University of Alberta

The Association Between Neighbourhood Stressors and Asthma Prevalence of School Children in Winnipeg

by

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Abstract

It is generally surmised that neighbourhood stressors have an incubating effect for a variety of diagnoses on maternal and child health. What is of interest is to determine if the frequency of asthma prevalence is greater amongst children resident of chronic stress neighbourhoods, after adjusting for family history of asthma and socioeconomic status (SES). The City of Winnipeg, Canada is used as a study location with the urban component of children (1472 entire; 698 birth home) extracted from the Study of Asthma, Genes and the Environment (SAGE) Survey administered in 2002-2003 to a birth cohort from 1995 in Manitoba. Dichotomous parent report of child asthma from the SAGE Survey nested within birth cohort are geocoded by postal code, which allows designation of neighbourhood. Hierarchical linear modelling (HLM) allows the individual effect of environmental exposures such as home smokers and pets to be isolated from the proportion of variance explained by stressor exposure grouped at the neighbourhood level in dependent outcome. Principal component and factor analysis are explored to reduce the dimensionality of collinear SES variables, and analysis of sensitivity and specificity was performed to validate parent report of child asthma to pediatric-allergist diagnosis for a subgroup of children. Flunctuation of childhood asthma between neighbourhoods is shown by geographical information systems (GIS), with the effect of neighbourhood in multilevel models observed to explain small to intermediate proportions of variance in parent report of child asthma. Children living in census tracts assigned low SES scores by compositional stressors obtained from the 1996 Canada Census were found to have a decreased odds of parent report of asthma, while those inhabiting profiles with high contextual crime rates from the 2001 Winnipeg Police Service Crime Data were at increased risk. Respondents who experienced relocation to low SES neighbourhoods were shown to have a higher odds of asthma than children resident of same neighbourhoods in birth home.

Keywords: Childhood Asthma, SAGE Survey, Hierarchical Linear Modelling, Spatial Statistics

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To my parents and family, this thesis is dedicated for their unconditional love and support behind all the endeavers I have attempted, retried and succeeded at over the past six years.

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Chapter 1

Introduction

1.A Significance of the Issue

Hospitalization rates for asthma disproportionately burden economically disadvantaged youth residing in urban communities (Lee et al., 2006, 126). This comes at a time when there is recognition that even the most expensive and complex of medical procedures are unable to dissipate levels of childhood chronic disease (Szreter & Woolcock, 2004, 650). It is increasingly evident that in addition to poverty, the chronic stress of living in a neighbourhood affects the health of children. Neighbourhood stressors influence not only the health of the individual, but reduce the capacity of the population in a community to withstand decay (Matheson et al., 2006, 2605). Environmental safety and resources are crucial in the linkage of maternal health, which can foster a setting of anxiety and depression (Cutrona et al., 2006, 3). Children of mothers with depressive symptoms have been shown to have more behavioral problems and poorer health, which in turn may further exacerbate the condition of caregiver (Mulvaney & Kendrick, 2005, 202). Little information exists about the effects of neighbourhood stress and socioeconomic status on the risk of asthma in Canadian children.

1.B Purpose of the Study and Delimitations

The primary research objective is to determine if children of mothers in high stress neighbourhoods have a greater risk of developing asthma, compared to children in healthy neighbourhoods. A nested case-control survey within a birth cohort from 1995 denoting indicators pertinent to childhood asthma on the individual-level is linked retrospectively to factors representing stress on the neighbourhood level, known as stressors. Measures of stress at the neighbourhood level include perceptions of crime, disorder and interaction aggregated at the census tract level. A temporal period from birth (1995) to date prior of survey administration (2002-2003) is assured for linkage of stressors to the SAGE cohort, as this time frame is likely to have an incubating effect for early childhood exposure from neighbourhood in birth homes. It is of interest to investigate if target areas of study are evident from the clustering of census tracts in neighbourhood profiles, and if SES deprivation is able to explain a large proportion of variance in parent report of child asthma status for respondents after adjusting for family history of asthma, and personal exposures such as mold, smoking and pets in household.

A conceptual framework of the role neighbourhood stressors are hypothesized to exert in predicting parent report of child asthma in addition to measures obtained at the individual-level from the SAGE Survey is presented in Figure 1.1, and is similar in template to that proposed by Morello-Frosch & Shenassa (2006, 1151). With regards to SES stressors, it is evident that exposure occurs in the built environment, but the exact pathway that deterioration of neighbourhood facilitates in susceptibility to disease remains unclear. Some stressors and individual-level exposures may provide protective benefits, while others may exacerbate asthma expression amongst children of different neighbourhoods along the socioeconomic gradient.

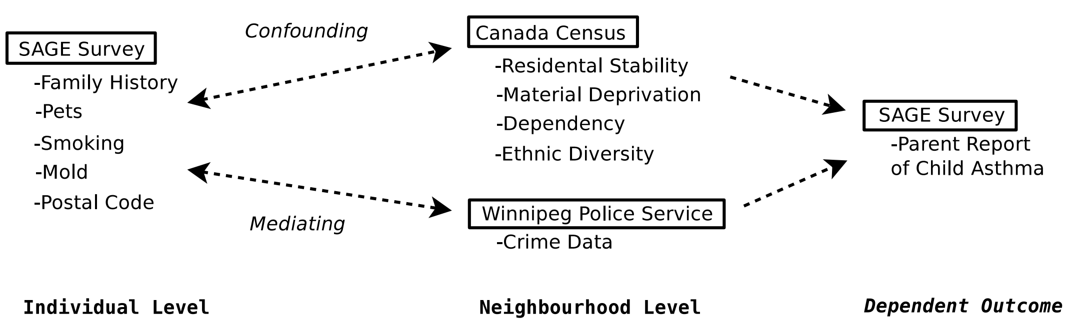


Figure 1.1: Conceptual Framework of Neighbourhood Stressors with SAGE Survey

1.C Theoretical Perspective

Stressors are grouped under the three domains of crime and violence, residential stability and physical disorder. This will verify the consistency, plausibility and coherence of the hygiene hypothesis if it is observed that children resident of low income neighbourhoods have decreased odds for parent report of child asthma compared to children in higher income neighbourhoods (Shankardass et al., 2007, 1801). If an increased odds of asthma is observed amongst children resident of a low SES although high crime neighbourhood, a plausible relationship may exist between the connection of maternal health to childhood asthma induced by the incivilities of criminal proximity with the protective elements of infectious challenges exposure at an early age.

Hierarchical linear modelling is a tool that allows covariates such as maternal smoking and parental atopy at the individual-level to be nested within neighbourhood stress scores for a regressed predicted value of child asthma status. Individual-level models typically underestimate or ignore the effect modification of neighbourhood on interactions for response outcome (Sellstrom & Bremberg, 2006, 546). Finley et al. (2007, 2) acknowledged that it is "well recognized in the statistics literature that spatial associations are captured most effectively using hierarchical models that build dependencies in different stages". Lurking variables, which are confounded and undoubtedly exist in SES datasets, become less relevant in hierarchical models with fewer stringent assumptions as aggregation units are more stratified (Finley et al., 2007). Previous studies have been published examining the effect of neighbourhood income score to childhood asthma in Canada and the US, and it is of interest to compare these results with regards to the SAGE Survey in Winnipeg (Burra et al., 2009; Shankardass et al., 2007).

Recent improvements in hardware platforms and computation algorithms such as Bayesian Markov chains Monte Carlo (MCMC) methods has led to more powerful statistical tests for hierarchical linear models (Yan et al., 2007; Finley et al., 2007). Minimal assumptions about the prior distribution of data obtained in survey techniques employing random sampling, or cohort studies with high lost to follow-up need not ensue normality. These methods lead to more accurate statistical outcomes at the ecological level, and will be compared to traditional statistical models that are dependent upon logit-linkage techniques of binomially distributed data for explanatory continuous variables and discrete factor levels with dichotomous outcome.

1.D Research Question and Hypothesis

The aim of the present study is to explore the association between neighbourhood stressors and parent report of child asthma, and the contribution of these stressors to socioeconomic inequalities in asthma prevalence. If parent report of child asthma is related to stress from the environment after adjusting for family history of asthma to proxy the genetic component, then children resident of neighbourhoods with higher exposure to chronic stressors will have a greater frequency of asthma.

Some cohort studies have shown low individual SES to be a significant predictor for asthma in children (Kozyrskyj et al., 2010; Bacon et al., 2009). However, this disagrees with studies using ecologic data, showing high community SES being associated with asthma prevalence (Shankardass et al., 2007; Farfel et al., 2010). Other studies have shown an inclusive relationship from individual-level data, such as increasing maternal education generally being associated with city location and lower odds for child asthma, but with children in urban areas having significantly higher odds of asthma than those in rural areas (Hijazi et al., 2000).

Chapter 2

Review of the Literature

2.A Maternal Health and Childhood Asthma

The contribution of external pressures and stress has been described as a 'double jeopardy' situation for maternal health, in that negative exposures facilitating poor health of mother often translate to an environment of less optimal outcome for child (Morello-Frosch & Shenassa, 2006, 1150). Parent report of the development of child asthma at age 7-8 from the SAGE Survey in Manitoba was found to have a high correspondence to antibiotic use and maternal distress (Kozyrskyj et al., 2009, 1191). Maternal distress is likely to be clustered in predominantly low income neighbourhoods, which can be defined by measures of incivility that include social interactions, housing conditions and litter in public spaces (Laraia et al., 2006, 5). Self-report Centre for Epidemiologic Studies Depression Scale (CES-D) scores through mail-out surveys is a common method of screening for depression without access to healthcare databases, and with regards to a geographic cohort this measure of psychological distress was most compelling for minority and Black women in large urban neighbourhoods, and inversely related with education and earnings (Henderson et al., 2005, 326). A physical incivility scale in a southern US city was also determined to be moderately correlated with poverty, Black race and low education amongst pregnant mothers, while being simulatneously correlated with non-Hispanic White race and professional vocation in the negative direction (Laraia et al., 2006, 7). From the first and second cycles of the National Longitudinal Survey of Children and Youth in Canada, it was found that maternal depression contributed significantly and increased the odds of poor development attainment in children by 64% over a two year follow-up period (To et al., 2004, 647). A study involving over 500 adult patients in Montréal, Canada found that those with an anxiety disorder or depressive disorder were associated with worse asthma-related quality of life and control (Lavoie et al., 2006, 1039).

Kozyrskyj et al. (2008, 142) found that children of mothers with high levels of distress had an elevated risk of developing asthma in the initial years of life. Agreement on the causal role of stressors to asthma is elabourated by risk factors at the individual and family-level, including gender, household size, breastfeeding and exposure to allergens (Subbarao et al., 2009, 1). Children of women caregivers who reported stress from lifestyle or occupation were found to be at higher risk of developing asthma (Klinnert et al., 2001). The health and lifestyle of the mother serves as a indicator to how the infant will develop, with the prenatal diet being a factor that may influence asthma outcome in child, for example. It is thought that a biological pathway exists in which increased stress levels of the mother elicit an immune response, which are amplified and passed to the child through the prenatal or early developmental period (Kozyrskyj et al., 2008, 142). It is known that children of female lone parents have a strong, negative relationship with well-being and health compared to youth of two parent households (Curtis et al., 2004, 1922). Children of mothers who sought professional help for anxiety or depression during their infants's first year of life as defined by the International Classification of Diseases - 9th revision (ICD-9) codes in a health insurance database had a 38% higher odds of asthma at age 7-8 than their non-exposed peers (Kozyrskyj et al., 2008, 143).

Target areas of study, such as the clustering of census tracts in low income neighbourhoods or the pathways of exposure for disease are evident through recent initiatives of spatial mapping techniques. The idea is that health issues concerning mothers and children cannot be solved through individual focus alone, since neighbourhood plays an attributable role in response to treatment. From a cross-sectional study sampled nationwide in Canada, it was found that unmarried females of childbearing age residing in neighbourhoods of high material deprivation and residential instability had an elevated odds for depression (Matheson et al., 2006, 2611). Children interact and receive the bulk of their inputs upon what constitutes societial norms at an early age from the community that surrounds them, with the perception of how their mothers are accomodated being very influential (Duncan & Raudenbush, 1999, 29). Maternal and child health in what may be described as high risk areas can be improved through access to "comprehensive, community-based services" (Aronson et al., 2007, 374). Public health strategies to improve infant health as denoted by low birth weight should focus on high stress neighbourhoods with low levels of residential stability and safety (Auger et al., 2008, 467). In the north-central downtown area of Winnipeg, projects have been instituted with government and community support to prevent crime and develop programs which foster education and build employment capacity (Kohm, 2009, 7). Intergenerational ties between families acts to yield a social good that unconditionally benefits the needs of all children in a community, with exchange found to be greatest in neighbourhoods with high levels of affluence and residential stability (Sampson et al., 1999, 656).

A sustained increase of asthma incidence rates among school children have been observed globally since measurements began in the 1970s, with the hypothesized link of being tied to air pollution remaining unproven (Guo et al., 1999, 1001). Half of the children with asthma diagnosed at age 6 may be in remission by age 12, while those experiencing hospitalization for asthma within first year of diagnosis being more likely to have persistence of symptoms later in life (To et al., 2007, 1197). Annotative research from a comphrensive literature review of longitudinal and cohort studies has shown that obese women and adolescent girls have a higher risk of developing asthma (Subbarao et al., 2009, 6). However, it remains unclear whether children of low income backgrounds have a greater or reduced chance of developing asthma when followed longitudinally over time (Kozyrskyj et al., 2010, 1). What is known is that healthy pre- and postnatal environments are essential for care bearers, with an emphasis on preventative interventions such as discouraging smoking both during and after pregnancy, for example, going a long ways in determining personal health and influencing social interactions (Sellstrom & Bremberg, 2006, 545).

2.B Role of Social Stress in Inducing Asthma

A biological explanation may be plausible for the role that social distress in peoples' lives may have in altering and identifying the mechanisms which create stress in the human body. It has been hypothesized that the response of chronic flunctuations in the level of corticosteriods induced by social stressors may lead to allostatic load, or a change that makes it easier for stimuli to elicit restriction of airways (Haczku & Jr., 2010, 551). These pathways exist as responses which under a short duration in the immune system serve to rid the body of infection, however, high concentrations of glucocorticoids are responsible for immunosuppression in tissues that may be stress-induced (Curry et al., 2010, 394). Short durations of stress can be healthy in which elevated levels of corticosteriods occur from the 'flight-or-fight response' that influences coping to uncertain challenges (Haczku & Jr., 2010, 551). Prolonged or chronic play of this mechanism may make it more susceptible for stimuli factors to trigger an asthmatic attack.

The study of social disruption (SDR) in animal models is the closest that comes to mimicking psychological stress the human scenario under experimental trials, in which the presence of an aggressive intruder elicits an authorative confrontation that may be representative of a class conflict with the establishment of a hierarchy (Haczku & Jr., 2010, 551). A SDR model was shown to induce pulmonary inflammation without the existence of an inflammatory challenge from examining the lung tissue of mice after the morning of social interaction cycle (Curry et al., 2010). It is hypothesized that the reason glucocorticoid resistance develops in subordinate animals from social disruption is partly to allow the healing of wounds that occurred physical conflict to heal when the body has high levels of corticosteriods (Avitsur et al., 2001, 247). Animals models have also shown that programming of hypothalamic-pituitary-adrenal (HPA) axis in the neuroendocrine system from stressful events targetting young male mice yielded hyperesponsiveness in the production of eosinophils that caused airway inflammation (Chida et al., 2007, 316). Conherently, this agrees to the descriptive epidemiology of asthma exacerbations in Canadian children whose observation in healthcare utilization seems to worsen in proximity to neighbourhood stressors characteristic of income disparity or maternal depression (To et al., 2007; Kozyrskyj et al., 2008).

2.C Methods to Ascertain Childhood Asthma

Asthma is a multifactorial lung disease in that cause is not from one source, therefore diagnosis is not usually made on one symptom (Lavoie et al., 2006, 1039). There is some evidence to suggest that children treated with broad spectrum antibiotics at a younger age from the SAGE cohort in Manitoba have a higher risk of developing asthma, and that children of lower income households are more likely to be prescribed antibiotics in physician visits (Kozyrskyj et al., 2007, 2004). It has been recognized that there is a better need for diagnostic tools that are simpler and more exact (Friedman, 2010, 309). The consistency of replicable, unbiased testing procedures offers the benefit of improving assessment and control for all forms of pulmonary disease (EIGEN et al., 2001, 622).

2.C.1 Skin Prick Tests

Skin prick testing is measure of determining atopy, and is usually performed using a lancetter held at 90° to the surface of skin pressing an allergen for a minimum duration of one second on the subject's arm or back, then waiting a period of 15 minutes to measure the diameter of any wheals (Chan-Yeung et al., 2010, 1405). Determining whether or not if a child is atopic, or sensitive to allergens, is a preliminary check before administering a lung function test. Allergens applied in testing are environmental and location specific, with common types being tree and grass pollen, mold, mites, feline dander, cockroach and ragweed (Chan-Yeung et al., 2010, 1405). Atopy is commonly defined as a positive skin prick test to one or more of these allergens, with a diameter of mean wheals being greater than 3 mm (Carlsten et al., 2010). Children with a positive skin prick test had a four times higher odds for physician confirmation of asthma than those without (Hijazi et al., 2000, 777). From the SAGE Survey, residents of rural northern areas were less likely to have a family history of atopy compared to other locations in Manitoba, while children aggregated province-wide with a family history of atopy had over a three and a half times higher odds for parent report of asthma (Kozyrskyj & Becker, 2004, S306).

2.C.2 Lung Function Studies

Assessing if whether a young child has asthma through lung function studies is often difficult, because many children wheeze in the first years of life (Mark, 2009, 578). However, spirometry procedures and methods have been devised for measuring this in young children. A standard routine would involve attaching a rubber mouthpiece to standing subjects wearing nose clips and measuring peak expiratory flow rate (PEFR), forced vital capacity (FVC), and forced expiratory volume in 1 second (FEV_1) has been developed (EIGEN et al., 2001, 620). Air flow obstruction of lung function in spirometry testing using these measurements is commonly defined as the ratio of FEV_1 to FVC (D'Urzo, 2010, 127). It was determined that the mean predicted FEV_1/FVC value for healthy, non-asthmatic children ages 3 to 6 years old without a history of respiratory ailment was 0.97 (95% CI: 0.87-1.11) at 90 cm height, and 0.89 (95% CI: 0.78-1.01) at 125 cm height, with no differences between gender or race (EIGEN et al., 2001, 621).

There is disagreement about the use of spirometry techniques amongs physicians in Canada, since access to equiptment is not standard in general practice, and diagnosis of asthma has generally been made through the referral of patients to specialists with methacholine tests (Hargreave & Nair, 2009, 1656). Some physicians are in favour of this test being performed for suspected asthmatics, because they believe it can rule out immediately other pulmonary ailments such as upper respiratory tract infection before pursuing treatments and other tests for a chronic illness such as asthma (Kaplan & Stanbrook, 2010, 126). Patients who undergo spirometry testing may also be more likely to be encouraged in improving their lung capacity through health conscious choices such as stopping smoking. Others, however, are not because they fear that patients may request access to spirometry testing equiptment in practices that currently do not offer it, and it may lead to an onus in the medical system, and there is disagreement that some patients with asthma may have good lung function with respect to air flow obstruction measurements (D'Urzo, 2010, 127). One Canadian study showed that methacholine challenge testing was used to confirm over four times as many asthma cases than spirometry methods, and that approximately one third of obese and non-obese adult over age 16 in the study had a misdiagnosis of asthma (Aaron et al., 2008, 1128).

Methacholine challenge testing is also a method in determining if a child is asthmatic, and is usually administered to children after they have undergone atopy testing from a skin prick test. A measure on airway bronchial hyperreactivity is obtained by drop of transcutaneous oxygen pressure ($TcTO_2$), with a positive test being given if a 20% fall in $TcTO_2$ is observed is less than 1 mg/ml of methacholine administered nasally through a handheld nebulizer (Castro-Rodriguez et al., 2010, 930). A Canadian study composed of children age 7 deemed to be at high risk of asthma found that having a cut-off value of 2 mg/ml for methacholine in bronchial hyperractivity testing ensured both a high sensitivity and specificity in diagnosing asthma (Carlsten et al., 2010). The benefits of methacholine challenge testing is that it is similar to exercise induced wheezing in mimicking asthmatic attacks, but this procedure might not be useful in diagnosing asthma for nonatopic boys (Castro-Rodriguez et al., 2010, 933). Another downside is that this type of testing is temporarily stressful to the subject.

2.D Treatment of Childhood Asthma

The most common treatment of childhood asthma is through anti-inflammatory medications such as inhaled corticosteriods, quick relief bronchodilators, and preventing or mitigating environmental triggers (Jr. & Busse, 2010, 449). The benefit of inhaled corticosteriods is that they act as controllers in reducing mucus producing cells in airways and can lead to fewer asthma exacerbations, but have the disadvantage that their potency may not be enough for severe forms of asthma, and the effects are not permanent when treatment is stopped, and higher doses may lead to the development of cataracts and adrenal suppression (Mark, 2009, 579). This contrasts to reliever drugs such as $beta_2$-agonist bronchodilators, which when inhaled for acute symptoms of asthma are fast acting within minutes and provide relief for the duration of a few hours, but have the side effect that asthma control may be unresponsive in patients not using an inhaled corticosteroid treatment (Jr. & Busse, 2010, 451).

Recently there has been focus on alternative treatments involving a modification of lifestyle patterns such as nutrition and exercise that reduce asthma exacerbations (Mark, 2009, 581). This is especially valid, considering that the increase in child asthma rates is likely due to population susceptibility rather than an increase in environmental toxicity, with diet being an important determinant (Hijazi et al., 2000, 775). The benefits of improving overall diet health is that the effects are not just limited in preventing asthma exacerbations, but also preventing other health problems. There has been a significant link between fast food consumption and wheezing in children (Hijazi et al., 2000; Mai et al., 2009). Mai et al. (2009, 556) found that children with asthma from a case-control study of the SAGE cohort in Manitoba were one a half times more likely to consume fast food than those without asthma. It was also determined that asthmatic children from a nested case-control study in Norway had a higher soft drinks with sugar intake than non-asthmatic children (Bueso et al., 2010, 3). Another case-control study involving stratified children in Saudia Arabia determined that asthmatic cases had a significantly lower intake of milk and vegetables than non-asthmatic controls (Hijazi et al., 2000, 776).

2.E Compositional Measures of Neighbourhood Stress

Compositional stressors are those which relate to the nature of the population living in a defined area, and involve mainly measures on housing and psychological distress (Kearns & Smith, 1993, 274). The understanding is imperative that physical and social environments of higher socioeconomic status are beneficial for childhood development (Duncan & Raudenbush, 1999, 30). Neighbourhood stress, also known as chronic strain is generally characterized by a lack of affluence, and is believed to have a greater "influential role in mediating the relation between socioeconomic status (SES) and physical health than acute stress" (Steptoe & Feldman, 2001, 177). Grzywacz & Fuqua (2000, 109) have suggested that stress in the social and ecological perspectives is a consistent theme in linking SES to health. It is conjectured that low income communities serve as dropping points for members of society in 'downward drift', and that residential mobility is indicative as a measure of stress. Low SES neighbourhoods are often amenity poor, and individuals residing are likely financially disenfranchised and unable to care for the upkeep of their community. It is probable that relocation by residents of constrained financial capital is limited to other low SES neighbourhoods between displacements. Thus, stressors of physical environment are said to be chronic and unavoidable, having a negative impact on psychological well-being (Matheson et al., 2006). Measures from census data can be viewed as compositional, since they are descriptive of the aggregated individuals who reside within the defined ecologic unit.

As proposed by O'Campo et al. (2009, 57), social capital "has been hypothesized to play a complex role in the production of mental well-being by acting as a mediator between neighbourhood disorder and health". Neighbourhood problems may be descriptive for a lack of social control, and it is argued that social integration and regulation is a "[characteristic] of the social environment rather than the individual" (Matheson et al., 2006, 2605). The continuity of neighbourhood structure is essential to the development and sustenance of social capital (Sampson et al., 1999, 636). Social disorder, which occurs in the deficiency of structure can be linked to physical disorder. A landscape encompassing poorly maintained buildings and streets with high rates of litter, vandalism, noise from traffic and other homes may be the analogues of psycho-physiological distress, and has a direct correspondence to health outcomes (Steptoe & Feldman, 2001). More orderly public places are thought to "promote personal interaction, thereby increasing opportunities for social control and activity within one's neighbourhood" (Laraia et al., 2006, 8). Structured activities were found to be beneficial as a preventative measure in lowering depression and substance abuse rates among inner city youth comprising a longitudinal cohort followed over six years (Fauth et al., 2007, 760). Participation in group activities that promote a civic responsibility has many protective elements, and helps foster a positive self image. However, participation in unstructured or uncivil activities by youth may also instigate risky choices (Fauth et al., 2007, 761).

Neighbourhoods are commonly defined as census tracts, with a population typically between 4,000 to 6,000 people (Cutrona et al., 2006; Sampson et al., 2002). Census tracts often serve as reasonable approximations of community unit, since boundaries are truncated as major street ways, railways, rivers and other delimiting factors at the pedestrian level. There is evidence that the built environment affects the health and social capital of residents and determines peer networks, with mixed-use and pedestrian oriented design being more humanizing (Leyden, 2003, 1550). Walkable scale is important, due to historical consequences of older, inner city neighbourhoods, and the generality that youth and low income individuals are unlikely to drive vehicles. Census tracts were compared to 'natural' neighbourhoods for a study encompassing the urban core and fringe in Montréal, Canada spanning a variety of linguistic and ethnic differences, and were found to be in close approximation (Ross et al., 2004). Natural neighbourhoods are usually defined by symbolic boundaries, instances being: ethnic composition, architecture or housing type, lifestyle and socioeconomic status (Ross et al., 2004). Assuming community by geographic proximity is incorrect, as residences could be spatially clustered due to land use policy, but socially inept as a coherent unit (Galster, 2001). Mutual agreement upon behaviourally meaningful, unambiguous boundaries is difficult to achieve since neighbourhood composition changes over time. A neighbourhood may not be homogeneous, but a fundamental sense of place exists. Sometimes congruent boundaries are difficult to demarcate, but exist in opposition to other neighbourhoods. This makes comparisons between units possible through the common sociological convention of 'relative deprivation' (Brooks-Gunn et al., 1993, 355).

Separating out the effect of neighbourhood is of interest after adjusting for the stress at the individual level, for responses within ecologic units are nested and display family-like effects that should be taken into considersation (Sellstrom & Bremberg, 2006, 545). This highlights the applicability of multilevel modelling, and is the cornerstone of recent epidemiological research (Oliver et al., 2007, 848). Neighbourhoods with high levels of social capital act as cohesive in influencing health benefits of social control, with the construct of social captial being a collective experience (Theall et al., 2009, 323). For example, it was determined in a cross-sectional study that mothers of higher education levels residing in low education neighbourhoods had higher risk of low birth weight and preterm birth infants than mothers of moderate or low education in neighbourhoods of higher education attainment (Nkansah-Amankra et al., 2009, 6). The random error in hierarchical linear models, which measures within-profile deviance can be used to explain the total amount of variance in dependent outcome attributable to the impact of neighbourhood grouping (Sampson et al., 1999; Raudenbush & Bryk, 2002).

Geographical information systems (GIS) offers the ability to model exposures over a joint terrestrial region. Difference of disease occurrence in groups is usually apparent amongst examination of differences in the SES gradient (Thompson et al., 2008, 11). It is common for aggregate census tract measures to subsitute for individual-level SES, with a large variation of scores within assigned quintiles being beneficial for spatial calculation techniques to proximity of exposures (Burra et al., 2009, 573). Aronson et al. (2007, 373) have described mapping initiatives as being able to "study community change and to describe community assets and structural, epidemiological, and social features of neighbourhoods that may influence program implementation and outcomes". Multiple stressors may have similar geographic patterns, but those that differ in terms of intensity associated with a particular pathway that becomes spatially evident as a confounding factor.

2.E.1 Theory of Unequal Access and Exchange

The foundation in which neighbourhood effects is investigated is based upon the notion that "individuals and families who live in a neighbourhood collectively create a social context that influences the developing child" (Oliver et al., 2007, 848). This is termed collective socialization, and has its foundation in the belief that individuals are active participants of their community (Duncan & Raudenbush, 1999, 30). Additionally, social capital plays a role in establishing a control-hierarchy structure in neighbourhoods to enforce disciplinary norms suitable for child development (Sampson et al., 1999). Broadening horizons of socioeconomic inequality are of increasing concern with regards to social capital flight, as a visible income gap fuels perception that citizens' rights and inclusion have been eroded (Szreter & Woolcock, 2004, 652). Local communities are of increased importance in the era of globalization, as spatialized racism and inequality exhibited through urban poverty becomes more pronounced in the postindustrial decay of Canadian and American manufacturing (Sampson et al., 1999). However, close proximity to wealthy neighbourhoods was found to have a positive effect on raising the social standards of disenfranchised youth, with affluent neighbors "commonly believed to influence behavior, attitudes, values, and opportunities" (Brooks-Gunn et al., 1993, 353). A critical mass or density of capital is needed to be "effective in shaping the behaviours of others" (Galster, 2001, 2119). This is based upon the theory of conformity and compliance, and in instances where the dominant class lacks quantity of members, density can be exerted by means of monetary resource. Access to higher-paid employment may be offered to those of lower social class through networks with affluent neighbours, as they have greater tendency to offer venture capital than what is likely amid middle-income households (Brooks-Gunn et al., 1993, 358).

Traditional focus on inequality addresses joblessness in the inner-city, based on the decline of local industry and other jobs associated with low-literacy skills (Brooks-Gunn et al., 1993, 355). Less wealthy populations have been shown to be located in closer proximity to industrial areas and other sources of environmental air pollutants, which has an association in them disapportinately carrying the burden in hospitalizations for childhood asthma (Burra et al., 2009, 573). However, it is argued that the concentration of poorer racial miniority populations is 'externally induced' through an in-migration of households by outside forces (Galster, 2001, 2118). Suburban sprawl is arguably the principal driver of this inequality and spatialization, with the movement of wealthier households to newer neighbourhoods leaving a void in previous place of residence that may lack renewed social systems. The dimension of neighbourhood score is changed over time by the development of new communities on the peripheral edge of cities, which function as mechanisms for transferring wealth out of existing neighbourhoods (Galster, 2001, 2115). The reversal is true in situations of gentrification, where redevelopment of an existing neighbourhood takes place with steady or new flows of capital. It is suggested that government intervention by way of "financial incentives, regulations and investments of infrastructure and public services" is the only method of preventing neighbourhood decay (Galster, 2001, 2122).

A measure of residential stability can be deduced through the proportion of rental units in built housing stock. Tenant levels influence attachment, as renters are less likely to invest money and time in their community. A valid concern is the discretion between 'owner-occupied' and 'absentee' landlords in assessing neighbourhood stress levels. A highly positive correlation between the proportion of renter households and those identifying as low income was found in Canadian neighbourhoods (Jackson et al., 2004, 43). Capitalism has the tendency to increase the capacity of rental residencies in a given neighbourhood over time through absentee landlords (Galster, 2001, 2116). Rental costs for housing have the characteristic that they are relatively inelastic, and they have the tendency of disenfranchising future generations of their social liberties and civic participation (Jackson et al., 2004, 27). Chronic inequalities in access to resources across neighbourhoods by racial segregation is theorized as a major driver of stress, with the underlying impetus being lack of affordable housing (Krieger, 2008; Nkansah-Amankra et al., 2009).

Material deprivation may act as an incubator of neighbourhood stress, as households and individuals evaluate their situation in regards to wealth of their neighbors through relative deprivation (Duncan & Raudenbush, 1999, 30). Deteriorated populations are less likely to respond to strain, as there is greater hinderance to them possessing the coping mechanisms to deal with life changes which affects one negatively. This is worthy of investigation, since traditional methods of appraising health for inner city populations using measures such as levels of physical activity or the frequency of eating vegetables and fruits were determined to be statistically insignificant for quantifying socioeconomic deprivation at the both the individual and neighbourhood level (Steptoe & Feldman, 2001). HLM offers an opportunity to understand the comprehensiveness of quantitative studies at multiple levels, with regards to individual and neighbourhood effect at the interaction of community peers (O'Campo et al., 2009, 57). This is contributory to a widening scope of literature signifying that "place also matters" (Matheson et al., 2006, 2614).

2.F Contextual Measures of Neighbourhood Stress

Contextual stressors are those which occur in a referenced area, but may not define a population trait of residents in the neighbourhood. Rather, they rely more on association, and may be subjective to preferences of the respondent in reporting (Stafford et al., 2005, 1682). Neighbourhood influences based on peers and role models are especially important for youth, and may be sensitive to social disorganization (Duncan & Raudenbush, 1999, 30). An example of this is perception of safety in neighbourhood between members of different genders and occupation income. A survey administered through random digit dialing in Winnipeg found that the perceived number of neighbourhood opportunity structures in regards to health and recreation amongst residents differed substantially from the objective count (Frohlich et al., 2007, 296). Leisure activities and accessibility to sports, health, and knowledge capital facilities are also contextual measures (Staempfli, 2007, 401). Conflating race with aggregate scores that model socioeconomic status, or treating their combined effect as additive may also be thought of as contextual (Schwabe & Kodras, 2000, 235). Social status is hypothesized to mediate the intensity of exposure to chronic stress for individuals, with gender influencing accessibility (Matheson et al., 2006, 2606).

Indicators such as crime or violence statistics aggregated over a neighbourhood can be viewed as contextual, since many of the infringements are committed by perpetrators not resident of neighbourhoods that the aggregated score is assigned. A multilevel analysis on community violence and urban childhood asthma in Chicago amongst African-American youth found that children resident of high crime neighbourhoods had a 56% higher odds of asthma than those resident of low crime neighbourhoods, adjusting for individual-level covariates (Sternthal et al., 2010). Poor children in urban environments are often spatially clustered together, and more likely to be exposed to more dangerous neighbourhoods in physical decay with less social services, with high levels of violence and crime as chronic psychosocial stressors in particular being negatively correlated with social capital (Williams et al., 2009, S175-S176). Williams et al. (2007, 170) also found that neighbourhood crime rates could provide additional prediction in adherence to prescribed inhaled corticosteroids for asthma treatment amongst disadvantaged populations in Detroit, with African-Americans having significantly lower adherence to medication use compared to Whites in urban environments after stratifying for race.

Walkable, mixed-use development not only ensures access to nurtitional food and medical service, but may also encourage the development of social networks by one simply recognizing their neighbors (Theall et al., 2009, 323). Increased pedestrian traffic flows on sidewalks is symptomatic of increased neighbourhood safety, as citizens are encouraged to move freely without fear of crime and victimization or worry about entering negative social networks (Theall et al., 2009, 331). This in turn may act a protective element in stopping additional neighbourhood physical disorder from occuring through reciprocal exchange, which was determined to be significantly more likely in communities with high proportions of homeowners and longterm residents (Sampson et al., 1999, 644).

2.F.1 Winnipeg Crime

Winnipeg is a municipality cited for crime, and the victimization associated with its inner city neighbourhoods (Kohm, 2009, 2). High rates of criminal offense is seen as anti-social activity, and is descriptive of negative types of social captial expressed through gang activity. (Szreter & Woolcock, 2004, 654). It has been suggested that in order to prevent crime, the impression of fear, disorder and stress in the community needs to be measured (Kohm, 2009, 2). Measures of disorder in the community, such as graffiti or fires in trash bins are more amenable to quantify than victimization, since they are visible. The fear of criminal victimization due to physical disorder in neighbourhood, rather than the actual crime itself, is a basis for influencing respondent perception of safety in neighbourhood. Clean up of untidiness is often the goal of improvement, but does not address the roots of disorder, which are more the target of community groups (Cutrona et al., 2006, 3).

Using the results of the 2004 General Social Survey (GSS) on Victimization, Kohm (2009, 11) found that only a third of downtown residents in a north-central neighbourhood of Winnipeg felt satisfied with their overall personal safety, compared to more than 90% of Winnipeg residents as a whole. Specifically, the Spence neighbourhood specifically in the north-central downtown had the highest rate of crime within the city, as well as the greatest perception of crime among residents and non-residents of the community, with refugees, newer immigrants and Aboriginal peoples calling this neighbourhood home with increasing proportions in recent years (Kohm, 2009, 7). A cross-sectional survey administered in Winnipeg during 2002-2003 utilizing multilevel modelling techniques found that resident perception of crime in neighbourhood was one of the only individual-level predictors that was closely correlated with the objective reality, with the effect of neighbourhood level explaining approximately 22% of the variance in outcome (Frohlich et al., 2007, 294).

Chapter 3

Methods

3.A Type of Research Design

The research design proposed is that of a quantitative study, of a secondary data source. Special consideration will be made for the dependent variable of interest: parent report of child asthma at age 7-8 from the SAGE Survey. Predictor variables such as pets in household, and percentage low income at the neighbourhood level will be screened if they affect model significance from the stepwise selection procedure, with a full list given in Appendix 2.A. Non-spurious associations between explanatory variables and the response are desired, which enforces the specificity and strength of the relationship observed. If odds or risk ratios are less than 1.5 with data from an observational study, a risk of bias influencing affiliation is possible, and a spurious relationship may be observed (Aschengrau & Seage, 2008, 263). Confounding or lurking variables may be unequally distributed across response groups, having a directional effect on the hypothesized value of the true association. Consideration must be given to the proportion of variance explained in associations, and not just effect size, which is overlooked in many epidemiological studies (Duncan & Raudenbush, 1999, 29).

3.B Population, Sample, and Participants

3.B.1 SAGE Survey in Manitoba

The Study of Asthma, Genes and the Environment (SAGE) Survey was conducted by the Department of Community Health Sciences at the University of Manitoba in 2002-2003. It is a longitudinal study of a complete birth cohort for the year 1995 in the province of Manitoba, focusing on environmental exposures and parent report of child asthma (Kozyrskyj et al., 2009). Out of 12,556 questionnaires mailed out through Manitoba Health to parents of children in 2002-2003, 3,598 were returned representing a response rate of 28.6% (Kozyrskyj et al., 2009, 1186). Full details of indicators assembled is shown in Appendix 2.A on page 146, with the mail-out questionnaire attached in Appendix 2.B.

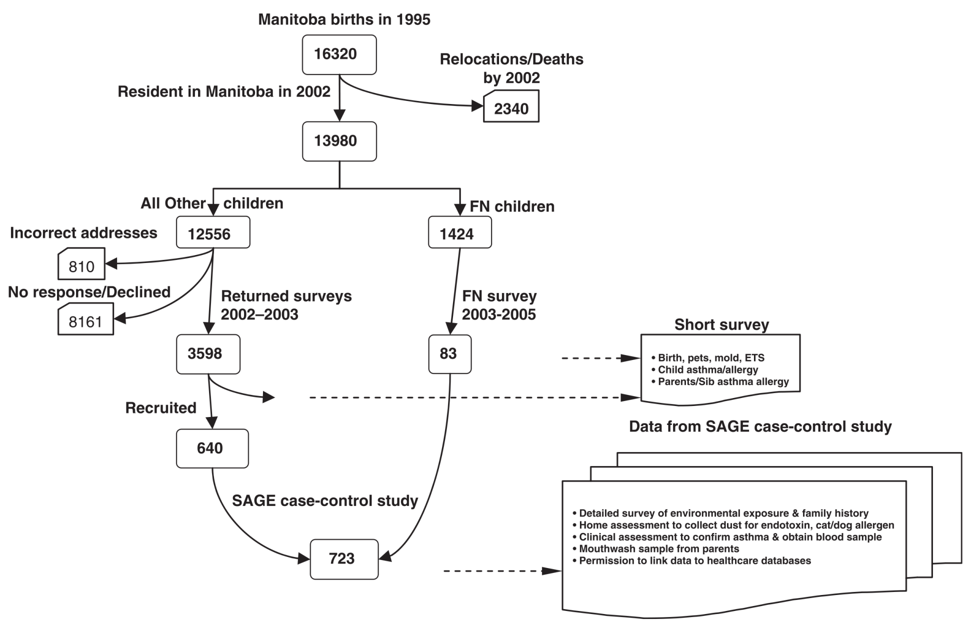


Figure 3.1: Design for SAGE Cohort and Case-Control Study (Kozyrskyj et al., 2009)

The survey itself is an example of a nested case-control study, chosen because of efficiency and economics (Kozyrskyj et al., 2009). Survivor sampling was employed, in that controls were selected at end of follow-up (survey return) as subjects with no parent report of child asthma. Cases were defined as children with report of asthma. Nested case-control studies are efficient for rare diseases with prevalence of less than 20% in cohort (child asthma $\sim$ 12%), but may be difficult to gather information on multiple exposures since data is collected retrospectively (Aschengrau & Seage, 2008, 255). Temporal relationships are problematic to infer between exposure occurrence and disease outcome of asthma, but a period from birth (1995) to prior date of survey administration (2002-2003) is assured for linkage of stressors. An indicator on birth home is available from respondents in the Winnipeg CMA, but for the majority of children where the measure was completed, 59.6% ($\frac{1795-725}{1795}$) inhabited a different home at age 7-8 than location resident at birth. Particular focus is on respondents of the SAGE Survey resident within the City of Winnipeg municipal boundaries at time of data collection. Population membership is assumed part of a fixed cohort from year of 1995 in the province of Manitoba, with a measure on childhood asthma prevalence possible, but not incidence. Thus, it is theoretically applicable to retrospectively assemble information on stressor exposure at neighbourhood level from a variety of datasets.

From the SAGE Survey, the percentage of cases of parent-declared child asthma was approximately 12% ($\frac{448}{3596}$) for the province of Manitoba among 3596 participants. Ecologically, this compares to an asthma prevalence rate of 27.7% amongst children born in 1994 at age 6 in the neighboring province of Ontario from physician diagnosis and hospital admission (To et al., 2007, 1199). Among respondents of birth homes in the City of Winnipeg, the percentage of cases of parent-declared child asthma was also 12% ($\frac{84}{698}$). This is in agreement to findings of a survey rate of 10% in southern rural areas and 14% in urban areas for Manitoba (Mai et al., 2007; Kozyrskyj & Becker, 2004). It has been suggested that population-based cross-sectional surveys do not reflect the true outcome of asthma, since they are dependent upon parent report of symptoms and not physician diagnosis (Subbarao et al., 2009, 2). The alternative is to follow asthma respondents over a period of many years, since risk factors originally thought of as beneficial may later be demonstrated as harmful (Subbarao et al., 2009, 3). Minimal data clean-up on the SAGE Survey was necessary to exclude respondents that could not be geocoded through use of the Postal Code Conversion File (PCCF) (Wilkins, 2009). Two records were removed, one that listed an Australia postal code, and another which provided no postal code.

Neighbourhood indicators for the province of Manitoba are available at census subdivision (CSD) and census tract (CT) level through federal, provincial and municipal agencies.

