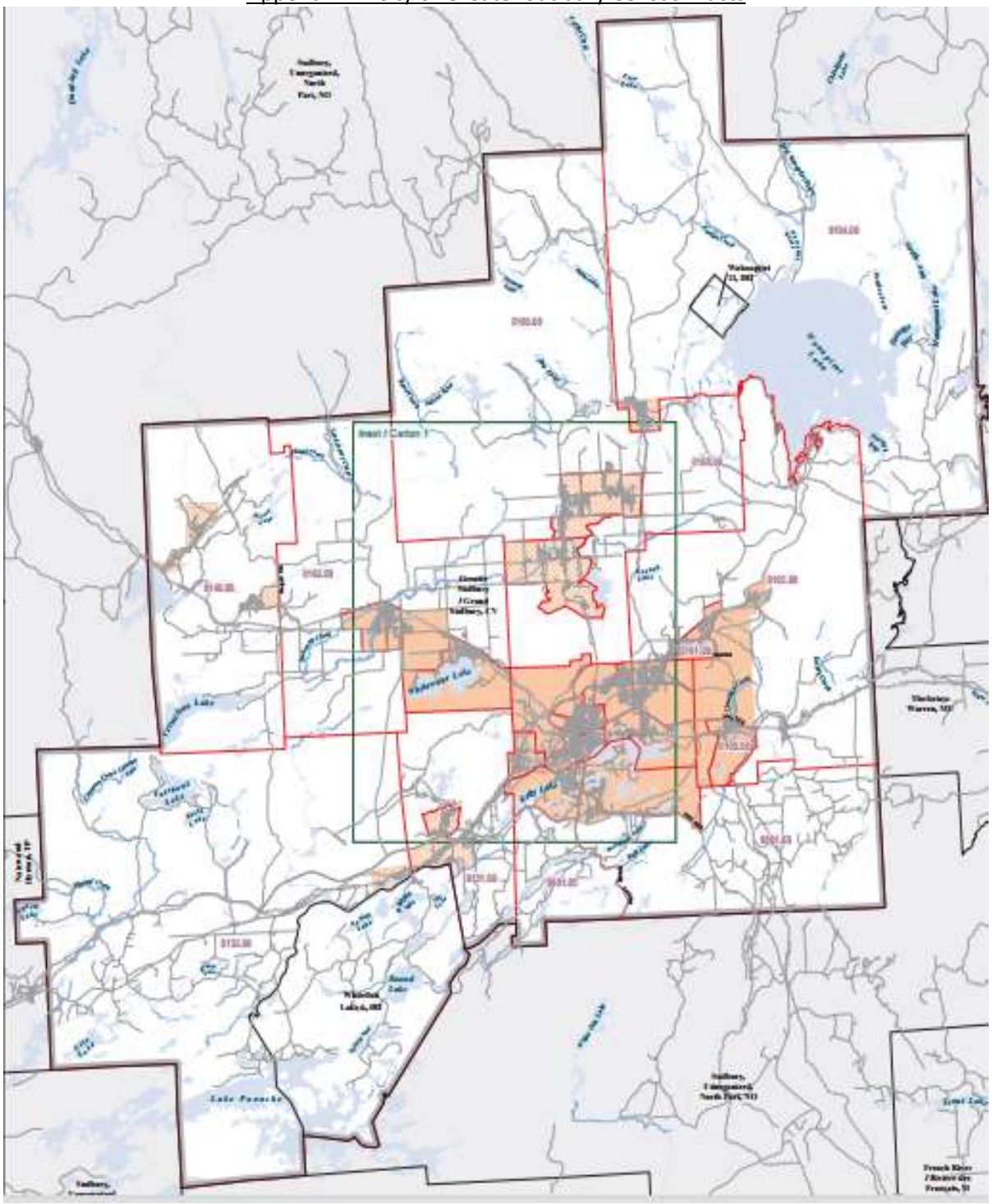
