A Geographic Exploratory Analysis of Health and Crime in Toronto Neighbourhoods

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Crime impacts may pose a health risk to victims and result in potential demands on healthcare services. However, the impacts from crime on health are complex and diverse. It is difficult to measure and quantify such impacts, since conventional police-recorded crime statistics do not collect data on people's perception of the risk of crime and the impacts of victimization on health and wellbeing.

This manuscript-style thesis consists of two parts. The first study assesses crime and wellbeing at the individual level, conducting a questionnaire survey in four selected neighbourhoods in Toronto. The purpose of this study is to explore how crime affects people's health and quality of life. The impacts of crime on both physical and psychological health and wellbeing are explored. Findings from this study may potentially contribute to developing effective strategies for crime reduction and prevention.

Results from the questionnaire survey suggest a significant impact of crime on mental health, both short-term and long-term, which may have a significant effect on an individual's quality of life. Hence, availability and accessibility of mental health services for Victim Support is important to consider from a health policy and services perspective. The second study in this manuscript-style thesis evaluates the risk of poor mental health in Toronto and assesses spatial accessibility to mental healthcare services. Two accessibility measures were applied, namely, the gravity model and the two-step catchment area method. The spatial patterns of accessibility to mental healthcare by these two measures were compared, along with variation in accessibility ratios. A risk map of poor mental health was developed by applying a multi-criteria evaluation methodology, while considering crime rates and deprivation. Areas with high risk of poor mental health and low accessibility to mental healthcare were identified after comparing the risk and accessibility maps. This study contributes to identifying inequities in accessibility to mental healthcare in Toronto, as well as promoting services that can help improve public mental health.

Overall, this thesis explores the health of victims of crime based on a conceptual social model that highlights the links between crime, deprivation and health. Findings indicate that residents' mental health and psychological wellbeing are significantly affected by crime in selected Toronto neighbourhoods, but existing mental healthcare facilities are not sufficient to serve residents with varying mental healthcare needs, especially those living in Downtown areas.

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Chapter 1. Introduction

1.1 Statement of the Research Problem

Crime is defined as an act of breaking rules or laws, potentially having adverse impacts on citizens, the economy, and society (Lu et al., 2012). With increasing urbanization and industrialization, there are growing concerns with perceived increasing levels of crime (Deflem, 2006). Criminologists have traditionally focused on offenders and their criminal motivations, as well as crime detection and punishment (Robinson & Keithley, 2000). However, attention has shifted towards victims and victimization, along with developing approaches and strategies for crime prevention. In particular, a growing number of studies have focused on the consequences of victims on health and the substantial demands on healthcare systems (e.g. Resnick, 1997; Koss et al., 1991; Heise et al., 1994).

Should crime be considered as a public health issue and what are the impacts of crime on health? Research indicates that injury from criminal offenses can cause temporary or permanent disability, mental disease, or even death world-wide (Krug et al., 2002). Canada spent over $85 billion on crime, among which the cost of direct and immediate healthcare for victims was estimated to be $0.1 billion, while the cost of crime on people's suffering and reduced quality of life constituted over half of the total amount (Easton et al., 2014). In fact, crime may also affect people indirectly, since victims also suffer from a wide range of psychological effects, such as serious mental illness, substance abuse, and smoking (Goodwin, 2004). Moreover, people's fear of crime causes them to feel unsafe.

Although crime is a public health issue, research in health and criminology has developed independently of one another. It remains difficult to assess the impacts of crime on health and quality of life, and the links between fear of crime and health. To capture and explore such relationships, a conceptual social model of crime and health is shown in Figure 1.1, which forms the theoretical foundation of this thesis. The framework identifies the relationships between crime, deprivation, health, and healthcare. The principle research questions that arise from this conceptual model are: 1) How do socioeconomic factors

affect the occurrence of crime? 2) What are the impacts of crime on health? 3) How does access to healthcare services affect the health of victims?
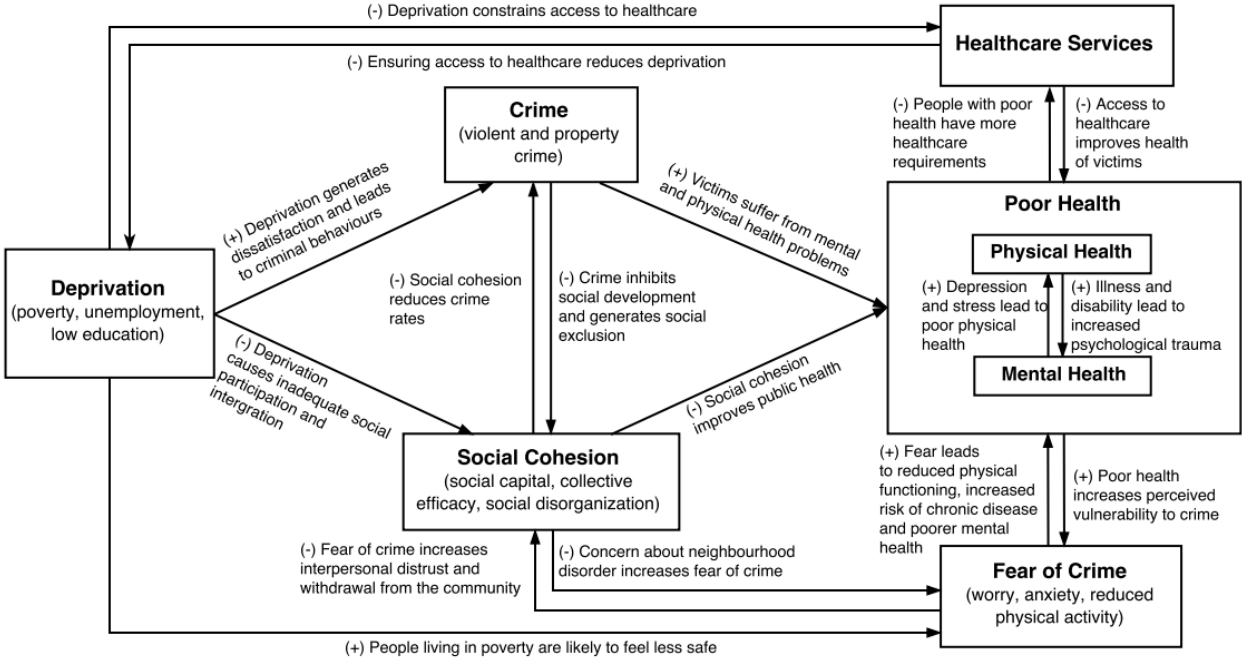
Figure 1.1 Conceptual social model of health and crime (Based on: Kawachi et al., 1999; Jackson & Stafford, 2009; Tan, 2008)

1.1.1 The Links between Crime, Deprivation and Social Cohesion

Most research suggests that crime is prevalent where large disparities exist in material standards of living (Kawachi et al., 1999). Many studies have explored the links between deprivation and crime. For example, Social Disorganization Theory suggests a direct relationship between crime and deprivation (Shaw & McKay, 1942). In general, discrepancy exists between people's expectations and their actual conditions with regard to wealth, income, power, and social class. Such dissatisfaction and strain may subsequently lead to feelings of despair, frustration, and anger, and even drive people to commit a crime.

Levels of crime in society are associated with how people interact with and trust each other, and how common values and goals are shared (Uchida et al., 2013). It is also widely

believed that deprivation is associated with lower social cohesion and increased social problems (Wilkinson, 1997). Social disorganization involves a breakdown in social cohesion and can be linked with increasing levels of crime.

The Social Disorganization Theory (Shaw & McKay, 1942) suggests that crime is a product of society and cultural environment. Rapid social changes, consistent immigrants, and population movements result in social diversification, having different nationalities living unavoidably together, and further making it difficult for people to adapt to a mixed social and cultural environment. This can potentially lead to an increase in criminal behaviour (Kubrin, 2013). In contrast, social cohesion is associated with reduced crime, since a higher level of social control and guardianship in a cohesive environment can potentially prevent the occurrence of crime. Therefore, research in criminology tends to focus on the role of social cohesion as a preventive force (Kawachi & Berkman, 2000; Morenoff et al., 2001). In summary, effects of the social context on crime can be demonstrated in relationships between, (a) crime and deprivation (from the measure of inequality in material assets), and (b) crime and social cohesion (from the measure of social capital and collective efficacy).

1.1.2 The Impacts of Crime and Fear of Crime on Health

The links between crime and health are complex and diverse. Crimes can be divided into violent and property crime categories, according to the different nature of their health effects on victims (Hanson et al., 2010). Violent crimes (e.g. physical assault, sexual violation, and robbery) can lead to physical and psychological harm, which are potentially long-lasting or may even result in permanent damage (Wasserman & Ellis, 2007). In addition, injury from violence is a significant public health problem that places a demand on healthcare systems (Robinson & Keithley, 2000). Property crimes (e.g. burglary, vandalism, and automobile theft) can also generate significant psychological harm, affecting the regular life and daily wellbeing of individuals (Cornaglia et al., 2014). Crime is not only a violation of persons or property, but also an act that has negative impacts on public lives and safety in general.

Victims can also suffer from indirect harmful effects of crime, which may involve feelings of fear of crime and potential impacts on physical health and mental wellbeing (Seymour & Lord, 2012). People who listen to information about the experiences of crime may model the actual crime scene and thus experience anxiety and fear of crime (Bursik & Grasmick, 1994). Therefore, those who are not victims may also have feelings of worry, anxiety, concern, and fear (Cordner, 2010). Fear of crime not only reflects people's concerns about their quality of life, but also reveals their doubts about the effectiveness of crime protection strategies.

However, fear of crime is not directly related to the actual victimization rate. The relationship between crime and fear is complex and not straight forward (Cossman & Rader, 2011). Fear is not necessarily a response to crime, instead, it is dependent on factors related to the risk of crime and perception of risk (Grinshteyn, 2013). For example, media has profound impacts on public levels of fear (Cachmore, 2014). In addition, existing literature has also focused on the links between fear and the physical and social environment (Whitley & Prince, 2005). Fear has been found to be significantly associated with physical signs of social disorder, such as litter, graffiti, street lighting, and land use patterns (Lorenc et al., 2012). In addition, studies have found that many socioeconomic factors (e.g. sex, ethnicity, and socioeconomic status) are significantly related to the fear of crime (Chiricos et al., 2001). Therefore, fear of crime can be regarded as a response from the interaction between the neighbourhood and crime. The study of fear is important to public health research, since it can enhance understanding of neighbourhood contextual effects on health and wellbeing.

Fear of crime and health are inevitably linked together. Fear directly relates to an individual's physical and mental health. People who perceive high risk of crime would prefer to stay home instead of going out alone or going to certain areas. Therefore, fear is associated with reduced outdoor activity and physical functioning. Worry and anxiety may further restrict people in participating in social activities, and limit the forming of social ties (Stafford et al., 2007). Individuals with high levels of fear of crime may be more likely to experience negative mental health effects and depression than those with a low level or absence of fear. In turn, research indicates that people with pre-existing mental health

conditions may be more fearful of crime, while people with poor physical health conditions may perceive a higher degree of vulnerability (Jackson, 2009).

In general, crime may have direct impacts on physical and psychological health, thus potentially placing demands on healthcare services. Therefore, strategies on crime reduction and prevention may also benefit public health. Better understanding crime-health relationships may contribute to providing necessary information for encouraging service partnerships between healthcare and crime prevention agencies.

1.1.3 Access to Healthcare Services

Since crime poses a potential health risk to its victims and other related individuals, it consequently results in substantial demands on the utilization of healthcare services (Robinson & Keithley, 2000). Research suggests that the increased utilization of emergency and urgent medical care services are observed among victims of sexual assault (Surís et al., 2004), intimate partner violence (Coker et al., 2000), gunshot (Corso et al., 1999). Most victims of violence tend to seek medical attention for treatment of physical injuries, since prolonged suffering and additional injuries may result when delaying and avoiding proper treatment.

Many victims also suffer from feelings of fear, shock, anger, and anxiety after the occurrence of a crime event. This is often followed by mental conditions of depression, helplessness, hopelessness, and social isolation. Research has indicated that Post-Traumatic Stress Disorder (PTSD) is prevalent among victims of crime (Ozer et al., 2008). Research suggests that people who do not discuss or confide in their traumatic crime experiences are more likely to have poorer physical health and greater mental distress (Bebbington et al., 2004). Therefore, it may be potentially beneficial for victims of crime to seek and receive mental health treatments for their psychological conditions.

Healthcare services provide treatments and therapies for a victim's injuries; however, a rich body of research exists on barriers in accessing healthcare. In the U.S and many other countries, high cost of healthcare service and insufficient insurance are important factors that restrict victims of crime from accessing to healthcare services (Vick et al., 2012).

Although Canadians have access to public health insurance provided under socialized healthcare system, it is sill problematic in certain circumstance that individuals might not be able to access to the social support they need. For example, there is a waiting period for refugees and new immigrants in Canada to obtain health cards, resulting in potential delays in access to services. Health coverage is handled by different provinces and territories, so the accessibility gap also exists when moving from one province to another. In addition, a large amount of Canadians have reported their accessibility problems (Wilson & Rosenberg, 2004). For example, there were 11.2% Canadians reporting an unmet health need (Statistics Canada, 2014) and 15.5% indicating the lack of a regular family doctor (Statistics Canada, 2013).

The lack of healthcare resources in certain areas is likely associated with potential delays in accessing treatments (Jones & Jerman, 2014). Geographic accessibility and availability of healthcare services are significant factors for individuals when considering healthcare affordability and utilization, since not everyone has equal access to healthcare (Guagliardo, 2004). The nature of Canadian large rural and remote areas may result in problems related to spatial access to healthcare (Schuurman et al., 2010). Social disadvantaged groups may be affected, such as people with low-income (Roll et al., 2013), low education attainment (Mojtabai, 2009), poor living conditions (Wang et al., 2005).

Reducing inequity in access to healthcare and maintaining equity in terms of treatments are key objectives for Victim Support and healthcare facility planning (Yang et al., 2006). It is possible to explore equitability and accessibility to mental healthcare resources utilizing recent advances in geospatial analysis (Guagliardo, 2004). Such assessments can contribute to the planning of new healthcare services, as well as informing health policy and practices for supporting necessary services for victims of crime.

1.2 Research Goal and Objectives

The aim of this thesis is to explore the health of victims of crime, based on a conceptual social model of health. More specifically, the primary goal is to investigate the links

between deprivation, crime, and health to gain a better understanding about the impacts and consequences of crime on health in Toronto neighbourhoods. This study involves conducting a questionnaire survey based on selected neighbourhoods in Toronto and a geospatial analysis of aggregated quantitative data drawn from crime statistics and the census. The objectives of this thesis are as follows:

a) to investigate how socioeconomic, demographic, and location-based characteristics affect victimization,

b) to assess the impacts of crime on physical health, mental health, and quality of life at the individual level,

c) to explore public mental health based on the contextual effects of crime and deprivation and people's spatial accessibility to mental healthcare providers.

1.3 Defining Crime and Health

Crime is defined as "an act that violates the criminal law and is punishable with jail terms, fines, and other sanctions" (Linden, 2011). According to Canadian Uniform Crime Report system (UCR), crimes are typically categorized as serious crime offenses and less serious offenses, respectively. The former types of offenses are further categorized as violent crimes and property crime to distinguish whether offences are detrimental to human health (Getlegal, 2012). Violent crimes refer to offenses that are against or threatening an individual, including assault, rape, murder and robbery. Property crimes refer to incidents with the aim to gaining property, instead of resulting in bodily harm. Breaking and entering, property theft, and motor vehicle theft are typical examples.

The thesis considers this two major categories of crime, since violent crimes could always lead to physical and psychological harm, and property crimes could also result in significant psychological harms that affect people's regular lives and daily wellbeing. This thesis does not account traffic incidents involving injury and death, which are included in UCR traffic violations. In addition, the less serious offenses as categorized in Other Criminal Code violations are excluded in this thesis. They include disturbing the peace, prostitution,

child pornography, mischief, etc. White-collar crime types are also overlooked in this thesis, which might have far negative impacts on the society, leading to great economic loss and further disruption and social disorganization. White-collar crime will be discussed later in the following Chapter 2.

There are many ways to define health, and the definition has evolved over the years. The World Health Organization defines health as "a state of complete physical, mental and social well-being" rather than merely the absence of disease (World Health Organization, 1946). Although the definition broadened the traditional medical perspective of health, it has received criticisms as being excessively broad, vague, and unmeasurable (Inglehart & Bagramian, 2002). A new conception of health emerged in the 1980s, when health promotion was developed and health was considered as a process. Amplified in the Ottawa Charter for Health Promotion (1986), health was defined as a resource for living that enables people to "realize aspirations, to satisfy needs, and to change or cope with the environment". Alternatively, health can be also referred as the capability of individuals to cope with diseases, maintain physically and mentally wellness, and function effectively in the society.