In total, there were 277 census subdivisions for Manitoba in the 1996 Canada Census, and 157 census tracts that encompassed the Winnipeg CMA (Statistics Canada, 2009b,a). Census tracts were superimposed upon Winnipeg CMA census subdivision identifier (CSDUID) codes 4611040, 4613056, 4613032, 4612047, 4613037, 4611042, 4602075, 4602069, 4614015 and 4610035 to bring a more finite scale unit for analysis. This corresponds to the boundaries of the Winnipeg CMA, where roughly 50% ($\frac{1795}{3596}$) of SAGE Survey respondents resided. It was felt that the CSDUID was more suitable than parent account of municipality, since some who reported 'WINNIPEG' as their place of residence resided outside the Winnipeg CMA by postal code ($\frac{4}{3596}$). Conversely, 279 out of 3596 respondents residing within the Winnipeg CMA and did not report 'WINNIPEG' as their place of residence. They are perhaps visitors from other parts of Manitoba to whom the survey was mailed, or inhabitants of commuter communities.

3.C Data Collection, Variables, and Materials

3.C.1 Statistics Canada Census, 1996, 2001 and 2006

Demographic and class characteristics of neighbourhoods at the census tract level are easiest to measure, since data is readily available and collected on a regular frequency by federal, provincial and municipal governments for taxation and service purposes. Other demarcations of defining neighbourhood are proposed, but are more difficult to quantify or gather (Galster, 2001, 2112).

Residential location of asthma respondents from the SAGE Survey were found to have higher correlations with SES indicators from the 1996 Canada Census compared to the 2001 or 2006 censuses (Statistics Canada, 2009a). Statistics Canada modified the geography starting with the 2001 Census to include new census tracts that focus on daytime areas of work in industrial locations, in addition to keeping the primary (nighttime) residential locations of respondents from previous censuses (Statistics Canada, 2010). This may have an influence on the decreased significance observed with SES indicators from the 2001 and 2006 censuses for the SAGE Survey.

To ease computation for multilevel logistical modelling techniques, and to be able to compare to other SES indicators gathered on an ordinal scale, a relative ranking score from one to five (quintile) was assigned to each neighbourhood unit denoting a stressor value from 1996 Census in reference to other census tracts encompassing the census metropolitan area (CMA). This convention will also be used to impute scores from the General Social Survey (GSS) and Uniform Crime Reporting Incident-Based Survey (UCR2). Indicators were collected over multiple censuses (1996, 2001 and 2006) to determine temporal change of neighbourhood. Census tract demarcation boundaries for the City of Winnipeg were found not to change much over this period, but additional zones were created in outlying rural and suburban regions. A visual presentation of census tracts comprising the City of Winnipeg is shown in Figure 3.3 on page 28.

Brooks-Gunn et al. (1993, 386) used the following census tract measures to model neighbourhood stress in the early 1990s in the United States:

- Fraction of families with incomes < \$10,000
- Fraction of families with incomes > \$30,000
- Fraction black in neighbourhood
- Fraction of families with children and female head
- 40% + poor and < 10% families with incomes > \$30,000
- Fraction with public assistance
- Fraction of males not in labour force (ages 16-64)
- Managerial/professional in neighbourhood < 5%
- Managerial/professional in neighbourhood 5%-10%

Neighbourhood effects of the highest SES quartile were determined to significantly lower the risk of teenagers dropping out of highschool or having an out of wedlock birth after adjusting for individual SES, and of children at age 36 months to have a higher IQ score (Brooks-Gunn et al., 1993, 370-372).

A comprehensive study of health index scores for Manitoba communities was conducted by Frohlich & Mustard (1996). Manitoba may be beneficial as a unit worthy of study in the public health context, because of its centralized location in Canada serving as a crossroads for people of different backgrounds at a regional scale.

The following census tract indicators were entered as covariates in a stepwise regression model that formulated a socioeconomic risk index with a dependent variable of health status, for a temporal period of the mid-1990s in the province of Manitoba (Frohlich & Mustard, 1996, 1275):

- Labour force unemployment for people ages 15-24
- Unemployment amongst residents ages 45-54
- Percentage of female long parent households
- Fraction of families with children and female head
- Percentage of population ages 25-35 with high school diploma
- Female labour force participation
- Average value of owner-occupied housing

The combination of index measures above was found to explain 87% of the total variation in health status at the ecologic level for Manitoba, and 91% of the variance in premature mortality (Frohlich & Mustard, 1996, 1275-6).

Matheson et al. (2006, 2608-9) found the following variables from the 2001 Canada Census, in addition to Cycle 1.1 of the Canadian Community Health Survey (CCHS) to be significant as predictors at the neighbourhood level for depression. These indicators were grouped into factors loadings, with the respondent population obtained from a cross-sectional survey encompassing 25 Canadian CMAs. Some additional indicators were added, as shown in Appendix 2.C on page 151.
1st factor measures residential stability:

- Percent of youth 5-14 years
- Average family size
- Percent living in apartment buildings
- Percent married
- Percent home ownership
- Percent moving within the last 5 years
- Percent population change in census tract in last 5 years

2nd factor measures material deprivation:

- Percent age 25-64 without high school certificate, diploma or degree
- Percent lone parents

- Percent of families receiving government transfer payments
- Percent 15+ unemployed
- Prevalence of low income ratio after 2005 (Statistics Canada measure)
- Percent of homes needing major repairs
- Population density per square kilometre

3rd factor measures dependency:

- Percent of population seniors (age 65+)
- Ratio of population age 0-14 and 65+ divided by population age 15-64
- Labour force participation (age 15-64)

4th factor measures ethnic diversity:

- Percent recent immigrants within period 2001-2006
- Percent visible minorities

The 1st and 2nd factors were found to be the most significant, as they capture the degree of chronic stress in neighbourhood and were determined to give a 12% increased in odds for depression. The 3rd and 4th factors were also significant, but gave a negative association with regards to individual report of depression, signalling that neighbourhoods with high proportions of workers and immigrants offer healthy benefits with regards to mental health (Matheson et al., 2006, 2611).

3.C.2 Winnipeg Police Service Crime Data, 2001

Winnipeg Police Service provides crime statistics for 23 aggregated neighbourhood profiles cross-tabulated annually on request, as shown in Figure 3.2 (Winnipeg Police Service, 2001). These 23 neighbourhood profiles correspond to the 155 census tracts encompassing the City of Winnipeg. The 2006 Winnipeg CMA boundary shapefile is used as a mapping device, since it is most recent and census tract geography encompassing the City of Winnipeg itself has not changed since 1996, with exception to the inclusion of an extra '0' in substring of the CTUID code after CMA denotation as part of the historical compatibility rule (Statistics Canada, 2007). Census tract identifiers excluded from the 168 localities included in the 2006 Canada Census, Winnipeg CMA boundary file are: 6020150.00, 6020160.00, 6020161.00, 6020520.04, 6020570.00, 6020580.00, 6020585.00, 6020590.01, 6020590.02, 6020595.01, 6020595.02, 6020600.00 and 6020700.00 which gives a coverage area corresponding to the same 155 census tracts delineating municipal boundaries in 1996. Approximation using census tracts provides a good fit for City of Winnipeg neighbourhood profiles, as evident in Figure 3.3 on page 28. This is mostly likely because census demographers and municipal planners in Canada take great effort to ensure cohesion of census tract by neighbourhood (Ross et al., 2004). A slight discrepancy for census tract 6020051.01 arises, which is split between two neighbourhood profiles. The majority of surface area in this census tract belongs in profile Seven Oaks West, but the majority of population inferred by road network concentration lies in Inkster West. The same argument is also made for census tract 6020007.00, which is irregularly shaped and placed in River Heights West neighbourhood by concentration of roads. Census tract 6020560.06 has the majority of its residential population placed in profile Fort Garry North, with an industrial area and undeveloped land located in Fort Garry South.

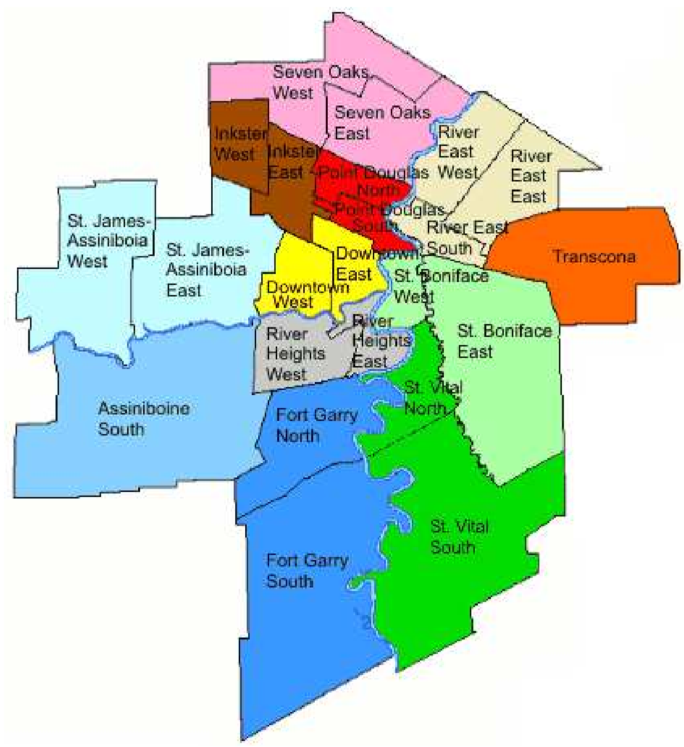


Figure 3.2: City of Winnipeg Neighbourhood Boundaries (City of Winnipeg, 2001)

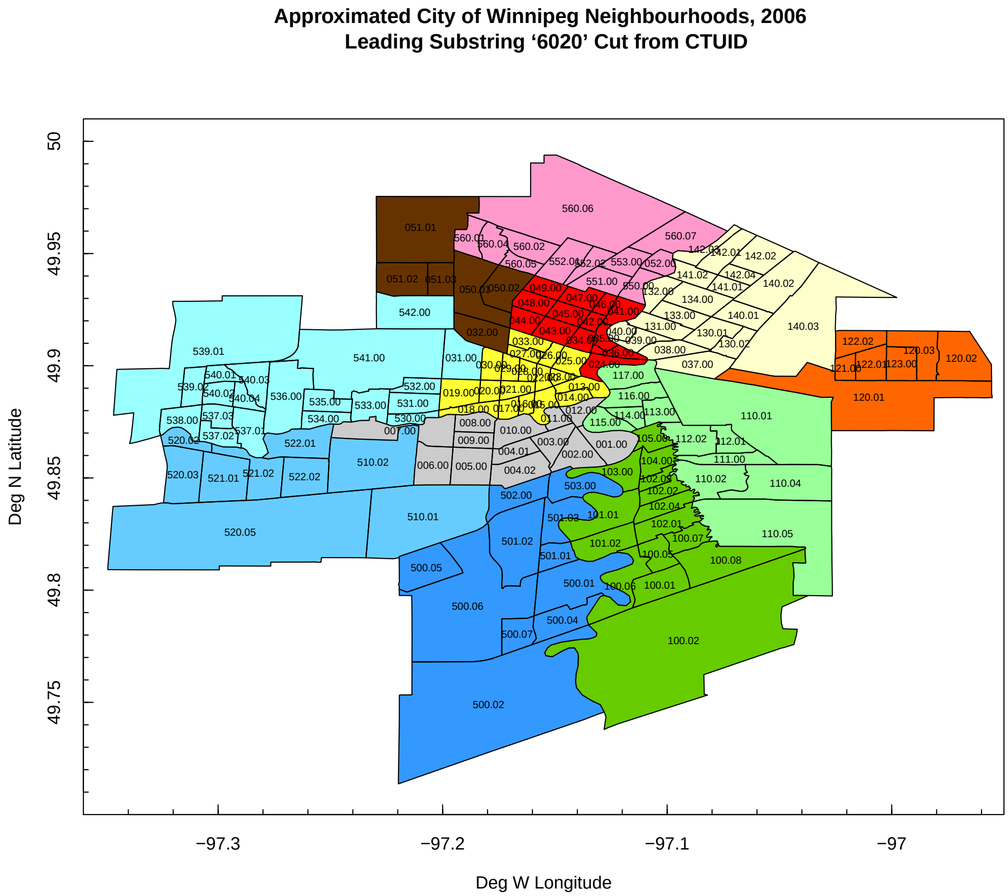


Figure 3.3: Neighbourhood Profile Approximation by Census Tract

Importance is placed on grouping census tracts in to appropriate neighbourhood profiles, since crime data provided by Winnipeg Police Service is raw aggregate. Population ratios are used to compare order of magnitude for crime categories amongst neighbourhoods, determined by dividing indicator of interest by the sum of census tract population for each profile. Because the crime statistics are an aggregation of counts and discrete, a Poisson function may be suitable to explore for the link between covariates in modelling, as one can assume a fixed period of time with independence between events (Bates & Maechler, 2009).

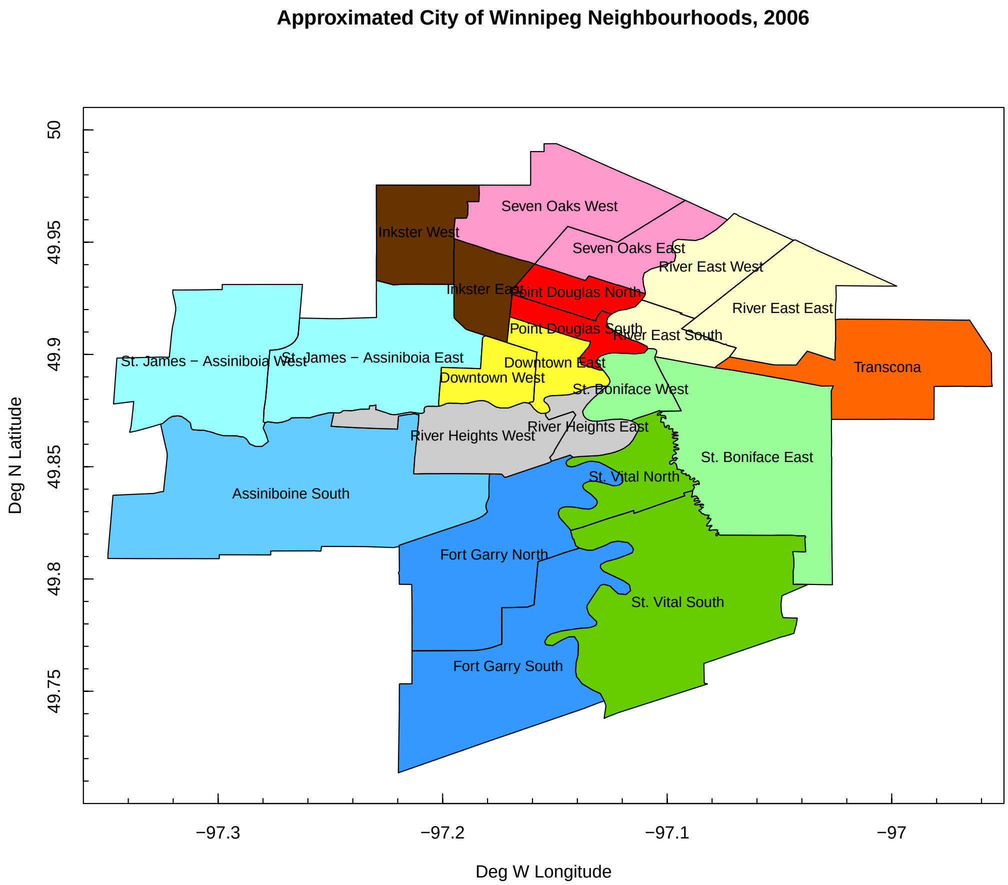


Figure 3.4: Labeled Neighbourhood Profiles by Census Tract

The year 2001 was chosen for capture period with crime statistics, as it corresponds to a census year and precedes distribution of the SAGE Survey in Manitoba. It is also one of the earliest periods that Winnipeg Police Service has neighbourhood profile data available. The population of the aggregated census tracts from the 2001 Canada Census is used to attain a crime incidence rate per 10,000 persons for the year. The list of crime measures included, as well as neighbourhood profile names is available in Appendix 2.D on page 152.

3.D Data Analysis Procedures

3.D.1 Data Assembly, Coding and GIS

Data assembly and analysis for this project was completed in `R`, a computational environment which includes many freely accessible statistical and graphical packages with a large support network (R Development Core Team, 2009; Venables & Smith, 2009). The Postal Code Conversion File (PCCF) was used for assigning geo-coordinates to Canadian postal codes, and runs in SAS® (Wilkins, 2009). LaTeX 2ε is the environment for typesetting, with `Sweave` being utilized to integrate R programming code directly within the finished document (Leisch, 2003). BibTeX was used to manage and reference citations within the manuscript.

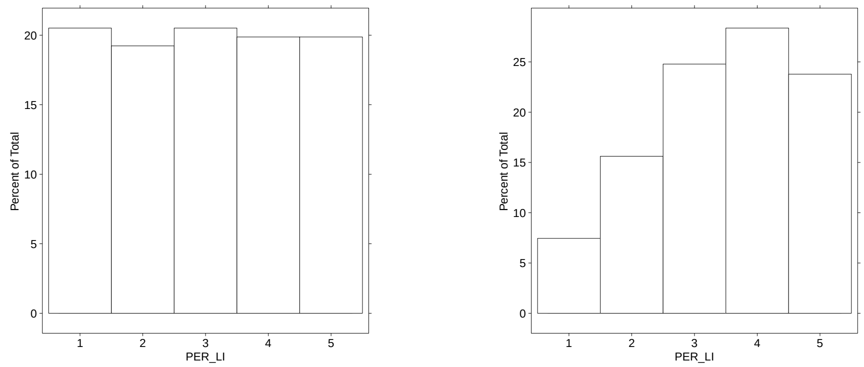
PCCF versions 4G and 5D in particular were used to inspect and geocode Manitoba postal codes, and correspond to the 2001 and 2006 boundary files respectively for census geography. PCCF version 5D was ultimately chosen to assign geocoordinates to respondents of the SAGE Survey, as its reference list is newest. In large, urban municipalities, a six character postal code is commonly unique for each city block. The first three characters are unique to the municipality, known as the forward sortation area (FSA), and the last three characters are known as the local delivery unit (LDU) (Wilkins, 2009). The PCCF runs as a script in SAS®, and assigns a slight variation at random in latitude and longitude coordinates for six character postal codes corresponding to a city block, so that two respondents with the same postal code do not overlap (Wilkins, 2009). A census tract (CTUID) and census subdivision identifier (CSDUID) were assigned to observations, which could be checked for accuracy using longitude and latitude values with a 'points in polygon' calculation available in the `PBSmapping` package.

The `maptools` and `sp` packages are the primary graphical tools which provide the interface upon which many of the spatial figures are created in plotting boundary shapefiles obtained from Statistics Canada (Lewin-Koh et al., 2009; Pebesma & Bivand, 2005). The `PBSmapping` package, written by Jon T. Schnute, Nicholas Boers, Rowan Haigh and Alex Couture-Beil at the Pacific Biological Station (PBS) in Nanaimo, British Columbia, Canada allows point in polygon calculations to be made, which assigns event data characteristics of the enclosing census tract. Universal Transverse Mercator (UTM) coordinate system with ellipsoid dating World Geodetic System 1984 (WGS84) is the encoding of shapefiles (Schnute et al., 2008). Dedication by members of these software package teams makes it possible to utilize complex GIS techniques without purchasing costly software licenses from MapInfo® or ArcGIS®.

3.D.2 Exploratory Data Analysis

To impute SES indicators obtained from the Canada Census, 1996, 2001 and 2006 in to usable format, ratios indicative of population weight are necessary. This routinely involves dividing the specified indicator by census tract population. It is important to note that use of parametric tests assuming normality is only possible for continuous variables. Variables taking ordinal values or factor levels cannot make use of parametric tests assuming normality with the use of a Gaussian link. Accurate confidence intervals cannot be calculated for parametric tests assuming a non-Gaussian distribution or non-parametric tests, but are possible to construct through use of an exact method (Gelman et al., 2004, 4). Census tract SES indicators are broken up into class intervals to assign quintile values used in assigning factor levels. This is similar in format to what was done by To et al. (2007, 1198) in assignining to respondents a SES indicator score from the 1996 Canada Census, with quintile 1 corresponding to the poorest neighborboods and quintile 5 to the richest.

Histograms of predictor variables show the spread of data from sampling, and the approprite fit of sampling distribution that may be considered. Traditionally, the Gaussian distribution is assumed in traditional hypothesis testing for a Cumulative Density Function (CDF), even though in our case it is known quintile levels are on discrete scale and not continuous. In the situation for probability models of continuous variables that are highly skewed to the right, an exponential distribution may be ascertained, such as one that models survival times (Woodward, 2005, 610). A log-logistic distribution may also suffice for predictor variables skewed to the left, as commonly found in the SAGE Survey with highest proportions of children residing in low income neighbourhoods (Woodward, 2005, 89, 618). However, given that the SES indicators are on an ordinal scale and were discretized, approximation by an exponential distribution may not be valid, thus a known discrete distribution such as the binomial should be considered (Wackerly et al., 2002, 97).



(a) Winnipeg Census Tracts (CTs) by Quintile

(b) SAGE Birth Home Responses by Winnipeg CT Quintile

Figure 3.5: Quintile Scores for Stressor 'Incidence of Low Income in Households'

Non-parametric tests have fewer restrictive assumptions than parametric tests, and can still be used for simple hypothesis testing. Smaller sample sizes can be used, but the median may be used as a measure of comparison rather than mean since it is more robust to outliers and skewness (Woodward, 2005, 96). However, none of the 'traditional' non-parametric methods offer the possibility to provide insight in testing interactions with complicated covariate or multilevel models.

Principal Component and Factor Analysis

Principal component analysis is an exploratory multivariate technique which can be used to reduce the dimensionality of data given many SES stressors. It can be thought of as a parametric technique where data is scaled, and highly correlated variables are deflated together into a common axis which are orthogonal and relatively independent of other deflated variable axes (Venables et al., 2002, 322). Uncorrelated Linear combinations of the entire data matrix are taken with large variance calculated (Venables et al., 2002, 321). The 'prcomp' function from the `stats` package in `R` is used.

Factor analysis is similar to principal component analysis, but differs in that linear combinations of variables are taken instead of data combinations itself (Venables et al., 2002, 321). The 'factanal' function allows use of this technique from the `stats` package. A 'varimax' rotation is taken with factor loadings, to ensure maximal independence amongst observations. (R Development Core Team, 2009). Factors can be thought of as underlying or latent variables with large directional effect on the observed outcome of interest, and it is generally difficult to find dataset examples for which this method is well suited (Venables et al., 2002, 323). Factor analyzing techniques in `R` are not developed at time of writing that allows easy use of assigning constructed loadings as neighbourhood scores for predictors in the two-parameter item response model with covariates by HLM to the same regards as what is possible with SAS® version 9.1 (Rizopoulos, 2006; Matheson et al., 2006). At present, the `ltm` package through the 'ltm' function allows the construction of latent trait models with binary data, the restriction being that all variables are allowed only two distinct values (Rizopoulos, 2010, 32).

Linear Discriminant Analysis

Linear discriminant analysis (LDA) is different from principal component and factor analysis, in that classification can be used for a variable of binary outcome to predict new cases given auxiliary covariate information. This can be thought of as an example of a non-parametric classification scheme that is somewhat similar to logistic regression modelling, but is ultimately a 'black box' method in which little explanation can be provided for divisions made (Venables et al., 2002, 331). A training set and testing set are automatically specified, which can be used in assessing prediction of the pattern fit. The 'lda' function from the `MASS` package is used.

Cluster Analysis

Clustering methods can be used to discover specific groupings of numeric SES indicators by similarities or dissimilarities based on different linkage schemes (Venables et al., 2002, 316). Clustering is a type of spatial correlation in which measurements that are physically closer to one another tend to be similar than those located further apart (Ott & Longnecker, 2001, 274). Two main functions are available as clustering approaches: divisive analysis (DIANA) and agglomerative nesting (AGNES) clustering (Venables et al., 2002; Maechler et al., 2005). Visual display of clusters is possible using mapping techniques at the neighbourhood level.

DIANA and AGNES clustering procedures can be used to composite index score of stressors to group neighbourhoods together which feature similar characteristics. AGNES starts by using a complete or nearest neighbor method, in which the furthest distance is calculated between points in subsequent clusters that are aggregated together (Maechler et al., 2005). DIANA functions the opposite as AGNES, with all observations in one large cluster, and separates observations with largest differences from one another into subsequent clusters. Manhattan metric is used in both methods for specifying differences, which corresponds to the grid pattern used in city neighbourhoods (Maechler et al., 2005). Both clustering techniques are explored in Section 4.B.

3.D.3 Hierarchical Linear Modelling Techniques

The linear mixed-effects regression (LMER) function from the `lme4` package was chosen to fit a generalized linear mixed model with a binomial family, as it is analogous in usage to the 'PROC MIXED' and 'PROC GLIMMIX' functions in SAS® and can provide odds ratios to a reference factor level (Bates & Maechler, 2009). Estimates from LMER procedure are generally construed as more stable in the statistical community since they are calculated using a form of numeric integration known as the Laplace approximation, compared to estimates calculated from the 'PROC GLIMMIX' procedure using the penalized quasi-likelihood (PQL) approach (Bates, 2007a; Kleinman & Horton, 2010, 141). PQL routines were provided for the LMER procedure in the past, but have been discontinued (Bates, 2007b). Exact methods in calculating confidence intervals for estimates of binomial data is not provided to S4 classes from LMER output, as it is felt that variance is asymmetrical and that the confidence interval estimates provided by proprietary software are untrustworthy given they are often on the boundary of parameter space (Gelman, 2008). However, model comparison was made to the output from the 'PROC GLIMMIX' procedure implemented in SAS® version 9.2 (SAS Institute, 2010). Specifically, the "GLIMMIX procedure can fit models for non-normal data with hierarchical random effects, provided that the random effects have a normal distribution" (Schabenberger, 2008, 3). The LMER procedure was originally sought in specifying hierarchical models, but a switch to GLIMMIX was done to comply to norms in the public health field.

A random-intercept model with fixed predictor at the individual-level was chosen, as is commonly found in most ecologic models fitting retrospective or observational data (MacLeod et al., 2008, 289). SES deprivation scores are treated as a fixed effect, since it is known the selection of neighborhood sampling units in Winnipeg coincides the entire population frame. Given that Winnipeg encompasses 155 census tracts and the urban component of the SAGE Survey has 1472 respondents, which reduces to 698 given residence in birth home, a minimum number of 25 respondents per grouping unit for census tract cannot be ensured. Quintile scores from the 1996 Canada Census indicators are assigned as predictors to each individual, since uniform values of these quintile scores are not nested within same the 'NEIGH' grouping unit. The intercept component of the fixed effects in all models was found to be highly significant, in addition to family history of asthma in household. Other covariates at the individual-level such as smoking, cat or dog presented in household are also included in models if found significant. Centering of variables at their respective means can be used to reduce collinearity, but is not necessary if only a few predictors are fitted at once in model specification (Woodward, 2005, 38). Spatial autocorrelation in the data set is assumed to be high given the number of respondents in same neighbourhood grouping unit with similar characteristics, and is explored in Section 4.C.

A three-level LMER model fitting census tracts (CTUID) nested within neighbourhood profile (NEIGH) for a binary outcome such as parent report of child asthma is specified as follows for a given STRESSOR:

```
output.lmer = lmer(asth_child ~  1 + fh_asthma + STRESSOR
                + (1 | NEIGH/CTUID), family = binomial, data = ...);
```

While a two-level LMER model fitting responses grouped within neighbourhood profile (NEIGH) is specified as follows:

```
output.lmer = lmer(asth_child ~  1 + fh_asthma + STRESSOR
                + (1 | NEIGH), family = binomial, data = ...);
```

For comparison, a three-level GLIMMIX model fitting census tracts (CTUID) nested within neighbourhood profile (NEIGH) for a binary outcome such as parent report of child asthma is specified as follows for the STRESSOR:

```
proc glimmix data = ... order = ... ic = pq ;
        class CTUID NEIGH fh_asthma STRESSOR ;
        id CTUID NEIGH ;
        model asth_child(ref = first) = fh_asthma STRESSOR
                / ddfm = kr oddsratio link = logit dist = binary ;
```

```
        random int / subject = NEIGH ;
        random int / subject = CTUID(NEIGH) ;
        nloptions tech = nrridg maxiter = 200 ;
        random _residual_ ;
        covtest zeroG / cl ;
run ;
```

And a two-level GLIMMIX model fitting responses grouped within neighbourhood profile (NEIGH) is specified as follows:

```
proc glimmix data = ... order = ... ic = pq ;
        class CTUID NEIGH fh_asthma STRESSOR ;
        id CTUID NEIGH ;
        model asth_child(ref = first) = fh_asthma STRESSOR
                / ddfm = kr oddsratio link = logit dist = binary ;
        random int / solution subject = NEIGH ;
        nloptions tech = nrridg maxiter = 200 ;
        random _residual_ ;
        covtest zeroG / cl ;
run ;
```

Explicitly, in fitting a random-intercept binomial mixed model with fixed predictors at the individual-level for a two-level model, the formal definition fitting stressors on a continuous scale such as those from the 2001 Winnipeg Police Service Crime Data has the notation:

$$y_{il} = \mu + \alpha_l + \beta x_{il} + \epsilon_{il} \tag{3.1}$$

where y_{il} represents the binary outcome of parent report of child asthma for subject i in grouping unit l and μ is the conditional mean or intercept of fixed effects; α_l represents the random family effects intercept with an assumed mean of zero with variance ${\sigma_\alpha}^2$; x_{il} is an indicator variable that takes values 0 and 1 for different predictors; β is a vector represents the fixed effect of stressor x_{il} on y_{il}, and ϵ_{il} represents the random error with a mean of zero and variance ${\sigma_\epsilon}^2$ assuming that α_i and ϵ_{il} are mutually independent (Stanish & Taylor, 1983, 221).

The form of this model in logistic regression utilizing stressors from the 1996 Canada Census, where reference level is set at either the first or fifth quintile is expressed:

$$\ln\left(\frac{\pi_{il}}{1-\pi_{il}}\right) = \mu + \alpha_l + \beta x_{il} \tag{3.2}$$

where π_{il} represents the probability of parent report of child asthma for subject i in grouping unit l, and $\frac{\pi_{il}}{1-\pi_{il}}$ is known as the odds.

Determing the effect of neighbourhood can be assessed by use of the intraclass correlation coefficient (ICC) in logistic regression models (Matheson et al., 2006, 2610). Values of this coefficient vary between extremes of no variation between neighbourhood levels (0), and cases where the variation between neighbourhoods is greater than the variation within neighbourhoods (1), and is calculated from the correlation of random effects through all levels (Faraway, 2006, 154). The ICC is defined as:

$$\rho = \frac{{\sigma_\alpha}^2}{{\sigma_\alpha}^2 + {\sigma_\epsilon}^2} \tag{3.3}$$

Thus when neighbourhoods are homogeneous to each other, the intraclass correlation coefficient takes small values and possibly non-HLM techniques may yield similar results for fixed effects. Even in the scenario where ICC values may be small, the effect of neighbourhood may not be minimal (Matheson et al., 2006; Snijders & Bosker, 1999; Duncan & Raudenbush, 1999).

Ideally, it is imperative that in analyzing responses from the nested case-control SAGE Survey, only one child per postal code is sampled. This ensures the independence assumption for complicated logistic regression with spatial covariates, and coordinate data cannot have duplicate points. Since responses are geocoded by postal code, thus exclusiveness of geo-coordinates is dependent upon its singularity. Ensuring unique postal codes for the bounded region confining the City of Winnipeg, a total of 1404 responses are included from the SAGE Survey, which reduces to 668 for those resident of birth home. In the case of duplicate points for a specific postal code, the response with positive report of child asthma case is chosen. The proportion of respondents sharing the same postal code in 2002-2003 was determined to be roughly 4.6% ($\frac{1472-1404}{1472}$) or 4.3% ($\frac{698-668}{698}$) for those residing in birth home. Well not a negligible amount, the assumption of spatial independence should only be minimally violated.

The effect of neighbourhood in the regression models can be compared to modelling techniques which involve only fixed effects, and do not include potential random effects amongst neighbourhood grouping units. Frank Harrell's `Design` package in `R` offers a multitude of regression functions incorporated towards logistic and binary response variables. The most common example is the logistic regression model (LRM) function. Reference levels are easily specified for factors in the model summary, allowing construction of odds ratios (Harrell, 2009). If the regressor variable is not a factor level (i.e. continuous), odds ratios are calculated for coefficients based on the difference of lower and upper values of quartile ranges, known as inter-quartile effects. This may be preferred, since a quartile or quintile difference is often more plausible for interpretation of effect in medical studies, rather than a one-unit change in exposure. Difference in response over the quintile range may also be more appropriate, since relation between exposure and disease occurrence might not be linear (Harrell, 2009). The R Development Core Team's library `stats` provides a generalized linear modelling (GLM) package that fits a variety of distributions such as logistic 'logit' and 'probit' (R Development Core Team, 2009). This is used in comparison to test the robustness of models specified by `Design`.

In assessing goodness of fit and model selection, the Akaike information criterion (AIC) and Bayesian information criterion (BIC) and log of maximized restricted likelihood (logLik) are compared. These measures are fairly standardized and included in most statistical packages written for `R` and GLIMMIX. Smaller values of the mentioned criterion usually correspond to a better model fit (Fox, 2002). Pearson residuals are an appropriate method of examining model adequacy with regards to logistic regression of binary outcome, and allowing identification of possible outliers (Montgomery et al., 2006, 445). A Pearson residual is defined:

$$r_i = \frac{y_i - n_i\hat{\pi}_i}{\sqrt{n_i\hat{\pi}_i(1-\hat{\pi}_i)}}, \qquad i = 1, 2, ..., n \tag{3.4}$$

Chapter 4

Results

Stressors obtained from the 1996 Canada Census and 2001 Winnipeg Police Service Crime Data are listed in ascending order by AIC criterion starting in Section 4.D under the three environmental domains of: Neighbourhood Social Capital, Neighbourhood Physical Disorder, and Neighbourhood Crime and Violence as determined by groupings in the principal component and factor analysis. An in-depth explanation is done for the measures: Males Age 15+ Unemployed, Labour Force Participation, Theft Over $5,000 and Sexual Assault, with tables and figures given for interpretation of subsequent stressors. Due to space limitation in columns, full names of the variables is provided in the data dictionary in Appendices 2.A, 2.C and 2.D. In the spatial maps provided, census tracts corresponding to the quintile value (first or fifth) set as the reference level in the GLIMMIX model are highlighted. Appendices D and E show tables for the correlation and covariance matrices of predictors. Fitting the predictor Family History of Asthma was found to be significant in all models, but this was excluded and changed to Father has Asthma or Mother has Asthma when significant to give a measure of the genetic pathway in exposure. Additional confounding is adjusted for by including the covariates on the individual-level such as canine, smoking cigarettes or feline in household for certain models. Effect modification is present in models with interaction terms.

The two-level GLIMMIX model fitting the neighbourhood predictor Low Income amongst respondents of birth homes was found to have the lowest AIC value, being 3608.17 respectively. The neighbourhood predictor Home Owner Household gave the lowest Chi-Square value of 614.77. A generally consistent relationship was observed in that census tracts with higher incidence of low income in households were at decreased odds of parent report of child asthma in the SAGE Survey. This direct relationship observed is consistent to that of other stressors from the Canada Census, 1996. However, it differs from the Winnipeg Police Service crime data, in which neighbourhoods with higher crime generally have higher odds of parent report for child asthma. In general, observing the tables of random effect, the impact of neighbourhood level had greatest positive correlation of parent report of child asthma with the profiles Fort Garry North and St. Boniface West, while respectively having strongest negative correlation with profile River East West. Models were defined so that increasing levels of the neighbourhood stressor described higher percentages for each respective measure. For example, quintile 1 corresponds to the category with the lowest percent of the population, while quintile 5 denotes the highest.

For the City of Winnipeg, census tract identifier (CTUID) codes 602585.00 and 602600.00 from the 1996 Canada Census were removed to correspond to a subset of respondents residing within 155 census tracts that delineated municipal boundaries. Given these constraints, approximately 40.9% ($\frac{1472}{3596}$) of the SAGE Survey respondents were resident of Winnipeg neighbourhoods. From period of birth (1995) to time of survey of administration in 2002-2003 the percentages of individual-level exposure for Winnipeg children were as follows: smoking households of 24.3% ($\frac{357}{1472}$), cat in household of 25.1% ($\frac{369}{1472}$), dog in household of 29.9% ($\frac{440}{1472}$) and mold in household of 26.8% ($\frac{395}{1472}$). Roughly 56.9% ($\frac{112}{197}$) of Winnipeg children with parent report of asthma had a history of asthma in a close family member. A slight differential of asthma prevalence in children at age 7-8 exists for the entire city of 13.4% ($\frac{197}{1472}$) versus those in birth homes of 12% ($\frac{84}{698}$), which strengthens the research hypothesis on the effect of neighbourhood chronic exposures.

4.A Principal Component and Factor Analysis

The principal components of the dataset featuring the entire set of stressors from the 1996 Canada Census at the census tract level for 165 census tracts in the Winnipeg CMA, and the entire set of stressors from the 2001 Winnipeg Police Services Crime Data at the profile level for the 23 neighbourhood profiles show three apparent domains as evident between Figures 4.1 and 4.3. These components are similar to those observed by other principal component and factor analysis methods in the literature review (Matheson et al., 2006, 2610). A check of multicollinearity can be performed by examining the covariance and correlation of stressors to one another in Appendices D and E. Strong multicollinearity between two or more variables can be assessed through large covariances (Montgomery et al., 2006, 327). However, this is not of necessity as none of the stressors are analyzed simultaneously in any of the HLMs specified. It is evident that many of the crime stressors are highly correlated to one another, with low to moderate correlation observed amongst indicators from the census data. Covariance values are relatively low amongst the census data, with the exception of Median Income which varies between extremely positive and negatively large covariances. Covariance values amongst the crime stressors from neighbourhood profiles are highly inflated with the absolute values greater than 3, suggesting near-linear dependencies (Montgomery et al., 2006, 323).

It can be observed from the biplot of neighbourhood stressors determined to be significant by regression modelling techniques in Figure 4.1 that the two orthogonal domains are evident. The first principal component can be thought of under the heading of a neighbourhood social capital and residential stability domain, while the second principal component can be thought of to express neighbourhood physical disorder. Most of the variance in the data is explained by the domain corresponding to neighbourhood social capital, as suggested from investigating the factors in Table 4.1. Examining the biplot in Figure 4.3, one principal component domain is evident that expresses neighbourhood crime and violence, with some indicators off the main axis. This provides indication as an exploratory method of some latent structures plausible within the dataset, but stressors are ultimately sorted to the domain felt they have the most association with. Ill-conditioning from multicollinearity can be addressed through variable elimination, however, this solution may not be satisfactory when it is felt that dropped regressor may have significant explanatory power relative to the response outcome (Gelman et al., 2004, 371).

As a general rule, it is only worthwhile to consider number of principal components that have eigenvalues over a value of 1, as those that are less than that are treated to consitute random variance (Macrosson, 1999, 536). Very small eigenvalues (say ≤ 0.1) can also be indicative of multicollineary amongst components (Montgomery et al., 2006, 336). Examining the scree plot in Figure 4.2, it is evident that four or more principal components may describe the dimensions of the 1996 Canada Census stressor data set by census tract. However, a big drop is observed in eigenvalues after the second principal component. For the factor loadings presented in Table 4.1, there is a partial separation of forms on the second factor suggesting orthogonality in projection (Venables et al., 2002, 305). In Figure 4.3 only one principal component is found to have an eignvalue ≥ 1 for the crime data stressor data set by neighbourhood profile. Given the 1996 Canada Census data for Winnipeg census tracts, more than five factor loadings would have to be fitted in order to explain a signficantly adequate proportion of variance within the dataset, which differs from the findings suggested in Appendix 2.C as suggested by Matheson et al. (2006, 2610).