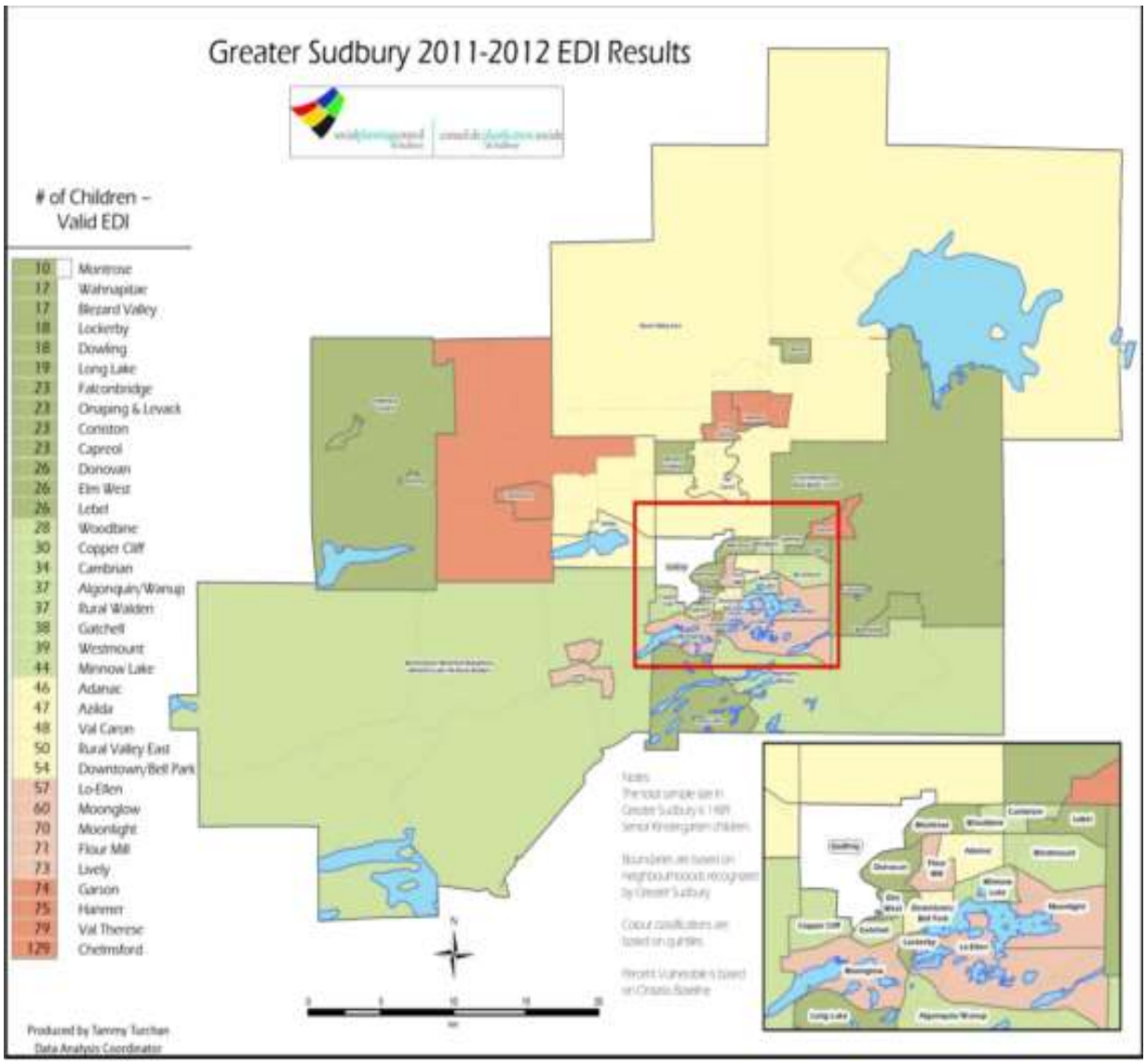
Appendix: Figures