Wellbeing is a broader term from numbers of static conditions, including health and people's standard of living (National Institute of Dental and Craniofacial Research, 2014). Wellbeing could be impacted by individual's subjective experiences, such as overall sense of wellbeing, and psychological and emotional wellbeing. In addition, a comparison of the actual life conditions with social norms and values could also impact wellbeing (Centre for Disease Control and Prevention, 2016). For example, people would compare their current life circumstance with general population with regard to health, education, housing, income, and social class.

Public health is a concern of general population. It refers to the sciences of improving and protecting the health through preventing injury, detecting and controlling disease, and promoting healthy lifestyles (Public Health Agency of Canada, 2008). Public health refers to a combination of programs, services, regulations, and policies with regard to health of public population to keep people from being sick and enable people to live a healthy life.

In this study, health was measured from the three aspects as follows. First, physical health refers to the condition and functionality of body. It also relates to healthy diet, regular exercises, and the absence of illness and disease. Second, mental health refers to the presence of mental illness and a state of psychological and emotional wellbeing. Third, quality of life indicates the influence of current health status on an individual's daily life.

1.3 Study Area – the City of Toronto

This thesis focuses on the City of Toronto, which is the provincial capital city of Ontario. It is located in Southern Ontario and on the northwestern shore of Lake Ontario as shown in Figure 1.2. The city is divided into six districts and consists of varied and unique communities and neighbourhoods. Toronto is the most populated and multicultural city in Canada, with a population of over 2.6 million people (Statistics Canada, 2011). Over 30% of Toronto residents speak a foreign language, and over 47% of residents report themselves as a visible minority (City of Toronto, 2013). Toronto is also the chief reception center for immigrants to Canada and more than 50% of residents were born outside of Canada.

Toronto is also considered to be a major economic hub for business and finance. As the third largest financial service center in North American, the city is home to many national and international companies, and many job opportunities are thus available in various industries (City of Toronto, 2015). The developed economic activities are attractive for a large number of highly skilled and multilingual workers. The percentage of Toronto residents with a post-secondary education (32.9%) is much higher than the national average (20.9%) based on Statistics Canada 2011 Census. The average individual income ($40,376) in Toronto is also much higher than the national average ($35,498) (Charron, 2009).

Figure 1.2 Map of the City of Toronto, Ontario (Source: Lencer, 2012)

Average household income in Toronto is high, but not evenly distributed among residents. In fact, Toronto is problematic for income inequality and its most deprived groups experience high risks of unemployment and low income levels (Mukerjee, 2005). With increasing income inequality, poverty levels have also increased, which has potential impacts on individuals, society, and public wellbeing. Crime rate in Toronto is relatively low compared to other major cities in Canada, such as Vancouver, Montreal, Edmonton, and Winnipeg (Brennan, 2012). According to Statistics Canada (2012), the overall volume of police-recorded crime in the Toronto census metropolitan area has been following a downward trend since 1991.

Although the overall crime rate in Toronto is lower than the national average, the violent crime rate in Toronto is higher than the national average. Reports of violent assault remain high in Downtown Toronto (Alamenciak, 2012). Crime rates in the City of Toronto are higher than those of surrounding regions in the Greater Toronto Area (GTA), while the

Downtown crime rate is more than twice the crime rates in Markham, Richmond Hill, and Burlington. Rates of homicide, assault, shoplifting, and harassment in Toronto are higher than surrounding cities (Charron, 2009).

1.4 Thesis Structure

This thesis is comprised of two standalone manuscripts that focus on, (1) exploring crime and its impacts on public wellbeing at the individual level in Toronto neighbourhoods, and (2) assessing spatial accessibility to mental health physicians in Toronto.

The first two objectives of this thesis are addressed in the first manuscript, which explores the relationship between crime and public wellbeing. A postal questionnaire survey was administered in a random sample of households in four selected Toronto neighbourhoods with an aim of collecting information on people's previous crime experiences, awareness of crime occurring in the neighbourhood, health and quality of life impacts of being victims of crime. Chi-square tests and logistic regression models were employed to quantify the impacts of crime on both physical health and mental health from collected survey responses. In addition, the role of socio-economic and neighbourhood characteristics that affect victimization were explored.

The second manuscript addresses the third objective of this thesis. It assesses the spatial accessibility to mental healthcare services in Toronto. Two spatial accessibility measures were applied, namely, the gravity model and the two-step catchment area method. In addition, risk of poor mental health was evaluated based on the social model of health, considering multiple socio-economic and demographic indicators. Population groups were further explored by comparing the risk and accessibility maps and identifying groups with high risk of poor mental health and low accessibility to mental healthcare.

A conclusion chapter summarizes main findings from the two studies. It also provides a discussion on the significant contributions of this study, along with recommendations about future developments of this research.

Chapter 2. Exploring the Link between Crime and Health

2.1 Introduction

The impacts of crime on health are complex and diverse (Robinson & Keithley, 2000). Violent crimes can cause significant physical and psychological harm with potentially long-lasting and permanent effects. Property crimes can also result in psychological impacts, which may significantly affect an individual's daily routines and quality of life (Cornaglia et al., 2014). Crime can also result in indirect and long-lasting effects on victims, witnesses, and their friends and families, due to feeling unsafe and an increased fear or perception of crime (Goodwin, 2004).

A considerable number of studies have analyzed secondary crime data to explore the rates and patterns of crime. These have mainly utilized police-recorded crime statistics (e.g. Charron, 2009; Poulsen & Kennedy, 2004), which are typically expressed in percentages or rates and averaged over an aggregate geographic area, such as neighbourhoods or census tracts (Lauritsen & Rezey, 2013). However, police-recorded crimes do not include information on people's perception of the risk of crime or the impacts of victimization on general health and wellbeing. Moreover, according to Statistics Canada (Perreault, 2015), only under one third of victimizations come to the attention of police, while the majority of the incidents are never reported to police. Therefore, the accuracy of findings are affected by the likelihood of people to report crimes to the police (Myers, 1980).

Qualitative approaches of crime analysis have investigated the impacts and consequences of crime at the individual level. Examples include surveys administered for studying the relationships between criminal victimization and mental health (Morrall et al., 2010), and the links between violence and healthcare usage (Bjorklund et al., 2010); interviews conducted for studying health consequences of intimate partner violence (Garcia-Moreno et al., 2006). The majority of studies focus on victims of criminal incidents, without taking witnesses, families, friends and other related people into account. In fact, crime may not only affect the victim's health, but may also influence public health and general wellbeing of

the local community. Few studies have explored the impacts of crime on health, quality of life, and wellbeing at the neighbourhood or community level.

The aim of this study is to explore the impacts of crime on health and quality of life among victims and people who are aware of crime at the individual-scale of analysis by survey administrated in Toronto neighbourhood. The primary objectives of this study are:

a) to explore the links between neighbourhood and location-based characteristics and the occurrence of crime,
b) to explore the types of crime that victims have experienced in Toronto neighbourhoods,
c) to assess the impacts of crime on victims' health and quality of life,

to assess the impacts of fear of crime in the neighbourhood on psychological health and quality of life.In this study, a postal questionnaire survey was administered to local residents in selected Toronto neighbourhoods, with an aim of collecting information about previous crime experiences and impacts on physical health, psychological wellbeing, and quality of life. Using statistical approaches including Chi-square tests and logistic regression models, this study evaluates victimization experience as an explanatory variable for physical and mental health conditions in Toronto neighbourhoods. Findings from this study may potentially contribute valuable information for developing effective strategies for crime reduction and prevention, as well as providing information necessary for encouraging service partnerships between health and crime-prevention agencies.

2.2. Literature Review
2.2.1 Ecological Theories of Crime and Social Contexts

While the majority of criminological studies focus on the individual's experience of crime (i.e. offenders, victims, and offences) (Thornhill & Thornhill, 1983; Miller et al., 1993; Gottfredson & Hirschi, 1990), a considerable number of benchmark studies have also explored ecological aspects of crime (Cohen & Felson, 1979; Sampson & Grove, 1989; Sampson et al., 1997). For example, people might associate the risk of crime with certain

locations, such as the neighbourhoods in which they reside and the places where they frequently visit (Wilson et al., 2009). Several theories have been proposed in the literature to explain why crime may be more associated in certain locations versus others. Two theories are widely known and briefly described in the following sections, including: (1) Social Disorganization Theory, and (2) Routine Activity Theory.

2.2.1.1 Social Disorganization Theory

It is widely recognized that crime events are not randomly distributed in a city, but most often occur in clusters in more than one geographic location. Social Disorganization Theory is one of the most widely cited social structural theories of crime based on the Chicago School of Criminology, namely by Park and Burgess (1925) who studied the effect of urban land use change on local communities. They also developed the Concentric Zone Model, which suggests that urban land uses are expanded in concentric circles as shown in Figure 2.1. This model is based on the central business district (CBD), which is the geographic heart and commercial center of the city. The zone in transition then follows, which is an extension of the CBD, where industrial activities, factories, and deteriorated housing and buildings tend to be present. The outer loops are residential zones, where people with middle and high income levels commute varying distances into the inner city in order to work (Kubrin, 2009).

The zone in transition is often the most problematic, since crime incidents and other social problems are usually quite intensive in this area (Brantingham & Brantingham, 1995). The zone in transition is thus associated with the poor, homelessness, immigrants, drug transactions, and criminal gatherings and ultimately related to social disorganization (Burgess, 1925). Shaw and McKay (1942) studied juvenile delinquency and social structure in 16 U.S. cities, and found that high rates of juvenile delinquency always emerged in the zone of transition, and the rates were closely related to the composition of the population in an area (Kubrin, 2009). Furthermore, they determined three primary dynamics that were associated with delinquency, or socially disorganized neighbourhoods: high rates of residential turnover, population heterogeneity, and high level of poverty (Paynich & Hill, 2010). In general, delinquency is defined as a response committed by

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normal individuals under certain circumstances (Bridges, 1927). This phenomenon could occur when a community is imperfectly policed and lacking self-policing, which is led by residential mobility, poverty, and racial heterogeneity in such areas.
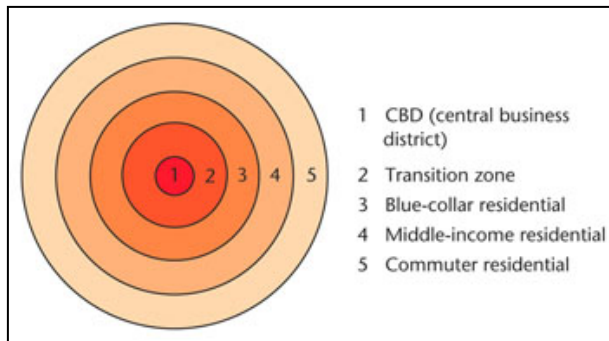
Figure 2.1 Urban land uses in concentric zones (Source: Meetz, n.d.)

Although Social Disorganization Theory is one of the most cited theories in environmental criminology, it has also received a number of criticisms. For example, the theory is based on the concentric zone model, but the model can only explain land uses development in Chicago. Canadian cities do not develop in concentric rings, since the newly built road networks and highly upgraded transportation vehicles make the development of land uses no longer in clear "zones" (Bunyi, 2010). In addition, controversies also exist on how social disorganization can be measured (Bursik, 1988). Since Shaw and McKay did not clarify the direct link between social disorganization and neighbourhood delinquency, crime can be regarded as both an example and an outcome of disorganization. Social Control Theory addresses the measure of social disorganization as a neighbourhood fails to regulate itself through formal (e.g., police and court) and informal (e.g., social customs, norms, and mores) social control (Li, 2008). It has been shown that lack of social control is the cause of high crime rate in a disorganized neighbourhood (Sampson & Groves, 1989).

Over the last few decades, researchers have focused increasingly on the social contextual characteristics of crime. Social Disorganization Theory has put an ecological perspective on crime studies at the group level, rather than focusing on crime as an individual process. It follows that crime is a product of society and the ecological environment. Rapid social

change, constant immigration, and population movement result in social diversification, making different nationalities cohabit together. This brings together people who may find it difficult to adapt to the mixed social and cultural nature of neighbourhoods, which may subsequently contribute to criminal and deviant behavior (Kubrin, 2013).

2.2.1.2 Routine Activity Theory

Routine Activity Theory provides a powerful and simple insight into an environmental and place-based explanation of the causes of crime. The theory suggests that the routine of people's daily life activities makes some individuals more likely to be victims of crime than others. A crime incident is likely to occur when three factors come together: "a likely offender, a suitable target, and the absence of a capable guardian" (Cohen & Felson, 1979). Crime is regarded as a normal occurrence, comprised of three indispensable opportunities. The likelihood of a crime occurring increases when one or more potential offenders are motivated to commit a crime, a potential victim as a suitable target is available, and there is no guardian to deter the offender (Akers, 1994). Routine Activity Theory has been tested on multiple crime studies, such as investigating urban homicide patterns (Messner & Tardiff, 1985), hot spot detection (Sherman et al., 1989), women's stalking victimization (Mustaine & Tewksbury, 1999), and street robbery (Groff, 2007).

As an application of the routine activity theory, the Broken Windows Theory of Policing (Wilson & Kelling, 1982) suggests that the prevalence of neighbourhood social and physical incivilities (e.g. broken windows) might lead to fear of crime and withdrawal from community activity, and then lead to further disorder and crime. The theory is based on an experiment conducted by psychologist Philip Zimbardo in 1969. He placed two unoccupied vehicles in two distinct neighbourhoods: one in New York and the other in California. The car in New York was vandalized within ten minutes after its placement and nothing valuable remained in the car after one day. Passers-by continued taking away its upholstery and smashing its windows afterwards. The car placed in California remained unbroken for a week until Zimbardo smashed it. The car was subsequently vandalized and destroyed thoroughly in the following hours. Therefore, Wilson and Kelling (1982)

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concluded that crime can occur in any neighbourhood, rather than only being restricted to socially disorganized areas.

Due to the social and physical structure of the neighbourhood, any minor disorder can potentially lead to serious social disorganization or even community decay (Paynich & Hill, 2010). A less maintained neighbourhood may send people the signal that crimes are tolerated, while a well maintained neighbourhood may indicate that criminal behaviours are at high risk of detection. Accordingly, maintaining or monitoring neighbourhoods in a well-ordered condition may eliminate further vandalism or crime occurrence. Therefore, the Routine Activity Theory is regarded as a foundational document for law enforcement and policing. It has profoundly influenced the way in which police and government officers have formulated strategies for crime prevention (Pratt et al., 2010).

2.2.1.3 Summary

In general, both theories consider that crime is not randomly distributed but associated with certain factors. These factors affect the prevalence and type of crime that occurred in neighbourhood. Although the two theories have an overlap in explaining the causes of crime, a remarkable distinction is found. The Social Disorganization Theory is based on an observation of an aggregation, such as neighbourhoods, while the Routine Activity Theory focuses on the unique characteristics of crime incidents in an area as a function of an individual's daily activities. Routine Activity Theory suggests that crime is determined by specific crime events and particular offenders, while the Social Disorganization Theory maintains that social and neighbourhood contextual effects are the explanation of crime causation.

Bursik and Grasmick (1994) suggested that a combination of the two theories would provide with a more systematic explanation and prediction of crime patterns and trends. Neighbourhood characteristics also affect the presence or absence of the three influencing factors that relate to the occurrence of a crime incident (Moriarty & Williams, 1996). For example, decreasing population density and economic deprivation may result in a

corresponding decrease in the number of motivated offenders and potential victims. In contrast, weakened social controls on neighbourhoods may lead to the lack of formal guardianship (Moriarty & Williams, 1996). Therefore, it is believed that all three elements of making up a crime are more likely to associate with areas where social disorganization is present, but less likely to associate with social organized areas.

Based on the two theory, this study was developed to explore victimization and the cause of victimization. Routine activity theory suggests that individual's personal demographic and economic characteristics may influence his/her chance of being victimized. Social disorganization theory indicates that the community and neighbourhood in which the individual reside may also impact his/her risk of victimization. The role socio-economic and neighbourhood characteristics can be assessed after examining their relationships with victimization.

2.2.2 Impacts of Crime on Health

Crime may have direct and indirect impacts on health and wellbeing. Goodwin (2004) indicated that two negative health impacts could be generalized from crime incidents: (1) direct physical injury that victims suffer, and (2) indirect psychological effects that cause people to feel fearful of crime. Crime is considered to be a public health issue, since the most common direct impacts of crime on health are physical injury, disability and death. Many indirect psychological issues may also persist over a long period of time as a result of direct physical consequences of injury and fear of crime.

The relationship between crime and health is likely dependent on the type of victimization experienced. For example, violent crimes (e.g. physical assault, sexual violation, and robbery) may directly lead to physical injury and psychological harm, while property crimes (e.g. burglary, vandalism, automobile theft) may also materially affect a victims' living standards and generate psychological harm, thus influencing their daily life and wellbeing (Cornaglia et al., 2014). Although the majority of victims may not have direct crime-related injuries, fear of crime persists among both victims and non-victims (Morall et

al., 2010). This may also result in serious health-related problems, such as smoking, substance abuse, or even mental health problems (Goodwin, 2004). Crime can also affect an individual's performance across a variety of roles, such as parenting, occupational, and social functioning, which may also be associated with the individual's overall quality of life and wellbeing (Hanson et al., 2010).