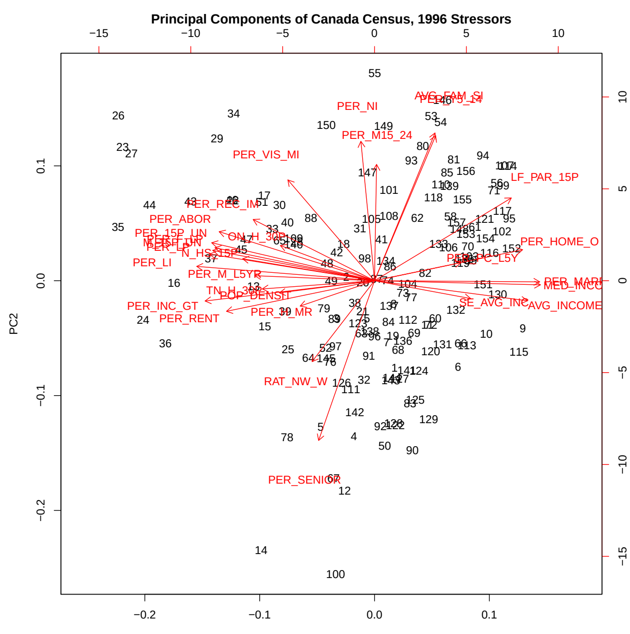


Figure 4.1: Principal Components of Canada Census Stressors

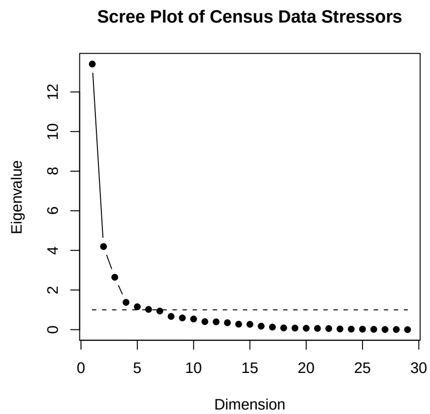


Figure 4.2: Scree Plot of Principal Components with Census Data

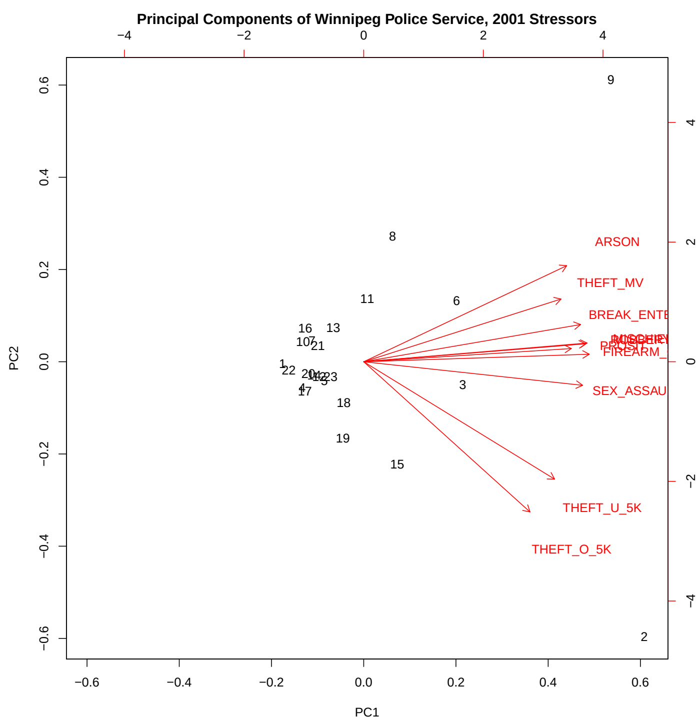


Figure 4.3: Principal Components of Crime Data Stressors

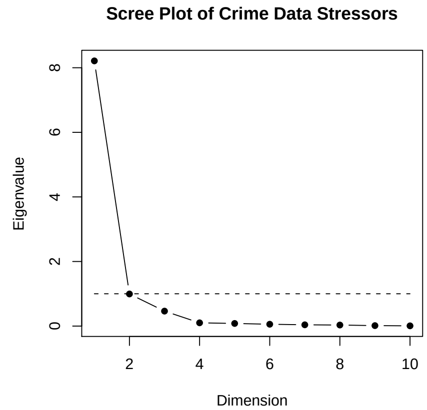


Figure 4.4: Scree Plot of Principal Components with Crime Data

Test of the hypothesis that 2 factors are sufficient.
The chi square statistic is 3841.19 on 349 degrees of freedom.
The p-value is 0

	Factor 1	Factor 2
Aboriginal	0.902	0.201
Age 15+ Unemployed	0.925	0.112
Age 5 to 14	-0.186	0.937
Average Family Size	-0.190	0.919
Average Income	-0.809	
Female Lone Parent Household	0.880	
Home Owner Household	-0.756	0.402
Homes Needing Major Repairs	0.390	
Income Government Transfer	0.897	-0.134
Labour Force Participation	-0.660	0.426
Lone Parent Household	0.907	
Low Income	0.977	
Males Age 15 to 24		0.348
Males Age 15+ Unemployed	0.907	
Median Income	-0.873	0.137
Moved Last 5 Years	0.644	-0.233
No Income Household	0.171	0.703
No School Diploma Age 15+	0.720	0.143
Owner Housing Unaffordable	0.511	
Population Change Last 5 Years	-0.445	0.131
Population Density	0.446	-0.255
Population Married	-0.896	0.200
Ratio Nonworkers to Workers	0.282	-0.172
Recent Immigrant	0.659	0.121
Rental Household	0.755	-0.399
Renter Housing Unaffordable	0.570	
Senior Population	0.160	-0.758
Standard Error Average Income	-0.472	
Visibile Minority	0.497	0.338
SS loadings	12.828	3.891
Proportion Var	0.442	0.134
Cumulative Var	0.442	0.577

Table 4.1: Factor Loadings of Census Stressors

Examining a summary of this data set in Table 4.1, one finds that two factor loadings of the provided neighbourhood stressors corresponds to 57.7% of the variance, which is an overall moderate proportion and agrees somewhat that random variance should not exceed 40% (Macrosson, 1999, 536). Using a two factor varimax rotation in the loading analysis, a p-value approaching 0 is attained. This rejects the null hypothesis that the three factors are sufficient, meaning that either loadings with factors is desirable or there are many outliers with regards to variability of neighbourhood stressors for respondents of the SAGE Survey. The presence of census tracts that are outliers is evident, observing Figure 4.1. A final grouping of stressors by proposed domains is shown in Table 4.2, as chosen by factor sorting and placing Homes Needing Major Repairs and Labour Force Participation stressors under the Neighbourhood Physical Disorder domain.

1st Domain - Neighbourhood Social Capital
Aboriginal
Age 15+ Unemployed
Average Income
Female Lone Parent Household
Home Owner Household
Income Government Transfer
Lone Parent Household
Low Income
Males Age 15+ Unemployed
Median Income
Moved Last 5 Years
No School Diploma Age 15+
Owner Housing Unaffordable
Population Change Last 5 Years
Population Density
Population Married
Ratio Nonworkers to Workers
Recent Immigrant
Rental Household
Renter Housing Unaffordable
Standard Error Average Income
Visibile Minority
2nd Domain - Neighbourhood Physical Disorder
Age 5 to 14
Average Family Size
Homes Needing Major Repairs
Labour Force Participation
Males Age 15 to 24
No Income Household
Senior Population

Table 4.2: Domains of Census Stressors

Many of the measures in the Neighbourhood Social Capital domain are similar to those in deprivation or low income domains presented in the literature (Matheson et al., 2006, 2610). The rationale for grouping indicators on income under social capital is that it was determined that perception of quality and social relations in Canadian neighbourhoods is tied directly to SES and the quality of housing that one can afford, with wealth inequality serving a power relation (Dunn & Hayes, 2000, 563). Economically stressed residents are also more likely to have a stronger association between reporting low social capital and self-identify a common mental disorder (Stafford et al., 2008, 403). With these considerations in mind, the income stressors presented from the 1996 Canada Census serve as an ideal proxy of social affluence for neighbourhood with regards to children in the SAGE Survey.

Test of the hypothesis that 1 factors are sufficient.
The chi square statistic is 115.32 on 35 degrees of freedom.
The p-value is 1.67e-10

	Factor 1
Arson	0.898
Break and Enter	0.924
Firearm Offensive Weapon	0.993
Mischief	0.952
Prostitution	0.929
Robbery	0.982
Sexual Assault	0.946
Theft Motor Vehicle	0.820
Theft Over $5,000	0.681
Theft Under $5,000	0.783
SS loadings	8.023
Proportion Var	0.802
Cumulative Var	0.802

Table 4.3: Factor Loadings of Crime Stressors

One factor loading was found to account for 80.2% of the variance observed in the Winnipeg Police Service crime stressor data set examining the output in Table 4.3. A p-value approaching 0 is obtained, meaning that more factor loadings are desirable in explaining variability of the data set given outlying neighbourhood profiles.

4.A.1 Linear Discriminant Analysis

None of the discriminant training and test models fitting only stressors from the 1996 Canada Census or the 2001 Winnipeg Police Service Crime Data found significant in regression models (Tables 4.1 and 4.3) to respondents of birth homes were able to accurately classify a yes response for asthma given the SAGE Survey. A specificity of $\frac{87.8\%}{11.9\%+87.8\%} = 88.1\%$ is calculated, while a sensitivity of $\frac{0.1\%}{0.1\%+0.1\%} = 50.0\%$ is obtained in Table 4.4. Thus, a large portion of children without parent report of asthma are correctly classified, whereas half of children with a positive report of asthma were correctly identified.

Parent Report of Child Asthma	LDA Prediction of Child Asthma	
	YES	NO
YES	0.1%	11.9%
NO	0.1%	87.8%

Table 4.4: LDA Contingency Table of Neighbourhood Stressors

LDA was fitted to child asthma responses in the City of Winnipeg to supplementary and exposure indicators at the child level from the SAGE Survey, in addition to the scores obtained as neighbourhood stressors. This encompasses all predictors from Appendices 2.A, 2.C, and 2.D were included to obtain a sensitivity and specificity chart presented in Table 4.5. A specificity of $\frac{84.7\%}{8.2\%+84.7\%} = 91.2\%$ is calculated, while a sensitivity of $\frac{3.9\%}{3.9\%+3.3\%}$ $= 54.2\%$ is obtained. The predictive value can also be determined, which is used to measure a screening program's feasibility such as LDA with predictors (Aschengrau & Seage, 2008, 423). Knowing that the prevalence of asthma in the general population is not very high, a screening program may be of interest to pursue since a better predicted values on tests are obtained in this scenario with a potentially large reservoir of candidates. A predicted value positive of $\frac{3.9\%}{3.9\%+8.2\%} = 32.2\%$ was calculated, and a predicted value negative of $\frac{84.7\%}{3.3\%+84.7\%} =$ 96.3% was obtained. Given the absurdly low value of the predictive value positive, very few children with a positive test in the LDA method actually have a parent report of childhood asthma. The advantage of LDA as a screening method is negligible.

Parent Report of Child Asthma	LDA Prediction of Child Asthma	
	YES	NO
YES	3.9%	8.2%
NO	3.3%	84.7%

Table 4.5: LDA Contingency Table of SAGE Survey and Stressors

4.B Cluster Analysis

It is evident from Figures 4.5 and 4.6 that AGNES and DIANA clustering schemes of 1996 Canada Census stressors produces different groupings. Census tract 6020538.00 in the western part of Winnipeg has a combination of the entire set of stressors that is more similar to downtown than other suburban census tracts. As well, its adjacent census tract 6020537.03 seems to have a distinct grouping of the stressors from Table 4.2 compared to the rest of the city in the DIANA clustering, which may be due to income or rental housing zoning. This is assuming there are five different types of neighbourhoods present in the city itself based on compositional stressors, in that they define the population of residents who live in the respective census tracts. Settlement patterns may correlate to land use, and historical time periods in the city's development. The downtown region forms its own contiguous cluster, whereas other neighbourhood types seem to be spread throughout the Census Metropolitan Area. The university area seems to have a clustering that is more similar to inner city neighbourhoods. Osbourne Village, and the neighbourhoods immediately south of the downtown also appear to have a different population aggregation, which may be due from lifestyles and age structure. It is interesting that in the DIANA clustering, the Osbourne Village and university areas form an assemblage that is distinct from the rest of Winnipeg. A ring pattern of census tract clusterings is somewhat observable radiating out from the downtown core in the AGNES clustering, which agrees with the Burgress and concentric ring model in that higher SES neighbourhoods are located on the edge of the city (Dear, 2002, 14).

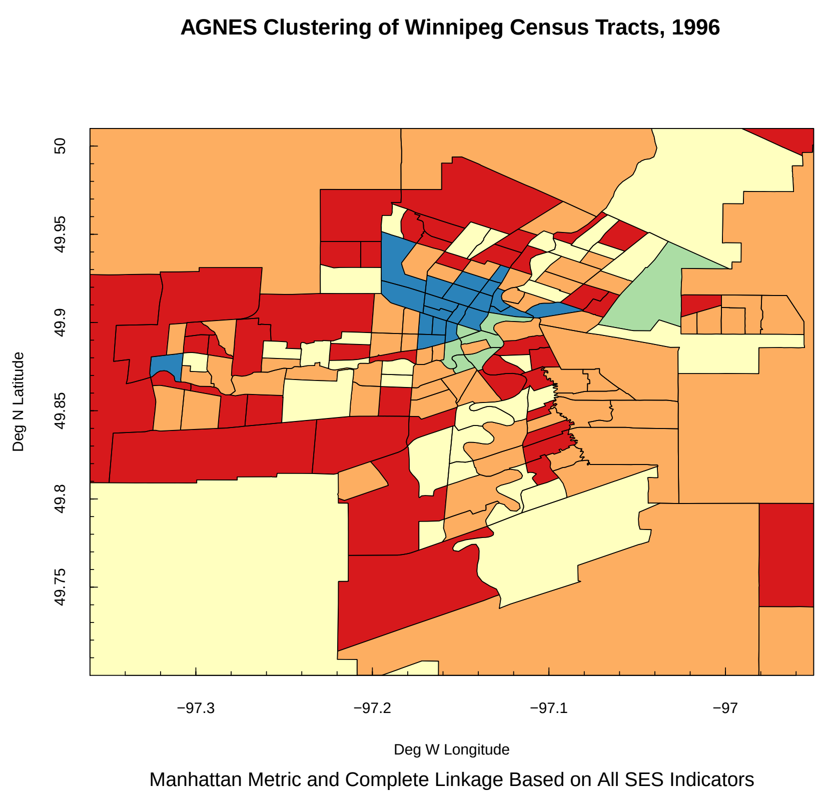


Figure 4.5: AGNES Clustering of Winnipeg Census Tracts

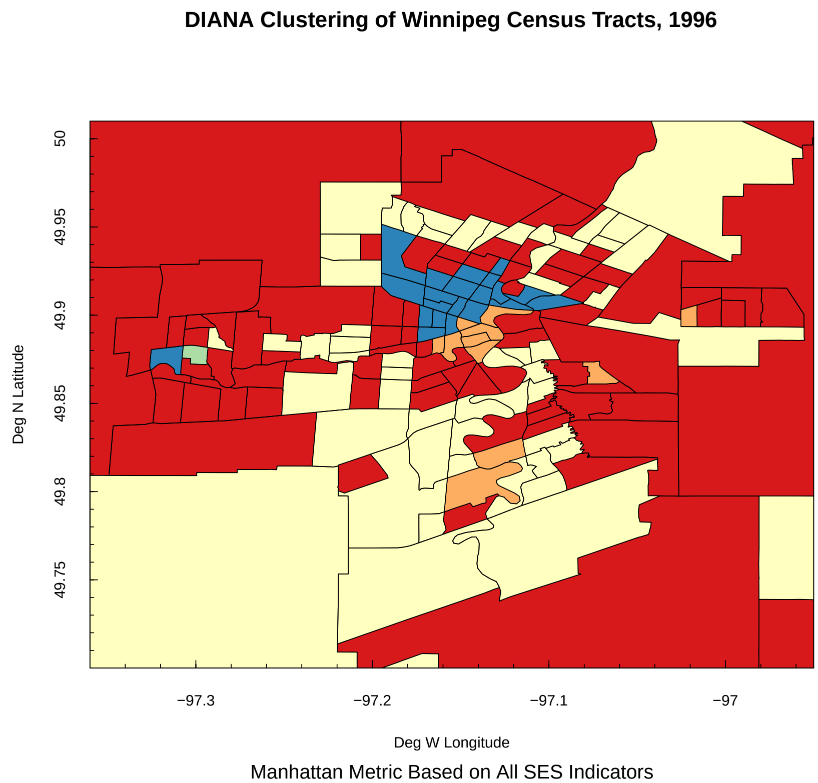


Figure 4.6: DIANA Clustering of Winnipeg Census Tracts

Clustering techniques with regards to the 2001 Winnipeg Police Service Crime Data in Figures 4.7 and 4.8 are more intuitive, for an increased level of each crime stressor is generally annotated as undesirable. Delinated boundaries from only the City of Winnipeg are represented, with no score assigned to outlying regions as data is municipal. It is evident that neighbourhood profiles in the downtown and north-central communities of Winnipeg have a distinct combination of the entire set of crime stressors compared to other districts of the city, which are rather homogeneous. The concentric ring model is perhaps more apparent in this application, with both agglomerative and divisive clustering schemes determining similar classification of neighbourhood profiles. Spatial autocorrelation may be more of an issue with stressors from the crime domain, given that aggregation units in terms of neighbourhood profiles are fewer and larger in spatial extent than for census tracts used in assigning neighbourhood scores under the residential stability and crime/violence domains. This will be investigated in Section 4.C.

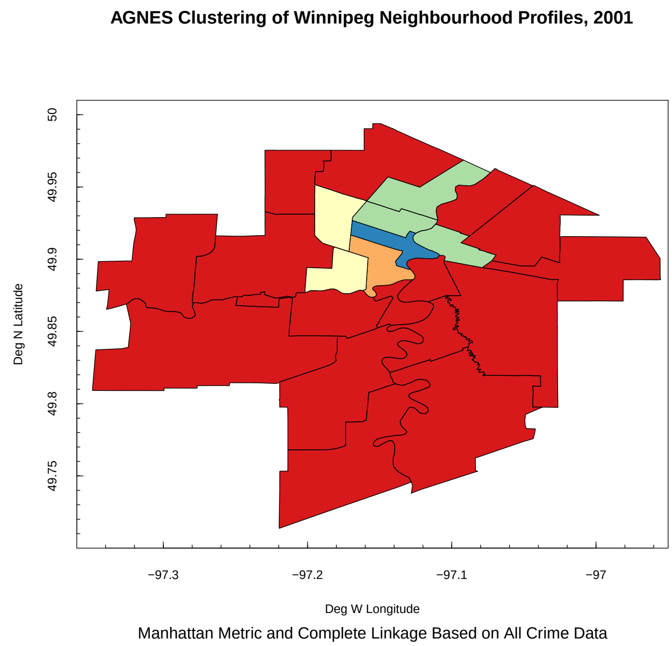


Figure 4.7: AGNES Clustering of Winnipeg Neighbourhood Profiles

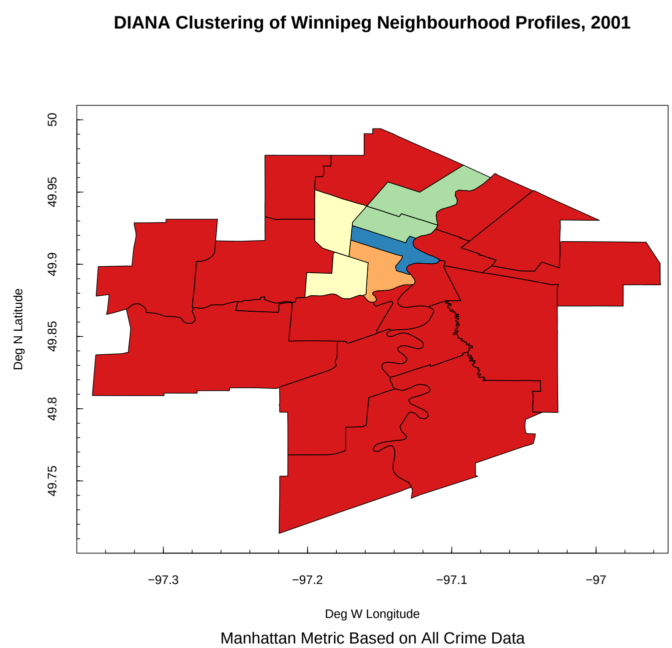


Figure 4.8: DIANA Clustering of Winnipeg Neighbourhood Profiles

4.C Spatial Autocorrelation

Spatial autocorrelation for the SAGE Survey of residents inhabiting the City of Winnipeg was assessed through use of the Moran's I statistic, available through use of the 'Moran.I' function from the `ape` package (Paradis et al., 2004). This statistic is calculated for the stressor found most significant under the neighbourhod social capital, physical disorder and crime/violence domains from Sections 4.D, 4.E and 4.F through use of the GLIMMIX procedure. Residual variogram plots were attached over equal breaks of the distance interval through use of the 'variog' function in the `geoR` package, which is a standard procedure for analysing correlated spatial data (Jr & Diggle, 2001, 15).

	Observed	Expected	S.D.	P-value
Moran's I	-0.00156	-0.00143	0.00002	0.00000

Table 4.6: Spatial Autocorrelation of Males Age 15+ Unemployed

Figure 4.9: Variogram Plot of Males Age 15+ Unemployed

	Observed	Expected	S.D.	P-value
Moran's I	-0.00153	-0.00143	0.00002	0.00002

Table 4.7: Spatial Autocorrelation of Labour Force Participation

Figure 4.10: Variogram Plot of Labour Force Participation

	Observed	Expected	S.D.	P-value
Moran's I	-0.00150	-0.00143	0.00002	0.00472

Table 4.8: Spatial Autocorrelation of Theft Over $5,000

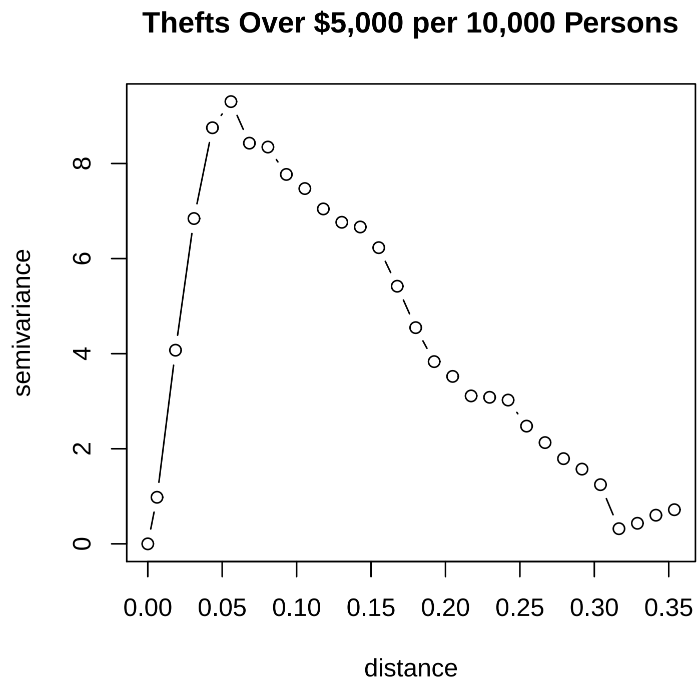


Figure 4.11: Variogram Plot of Theft Over $5,000

Observed and expected values of the autocorrelation coefficient close to zero from Tables 4.6, 4.7 and 4.8 in relation to the location of latitude and longitude coordinates from respondents of birth homes and non-birth homes respective to levels of specific stressor is indicative of a random spatial pattern (Getis & Aldstadt, 2004, 98). Considering the small p-values, the null hypothesis of zero spatial autocorrelation for the respective stressor is rejected (UCLA: Academic Technology Services, Statistical Consulting Group, 2010). Thus, there is evidence to suggest that child asthma respondents of similar stressor values are located in nearby geographic proximity, which is expected given neighbourhood score. Examining the semivariances from Figures 4.9, 4.10 and 4.11, most seem relatively constant and below 3 in magnitude, with the exception of the crime stressor Theft Over $5,000. Deviances this large are common with geospatial data, the importance is that the variance stays relatively constant and does not increase exponentially with increasing lag (Venables et al., 2002, 429). With this in mind, assumptions of independence and equal variance implied by the HLM techniques should hold.

4.C.1 Comparison to Pediatric-Allergist Diagnosis for Asthma

Pediatric-allergist diagnosis for asthma, hay fever and atopic dermatitis was conducted on 723 children recruited for a case-control study in the province of Manitoba, who previously participated in the SAGE Survey(Kozyrskyj et al., 2009, 1186). Of this enrolment, 102 children were recruited before age 9 and were resident of birth homes in Winnipeg. The measures assigned by the pediatrica-allergist are compared to the corresponding SAGE Survey responses parents made on report of asthma for their child, to evaluate the sensitivity and specificity of using a survey method instead of actual clinician diagnosis for screening.

A wide variety of children resident of most neighbourhoods in Winnipeg and all socioeconomic quintiles for median neighbourhood income participated in the clinical assessment, as evident for the subgroup of 102 children resident of Winnipeg birth homes in Figure 4.12.

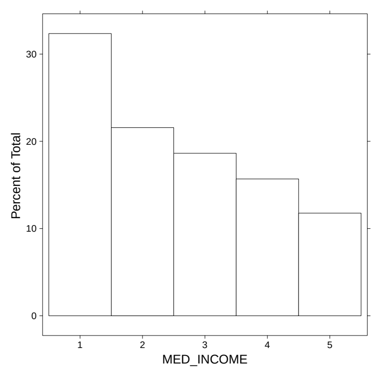


Figure 4.12: Histogram of Pediatric-Allergist Inclusion for Median Income

Using parent report of asthma from the SAGE Survey as a screening test for allergist diagnosis of asthma, a sensitivity of $\frac{41.2\%}{41.2\%+7.8\%} = 84.1\%$ is calculated, while a specificity of $\frac{45.1\%}{5.9\%+45.1\%} = 88.4\%$ is obtained. A high specificity means that the majority of parents from the SAGE Survey were good at being able to determine if their child does not have asthma. Additionally, a high sensitivity from this result alludes that parents are able to identify if their asthmatic child really does have the morbidity asthma.

Allergist Diagnosis for Asthma	Parent Report of Child Asthma	
	YES	NO
YES	41.2%	5.9%
NO	7.8%	45.1%

Table 4.9: Contingency Table for Allergist Diagnosis of Asthma

For a slightly different variation, using parent report of asthma as a screening test for allergist diagnosis of hay fever, a specificity of $\frac{37.3\%}{13.7\%+37.3\%} = 73.1\%$ is calculated, while a sensitivity value of $\frac{26.5\%}{26.5\%+22.5\%} = 54.1\%$ is obtained. Due to the low sensitivity, it appears that a positive value for parent report of child asthma from the SAGE Survey is not very useful in determining if the same child has a clinical diagnosis of hay fever.

Allergist Diagnosis for Hay Fever	Parent Report of Child Asthma	
	YES	NO
YES	26.5%	13.7%
NO	22.5%	37.3%

Table 4.10: Contingency Table for Allergist Diagnosis of Hay Fever

Using parent report of asthma as a screening test for allergist diagnosis of atopic dermatitis, a specificity of $\frac{41.2\%}{9.8\%+41.2\%} = 80.8\%$ is calculated, while a sensitivity of $\frac{10.8\%}{10.8\%+38.2\%} = 22.0\%$ is obtained. Again, a positive value for parent report of child asthma from the SAGE Survey is not useful in determining clinical diagnosis of atopic dermatitis in child, which is understandable considering they are two different morbitities. However, it is interesting to note from the high specificity that the majority of respondents who have a negative value for parent report of child asthma also have a negative response in allergist diagnosis of atopic dermatitis.

Allergist Diagnosis for Atopic Dermatitis	Parent Report of Child Asthma	
	YES	NO
YES	10.8%	9.8%
NO	38.2%	41.2%

Table 4.11: Contingency Table for Allergist Diagnosis of Atopic Dermatitis

4.D HLMs for Social Capital Domain

4.D.1 Incidence of Low Income in Households:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	4.523	687.1	2.390	8.559
Father has Asthma - Not Sure:No	2.827	687.3	0.895	8.928
Mold in Household 1995 - No:Yes	0.162	684.5	0.027	0.966
Low Income - 5:1	0.504	158.1	0.202	1.256
Low Income - 4:1	0.419	159.7	0.169	1.034
Low Income - 3:1	0.380	263.8	0.153	0.948
Low Income - 2:1	0.534	401.7	0.214	1.334

Table 4.12: GLIMMIX Fixed Effects for Low Income

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.1931	0.1643	0.05994	3.2084
Residual (VC)	0.9213	0.05035	0.8301	1.0286
Neighbourhood Profile	Estimate	Error	t Value	P-value
River Heights West	-0.1003	0.3715	-0.27	0.7934
St. Vital South	-0.1822	0.3988	-0.46	0.6620
St. Boniface East	0.3075	0.4099	0.75	0.4815
River East East	-0.1912	0.3741	-0.51	0.6220
Fort Garry North	0.5125	0.3783	1.35	0.2115
Assiniboine South	0.09237	0.3675	0.25	0.8073
Inkster West	-0.08520	0.4210	-0.20	0.8471
St. James - Assiniboia East	0.2589	0.3783	0.68	0.5124
St. Vital North	-0.3040	0.4061	-0.75	0.4806
Transcona	0.1427	0.3728	0.38	0.7111
River East West	-0.5376	0.3989	-1.35	0.2202
Fort Garry South	-0.2274	0.4104	-0.55	0.5993
St. James - Assiniboia West	0.1663	0.3653	0.46	0.6594
River Heights East	-0.1180	0.4365	-0.27	0.7995
Downtown West	0.2732	0.3806	0.72	0.4925
Seven Oaks East	-0.09637	0.4368	-0.22	0.8357
St. Boniface West	0.4758	0.4204	1.13	0.3054
River East South	0.02748	0.4104	0.07	0.9488
Point Douglas North	-0.1225	0.4237	-0.29	0.7837
Point Douglas South	-0.03984	0.4417	3.653	0.9329
Seven Oaks West	-0.2594	0.4390	-0.59	0.5861
Inkster East	-0.1529	0.4430	-0.35	0.7499

Table 4.13: GLIMMIX Random Effects for Low Income

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3588.17	3608.17	3608.50	3653.54	635.72

Table 4.14: GLIMMIX Model Criteria for Low Income

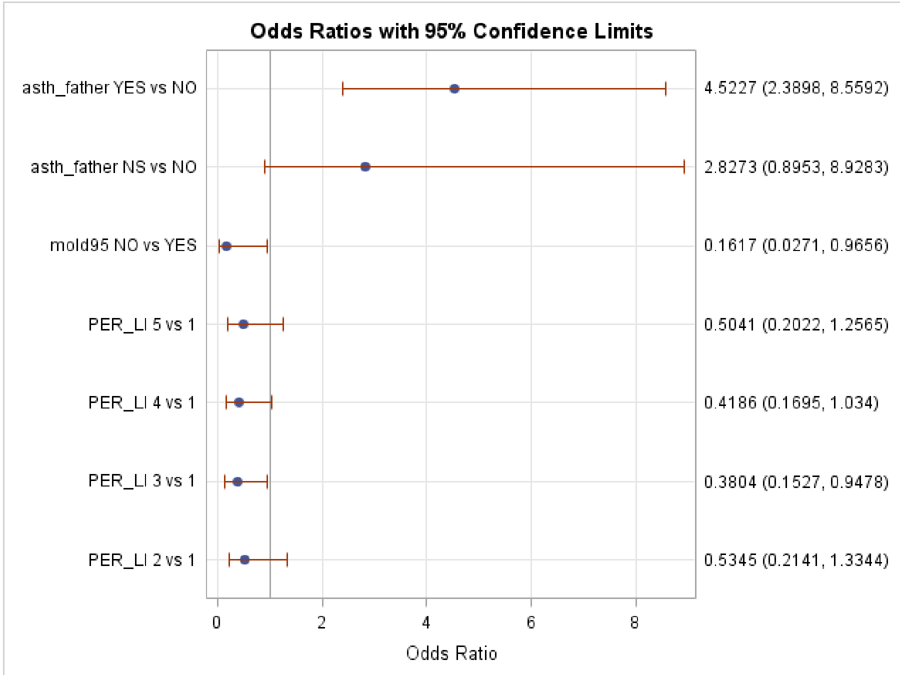


Figure 4.13: GLIMMIX Odds Ratio Plot for Low Income

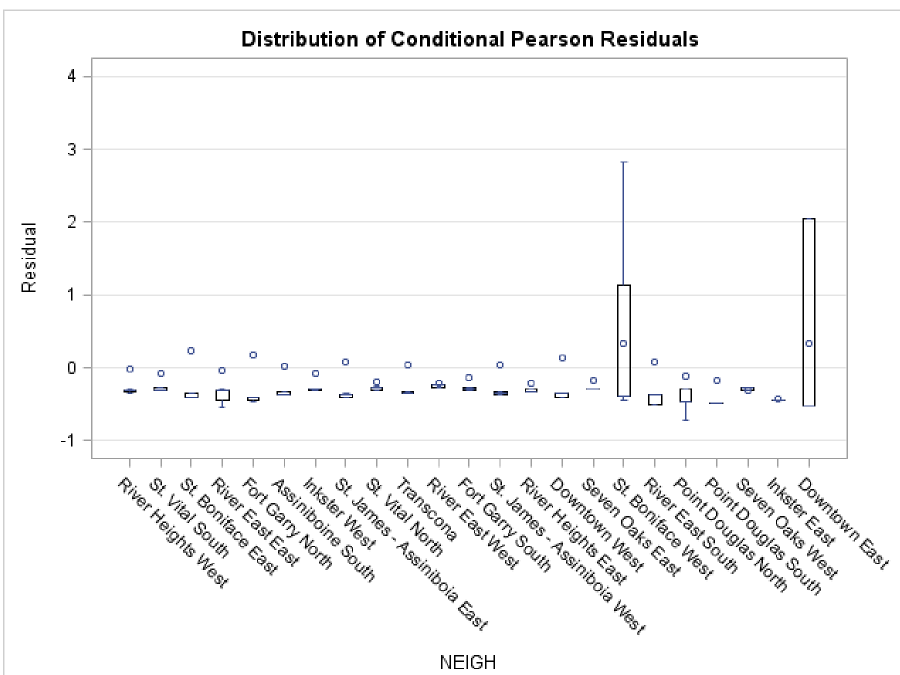


Figure 4.14: Boxplot of GLIMMIX Residuals for Low Income

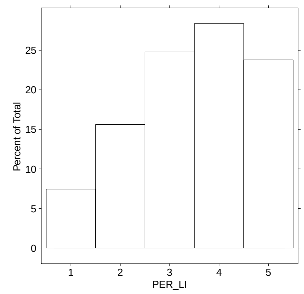


Figure 4.15: Histogram of Birth Home Responses for Low Income

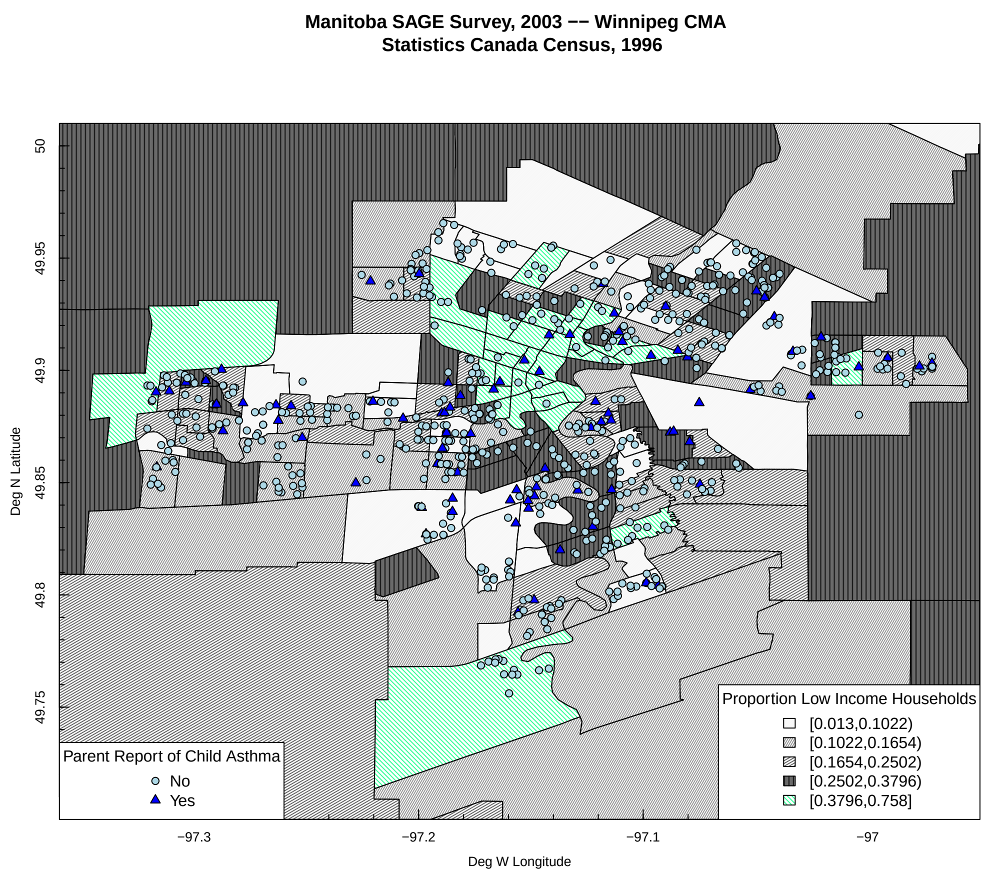


Figure 4.16: Winnipeg Respondents and Low Income Quintiles

4.D.2 Households that are Home Owner Household:

	Odds Ratio	df	95% CI lower	95% CI upper
Mother has Asthma - No:Yes	0.373	688.8	0.191	0.729
Mother has Asthma - Not Sure:Yes	0.320	684.6	0.064	1.605
Father has Asthma - No:Yes	0.241	685.9	0.127	0.458
Father has Asthma - Not Sure:Yes	0.697	688.4	0.186	2.613
Home Owner Household - 1:5	0.684	395.9	0.280	1.672
Home Owner Household - 2:5	0.287	353.7	0.107	0.771
Home Owner Household - 3:5	0.522	568.4	0.213	1.276
Home Owner Household - 4:5	0.519	546.1	0.202	1.330

Table 4.15: GLIMMIX Fixed Effects for Home Owner Household

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.3121	0.2105	0.1161	2.2353
Residual (VC)	0.8923	0.04885	0.8038	0.9963
Neighbourhood Profile	Estimate	Error	t Value	P-value
Assiniboine South	0.004403	0.3822	0.01	0.9909
Downtown East	0.3000	0.5304	0.57	0.5889
Downtown West	0.3607	0.4045	0.89	0.3834
Fort Garry North	0.6078	0.4018	1.51	0.1464
Fort Garry South	-0.2308	0.4702	-0.49	0.6321
Inkster East	-0.1953	0.5458	-0.36	0.7329
Inkster West	-0.1710	0.4735	-0.36	0.7243
Point Douglas North	-0.01828	0.4881	-0.04	0.9708
Point Douglas South	0.01624	0.5386	0.03	0.9769
River East East	-0.2827	0.4008	-0.71	0.4890
River East South	0.2174	0.4617	0.47	0.6455
River East West	-0.8355	0.4403	-1.90	0.0767
River Heights East	-0.1642	0.5134	-0.32	0.7568
River Heights West	-0.2604	0.3992	-0.65	0.5218
Seven Oaks East	-0.1717	0.5246	-0.33	0.7522
Seven Oaks West	-0.3831	0.5234	-0.73	0.4859
St. Boniface East	0.6436	0.4671	1.38	0.1928
St. Boniface West	0.5932	0.4590	1.29	0.2181
St. James - Assiniboia East	0.2332	0.3972	0.59	0.5635
St. James - Assiniboia West	0.04837	0.3823	0.13	0.9005
St. Vital North	-0.3321	0.4608	-0.72	0.4836
St. Vital South	-0.3900	0.4418	-0.88	0.3917
Transcona	0.4100	0.4191	0.98	0.3415

Table 4.16: GLIMMIX Random Effects for Home Owner Household

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3600.80	3622.80	3623.19	3672.68	614.77

Table 4.17: GLIMMIX Model Criteria for Home Owner Household

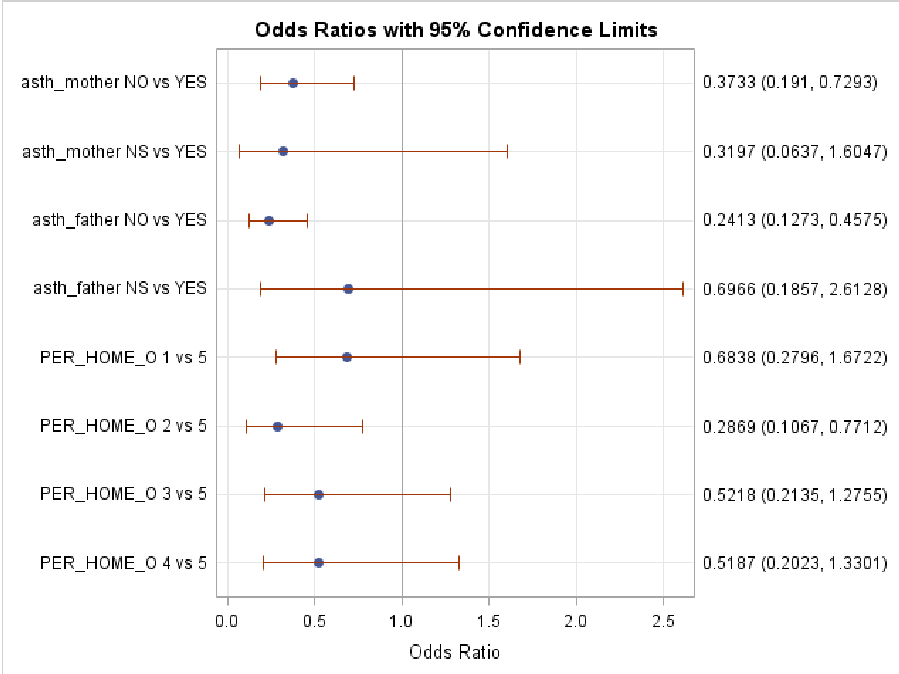


Figure 4.17: GLIMMIX Odds Ratio Plot for Home Owner Household

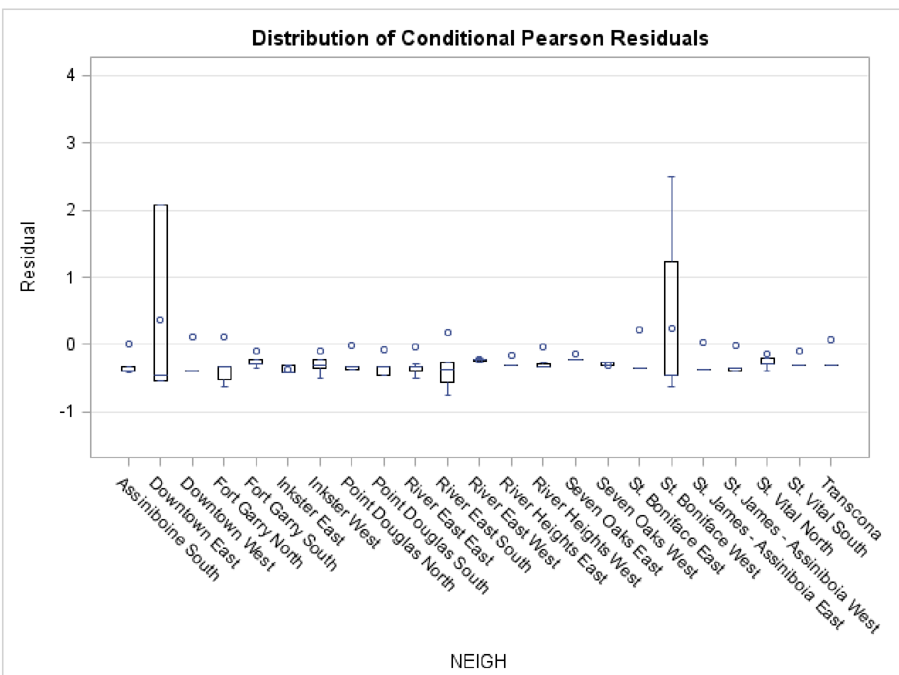


Figure 4.18: Boxplot of GLIMMIX Residuals for Home Owner Household

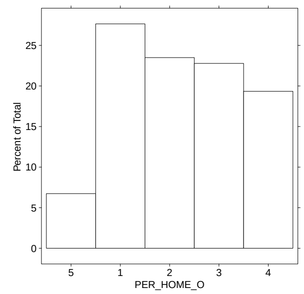


Figure 4.19: Histogram of Birth Home Responses for Home Owner Household

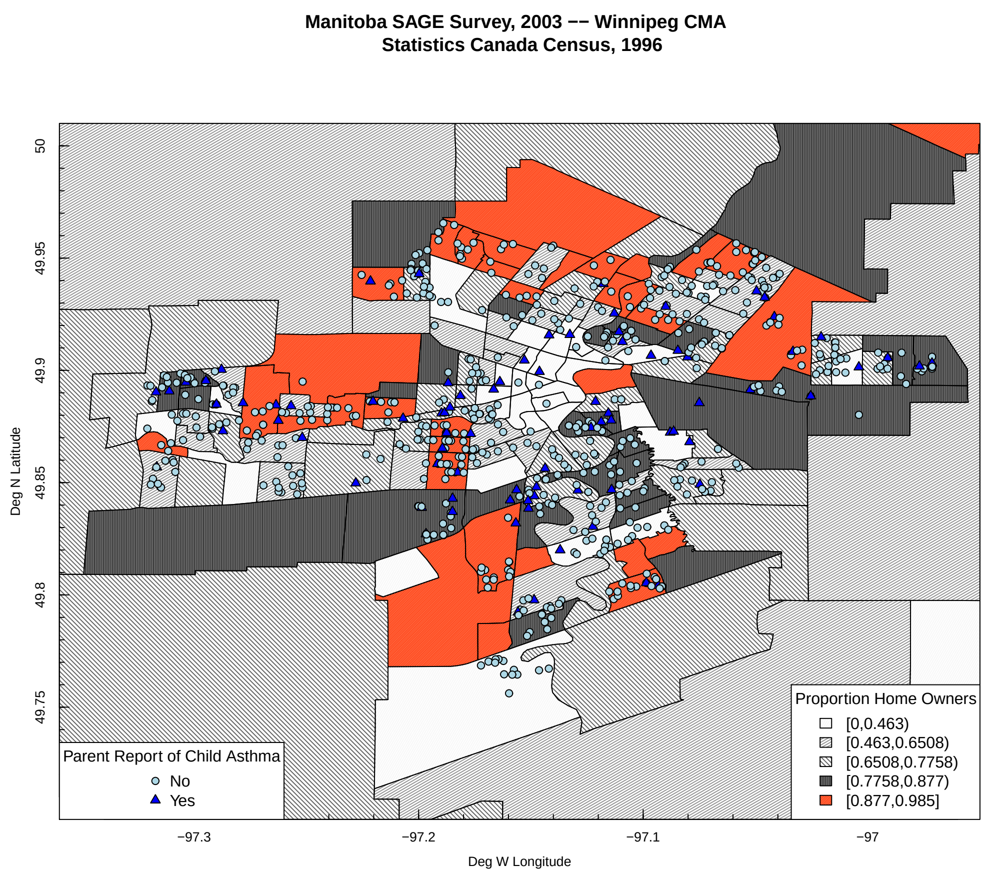


Figure 4.20: Winnipeg Respondents and Home Owner Household Quintiles

4.D.3 Income Government Transfers Comprise:

	Odds Ratio	df	95% CI lower	95% CI upper
Mother has Asthma - No:Yes	0.387	686.5	0.197	0.761
Mother has Asthma - Not Sure:Yes	0.320	687	0.062	1.662
Father has Asthma - No:Yes	0.240	684.9	0.125	0.458
Father has Asthma - Not Sure:Yes	0.676	688.9	0.178	2.558
Income Government Transfer - 1:5	2.760	104.9	1.046	7.281
Income Government Transfer - 2:5	1.515	196.8	0.678	3.384
Income Government Transfer - 3:5	1.250	220.5	0.579	2.702
Income Government Transfer - 4:5	1.056	217.9	0.508	2.194

Table 4.18: GLIMMIX Fixed Effects for Income Government Transfer

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.2438	0.1914	0.08073	2.8975
Residual (VC)	0.9322	0.05104	0.8397	1.0409
Neighbourhood Profile	Estimate	Error	t Value	P-value
Assiniboine South	0.1578	0.3956	0.40	0.6975
Downtown East	0.2159	0.4859	0.44	0.6763
Downtown West	0.2871	0.3930	0.73	0.4789
Fort Garry North	0.6416	0.3954	1.62	0.1314
Fort Garry South	-0.2178	0.4489	-0.49	0.6415
Inkster East	-0.1985	0.4912	-0.40	0.7055
Inkster West	-0.08674	0.4558	-0.19	0.8545
Point Douglas North	-0.1719	0.4578	-0.38	0.7189
Point Douglas South	-0.04149	0.4884	-0.08	0.9359
River East East	-0.03100	0.4015	10.9	0.9398
River East South	0.05640	0.4407	0.13	0.9013
River East West	-0.7290	0.4294	-1.70	0.1244
River Heights East	-0.09641	0.4784	-0.20	0.8477
River Heights West	-0.06734	0.3935	-0.17	0.8670
Seven Oaks East	-0.3547	0.4701	-0.75	0.4794
Seven Oaks West	-0.2727	0.4842	-0.56	0.5979
St. Boniface East	0.3941	0.4364	0.90	0.3921
St. Boniface West	0.5085	0.4457	1.14	0.2880
St. James - Assiniboia East	0.2040	0.3989	0.51	0.6189
St. James - Assiniboia West	0.1426	0.3874	0.37	0.7190
St. Vital North	-0.3311	0.4344	-0.76	0.4665
St. Vital South	-0.1543	0.4327	-0.36	0.7303
Transcona	0.1448	0.3773	0.38	0.7071

Table 4.19: GLIMMIX Random Effects for Income Government Transfer

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3612.26	3634.26	3634.65	3684.14	642.25

Table 4.20: GLIMMIX Model Criteria for Income Government Transfer

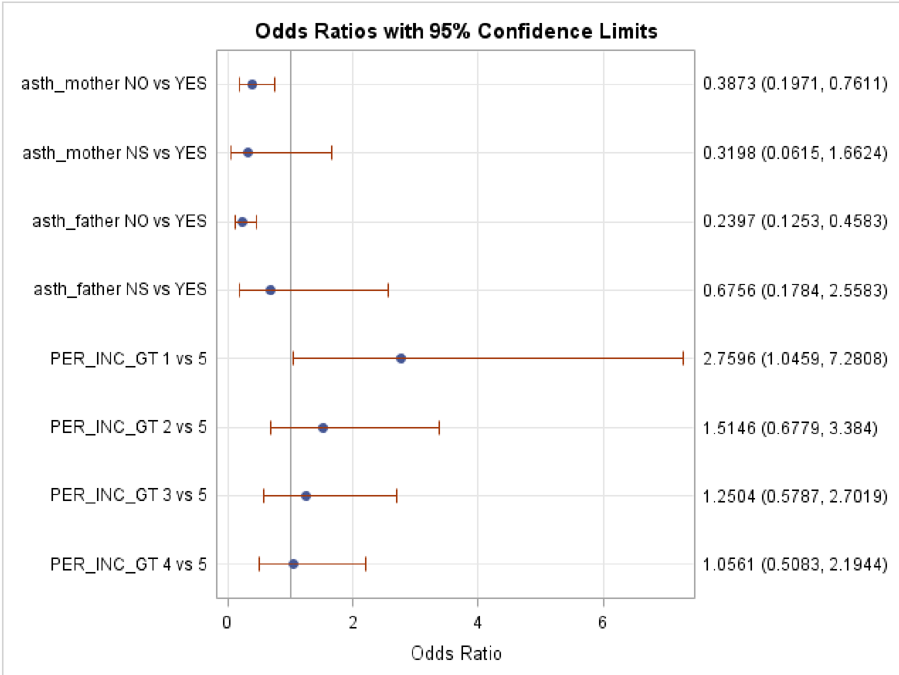


Figure 4.21: GLIMMIX Odds Ratio Plot for Income Government Transfer

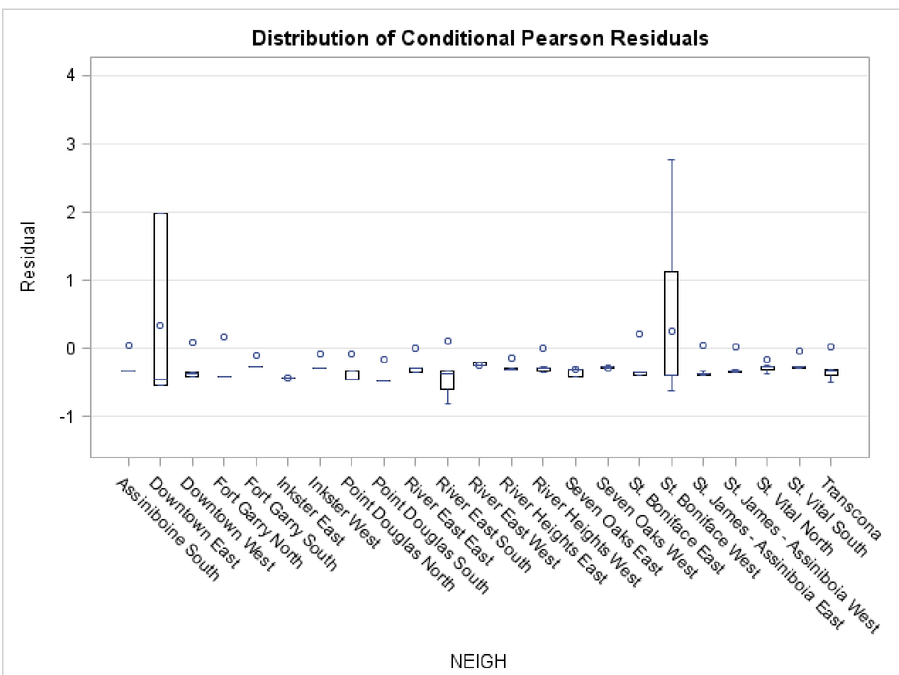


Figure 4.22: Boxplot of GLIMMIX Residuals for Income Government Transfer

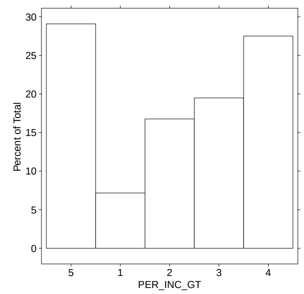


Figure 4.23: Histogram of Birth Home Responses for Income Government Transfer

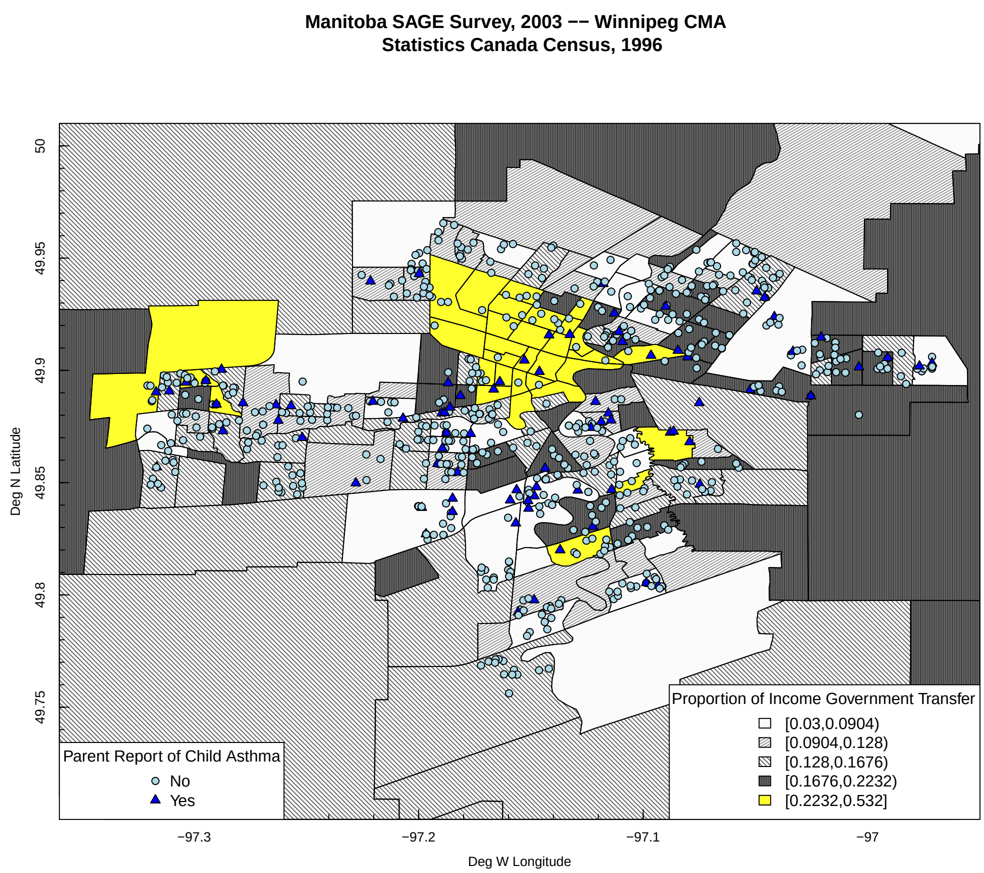


Figure 4.24: Winnipeg Respondents and Income Government Transfer Quintiles

4.D.4 Aboriginal Population Composition:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	4.132	687.2	2.074	8.233
Father has Asthma - Not Sure:No	2.641	690	0.784	8.897
Hay Fever in Child - No:Yes	0.095	668.6	0.049	0.183
Aboriginal - 5:1	0.412	74.54	0.154	1.108
Aboriginal - 4:1	0.315	187.7	0.108	0.915
Aboriginal - 3:1	0.480	101.5	0.181	1.275
Aboriginal - 2:1	0.556	240.7	0.211	1.462

Table 4.21: GLIMMIX Fixed Effects for Aboriginal

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.2392	0.2091	0.07261	4.5084
Residual (VC)	0.9208	0.05044	0.8294	1.0282
Neighbourhood Profile	Estimate	Error	t Value	P-value
River Heights West	0.02803	0.4128	0.07	0.9475
St. Vital South	-0.2693	0.4411	-0.61	0.5621
St. Boniface East	0.5366	0.4514	1.19	0.2781
River East West	-0.6104	0.4445	-1.37	0.2141
Fort Garry North	0.3938	0.4206	0.94	0.3774
Assiniboine South	0.3129	0.4078	0.77	0.4640
St. James - Assiniboia West	0.2090	0.3997	0.52	0.6135
Inkster West	-0.1286	0.4686	-0.27	0.7942
River East East	-0.02276	0.4115	-0.06	0.9571
St. James - Assiniboia East	0.1592	0.4181	0.38	0.7130
Transcona	0.04517	0.4151	0.11	0.9160
River Heights East	-0.04399	0.4871	-0.09	0.9323
St. Vital North	-0.3487	0.4417	-0.79	0.4562
Fort Garry South	-0.3335	0.4538	-0.73	0.4905
Seven Oaks East	-0.05185	0.4872	-0.11	0.9203
St. Boniface West	0.3983	0.4672	0.85	0.4316
Downtown West	0.2652	0.4220	0.63	0.5478
River East South	0.04850	0.4488	0.11	0.9173
Point Douglas South	-0.00134	0.4926	-0.00	0.9980
Point Douglas North	-0.3344	0.4729	-0.71	0.5117
Seven Oaks West	-0.3676	0.4853	-0.76	0.4892
Downtown East	0.2697	0.4916	0.55	0.6148

Table 4.22: GLIMMIX Random Effects for Aboriginal

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3700.39	3720.39	3720.71	3765.75	635.34

Table 4.23: GLIMMIX Model Criteria for Aboriginal

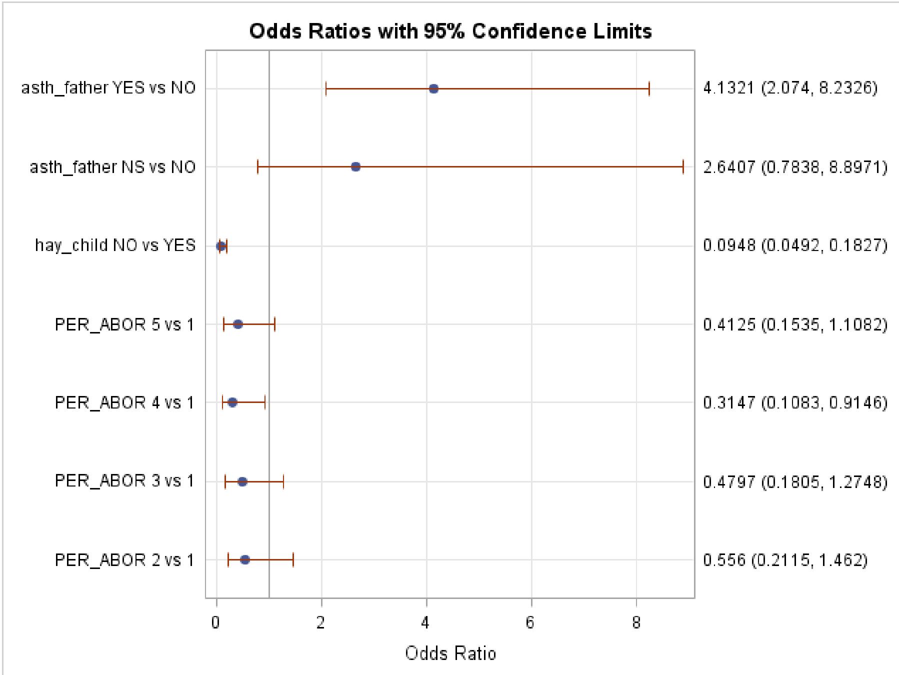


Figure 4.25: GLIMMIX Odds Ratio Plot for Aboriginal

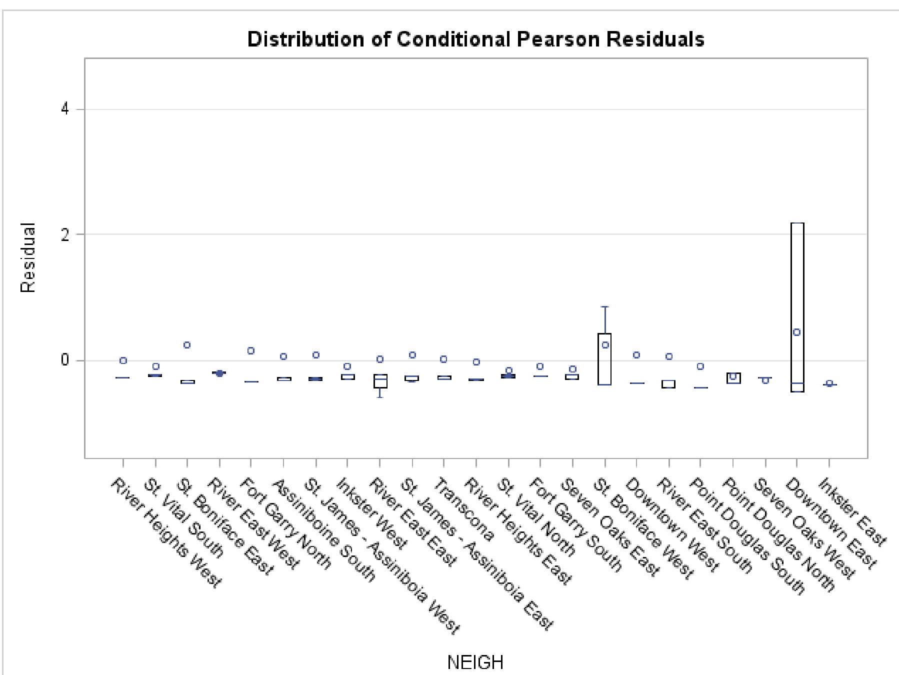


Figure 4.26: Boxplot of GLIMMIX Residuals for Aboriginal

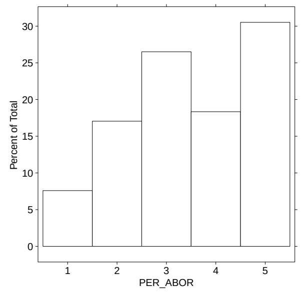


Figure 4.27: Histogram of Birth Home Responses for Aboriginal

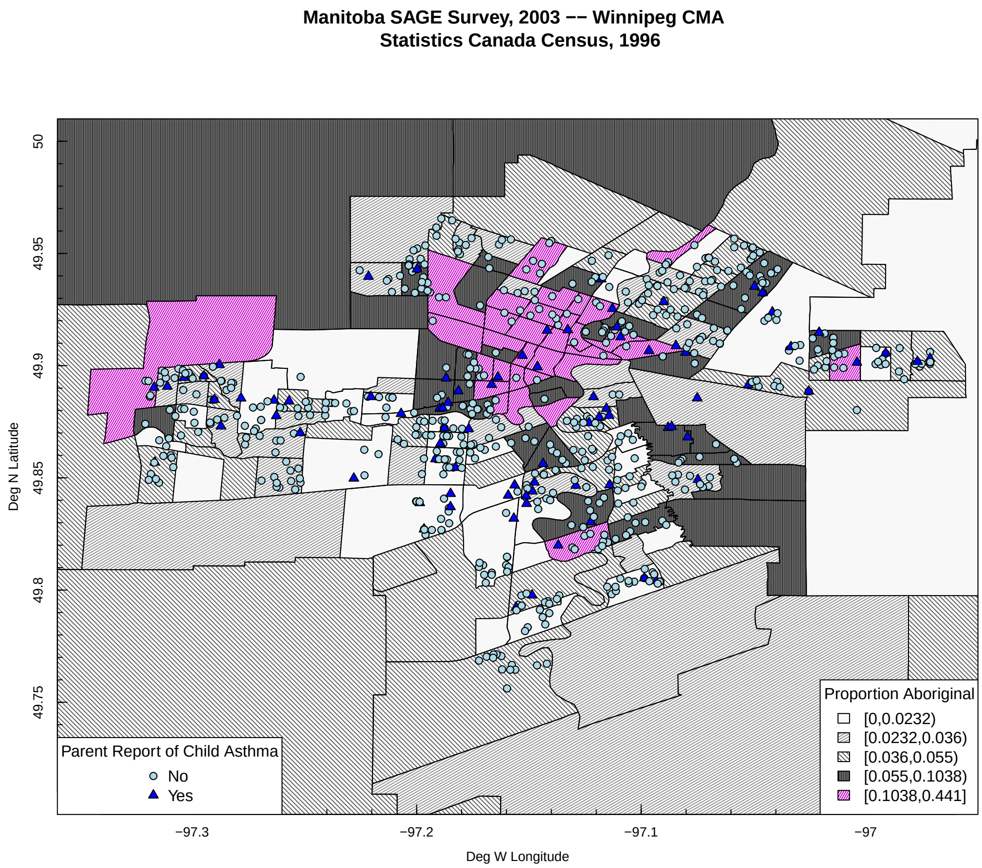


Figure 4.28: Winnipeg Respondents and Aboriginal Quintiles

4.D.5 Median 1995 Income of Population Age 15+:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	4.358	684.4	2.173	8.738
Father has Asthma - Not Sure:No	2.951	685.1	0.842	10.340
Hay Fever in Child - No:Yes	0.091	651.4	0.047	0.176
Mold in Household 1995 - No:Yes	0.100	678.1	0.016	0.632
Median Income - 5:1	3.064	90.34	1.169	8.029
Median Income - 4:1	0.985	209.1	0.438	2.215
Median Income - 3:1	0.716	230.7	0.320	1.603
Median Income - 2:1	1.019	229.9	0.497	2.089

Table 4.24: GLIMMIX Fixed Effects for Median Income

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.1627	0.1790	0.04059	12.5386
Residual (VC)	0.9392	0.05147	0.8460	1.0488
Neighbourhood Profile	Estimate	Error	t Value	P-value
Point Douglas South	-0.03920	0.4227	-0.09	0.9343
St. James - Assiniboia East	0.09511	0.3956	0.24	0.8217
St. Boniface West	0.2960	0.4207	0.70	0.5344
Downtown West	0.2580	0.4008	0.64	0.5560
Point Douglas North	-0.2230	0.4217	-0.53	0.6370
St. Vital North	-0.2151	0.4127	-0.52	0.6354
River East South	0.04041	0.4133	0.10	0.9278
River East West	-0.4662	0.4100	-1.14	0.3286
Fort Garry South	-0.2359	0.4150	-0.57	0.6074
Seven Oaks East	-0.03266	0.4250	-0.08	0.9451
Transcona	0.06622	0.3930	0.17	0.8741
Inkster West	-0.06870	0.4234	-0.16	0.8828
St. James - Assiniboia West	0.1696	0.3925	0.43	0.6870
Fort Garry North	0.2934	0.3975	0.74	0.5019
River Heights East	-0.06663	0.4252	-0.16	0.8883
St. Vital South	-0.2421	0.4066	-0.60	0.5878
Assiniboine South	0.1953	0.3863	0.51	0.6379
River Heights West	0.003871	0.3954	0.01	0.9927
St. Boniface East	0.3788	0.4166	0.91	0.4297
River East East	0.03160	0.3959	0.08	0.9402
Seven Oaks West	-0.2587	0.4252	-0.61	0.5973
Downtown East	0.1483	0.4234	0.35	0.7578
Inkster East	-0.1286	0.4210	-0.31	0.7890

Table 4.25: GLIMMIX Random Effects for Median Income

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3723.12	3745.12	3745.51	3795.01	647.11

Table 4.26: GLIMMIX Model Criteria for Median Income

Figure 4.29: GLIMMIX Odds Ratio Plot for Median Income

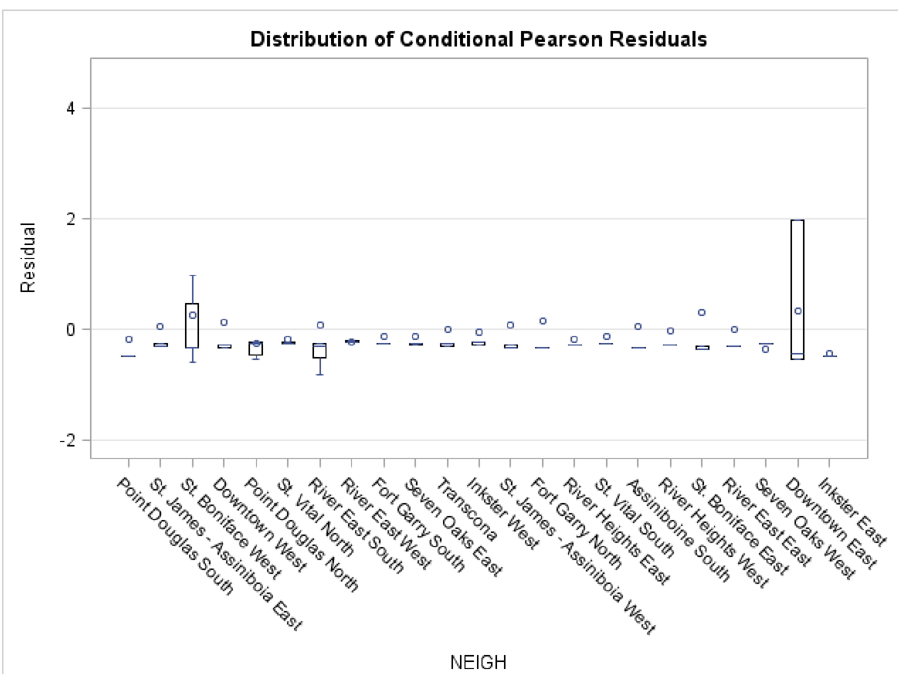


Figure 4.30: Boxplot of GLIMMIX Residuals for Median Income

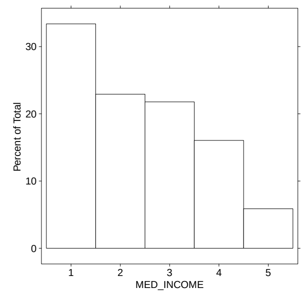


Figure 4.31: Histogram of Birth Home Responses for Median Income

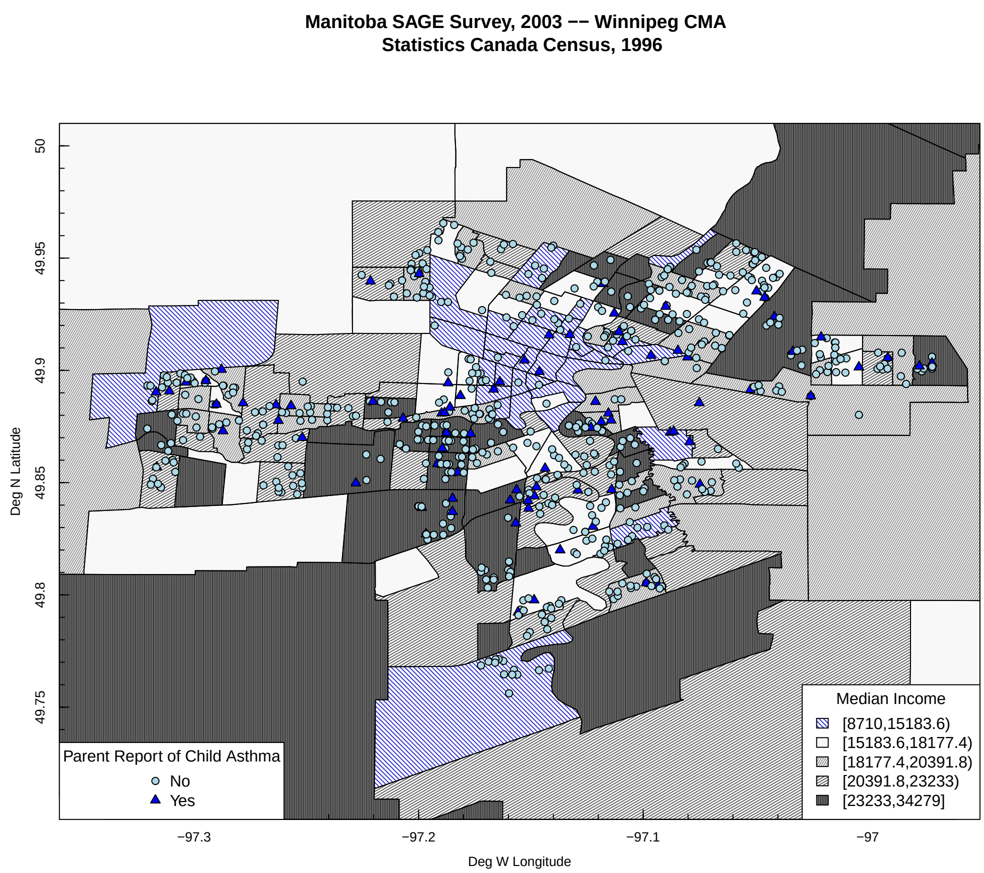


Figure 4.32: Winnipeg Respondents and Median Income Quintiles

4.D.6 Male Population Age 15+ and Unemployed:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	4.288	686.4	2.105	8.736
Father has Asthma - Not Sure:No	3.081	688.1	0.875	10.848
Hay Fever in Child - Yes:No	10.329	646	5.229	20.402
Mold in Household 1995 - No:Yes	0.104	658.9	0.016	0.665
Males Age 15+ Unemployed - 5:1	0.395	90.8	0.150	1.038
Males Age 15+ Unemployed - 4:1	0.241	133.7	0.089	0.655
Males Age 15+ Unemployed - 3:1	0.228	197	0.082	0.629
Males Age 15+ Unemployed - 2:1	0.366	246.1	0.141	0.948

Table 4.27: GLIMMIX Fixed Effects for Males Age 15+ Unemployed

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.1334	0.1737	0.02863	49.4751
Residual (VC)	0.9727	0.05331	0.8762	1.0863
Neighbourhood Profile	Estimate	Error	t Value	P-value
St. James - Assiniboia East	0.1246	0.3965	0.31	0.7790
River Heights West	0.01066	0.3905	0.03	0.9802
St. Vital South	-0.2049	0.3975	-0.52	0.6525
Transcona	0.02981	0.3860	0.08	0.9437
River East West	-0.3547	0.4016	-0.88	0.4665
River East East	-0.02451	0.3916	-0.06	0.9547
Fort Garry North	0.2368	0.3950	0.60	0.6016
Assiniboine South	0.1957	0.3885	0.50	0.6539
St. James - Assiniboia West	0.1046	0.3871	0.27	0.8060
Inkster West	-0.06878	0.4046	-0.17	0.8823
St. Vital North	-0.2000	0.4013	-0.50	0.6642
St. Boniface East	0.3633	0.4041	0.90	0.4719
Seven Oaks East	-0.04253	0.4001	-0.11	0.9275
River Heights East	-0.04038	0.3981	-0.10	0.9311
Downtown West	0.2472	0.3971	0.62	0.5880
Fort Garry South	-0.1232	0.4041	-0.30	0.7908
River East South	0.04029	0.4039	0.10	0.9298
Point Douglas North	-0.2014	0.4042	-0.50	0.6718
St. Boniface West	0.1693	0.4043	0.42	0.7198
Point Douglas South	-0.03196	0.3936	-0.08	0.9452
Seven Oaks West	-0.2435	0.4012	-0.61	0.6195
Downtown East	0.1190	0.3951	0.30	0.8007
Inkster East	-0.1054	0.3902	-0.27	0.8220

Table 4.28: GLIMMIX Random Effects for Males Age 15+ Unemployed

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3752.12	3774.12	3774.51	3824.01	670.21

Table 4.29: GLIMMIX Model Criteria for Males Age 15+ Unemployed

The odds ratio of asthma among children residing in census tracts for the fourth quintile of percentage males age 15+ and unemployed was 75.9% lower (OR 0.241; 95% CI 0.089-0.655) than asthma prevalence in the lowest quintile of percentage males age 15+ and unemployed fitting a hierarchical model. Respondents with a father history of asthma had an over four times increased odds of parent report of child asthma than those without. The ICC of observations grouped within neighbourhood profiles was determined to be 0.1334, suggesting on average that 13.34% of the variance in the dependent variable parent report of child asthma can be attributed to the neighbourhood level in Table 4.28. The Residual (VC) estimate of 0.9727 measures overdispersion and is close to unity, suggesting that a reasonable amount of variation is encountered in the dataset. Examining the random effect estimates of correlation across neighbourhoods, there is slight variation amongst neighbourhoods for dependent variables outcome given the effect percentage males age 15+ and unemployed. The P-values of random effects are greater than 0.05, suggesting that no neighbourhood is significantly different from the others. Location of census tracts with accompanying quintile values is shown in Figure 4.36.

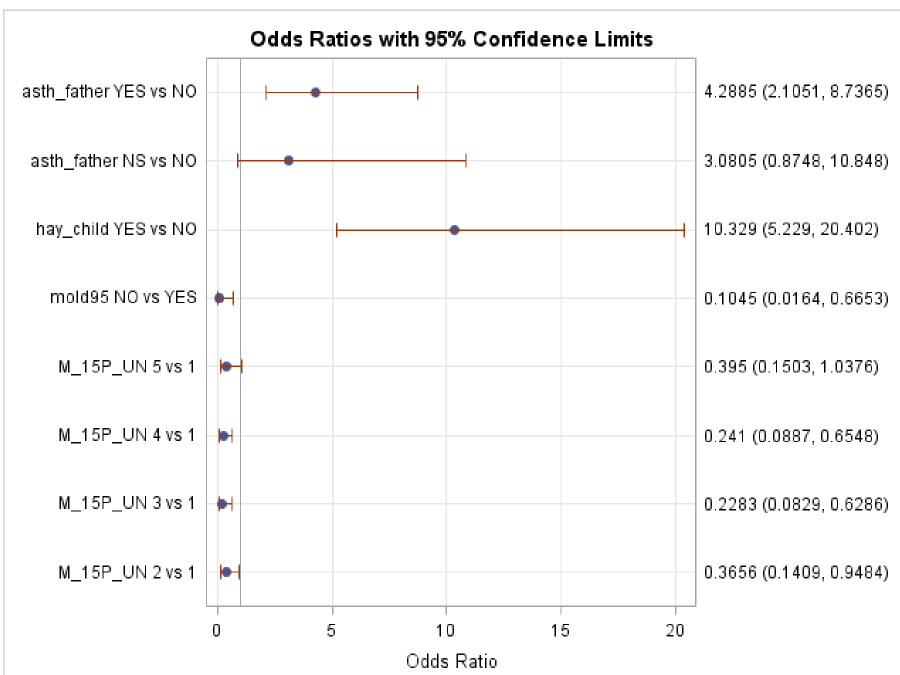


Figure 4.33: GLIMMIX Odds Ratio Plot for Males Age 15+ Unemployed

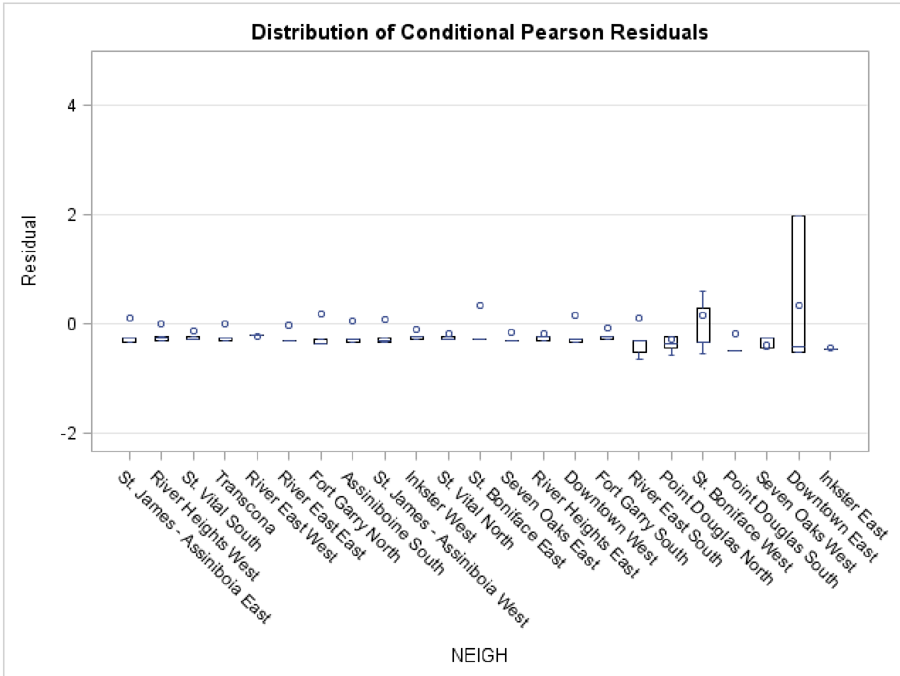


Figure 4.34: Boxplot of GLIMMIX Residuals for Males Age 15+ Unemployed

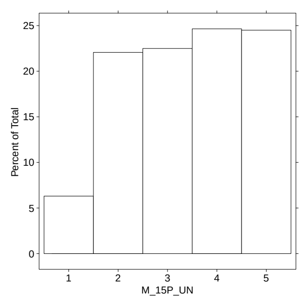


Figure 4.35: Histogram of Birth Home Responses for Males Age 15+ Unemployed

Examining the histogram of birth home survey responses in Figure 4.35, it is apparent that most children reside in census tracts of the highest quintiles male population age 15+ and unemployed. Inspecting the boxplot of Pearson residuals in Figure 4.34, responses within the profile Downtown East had more positive deviation in the fitted model versus actual data observed. This suggests that stressor values are more likely to contribute to parent report of asthma than what the model captures. However, the bulk of residuals are relatively small in magnitude.

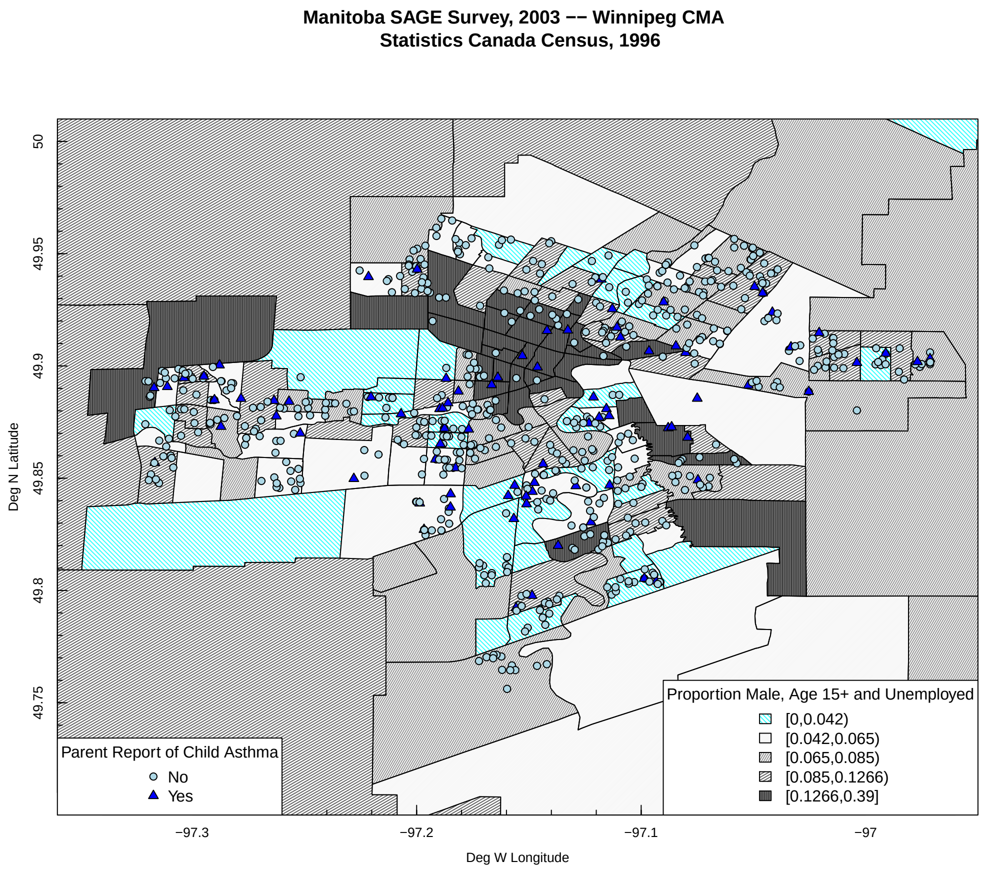


Figure 4.36: Winnipeg Respondents and Males Age 15+ Unemployed Quintiles

LRM and GLM Check of Males Age 15+ Unemployed:

The models below are of fixed effects, and show the difference in effect of neighbourhood being removed for the particular stressor of Males Age 15+ Unemployed assigned at the individual-level.