Appendix A: City of Greater Sudbury Census Tracts



(Statistics Canada, 2012).

Appendix B: EDI Neighbourhoods based on Statistics Canada Census Tracts



(Turchan, 2013).

Appendix C: EDI Questionnaire for Physical Health and Wellbeing

Section A - Physical Well-being

1. About how many regular days (see Guide) has this child been absent since the beginning of school in the fall? Number of days absent: [ ][ ].[ ][ ]

Since the start of school in the fall, has this child sometimes (more than once) arrived:

	yes	no	don't know
2. over- or underdressed for school-related activities	O	O	O
3. too tired/sick to do school work	O	O	O
4. late	O	O	O
5. hungry	O	O	O

Would you say that this child:

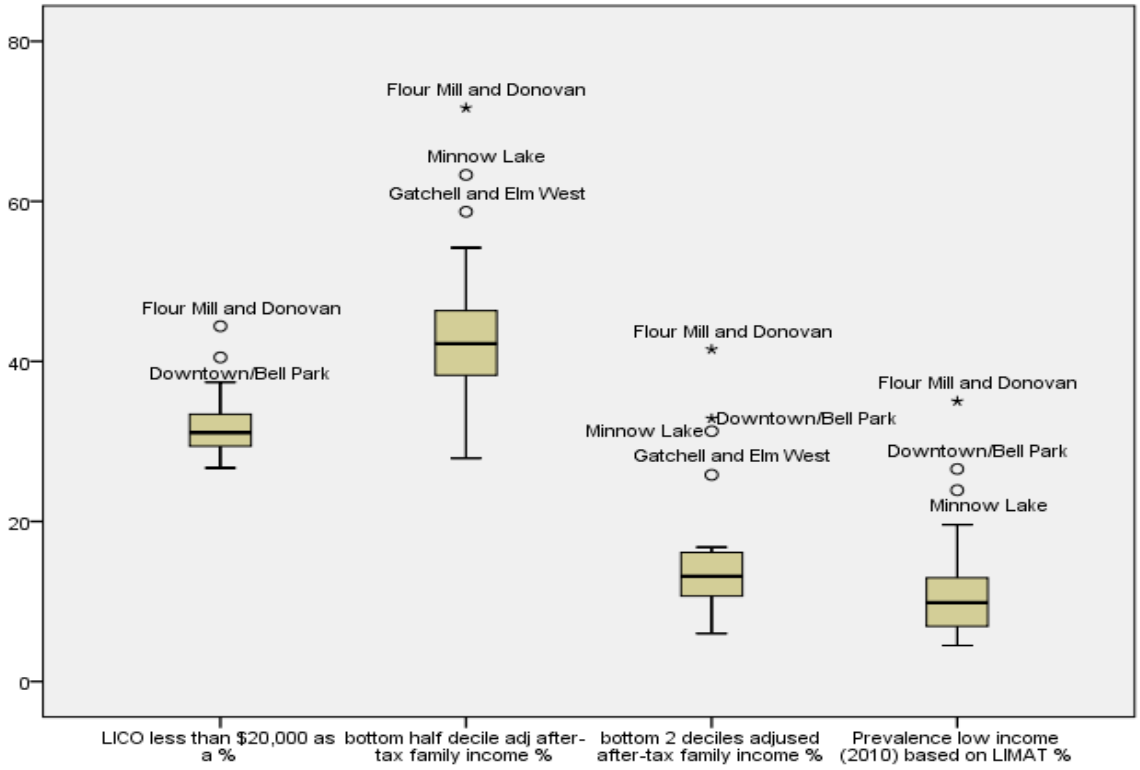
	yes	no	don't know
6. is independent in washroom habits most of the time	O	O	O
7. shows an established hand preference (right vs. left or vice versa)	O	O	O
8. is well coordinated (i.e., moves without running into or tripping over things)	O	O	O

How would you rate this child's:

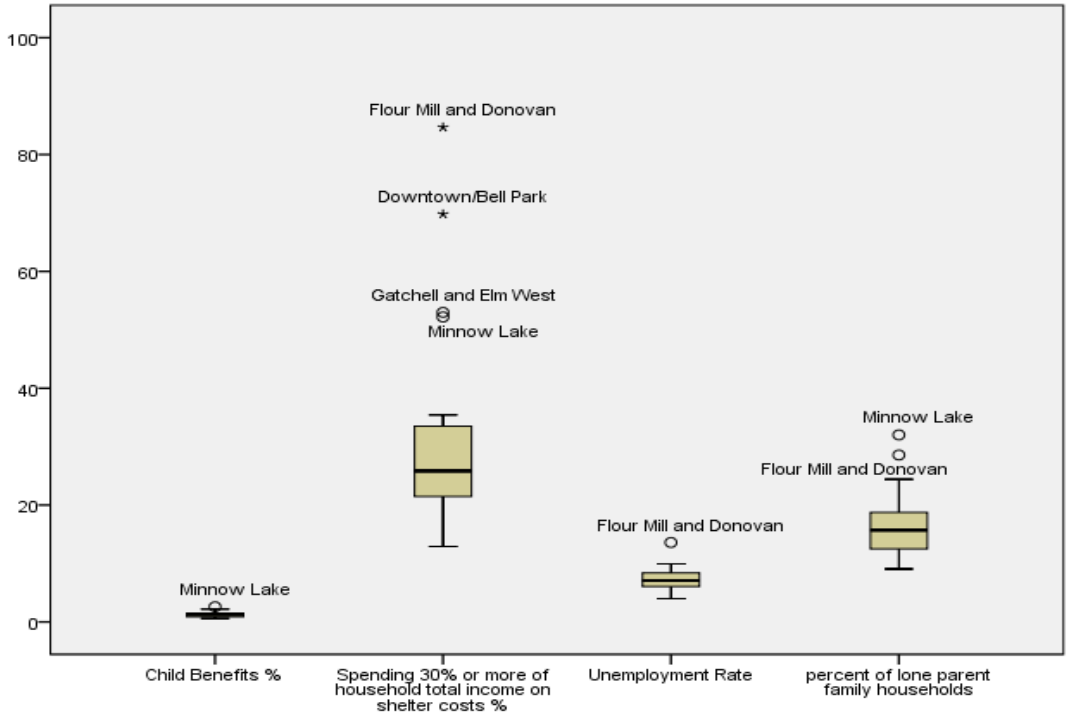
	very good/ good	average	poor/ very poor	don't know
9. proficiency at holding a pen, crayons, or a brush	O	O	O	O
10. ability to manipulate objects	O	O	O	O
11. ability to climb stairs	O	O	O	O
12. level of energy throughout the school day	O	O	O	O
13. overall physical development	O	O	O	O

(Janus et al., 2007).

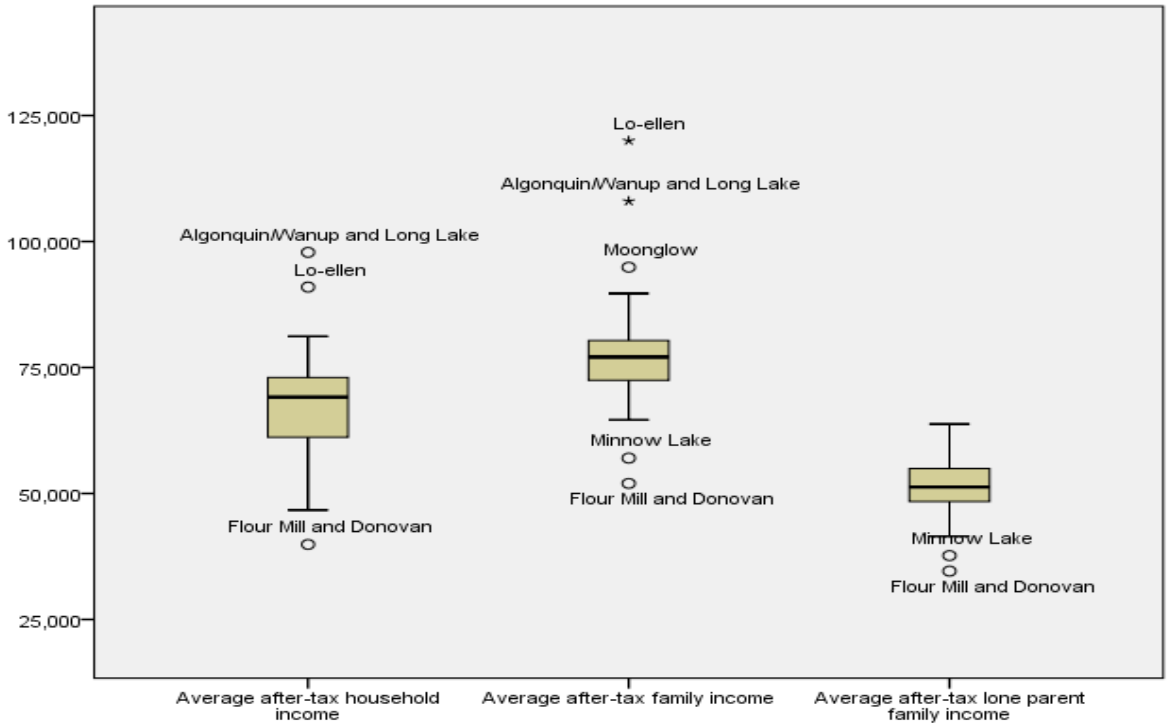
Appendix D: Outliers for Low Income Measures