In general, crime has potentially significant impacts on both physical and mental health, which affect victims, witnesses, and other related persons. The direct impacts can result in temporary or permanent disability or even death, while indirect impacts can cause mental health problems that affect one's quality of life and wellbeing in the long-term. Particular groups in society may be disproportionately affected, such as people with low-income, and socially disadvantaged groups. In turn, such inequitable risks may again generate conditions that lead to further neighbourhood delinquency and criminal activity. Therefore, crime is one of the factors in predicting health inequalities. Understanding the crime-health relationship is fundamental for supporting a public health approach for crime reduction and prevention.

2.2.2.1 Findings from Victimization Surveys in Canada

A cross-sectional General Social Survey (GSS) on victimization is conducted every five years to ask a sample of Canadians about criminal victimization, including crime experience, impact of crime on wellbeing, and crime prevention (Statistics Canada, 2013). Respondents' victimization data provide useful insight into personal victimization experiences and perceived crime rates, which can be subsequently used to assess the consequences and impacts of crime.

According to the GSS reports over recent years, the consequences and impacts of crime on mental and physical health are different with regard to different types of crime experiences and victim characteristics. Although physical injuries or even death are widely considered associated with violence, the majority of Canadian violent incidents did not involve an injury or weapon (Perreault, 2015; Perreault & Brennan, 2009). More specifically, approximately 25% of violent incidents involved a weapon and only about 20% caused an

injury (Perreault, 2015). However, victims of violent victimization were associated with higher drug and alcohol consumption, since victims occupied over 80% of drug users and 68% of alcoholic drinkers (Perreault, 2015).

In addition, victims of violence were also affected emotionally, since a considerable number of them reported experiencing anger, depression, anxiety attacks, and sleep difficulties. Moreover, research indicates that victims of violence are likely to experience PTSD, which further results in individual impaired mental and physical health, and reduced life quality (Cameron et al., 2003). Although property crimes generally result in financial distress, victims of these crime were also affected emotionally. For example, victims of breaking and entering were more liked to reported experiencing psychological problems, such as sleeping difficulties and depression (Perreault, 2015).

The emotional effects of crime also include victim's perceptional of personal safety. Although the majority of Canadians felt satisfied with their personal safety (Perreault & Brennan, 2009), feeling of fearful was still prevalent among victims of violence (Cannon & Mihorean, 2004). In addition, victims of breaking and entering were more likely to experience fear than victims of other property crime types. Victims of breaking and entering were thus more cautious about crime.

In general, GSS results indicate that crime has significant impacts on Canadian victims' health and wellbeing. Victimization surveys provide an important complement to police-recorded crime statistics, since victimization data tends to capture incidents that are potentially under-reported. They also provide useful insight into the nature and consequences of crime that occurred in Canada.

2.3 Survey Design

2.3.1 Questionnaire Design

In order to study how people's health and quality of life are affected by crime, a postal questionnaire survey was administered across a random sample of households in the City of Toronto, Ontario, Canada. The cross-sectional study was carried out to explore the

prevalence of crime-health relationships in a subgroup from selected households in Toronto.

The survey was designed to collect information about health and life changes experienced after a crime event, along with their perceptions of being victims. Fear of crime may also be prevalent among non-victims, who may be aware of crime occurring in their neighbourhoods of residence. Awareness of crime may affect an individual's perception of risk and/or vulnerability to victimization, thus potentially affecting one's feelings of worry, anxiety, concern, and fear (Cordner, 2010). The survey also addresses the links between the knowledge of crime occurring in one's neighbourhood of residence and the overall fear of crime.

The questionnaire survey instrument is a modification of a previous study conducted in Sheffield, UK during 2006 (Tan, 2008). The original 2006 questionnaire was comprised of three sections. The first section focused on personal experiences of crime and the impact on health and quality of life. The second section asked people about their awareness of crime occurring in their neighbourhood of residence and the impact this had on their quality of lives. Finally, the third section of the survey collected neighbourhood and socio-demographic data about respondents. Modifications to the original 2006 UK survey include collecting information on participants' perceptions of neighbourhood/community health and the surrounding built environment. Further details about survey development and modifications made to the original 2006 UK survey are described in Appendix A.

The resulting survey questionnaire was comprised of three sections with 53 questions printed on seven double-sided pages. The questionnaire was reviewed and received full ethics clearance through the University of Waterloo Research Ethics Committee.

2.3.2 Sampling Methodology

Sample size was determined based on the need to make statistical inferences about the population and the expense to cover data collection. The following equation is usually applied to determine sample size *n* (Statistics Canada, 2010):

$$n = \frac{z^2 \hat{p}(1-\hat{p})}{e^2 + \frac{z^2 \hat{p}(1-\hat{p})}{N}} \hspace{4cm} (2.1)$$

where z is a score related to a level of confidence, $\hat{p}$ refers to the precision of an estimated proportion of population, e is a margin of error, and N indicates the size of total population of this study.

For most surveys based on a simple random sampling method, a convention of 10 percent margin of error at 95 percent confidence level is often adopted (Turner, 2003). The corresponding z score is valued at 1.96. The population is usually normally distributed and a value of 0.5 is applied to $\hat{p}$. The total number of households in Toronto is approximately 1,000,000 (Statistics Canada, 2011). Based on Equation 2.1, the minimum required sample size is 97 households, and the minimum required sample population is 1,940 based on an estimated response rate of 5%.

According to the available research budget for covering printing and mailing costs, a sample population of 2,700 was determined for this study, which is sufficient when considering sampling error. A local printing and mailing company was employed for survey printing and mail-out.

This study focuses on residential households sampled from Toronto neighbourhoods. Although a random sample of households throughout Toronto could be selected to ensure a representative sample of the population (Woodruff et al., n.d.), the study also aims to explore prevalence of crime and health relationships at the neighbourhood scale of analysis. Survey participants were selected based on shared neighbourhood characteristics to ensure that samples were similar.

Four Toronto neighbourhoods were selected as the final sampled areas. Six crime and health-related factors were considered when sampling neighbourhoods, including violent crime rates, property crime rates, mental health status, disability status, and material and social deprivation indices. Both crime statistics were retrieved from the 2006 Uniform Crime Reporting Survey. Mental disease and disability were selected as indicators of health conditions. Two deprivation indices for health were developed by taking six socio-

demographic indicators into account: education, employment, income, the percentage of individuals living alone, the percentage of separated, divorced, or widowed individuals, and the percentage of single–parent families (Pampalon & Roymond, 2000).

Finally, four neighbourhoods were selected based on the aforementioned criteria. Among them, three neighbourhoods were selected with relatively high crime rates, high percentages of mental disease and disability patients, and high deprivation index scores. One neighbourhood was selected for comparison with a relatively low crime rate, lower occurrence of mental disease and disability, and low deprivation score. In addition, the spatial locations of selected neighbourhoods were considered. All four selected neighbourhoods are located throughout the city, so that they are not spatially clustered and not sharing similar neighbourhood characteristics.

A map of the selected four neighbourhoods is provided in Figure 2.2. The following four neighbourhoods were chosen: (a) Cabbagetown, which lies on the east end of Downtown; (b) East-end Danforth, which is located in the East End region; (c) Dovercourt-Wallace-Emerson-junction, which is situated on the west side to Downtown; and (d) Weston, which is located in the northwest of the city.

Random sampling was subsequently conducted to sample households from the four selected neighbourhoods. The addresses of local households were considered to be a sampling frame, which was retrieved from Toronto Open Data (Address Points (Municipal) - Toronto One Address Repository). According to the attribute information of listed addresses, the point addresses with "low density residential" and "high density residential" refer to residential households in Toronto. Each "low density residential" address is associated with one single house, while "high density residential" refers to the address of an apartment or a condominium. However, the "high density residential" addresses do not contain the specific unit number of a building, in fact, the exact addresses of households residing in apartments or condos were not retrievable. As a result, the study was only targeted at households residing in single-family houses.
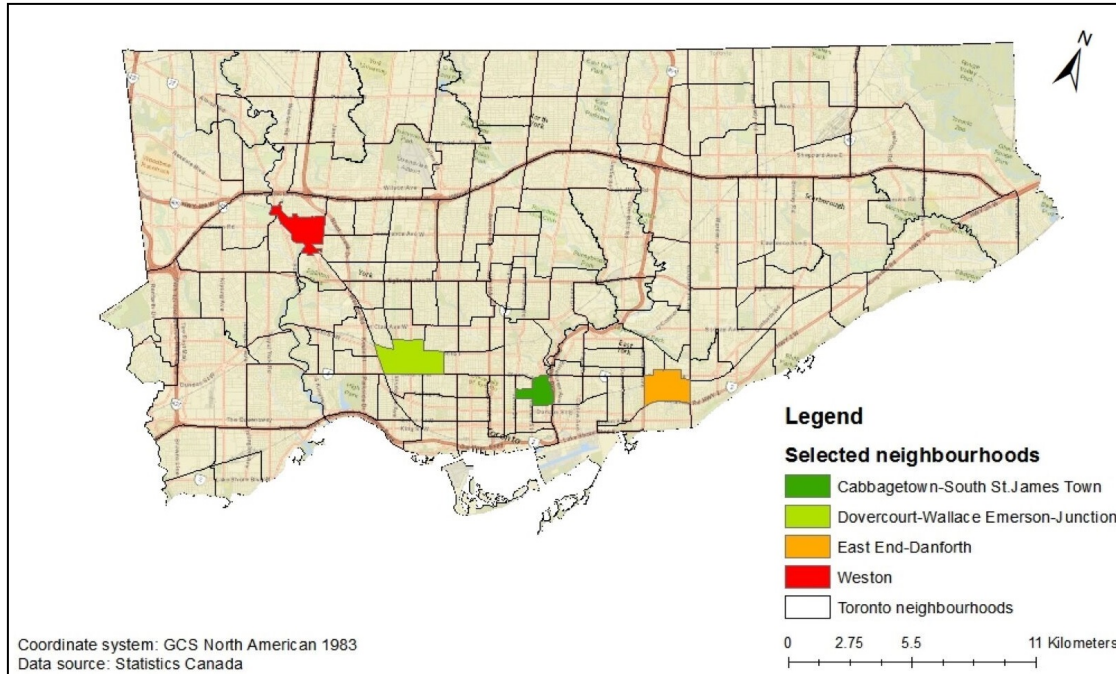
Figure 2.2 Map of selected four neighbourhoods as the targets of the crime-health survey

2.3.3 Survey Administration

The Tailored Designed strategy developed by Dillman (2000) has outlined five key practices to improve postal survey responses, including "(1) a respondent friendly questionnaire, (2) up to five contacts, (3) inclusion of stamped return envelopes, (4) personalized correspondence, and (5) a token financial incentive". However, due to time and budget limits, only procedures (1), (3), and (5) were included in this survey. No follow up mail-out was conducted after the initial mail-out due to cost and time considerations. No invitation letter was provided to respondents prior to the administration of the paper questionnaire. Only an information cover letter was included in the survey envelope, describing the study and options by which respondents could choose to participate in the survey. Participants could elect to either return the questionnaire via a postage stamped return-addressed envelope, or else submit an online questionnaire through a website URL printed on the cover page using Survey Monkey software. Only one submission was requested from each participant. An incentive of a prize draw of $50 Tim Horton's gift card was provided to enhance respondents' engagement and participation.

The postal questionnaire was mailed to 2,700 households in the four selected Toronto neighbourhoods on February 6, 2015. Participants were instructed to complete and return the paper survey or to submit the online survey within three weeks after receipt. Among all surveys mailed out, 14 were returned to the sender and marked as "moved", "unknown", or "incomplete". A total of 203 surveys were collected by April 11. Among them, 199 surveys had fully completed answers and included in the analysis. The remaining 4 surveys were incomplete and not included in the study. Table 2.1 reports the survey response rate.

Table 2.1 Summary of survey response data

Sample size	Total		2,700	100%
Respondents (# of returned and analyzed)	Mail		158	79.40%
	Online		41	20.60%
	Total		199	100%
Non-respondents (# of unanalyzed)	Non-reachable addresses		14	0.56%
	Returned but incompletely answered		4	0.16%
	Returned too late		2	0.08%
	Unaccounted		2,481	99.20%
	Total		2,501	100%
Response rate*				**7.41%**

*Response rate was calculated by dividing the total respondents (total returned and analyzed) by the sample size minus number of non-reachable addresses.

The response rate for this study was 7.41%, which indicated that non-response rate was remarkable. Therefore, response bias should be acknowledged. Since there is no way of knowing how people responded might differ from those did not, the results generated from this study was not representative of Toronto neighbourhoods. The results only represent the participated households from sampled neighbourhoods in Toronto.

2.4 Methodology

Survey responses were organized in an Excel spreadsheet. Data descriptive statistics and statistical analyses were performed using IBM SPSS software. Descriptive statistics were applied to summarize features of the sample, including the frequency of observations, respondents' victimization rate, sex ratio, and the distribution of age groups. Two inferential statistical approaches were applied to further investigate the underlying

relationships among variables, namely, the Chi-square test and the logistic regression model.

2.4.1 Measures

Victimization. Victimization was assessed based on the question: "Have you personally been a victim of crime in the past 5 years?" Responses were coded as "1" for "yes" and "0" for "no". Each respondent who replied "yes" was asked to identify the type of victimization from nine categories, including sexual assault, robbery, physical assault, and uttering threats. Breaking and entering, theft of credit card, vehicle-related theft, theft of other forms, and vandalism were considered to be examples of property-related victimization. Responses were coded as "1" for the occurrence of a specific type of crime. Respondents were also asked to state the number and locations of incidents, and whether they were reported to the police.

Awareness of crime in the neighbourhood. The awareness of neighbourhood crime was evaluated from the question: "In the neighbourhood where you currently live, do you know anyone who has been a victim of crime during the last 6 months?" Respondents were asked to provide details about crime incidents occurring in their neighbourhood of residence, including the types of the incidents and time they occurred.

Physical health impacts. Physical health problems associated with victimization experiences were assessed from questions, such as: "Did you feel it was necessary to take any special medical steps as a result of being a victim of crime?" Victims were then asked whether they had visited a hospital/doctor, taken medication, or received counseling as a direct result of their crime experience.

Psychological effects. In addition to physical impacts on health, this study also explored emotional and psychological effects of victimization manifested in the form of feelings of stress, panic attacks, depression, and lack of confidence. Respondents were also asked whether they had experienced such feelings as a result of fear of crime occurring in their neighbourhood of residence.

Behavioural changes. The presence or absence of behavioural changes after victimization were assessed based on reported experiences of sleeping difficulties, appetite changes, use of substances (alcohol, medication, and tobacco), and work absenteeism after a crime experience. Victims were asked to indicate whether they adopted self-protective behaviour due to the fear of crime. These behavioural changes include, (a) reducing outdoor activities (e.g. avoid going out alone, after dark, certain areas), (b) enhancing home door security, (c) being more vigilant about personal belongings and physical environment, and (d) moving houses or planning to move houses. The changes were reflections of victims' perceptions about risk of crime. Since fear may impact individual over sense of wellbeing and life satisfaction, these changes were also indicators of victims' quality of life changes.

Demographic and socioeconomic characteristics. The survey included questions related to demographic and socioeconomic characteristics of respondents. Response categories were number coded for subsequent statistical analysis. For example, gender was coded as "0" for "male" and "1" for "female". Age was coded as number "1" to "6" for the six listed age groups. Education was coded from "1" to "3" based on categories of "no certificate, diploma or degree or high school diploma or equivalent", "postsecondary certificate or diploma below bachelor level", and "postsecondary certificate or diploma at bachelor level or higher". Employment was coded as "1" to "3", representing "employment", "unemployment", and "not in the labour force", respectively.

Neighbourhood- and location-based characteristics. Respondents' perceptions about neighbourhood safety and indicators of social cohesion were also assessed. Neighbourhood characteristics were related to, (a) residence ownership, (b) perceptions about neighbourhood safety and built environment, (c) walkability and accessibility to nearest public facilities and businesses, (d) whether people know their neighbours, (e) participation in the Neighbourhood Watch Program, and (f) perception of risk of crime in their neighbourhood of residence.

2.4.2 Chi-square Test

Similar to single variable frequency analysis, cross-tabulation analysis is a powerful and useful analytical approach for categorical data. A cross table records a wealth of information about the frequency of respondents in terms of row and column variables. The Chi-square test is used to statistically determine whether there is a significant relationship between row variables and column variables in a cross table (Qualtrics, n.d.). In other words, it can be used to identify whether one or more observations are occurring in equal frequencies, and whether the expected frequencies differ significantly from the observed frequencies (Buglear, 2013).

Chi-square statistics are based on a null hypothesis, which assumes the two variables are not related (independent). The contrary hypothesis indicates that two variables are related (dependent).