	Low	High	Δ	Effect	S.E.	Lower 0.95	Upper 0.95
Father has Asthma - Not Sure:No	1	2		1.11	0.64	-0.15	2.37
Odds Ratio	1	2		3.04		0.86	10.75
Father has Asthma - Yes:No	1	3		1.42	0.36	0.70	2.13
Odds Ratio	1	3		4.12		2.02	8.40
Hay Fever in Child - Yes:No	1	2		2.32	0.34	1.65	2.99
Odds Ratio	1	2		10.17		5.20	19.88
Mold in Household 1995 - 0:1	1	2		-2.31	0.94	-4.15	-0.47
Odds Ratio	1	2		0.10		0.02	0.63
Males Age 15+ Unemployed - 2:1	1	2		-1.00	0.46	-1.91	-0.09
Odds Ratio	1	2		0.37		0.15	0.92
Males Age 15+ Unemployed - 3:1	1	3		-1.51	0.49	-2.47	-0.55
Odds Ratio	1	3		0.22		0.08	0.58
Males Age 15+ Unemployed - 4:1	1	4		-1.38	0.48	-2.31	-0.45
Odds Ratio	1	4		0.25		0.10	0.64
Males Age 15+ Unemployed - 5:1	1	5		-0.90	0.45	-1.77	-0.02
Odds Ratio	1	5		0.41		0.17	0.98

Table 4.30: LRM for Males Age 15+ Unemployed

# Observations	Somers' Dxy	Goodman-Kruskal's γ	Kendall's τ_a	R-Squared
698	0.4288	0.4779	0.0909	0.2009

Table 4.31: LRM Diagnostics for Males Age 15+ Unemployed

	Estimate	S.E.	t value	P-value
Father has Asthma - Not Sure:No	1.1129	0.6439	1.73	0.0839
Father has Asthma - Yes:No	1.4160	0.3636	3.89	0.0001
Hay Fever in Child - Yes:No	2.3196	0.3419	6.79	0.0000
Mold in Household 1995 - No:Yes	-2.3115	0.9398	-2.46	0.0139
Males Age 15+ Unemployed - 2:1	-0.9961	0.4640	-2.15	0.0318
Males Age 15+ Unemployed - 3:1	-1.5111	0.4899	-3.08	0.0020
Males Age 15+ Unemployed - 4:1	-1.3805	0.4753	-2.90	0.0037
Males Age 15+ Unemployed - 5:1	-0.8958	0.4468	-2.00	0.0450

Table 4.32: GLM for Males Age 15+ Unemployed

The odds ratio of Males Age 15+ Unemployed 4:1 census tracts, and a rough estimate of the 95% confidence interval associated with it, can be calculated by the following method: $\hat{\Psi}^{(4:1)} = \exp\left(\beta_1{}^{(4)} - \beta_1{}^{(1)}\right) = \exp\left(\beta_1{}^{(4:1)}\right) = \exp\left(-1.3805\right) = 0.251$ is the odds ratio. $\hat{se}(\hat{logit}^{(4)} - \hat{logit}^{(1)}) = \hat{se}(\hat{logit}^{(4:1)}) = 0.4753$ is the standard error. Thus, an approximate 95% confidence interval for $\hat{\Psi}^{(4:1)}$ is $\exp\left(-1.3805 \pm 1.96 \times 0.4753\right)$, that is $\exp\left(-1.4940 \pm 0.932\right)$ or (0.099, 0.638). This agrees very much to the confidence interval obtained from the LRM with Males Age 15+ Unemployed. The effect of grouping variance through neighbourhood in the GLIMMIX model was found not to influence greatly the predictor estimate in this example, but may be more pronounced for other stressors.

The coefficient of determination, also known as the R-Squared value of 0.2009 obtained from the LRM output explains the total amount of variation that the predictors neighbourhood quintile proportion of males unemployed age 15+, father history of asthma, history of hay fever in child, and 1995 report of mold in household account for amongst respondents in the SAGE Survey to parent report of child asthma status. Based on the findings of R-Squared having a low value, it would be inappropriate to infer a pathway of disease (childhood asthma) based solely on the predictors presented above. However, R-Squared is not an entirely accurate diagnostic to use for data with a binary outcome, as a non-Gaussian distribution is used. Somers' Dxy rank correlation is a better measure, since it is explicitly a non-parametric method that gives a measure of total variance explained that is analogous to R-Squared (Jr & with contributions from many other users., 2009). A Dxy correlation of 0.4288 is obtained form the LRM output, which although much better than that of R-Squared, explains less than half of the total variance observed.

Urban Males Age 15+ Unemployed Including Non-Birth Homes:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	2.601	1463	1.611	4.199
Father has Asthma - Not Sure:No	3.554	1461	1.813	6.964
Hay Fever in Child - Yes:No	8.818	1329	5.788	13.435
Mold in Household 1995 - No:Yes	0.854	1463	0.558	1.309
Males Age 15+ Unemployed - 5:1	0.684	98.58	0.380	1.231
Males Age 15+ Unemployed - 4:1	0.499	146.6	0.272	0.916
Males Age 15+ Unemployed - 3:1	0.718	168.4	0.403	1.278
Males Age 15+ Unemployed - 2:1	0.909	330.2	0.504	1.637

Table 4.33: GLIMMIX Fixed Effects for Urban Males Age 15+ Unemployed

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.01393	0.04929	0.001337	2.086E17
Residual (VC)	0.9905	0.03684	0.9221	1.0669
Neighbourhood Profile	Estimate	Error	t Value	P-value
St. James - Assiniboia East	0.03377	0.2012	0.17	0.8941
St. Vital South	-0.06014	0.1884	-0.32	0.8033
Fort Garry North	0.03233	0.1921	0.17	0.8938
River Heights West	-0.02726	0.2120	-0.13	0.9186
St. Vital North	-0.00854	0.1946	-0.04	0.9721
Transcona	0.007752	0.2083	0.04	0.9763
River East West	-0.08241	0.2077	-0.40	0.7595
River East East	0.02748	0.2070	0.13	0.9160
Assiniboine South	0.005403	0.2029	0.03	0.9831
St. James - Assiniboia West	-0.01403	0.2012	-0.07	0.9557
Seven Oaks West	-0.02174	0.1659	-0.13	0.9171
Inkster West	0.04371	0.1864	0.23	0.8534
St. Boniface East	0.05431	0.1790	0.30	0.8125
Seven Oaks East	-0.02186	0.1597	-0.14	0.9134
Downtown West	0.02713	0.1966	0.14	0.9127
River Heights East	-0.01452	0.1533	-0.09	0.9399
Point Douglas North	-0.03370	0.1782	-0.19	0.8810
Fort Garry South	-0.00287	0.1905	-0.02	0.9904
River East South	0.005731	0.1702	0.03	0.9786
St. Boniface West	0.000269	0.1806	0.00	0.9991
Point Douglas South	0.002879	0.1415	0.02	0.9870
Downtown East	0.02270	0.1474	0.15	0.9027
Inkster East	0.02361	0.1461	0.16	0.8980

Table 4.34: GLIMMIX Random Effects for Urban Males Age 15+ Unemployed

-2 Res logLik	AIC	AICC	BIC	Chi-Square
7676.45	7698.45	7698.63	7756.62	1449.11

Table 4.35: GLIMMIX Model Criteria for Urban Males Age 15+ Unemployed

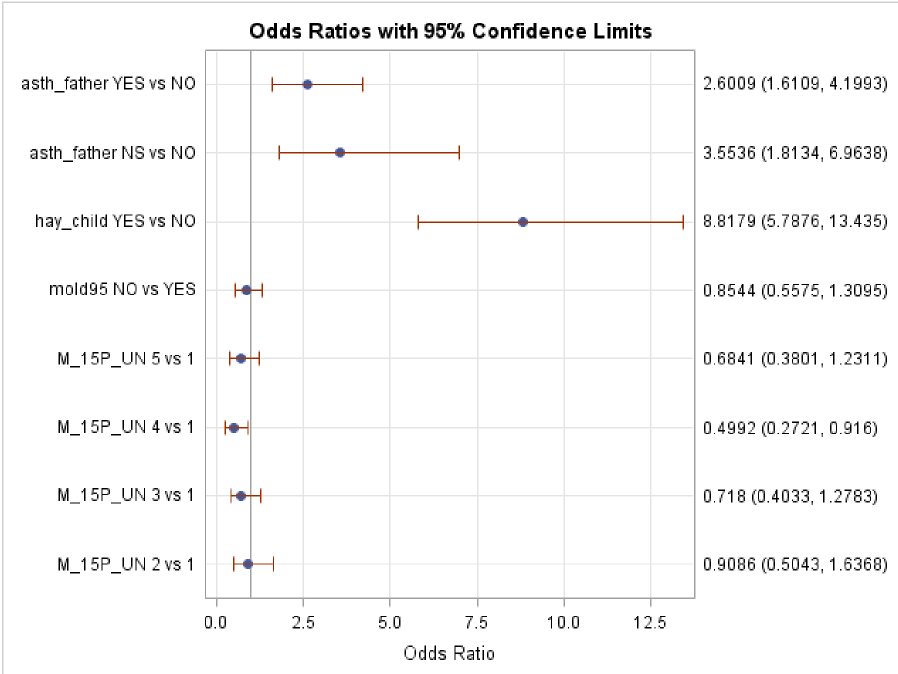


Figure 4.37: GLIMMIX Odds Ratio Plot of Urban Responses for Males Age 15+ Unemployed

It is of interest to determine the hierarchical model output of urban component for the entire SAGE cohort inclusive of respondents residing in both birth and non-birth homes at time of survey administration. Impact of neighborbood stressor can be gauged amongst residents of birth homes to that of entire neighbourhood respondents in 2002-2003. The differences can be compared to those of the fixed and namely random effects in Tables 4.34 and 4.28. The strength of the relationship between asthma prevalence and higher quintiles of percentage males age 15+ and unemployed is weaker in odds ratio and less significant among entire neighbourhood respondents than those resident of birth homes. This is an example of non-directional selection bias in a cohort study (Aschengrau & Seage, 2008, 267). Of remark is that for children whom it is unsure if the father has asthma were significantly more likely to have three and a half times the odds for parent report of asthma compared to children where it was known the father has no history of asthma.

Notice that the proportion of variance explained in dependent variable by the neighbourhood level is much less for respondents grouped in neighbourhood profiles in Table 4.34 compared to residents of birth homes, which suggest that a neighbourhood effect is discernible for children who have remained resident of the same neighbourhood. The model selection criteria in Table 4.35 provide a poorer fit compared to Table 4.29.

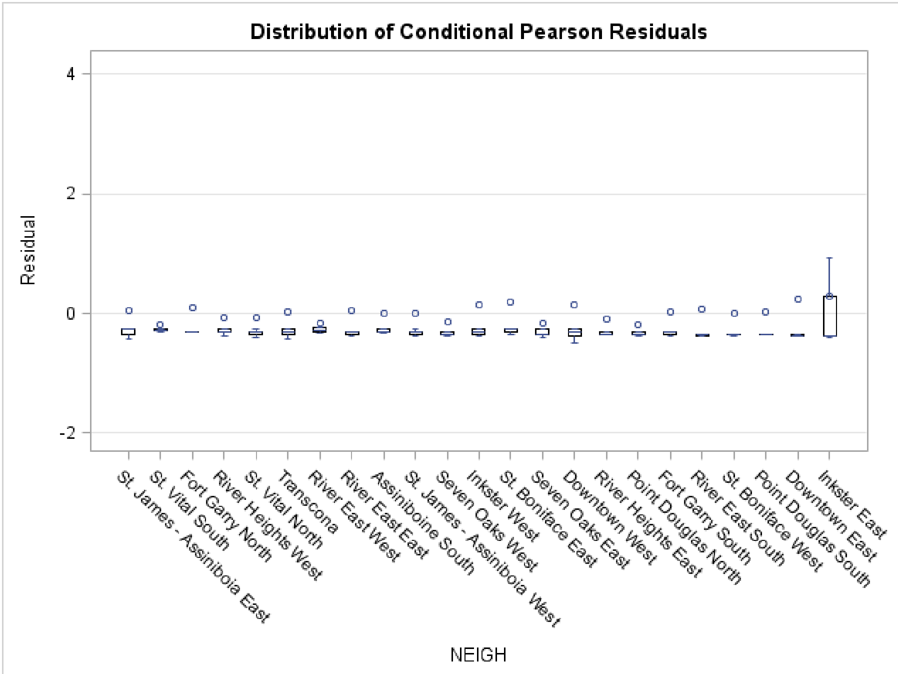


Figure 4.38: Boxplot of GLIMMIX Residuals for Urban Males Age 15+ Unemployed

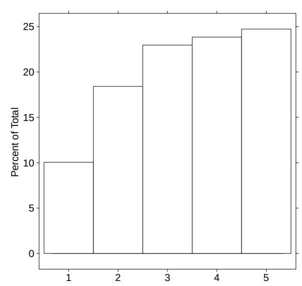


Figure 4.39: Histogram of Responses for Urban Males Age 15+ Unemployed

Examining the histogram of urban survey responses in Figure 4.39, it is apparent that most children reside in census tracts of the highest quintiles male population age 15+ and unemployed. Inspecting the boxplot of Pearson residuals in Figure 4.38, the profile Inkster East had the worst model fit with positive residuals in parent report of child asthma.

4.E HLMs for Physical Disorder Domain

4.E.1 Population that is Male Age 15 to 24:

	Odds Ratio	df	95% CI lower	95% CI upper
Family History of Asthma - Yes:No	4.518	689.6	2.783	7.334
Smoking in Household - No:Yes	0.575	684.1	0.334	0.987
Males Age 15 to 24 - 5:1	1.412	258.6	0.593	3.362
Males Age 15 to 24 - 4:1	1.642	318.1	0.759	3.554
Males Age 15 to 24 - 3:1	2.311	447.2	1.113	4.800
Males Age 15 to 24 - 2:1	1.953	540.2	0.881	4.330

Table 4.36: GLIMMIX Fixed Effects for Males Age 15 to 24

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.1091	0.1471	0.02268	60.6344
Residual (VC)	0.9766	0.05338	0.8798	1.0903
Neighbourhood Profile	Estimate	Error	t Value	P-value
St. James - Assiniboia East	0.1852	0.3650	0.51	0.6591
Fort Garry North	0.3567	0.3673	0.97	0.4330
River Heights West	-0.09361	0.3611	-0.26	0.8165
River East South	0.04847	0.3704	0.13	0.9094
River East West	-0.3758	0.3673	-1.02	0.4115
St. James - Assiniboia West	0.08097	0.3604	0.22	0.8402
Seven Oaks East	-0.06726	0.3639	-0.18	0.8763
River Heights East	-0.1141	0.3669	-0.31	0.7938
Point Douglas North	0.01215	0.3678	0.03	0.9775
St. Vital South	-0.1287	0.3688	-0.35	0.7611
River East East	-0.04681	0.3636	-0.13	0.9082
Fort Garry South	-0.1209	0.3704	-0.33	0.7792
St. Boniface West	0.2568	0.3695	0.70	0.5733
Downtown West	0.1326	0.3648	0.36	0.7488
Point Douglas South	0.01693	0.3518	0.05	0.9681
St. Vital North	-0.1735	0.3698	-0.47	0.6877
Assiniboine South	-0.03958	0.3564	-0.11	0.9199
Inkster West	-0.06163	0.3696	-0.17	0.8859
Transcona	0.07331	0.3587	0.20	0.8540
St. Boniface East	0.1364	0.3701	1.816	0.7510
Seven Oaks West	-0.08450	0.3539	-0.24	0.8440
Downtown East	0.09078	0.3578	0.25	0.8337
Inkster East	-0.08394	0.3524	-0.24	0.8447

Table 4.37: GLIMMIX Random Effects for Males Age 15 to 24

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3694.38	3712.38	3712.65	3753.22	674.81

Table 4.38: GLIMMIX Model Criteria for Males Age 15 to 24

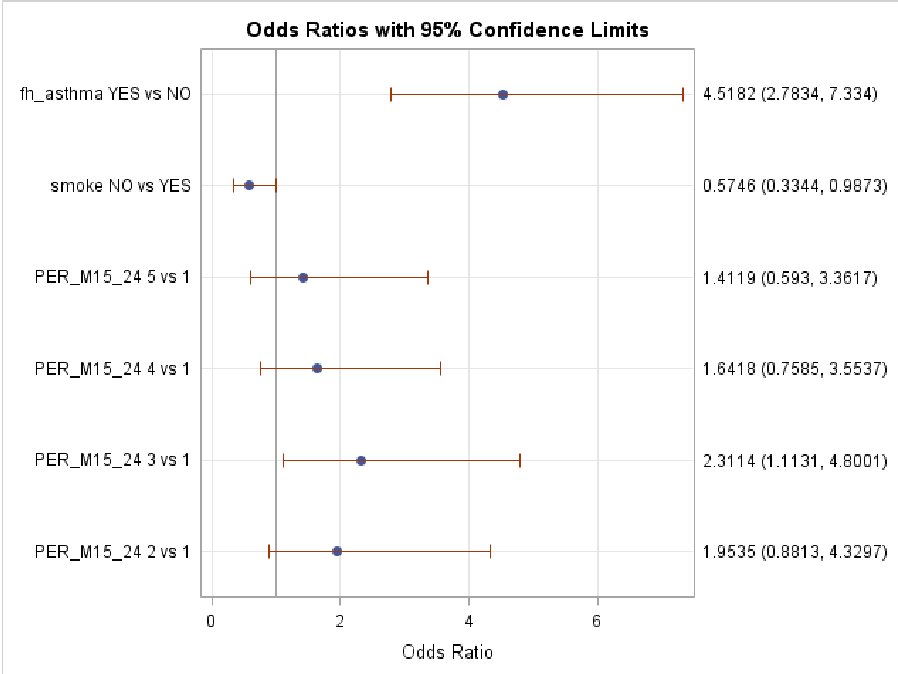


Figure 4.40: GLIMMIX Odds Ratio Plot for Males Age 15 to 24

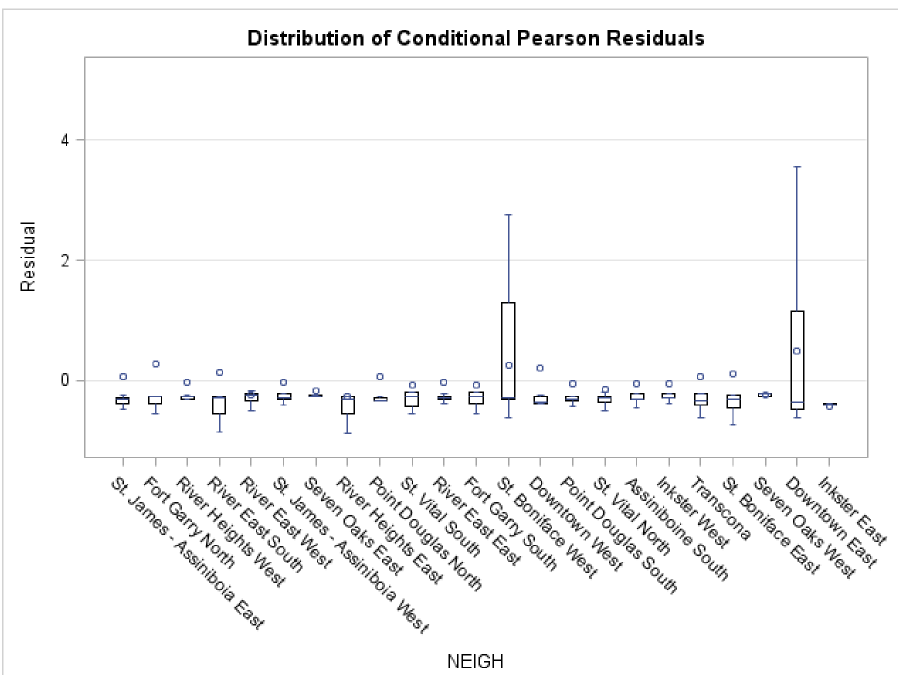


Figure 4.41: Boxplot of GLIMMIX Residuals for Males Age 15 to 24

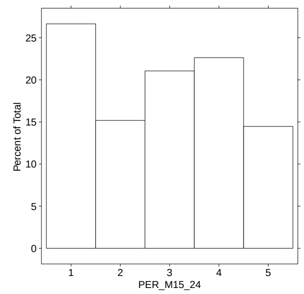


Figure 4.42: Histogram of Birth Home Responses for Males Age 15 to 24

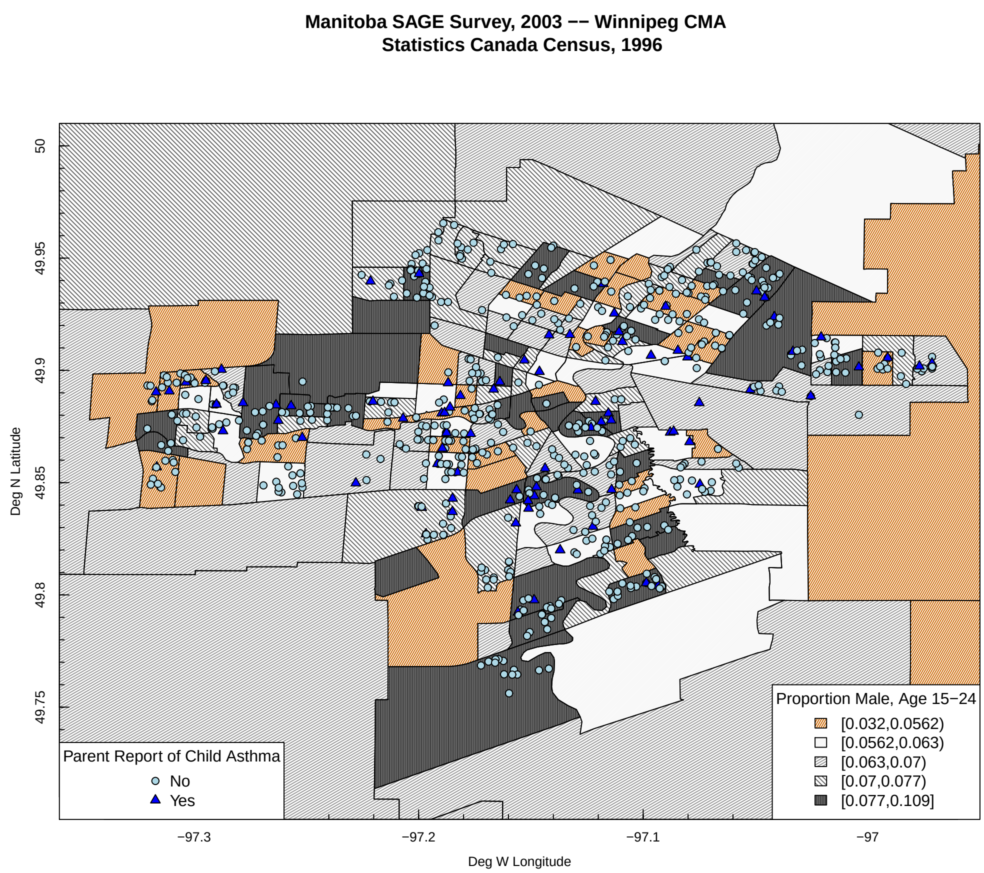


Figure 4.43: Winnipeg Respondents and Males Age 15 to 24 Quintiles

4.E.2 Labour Force Participation Age 15 to 64:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	4.276	685.2	2.155	8.486
Father has Asthma - Not Sure:No	2.682	691.3	0.804	9.050
Hay Fever in Child - No:Yes	11.337	670.9	5.877	21.870
Mold in Household 1995 - No:Yes	0.123	685.8	0.020	0.747
Labour Force Participation - 5:1	1.836	222.1	0.678	4.972
Labour Force Participation - 4:1	2.275	162.9	1.016	5.098
Labour Force Participation - 3:1	1.070	371.5	0.500	2.288
Labour Force Participation - 2:1	1.544	144.3	0.690	3.456

Table 4.39: GLIMMIX Fixed Effects for Labour Force Participation

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.3088	0.2334	0.1053	3.1880
Residual (VC)	0.8931	0.04899	0.8044	0.9975
Neighbourhood Profile	Estimate	Error	t Value	P-value
St. James - Assiniboia East	-0.04130	0.4243	-0.10	0.9238
River East West	-0.9025	0.4694	-1.92	0.0823
Point Douglas South	0.08972	0.5479	0.16	0.8765
St. James - Assiniboia West	0.1787	0.4040	0.44	0.6640
St. Boniface West	0.4489	0.4858	0.92	0.3792
River Heights West	-0.09990	0.4077	-0.25	0.8095
Point Douglas North	-0.2590	0.4962	-0.52	0.6152
St. Vital North	-0.3837	0.4672	-0.82	0.4296
Seven Oaks East	-0.2229	0.5174	-0.43	0.6797
Transcona	0.1183	0.4130	0.29	0.7784
Fort Garry North	0.3895	0.4244	0.92	0.3740
Downtown West	0.4433	0.4209	1.05	0.3094
River East South	0.1474	0.4790	0.31	0.7648
River Heights East	-0.1030	0.5284	-0.19	0.8517
Inkster West	-0.1487	0.4986	-0.30	0.7729
Fort Garry South	-0.4334	0.4818	-0.90	0.3910
St. Vital South	-0.2097	0.4741	-0.44	0.6681
St. Boniface East	0.5418	0.4640	1.17	0.2681
River East East	0.1667	0.4347	0.38	0.7077
Assiniboine South	0.4425	0.4195	1.05	0.3096
Seven Oaks West	-0.4132	0.5331	-0.78	0.4682
Downtown East	0.4157	0.5438	0.76	0.4778
Inkster East	-0.1653	0.5514	-0.30	0.7774

Table 4.40: GLIMMIX Random Effects for Labour Force Participation

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3695.61	3717.61	3718.00	3767.50	615.36

Table 4.41: GLIMMIX Model Criteria for Labour Force Participation

It was observed that the odds ratio of asthma among children residing in census tracts for the fourth quintile of percentage labour participation age 15 to 64 was over twice as high (OR 2.275; 95% CI 1.016-5.098) as asthma prevalence in the lowest quintile of percentage labour force participation age 15 to 64 fitting a hierarchical model. Respondents with a father history of asthma had an over four times increased odds of parent report of child asthma than those without. Children of households without mold in 1995 had an eight times (OR 0.123; 95% CI 0.020-0.747) lower odds for parent report of asthma than those with. The effect of neighbourhood on parent report of child asthma is modestly large in magnitude, with 30.9% of the variance in the dependent variable attributable to the neighbourhood level. Relatively large and different correlations amongst neighbourhood profiles is apparent in Table 4.40, with differences in quintile value of percentage labour participation age 15 to 64 being highly positively associated with parent report of child asthma in profiles St. Boniface East and St. Boniface West, and negatively correlated in Fort Garry South and Seven Oaks West.

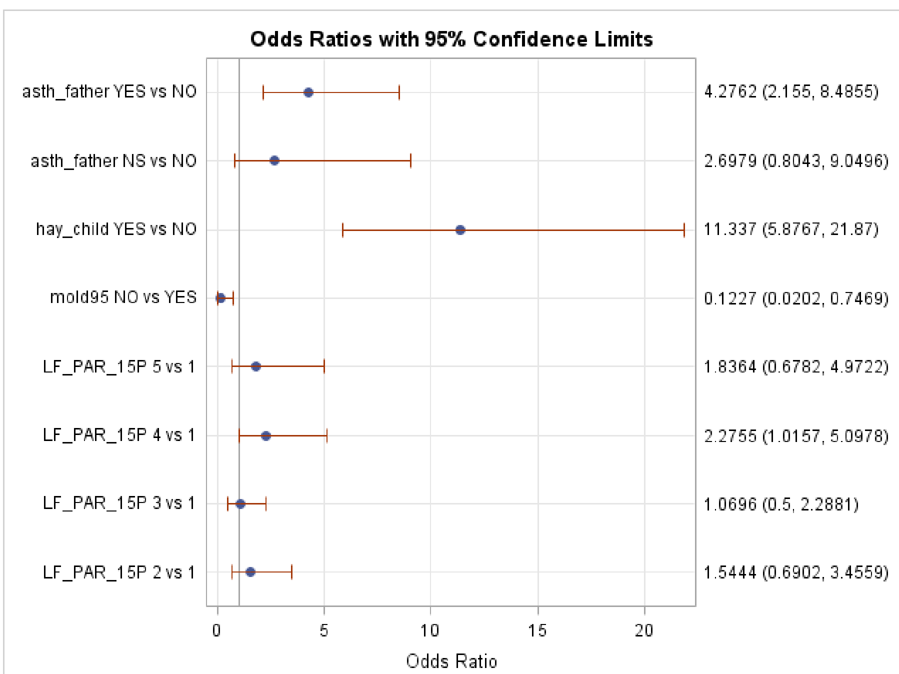


Figure 4.44: GLIMMIX Odds Ratio Plot for Labour Force Participation

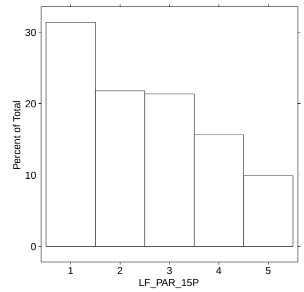


Figure 4.45: Histogram of Birth Home Responses for Labour Force Participation

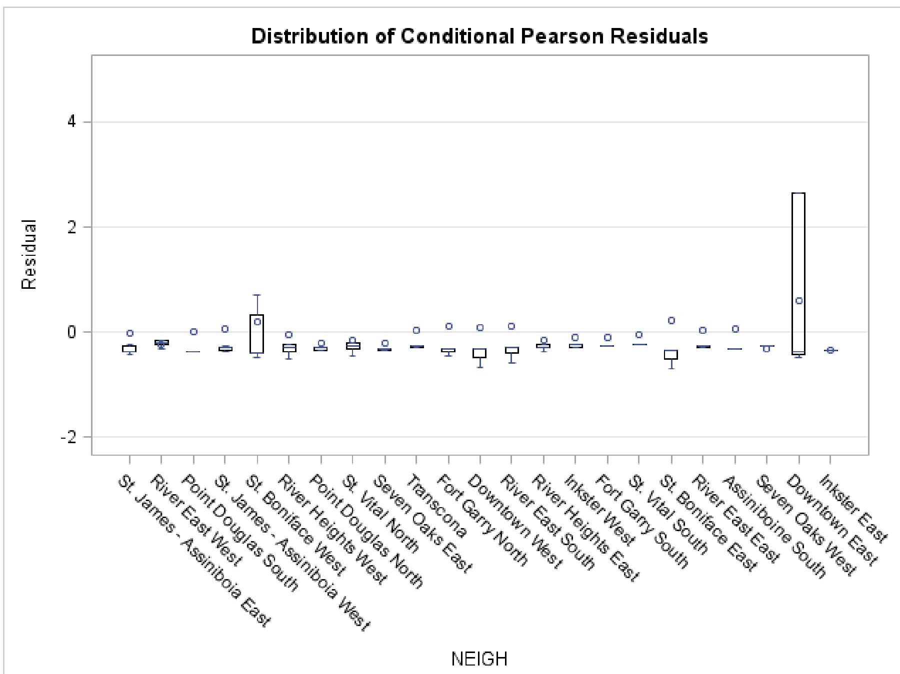


Figure 4.46: Boxplot of GLIMMIX Residuals for Labour Force Participation

Examining the histogram of birth home survey responses in Figure 4.45, it is apparent that most children reside in census tracts of the lowest quintiles labour force participation age 15 to 64. Inspecting the boxplot of Pearson residuals in Figure 4.46, responses from profiles Downtown East and St. Boniface West provide the most deviance for model fitting.

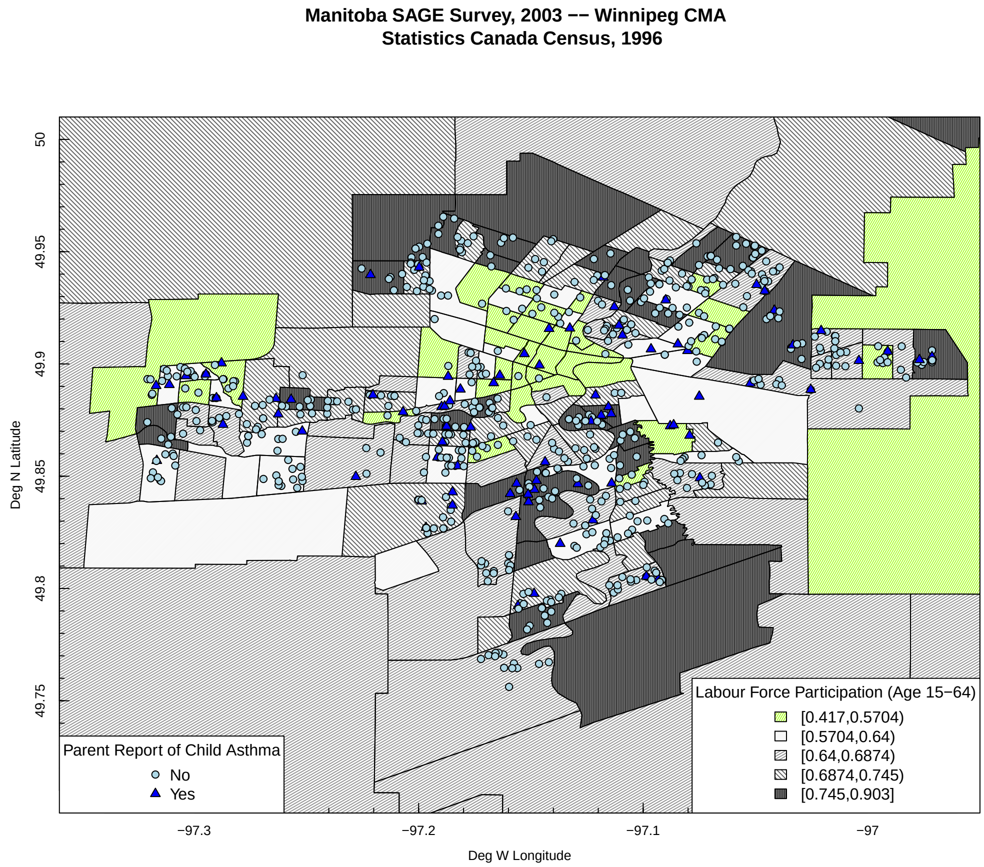


Figure 4.47: Winnipeg Respondents and Labour Force Participation Quintiles

LRM and GLM Check of Labour Force Participation:

The models below are of only fixed effect parameters ignoring random effect, and show the difference in effect of neighbourhood being removed for the particular stressor of Labour Force Participation assigned at the individual-level.

	Low	High	Δ	Effect	S.E.	Lower 0.95	Upper 0.95
Father has Asthma - Not Sure:No	1	2		0.96	0.63	-0.28	2.20
Odds Ratio	1	2		2.61		0.75	9.04
Father has Asthma - Yes:No	1	3		1.37	0.36	0.66	2.08
Odds Ratio	1	3		3.93		1.94	7.99
Hay Fever in Child - No:Yes	1	2		-2.35	0.34	-3.01	-1.69
Odds Ratio	1	2		0.10		0.05	0.18
Mold in Household 1995 - No:Yes	1	2		-2.14	0.94	-3.99	-0.29
Odds Ratio	1	2		0.12		0.02	0.75
Labour Force Participation - 2:1	1	2		0.21	0.36	-0.50	0.92
Odds Ratio	1	2		1.24		0.61	2.52
Labour Force Participation - 3:1	1	3		0.03	0.37	-0.70	0.76
Odds Ratio	1	3		1.03		0.50	2.13
Labour Force Participation - 4:1	1	4		0.67	0.36	-0.04	1.38
Odds Ratio	1	4		1.95		0.96	3.97
Labour Force Participation - 5:1	1	5		0.22	0.48	-0.71	1.16
Odds Ratio	1	5		1.25		0.49	3.18

Table 4.42: LRM for Labour Force Participation

# Observations	Somers' Dxy	Goodman-Kruskal's γ	Kendall's τ_a	R-Squared
698	0.4353	0.4988	0.0923	0.1833

Table 4.43: LRM Diagnostics for Labour Force Participation

	Estimate	S.E.	t value	P-value
Father has Asthma - Not Sure:No	0.9591	0.6338	1.51	0.1302
Father has Asthma - Yes:No	1.3692	0.3618	3.78	0.0002
Hay Fever in Child - No:Yes	-2.3509	0.3374	-6.97	0.0000
Mold in Household 1995 - No:Yes	-2.1367	0.9442	-2.26	0.0236
Labour Force Participation - 2:1	0.2146	0.3624	0.59	0.5537
Labour Force Participation - 3:1	0.0276	0.3723	0.07	0.9410
Labour Force Participation - 4:1	0.6675	0.3628	1.84	0.0658
Labour Force Participation - 5:1	0.2218	0.4778	0.46	0.6425

Table 4.44: GLM for Labour Force Participation

The odds ratio of Labour Force Participation 4:1 census tracts, and a rough estimate of the 95% confidence interval associated with it, can be calculated by the following method:

$\hat{\Psi}^{(4:1)} = \exp(\beta_1{}^{(4:1)}) = \exp(0.6675) = 1.949$ is the odds ratio. $\hat{se}(\hat{logit}^{(4)} - \hat{logit}^{(1)}) = \hat{se}(\hat{logit}^{(4:1)}) = 0.3628$ is the standard error. Thus, an approximate 95% confidence interval for $\hat{\Psi}^{(4:1)}$ can be calculated as $\exp(0.6675 \pm 1.96 \times 0.3628)$, or (0.957, 3.969). This agrees with the confidence interval obtained from the LRM with Labour Force Participation.

The Goodman-Kruskal's Gamma test statistic is given in Table 4.43 with a value of 0.4988, which suggests that assuming ordinal values for both the predictor Labour Force Participation and dependent outcome parent report of child asthma, a positive association is observed (Harrell, 2009, 86). This means that children resident of neighbourhoods with higher proportions of the working age population holding active employment are more likely to have report of asthma. Kendall's Tau-A is similar to Goodman-Krustal's Gamma, but can also use values that are continuous and gives a measure of association between ordered explanatory and dependent ranked variables when the assumptions in Pearson's correlation coefficient are not met (Arndt & Magnotta, 2001, 18). Kendall's Tau-A is more useful than Spearman's rank correlation, in that an estimate on both the significance and strength of relationship can be inferred, whereas the Spearman's coefficient is not meaningful for strength of the relationship (Peacock & Kerry, 2007, 96). Both the Goodman-Kruskal's Gamma and Kendall's Tau-A test statistics range between values of -1 and +1, with the lower end meaning perfect discordant pairs, upper end perfect concordant pairs, and 0 signifying no association (Kianifard & Chen, 1999, 524). A value of 0.0923 is observed for Kendall's Tau-A, which alludes that the relationship between the proportion of working population in neighbourhoods and childhood asthma appears to be relatively independent. However, this is incorrect, given that it is known the predictor and dependent variables are not on a continous scale.

Urban Labour Force Participation Including Non-Birth Homes:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	2.618	1463	1.624	4.220
Father has Asthma - Not Sure:No	3.297	1456	1.694	6.417
Hay Fever in Child - No:Yes	0.117	1397	0.077	0.178
Mold in Household 1995 - Yes:No	1.172	1462	0.766	1.795
Labour Force Participation - 5:1	1.139	224	0.623	2.083
Labour Force Participation - 4:1	1.431	146.9	0.850	2.410
Labour Force Participation - 3:1	1.217	494.2	0.745	1.990
Labour Force Participation - 2:1	1.476	141.5	0.901	2.419

Table 4.45: GLIMMIX Fixed Effects for Labour Force Participation

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.04243	0.05932	0.008535	37.1249
Residual (VC)	0.9826	0.03656	0.9147	1.0583
Neighbourhood Profile	Estimate	Error	t Value	P-value
Point Douglas North	-0.05211	0.2319	-0.22	0.8502
St. Boniface West	0.04464	0.2335	0.19	0.8706
River East West	-0.2469	0.2319	-1.06	0.4011
St. James - Assiniboia East	0.02620	0.2325	0.11	0.9213
River Heights West	-0.1192	0.2299	-0.52	0.6539
Downtown West	0.08550	0.2336	0.37	0.7538
Point Douglas South	0.02976	0.2173	0.14	0.9115
St. Vital North	-0.03828	0.2338	-0.16	0.8874
St. James - Assiniboia West	-0.03172	0.2332	-0.14	0.9055
Seven Oaks East	-0.06467	0.2275	-0.28	0.8154
Transcona	0.03677	0.2315	0.16	0.8890
Fort Garry North	0.07313	0.2336	0.31	0.7881
River Heights East	-0.04326	0.2249	-0.19	0.8744
River East South	0.04441	0.2303	0.19	0.8720
Assiniboine South	-0.00111	0.2317	-0.00	0.9967
Inkster West	0.1235	0.2335	0.53	0.6618
River East East	0.09905	0.2315	0.43	0.7122
Fort Garry South	-0.03851	0.2333	-0.17	0.8875
Seven Oaks West	-0.05949	0.2287	-0.26	0.8297
St. Vital South	-0.1468	0.2326	-0.63	0.6099
St. Boniface East	0.1041	0.2339	0.45	0.7094
Downtown East	0.09217	0.2209	0.42	0.7404
Inkster East	0.08272	0.2212	0.37	0.7650

Table 4.46: GLIMMIX Random Effects for Urban Labour Force Participation

-2 Res logLik	AIC	AICC	BIC	Chi-Square
7654.52	7676.52	7676.71	7734.69	1437.49

Table 4.47: GLIMMIX Model Criteria for Urban Labour Force Participation

It is of interest to determine the hierarchical model output of urban component for the entire SAGE cohort for the neighbourhood stressor of labour force participation age 15 to 64 including respondents residing in both birth and non-birth homes. The effect of neighbourhood stressor is weaker in terms of odds ratio comparing Tables 4.45 and 4.39 for residents of the fourth quintile neighbourhoods, but residents of second quintile neighbourhoods gave significance where none existed before as possible directional selection bias. The effect of neighbourhood level is decreased examining Table 4.40 in regards to Table 4.40 amongst just respondents of birth homes. The histograms in Figures 4.50 and 4.45 are similar in groupings and profile, meaning that there is little differential in terms of quintile score proportions. Thus, respondents relocating to second quintile neighbourhoods of labour force participation age 15 to 64 amongst entire survey respondents are different than those who are resident of birth homes. Children who are assumed to have been raised in second quintile neighbourhoods of Labour Force Participation their whole lives have a markedly less and non-significant odds of parent report of asthma than their non-birth home peers, yeilding questions about possible pathways of exposure.