Appendix E: Outliers for Measures of Poverty



Appendix F: Outliers for Measures of Neighbourhood Income



Appendix: Tables

Appendix G: Bivariate Results for Physical Readiness for the School Day

Independent Variables	R	P	R*	P*
Income less than %20,000	.428	.053	-.286	.236
Employment Insurance %	.399	.073	.105	.667
% Bottom half decile adjusted after-tax family income %	.626	.002**	.024	.921
% Bottom two deciles adjusted after-tax family income	.661	.001**	.020	.937
% Spending 30% or more of household income on shelter costs	.543	.011*	-.199	.413
Prevalence of low income (2010) based on LIMAT %	.660	.001**	.007	.978
Child benefits as a % of total income	.756	.000**	.420	.074
Government transfer payments as a % of total income	.562	.008**	-.139	.571
% of rented dwellings	.467	.033*	-.065	.793
% no certificate, diploma, or degree	.271	.236	.014	.955
% with a postsecondary education	-.356	.113	-.140	.567
Average after-tax household income	-.510	.018*	-.016	.947
Average after-tax family income	-.502	.020*	-.102	.678
Average after-tax lone-parent family income	-.679	.001**	-.246	.309
Unemployment rate %	.463	.034*	-.113	.644
Participation Rate %	-.184	.423	.314	.191
% of lone-parent family households	.662	.001**	.117	.632

Appendix H: Bivariate Results for Physical Independence

Independent Variables	R	P	R*	P*
Income less than %20,000	.209	.364	-.215	.378
Employment Insurance %	.463	.035*	.112	.647
% Bottom half decile adjusted after-tax family income %	.520	.016*	.061	.804
% Bottom two deciles adjusted after-tax family income	.523	.015*	.057	.815
% Spending 30% or more of household income on shelter costs	.382	.087	-.084	.733
Prevalence of low income (2010) based on LIMAT %	.480	.028*	-.003	.989
Child benefits as a % of total income	.752	.000**	.362	.128
Government transfer payments as a % of total income	.454	.039*	-.067	.784
% of rented dwellings	.347	.124	-.078	.749
% no certificate, diploma, or degree	.009	.970	-.040	.871
% with a postsecondary education	-.172	.456	-.100	.685
Average after-tax household income	-.425	.055	-.028	.908
Average after-tax family income	-.437	.048*	-.106	.667
Average after-tax lone-parent family income	-.622	.003**	-.296	.219
Unemployment rate %	.094	.687	-.292	.225
Participation Rate %	-.018	.937	.191	.434
% of lone-parent family households	.598	.004**	.015	.950

Appendix I: Bivariate Results for Gross and Fine Motor Skills

Independent Variables	Pearson Correlation	Significance (p>.05)
Income less than %20,000	.176	.445
Employment Insurance %	.056	.811
% Bottom half decile adjusted after-tax family income %	.281	.217
% Bottom two deciles adjusted after-tax family income	.155	.502
% Spending 30% or more of household income on shelter costs	.176	.446
Prevalence of low income (2010) based on LIMAT %	.189	.412
Child benefits as a % of total income	.219	.430
Government transfer payments as a % of total income	.228	.320
% of rented dwellings	.054	.816
% no certificate, diploma, or degree	.159	.491
% with a postsecondary education	-.142	.540
Average after-tax household income	-.221	.336
Average after-tax family income	-.234	.307
Average after-tax lone-parent family income	-.110	.635
Unemployment rate %	.217	.334
Participation Rate %	-.325	.150
% of lone-parent family households	.193	.403