The Chi-square test was calculated using the equation below (Pearson, 1900):

$$x^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \tag{2.2}$$

where x^2 is the Chi-square statistic, O_i represents the observed frequency, E_i is the estimated frequency, and i stands for the ith cell in the table. In terms of calculating the Chi-square value between two variables, the expected value for each cell can be calculated by the equation below:

$$E_i = \frac{(Row\ total)(Column\ total)}{Grand\ total} \tag{2.3}$$

The degrees of freedom between two variables are calculated as follows:

$$Degrees\ of\ freedom = (\#\ of\ row - 1)(\#\ of\ column - 1) \tag{2.4}$$

A Chi-square table (provided in Appendix B) is a reference for the critical values of the Chi-square distribution. A critical value is determined based on a significant level of *p=0.1* and the degrees of freedom. If the calculated Chi-square value is greater than the critical value, the null hypothesis is likely to be rejected and a significant association is observed between

two variables. However, a Chi-square test is not applicable whenever the minimum expected value is less than one, or over 20% of the cells have expected values smaller than five (Yates et al., 1999).

For example, a hypothesis indicates that crime experience (victim of crime and non-victim of crime) is significantly associated with a psychological effect (yes and no), and Table 2.2 displays the frequency of each observation.

Table 2.2 Observations for crime experience and psychological effect

Frequency		Psychological effect		
		Yes	No	Total
	Yes	61	31	92
Crime experience	No	48	45	93
	Total	109	76	185

The expected frequency for the cell in the 1st row and the 1st column (respondents with psychological effect who are victims) can be calculated as follows:

$$E_i = \frac{(Row\ total)(Column\ total)}{Grand\ total} = \frac{92 \times 109}{185} = 54.21$$

Therefore, after calculating the expected frequency for all cells, the Chi-square value is calculated as follows:

$$x^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} = \frac{(61-54.21)^2}{54.21} + \frac{(31-37.79)^2}{37.79}$$

$$+ \frac{(48-54.79)^2}{54.79} + \frac{(45-38.21)^2}{38.21} = 4.12$$

Degrees of freedom is calculated as follows:

$$Degrees\ of\ freedom = (\#of\ row - 1)(\#\ of\ column - 1)$$

$$= (2-1) \times (2-1) = 1$$

According to the Chi-square table, the critical value with a significant level of *p=0.1* and *df=1* is 2.71. The calculated Chi-square value is greater than the critical value at the probability level of *p=0.1*. Therefore, there is a significant relationship between crime victimization and psychological effect.

Above all, Chi-square tests were employed to explore the strength of association between crime and health variables of the survey questionnaire. Table 2.3 lists all the underlying associations that were explored using Chi-square tests in this study.

Table 2.3 Relationships between crime and health variables examined using Chi-square tests in this study

#	Row Variable	Column Variable
1	Victimization	Psychological effect
2	Victimization	Behavioural change
3	Awareness of crime in the neighbourhood	Psychological effect
4	Awareness of crime in the neighbourhood	Behavioural change

2.4.3 Logistic Regression Model

In order to estimate the effect of an explanatory variable(s) on another variable(s), regression analysis is often used to quantify such relationships. The simplest approach is a linear regression model, which describes variables based on a linear relationship (Simonoff, 2011). The model involves a dependent variable (*DV*) in the model and a set of independent variables (*IVs*) related to predicting the *DV*. The equation below quantifies the linear relationship between a *DV* and a set of *IVs*:

$$y_i = \beta_0 + \beta_1 x_{1i} + \cdots + \beta_p x_{pi} + \varepsilon_i \qquad (2.5)$$

where y is the *DV* and x_1, x_2, x_p are the *IVs*. β is the coefficient and ε is the random error term.

Linear regression is applied to predict continuous *DV*. When a dichotomous and categorical *DV* exists, especially for survey data with categorical values, logistic regression analysis is employed instead to predict the probability of an event occurring (Park, 2013). There are two types of logistic regression models: binary and multinomial. Binary logistic regression deals with dichotomous *DV*, while multinomial logistic regression is used when the *DV* is comprised of more than two categories. This study focuses on the binary logistic regression as all the *DVs* of interest are dichotomous, with yes/no or present/absent categories.

The index odds in the logistic regression indicates a ratio of the probability of an event occurring to the probability that it will not. For instance, if the probability of an event occurring is p, the probability of the event not occurring is $(1 - p)$. Thus, the odds of that event can be calculated using Equation 2.5:

$$\boldsymbol{odds = \frac{p}{1-p}} \tag{2.6}$$

Compared to linear regression, logistic regression employs a logit function to the DV. Therefore, instead of predicting y, the logit model predicts logit (y) from IVs. The logit is the natural logarithm (ln) of the odds of DV (Peng et al., 2002). Therefore, the logistic regression model is as follows:

$$\boldsymbol{logit\,(y) = ln(odds) = ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p} \tag{2.7}$$

Therefore,

$$\boldsymbol{p = \frac{e^{\beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p}}{1 + e^{\beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p}} = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p)}}} \tag{2.8}$$

The odds ratio (OR), or relative odds, is a ratio of two odds. It is used to assess the association between an exposure and an outcome (Szumilas, 2010). It demonstrates the odds of the presence of an outcome at a particular condition (exposure), compared to the odds of the presence of an outcome without the condition. For example, as shown in Table 2.2, odds for Psychological Effect $_{vicitms}$ = 61/31 = 1.97, and odds for Psychological Effect $_{non-vicitms}$ = 48/45 =1.07; hence, the OR for Psychological Effect $_{victims}$ = (61/31) / (48/45) = 1.84. Therefore, it can be concluded that the probability of experiencing a psychological effect among victims of crime is 1.84 times that of non-victims.

According to the logistic regression model, β_i is the coefficient for IV x_i, and e^{β_i} represents the OR, which indicates the change in the probability of y based on a unit change in x_i. Based on the value of the OR, it can be determined whether the exposure is a risk factor for the particular outcome (Park, 2013). An OR equal to 1 represents that the exposure does not have an impact on the odds of the outcome. An OR greater than 1 indicates that the exposure is associated with higher odds of an outcome. An OR smaller than 1 suggests that

the exposure relates to lower odds of an outcome. Therefore, the OR can also be used to determine the strength of association between an exposure and an outcome, and the impact of confounding variables on an outcome (Wang, 2011).

In this study, logistic regression modeling was employed to quantify the relationship between crime and health, and to further investigate how neighbourhood and location-based characteristics predict crime occurrence. Table 2.4 summarizes all the underlying relationships explored and tested by logistic regression models in this study.

Table 2.4 Logistic regression models tested in this study

#	Dependent Variable	Independent Variable(s)
1	Odds of victimization	Demographic information
2	Odds of victimization	Neighbourhood and location characteristics
3	Odds of psychological effect	Specific type of victimization
4	Odds of behavioural change	Specific type of victimization
5	Odds of psychological effect	Awareness of specific type of crime in the neighbourhood
6	Odds of behavioural change	Awareness of specific type of crime in the neighbourhood

2.5 Survey Results

2.5.1 Crime Victimization

2.5.1.1 Victims of Crime in the Selected Four Neighbourhoods

To explore the magnitude of crime occurring in the neighbourhood, crime incidents reported from survey respondents were aggregated and the respondents' victimization rates were compared. Table 2.5 indicates the number of victims and rates of different types of crime, summarized by each Toronto neighbourhood. According to survey responses, 97 respondents had experienced prior victimization, resulting in a respondents' victimization rate (denoted as RVR) of 48.7 per 100 people.

Comparing the four surveyed neighbourhoods, respondents from Cabbagetown reported the highest victimization rate with 41 previous victims, entailing a respondents' victimization rate of 45.8 per 100 people. For all neighbourhoods, the most frequently occurring crime was crimes against property with 86 victims (RVR=43.2) of property crimes, while 34 (RVR=17.1) had experienced violent crime. Rates of both violent and

property crime were consistently highest in Cabbagetown, while East End-Danforth had the lowest violent victimization rate and Dovercourt-Wallace Emerson-Junction had the lowest property victimization rate.

Figure 2.3 indicates total number of victims sorted by different types of crime. Overall, the vehicle-related theft resulted in the highest victimization with 63 cases were reported from 33 survey respondents. Other forms of theft followed with 44 cases of theft reported from 29 respondents. Breaking and entering was the third most-reported crime, involving 26 respondents and 40 incidents. There were 35 cases of credit card theft from 21 respondents and 21 cases of vandalism reported from 15 respondents.

Among violent crime categories, the most frequently cited was robbery with 18 respondents reporting 19 cases. This was followed by uttering threats and physical assaults with 12 respondents reporting 16 cases and 9 respondents reporting 11 cases, respectively. Only one respondent had experienced sexual violation, which was the least-reported crime offence.

Table 2.5 Victims of different types of crimes in sampled Toronto neighbourhood

Crime	Total Victims	East End-Danforth	Cabbagetown	Dovercourt-Wallace Emerson-Junction	Weston
	Count (Rate[1])				
Total	**97 (48.7)**	**22 (45.8)**	**41 (59.4)**	**13 (37.8)**	**18 (43.9)**
Violent crime	**34 (17.1)**	**6 (12.5)**	**15 (21.7)**	**6 (16.2)**	**7 (17.1)**
Physical assault	9 (4.5)	-	4 (5.8)	3 (8.1)	2 (4.9)
Robbery	18 (9)	4 (8.3)	9 (13)	1 (2.7)	4 (9.8)
Sexual violation	1 (0.5)	-	-	1 (2.7)	-
Uttering threats	12 (6)	1 (2.1)	6 (8.7)	3 (8.1)	2 (4.9)
Property crime	**86 (43.2)**	**20 (41.7)**	**37 (15.6)**	**11 (29.7)**	**16 (39)**
Breaking and entering	26 (12.1)	5 (10.4)	13 (18.8)	2 (5.4)	4 (9.8)
Theft of credit card	21 (10.6)	7 (14.6)	8 (11.6)	4 (10.8)	2 (4.9)
Vehicle-related theft	33 (16.6)	6 (12.5)	16 (23.2)	4 (10.8)	7 (17.1)
Other forms of theft	29 (14.6)	8 (16.7)	12 (17.4)	5 (13.5)	4 (9.8)
Vandalism	15 (7.5)	1 (2.1)	9 (13)	3 (8.1)	1 (2.4)

Note: [1]Rate is calculated based on per 100 people
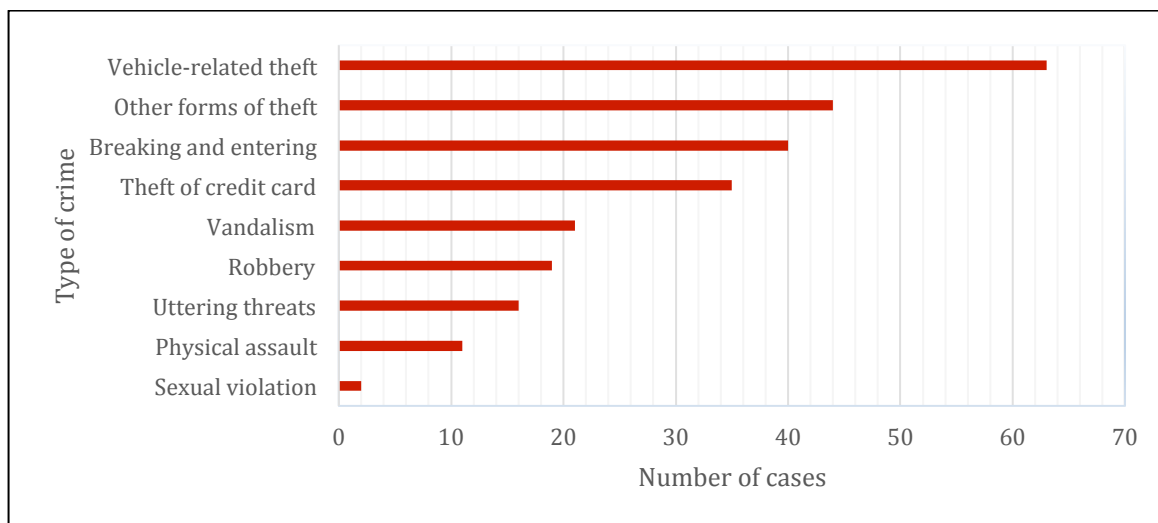
Figure 2.3 Total number of victimizations reported by type of crime

Table 2.6 shows whether victims reported incidents to the police. Compared to victims of violent crime, respondents who had experienced property crimes were less likely to report them to the police, except for breaking and entering. Almost all victims of breaking and entering among survey respondents had contacted the police but less than 50% of victims reported other property crimes. The least-reported property crime was theft of credit card, as many of the respondents indicated that they had contacted their credit card company to resolve the problem. Victims of other forms of theft who did not report the crime to the police considered the victimization as minor and not significant enough to report them. However, it is interesting to note that 51.5% victims of vehicle-related theft indicated they did not report their incidents to the police. In reality, people have to notify the police and their automobile insurance company to file a car claim. In other words, all vehicle-related theft should be reported to the police. So it reveals that respondents might not understand the question.

People who sought and received help after being a victim of crime are reported in Table 2.7. Among them, 30 (32.6% of total 97 victims of respondents) had sought or received help after a crime experience. The majority of victims received help from a neighbour, friend, church, family member, or someone they personally knew. Only six (6.6%) had received help from Victim Support services and they were all victims of violent crime. The six

victims also had received other forms of help, such as counseling from a psychotherapist or other places. Among survey respondents, 54.5% of victims of violent crime and 36% of property crime received help from someone they personally knew. Victims of credit card theft were less likely to seek assistance.

Table 2.6 Reporting crime to the police by type of crime

Crime	Reported		Unreported		N/A[1]	
	Count	Percent[2]	Count	Percent	Count	Percent
Total	**68**	**70.1**	**24**	**24.7**	**5**	**5.2**
Physical assault	7	77.8	2	22.2	-	-
Robbery	14	77.8	4	22.2	-	-
Sexual violation	-	-	1	100	-	-
Uttering threats	8	66.7	4	33.3	-	-
Breaking and entering	23	99.5	2	7.7	1	3.8
Theft of credit card	7	33.3	13	61.9	1	4.8
Vehicle-related theft	16	48.5	17	51.5	-	-
Other forms of theft	11	37.9	16	55.2	2	6.9
Vandalism	6	40	8	53.3	1	6.7

Note: [1] N/A refers to the missing respondents, [2] Percent is calculated by (number of respondents reported crime to the police) divided by (total number of victimizations minus number of missing values)

Table 2.7 Sought/received any form of help after being a victim of crime

Crime	Help of any form(s)		Help from a person they personally know		Help from Victim Support services		Help of other form(s)	
	Count	Percent[1]	Count	Percent	Count	Percent	Count	Percent
Total	**30**	**32.6**	**26**	**28.6**	**6**	**6.6**	**6**	**6.6**
Violent crime	21	61.8	18	54.5	6	18.2	5	15.2
Physical assault	5	55.6	5	55.6	1	11.1	3	33.3
Robbery	12	66.7	10	55.6	4	23.5	1	5.9
Sexual violation	1	100	1	100	-	-	-	-
Uttering threats	7	58.3	6	54.5	1	8.3	3	25
Property crime	26	32.1	22	27.5	6	7.5	5	6.4
Breaking and entering	11	44	9	36	3	12.5	1	4.3
Theft of credit card	5	27.8	5	27.8	-	-	-	-
Vehicle-related theft	7	23.3	6	20.7	2	6.9	1	3.4
Other forms of theft	11	37.9	8	28.6	4	13.8	5	17.2
Vandalism	6	42.9	5	38.5	1	7.1	3	21.4

Note: [1] Percent is calculated by (number of respondents receive help) divided by (total number of victimizations minus number of missing values)

2.5.1.2 Awareness of Crime in the Neighbourhood of Residence

In addition to people's personal crime experience, this study also collected data on respondents' awareness of crime occurring in their neighbourhood of residence. According

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to Table 2.8 and Figure 2.4, 79 respondents (39.9% of total 199 respondents) indicated their awareness of criminal cases having occurred in their neighbourhood. There were 21 (10.6%) respondents aware of physical assault, which was more than cases of physical assault. Notably, no victimization was reported in East End-Danforth, but five (10.4%) respondents had indicated that they were aware of physical assaults occurring in their neighbourhood. Similarly, in Dovercourt-Wallace Emerson-Junction, five people were aware of sexual violation in their area, but only one person reported previously being a victim. A few respondents also indicated knowledge or awareness of other violent crimes, such as murder, shooting, and stalking.

In terms of property crime, people were more aware of breaking and entering and vehicle–related theft than other forms of theft. According to the number of incidents reported based on peoples' awareness of neighbourhood crime, breaking and entering was most frequently reported. In this survey, reports of physical assault and robbery were much more likely to come from neighbours than from victims. However, less credit card theft and uttering of threats were reported by neighbours than actually occurred according to victims' reports.