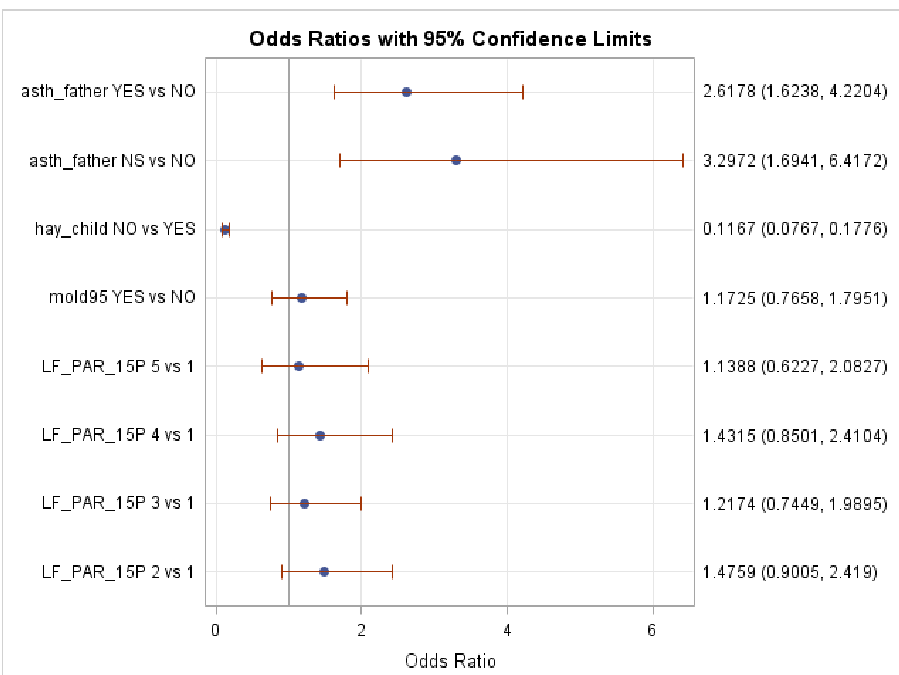


Figure 4.48: GLIMMIX Odds Ratio Plot for Urban Labour Force Participation

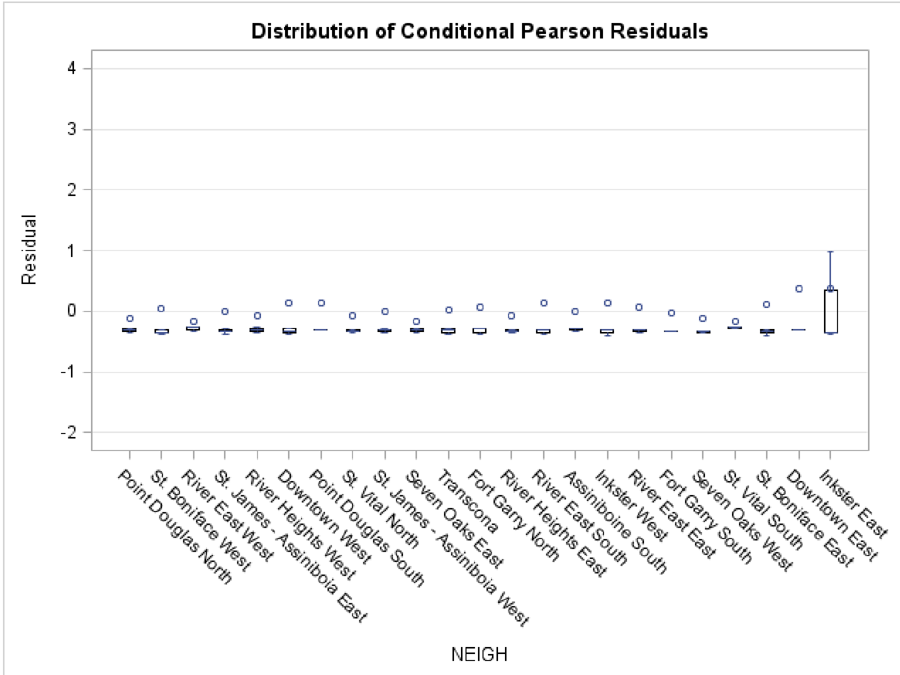


Figure 4.49: Boxplot of GLIMMIX Residuals for Urban Labour Force Participation

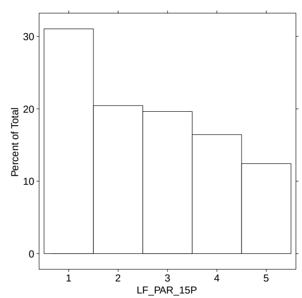


Figure 4.50: Histogram of Responses for Urban Labour Force Participation

Examining the histogram of urban survey responses in Figure 4.50, it is apparent that most children reside in census tracts of the lowest quintiles labour force participation age 15 to 64. Inspecting the boxplot of Pearson residuals in Figure 4.49, the model slightly overstates the impact of predictors with respect to parent report of child asthma in neighbourhoods, the exception being Inkster East.

4.E.3 Homes Needing Major Repairs:

	Odds Ratio	df	95% CI lower	95% CI upper
Family History of Asthma - No:Yes	0.237	690.1	0.147	0.385
Smoking in Household - No:Yes	0.587	674.2	0.341	1.010
Homes Needing Major Repairs - 1:5	1.366	62.91	0.623	2.997
Homes Needing Major Repairs - 2:5	2.128	74.59	1.026	4.415
Homes Needing Major Repairs - 3:5	0.995	272.7	0.446	2.218
Homes Needing Major Repairs - 4:5	0.620	405.7	0.287	1.340

Table 4.48: GLIMMIX Fixed Effects for Homes Needing Major Repairs

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.05948	0.1153	0.008907	24046
Residual (VC)	0.9851	0.05362	0.8879	1.0993
Neighbourhood Profile	Estimate	Error	t Value	P-value
Assiniboine South	0.04444	0.3220	0.14	0.9127
Downtown East	0.04947	0.2765	0.18	0.8873
Downtown West	0.09126	0.3134	0.29	0.8196
Fort Garry North	0.1778	0.3161	0.56	0.6739
Fort Garry South	-0.02380	0.2959	-0.08	0.9489
Inkster East	-0.03941	0.2658	-0.15	0.9063
Inkster West	-0.03880	0.3007	-0.13	0.9183
Point Douglas North	0.004372	0.2928	0.01	0.9905
Point Douglas South	-0.00155	0.2705	-0.01	0.9964
River East East	0.03056	0.3149	0.10	0.9384
River East South	-0.04682	0.3101	-0.15	0.9046
River East West	-0.2281	0.3189	-0.72	0.6047
River Heights East	-0.08431	0.2952	-0.29	0.8229
River Heights West	-0.07282	0.3214	-0.23	0.8582
Seven Oaks East	-0.05430	0.2884	-0.19	0.8815
Seven Oaks West	-0.05235	0.2740	-0.19	0.8798
St. Boniface East	0.09782	0.3071	0.32	0.8037
St. Boniface West	0.07593	0.3039	0.25	0.8441
St. James - Assiniboia East	0.09978	0.3166	0.32	0.8056
St. James - Assiniboia West	0.09860	0.3194	0.31	0.8094
St. Vital North	-0.1205	0.3143	-0.38	0.7669
St. Vital South	-0.04892	0.3111	-0.16	0.9007
Transcona	0.04171	0.3230	0.13	0.9182

Table 4.49: GLIMMIX Random Effects for Homes Needing Major Repairs

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3709.47	3727.47	3727.74	3768.31	680.71

Table 4.50: GLIMMIX Model Criteria for Homes Needing Major Repairs

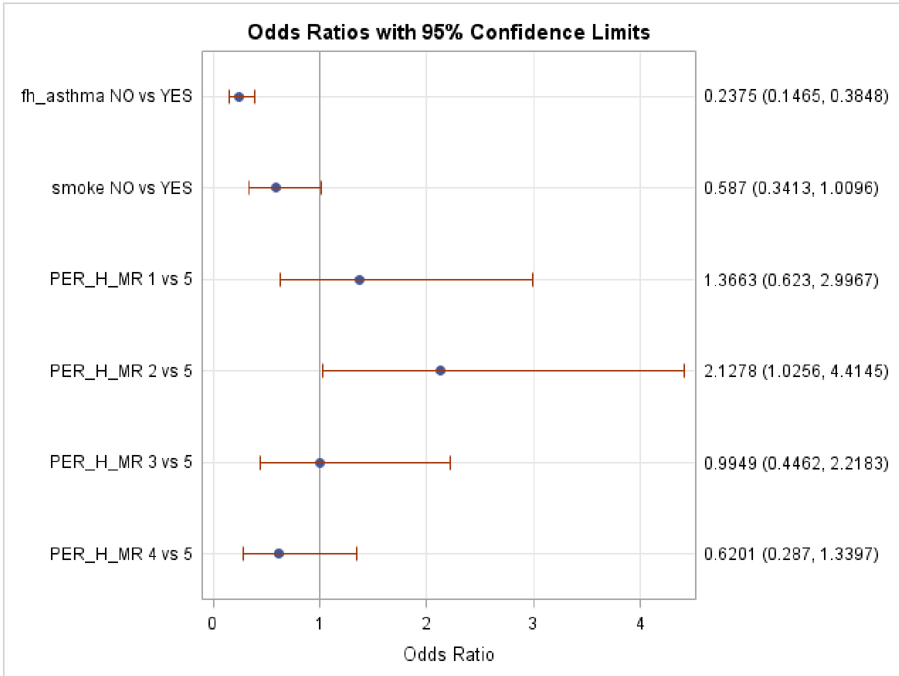


Figure 4.51: GLIMMIX Odds Ratio Plot for Homes Needing Major Repairs

In this model, reference category for proportion of homes needing major repairs is the highest quintile, or neighbourhood census tracts with the most dilapidated housing.

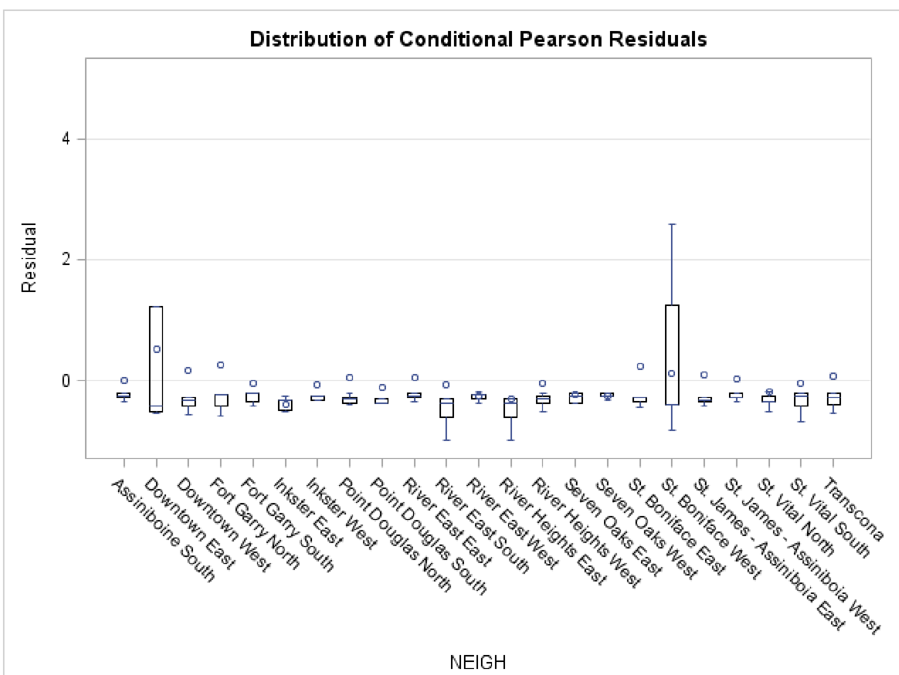


Figure 4.52: Boxplot of GLIMMIX Residuals for Homes Needing Major Repairs

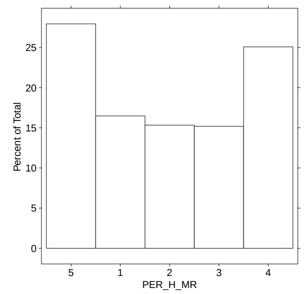


Figure 4.53: Histogram of Birth Home Responses for Homes Needing Major Repairs

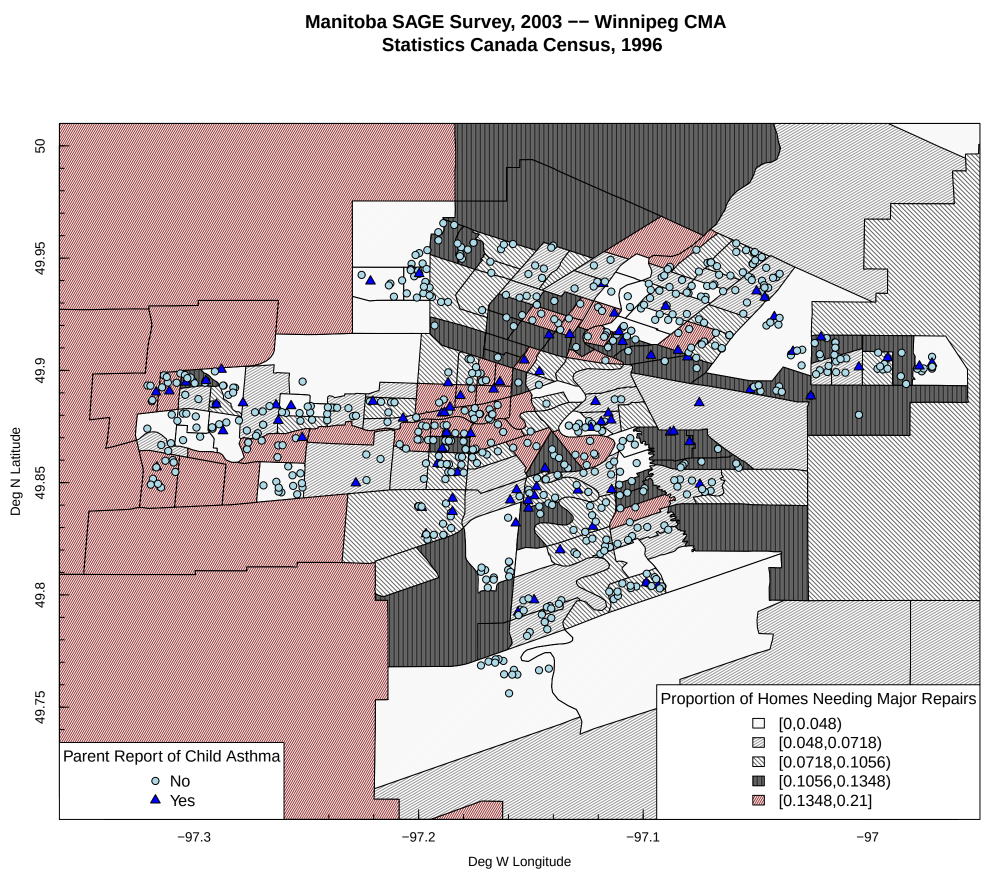


Figure 4.54: Winnipeg Respondents and Homes Needing Major Repairs Quintiles

4.F HLMs for Crime and Violence Domain

4.F.1 Sexual Assaults per 10,000 Persons:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	4.111	687.2	2.056	8.219
Father has Asthma - Not Sure:No	2.719	691.7	0.793	9.325
Hay Fever in Child - No:Yes	0.092	648	0.047	0.177
Mold in Household 1995 - No:Yes	0.134	663.6	0.022	0.821
Sexual Assault - 56.13:2.03	5.584	35.48	1.072	29.073

Table 4.51: GLIMMIX Fixed Effects for Sexual Assault

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.1289	0.1625	0.02848	33.8524
Residual (VC)	0.9465	0.05173	0.8528	1.0567
Neighbourhood Profile	Estimate	Error	t Value	P-value
Point Douglas South	-0.01898	0.3812	-0.05	0.9661
Downtown West	0.09650	0.3809	0.25	0.8189
Point Douglas North	-0.1399	0.3929	-0.36	0.7564
Fort Garry South	-0.2285	0.3897	-0.59	0.6098
St. James - Assiniboia West	0.06954	0.3719	0.19	0.8633
River East South	0.08280	0.3922	0.21	0.8512
Transcona	-0.01773	0.3717	-0.05	0.9649
St. Boniface West	0.2874	0.3935	0.73	0.5447
St. James - Assiniboia East	0.06086	0.3798	0.16	0.8837
River Heights East	-0.04536	0.3895	-0.12	0.9200
Seven Oaks East	-0.03489	0.3898	-0.09	0.9384
St. Vital North	-0.1864	0.3900	-0.48	0.6750
Fort Garry North	0.2714	0.3830	0.71	0.5369
St. Boniface East	0.3400	0.3927	0.87	0.4772
River East West	-0.4070	0.3874	-1.05	0.3884
Assiniboine South	0.2122	0.3749	0.57	0.6123
River East East	0.05228	0.3812	0.14	0.9007
Inkster West	-0.06283	0.3930	-0.16	0.8884
St. Vital South	-0.1625	0.3875	-0.42	0.7102
River Heights West	0.04102	0.3799	0.11	0.9216
Seven Oaks West	-0.1819	0.3898	-0.47	0.6952
Downtown East	0.04126	0.3710	0.11	0.9252
Inkster East	-0.06924	0.3774	-0.18	0.8772

Table 4.52: GLIMMIX Random Effects for Sexual Assault

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3717.02	3733.02	3733.23	3769.3	654.99

Table 4.53: GLIMMIX Model Criteria for Sexual Assault

The predictor Sexual Assault gave marginal significance for fit in a logistic regression model. Since it is a continuous variable, interpretation is a little different from that of a predictor with factor levels. Children whose father had a history of asthma were more than four times (OR 4.111; 95% CI 2.056-8.219) as likely to have parent report of asthma than those without. Examining the values from Table 4.54, it appears that River Heights West had the lowest sexual assault rate with with 2.03 per 10,000 people, while the neighbourhood profile Downtown East had the highest rate with 56.13 per 10,000 people in 2001. Comparing these profiles, respondents resident of Downtown East had a five and a half times (OR 5.584; 95% CI 1.072-29.073) higher odds for parent report of asthma than those in River Heights West.

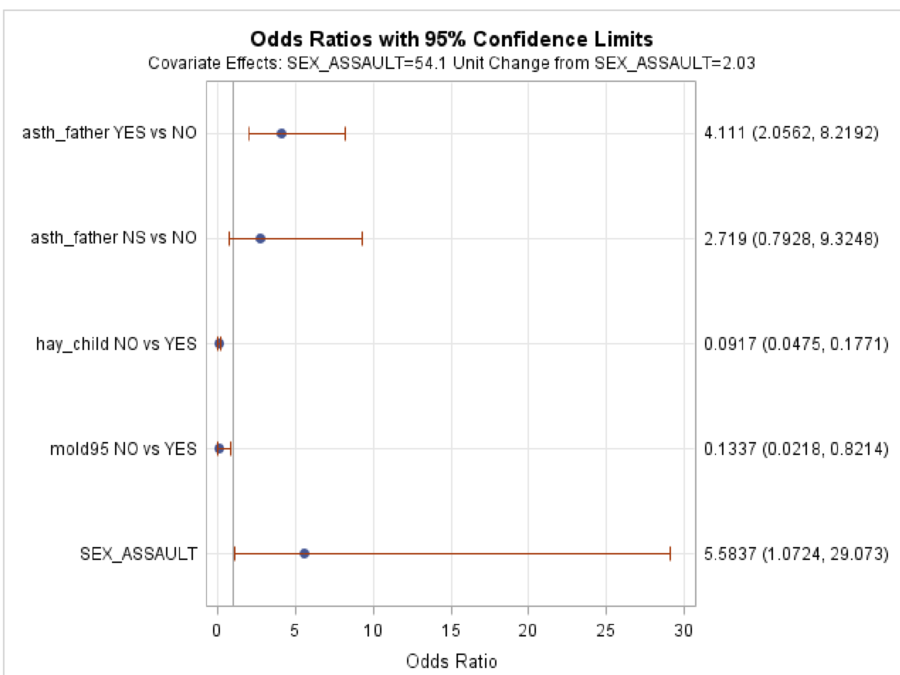


Figure 4.55: GLIMMIX Odds Ratio Plot for Sexual Assault

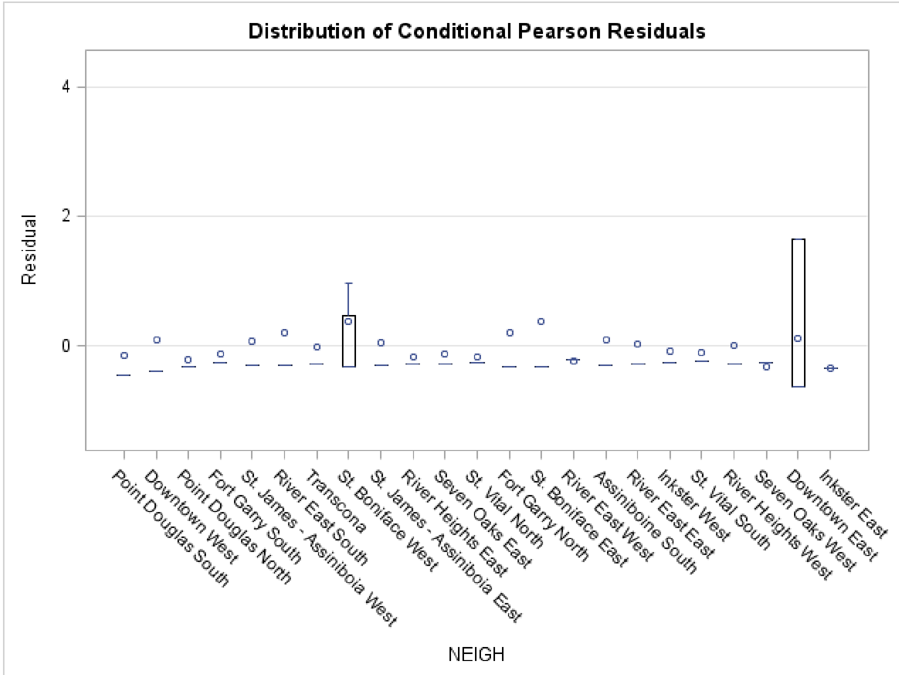


Figure 4.56: Boxplot of GLIMMIX Residuals for Sexual Assault

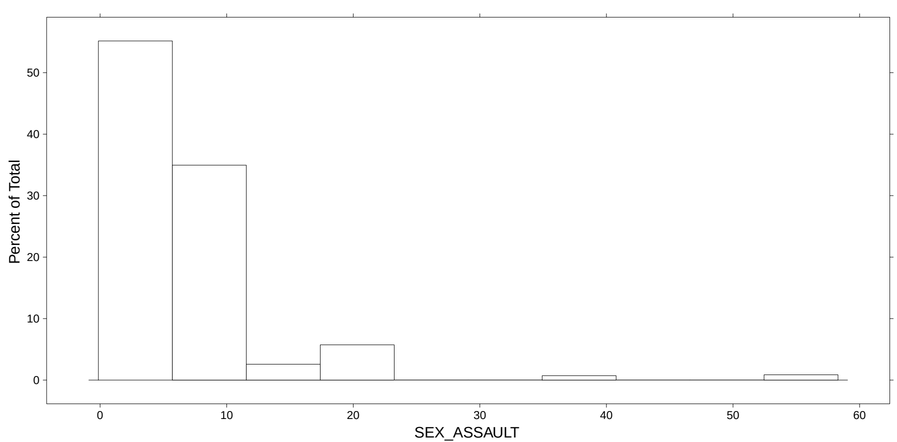


Figure 4.57: Histogram of Birth Home Responses for Sexual Assault

Neighbourhood Profile	Sexual Assault Crimes per 10,000 in 2001
Assiniboine South	2.69
Downtown East	56.13
Downtown West	21.84
Fort Garry North	4.37
Fort Garry South	9.29
Inkster East	20.34
Inkster West	2.34
Point Douglas North	17.13
Point Douglas South	37.50
River East East	2.43
River East South	7.71
River East West	3.00
River Heights East	5.81
River Heights West	2.03
Seven Oaks East	4.84
Seven Oaks West	7.56
St. Boniface East	3.09
St. Boniface West	6.96
St. James - Assiniboia East	6.50
St. James - Assiniboia West	9.08
St. Vital North	4.45
St. Vital South	2.08
Transcona	7.04

Table 4.54: Profile Name Corresponding to Sexual Assault

Examining Figure 4.57 and Table 4.54, it is apparent that the distribution of sexual assault crimes is highly positively skewed to the right, with the residential neighbourhood profiles of south Winnipeg having the lowest crime rate. The downtown core has the highest crime rate specifically in five profiles, with the northern, west and east sides of the city having intermediate values.

LRM and GLM Check of Sexual Assault:

The models below include only fixed effects, and show the difference in effect of neighbourhood being removed for the particular stressor of Sexual Assault assigned at the individual-level.

	Low	High	Δ	Effect	S.E.	Lower 0.95	Upper 0.95
Father has Asthma - Not Sure:No	1.00	2.00		0.98	0.64	-0.27	2.24
Odds Ratio	1.00	2.00		2.68		0.77	9.35
Father has Asthma - Yes:No	1.00	3.00		1.38	0.36	0.68	2.09
Odds Ratio	1.00	3.00		3.99		1.97	8.06
Hay Fever in Child - No:Yes	1.00	2.00		-2.37	0.34	-3.03	-1.71
Odds Ratio	1.00	2.00		0.09		0.05	0.18
Mold in Household 1995 - No:Yes	1.00	2.00		-2.02	0.93	-3.84	-0.19
Odds Ratio	1.00	2.00		0.13		0.02	0.82
Sexual Assault	2.03	56.13	54.1	1.74	0.74	0.30	3.19
Odds Ratio	2.03	56.13	54.1	5.72		1.35	24.18

Table 4.55: LRM for Sexual Assault

# Observations	Somers' Dxy	Goodman-Kruskal's γ	Kendall's τ_a	R-Squared
698	0.4246	0.4606	0.0900	0.1856

Table 4.56: LRM Diagnostics for Sexual Assault

	Estimate	S.E.	t value	P-value
(Intercept)	1.6431	0.9836	1.67	0.0948
Father has Asthma - Not Sure:No	0.9845	0.6384	1.54	0.1231
Father has Asthma - Yes:No	1.3830	0.3591	3.85	0.0001
Hay Fever in Child - No:Yes	-2.3701	0.3353	-7.07	0.0000
Mold in Household 1995 - No:Yes	-2.0161	0.9302	-2.17	0.0302
Sexual Assault	0.0322	0.0136	2.37	0.0178

Table 4.57: GLM for Sexual Assault

The output of Table 4.55 for coefficient estimates is effectively the same as that of Table 4.51, showing that the effect of neighbourhood grouping for random effect is minimal. The coefficient of determination, or R-Squared value has a value of 0.1856 obtained from the LRM output. Somers' Dxy rank correlation has a value of 0.4246.

Examining the fixed effects of Table 4.57, the logistic regression model can be thought conceptually as:

$$\begin{aligned}
logit(p) = \beta_0 + \beta_1 &\times \text{Father has Asthma - Not Sure:No} \\
+\beta_2 &\times \text{Father has Asthma - Yes:No} \\
+\beta_3 &\times \text{Hay Fever in Child - No:Yes} \\
+\beta_4 &\times \text{Mold in Household 1995 - No:Yes} \\
+\beta_5 &\times \text{Sexual Assault}
\end{aligned} \tag{4.1}$$

which for intercept and coefficient estimates keeping a fixed value for Sexual Assault is:

$$\begin{aligned}
logit(p) = 1.6431 + 0.9845 &\times \text{Father has Asthma - Not Sure:No} \\
+1.3830 &\times \text{Father has Asthma - Yes:No} \\
-2.3701 &\times \text{Hay Fever in Child - No:Yes} \\
-2.0161 &\times \text{Mold in Household 1995 - No:Yes} \\
+0.0322 &\times \text{Sexual Assault}
\end{aligned} \tag{4.2}$$

To determine the odds ratio of parent report of child asthma for a child with a father history of asthma, history of hay fever, and mold in 1995 household residing in neighbourhood profile Downtown East compared to the River Heights West can be calculated as:

$$\begin{aligned}
logit(p)(\text{Sexual Assault} = 56.13) &= 1.6431 + 1.3830(1) \\
&+0.0322 \times 56.13 = 4.8335
\end{aligned} \tag{4.3}$$

$$\begin{aligned}
logit(p)(\text{Sexual Assault} = 2.03) &= 1.6431 + 1.3830(1) \\
&+0.0322 \times 2.03 = 3.0915
\end{aligned} \tag{4.4}$$

$$\exp \hat{\Psi}^{(56.13:2.03)} = \exp(4.8335 - 3.0915) = \exp(1.7420) = 5.709 \tag{4.5}$$

is the odds of parent report of child asthma for the increase in crime rate observed.

4.F.2 Thefts Over $5,000 per 10,000 Persons:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	4.142	688.4	2.059	8.331
Father has Asthma - Not Sure:No	2.682	691.3	0.784	9.171
Hay Fever in Child - No:Yes	0.090	651	0.046	0.175
Mold in Household 1995 - No:Yes	0.124	659.6	0.020	0.768
Theft Over $5,000 - 19.05:0.48	7.686	31.05	1.443	40.945

Table 4.58: GLIMMIX Fixed Effects for Theft Over $5,000

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.1181	0.1475	0.02630	28.2459
Residual (VC)	0.9473	0.05165	0.8537	1.0573
Neighbourhood Profile	Estimate	Error	t Value	P-value
Seven Oaks East	-0.1274	0.3728	-0.34	0.7688
St. James - Assiniboia East	-0.1139	0.3630	-0.31	0.7770
Downtown West	0.09362	0.3642	0.26	0.8163
St. Boniface West	0.2183	0.3752	0.58	0.6213
St. Boniface East	0.2687	0.3750	0.72	0.5454
Point Douglas South	0.05130	0.3607	0.14	0.9042
River East West	-0.4149	0.3702	-1.12	0.3609
River Heights West	-0.00282	0.3635	-0.01	0.9943
Transcona	-0.00217	0.3594	-0.01	0.9956
River East South	0.09728	0.3750	0.26	0.8190
Fort Garry North	0.2574	0.3683	0.70	0.5439
St. James - Assiniboia West	0.1307	0.3616	0.36	0.7433
St. Vital North	-0.1668	0.3734	-0.45	0.6953
Inkster West	-0.06308	0.3750	-0.17	0.8828
St. Vital South	-0.1544	0.3714	-0.42	0.7131
Fort Garry South	-0.1502	0.3739	-0.40	0.7248
Assiniboine South	0.2269	0.3629	0.63	0.5809
Point Douglas North	-0.02775	0.3742	-0.07	0.9483
River Heights East	-0.01788	0.3686	-0.05	0.9667
River East East	0.09228	0.3681	0.25	0.8219
Seven Oaks West	-0.1425	0.3691	-0.39	0.7449
Downtown East	0.009429	0.3528	0.03	0.9819
Inkster East	-0.06220	0.3595	-0.17	0.8839

Table 4.59: GLIMMIX Random Effects for Theft Over $5,000

-2 Res logLik	AIC	AICC	BIC	Chi-Square
3719.26	3735.26	3735.47	3771.58	655.56

Table 4.60: GLIMMIX Model Criteria for Theft Over $5,000

The predictor Theft Over $5,000 gave moderate significance for fit in a logistic regression model with GLIMMIX. Since it is a continuous variable, interpretation is a little different from that of a predictor with factor levels. Determining the odds of parent report of child asthma comparing a neighbourhood with a high crime rate to that with low can also be done from multiple logistic regression models with several explanatory variables (Woodward, 2005, 544). The neighbourhood profile River Heights East had the lowest Theft Over $5,000 rate with 0.48 per 10,000 people, while Downtown East had the highest rate with 19.05 per 10,000 people in 2001. From the intraclass correlation factor, on average approximately 11.8% of the variance in the dependent variable can be attributed to the neighbourhood level, with correlation differences amongst neighbourhood profiles shown in Table 4.59. The neighbourhood profile St. Boniface East had the highest random effect correlation estimate for parent report of child asthma, while the profile River East West had the lowest. Examining the fixed effects of Table 4.58, children residing in profile Downtown East had over seven times (OR 7.686; 95% CI 1.443-40.945) the odds for parent report of asthma compared to children in River Heights East. Additionally, children without a history of hay fever had an eleven times lower (OR 0.090; 95% CI 0.046-0.175) odds for asthma than those with.

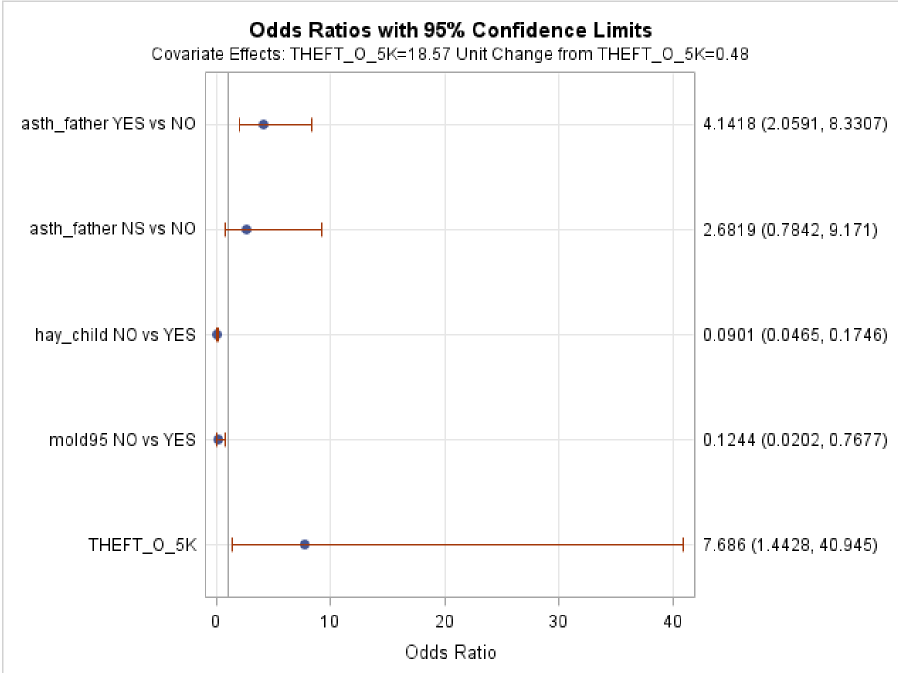


Figure 4.58: GLIMMIX Odds Ratio Plot for Theft Over $5,000

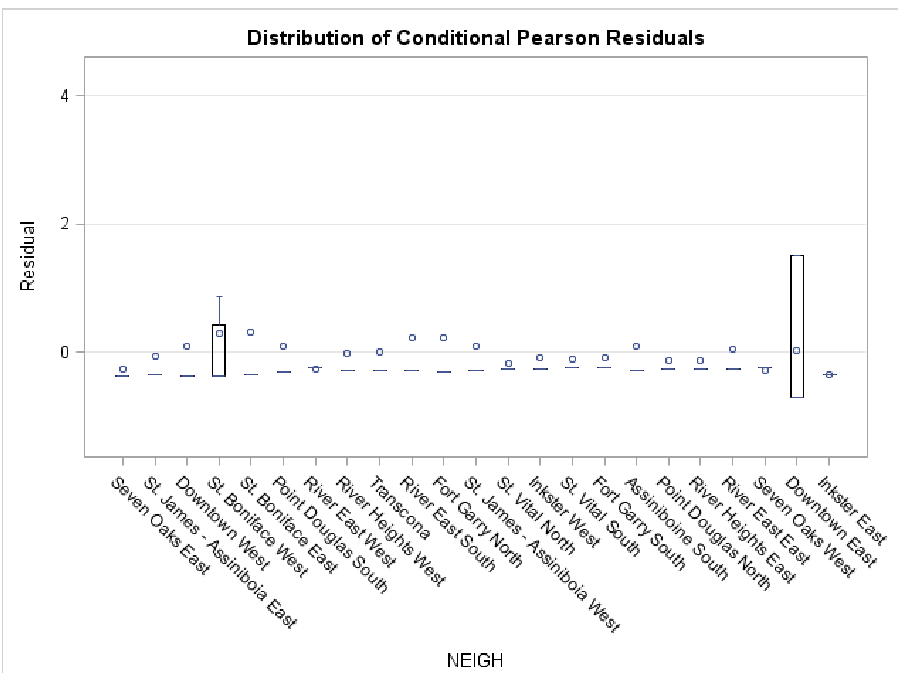


Figure 4.59: Boxplot of GLIMMIX Residuals for Theft Over $5,000

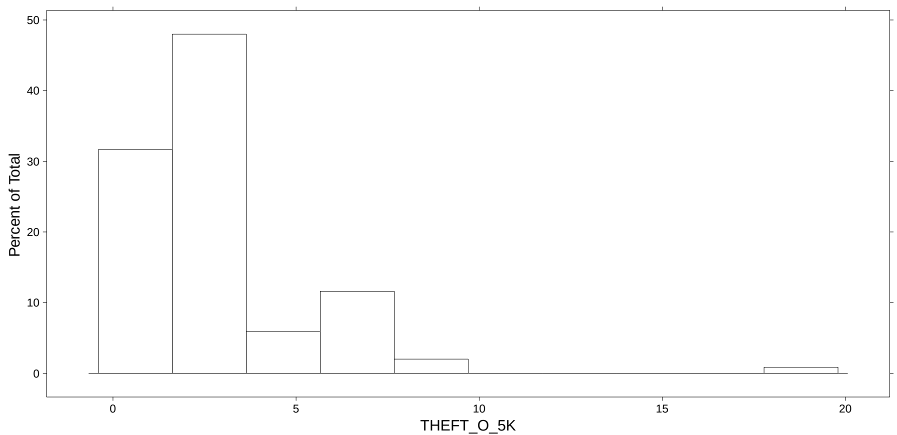


Figure 4.60: Histogram of Birth Home Responses for Theft Over $5,000

Examining the histogram of birth home survey responses in Figure 4.60, it is apparent that most children reside in neighbourhood profiles of the lowest quintiles thefts over $5,000 per 10,000 persons. Inspecting the boxplot of Pearson residuals in Figure 4.59, most deviations in the model fit are minimal.

Neighbourhood Profile	Theft Over $5,000 Crimes per 10,000 in 2001
Assiniboine South	0.98
Downtown East	19.05
Downtown West	7.08
Fort Garry North	2.02
Fort Garry South	1.21
Inkster East	6.51
Inkster West	1.75
Point Douglas North	0.78
Point Douglas South	3.33
River East East	0.35
River East South	2.20
River East West	2.73
River Heights East	0.48
River Heights West	2.54
Seven Oaks East	8.23
Seven Oaks West	0.95
St. Boniface East	3.78
St. Boniface West	5.22
St. James - Assiniboia East	7.11
St. James - Assiniboia West	1.88
St. Vital North	1.85
St. Vital South	1.48
Transcona	2.46

Table 4.61: Profile Name Corresponding to Theft Over $5,000

Examining Figure 4.60 and Table 4.61, it is apparent that the distribution of high value theft (over $5,000) crimes is also positively skewed to the right. Interestingly, the neighbourhood profiles with lowest major theft crime rates are spread throughout the city, with lowest values observed in profiles on the far south, north and inner city areas. Profiles with highest crime rate values are observed in the downtown core, and intermediate neighbourhoods between inner city and suburbs. Since an increase in Theft Over $5,000 is positively associated with an increased odds of parent report of child asthma, this would suggest that is it perhaps these neighbourhoods that warrant inspection for environmental factors at the individual-level.

LRM and GLM Check of Theft Over $5,000:

The models below include only fixed effects, and show the difference in effect of neighbourhood being removed for the particular stressor of Theft Over $5,000 assigned at the individual-level.

	Low	High	Δ	Effect	S.E.	Lower 0.95	Upper 0.95
Father has Asthma - Not Sure:No	1.00	2.00		0.97	0.64	-0.28	2.22
Odds Ratio	1.00	2.00		2.64		0.76	9.16
Father has Asthma - Yes:No	1.00	3.00		1.39	0.36	0.68	2.10
Odds Ratio	1.00	3.00		4.01		1.97	8.18
Hay Fever in Child - No:Yes	1.00	2.00		-2.39	0.34	-3.05	-1.72
Odds Ratio	1.00	2.00		0.09		0.05	0.18
Mold in Household 1995 - No:Yes	1.00	2.00		-2.11	0.93	-3.93	-0.28
Odds Ratio	1.00	2.00		0.12		0.02	0.76
Theft Over $5,000	0.48	19.05	18.57	1.98	0.74	0.54	3.43
Odds Ratio	0.48	19.05	18.57	7.26		1.71	30.80

Table 4.62: LRM for Theft Over $5,000

# Observations	Somers' Dxy	Goodman-Kruskal's γ	Kendall's τ_a	R-Squared
698	0.4336	0.4551	0.0919	0.1894

Table 4.63: LRM Diagnostics for Theft Over $5,000

	Estimate	S.E.	t value	P-value
(Intercept)	1.6633	0.9835	1.69	0.0908
Father has Asthma - Not Sure:No	0.9701	0.6353	1.53	0.1268
Father has Asthma - Yes:No	1.3899	0.3635	3.82	0.0001
Hay Fever in Child - No:Yes	-2.3866	0.3383	-7.05	0.0000
Mold in Household 1995 - No:Yes	-2.1064	0.9322	-2.26	0.0238
Theft Over $5,000	0.1067	0.0397	2.69	0.0072

Table 4.64: GLM for Theft Over $5,000

Examining the fixed effects of Table 4.64, the logistic regression model can be thought conceptually as:

$$
\begin{aligned}
logit(p) = \beta_0 + \beta_1 \times \text{Father has Asthma - Not Sure:No} \\
+\beta_2 \times \text{Father has Asthma - Yes:No} \\
+\beta_3 \times \text{Hay Fever in Child - No:Yes} \\
+\beta_4 \times \text{Mold in Household 1995 - No:Yes} \\
+\beta_5 \times \text{Theft Over \$5,000}
\end{aligned} \tag{4.6}
$$

which for intercept and coefficient estimates keeping a fixed value for Theft Over $5,000 is:

$$
\begin{aligned}
logit(p) = 1.6633 + 0.9701 \times \text{Father has Asthma - Not Sure:No} \\
+1.3899 \times \text{Father has Asthma - Yes:No} \\
-2.3866 \times \text{Hay Fever in Child - No:Yes} \\
-2.1064 \times \text{Mold in Household 1995 - No:Yes} \\
+0.1067 \times \text{Theft Over \$5,000}
\end{aligned} \tag{4.7}
$$

To determine the odds ratio of parent report of child asthma for a child with no father history of asthma, no history of hay fever, and no mold in 1995 household residing in neighbourhood profile River Heights East compared to the Downtown East can be calculated as:

$$
\begin{aligned}
logit(p)(\text{Theft Over \$5,000} = 19.05) = 1.6633 - 2.3866(1) - 2.1064(1) \\
+0.1067 \times 19.05 = -0.7971
\end{aligned} \tag{4.8}
$$

$$
\begin{aligned}
logit(p)(\text{Theft Over \$5,000} = 0.48) = 1.6633 - 2.3866(1) - 2.1064(1) \\
+0.1067 \times 0.48 = -2.7785
\end{aligned} \tag{4.9}
$$

$$
\exp \hat{\Psi}^{(19.05:0.48)} = \exp(-0.7971 + 2.7785) = \exp(1.9814) = 7.253 \tag{4.10}
$$

is the odds of parent report of child asthma for the increase in crime rate observed, which agrees very similarly to what was observed by the GLIMMIX model and the LRM in Tables 4.58 and 4.62, respectively. The odds ratio of the predictor Theft Over $5,000 is slightly stronger in the hierarchical model, which confirms that there is an effect of neighbourhood grouping for random effect of variance.

The coefficient of determination, or R-Squared value has a value of 0.1894 obtained from the LRM output. Somers' Dxy rank correlation has a value of 0.4336. It is apparent that logistic regression models featuring predictors of stressors from the 2001 Winnipeg Police Services Crime Data explain a similar proportion of the total variance amongst respondents in the SAGE Survey for outcome of parent report of child asthma, compared to predictors from the 1996 Canada Census.