Appendix J: Linear Regression Results for the Bottom 25th Percentile

Independent Variable	Y/X	R	R^2	R^2 adjusted	SE	P<.05
Bottom half decile family income	Y1, X1	.501	.251	.211	6.61	.021*
Bottom 2 decile family income	Y1, X2	.491	.241	.201	6.65	.024*
Spending 30% on shelter costs	Y1, X3	.439	.193	.150	6.86	.046*
Low income measure after taxes	Y1, X4	.517	.267	.228	6.54	.016*
Child benefits % of total income	**Y1, X5**	**.582**	**.339**	**.304**	**6.21**	**.006****
Government transfer payments	Y1, X6	.466	.217	.176	6.76	.033*
After-tax lone parent family income	Y1, X7	.433	.187	.144	6.88	.050
Average after-tax family income	Y1, X8	.421	.177	.134	6.93	.058
Average after-tax household income	Y1, X9	.423	.179	.136	6.92	.056
% lone parent family households	Y1, X10	.540	.292	.254	6.43	.012*

Appendix K: Two Variable Regression Results for % Not on Track

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
X1 Bottom half decile family income X5 Child benefits % of total income	.594	.353	.281	6.31	.020*	2.078
X1 Bottom half decile family income X10 % lone parent family households	.501	.251	.211	6.61	.021*	1.000
X2 Bottom 2 decile family income X5 Child benefits % of total income	.612	.374	.304	6.21	.015*	1.507
X2 Bottom 2 decile family income X10 % lone parent family households	.491	.241	.201	6.65	.024*	1.000
X3 Spending 30% on shelter costs X5 Child benefits % of total income	.613	.376	.307	6.20	.014*	1.268
X3 Spending 30% on shelter costs X10% lone parent family households	.540	.292	.213	6.60	.045*	2.899
X4 Low income measure after taxes X5 Child benefits % of total income	**.628**	**.395**	**.327**	**6.10**	**.011***	**1.427**
X5 Child benefits % of total income X6 Government transfer payments	.588	.346	.273	6.34	.022*	1.929
X5 Child benefits % of total income X10 % lone parent family households	.609	.371	.301	6.22	.015*	2.026
X6 Government transfer payments X10 % lone parent family households	.542	.294	.216	6.59	.043*	2.851
X7 After-tax lone parent family income X10 % lone parent family households	.551	.304	.227	6.54	.038*	1.705

Appendix L: Three Variable Regression for % Not on Track

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
X1 Bottom half decile income X5 Child benefits X7 lone parent family income	.610	.373	.262	6.39	.043	2.80/3.01/3.83
X1 Bottom half decile income X5 Child benefits X10 % lone parent households	.609	.371	.260	6.40	.044	4.5/2.21/4.39
X2 Bottom 2 decile income X5 Child benefits X6 Gov. transfer payments	.610	.377	.267	6.37	.041	2.82/1.93/3.61
X3 Shelter costs X5 Child benefits X6 Gov. transfer payments	.622	.387	.278	6.32	.036	3.22/2.06/4.90
X4 Low income measure X5 Child benefits X6 Gov. transfer payments	**.635**	**.403**	**.298**	**6.24**	**.029**	**2.48/1.93/3.36**
X5 Child benefits X6 Gov. transfer payments X10 % lone parent households	.610	.372	.262	6.40	.044	2.21/3.11/3.27

Appendix M: Linear Regression Results for Physical Readiness for the School Day

Independent Variable	Y/X	R	R^2	R^2 adjusted	SE	P<.05
Bottom half decile family income	Y2, X1	.626	.392	.360	6.61	.002**
Bottom 2 decile family income	Y2, X2	.661	.437	.407	6.65	.001**
Spending 30% on shelter costs	Y2, X3	.543	.295	.258	6.86	.011*
Low income measure after taxes	Y2, X4	.660	.436	.406	6.54	.001**
Child benefits % of total income	**Y2, X5**	**.756**	**.572**	**.549**	**6.21**	**.000****
Government transfer payments	Y2, X6	.562	.316	.280	6.76	.008**
% of rented dwellings	Y2, X7	.467	.218	.177	3.59	.033*
Average after-tax household income	Y2, X8	.510	.260	.221	3.49	.018*
After-tax lone parent family income	Y2, X9	.679	.461	.433	2.98	.001**
% lone parent family households	Y2, X10	.662	.438	.408	3.04	.001**