Table 2.8 Reported crime(s) occurred in the neighbourhood of residence by type of crime

Crime	Total	East End-Danforth	Cabbagetown	Dovercourt-Wallace Emerson-Junction	Weston
			Count (Rate)		
Total	**79 (39.9)**	**15 (31.3)**	**33 (47.8)**	**9 (25)**	**22 (53.7)**
Violent crime	**46 (23.2)**	**10 (20.8)**	**21(30.4)**	**5 (13.9)**	**10 (24.4)**
Physical assault	21 (10.6)	5 (10.4)	11 15.9	1 (2.8)	4 (9.8)
Robbery	24 (12.1)	4 (8.3)	10 (14.5)	2 (5.6)	8 (19.5)
Sexual violation	5 (2.5)	-	1 (1.4)	2 (5.6)	2 (4.9)
Uttering threats	5 (2.5)	-	4 (5.8)	-	1 (2.4)
Property crime	**69 (34.8)**	**11 (22.9)**	**30 (43.5)**	**8 (22.2)**	**20 (48.4)**
Breaking and entering	52 (26.3)	10 (20.8)	25 (36.2)	4 (11.1)	13 (31.7)
Theft of credit card	5 (2.5)	2 (4.2)	1 (1.4)	1 (2.8)	1 (2.4)
Vehicle-related theft	21 (11.1)	2 (4.2)	8 (11.6)	3 (8.3)	9 (22)
Other forms of theft	11 (5.6)	1 (2.1)	6 (8.7)	2 (5.6)	2 (4.9)
Vandalism	15 (7.6)	1 (2.1)	8 (11.6)	2 (5.6)	4 (9.8)

Note: [1]Rate is calculated based on per 100 people
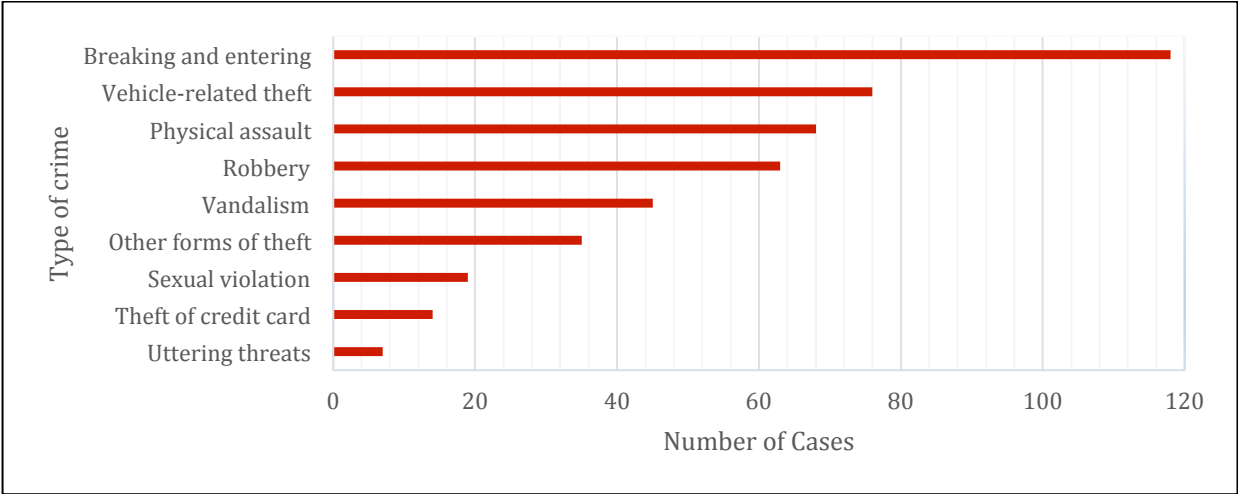
Figure 2.4 Number of victimizations occurring in the neighbourhood, by type of crime

2.5.2 Predicting Crime

In order to investigate the underlying relationship between respondents' neighbourhood characteristics and their odds of victimization, two sets of logistic regression models were estimated to predict the likelihood of crime occurrences.

In the first set of models, respondents' socio-demographic characteristics were considered to be the independent variables, while different types of crime victimization were the dependent variables. According to the logistic regression results shown in Table 2.9, people who were single were significantly related to an increased odds of physical assault and robbery, compared to the reference group, which was married couples. However, married individuals were more likely to be victims of breaking and entering, comparing to people who were widowed, divorced, and/or separated. The respondents from low-income households were more likely to experience crimes, such as physical assault and uttering threats, but less likely to be victims of vehicle-related theft, compared to people from households with income over $80,000 per year. Individuals with lower education status may be more likely to experience vandalism, compared to those with a post-secondary certificate.

Location is also a significant determinant for specific types of crime. Therefore, in the second phase of this analysis, respondents' neighbourhood and location-based characteristics were employed as independent variables in the logistics regression analysis (Table 2.10). Interestingly, people who were unfamiliar with their neighbours were more likely to be the victims of robbery and burglary. Respondents who rent their residence were more likely to experience physical assault. The longer people lived in their current residence, the more likely they were to be the victims of vehicle-related theft.

In summary, victims of both violent and property crimes can be estimated based on predictors from survey responses, such as a victims' demographic information and their location and neighbourhood characteristics. The odds of experiencing violent crime were related to those who were single and from low-income households. People who were from a high-income household and had lived in the neighbourhood for a long time were more likely to experience vehicle-related theft. Those who were married, but knew little about their neighbours were more likely to fall victim to breaking and entering.

Table 2.9 Demographic profile of the survey and odds of victimization

Demographic variable		Physical assault	Robbery	Uttering threats	Breaking and entering	Vehicle related theft	Vandalism
Gender		-	-	0.12**	-	-	-
Marital status	Single	42.01**	10.73**	-	-	-	-
	S,D,W[1]	-	-	-	0.02*	-	-
	Married	Reference	Reference	-	Reference	-	-
Family status		-	-	-	-	-	-
Disability status		-	-	-	-	-	-
Citizenship		-	-	-	-	-	-
Visible Minority		-	-	-	-	-	-
Education level	No post-secondary edu	-	-	-	-	-	-
	Some post-secondary edu	-	-	-	-	-	6.65*
	Finish post-secondary edu	-	-	-	-	-	Reference
Employment status	Unemployed	-	-	-	-	-	-
	Employed	-	-	-	-	-	-
	Not in the labor force	-	-	-	-	-	-
Annual household income	<$20,000	97.38*	-	-	-	-	-
	$20,000 - 39,000	-	-	-	-	-	-
	$40,000 - 59,000	-	-	-	-	0.11*	-
	$60,000 - 79,000	53.02**	-	6.96*	-	-	-
	>$80,000	Reference	-	Reference	-	Reference	-

Note: [1] SWD refers to separated, widowed, or divorced
**P<0.05 *P<0.1

Table 2.10 Neighbourhood and location based characteristics and odds of victimization

Neighbourhood characteristics	Physical assault	Robbery	Breaking and entering	Vehicle-related theft
Own residence	0.13*	-	-	-
Time living at the current address	-	-	-	1.57**
Know neighbours	-	0.49*	0.37**	-
Neighbourhood watch program	-	-	-	-
Perception of risk of crime in neighbourhood	-	-	-	-
Perception of risk of crime in Toronto	-	-	-	-

Note: **P<0.05 *P<0.1

2.5.3 Health and Life Impacts of Crime

2.5.3.1 Impacts of Crime after being a Victim

- *Medical steps taken by victims of crime*

To explore the physical health consequences of crime that survey respondents experienced, Table 2.11 summarizes medical steps victims had taken after crime occurred. Notably, most respondents (71.1% of total victims) had not taken any medical treatment after a crime experience. Only four (4.1%) victims reported visiting a hospital, doctor, or general practitioner, only six (6.2%) took medication to help with anxiety, pain, or sleeping problems, and only three (3.1%) had received counseling after a victimization event. All of these respondents were previous victims of violent crime. The four victims who visited a medical doctor had all experienced physical assault, while one of them had also experienced robbery and two had been a victim of uttered threats.

Table 2.11 Medical steps taken after being a victim of crime (n=97)

Crime	Went to see doctor	Took medication	Received counseling	None	N/A[1]
	Count (percent[2])				
Total	**4 (4.1)**	**6 (6.2)**	**3 (3.1)**	**69 (71.1)**	**20 (20.6)**
Violent crime	**4 (11.7)**	**6 (17.6)**	**3 (8.8)**	**21 (61.7)**	**5 (14.7)**
Physical assault	4 (44.4)	3 (33.3)	2 (22.2)	4 (44.4)	1 (11.1)
Robbery	1 (5.6)	3 (16.7)	1 (5.6)	12 (66.7)	3 (16.7)
Sexual violation	-	-	-	1 (100)	-
Uttering threats	2 (16.7)	1 (8.3)	2 (16.7)	8 (66.7)	1 (8.3)
Property crime	**2 (2.3)**	**3 (3.5)**	**2 (2.3)**	**64 (74.4)**	**18 (20.9)**
Breaking and entering	-	1 (3.8)	-	19 (73.1)	6 (23.1)
Theft of credit card	-	-	-	15 (71.4)	6 (28.6)
Vehicle-related theft	-	-	1 (3)	23 (69.7)	9 (27.3)
Other forms of theft	2 (6.9)	2 (6.9)	2 (6.9)	22 (75.9)	4 (13.8)
Vandalism	1 (7.1)	1 (7.1)	1 (7.1)	8 (57.1)	4 (28.6)

Note: [1] N/A refers to the missing respondents, [2] Percent is calculated by (number of respondents seek medical treatments) divided by (total number of victimizations minus number of missing values)

In summary, survey results indicated that all respondents who sought medical treatment were victims of violent crime with the majority having experienced physical assault and/or robbery. Nevertheless, it was not possible to investigate the statistical relationship between violent crime and medical steps taken after victimization due to the small number of reported cases.

- *Psychological effects and behavioural changes after being a victim of crime*

To explore mental health consequences of crime, Figure 2.5 shows the various ways in which a victim's health and quality of life can be affected by a crime experience. Most victims reported no impacts on mental health or general wellbeing. However, a significant number of respondents did report feelings of stress, which were followed by reports of sleeping difficulties, depression, lack of confidence, and panic attacks. Table 2.12 shows psychological impacts among victims of crime. Accordingly, 59 (65.6% of total victims) cited experiencing feelings of stress, including 25 (86.2%) victims of violent crime and 51 (63%) of property crime. Therefore, people who were victims of violent crime were more likely to report experiencing negative effects on psychological or mental health than victims of property crime.
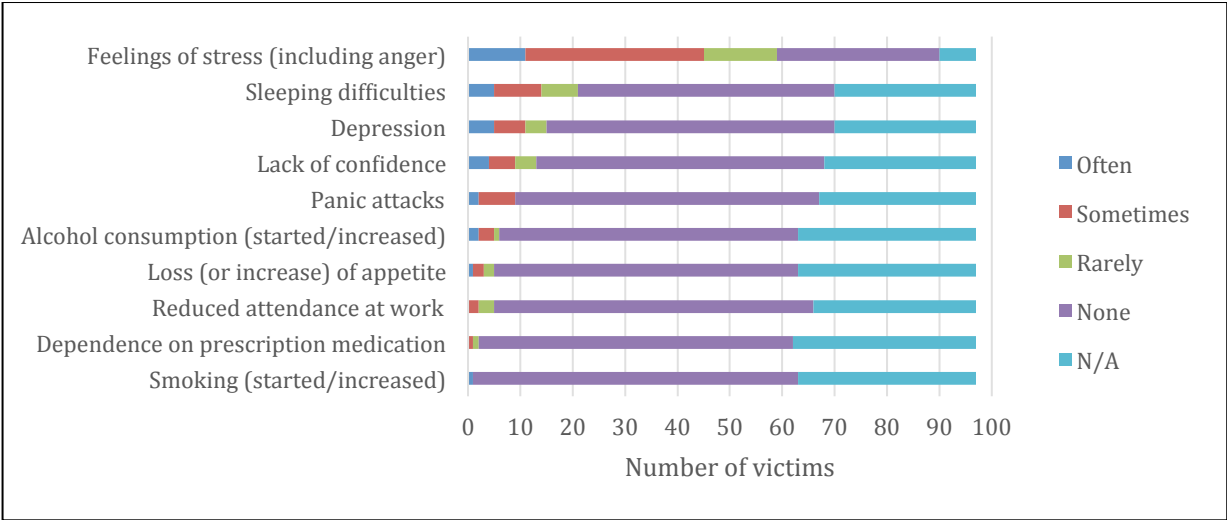
Figure 2.5 Psychological effects and behaviour changes in victims of crime (n=97)

Victims also noted changes in behaviour and lifestyle after experiencing a crime event. Notable changes were having sleeping difficulties, changing outdoor activities (e.g. avoid

going out alone, after dark, to certain areas), enhancing security of home property, and being more vigilant of personal belongings and surroundings. Table 2.13 indicates changed behaviours reported by respondents who had experienced being a victim of crime. Over 90% of victims who previously experienced robbery and burglary had enhanced their home door security. People who were victims of physical assault and other forms of property theft became more vigilant of personal and property safety.

Table 2.12 Psychological effects after being a victim of crime (n=97)

Crime	Feelings of stress	Panic attacks	Depression	Lack of confidence
	Count (Percent[1])			
Total	**59 (65.6)**	**9 (13.4)**	**15 (21.4)**	**13 (19.1)**
Violent crime	**25 (86.2)**	**7 (41.2)**	**12 (60)**	**10 (55.6)**
Physical assault	7 (87.5)	3 (60)	4 (66.7)	2 (50)
Robbery	13 (86.7)	3 (33.3)	6 (60)	4 (50)
Sexual violation	1 (100)	-	-	-
Uttering threats	8 (80)	3 (50)	6 (66.7)	4 (57.1)
Property crime	**51 (63)**	**7 (11.5)**	**12 (19)**	**10 (16.1)**
Breaking and entering	17 (68)	3 (16.7)	6 (31.6)	4 (22.2)
Theft of credit card	11 (57.9)	1 (7.1)	2 (14.3)	2 (14.3)
Vehicle-related theft	18 (60)	2 (9.5)	3 (13.6)	4 (18.2)
Other forms of theft	24 (82.8)	3 (16.7)	6 (30)	2 (11.1)
Vandalism	10 (71.4)	3 (30)	3 (30)	4 (36.4)

Note: [1]Percent is calculated by dividing (number of respondents have health and life impact) by (total number of victimizations minus number of missing values)

Table 2.13 Behavioural changes in victims of crime (n=97)

Crime	Sleeping difficulties	Changes on routine	Enhance security	More vigilant
	Count (Percent[1])			
Total	**21 (30)**	**29 (37.2)**	**45 (57.7)**	**24 (30.8)**
Violent crime	**12 (66.7)**	**17 (54.8)**	**21 (67.7)**	**9 (29)**
Physical assault	3 (60)	4 (57.1)	3 (42.9)	4 (57.1)
Robbery	8 (80)	8(44.4)	15 (93.3)	6 (33.3)
Sexual violation	-	-	1 (100)	-
Uttering threats	3 (50)	8 (72.8)	6 (54.5)	2 (18.2)
Property crime	**17 (26.6)**	**24 (34.8)**	**40 (58)**	**21 (30.4)**
Breaking and entering	8 (42.1)	8 (34.8)	21 (91.3)	3 (13)
Theft of credit card	4 (26.7)	4 (33.3)	4 (33.3)	5 (41.7)
Vehicle-related theft	7 (30.4)	9 (31)	16 (55.2)	8 (27.6)
Other forms of theft	5 (25)	8 (32)	13 (52)	13 (52)
Vandalism	3 (30)	6 (46.2)	4 (30.8_	2 (15.4)

Note: [1]Percent is calculated by (number of respondents have health and life impacts) divided by (total number of victimizations minus number of missing values)

In order to investigate the relationship between crime victimization and their impacts on health and quality of life, a Chi-square test was employed. However, due to the small sample size, over 20% of cells had expected values smaller than 5 when considering panic attacks, depression, and lack of confidence. These psychological effects were subsequently omitted when investigating whether a statistically significant association exists between people who had experienced crime victimization and the presence or absence of psychological effects.

Table 2.14 shows the relationship between impacts of victimization and crime experiences. According to Chi-square statistics, a p-value smaller than 0.1 indicates that the observed values are significantly different from the expected values. Therefore, feelings of stress were significantly related to one's experience of violent crime, robbery, and other forms of property theft. In addition, the experience of violent crime was significantly related to sleeping difficulties and changes in outdoor activities. Taking actions to enhance security were significantly related to victimization from robbery, breaking and entering, theft of credit card, and vandalism. Increased vigilance was associated with experiences of breaking and entering, and other forms of property theft.