Urban Theft Over $5,000 Including Non-Birth Homes:

	Odds Ratio	df	95% CI lower	95% CI upper
Father has Asthma - Yes:No	2.601	1466	1.610	4.201
Father has Asthma - Not Sure:No	3.347	1462	1.720	6.513
Hay Fever in Child - No:Yes	0.114	1364	0.075	0.173
Mold in Household 1995 - No:Yes	0.861	1465	0.562	1.320
Theft Over $5,000 - 19.05:0.48	2.878	41.19	0.996	8.317

Table 4.65: GLIMMIX Fixed Effects for Urban Theft Over $5,000

	ICC Estimate	Error	95% CI lower	95% CI upper
Neighbourhood Profile	0.02778	0.05056	0.004397	2437.47
Residual (VC)	0.9891	0.03673	0.9208	1.0652
Neighbourhood Profile	Estimate	Error	t Value	P-value
Seven Oaks East	-0.06355	0.1948	-0.33	0.7992
St. James - Assiniboia East	-0.01611	0.2109	-0.08	0.9515
Downtown West	0.02138	0.2092	0.10	0.9352
St. Boniface West	0.02727	0.2053	0.13	0.9159
St. Boniface East	0.06800	0.2069	0.33	0.7978
Point Douglas South	0.01705	0.1803	0.09	0.9400
River East West	-0.1789	0.2136	-0.84	0.5561
River Heights West	-0.06192	0.2136	-0.29	0.8204
Transcona	0.008325	0.2132	0.04	0.9752
River East South	0.04030	0.1968	0.20	0.8714
Fort Garry North	0.06329	0.2096	0.30	0.8133
St. James - Assiniboia West	-0.00480	0.2105	-0.02	0.9855
St. Vital North	-0.00302	0.2084	-0.01	0.9908
Inkster West	0.09479	0.2058	0.46	0.7252
St. Vital South	-0.1208	0.2077	-0.58	0.6647
Fort Garry South	0.02118	0.2070	0.10	0.9351
Assiniboine South	-0.00714	0.2123	-0.03	0.9786
Seven Oaks West	-0.01507	0.1928	-0.08	0.9504
Point Douglas North	-0.01790	0.1998	-0.09	0.9431
River Heights East	-0.01440	0.1865	-0.08	0.9509
River East East	0.08460	0.2112	0.40	0.7574
Downtown East	0.006311	0.1778	0.04	0.9774
Inkster East	0.05115	0.1845	0.28	0.8278

Table 4.66: GLIMMIX Random Effects for Urban Theft Over $5,000

-2 Res logLik	AIC	AICC	BIC	Chi-Square
7665.06	7681.06	7681.15	7723.38	1449.98

Table 4.67: GLIMMIX Model Criteria for Urban Theft Over $5,000

For comparative purposes, it is of interest to determine the hierarchical model output of urban component for the entire SAGE cohort for the neighbourhood stressor of thefts over $5,000 including respondents residing in both birth and non-birth homes. The effect of neighbourhood stressor is less significant and the odds ratio smaller comparing Tables 4.65 and 4.58, being an example of non-directional bias. Again, the effect of neighbourhood level is decreased examining Table 4.66 in regards to Table 4.59 amongst just respondents of birth homes. The histograms in Figures 4.63 and 4.60 are similar in groupings and profile, noting that most respondents live in neighbourhoods with low crime rate and that residents of birth homes are not visibly more likely to be located in higher major theft neighbourhoods compared to all survey respondents.

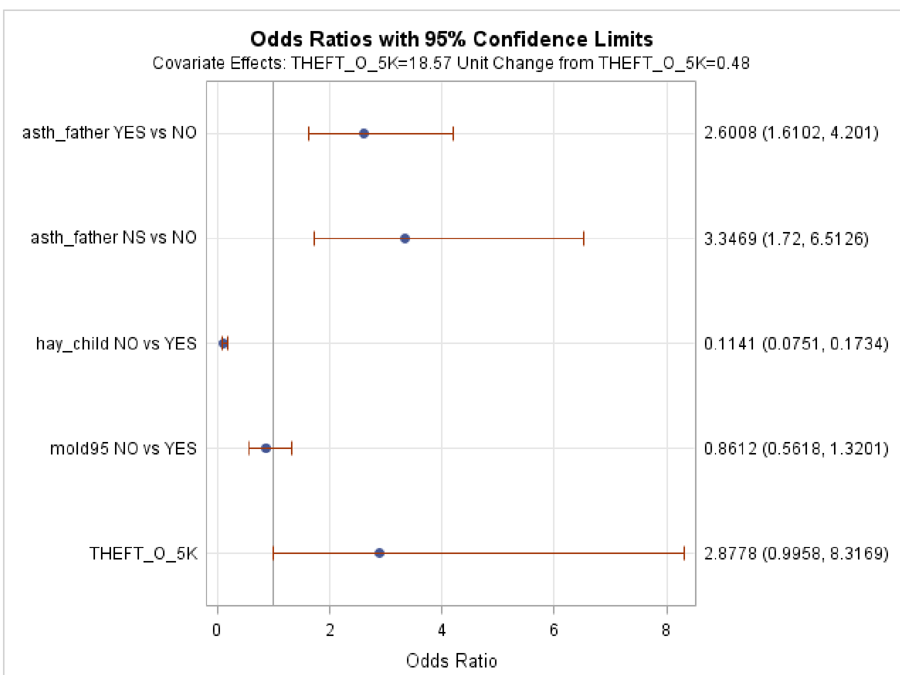


Figure 4.61: GLIMMIX Odds Ratio Plot for Urban Theft Over $5,000

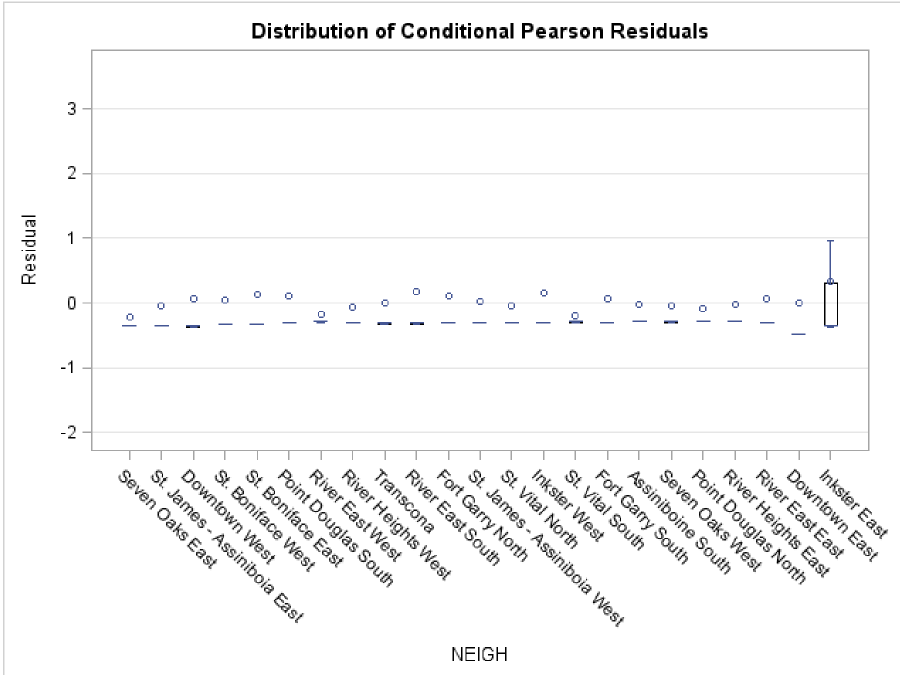


Figure 4.62: Boxplot of GLIMMIX Residuals for Urban Theft Over $5,000

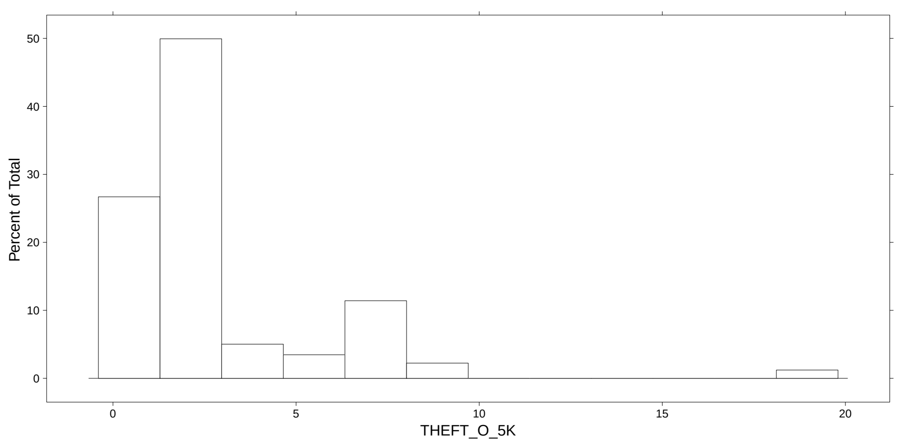


Figure 4.63: Histogram of Responses for Urban Theft Over $5,000

Examining the histogram of urban survey responses in Figure 4.63, it is apparent that most children reside in neighbourhood profiles of the lowest quintiles thefts over $5,000 per 10,000 persons. Inspecting the boxplot of Pearson residuals in Figure 4.62, it is apparent the model fitting stressor Theft Over $5,000 for urban respondents slightly underestimates report of asthma in most neighbourhoods with the exception of profile Inkster East.

4.G SAGE Survey Predictor Models

It was of interest to determine the best multivariate models that could be built using only predictors from the SAGE Survey, with respect to the response variable parent report of child asthma. Model selection was made through use of the stepwise prodecure in the `wle` package comparing lowest AIC values (Agostinelli, 2006).

	odds ratio	95% CI lower	95% CI upper	P-value
Father has Asthma - Not Sure:No	7.5016	1.2536	39.2100	0.0180
Father has Asthma - Yes:No	2.6866	1.2046	5.7707	0.0130
Sibling has Asthma - No Sibling:No	1.9025	0.7095	4.5889	0.1732
Sibling has Asthma - Yes:No	5.0973	2.8408	9.0897	0.0000
Hay Fever in Child - Yes:No	10.8943	5.3338	22.4861	0.0000
Hay Fever in Father - Not Sure:No	0.0545	0.0017	0.6163	0.0441
Hay Fever in Father - Yes:No	0.9349	0.4444	1.8638	0.8557

Table 4.68: GLM for Lowest AIC SAGE Survey Predictors

# Observations	AIC	Null Deviance	Residual Deviance
698	433.04	513.18	417.04

Table 4.69: GLM Model Criteria for Lowest AIC SAGE Survey Predictors

From the multivariate model fitting measures obtained from the individual-level as fixed effects in Table 4.68, it is interesting to note that children living in households where it was not known if the father had asthma had a much higher odds of asthma (OR 7.502; 95% CI 1.254-39.210) than children in families where the father did not have asthma. However, children of households where it was unknown if the father experienced hay fever had a lower odds (OR 0.055; 95% CI 0.002-0.616) of asthma, which raises a question about the coherence of the association observed. Children who experienced hay fever and had other siblings with asthma were more likely to be given a parent report of asthma. The measure Family History of Asthma was not found significant when adjustment for the variables Father has Asthma and Sibling has Asthma were made.

The AIC value of 433.04 in Table 4.69 is lower than any model fitted with a neighbourhood stressor, suggesting that the individual-level predictors by themselves are more robust at explaining model variance.

4.H Spatial Statistics

4.H.1 Random Points Model

The software package `spatstat` is the largest and most comprehensive spatial statistic library in `R`, and offers a variety of novel functions to fit kernel densities to respondent outcomes. Most of these techniques are catered to data irrespective of sampling scheme, based upon pixel intensity differences which are not comparable to providing statistical inference. The premise itself is given that when using the point process in spatial statistics, one assumes that it is simply a random set of points (Baddeley, 2008, 13). It is possible to fit the dichotomous response variable parent report of child asthma from the SAGE Survey dataset with analogous covariate information if additional non-asthma points are plotted as a separate pattern. The intensity is a non-parametric method of where child asthma cases exist based upon a point pattern, and should not be interpreted as probability (Baddeley & Turner, 2005).

Sometimes the polygons in ESRI® shapefiles self-intersect or overlap. To use features from the `spatstat` package such as the function 'owin' for census tracts, line segments must not cross over. The `PBSmapping` package offers the 'fixBound' function which can adjust the vertices of polygons closer to an actual boundary within a specified tolerance (Schnute et al., 2008). However, often this does not remedy short polygon segments that intersect over a boundary that is not coincident, and proprietary tools are needed. ArcInfo® offers the 'Repair geometry' and 'Integrate geoprocessing tool', which fixes slivers and makes polygon vertices and boundaries coincident, but may not solve overlap (ERSI, 2007). The 'Boundary Clean' tool from the `Spatial Analyst Tools` addition of ArcInfo is an all-in-one solution for most shapefiles.

In Figures 4.64 and 4.65, sigma $= 0.005\,^{-\circ}$ was chosen to give a standard deviation of the Gaussian smoothing kernel of roughly 172.05 metres. This derives from the window bounded by $50.01\,^{\circ}$latitude - $49.70\,^{\circ}$latitude, or a difference of $0.31\,^{\circ}$. One degree latitude is equivalent to roughly 111,230 metres in actual geo-distance, and one degree longitude equivalent to 71,670 metres at latitude 50 degrees north (Computer Support Group, Inc., 2010). Thus, 111,230 metres $*\ 0.31\,^{\circ}$ results in $34,481.3\,^{\circ}$ metres, which multiplied by sigma $= 0.005\,^{-\circ}$ results in 172.4 metres for the latitude axis, and 71,670 metres $*\ 0.31\,^{\circ}$ results in

$22,217.7^{\circ}$ metres, multiplied by sigma $= 0.005^{-\circ}$ results in 111.1 metres for the longitude axis. A window bounded by latitude -97.36° to -96.95° West, and longitude 49.70° to 50.01° North was chosen to encompass the City of Winnipeg, with birth home responses from the SAGE Survey outside those bounds excluded.

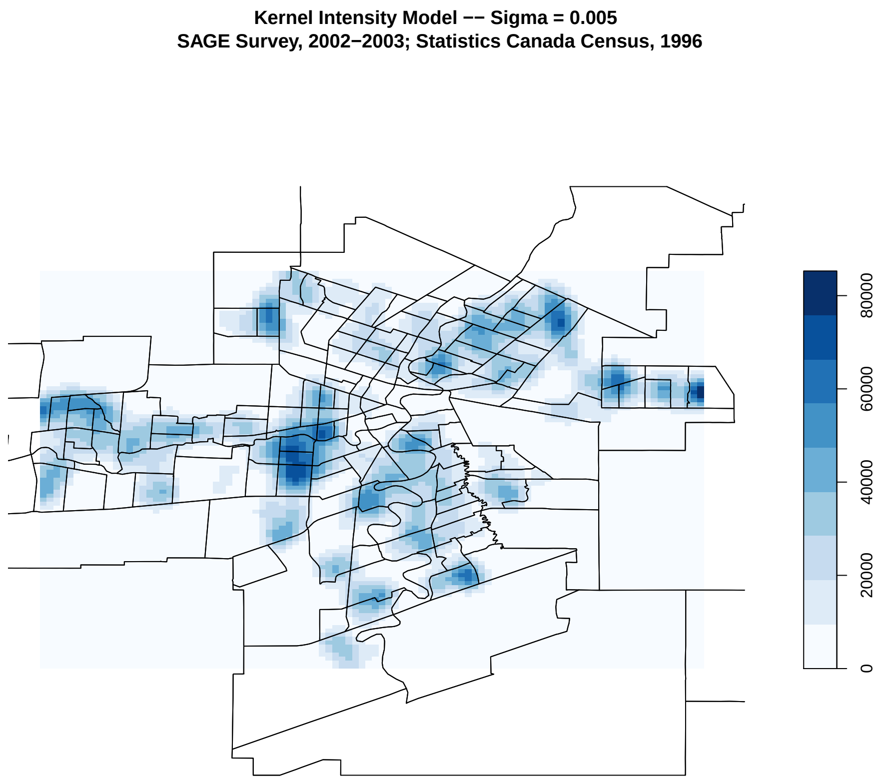


Figure 4.64: Kernel Density of SAGE Survey Asthma Responses

It is evident that parent report of child asthma events are concentrated in neighbourhoods with smaller proportions of low income households. The cluster of highest intensity without adjusting for explantory variables is located in the neighbourhood profile River Heights West, which counters the findings observed from that of HLM with regards to the random effects of neighbourhood level. This provides indication that models of non-parametric point patterns are most likely of limited application in quantifying neighbourhoods of greater risk for child asthma. Bayesian spatial modelling techniques may be of greater use, as they can adjust for covariate information and provide statistical inference.

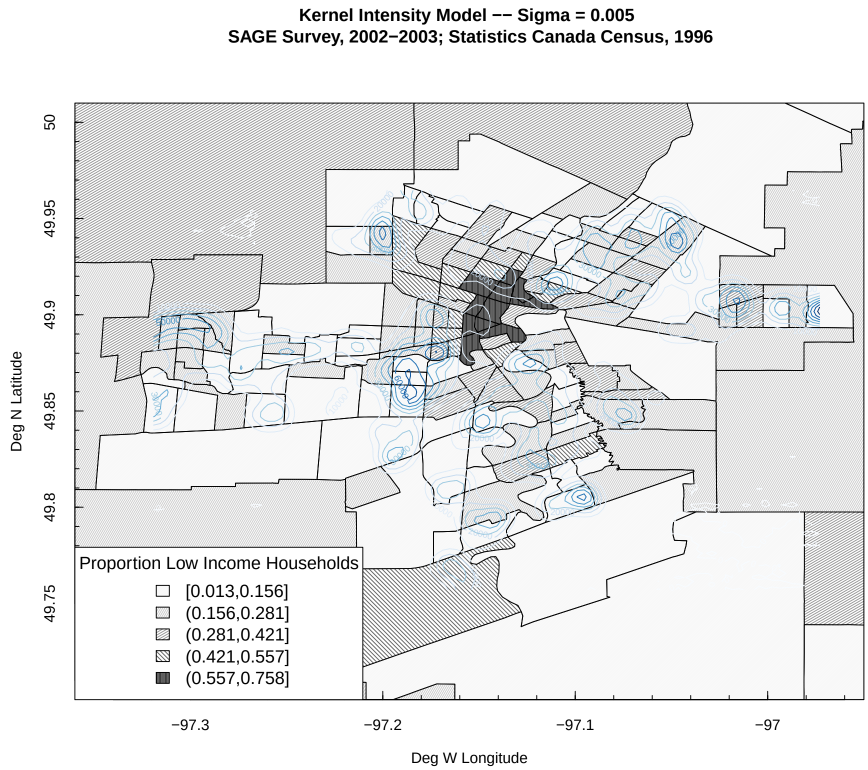


Figure 4.65: Kernel Density of SAGE Survey with Proportion Low Income

4.H.2 Hierarchical Point-Referenced Spatial Models

Given the relatively large sample of respondents from the SAGE Survey, fitting a Bayesian model to the stressors from Sections 4.D, 4.E and 4.F yielded results similar to the fixed and random effects from what was determined by models assuming a binomial linkage shown in their respective tables. This is based upon the theory of large-sample inference, in which normal approximations hold to the posterior distribution and serve as a connection between Bayesian and non-Bayesian methods in fitting an exact method (Gelman et al., 2004, 102). Spatial contour plots can add to the knowledge presented in statistical tables, and are an intuitive and relatively new method of showing the fixed effects of stressors at the individual-level, and the random effects at neighbourhood level for dependent outcome of parent report of child asthma over a fixed geographic region free of traditional grouping units.

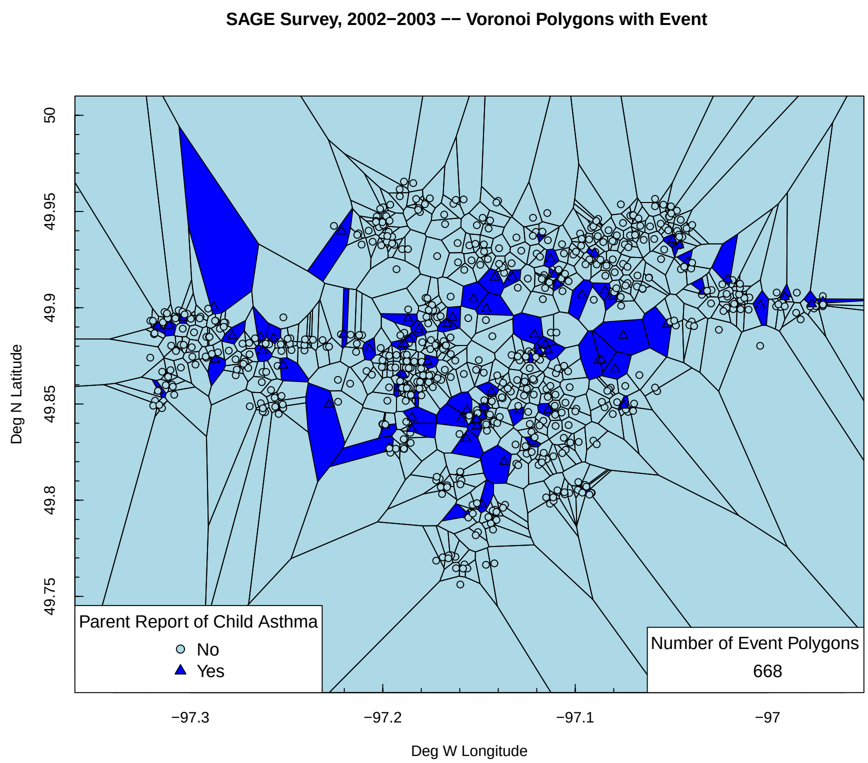


Figure 4.66: Voronoi Polygons of SAGE Survey Response Events

The `spBayes` provides many features for fitting Markov chain Monte Carlo (MCMC) methods to hierarchical spatial models (Finley et al., 2009b,a, 2007). Point estimates and distributions for Monte Carlo methods can be based upon data taken from observational studies when true statistical distribution of parameters is unknown, and assurance of a complete population cohort or random sampling scheme is not valid. A full probability model using Bayesian methods can be calculated from known and unknown quantities, which can be further used to evaluate the model using a posterior distribution. (Gelman et al., 2004, 3). In particular, the 'bayesGeostatExact' function is used to fit a simple Bayesian spatial linear model (Finley et al., 2009b, 6). The use of many of the methods in this library requires the Cholesky decomposition. Matrices must be positive-definite with no negative or zero elements to ensure that the algorithm converges, and that the matrix is not ill-conditioned for Cholesky to function (Finley et al., 2009a). Often, this requires that coordinate data cannot have duplicate points. For the SAGE Survey, responses were geocoded by postal code. Unique postal codes were ensured for the bounded region of the City of Winnipeg, encompassing 1351 urban responses from the entire city with 668 of those in birth homes. In the case of duplicate points for a specific postal code, response with asthma case was chosen. Accuracy of non-duplicate point data can be ensured by overlaying event response as voronoi polygons such as in Figure 4.66, which gives some idea of where spatial occurrences of asthma were observed.

BSLM for Male Population Age 15+ and Unemployed:

A simple Bayesian spatial linear model (BSLM) using geocoordinates was fitted to a random sample of 100 non-duplicate postal code respondents, which show up as green dots in Figure 4.67. Adjusting for Family History of Asthma, the model fitting the predictor proportion of males age 15+ that are unemployed in census tract was determined to give the lowest AIC and BIC values from Section 4.F under the neighbourhood social capital domain. Forty thousand iterations of posterior samples were taken, to generate the distribution in all predicted response plots. Yellow clusters mean a higher likelihood of parent report of child asthma, and takes a maximum value of 1. Red corresponds to spatial locations that have a lower chance of asthma, with the darkest shade corresponding to a minimum value of 0. All these locations are in the central area of Winnipeg noting latitude and longitude coordinates, and in communities corresponding to neighbourhood profiles: Downtown West, Downtown East, River Heights West and River Heights East. This geography is desirable in modelling since the area is predominantly residential with few gaps over the entire grid, making it suitable for Bayesian spatial techniques (Finley et al., 2007, 16). These can be described as older, residential communities to the downtown core, where the majority of respondents with young children resided.

The bottom two posterior predictive plots of Figure 4.67 illustrate how useful the model is in estimating spatial outcome of asthma with the 100 respondents given from the sample shown as black dots. The response outcome of the predicted plot agrees with that of the observed, but the effects of predicted response variances are almost as large as the fixed effects itself. Slightly greater variance from the predictor Males Age 15+ Unemployed is observed in the area corresponding to the profile Downtown East for predicted parent report of child asthma. It is evident from the random effects plot that the effect of neighbourhood given predictor is greater in the older, residential neighbourhoods to the west side of the downtown of Winnipeg. However, this effect can be considered minimal in encouraging outcome of child asthma, being less than exp (0.00295) or 1.00295 at most. Predicted response clusters are identified in the River Heights East and Downtown East neighbourhood profiles, which agree to that which was observed for respondents of birth homes in the SAGE Survey.

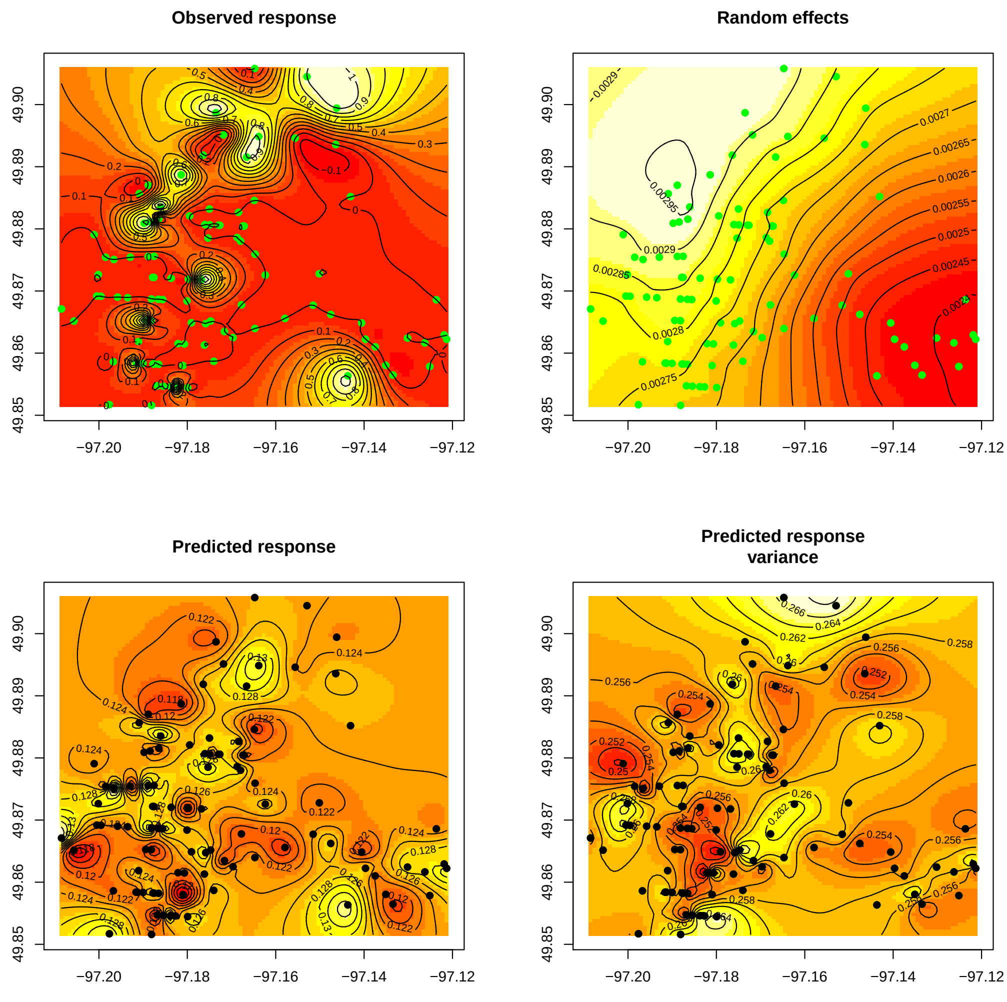


Figure 4.67: BSLM fitting Birth Home Males Age 15+ Unemployed

The random selection of points from respodents encompassing the entire City of Winnipeg in both birth homes and non-birth homes in Figure 4.68 is a slightly different coverage area when it comes to the Bayesian spatial linear model that was fitted only for birth homes in Figure 4.67. Note the random effects of neighbourhood in this scenario offer a protective element in weakly mitigating parent report of child asthma.

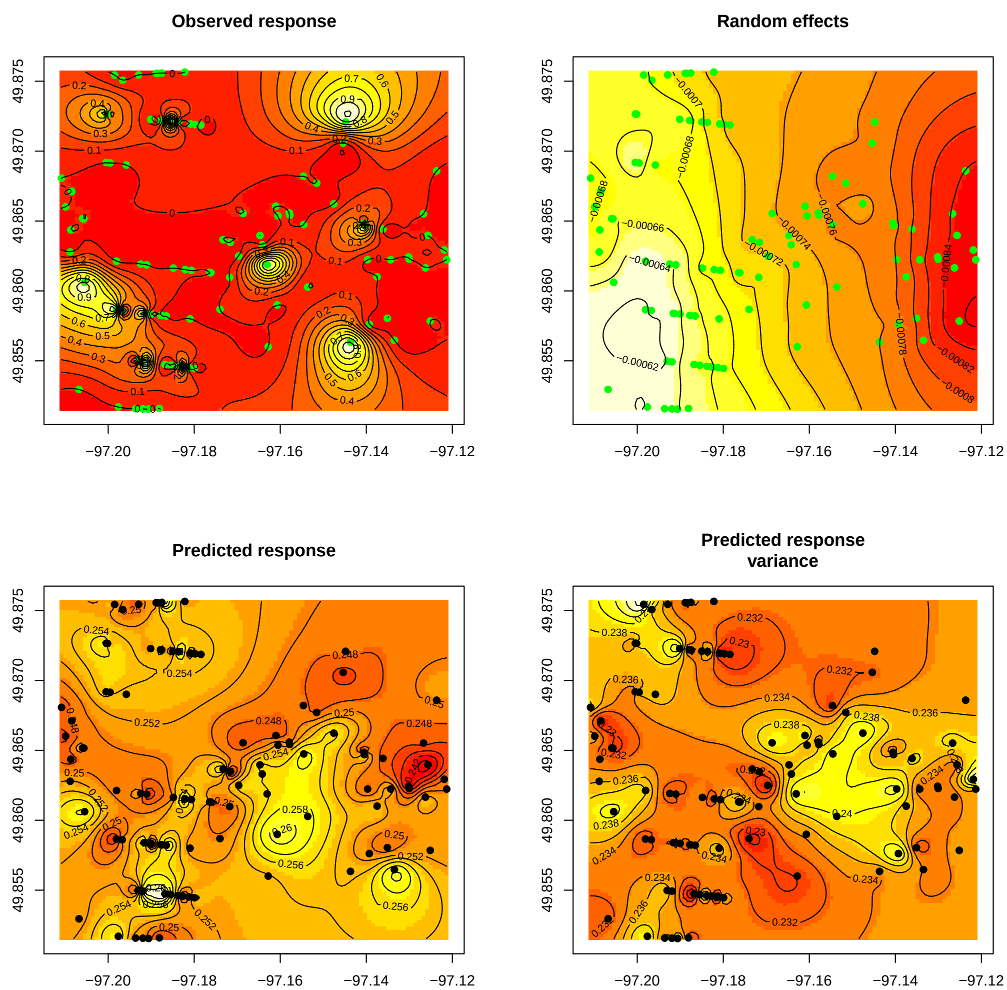


Figure 4.68: BSLM fitting Urban Males Age 15+ Unemployed

BSLM for Labour Force Participation Age 15 to 64:

The effect of stress at the neighbourhood level in Figure 4.69 was found to be protective for reducing parent report of asthma, with the greatest beneficial elements in neighbourhood corresponding to profile River Heights West. Predicted response variance is not as great as the values obtained for effect of predicted response, meaning that the predictor Labour Force Participation from the neighbourhood physical disorder domain may be better at quantifying the strength of association and consistency given the random sample of birth home respondents.

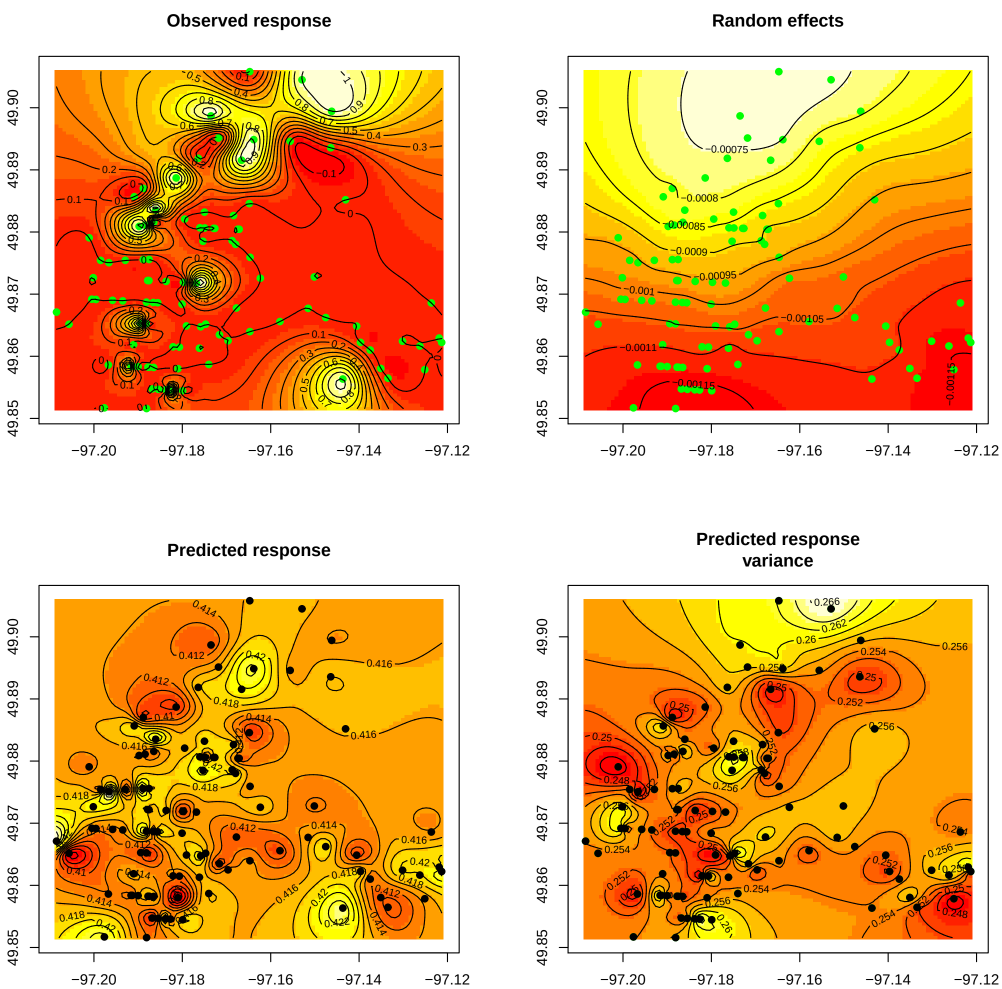


Figure 4.69: BSLM fitting Birth Home Labour Force Participation

Parent report of child asthma clusters in Figure 4.70 are shown in neighbourhoods corresponding to profile of River Heights West. Again, a protective element of neighbourhood level is observed amongst the plot of random effect. However, the area corresponding to profile of most beneficial exposure is that of River Heights East, with profile River Heights West providing higher effect of exposure from neighbourhood level. Interestingly, the effect of predicted response from the posterior plot is not as strong as that found fitting only respondents of birth homes. This highlights a differential effect that was observed before in Section 4.E through models fitted with the GLIMMIX function.

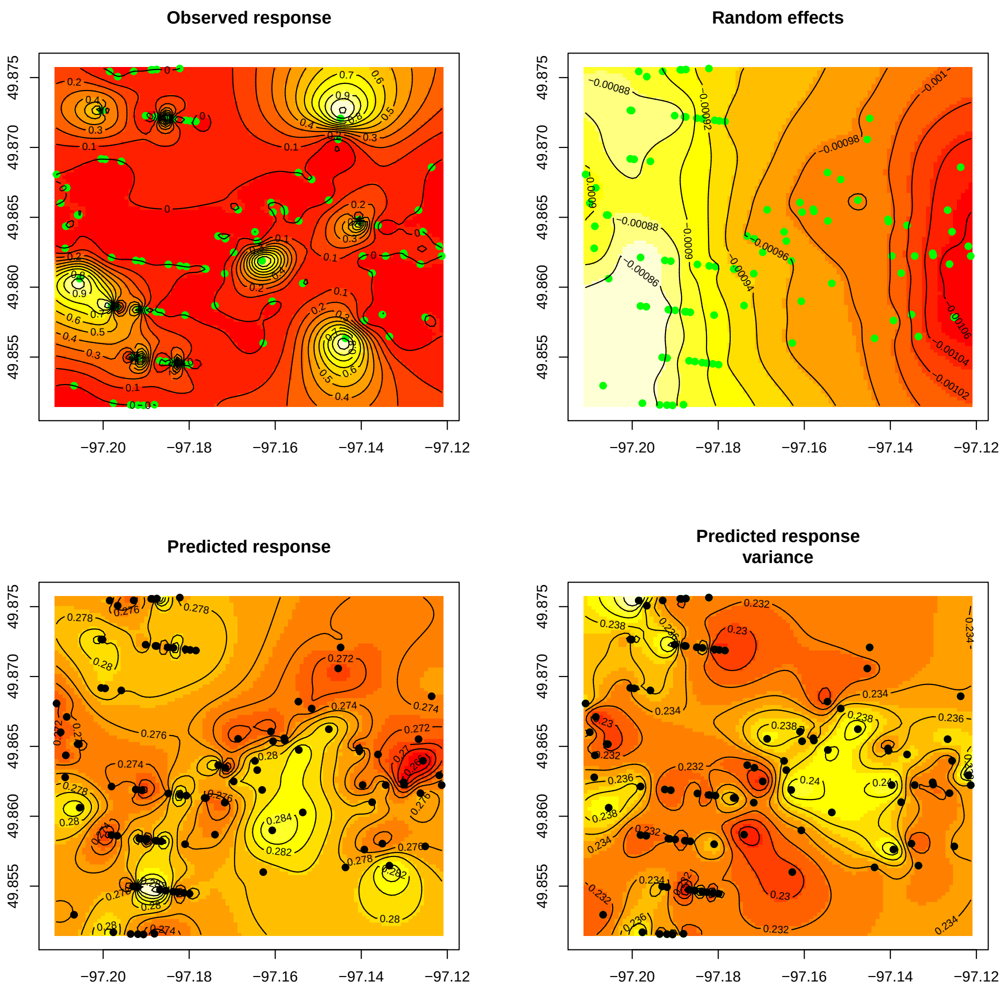


Figure 4.70: BSLM fitting Urban Labour Force Participation

BSLM for Thefts Over $5,000 per 10,000 Persons:

The spatial extent of fixed and random effects of the prior distribution for Theft Over $5,000 in Figure 4.71 are similar from that of the predictor Labour Force Participation in Figure 4.69. For random effects, the areas corresponding to high crime neighbourhood from profiles Downtown West and Downtown East are less in mitigating effect than that of low crime neighbourhoods such as River Heights East.

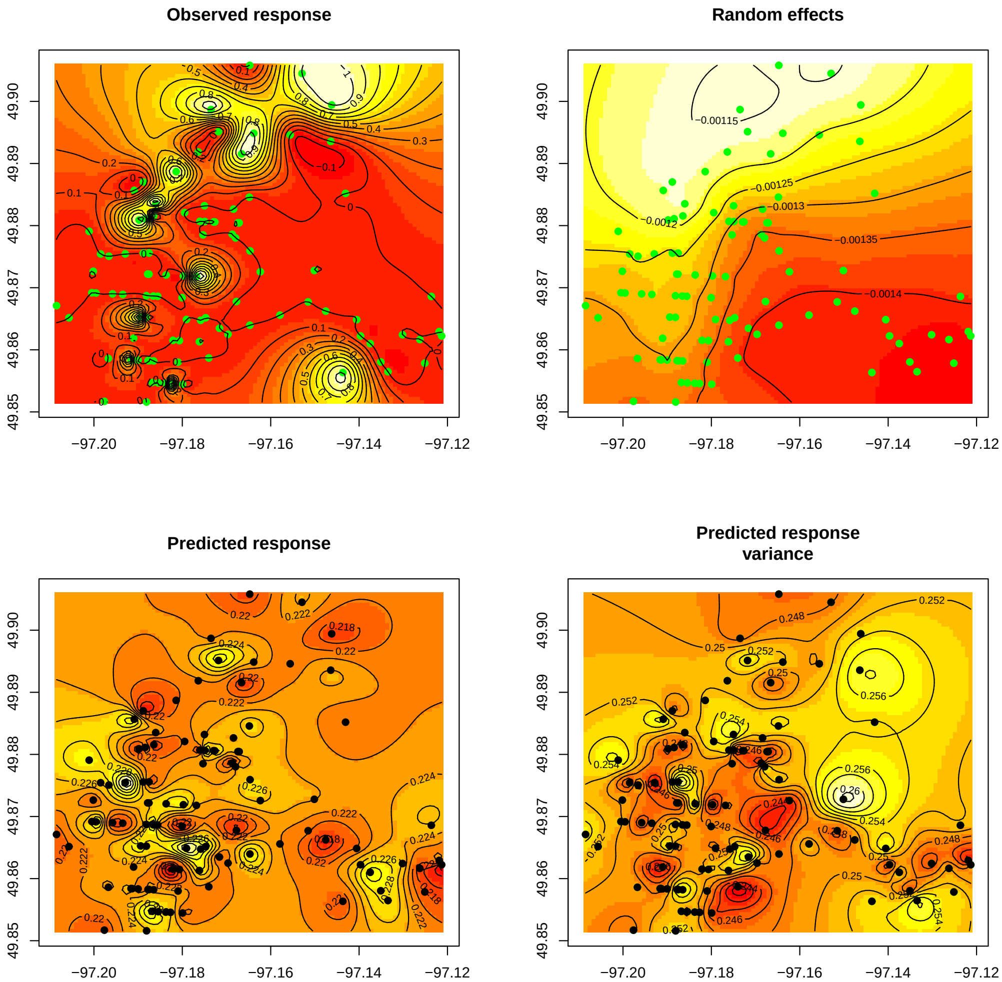


Figure 4.71: BSLM fitting Birth Home Theft Over $5,000

Observed responses in Figure 4.72 is similar to that of other predictors for the random sample of respondents inclusive of both birth homes and non-birth homes. The random effects plot also shows beneficial element of neighbourhood effect in reducing parent report of asthma outcome fitting the crime stressor Theft Over $5,000. This disagrees with the coherency suggested for the pathway of chronic neighbourhood stress inducing child asthma as stated in the research hypothesis. Perhaps this is a fault of the random sample scheme targetting low crime neighbourhoods with high respondent turnout such as River Heights West relative to the rest of the city, which is a form of selection bias.