Appendix N: Two Variable Regression Results for Physical Readiness for the School Day

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
X1 Bottom half decile family income X5 Child benefits % of total income	.765	.586	.540	2.68	.000	2.078
X2 Bottom 2 decile family income X5 Child benefits % of total income	.765	.586	.540	2.68	.000	2.078
X3 Spending 30% on shelter costs X5 Child benefits % of total income	.788	.620	.578	2.57	.000	1.268
X4 Low income measure after taxes X5 Child benefits % of total income	**.811**	**.658**	**.620**	**2.44**	**.000**	**1.427**
X5 Child benefits % of total income X6 Government transfer payments	.758	.574	.527	2.72	.000	1.929
X5 Child benefits % of total income X7 % of rented dwellings	.791	.626	.584	2.55	.000	1.120
X5 Child benefits % of total income X8 Average after-tax household income	.756	.572	.524	2.73	.000	1.782
X5 Child benefits % of total income X9 After-tax lone parent family income	.765	.586	.540	2.69	.000	2.860
X5 Child benefits % of total income X10 % lone parent family households	.776	.603	.559	2.63	.000	2.026
X9 After-tax lone parent family income X10 % lone parent family households	.740	.548	.497	2.81	.001	1.705

Appendix O: Three Variable Regression Results for Physical Readiness (Y^2)

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
X2 Bottom 2 decile family income X5 Child benefits % of total income X9 Lone parent family income	.804	.647	.585	2.55	.000	2.0/2.8/3.9
X3 Spending 30% on shelter costs X5 Child benefits % of total income X8 Average household income	.823	.677	.620	2.44	.000	2.9/1.8/4.2
X4 LIMAT X5 Child benefits % of total income X6 Government transfer payments	.832	.693	.639	2.38	.000	2.4/1.9/3.3
X4 LIMAT **X5 Child benefits % of total income** **X8 Average household income**	**.840**	**.705**	**.653**	**2.33**	**.000**	**2.3/1.8/2.8**
X4 LIMAT X5 Child benefits % of total income X9 Lone parent family income	.813	.660	.600	2.50	.000	1.9/2.8/3.9
X5 Child benefits % of total income X6 Government transfer payments X7 % of rented dwellings	.815	.663	.604	2.49	.000	2.2/4.5/2.6

Appendix P: Linear Regression Results for Physical Independence

Independent Variable	Y/X	R	R^2	R^2 adjusted	SE	P<.05
Employment insurance % of total income	Y3, X1	.463	.214	.173	6.11	.035*
Bottom half decile family income	Y3, X2	.520	.270	.232	5.89	.016*
Bottom 2 decile family income	Y3, X3	.523	.274	.235	5.88	.015*
Low income measure after tax	Y3, X4	.480	.230	.190	6.05	.028*
Child benefits % of total income	**Y3, X5**	**.752**	**.565**	**.542**	**4.55**	**.000***
Government transfer payments	Y3, X6	.454	.206	.165	6.14	.039*
Average after-tax family income	Y3, X7	.437	.191	.148	6.20	.048*
After-tax lone-parent family income	Y3, X8	.622	.387	.355	5.40	.003*
% lone parent family households	Y3, X9	.598	.358	.324	5.52	.004*

Appendix Q: Two Variable Regression Results for Physical Independence

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
X1 Employment insurance % of income X5 Child benefits % of total income	.759	.577	.529	4.61	.000	2.052
X2 Bottom half decile family income X5 Child benefits % of total income	.752	.566	.518	4.67	.001	2.078
X3 Bottom 2 decile family income X5 Child benefits % of total income	.759	.576	.529	4.61	.000	1.507
X4 Low income measure after tax X5 Child benefits % of total income	.756	.572	.524	4.64	.000	1.427
X5 Child benefits % of total income X6 Government transfer payments	.757	.574	.526	4.62	.000	1.929
X5 Child benefits % of total income X7 Average after-tax family income	**.773**	**.597**	**.553**	**4.49**	**.000**	**2.223**
X5 Child benefits % of total income X8 After-tax lone-parent income	.752	.566	.517	4.67	.001	2.860
X5 Child benefits % of total income X9 % lone parent family households	.757	.573	.526	4.63	.000	2.026