Table 2.14 Relationship between impacts of victimization and crime experiences (n=97)

Crime	Feeling of stress	Sleeping difficulties	Changes on outdoor activities	Enhance security	More vigilant
			X^2 (P)		
Violent crime	8.1 (0.004)	15.5 (0.000)	6.9 (0.009)	-	-
Physical assault	-	-	-	-	-
Robbery	3.6 (0.0059)	-	-	6.3 (0.012)	-
Sexual violation	-	-	-	-	-
Uttering threats	-	-	-	-	-
Property crime	-	-	-	-	-
Breaking and entering	-	-	-	15.1 (0.000)	4.8 (0.028)
Theft of credit card	-	-	-	3.4 (0.063)	-
Vehicle-related theft	-	-	-	-	-
Other forms of theft	5.6 (0.018)	-	-	-	7.8 (0.005)
Vandalism	-	-	-	4.6 (0.031)	-

In summary, based on Chi-square statistics of testing the significant relationship between victimization and health impacts, violent crimes were significantly related to negative

psychological effects, while both violent and property crime experiences were significantly related with adopting behavioural and lifestyle changes.

2.5.3.2 Impacts of Fear of Crime on Health and Wellbeing

Each survey respondent was asked to provide information about how their health and general wellbeing were impacted due to fear of crime occurring in the neighbourhood. Figure 2.6 shows that among survey respondents, 97 (53.9% of total respondents) cited feelings of stress, which was the most frequently cited effect on psychological and mental health. Similar to victims, sleeping difficulty was also prevalent among those people who were fearful of crime, since 36 (22%) respondents indicated that they had experienced the problem. Lack of confidence was the third most cited, followed by panic attacks and depression.
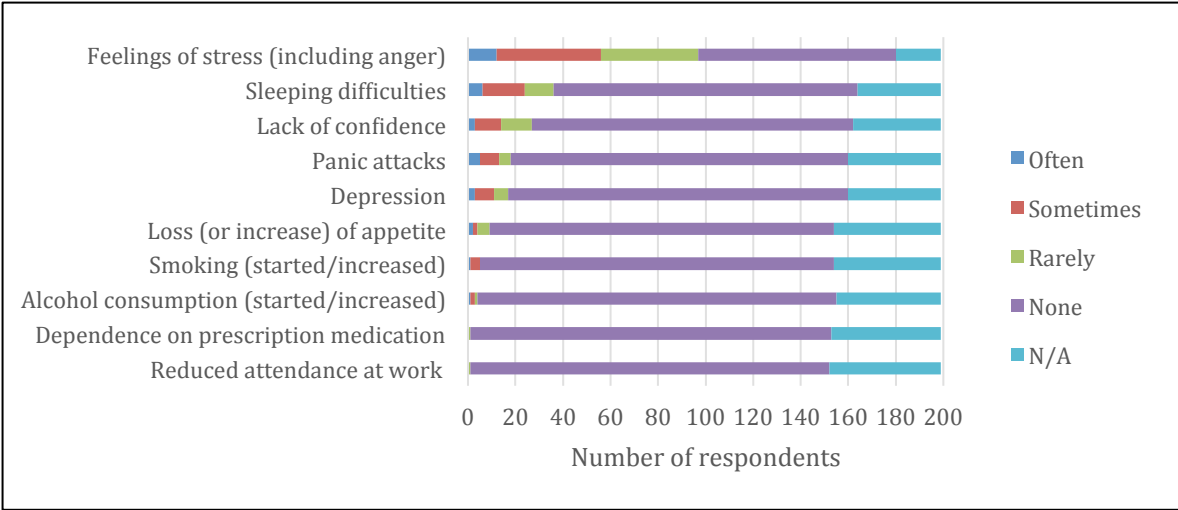
Figure 2.6 Impact on health and quality of life as a result of feelings related to the fear of crime in the neighbourhood of residence (n=199)

The most frequently reported psychological effect resulting from the fear of crime was feelings of stress. There were 43 survey respondents (57.9% of total respondents who had feelings of stress), who were aware of crime occurring in their neighbourhood with 27 (67.5%) being aware of violent crime cases and 37 (56.9%) being aware of property crime.

Table 2.15 indicates the Chi-square test results for relationships between awareness of crime and manifestation of psychological effects after victimization. Feelings of stress were significantly related to the awareness of violent crime or vehicle-related theft that occurred in the neighbourhood. Among respondents who were aware of crime, 11 (17.7%) had experienced panic attacks, which were related to the awareness of cases of robbery and uttering threats occurring in the neighbourhood.

The most prevalent behavioural changes due to crime occurring in the neighbourhood were sleeping difficulties, changes on outdoor activities, and enhancement of security measures. However, according to Chi-square results (Table 2.15), these changes were not all significantly related to awareness of crime occurring in the neighbourhood. Sleeping difficulties, reported by 21 respondents who were aware of crime, were significantly related to both violent and property crime. There were 87 respondents, who indicated changes on their outdoor activities when going out. However, there was no significant relationship between outdoor activities change and the awareness of neighbourhood crime. A significant relationship resulted between awareness of neighbourhood property crime in the neighbourhood and enhancing home door security.

Table 2.15 Relationship between impacts of fear of neighbourhood crime and awareness of crime (n=199)

Crime	Feeling of stress	Panic attacks	Depression	Sleeping difficulties	Enhance security system
			X^2 (P)		
Being aware of crime in the neighbourhood	-	4.3 (0.039)	3.2 (0.072)	7.2 (0.007)	-
Violent crime	3.8 (0.050)	7.6 (0.006)	-	17 (0.000)	-
Physical assault	-	-	-	-	-
Robbery	-	2.9 (0.090)	-	-	-
Sexual violation	-	-	-	-	-
Uttering threats	-	9.4 (0.002)	-	-	-
Property crime	-	3 (0.081)	-	6.7 (0.010)	4.7 (0.030)
Breaking and entering	-	-	-	4.7 (0.030)	-
Theft of credit card	-	-	-	-	-
Vehicle-related theft	3.6 (0.058)	-	-	-	-
Other forms of theft	-	-	-	-	-
Vandalism	-	-	-	-	-

2.5.4 Modeling Health

In order to model survey respondents' health impacts of crime, two sets of logistics regression models were estimated to predict psychological and behavioural impacts respectively. The first series of regression models considered victimization as the independent variables, while the second set of models considered awareness of neighbourhood crimes as the independent variables.

2.5.4.1 Health and Victimization

Eight types of victimization were taken into account to model psychological effects after being a victim. Sexual violation was excluded from the model, since there was only one victim resulting from the survey. Table 2.16 indicates the results from estimated logistic regression models. In general, respondents' violent crime experiences were significantly related to their increased odds of experiencing negative psychological effects. Robbery was consistently significant in predicting all psychological effects. Respondents who had experienced physical assault were more likely to report panic attacks and depression than those people who did not. Victims of uttering threats were more likely to experience depression and lack of confidence than those people who were previously not victims. Victims of other forms of theft had a significant odds of experiencing stress and depression.

Table 2.16 Odds of experiencing a psychological effect based on different types of crime (n=97)

Crime victimization	Feeling of stress	Panic attacks	Depression	Lack of confidence
Physical assault	5.83	**12.73****	**61.33****	4.92
Robbery	**8.34****	**13.32***	**101.83****	**10.17****
Uttering threats	1.41	2.56	**14.07****	**6.60***
Breaking and entering	1.06	1.51	4.95	0.70
Theft of credit card	1.29	1.52	5.27	1.02
Vehicle-related theft	1.33	0.92	1.36	1.15
Other forms of theft	**5.37****	5.30	**32.74****	0.63
Vandalism	1.99	5.64	1.47	2.89

Note: **P<0.05 *P<0.1

Logistic regression models were estimated to determine the odds of adopting a change in behaviour due to victimization. As shown in Table 2.17, breaking and entering was significantly related to the odds of enhancing home security. Victims of robbery were more

likely to experience sleeping difficulties compared to individuals who had not experienced robbery. Victims of uttering threats were more likely to take actions to change their outdoor activities in order to avoid being exposed to the risk of repeat victimization. Physical assault and other forms of theft were significantly related to the increased odds of becoming more vigilant of one's personal belonging and surroundings when going out.

Table 2.17 Odds of experiencing behaviour change based on different types of crime (n=97)

Crime victimization	Sleeping difficulties	Changes on outdoor activity	Enhanced security	More vigilance
Physical assault	5.59	1.041	0.47	**34.14**
Robbery	**23.45**	1.455	2.49	2.98
Uttering threats	0.96	**6.72**	1.30	0.12
Breaking and entering	1.96	0.67	**18.02**	0.17
Theft of credit card	1.68	1.01	0.23	1.58
Vehicle-related theft	2.52	0.55	1.21	1.27
Other forms of theft	1.78	0.60	1.11	**6.61**
Vandalism	1.50	1.11	0.23	0.17

Note: $**P<0.05$ $*P<0.1$

2.5.4.2 Health and Crime in the Neighbourhood of Residence

In order to model respondents' health and life impacts due to fear of crime occurring in the neighbourhood, the relationship between psychological effects and awareness of neighbourhood crime was estimated. The independent variable was considered to be awareness of certain types of crime, while psychological and behavioural changes were considered to be the dependent variables.

As shown in Table 2.18, both robbery and uttering threats were consistently related to an increased odds of experiencing panic attacks, depression, and lack of confidence. Property crime was also related to psychological change, since people who were aware of other forms of theft were more likely to experience feelings of stress and depression, while those aware of credit card theft were more likely to lack confidence.

Results of estimated logistic regression models that predict the odds of adopting a change in behaviour after a crime experience (Table 2.19) indicates that being aware of theft, including burglary, credit card theft and other property theft was significantly related to the odds of enhancing home security and personal safety. Being aware of uttering threats

and robbery was related to the odds of changing outdoor activities and being more protective of personal safety.

Table 2.18 How neighbourhood crimes contribute to a specific psychological effect (n=199)

Awareness of crime	Feeling of stress	Panic attacks	Depression	Lack of confidence
Physical assault	1.82	0.45	1.58	0.59
Robbery	1.88	**2.79***	**3.56**	**2.65**
Sexual violation	0.35	0.87	0.21	0.31
Uttering threats	1.47	**4.96**	**9.41**	**3.28***
Other-violent crime	1.88	1.65	**5.06**	0.98
Breaking and entering	0.71	0.98	0.76	1.45
Theft of credit card	1.23	1.73	1.32	**2.62***
Vehicle-related theft	1.81	0.69	0.81	1.43
Other forms of theft	**3.21**	1.76	**2.85***	0.37
Vandalism	1.73	1.00	0.88	1.03

Note: **P<0.05 *P<0.1

Table 2.19 How neighbourhood crimes contribute to a specific behavioural effect (n=199)

Awareness of crime	Sleeping difficulties	Changes on outdoor activity	Enhanced security	More vigilance
Physical assault	0.77	0.80	1.22	1.71
Robbery	2.00	1.68	1.87	**4.65**
Sexual violation	0.71	0.32	0.61	-
Uttering threats	2.93	**3.34***	2.03	0.67
Other-violent crime	2.44	1.92	1.21	1.37
Breaking and entering	1.79	0.98	**2.58**	**0.37***
Theft of credit card	1.31	1.23	**0.44***	1.68
Vehicle-related theft	1.48	0.96	1.58	1.92
Other forms of theft	1.34	0.73	1.79	**8.54**
Vandalism	1.10	1.20	0.91	1.15

Note: **P<0.05 *P<0.1

2.5.4.3 Summary

In summary, survey responses indicated that both violent and property crimes were significantly related to the odds of psychological and behaviour changes after being a victim of crime, or due to the fear of neighbourhood crime in sampled neighborhoods and households in Toronto. Violent crime was significantly related to manifested psychological effects. Robbery was consistently associated with an increased odds of psychological effects. People who were victims of violent crime or else aware of neighbourhood violent crime were more likely to experience depression than people who did not. In addition, victims of violent crime were significantly related to the odds of taking action to adopt

protective behaviours to ensure one's personal safety. On the other hand, property crime was related to the odds of adopting property safety measures, such as installing house alarms.

2.6 Discussion

2.6.1 The Types and Rates of Crime in Toronto Neighbourhoods

According to crime incidents reported in survey, 97 respondents had experienced victimization, accounting for approximately 50% of respondents. More property crimes were reported than violent crimes, and the highest number of cases reported were related to theft, including vehicle–related theft, breaking and entering, and other forms of theft. Violent crime incidents followed, including robbery, uttering threats, physical assault, and sexual violation. However, respondents' victimization rates from the survey was much higher than crime rate reported from the Toronto Police Service, which was reported to be less than 5%. Table 2.20 shows the aggregated police-recorded crime rate per 100 people in 2006, with respect to each neighbourhood and different crime type. Accordingly, physical assaults were reported the most, while other forms of theft were reported the least. Therefore, victimization information aggregated from this survey were not in agreement with official police-recorded statistics.

Table 2.20 Toronto crime rate (per 100 people) from Toronto Police Service

Crime rate	Toronto	East End-Danforth	Cabbagetown	Dovercourt-Wallace Emerson-Junction	Weston
Total	**4.03**	**5.52**	**6.74**	**4.27**	**5.88**
Violent crime	**1.04**	**1.56**	**1.53**	**1.29**	**1.93**
Physical assault	0.92	1.38	1.37	1.28	1.61
Robbery	0.21	0.35	0.28	0.28	0.27
Sexual violation	0.087	0.11	0.10	0.15	0.19
Uttering threats	-	-	-	-	-
Property crime	**2.99**	**3.96**	**5.21**	**2.98**	**3.95**
Breaking and entering	0.60	0.84	0.85	0.88	0.75
Theft of credit card	-	-	-	-	-
Vehicle-related theft	0.37	0.33	0.32	0.39	0.39
Other forms of theft	0.042	0.035	0.054	0.032	0.012
Vandalism	-	-	-	-	-

Many reasons may account for the differences observed between survey victimization rates and police-recorded crime rates. First, this survey conducted across a random sample of Toronto local households relied on voluntary participation. This may result in varying non-response rates across different neighbourhoods and findings are not reflective of all households in the region. For example, the survey will not include people under the age of 15 or people who are homeless. In addition, demographic information available for this study was juxtaposed to regional and national statistics to evaluate to what degree the survey sample could represent the overall population. Appendix D shows the demographic features of survey respondents, Toronto residents, and Canadian residents, respectively, aggregated from the 2011 Census. After comparison, the survey over-represented groups who were female, middle-to-older age ranges, and groups from higher social class status (i.e. higher household income, higher education level).

Since this survey represents a sample and not the entire Toronto population, respondents' victimization rate aggregated from this survey may not represent the actual crime rate of the entire population in reality. A few studies have found that males and females may respond differently to victimization experiences Females are more likely to respond with emotional reactions than males, and females worry about crime more often than males do (Sutton & Farall, 2005). Similar to females, older people tend to be more sensitive to victimization and they tend to feel fearful of crime much more often than young people do (Hale, 1996). Therefore, females and older peoples who were victims of crime were more likely to respond to surveys, as they were more likely to want to share their personal experience of victimization and their perception of crime and fear of crime. The high percentage of respondents from high-income households could account for why more property crimes occur than violent crimes in this survey. Since incomes are also related with the quality and quantity of property owned, high-income households are often more attractive for property-related offenders.

Crime rates aggregated from the police are also inaccurate, since they are collected only when crime incidents come to the attention of the police. Not all victims or witnesses of crime are likely to report incidents to the police, resulting in the under-reporting of victimization and lower crime rates than in reality. There are many reasons behind the

under-reporting of crime, since an individual's decision to report crime to the police could be influenced by a multitude of factors, including the fear of crime, unwillingness to report crime incidents, and changes in legislation (Australian Bureau of Statistics, 2007).

Based on survey responses, most property offences were not reported to the police, since respondents considered such incidents to be "unimportant or not resulting in significant losses". The majority of victims regarded those incidents to be personal issues and decided to handle them by themselves. Interestingly, a few victims said that they did not report an incident, since they considered the police to be "useless". Therefore, the police-recorded crime data may not be accurate, as it likely under-reports the number of crime incidents. The police-recorded crime data can be used to compare crimes across large geographic areas, but it may skew the results when based on aggregated data for a regional-scale study.

Nevertheless, both survey victimization rates and police-recorded crime rates highlighted Cabbagetown as the area with the highest victimization rates in terms of both violent and property crime among the four selected neighbourhoods. Cabbagetown is located in Downtown Toronto, where crime hot spots appear to be highly concentrated. Due to its fine collection of Victorian-style houses preserved since the 1840s, this neighbourhood attracts people from a wide variety of backgrounds (e.g. artists, musicians, writers, and social workers), as well as commerce, including cafes, bars, and grocery stores (SafeTech Security, 2012). Cabbagetown is a community with a variety of classes and mixed-income levels, however, it is also characterized by a high level of unemployment and poverty. This area is also home to immigrants, mix-culture, and multi-languages (Loney, 2012). Since crime is an inevitable product of society and ecological environment as suggested by Social Disorganization theory and Routine Activity Theory, the area's characteristics and socioeconomic profiles make it prone to crime and deviant behaviour.