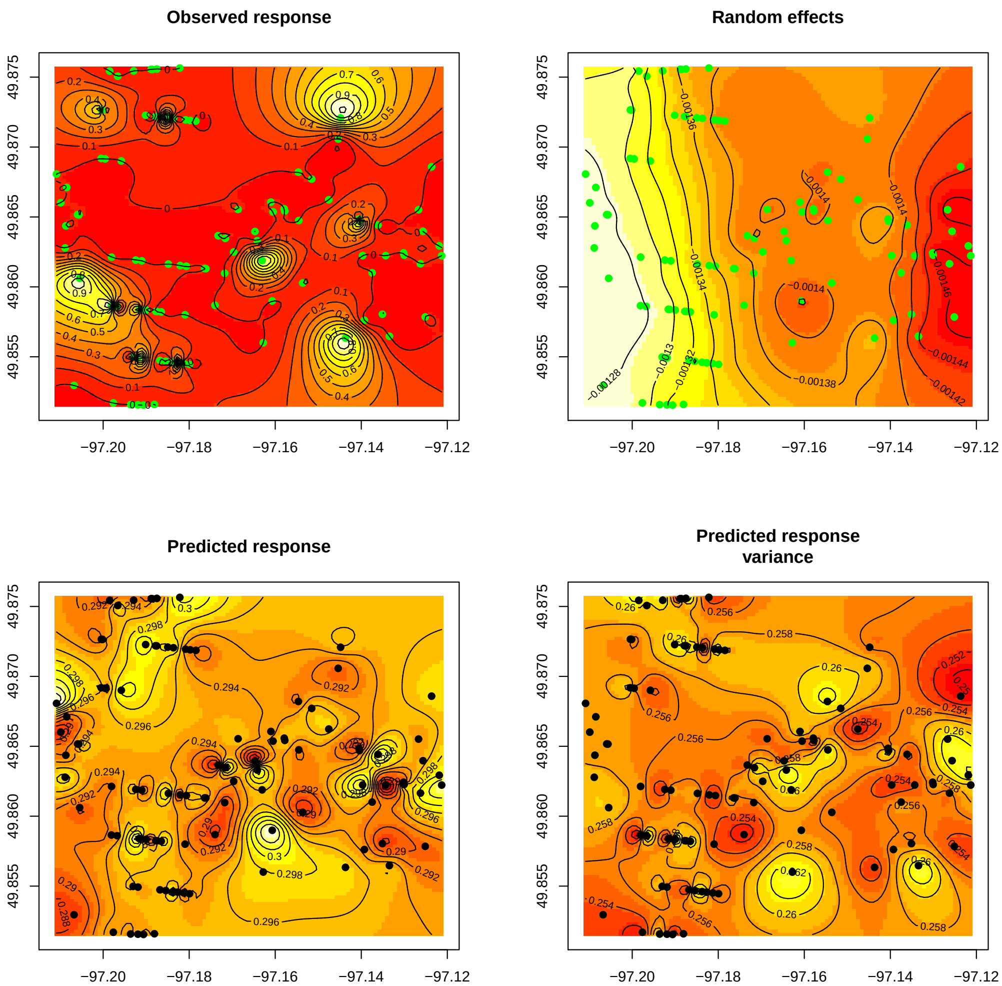


Figure 4.72: BSLM fitting Urban Theft Over $5,000

Chapter 5

Discussion

This observational study found that neighbourhood stressors related to social capital, physical disorder and crime domains contribute substantially to neighbourhood inequalities in parent report of child asthma amongst Winnipeg children. The main finding of the study is that after adjusting for family history of asthma, children resident of high stress neighbourhoods under the social capital and physical disorder domains are offered protective exposures from most measures, while those resident of high crime neighbourhoods face harmful exposures with respect to parent report of child asthma. Increasing levels of the stressors Aboriginal, Income Government Transfer, Low Income, and Males Age 15+ Unemployed under the social capital domain were found to significantly decrease the odds of parent report of child asthma, while increasing levels of the measure Median Income was determined to significantly have the opposite effect. For example, the odds ratio of parent report of asthma amongst children in birth homes residing in census tracts for the fourth quintiles of proportion males age 15+ and unemployed was 75.9% (OR 0.241; 95% CI 0.089-0.655) lower than asthma prevalence in the lowest proportion of males age 15+ and unemployed quintile. Under the physical disorder domain, increasing levels of the stressor Homes Needing Major Repairs was determined to decrease the odds of parent report of child asthma, while increasing levels of the stressors Labour Force Participation, Home Owner Household and Males Age 15 to 24 were determined to increase asthma odds. The odds of parent report of child asthma for residents of the fourth quintile census tracts of labour force participation age 15+ was over twice (OR 2.275; 95% CI 1.016-5.098) that of children residing in the lowest quintile. With the exception of Males Age 15 to 24, children resident of more affluent neighbourhoods were shown to have increased odds of asthma. This contrasts in the association concluded with contextual stressors from the Winnipeg Police Service Crime Data, where an increase level in crime rate for neighbourhood corresponded to an increased odds of parent report of asthma for child. For example, children resident of profile Downtown East with the highest Theft Over $5,000 crime rate were at much greater odds (OR 7.686; 95% CI 1.443-40.945) of parent report of asthma than those in profile River Heights East with the lowest crime rate. Neighbourhood stressors were determined to contribute up to 31% of the variance in parent report of child asthma amongst respondents residing in birth homes.

The difference in the effect of neighbourhood on asthma prevalence observed amongst children who grew up in the same low SES neighbourhood since birth, and those children who moved homes to a low income neighbourhood after 1995 needs to be noted. Children of birth homes in the fourth quintile of Males Age 15+ Unemployed (OR 0.241; 95% CI 0.089, 0.655), compared to children of both birth and non-birth homes in the fourth quintile (OR 0.499; 95% CI 0.272, 0.916) for the same stressor had a much lower odds of asthma with reference to the lowest quintile census tracts. Examining the measure Theft Over $5,000, children of birth homes (OR 7.686; 95% CI 1.443, 40.945) in the neighbourhood profile Downtown East with reference to River Heights East, compared to children of both birth homes and non-birth homes (OR 2.878; 95% CI 0.996, 8.317) had a much higher odds for parent report of asthma. This suggests that children of less stability, whose guardians relocate to low SES neighbourhoods from other localities or experience 'downward drift' may have higher rates of asthma than the children who grew up in the same neighbourhood from birth under a social capital domain. The opposite relationship was observed under a crime and violence domain, where children resident of the same neighbourhood since birth had a much higher odds of asthma than children who moved in. Both of these considerations make linkage to a hypothesized element of maternal distress, in that asthma development is multifactorial in terms of pathways with both genetics and environment having a role. Chronic exposure to some stressors at the neighbourhood level may have a positive association with increased asthma outcome, but is not entirely determinate. Agreement to these findings was recognized in the literature, in that "community violence is associated with asthma risk when controlling for individual- and neighborhood-level confounders... neither community violence nor the other individual- level factors fully accounted for the excess asthma burden among [a disadvantaged population]" (Sternthal et al., 2010). There may be further genetic or environmental pathways accountable for the observed level in report of child asthma cases that was not acknowledged in our methodology.

Labour force participation in the study was *a priori* defined as a stressor in the physical disorder domain. Having a regular job is equated to owning a home for most members in a capitalist society, as social assistance generally does not pay enough to support home ownership. The wealthy have the greatest selection of places to live in a defined municipality, with many poor populations unable to afford rent for the most dilapidated properties (Kearns & Smith, 1993, 267). Labour force participation by itself does not translate into a measure of social capital, as there are many jobs that are low paying. However, it is the proximity of members from low-income communities to high income populations that is linked to high social capital for children (Curtis et al., 2004, 1918). Support towards this antecedent was given from the literature review, in that adolescents and young adults of working age (age 15+) are most likely to commit vandalism in public space, with evidence for some time that the presence of youth hanging out idly in public space fosters an impression of physical disorder (Hipp, 2007, 667). The grouping of labour force participation, in addition to the measures length of residence in neighbourhood and proportion home owners under a perceived physical environmental stress domain for dependent outcome were fitted from survey in a multilevel model for inner Detroit neighbourhoods by Schulz et al. (2008, 652). Additionally, these three indicators were also fitted and compared under a perceived social environmental stress domain for dependent outcome in the same study, with the measure labour force participation having a smaller p-value under the perceived physical environment stress domain. Participants in the labour force versus the unemployed, and home owners versus renter households had a lower perception of physical environmental stress, which counters findings from the SAGE Survey that low values of these respective stressors offer protective benefits (Schulz et al., 2008, 653).

Ross et al. (2004, 1492) found that increasing values of the stressor median household income at the neighbourhood level increased positive health outcomes in individuals, however this measures were not significant in model output. Compared to the SAGE Survey, opposite findings were obtained, in that children in birth homes residing in census tracts for the highest quintile of median household income had three times the odds (OR 3.064; 95% CI 1.169-8.029) for parent report of asthma than children in the lowest quintile of median household income. There was more agreement with findings from the SAGE Survey in regards to stressor effect and measure from the crime and violence domain with regards to other studies published. Theall et al. (2009, 330) found that perception of positive neighbourhood safety at the individual level greatly enhanced score of collective efficacy in social networking. Interestingly, results opposite to ours for stressors under all three domains were obtained in a cohort study for cognitive development amongst African-American preschool children in Baltimore. Caughy & O'Campo (2006, 149) found that higher values of neighbourhood stressors under a physical and social disorder domain were associated with decreased educational reasoning, while a measure on fear of victimization was associated with higher processing performance (Caughy & O'Campo, 2006, 149). Recent study findings very similar to our were obtained among an asthma cohort of children in Chicago, in which the odds of asthma report was decreased 12% among children in low versus high SES neighbourhoods under a social capital domain, but was significantly elevated approximately 30% to 90% comparing children in high versus low violent crime neighbourhoods (Gupta et al., 2010, 304). Additionally, after adjusting for confounding variables for another study in Chicago, a neighbourhood level measure on collective efficacy instead of perceived violence was more significant for sexual assault in males, but not females (Jain et al., 2010, 1740).

A possible reason with the discordance of findings from the SAGE Survey to that of other studies may be due to the lack of participants from inner city neighbourhoods of central Winnipeg, where the highest stress census tracts under the social capital and physical disorder domains were located. Coverage to families of high stress census tracts was inclusive, in that many children who participated in the SAGE Survey were resident of the lowest income quintile. However, most of these children resided in neighbourhoods prinicpally outside the downtown core. Perhaps if the response rate from parents of children in the most high stress neighbourhoods was greater, our findings would be in closer agreement to that of other studies recently published. The limitation of running models with the confoundment of low income and Aboriginal status should also be discussed. The measure denoting Aboriginal status was ecologic in nature as a population proportion, and it was felt that assigning this indicator as a covariate would be appropriate only in neighbourhoods with high proportions of self-identified Aboriginal residents, which showed a large variance. For particular in Winnipeg census tracts, Aboriginal respondents comprised a range from less than 2% to roughly 50% of the population, with the greatest concentration in the north-central part of city with the fewest SAGE Survey respondents.

The difference in asthma prevalence amongst children of different SES neighbourhoods could be due to a variety of confounding factors, such as diet, exercise, weight, maternal age, housing structure, and possibly the number of children per household. Conflicting results have been attained on the association of SES and asthma, with this study ascertaining a direct relationship betwen neighbourhood SES and prevalence of asthma in Winnipeg. It has been suggested that in countries such as the United States, prevalence of asthma may be higher amongst poorer populations due to inaccessibility of primary health services (Williams et al., 2009, S179). Conversly, parents of asthmatic children from wealthier backgrounds may be more trusting and likely to participate in answering a mail-out survey from an academic institution than less affluent populations, which may face more stigma or scrutiny in reporting a child illness. With regards to the cohort of children studied in Winnipeg, accessibility to health care is probably not so much a limiting factor, and neither is payment for child asthma medications. From a clinical perspective, children of higher income background in wealthier countries receive more immunizations and medical treatment, and have better accessibility to nutritious foods than children in lower income households. Having fewer infections in a more sterile environment may lead a weaker immune system, and put children at higher risk of atopy and other environmental sensitivities (Farfel et al., 2010, 494). An additional study on the same age group of children in Manitoba from prescription and health care databases found that children receiving more than four courses of antibiotics in the first year of life had a 50% higher risk of allergist-declared asthma as age 7 than children who had no antibiotic use (Kozyrskyj et al., 2007, 1757).

Several methodological caveats of this research should be acknowledged, such that parent report of child asthma was self-reported, and measurement error could be expected in determing between wheezing or respiratory infection. Secondly, the study was ecological in nature and suffers from the fallacy that not all children residing in a specific census tract or neighbourhood exhibit the same characteristics in terms of SES or proximity to crime which define the neighbourhood. A response rate of 28.6% in the SAGE Survey also limits suitability of providing confidence intervals for estimates of the odds ratios, since it is unknown if participants are different from the population of non-responders in making inferences to the sampling frame of cohort children. However, comparing parent report of asthma from the SAGE Survey as a screening test amongst a subgroup of children for allergist diagnosis of asthma which is used the gold standard, a sensitivity of 84.1% and a specificity of 88.4% were obtained. This means that parents who participated in the SAGE Survey did a relatively good job at determining correctly if their child did, or did not have asthma that agreed to a specialist's diagnosis, validating the assurance that we can give to parent report of child asthma. Risk to children from the birth cohort in the SAGE Survey is considered minimal, since all personal identifiers such as gender, were removed. The full six digit postal code, comprising the forward sortation area (FSA) and local delivery unit (LDU) was given for each respondent. In urban areas, this corresponds to a geographic locale the size of a city block, and may only contain ten to twenty houses in a sparsely populated zone. Consent and ethics approval were obtained through all aspects of study design from the Health Research Ethics Board (HREB) at the University of Manitoba, and HREB Panel B at the University of Alberta.

Given that a period of 7 to 8 years has elapsed since respondent data was collected in 2002-2003, the ability to identify subjects is further reduced. The present study tests a secondary aim of the SAGE Survey, which does not ask questions on respondent perception of social networks or SES. Modelling techniques used are purely ecological in design, and SES associations apparent at the neighbourhood level may not be valid for the individual. Research may be beneficial to the respondents that participated in survey completion, if families of children in low income neighbourhoods shown at having a reduced risk of developing asthma experience less scrutiny in lifestyles and parenting skills supposing that the results from this study are published. The exhibited coherence and consistency on the associative pathway of beneficial exposures from compositional stressors for children in lower SES neighbourhoods is in agreement with the hygiene hypothesis (Shankardass et al., 2007, 1801). Examining the landscape of differences in income and asthma prevalence of children in Winnipeg exhibited by GIS methods, it is evident that the landscape in this larger Canadian city is not a society of equals. If access to better measures of neighbourhood perception and social justic were available from the General Social Survey, it would not be unexpected for members of the most disenfranchised communities to exhibit characteristics of anxiety having a negative effect on health (Szreter & Woolcock, 2004, 653).

Chapter 6

Conclusion

The effect of neighbourhood was observed in explaining small to intermediate proportions of variance in the dependent variable as denoted by the intraclass correlation factor for respondents grouped by neighbourhood profile, demonstrating the aptness of HLM techniques. However, little effect of neighbourhood was discernible for respondents grouped by census tracts nested within neighbourhood profiles for random effect. Very small values of R-Squared were obtained in the LRM function models featuring neighbourhood stressors as predictors. The Somer's Dxy rank correlation values were also quite low, meaning that none of the stressors were able to explain a large proportion of variance in parent report of child asthma status for respondents of the SAGE Survey for the Winnipeg component after accounting for family history of asthma. Interestingly, there was a difference in significance and effect observed between respondents of birth homes and the urban component of entire survey with regards to parent report of child asthma for low SES neighbourhoods amongst quintile values of the stressor Labour Force Participation. In particular, the odds of parent report of child asthma for residents of birth homes in the fourth highest quintile census tracts of labour force participation age 15+ was over twice (OR 2.275; 95% CI 1.016-5.098) that of children residing in the lowest quintile, compared to an odds ratio less than 1.5 times greater (OR 1.431; 95% CI 0.850-2.410) for children resident of both birth and non-birth homes at age 7-8.

Bayesian spatial methods were able to quantify observed hot spots for parent report of child asthma given neighbourhood stressors as predictors, given a random sample of points corresponding to a spatial area of relatively complete coverage. The random effect of stress at the neighbourhood level was found to be minimally harmful or protective for reducing parent report of asthma. However, the relationship in the effect of neighbourhood was not as strong compared to what was observed from HLM techniques specifying the neighbourhood profile as aggregating units, as it is more sensitive upon directional respondent turnout. Posterior power of the model was fair in gauging the predicted response of child asthma to be similar to that of the observed response, but the predicted response variance was often of the same magnitude as the predicted response itself.

Chapter 7

Recommendations

To obtain data collected by Statistics Canada telephone surveys at the census tract level, such as the GSS and CCHS, it is recommended that a similar study should be carried out for a location with indicators present for the desired neighbourhood geography. Prospective studies with SES information collected at the individual-level would be much better in reducing bias, and the limitation of the ecological fallacy that arises in assigning a score to the individual from the neighbourhood level. More consideration may be placed behind associations observed in this scenario as well, since the time lag between data collection and analysis will be minimal. However, it is important that a prospective cohort study include children both resident of the same and different homes since birth, even if all the respondent observations cannot be used in ensuring that value of stressor assigned to them from the neighbourhood level is indeed chronic and consistent. This is so that differences between members that stay stationary and those who move neighbourhoods can be compared. Linkage of the SAGE Survey to maternal depression scores obtained on the entire SAGE cohort would also be beneficial, to test a hypothesis on the association between between maternal distress and asthma in low-income households with a subset of children (Kozyrskyj et al., 2008, 145)

Linear discriminant analysis and other non-parametric classification schemes such as support vector machines may be promising in situations such as large cohort studies where data has already been collected, and linked retrospectively. A sensitivity of 54.2% and a specificity of 91.2% given neighbourhood stressors from the 1996 Canada Census and

2001 Winnipeg Police Service Crime Data was achieved, which included adjusting for all individual level indicators from the SAGE Survey to predict parent report of childhood asthma. Roughly half of all asthmatic children can be classified properly from the best models constructed of data provided for caregiver report of asthma, which compares to nine out of ten non-asthmatic children being identified correctly.

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Appendices

Appendix A

Summary Table

1.A Significant Adjusted Odds Ratios from HLMs

	Children of Birth Homes	All Children
Social Capital Domain		
Low Income - 3:1	0.380 (0.153 - 0.948)	
Home Owner Household - 2:5	0.286 (0.107 - 0.771)	
Income Government Transfer - 1:5	2.760 (1.046 - 7.281)	
Aboriginal - 4:1	0.315 (0.108 - 0.915)	
Median Income - 5:1	3.064 (1.169 - 8.029)	
Males Age 15+ Unemployed - 4:1	0.241 (0.089 - 0.655)	0.499 (0.272 - 0.916)
Males Age 15+ Unemployed - 3:1	0.228 (0.082 - 0.629)	
Males Age 15+ Unemployed - 2:1	0.366 (0.141 - 0.948)	
Physical Disorder Domain		
Males Age 15 to 24 - 3:1	2.311 (1.113 - 4.800)	
Labour Force Particioiation - 4:1	2.275 (1.016 - 5.098)	
Homes Needing Major Repairs - 2:5	2.128 (1.026 - 4.415)	
Crime and Violence Domain		
Sexual Assault - 56.13:2.03	5.584 (1.072 - 29.073)	
Theft Over $5,000 - 19.05:0.48	7.686 (1.443 - 40.945)	

Table A.1: Summary of Neighbourhood Stressors

Appendix B

Data Dictionary

2.A SAGE Survey Indicators, 2002-2003

Table B.1: SAGE Survey, 2002-2003

Variable Code	*Variable Definition*
`Response Variable`	`Dependent outcome of interest:`
asth_child	Parent report of child asthma
`Location Variables`	`Denotes geographical location of respondent:`
CityTown	Character name of municipality
pcode	Full six digit postal code from 2002-2003
CSDUID	Census subdivision identifier
CTUID	Census tract identifier for urban respondent
FNloc	First Nations location
loc	Stratified urban or rural
X	Longitude coordinate
Y	Latitude coordinate
`Suppl. Variables`	`Parent report indicators:`
arth_child	Arthritis for child
arth_mother	Arthritis for mother
arth_father	Arthritis for father
arth_sib	Arthritis for sibling
asth_mother	Asthma for mother
asth_father	Asthma for father
asth_sib	Asthma for sibling
bwl_child	Inflammatory bowel disease for child
bwl_mother	Inflammatory bowel disease for mother
bwl_father	Inflammatory bowel disease for father
bwl_sib	Inflammatory bowel disease for sibling
foodal_child	Food allergy for child
foodal_mother	Food allergy for mother
foodal_father	Food allergy for father
foodal_sib	Food allergy for sibling
hay_child	Hay fever for child
hay_mother	Hay fever for mother
hay_father	Hay fever for father
hay_sib	Hay fever for sibling
insul_child	Insulin dependent diabetes for child
insul_mother	Insulin dependent diabetes for mother
insul_father	Insulin dependent diabetes for father
insul_sib	Insulin dependent diabetes for sibling
noins_diab_child	Diet/pill dependent diabetes for child
noins_diab_mother	Diet/pill dependent diabetes for mother
noins_diab_father	Diet/pill dependent diabetes for father
noins_diab_sib	Diet/pill dependent diabetes for sibling
fh	Family history of atopy
fh_asthma	Family history of asthma
`Exposure Variables`	`Residence and environment indicators:`
bh	Same home in 2002-2003 as 1995
	Continued on next page

Table B.1 – Continued from previous page

Variable Code	*Variable Definition*
agehome	Integer age of current home
homeAge	Quintile age of current home
mold95	Mold present in 1995 home
mold	Mold present in 2002-2003 home
smoke95	Parent smoked in 1995
smoke	Parent smoked in 2002-2003
feline95	Cat present in 1995 home
feline	Cat present in 2002-2003 home
canine95	Dog present in 1995 home
canine	Dog present in 2002-2003 home
	Concluded

2.B Mail-Out SAGE Survey Questionnaire

HOW YOUR HOME MAY AFFECT YOUR CHILD'S HEALTH

I have read the consent form and agree to participate in this survey yes ☐ no ☐

THE HEALTH OF MY CHILD AND FAMILY

Does your 7 year old child or anyone in the immediate family (sisters, brothers and parents) have any of the following problems in the last 12 months?

	Child		Birth Mother			Birth Father			Child's Brother/Sister (any)		
Diabetes	yes	no	Yes	no	not sure	yes	no	not sure	yes	no	no brother or sister
Requiring insulin	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Controlled by diet/pills	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Food allergy	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Inflammatory bowel disease (colitis)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Asthma	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hayfever	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Arthritis	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

MY HOME ENVIRONMENT

What is the age of your home (where you live now)? ________ years

How long have you lived in this home? ________ years

Is there mold/mildew in this home? yes ☐ no ☐

Does anyone living in this home smoke (cigarettes or tobacco)? yes ☐ no ☐

Do they smoke inside the home? yes ☐ no ☐

In 1995 did anyone living in your home smoke (cigarettes or tobacco)? yes ☐ no ☐

Did they smoke inside the home in 1995? yes ☐ no ☐

The number of pets in your home now: Cats ________ Dogs ___________
The number of pets in your home in 1995: Cats ________ Dogs ___________

Were you living in your present home in 1995? yes ☐ no ☐

IF YOU have moved since 1995, please answer the following:

What was the age of your 1995 home ? ________ years

Was there mold/mildew in that home? yes ☐ no ☐

Was your 1995 home located on a First Nations community? yes ☐ no ☐

I am willing to be contacted about participating in a more in-depth study on my child's health and our environment. yes ☐ no ☐

To determine whether my child would be eligible for this study, I give permission for the researchers associated with this study to access my child's provincial health care records. * Please see note below yes ☐ no ☐

Phone number: ______________

OR, please use this contact information instead:

Name of Parent/Guardian Completing Questionnaire

______________________________ ______________________________

First Name Last Name

____

Address

____

City/Town Postal Code

____

Name of Additional Contact Person Phone number

____

*IF you say YES, the study number on this survey will be used to access your child's health care records such as visits to hospitals, clinics and doctor's offices, and prescription medications.

If you say NO, the study number will be removed from the survey and we will not access your child's health care records.

PLEASE RETURN THIS SHEET IN THE PRE-ADDRESSED ENVELOPE

KEEP THE CONSENT FORM FOR YOUR RECORDS.

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY!

HOW YOUR HOME MAY AFFECT YOUR CHILD'S HEALTH

Dear Parent/Guardian, January 15, 2003

In November a survey on children's health and the home environment was mailed to you. It is important to collect information on as many children in Manitoba as possible to understand how your home may affect your child's health.

Please take a few minutes to:

- Read the consent form and keep it in your files
- **COMPLETE** the survey (yellow page). It asks a few questions about your child born in 1995, your family and your home and whether you would like to be contacted about further study of your child and your home.
- **RETURN** the survey to us in the pre-addressed envelope.

There will be a draw for prizes from the returned surveys.

Thank you.

Dr. Allan Becker
DEPARTMENT OF PEDIATRICS AND CHILD HEALTH, UNIVERSITY OF MANITOBA
Phone: **977-5613** OR **1-866-446-4482**

2.C Statistics Canada Census, 1996

Master list of SES indicators from the 2001 Canada Census, aggregated into proposed latent factors that quantify stress at neighbourhood level as proposed by Matheson et al. (2006, 2610) in Subsection 3.C.1. Note that these groupings do not necessarily agree with latency factors exposed in 1996 Canada Census data for the Winnipeg CMA using similar methodology, as the groupings below are based on studying 25 Census Metropolitan Areas in Canada. However, it provided a good beginning point of what ecologic indicators to use in linking to the SAGE Survey for significance.

Variable Name	*Variable Code*	*Quintile Variable Definition*
Census Tract ID	CTUID	Census tract ID in character format
`1st Factor`		`Measures residential instability:`
Age 5 to 14	PER_Y5_14	% of population age 5 to 14
Average Family Size	AVG_FAM_SI	Average family size
Home Owner Household	PER_HOME_O	% of households which are home owners
Males Age 15 to 24	PER_M15_24	% of population that is male age 15 to 24
Moved Last 5 Years	PER_M_L5YR	% who have moved in last five years
Population Change Last 5 Years	PER_PC_L5YR	% population change in last five years
Population Married	PER_MARRIE	% of population which is married
Rental Household	PER_RENT	% of households which are renters
`2nd Factor`		`Measures material deprivation:`
Age 15+ Unemployed	PER_15P_UN	% of population age 15+ and unemployed
Average Income	AVG_INCOME	1995 income of population age 15+
Female Lone Parent Household	PER_F_LP	% of households headed by female lone parent
Homes Needing Major Repairs	PER_H_MR	% of homes needing major repairs
Income Government Transfer	PER_INC_GT	% of income government transfers comprise
Lone Parent Household	PER_LP	% of households headed by lone parent
Low Income	PER_LI	% incidence of low income in households
Males Age 15+ Unemployed	M_15P_UN	% of male population 15+ and unemployed
Median Income	MED_INCOME	Median 1995 income of population 15+
No Income Household	PER_NI	% of population age 15+ reporting no income
No School Diploma Age 15+	N_HS_15P	% age 15+ with no high school certificate
Owner Housing Unaffordable	ON_H_30P	% of owners spending 30%+ income on shelter
Population Density	POP_DENSIT	Population density of census tract per km^2
Renter Housing Unaffordable	TN_H_30P	% of renters spending 30%+ income on shelter
Standard Error Average Income	SE_AVG_INC	Standard error of average 1995 income age 15+
`3rd Factor`		`Measures dependency:`
Labour Force Participation	LF_PAR_15P	% labour force participation (age 15 to 64)
Ratio of Nonworkers to Workers	RAT_NW_W	Ratio of population 0-14 and 65+ divided by 15-64
Senior Population	PER_SENIOR	%t of population age 65+
`4th Factor`		`Measures ethnic diversity:`
Aboriginal	PER_ABOR	% Aboriginal population composition
Recent Immigrant	PER_REC_IM	% recent immigrants within period 1991-1996
Visibile Minority	PER_VIS_MI	% visible minorities population composition

Table B.2: Canada Census Indicators, 1996

2.D Winnipeg Police Service, 2001

Variable Name	*Variable Code*	*Continuous Variable Definition*
Neighbourhood Profile	NEIGH	City of Winnipeg profile name
Arson	ARSON	Arsons per 10,000 persons
Break and Enter	BREAK_ENTER	Break and enters per 10,000 persons
Firearm Offensive Weapon	FIREARM_OW	Firearms weapon charges per 10,000 persons
Mischief	MISCHIEF	Mischief charges per 10,000 persons
Prostitution	PROSIT	Prostitution charges per 10,000 persons
Robbery	ROBBERY	Robberies per 10,000 persons
Sexual Assault	SEX_ASSAULT	Sexual assaults per 10,000 persons
Theft Motor Vehicle	THEFT_MV	Motor vehicle thefts per 10,000 persons
Theft Over $5,000	THEFT_O_5K	Thefts over $5,000 per 10,000 persons
Theft Under $5,000	THEFT_U_5K	Thefts equal and below $5,000 per 10,000 persons

Table B.3: Neighbourhood Crime Data, 2001

Profile Name
Assiniboine South
Downtown East
Downtown West
Fort Garry North
Fort Garry South
Inkster East
Inkster West
Point Douglas North
Point Douglas South
River East East
River East South
River East West
River Heights East
River Heights West
Seven Oaks East
Seven Oaks West
St. Boniface East
St. Boniface West
St. James - Assiniboia East
St. James - Assiniboia West
St. Vital North
St. Vital South
Transcona

Table B.4: City of Winnipeg 'NEIGH' Values (23)

Appendix C

Winnipeg CMA Census Tracts

Table C.1: Census Tracts Ranked by Average Household Size, 1996

CTUID	*Contingent Community Name*	*Average Household Size*
6020011.00	McMillan	2.2
6020013.00	The Forks	2.2
6020014.00	Broadway Assiniboine	2.3
6020142.03	Valhalla	2.3
6020012.00	River-Osborne	2.5
6020015.00	Legislature	2.5
6020023.00	Central Park	2.5
6020501.03	Cresecent Park	2.5
6020004.02	Grant Park	2.6
6020104.00	Varennes	2.6
6020501.01	Montcalm	2.6
6020004.01	Rockwood	2.7
6020024.00	Exchange District	2.7
6020049.00	Robertson	2.7
6020102.03	St. George	2.7
6020110.01	St. Boniface Industrial Park	2.7
6020116.00	Central St. Boniface	2.7
6020121.00	Radisson	2.7
6020133.00	Valley Gardens	2.7
6020534.00	Silver Heights	2.7
6020536.00	Booth	2.7
6020551.00	Margaret park	2.7
6020553.00	Riverbend	2.7
6020001.00	Riverview	2.8
6020003.00	Earl Grey	2.8
6020006.00	Mathers	2.8
6020016.00	West Broadway	2.8
6020031.00	St. James Industrial	2.8
6020038.00	Talbot-Grey	2.8
6020050.02	Shaughnessy Park	2.8
6020102.02	St. George	2.8
6020102.04	Worthington	2.8
6020105.00	Glenwood	2.8
6020113.00	Norwood East	2.8
6020114.00	Norwood East	2.8
6020131.00	Munroe East	2.8
6020134.00	Springfield South	2.8
6020502.00	Beaumont	2.8
6020530.00	Bruce Park	2.8
6020531.00	King Edward	2.8
6020540.02	Crestview	2.8
6020540.04	Sturgeon Creek	2.8
6020550.00	Kildonan Park	2.8
6020552.01	Garden City	2.8
6020002.00	Lord Roberts	2.9
6020007.00	J.B. Mitchell	2.9

Continued on next page

Table C.1 – Continued from previous page

CTUID	*Contingent Community Name*	*Average Household Size*
6020010.00	Cresecentwood	2.9
6020017.00	Wolseley	2.9
6020018.00	West Wolseley	2.9
6020020.00	Minto	2.9
6020037.00	Tyne-Tees	2.9
6020103.00	Elm Park	2.9
6020112.02	Windsor Park	2.9
6020130.01	Kildonan Crossing	2.9
6020132.00	Kildonan Drive	2.9
6020141.01	Rossmere-B	2.9
6020141.02	Kildonan Drive	2.9
6020500.01	Fort Richmond	2.9
6020503.00	Wildwood	2.9
6020532.00	King Edward	2.9
6020533.00	Deer Lodge	2.9
6020535.00	Jameswood	2.9
6020537.01	Kirkfield	2.9
6020537.03	Westwood	2.9
6020538.00	Glendale	2.9
6020540.03	Heritage Park	2.9
6020005.00	South River Heights	3.0
6020009.00	North River Heights	3.0
6020019.00	Polo Park	3.0
6020022.00	Spence	3.0
6020039.00	Chalmers	3.0
6020043.00	Willian Whyte	3.0
6020044.00	Logan CPR	3.0
6020045.00	Lord Selkirk Park	3.0
6020047.00	Inkster-Faraday	3.0
6020048.00	Burrows Central	3.0
6020101.01	Pulberry	3.0
6020111.00	Windsor Park	3.0
6020112.01	Symington Yards	3.0
6020115.00	Norwood West	3.0
6020117.00	North St. Boniface	3.0
6020122.01	Radisson	3.0
6020123.00	Victoria West	3.0
6020161.00	St. Clements RM	3.0
6020510.02	Tuxedo	3.0
6020522.01	Varsity View	3.0
6020539.02	Buchanan	3.0
6020540.01	Crestview	3.0
6020542.00	Oak Point Highway	3.0
6020552.02	Templeton-Sinclair	3.0
6020008.00	Wellington Crescent	3.1
6020026.00	Centennial	3.1
6020027.00	West Alexander	3.1
6020030.00	Sargeant Park	3.1
6020032.00	Weston	3.1
6020036.00	North Point Douglas	3.1
6020040.00	Glenelm	3.1
6020041.00	Kildonan Park	3.1
6020042.00	Ormand's Creek Industrial	3.1
6020050.01	Burrows-Keewatin	3.1
6020100.02	St. Vital Perimetre Highway South	3.1
6020110.02	Southdale	3.1
6020120.03	Kildare-Redonda	3.1
6020130.02	Kildonan Crossing	3.1
6020142.01	River East	3.1
6020160.00	St. Clements RM	3.1
6020500.02	La Barriere	3.1
6020500.04	Cloutier Drive	3.1
6020537.02	Westwood	3.1
6020539.01	Saskatchewan North	3.1
6020560.02	Leila North	3.1
6020585.00	Rosser RM	3.1
6020021.00	St. Mathews	3.2
6020033.00	Dufferin Industrial	3.2

Continued on next page

Table C.1 – Continued from previous page

CTUID	*Contingent Community Name*	*Average Household Size*
6020034.00	Lord Selkirk Park	3.2
6020035.00	North Point Douglas	3.2
6020046.00	St. John's	3.2
6020100.03	Normand Park	3.2
6020100.04	River Park South	3.2
6020101.02	Minnetonka	3.2
6020140.01	Grassie	3.2
6020142.04	Rossmere-A	3.2
6020501.02	Chevier	3.2
6020520.03	Westdale	3.2
6020521.01	Betsworth	3.2
6020560.03	Rosser Old-Kildonan	3.2
6020560.05	Leila-McPhillips Triangle	3.2
6020570.00	West St. Paul RM	3.2
6020580.00	West St. Paul RM	3.2
6020590.02	Springfield RM	3.2
6020028.00	Daniel McIntyre	3.3
6020029.00	Daniel McIntyre	3.3
6020102.01	Meadowood	3.3
6020110.04	Southland Park	3.3
6020120.02	Canterbury Park	3.3
6020122.02	Meadows	3.3
6020140.03	Peguis	3.3
6020150.00	East St. Paul	3.3
6020520.01	Headingley RM	3.3
6020520.02	West Riverside Park	3.3
6020522.02	Assiniboine park	3.3
6020560.04	The Maples	3.3
6020590.01	Springfield RM	3.3
6020051.01	North Inkster Industrial	3.4
6020100.01	River Park South	3.4
6020140.02	Kil-Cona Park	3.4
6020142.02	River East	3.4
6020500.03	Richmond West	3.4
6020510.01	Linden Woods	3.4
6020600.00	Ritchot RM	3.4
6020025.00	China Town	3.5
6020051.02	Tyndall Park	3.5
6020051.03	Tyndall Park	3.5
6020120.01	Transcona South	3.5
6020595.00	Tache RM	3.5
6020541.00	Winnipeg Airport	3.6
6020560.01	Mandalay West	3.6
		Concluded

Appendix D

Covariance Matrices of Stressors

	PER_M15_24	PER_HOME_O	PER_INC_GT	M_15P_UN	PER_LI	PER_H_MR	MED_INCOME	LF_PAR_15P	PER_ABOR
PER_M15_24	0.00	-0.00	-0.00	0.00	0.00	-0.00	-3.91	0.00	0.00
PER_HOME_O	-0.00	0.06	-0.01	-0.01	-0.03	-0.00	815.95	0.01	-0.01
PER_INC_GT	-0.00	-0.01	0.01	0.01	0.01	0.00	-390.06	-0.01	0.01
M_15P_UN	0.00	-0.01	0.01	0.00	0.01	0.00	-265.26	-0.00	0.01
PER_LI	0.00	-0.03	0.01	0.01	0.03	0.00	-747.67	-0.01	0.01
PER_H_MR	-0.00	-0.00	0.00	0.00	0.00	0.00	-99.07	-0.00	0.00
MED_INCOME	-3.91	815.95	-390.06	-265.26	-747.67	-99.07	24914855.93	323.04	-325.78
LF_PAR_15P	0.00	0.01	-0.01	-0.00	-0.01	-0.00	323.04	0.01	-0.00
PER_ABOR	0.00	-0.01	0.01	0.01	0.01	0.00	-325.78	-0.00	0.01

Table D.1: Pearson's Covariance Matrix of Significant Stressors, Canada Census, 1996

	SEX_ASSAULT	ROBBERY	BREAK_ENTER	THEFT_O_5K	THEFT_U_5K	THEFT_MV	ARSON	MISCHIEF	PROSIT	FIREARM_OW
SEX_ASSAULT	168.88	575.81	998.62	38.67	2659.43	1251.57	99.85	1874.26	128.32	115.22
ROBBERY	575.81	2254.47	3766.63	122.71	8673.81	4764.47	407.56	7124.72	494.78	437.38
BREAK_ENTER	998.62	3766.63	8031.31	221.20	15539.21	10783.81	758.55	13692.05	786.31	774.72
THEFT_O_5K	38.67	122.71	221.20	16.60	914.06	252.02	14.84	425.16	26.29	26.61
THEFT_U_5K	2659.43	8673.81	15539.21	914.06	60291.84	19242.88	1224.56	31894.97	1888.34	1802.14
THEFT_MV	1251.57	4764.47	10783.81	252.02	19242.88	16565.69	1041.93	18863.69	916.22	973.78
ARSON	99.85	407.56	758.55	14.84	1224.56	1041.93	92.84	1385.47	89.63	81.04
MISCHIEF	1874.26	7124.72	13692.05	425.16	31894.97	18863.69	1385.47	26163.46	1496.40	1434.22
PROSIT	128.32	494.78	786.31	26.29	1888.34	916.22	89.63	1496.40	122.94	97.32
FIREARM_OW	115.22	437.38	774.72	26.61	1802.14	973.78	81.04	1434.22	97.32	89.07

Table D.2: Pearson's Covariance Matrix, Winnipeg Police Service, 2001

Appendix E

Correlation Matrices of Stressors

	PER_M15_24	PER_HOME_O	PER_INC_GT	M_15P_UN	PER_LI	PER_H_MR	MED_INCOME	LF_PAR_15P	PER_ABOR
PER_M15_24	1.00	-0.02	-0.18	0.04	0.00	-0.16	-0.03	0.27	0.05
PER_HOME_O	-0.02	1.00	-0.51	-0.47	-0.65	-0.17	0.54	0.43	-0.46
PER_INC_GT	-0.18	-0.51	1.00	0.59	0.66	0.34	-0.70	-0.71	0.54
M_15P_UN	0.04	-0.47	0.59	1.00	0.62	0.29	-0.63	-0.41	0.62
PER_LI	0.00	-0.65	0.66	0.62	1.00	0.27	-0.74	-0.48	0.65
PER_H_MR	-0.16	-0.17	0.34	0.29	0.27	1.00	-0.29	-0.25	0.30
MED_INCOME	-0.03	0.54	-0.70	-0.63	-0.74	-0.29	1.00	0.49	-0.64
LF_PAR_15P	0.27	0.43	-0.71	-0.41	-0.48	-0.25	0.49	1.00	-0.32
PER_ABOR	0.05	-0.46	0.54	0.62	0.65	0.30	-0.64	-0.32	1.00

Table E.1: Kendall's Correlation Matrix of Significant Stressors, Canada Census, 1996

	SEX_ASSAULT	ROBBERY	BREAK_ENTER	THEFT_O_5K	THEFT_U_5K	THEFT_MV	ARSON	MISCHIEF	PROSIT	FIREARM_OW
SEX_ASSAULT	1.00	0.57	0.47	0.21	0.53	0.43	0.64	0.51	0.51	0.51
ROBBERY	0.57	1.00	0.74	0.40	0.61	0.65	0.60	0.69	0.53	0.72
BREAK_ENTER	0.47	0.74	1.00	0.39	0.60	0.75	0.55	0.77	0.39	0.72
THEFT_O_5K	0.21	0.40	0.39	1.00	0.47	0.24	0.30	0.32	0.40	0.37
THEFT_U_5K	0.53	0.61	0.60	0.47	1.00	0.47	0.45	0.72	0.37	0.57
THEFT_MV	0.43	0.65	0.75	0.24	0.47	1.00	0.53	0.70	0.35	0.59
ARSON	0.64	0.60	0.55	0.30	0.45	0.53	1.00	0.58	0.39	0.60
MISCHIEF	0.51	0.69	0.77	0.32	0.72	0.70	0.58	1.00	0.38	0.69
PROSIT	0.51	0.53	0.39	0.40	0.37	0.35	0.39	0.38	1.00	0.46
FIREARM_OW	0.51	0.72	0.72	0.37	0.57	0.59	0.60	0.69	0.46	1.00

Table E.2: Kendall's Correlation Matrix, Winnipeg Police Service, 2001