Appendix R: Three Variable Regression Results for Physical Independence

Independent Variables	R	R^2	R^2 adjusted	SE	P<.05	VIF
X1 Employment insurance X2 Bottom half decile family income X5 Child benefits % of total income	.760	.577	.502	4.74	.002	2.0/2.1/2.9
X1 Employment insurance X3 Bottom 2 decile family income X5 Child benefits % of total income	.764	.584	.511	4.70	.002	2.1/1.5/2.8
X1 Employment insurance X4 Low income measure after tax X5 Child benefits % of total income	.762	.580	.506	4.72	.002	2.1/1.4/2.8
X1 Employment insurance X5 Child benefits % of total income X8 After-tax lone-parent income	.763	.582	.508	4.71	.002	2.3/3.1/3.3
X5 Child benefits % of total income X6 Government transfer payments X9 % lone parent family households	.780	.609	.540	4.56	.001	2.2/3.1/3.2
X5 Child benefits % of total income X7 Average after-tax family income X8 After-tax lone-parent income	.785	.616	.548	4.52	.001	3.1/2.9/3.7
X5 Child benefits % of total income X7 Average after-tax family income X9 % lone parent family households	**.785**	**.617**	**.549**	**4.51**	**.001**	**2.8/2.3/2.1**

Appendix: Ethics Approval

LaurentianUniversity
UniversitéLaurentienne

APPROVAL FOR CONDUCTING RESEARCH INVOLVING HUMAN SUBJECTS

Research Ethics Board – Laurentian University

This letter confirms that the research project identified below has successfully passed the ethics review by the Laurentian University Research Ethics Board (REB). Your ethics approval date, other milestone dates, and any special conditions for your project are indicated below.

TYPE OF APPROVAL / New X / Modifications to project / Time extension

Name of Principal Investigator and school/department	Kent Cox, Interdisciplinary MA Rural and Northern Health, supervisors, Nicole Yantzi, William Crumplin, School of the Environment
Title of Project	The influence of Social Determinants of Health on Child Physical Health and Wellbeing in Greater Sudbury Neighbourhoods
REB file number	2016-01-15
Date of original approval of project	March 02, 2016
Date of approval of project modifications or extension *(if applicable)*	
Final/Interim report due on: *(You may request an extension)*	March, 2017
Conditions placed on project	

During the course of your research, no deviations from, or changes to, the protocol, recruitment or consent forms may be initiated without prior written approval from the REB. If you wish to modify your research project, please refer to the Research Ethics website to complete the appropriate REB form.

All projects must submit a report to REB at least once per year. If involvement with human participants continues for longer than one year (e.g. you have not completed the objectives of the study and have not yet terminated contact with the participants, except for feedback of final results to participants), you must request an extension using the appropriate LU REB form. In all cases, please ensure that your research complies with Tri-Council Policy Statement (TCPS). Also please quote your REB file number on all future correspondence with the REB office.

Congratulations and best wishes in conducting your research.

Regina Langer

Rosanna Langer, PHD, Chair, *Laurentian University Research Ethics Board*

Curriculum Vitae

Name:	Kent Cox
Date of Birth	January 27th, 1989
Place of Birth	Elliot Lake, ON
Post-Secondary Education and Degrees	Laurentian University Sudbury, Ontario, Canada 2008-2012 B. A. (Honours) Nipissing University North Bay, Ontario, Canada 2012-2013 B. Ed. Laurentian University Sudbury, Ontario, Canada 2014-2016 M.A.
Experience	Graduate Teaching Assistant, Laurentian University, 2014-2016 Geography and History Teacher, United Kingdom, 2013-2104 Teaching Assistant, Laurentian University, 2012

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