2.6.2 Social and Neighbourhood Factors in Influencing Victimization

Results from logistic regression models suggest that crimes were more likely to occur among particular groups based on demographic and socioeconomic profiles. People living in low-income households were more likely to be victims of violent crime, but less likely to

experience property crime, compared to those from high-income households. Findings from this survey were consistent with those from a Statistics Canada report, which indicated that Canadians living in low-income households were exposed to more violent crime, but less property theft and property-related household crime (Taylor-Butts, 2004). Moreover, low-income households tend to concentrate in areas that are prone to high risk of crime, since poverty and delinquency are related as supported by Social Disorganization Theory. In contrast, income status is also related to the quality and value of property one might own, which explains why high-income households tend to be more attractive for property-related offenders.

Education was another socioeconomic predictor of crime considered in this study. However, little is known about the association between victimization and the victim's education level. In fact, education could also be linked with income status, occupation, and other social class profiles, which are associated with victimization. A notable number of studies have focused on criminal offenders and their education. For example, a study in Pennsylvania (Education Voters Pennsylvania, n.d.) indicated that the majority of State prisoners had not completed high school. People with low education attainment might experience a certain degree of psychological alienation, and also experience dissatisfaction and strain that may lead to feelings of despair, frustration, and anger, which can even drive them to commit a crime. People without a high school diploma were also more likely to re-conduct offences than those with higher education attainment. In contrast, people with higher education might risk obtaining qualifications if they behave criminally at school. As a result, public education may be a worthwhile investment from a crime prevention perspective.

The relationship between marital status and predicting crimes was also considered in this study. More specifically, people who were single were more likely to be victims of physical assault and robbery. In other words, marriage is associated with lower violent crime, perhaps because marriage leads to changes in people's daily routines and patterns, which offers companionship and may influence potential risk and exposure to violence and victimization (Sampson et al., 2006). For example, married couples tend to stay longer at home or associate with other couples, while single people are more likely to socialize with

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people they are not quite familiar with, or even with strangers. Therefore, single people are more exposed to the risk of property crime than those who are married, if they are often absent from home. In contrast, married people are more likely to be victims of breaking and entering, since married couples, especially with children, can often reside in large and appealing dwellings, which attracts burglary offenders.

Neighbourhood and location-based characteristics were also linked to victimization in survey results. People acquainted with more neighbours were less likely to be victims of robbery and burglary. Therefore, the direct connection between knowing neighbours and being safe is evident. In order to maintain a safe and healthy place to live, getting involved in the neighbourhood of residence and joining the Neighbourhood Watch program, would effectively work on crime prevention. A watchful neighbour might recognize a stranger in the backyard, but a policeman might not notice.

In summary, understanding the root causes of crime is key to crime prevention and reducing risk of victimization. While Social Disorganization and Routine Activity Theory provide a theoretical basis for the social contexts of crime, findings from this study also showed that crime is a result of a combination of multiple factors and adverse social, environmental, and economic conditions. Results may be relevant to policy makers in terms of developing effective strategies to address the root causes of crime, such as encouraging education, reducing income inequality, and enforcing Neighbourhood Watch programs.

2.6.3 Health and Life Impacts of Experiencing Crime among Victims

This study is not only interested in assessing respondents' victimization rates and prevalence in Toronto, but also in gauging the general feeling and public perceptions of crime and potential health impacts in the sampled neighbourhoods and households in Toronto, regardless of actual crime statistics. Based on survey results, victims of both violent crime and property crime reported the impacts of crime on their physical and psychological health. However, all respondents who sought medical treatment were victims of violent crime, although some of them also experienced property crimes. This finding was consistent with that from the General Social Survey (Statistics Canada, 2004),

which suggested that victims of violent crime were likely to involve a physical injury. It was found that physical assault and robbery could result in a higher risk of suffering from a physical injury than sexual assault. Statistics Canada reports also showed that although the majority of police-recorded sexual assaults did not involve a physical injury, many of them required some first aid instead of medical treatment (Vaillancourt, 2010). Although not all violent crimes result in direct physical health impacts, many could be linked to psychological ill health consequences and disruptions to quality of life, which extend beyond the direct impacts. Similarly, although property crime does not involve physical harm by its definition, it still results in emotional scars and disruptions to daily life and functionality.

Accordingly, compared to direct physical health impacts, the psychological effects after crime experiences were more prevalent among victims. Although the experiences of victimization and the consequences of crime vary a lot, it is widely known that victims are likely to suffer from severe depression and mental disorder problems and thus require mental health services (Weaver & Clum, 1995). Results from logistic regression models support the notion that violent crime victimization significantly relates to psychological health and wellbeing. For example, physical assault, robbery, and uttering threats relate to the increased likelihood of fear, panic attacks, and depression. Such impacts are associated with the serious degree of victimization that an individual has experienced. Feelings of hopelessness, powerlessness, and anger experienced after victimization can also be related to a person's general sense of safety. Property crimes are of a non-violent nature, but can also have associated psychological effects. For example, if victimization experiences damage to their home, he/she may perceive a serious violation of privacy and safety. Criminal victimization affects people's minds, bodies, and beliefs, making them doubt the safety of their surroundings.

Psychological effects can turn into serious mental disorders if the negative feelings continue and last for over several months. It can also turn into a condition called Post-Traumatic Stress Disorder (PTSD), which has potential to disrupt a victim's health and daily life. PTSD refers to an anxiety disorder that occurs when a traumatic event takes place (Foa et al., 1995). A number of studies have shown that victims of crimes are likely to suffer

from PTSD (Littleton & Henderson, 2009; Wagner et al., 1998; Nishith et al., 2001). Quite often, victims seek additional support from family and friends, and psychological interventions. Furthermore, other mental health complications can potentially occur and physical health can subsequently be compromised if PTSD persists and emotional distress continues. Victims are likely to develop chronic disease, hypertension, and heart disease if they continue to react with depression, anxiety, alcohol and drug abuse, or may even attempt suicide (Maser & Cloninger, 1990).

In addition, victims may experience functional disruptions that may negatively affect their quality of life and physical functioning. According to survey respondents, the most significant symptom is difficulty sleeping, which is considered to be a long-term reaction to crime that not only distresses one's health and quality of life, but also harms his/her families, friends, and other related individuals. In terms of the medical mechanism of experiencing sleeping difficulties after victimization, once a person responds to an external threat, he/she starts secreting adrenaline, which leads to oxygen intake, increases heart rate and blood flow, and keeps the brain excited to help struggle with the threat (The Association of the British Pharmaceutical Industry, 2007). After a crime event takes place, the brain needs some time to realize the threat has ceased, but it acts as though the threat is continuing. A person cannot fall asleep when his/her brain is excited and ready to react to the threat (Victim Support Service, 2007). Sleep patterns can subsequently be disrupted accordingly, often followed by nightmares in the aftermath of crime. Dreams are often related to what happened during waking hours (Anxiety Disorder, 2016). For example, violence or fear associated with the experience may manifest itself in a dream and be associated with the dreamer's fear about the crime.

Victims in this study also reported changing their outdoor activities, such as avoiding going out alone, or after dark, or to certain areas. These changes can be explained as "avoidance behaviour" (McShane & Williams, 1997). In order to decrease the exposure to risks of re-experiencing crime, victims of violent crime increase their distance from situations where risks of crime are perceived to be high (Garofalo, 1981). Some victims of property crime also mentioned they became more aware of personal safety and property security after crimes, which can be explained as "protective behaviour". In this case, victims took actions

to increase their resistance to crime victimization and threatening situations. In general, violent crimes relate to victims' actions on "avoidance behaviour", while property crimes are related to "protective behaviour".

In summary, victims of both violent crime and property crime can potentially suffer from psychological effects after experiencing the crime event. It is important to understand and assess the impact of crime and violence on health and quality of life, and develop strategies to reduce victimization. Victims may require support from family, friends and other sources to cope with and recover from trauma. However, only about 30% of surveyed victims have previously sought and received help in any form. In addition to these sources of support, psychological therapy can be beneficial in reducing and ceasing the negative impacts of trauma and to encourage overall positive mental health. Therefore, improving mental health and access to healthcare services may be important from a Victim Support perspective.

2.6.4 Health and Life Impacts of Fear of Crime among People in the Neighbourhood

In addition to victims of crime, people who were simply aware of crime occurring in the neighbourhood were also psychologically affected by the fear of crime. Even though different members of the community may respond differently to fear of crime, awareness of both violent and property crime may significantly affect psychological health and wellbeing, as shown in the logistic regression model results. The finding is consistent with previous research, which suggests that the effects of crime could extend beyond victims, making the entire community feel insecure (Brennan, 2011).

Literature indicates that high and increasing crime rates cause neighbourhoods to "decline" (Taylor, 1995), which may have a wide range of consequences from psychological, behavioural to social aspects. Psychological consequences of crime were evident negative mental health conditions reported in our survey, including feelings of stress, fear, and depression. In addition, a decreased satisfaction with the overall neighbourhood, a weaker sense and attachment to community, and an increased desire to move out of residence were also considered to mark a psychological decline of the neighbourhood.

Findings from the survey also indicated that fear of crime in the neighbourhood was significantly related to people's outdoor activity and behavioural changes, likely associated with surrounding neighbourhood characteristics or decline. For example, people might behave in a way to protect themselves from perceived risk of crime. This could result in fewer people walking on the streets and less people participating in social affairs, which could potentially lead to more mistrust between neighbours (Taylor, 1995). Neighbourhood decline can potentially be evidenced by decreasing housing prices and low socioeconomic status of average household income, since people would tend to move out and be less likely to buy a house or business in the neighbourhood. Behavioural consequences of neighbourhood crime, originating from fear and psychological effects, may eventually turn into economic and ecological consequences. Rapid population turnover and poverty might in turn cause high rates of neighbourhood delinquency and criminal activity.

Therefore, fear of crime in a neighbourhood is related to people's psychosocial and mental health within the community. Such psychological effects also manifest themselves in the form of adopted changes to people's daily life and behaviour, which may potentially lead to economic consequences for the entire community. The consequences of fear of crime in the neighbourhood might extend beyond psychological and behavioural consequences, and potentially have broader ecological implications. Considering the relationship between fear of crime and potential negative psychological impacts is important for both Victim Support services and community development perspectives.

2.6.5 Resident Telephone Feedback

An adverse event (defined by the UW Office of Research Ethics) occurred after the questionnaire survey was distributed to Toronto households. A concerned resident contacted the Office of Research Ethics of the University of Waterloo and expressed concern that the study was affiliated with the Toronto Police or any independent organization. She was also concerned that findings from the study would create a false impression of her neighbourhood and thus create a negative neighbourhood profile. A follow-up telephone call was made to the resident immediately after the adverse event was

reported. Although the resident's identity was unknown, the telephone conversation provided further feedback and qualitative comments that supplemented survey results.

During the telephone call, the study's objectives were explained and the resident was assured that the study was not affiliated with the Toronto Police or any independent organization. The resident was convinced that the survey results would not be representative of her neighbourhood of residence. The resident also speculated that the majority of the neighbourhood consisted of residents from Caribbean descent, whom may not respond to the survey.

Evidently, based on survey demographic data in Appendix D, only about 20% of survey respondents were landed-immigrants and 15% were visible minorities, while statistics for the City of Toronto were both at approximately 50%. Most survey respondents were White and English speaking, and only a few of them were non-native English speakers. People who could not speak English might lower the participation rate of this survey. Moreover, individual backgrounds and ethnicities may influence the likelihood of an individual responding to the survey.

The concerned resident also indicated that the majority of neighbours were from the white-collar class and that white-collar crime was quite prevalent in this area. However, this survey does not take this type of crime into account. The term "white-collar crime" was raised in 1930s by sociologist Edwin Sutherland. It refers to a number of non-violent crimes that are committed by business and financial professionals to gain financial profits (Legal Information Institute, n.d.), thus involving personal property loses and potentially psychological impacts. The psychopathic and sociopathic conditions associated with poverty are closely correlated with crime (Sutherland, 1940), thus traditional studies of crime focus extensively on people in poverty while often overlooking criminal offences committed by the middle and upper classes in society, such as individuals with high income, decent jobs, and dignified social positions. In reality, people from the upper socioeconomic class might also engage in criminal behaviours that are often neglected. Nowadays, over one third of Canadian organizations are victims of financial crime and

about 50% of organizations indicate they have experienced computer crimes (McKenna, 2014).

The study of white-collar crime has significant influences on criminology and criminal justice. Although white-collar crimes may not have direct effects on the physical health of their victims, they might have much more severe impacts on our society than any other types of crime. The most significant effect of white-collar crime on society is enormous economic loss. For example, the estimated cost of white-collar crime in the U.S. society is over $300 billion annually (Friedrichs, 2009). In addition, the credibility of the government and the commercial market is threatened due to corrupt and deceptive practices (Saxon, 1980). Moreover, social relations are potentially damaged, since people are no longer willing to trust each other, which may lead to further corruption of social values, lower social cohesion, and greater social disorganization (Geis, 2006).

Therefore, white-collar crime has far more negative impacts than any other types of crime, and these may eventually turn into ecological and social consequences, leading to further disruption and social disorganization. Crime can have potential negative consequences on society, which in turn may lead to more victimization and higher deprivation. The absence of informal social control is considered to be a significant factor affecting levels of crime (Foster, 1995). For example, an individual may not decide to commit crime if the neighbourhood where he resided in has severe punishment on deviant behaviours; if this person does not decide to commit a crime, other people in the neighbourhood may also decide not to. Therefore, in addition to formal social control such as law legislation to prevent and punish crime, certain informal social controls such as enforcing people to maintain social order may reduce victimization and increase community health and wellbeing.

2.6.6 Similar Study Comparison

Since the survey was a modification of a previous questionnaire survey conducted in Sheffield, UK in 2006 (Tan, 2006), a comparison study is designed in this section to explore the variation of survey results with different geographic localities. The comparison always

provides a significant context and benchmark to further the understanding of the findings. However, due to data confidentiality, the findings of Tan's (2006) survey was not available. Instead of an exact comparison, several potential considerations are provided as follows to compare the two studies.

First, the findings of relationships between crime and psychological health should be explored in Tan's (2006) research. Second, it would be interesting to investigate the impacts of crime on physical health, which was not discussed in this study. Third, previous experiences of different victimization types can be compared between survey respondents in the two studies. In addition, respondents' victimization rate of a specific crime type can also be compared. Finally, respondents' neighbourhood characteristics and aggregate socio-demographic profiles can be compared to further the understanding of survey respondents.

2.6.7 Limitations in Survey Respondents

To ensure representative of survey respondents, it is ideal to randomly select from a list of individuals of the city, however, such lists are usually unavailable. The questionnaire survey was administrated to randomly selected households in sampled Toronto neighbourhoods, since the household is typically used as a device to contact at the individual (World Health Organization, 2013). Only single house dwellers were employed as survey sample, as the information of households residing in building (e.g. apartments, condominiums) were not available.

Although building dwellers were excluded from survey sample, they must be not overlooked. According to 2011 National Household Survey (NHS), one in every five Toronto households resided in buildings. People reside in building have lower average annual household income compared with dwellers in other home types, and about 22.7% of building dwellings were occupied by renters (Ontario Ministry of Finance, 2014). In addition, the majority of building dwellers were under the age of 35, then followed by a group that aged over 65 (Babad, 2013). Therefore, people in building were usually associated with younger, older, and less wealthy groups.

Although young groups and deprivation (e.g. poverty, low income) in an area have direct association with crime rate and health conditions of that area, the 2014 GSS indicated that households in apartments and condo were associated with a lower risk of household victimization than those reside in single houses (Perreault, 2015). In general, buildings might protect to the dwellers from being the target of burglary or vandalism. For example, most buildings tend to have 24-hour concierges, and visitors often need permission from gateman before proceeding to a certain unit. Therefore, potential offenders may find it difficult to enter the building. In addition, car thieves are less likely to approach to vehicles in building's underground parking garage, while most vehicle -related theft would occur when a car is parked on street or on the driveway of a single house. Therefore, the victimization rate of property crimes might be over-represented in this survey, since buildings dwellers tend to have risk of property crime victimization.

People who are homeless were also overlooked in this survey. There are over 5000 people in Toronto who are homeless, and over 400 are sleeping on the street (City of Toronto, 2016). A Toronto Street Needs Assessment survey indicated that rough sleepers were associated with more criminal activities than shelter users (City of Toronto, 2006) and the 2014 GSS showed that the homeless were associated with a higher risk of violent victimization than other housed individuals (Perreault, 2015). Three quarter of homeless youth in Toronto were found being involved in delinquent activities, but they were also victimized frequently (Gaetz et al., 2010). In general, the homeless usually suffer from poor health and high mortality rates.

Since the survey was administrated to households, all of household members could answer questions. However, the survey failed to target to children, since all survey responses were provided through an adult member of the household. Participation of the survey was voluntary, some people might not be willing to participate, especially when they did not have previous crime experiences or they were involved in criminal activities previously. In general, the questionnaire survey is not representative of Toronto neighbourhoods. The results of survey only represent overall crime and health relationships from participated households from sampled neighbourhoods.

2.7 Conclusions

This study explored crime and its impacts on people's health and daily life at the individual scale of analysis based on a postal questionnaire survey administrated to Toronto neighbourhoods. Data on people's previous victimization experiences, the awareness of crime in the neighbourhood, and the effects of crime on physical and psychological health were collected and analyzed.

Findings of the survey suggested that more property crime offences occurred than violent crime offences in the responded neighbourhoods and households. The most-frequent occurring types of victimization were theft, including vehicle-related theft, breaking and entering, and credit card theft. Violent crime, including physical assault, robbery, uttering threats, and sexual violation, occurred less frequently than all types of reported property crimes. However, survey respondents who have experienced property crimes were less likely to report them to the police, since many of them considered property-related victimization to be a minor issue. Therefore, violent crimes appeared to be more prevalent than property crimes according to official police-recorded crime statistics.

In addition to measuring the prevalence and rates of crime, this survey also collected health and quality of life impacts after a crime experience. Survey results suggested that victims suffer from physical and psychological harm to various degrees after experiencing a crime incident. However, compared to direct physical health impacts, the psychological effects of crime were more prevalent among victims in sampled neighbourhood and households. People who were victims of violent crimes were more likely to report that they had experienced psychological harms than victims of property crimes. Victims of robbery reported similar feelings of stress, panic attacks, depression, and lack of confidence.

In addition to psychological impacts, crime was related to behavioural changes adopted after victimization. Robbery and burglary were significantly related to people's adopting protective behaviours, such as enhancing home door security and being more aware of personal belongings and surrounding areas. People who were victims of violent crime were more likely to report that they had engaged in avoidance behaviours, such as changing outdoor activities to reduce exposure to the risk of repeat victimization.

People in the sampled neighbourhood were also affected by fear of crime. Both violent and property crimes in the neighbourhood were significantly related to psychological effects. These effects also changed people's behaviours and participation in outdoor activities, since people reportedly became more vigilant and watchful due to crime occurring in their neighbourhood.

This study was based on Routine Activity Theory and Social Disorganization Theory, which highlight the role of socio-demographic and neighbourhood characteristics in affecting victimization. It was found that the occurrence of crime was significantly related to responded victims' both neighbourhood and social contexts. People living in low-income households were more likely to be victims of violent crime, while people from high-income households were more like to experience property crime. People who were single were more likely to be victims of physical assault and robbery than those who were married, while married people were more likely to experience breaking and entering. People acquainted with more neighbours were less likely to be victims of robbery and burglary than those who knew fewer neighbours.

The findings from this survey provide insight into the prevalence of crime and its impact on public health and life in sampled neighbourhood Toronto. However, survey respondents were not reflective of the diverse characteristics of Toronto's population. Compared with the city and national demographics, females and older respondents were over-represented in the survey. As a result, these groups of people were more likely to express their feelings of stress, anger, and fear about crime experiences. Most of the survey respondents were White, English speaking, and from middle-class households, who might experience "white-collar" or financial-related crimes, which were not explored in this study.

In summary, findings from this study suggest that the impact of crime on health in sampled Toronto neighbourhoods and households was significant, especially when considering psychological health. Therefore, this study contributes to providing information necessary for understanding the effects of crime, while promoting services that can potentially reduce the impacts of victimization and improve mental wellbeing of the entire community.

Chapter 3. Connecting Manuscript 1 and Manuscript 2

Findings from the first study indicated that the impacts and consequences of victimization on health and quality of life were significant. Just as violent crimes can potentially result in physical and psychological harm, property crimes can also have similar psychological impacts that may affect an individual's daily life and living standards. Moreover, individuals who do not experience victimization directly may also suffer from stress, panic attacks, and anxiety, as a result of being fearful of crime occurring in the neighbourhood.

The questionnaire survey results support the notion that crime is a public health issue in the sampled Toronto neighbourhoods and households. The consequences of crime can place a demand on healthcare systems. Research suggests that the increased utilization of emergency and urgent medical care are observed among victims of sexual assault (Surís et al., 2004), intimate partner violence (Plichta, 1992), gunshot (Cook et al., 1999). However, access to healthcare services is restricted by many factors, including the high cost of healthcare services, and social and culture barriers. The lack of healthcare resources in certain areas is associated with delays in accessing treatments. Therefore, exploring the geographic accessibility and availability of healthcare services is important for better understanding the association between healthcare affordability and utilization (Guagliardo, 2004).

Therefore, the second study of this thesis aims to explore neighbourhood residents' spatial accessibility to mental healthcare providers in Toronto. It provides a better understanding of the uneven spatial distribution of mental healthcare resources with regard to population demands at different geographic locations. Based on the conceptual social model of health, the risk of poor mental health can be evaluated from influencing social ecological factors. The association between risk scores and accessibility ratios are explored. This study provides valuable information for healthcare planning facilities when making decisions on where to better allocate resources to better support previous victims of crime, as well as improving accessibility to mental health services.

Chapter 4. Exploring Spatial Accessibility to Mental Healthcare in Toronto

4.1 Introduction

Recent statistics indicate that approximately one in every three Canadians have experienced at least one type of mental disorder in their lifetime, but about one third of Canadians who require mental healthcare feel their needs are unmet or only partially met (Person et al., 2013; Sunderland & Findlay, 2013). Therefore, access to mental healthcare is an issue of importance that influences people's daily life and wellbeing. In fact, a large proportion of Canadians deal with their mental health issues simply by visiting family physicians or general practitioners (Wittchen, 2003), while such primary health care services often focus on physical care, they often fail to diagnose mental disorders or provide appropriate treatment (Funk et al., 2008). Instead, mental healthcare providers, such as psychiatrists and psychologists, are professionals who provide detailed support and diagnosis with regard to specific mental illnesses and health conditions.

Therefore, access to mental healthcare providers is a major facilitator that contributes to improving and maintaining an individual's mental health, such as for treatment for trauma, victim support services, and diagnosis of other disorders. However, disparities in access to mental healthcare across different populations are well documented (e.g. Kataoka et al., 2002; Bowen, 2001; Corrigan, 2005). The availability of healthcare providers in a given location might also restrict people to access treatments (Jones et al., 2014). In addition, accessibility to mental health treatments may be affected by the number of patients who require mental health treatments in an area, people's awareness about available mental healthcare services, socio-demographic characteristics about the patient, and travel distance/time to the closest facility (Luo & Qi, 2009).

Previous accessibility studies conducted by economists and epidemiologists usually tend to focus on socioeconomic characteristics that affect people's access to healthcare. Recently, a considerable number of studies focus on measuring spatial accessibility to primary healthcare (e.g. Luo & Wang, 2003; Wang & Luo, 2005; Schuurman et al., 2010; Guagliardo,

2004), facilitated by advances in Geographic Information System (GIS) and proliferation of spatial aggregated population and medical data (Ngui & Apparicio, 2011). Spatial accessibility measures consider the potential utilization of services given the population size, location, healthcare resources, and travel impedance to healthcare. This study on the spatial accessibility to healthcare explores existing disparities in access to services, and the result could also help healthcare planning facilities better allocate resources and improve public access to such services.

Although the study of spatial accessibility to healthcare can enhance understanding about the uneven spatial distribution of mental healthcare resources, the majority of studies treat the entire population evenly, regardless of their actual needs for mental healthcare. Geographical equity in the provision of services is different from equality. Equality indicates an even distribution of services so that every member of the community enjoys equal accessibility, while equity focuses on uneven distribution of services to satisfy the varying population needs (Gatrell & Elliott, 2014). Specifically, population groups with higher risk of mental health problems but lower accessibility to mental healthcare should be treated differently from those with lower risk but higher accessibility, from a health policy and service practice perspective. Therefore, the aim of this study is to assess neighbourhood residents' spatial accessibility to mental healthcare providers and to explore geographical equity in the provision of healthcare providers. The objectives are:

a) to compare methods of measuring spatial accessibility to mental health providers, including the gravity model and the two-step floating catchment area method,
b) to evaluate the population risk of poor mental health in Toronto based on contextual effects of crime and deprivation,
c) to identify areas with high risk of poor mental health conditions and low spatial accessibility to mental healthcare providers, which could better inform healthcare facility planners.

In this study, two accessibility measures, namely, the gravity model and the two-step floating catchment area method, are applied to explore the uneven spatial distribution of mental healthcare resources with regard to different population demands at any given location. A GIS-based multi-criteria evaluation is adopted to explore risk of poor mental

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health in Toronto. Areas with low accessibility to mental healthcare but high risk of poor mental health are identified through the integration of risk and accessibility maps. The findings would help healthcare facility planners to better locate and allocate resources, as well as improving public accessibility to mental health.

4.2 Literature Review

4.2.1 Geographic Variation in the Prevalence of Mental Health Problems

Health inequality refers to the differences in health status between different population groups (Public Health Agency for Canada, 2011). For example, some population groups with low socioeconomic status may experience a higher risk in poor health status than those who are less disadvantaged. Health inequality is often presented by a variety of socioeconomic factors, including gender, income, employment status, education, and ethnicity group. It can also be described by geographic location. The geography of health inequality is a hot topic for research studies in medical geography.

A number of researchers have studied variability in physical health that is related to the ecological and environmental sciences (e.g. Sallis et al., 2008; Reidpath et al., 2002; Cummins et al., 2007). Generally, two theoretical frameworks can explain the contextual effects of how geography is related to health risks and health variations. First, the spatial patterns of physical and biological risks, such as climate, pollution, or housing characteristics, might influence public health. Second, space and place are important for neighbourhood characteristics and social relations, which in turn influence how people make choices on healthy behaviours.

When focusing on mental health, disparities in health status also exist among different places. Tracing back to the 1930s, sociologists Faris and Dunham (1939) studied the spatial pattern of schizophrenia hospitalization in Chicago, finding that the prevalence of schizophrenia decreased with increasing distance from the city center. Geographers were inspired since then and started investigating psychiatric geography. Many studies exist on the contextual issues related to mental health status with general findings indicating that "a

more stressful local socioeconomic environment" is associated with a higher proportion of residents with mental health problems, and those areas were mostly poverty and crime-ridden and located in inner-cities (Scull, 2014).

Urbanization, which refers to the rapid increase in city and urban population, is one of major factors that results in the increase in mental disorders (Srivastava, 2009). Urban living is inevitably linked with stress, which is arisen from adverse living conditions, poverty, and inadequate social support. Stress may compromise health since stress exposure is chronic. Those people typically have mood swing, and they are likely to experience frustration and anger, or even serious mental disorder. In addition, it is undeniable that cities have better facility supports with regard to healthcare, since there are typically more primary healthcare and community services available in cities. Living in an urban environment might also attract people with mental disorders, so that they can enjoy accessing to more resources and treatments. As a result, mental disorders are more prevalent in urban areas.

More evidence shows that people living in urban areas are more likely to experience mental health problems than people living in rural areas. A study of exploring urban-rural differences in psychiatric disorders indicated that the risk of schizophrenia was doubled for city dwellers (Peen et al., 2010). Another study showed that city living had negative effects on social evaluative stress processing in human brain structure, thus people living in the city did not handle stress as well as people who lived in the countryside (Lederbogen et al., 2011). Therefore, understanding the geographic variation in the prevalence of mental health problems is important.

4.2.2 Explaining Poor Mental Health
4.2.2.1 Theoretical Social Model to Explain Poor Mental Illness

The root causes of mental illness are fiercely debated, since many professionals across multiple disciplines approach the subject differently from their own disciplinary framework (Tyrer & Steinberg, 2009). Historically, it can be traced back to ancient civilizations, when moral and religious explanations, such as "demons" and "foul spirits",

were the causes to drive people depressed or crazy (Friedman, 2015). The illness framework emerged and shifted the ancient explanations towards formal diagnosis (Coppock & Dunn, 2009). Psychological model followed, since psychiatrists began to realize human emotions and opinions are influenced by subjective attitudes and beliefs, and thus uncertainties are around the diagnosis (Double, 2001).

However, neither the medical model nor the psychological model is sufficient to "underpin policy and practice in mental health" (Coppock & Dunn, 2009). The social model of health focuses on the intrinsic link between the environment and human behaviour (Tyrer & Steinberg, 2009), as a broader perspective to explain mental disorder. The social model considers social forces as the dominant predictors of mental health (Link & Phelan, 1995).

Based on the model, there are two theoretical foundations to explain mental illness in the social context. First, the labeling theory in sociology indicates that mental illness is a result of societal influence. Instead of deviant, those people act inappropriately are labelled as mental illness (Thoits, 2005). Second, a certain social situation can result in mental illness (Keleher & Armstrong, 2006). For example, unemployment and poverty could make people develop anxiety; challenges in a relationship could make people worried or even paranoid.

Although the exact causes of general mental health problems remain unknown, research indicates that most of the problems arise from a mix of genetic, biological, psychological, and socio-environmental factors (Goldberg, 2014). The social model does not imply a negation of the traditional medical and psychological models, but offers a wider range of different perspectives on mental health. The traditional medical model considers mental illness to result solely from inherited or acquired disability, and thus focuses on treatments in terms of individual symptoms. In contrast, the social model proposes a contextual framework in terms of the accumulated life experience of people with mental illness, and thus treatment comes in the form of general support and solutions to enable recovery from both personal and social perspectives, such as normal living arrangements.

4.2.2.2 Conceptual Social Model of Mental Health

The conceptual framework shown in Chapter 1 (Figure 1.1) outlines the influences of social contextual factors on determining mental health conditions. Crime and social cohesion have direct effects on mental health. Victimization has direct impacts on victims' mental health, since victims of crime may suffer from a wide range of psychological trauma. Victims of violence might experience Post-Traumatic Stress Disorder (PTSD), and it was prevalent among victims of domestic violence according to the 2014 GSS (Burczycka, 2016). Fear of crime can negatively drive people towards mental health problems and substance abuse (Swartz et al., 2014). Furthermore, family members and friends of the victims are also likely to be impacted by the crime experience, since fear of crime causes people to feel insecure. Therefore, crime and mental health are inevitably connected. Criminal victimization can be regarded as a significant indicator for predicting the prevalence of mental health problems.

To policy makers, social cohesion is always regarded as a solution to reduce health inequality (Fone et al., 2007). How does social cohesion influence an individual's mental health and wellbeing in a neighbourhood? Research suggests that social cohesion, which is underpinned by both formal and informal social control, mitigates poverty and social exclusion, and finally influences health inequality (Phillips, 2003). Social cohesion is also a mirror of collective community wellbeing. A higher level of social cohesion is associated with more social support and trust, and thus buffers negative effects of poor mental health (Stafford et al., 2007). Therefore, positive mental health is represented by a high level of social cohesion, while poorer mental health is associated with a lower level of social cohesion.

In addition, risk factors for many types of mental illness are strongly related to social inequalities, such as income, race, gender, and other socioeconomic status (SES) factors (Allen et al., 2014). The relationship between SES and the occurrence of mental health problems is considered to be well-known (Perry, 1996). Among the general social determinants of health, adverse living condition and poverty have been found to be dominant risk factors for poor mental health status (Orpana et al, 2009; Ontario Human

Rights Commission, n.d.). Therefore, deprivation, which refers to a lack of material and financial assets, can also be directly linked to poor mental health.

In general, the conceptual social model of mental health considers contextual effects, which often involves examining the entire community as a whole. Three key contributing factors are highlighted, since they have a direct effect on mental health outcomes. Both violent and property victimization in the neighbourhood affects the health of victims of crime. Crime also indirectly influences neighbours since fear of crime causes them to feel unsafe. Material deprivation, such as poverty and poor living conditions, is a significant risk factor of poor mental health. Social deprivation, which reflects the fragility of social relationships in the family and the community, is also associated with poor mental health.

4.2.3 Accessibility to Mental Healthcare

Due to the complex nature of mental illness, regular access to mental healthcare professionals is required to obtain successful treatment. However, mental healthcare services are not always available or accessible (Sareen et al., 2007). In Canada, approximately one in six people has reported his or her perceived needs for mental healthcare (Sunderland, 2013), but up to 50% of them have reported the treatment gap (McCart et al., 2010). The main factors contributing to barriers to access mental healthcare are listed as follows.

The high expenditure regarding psychiatric treatment is one of the great barriers to equal access to healthcare. High cost of mental health treatment disproportionately affects their decision about whether they should or should not visit mental healthcare services (Vick et al., 2012). Social and cultural characteristics also play important roles in influencing access to treatment. Low accessibility rates are observed among racial and ethnic minority groups because of language and cultural barriers (Leong & Kalibatseva, 2011). Since socioeconomic and cultural barriers are significant, healthcare services should account for diverse population segments with their socioeconomic and demographic profiles.

In addition, the unavailability of healthcare professionals in an area also restricts access to services. A report by the World Health Organization indicates that the average number of

mental health physicians is 0.05 per 100,000 people in low-income countries (Saxena et al., 2007). Although more mental healthcare professionals are available in developed countries, limited numbers of family doctors are willing to accept new patients with appropriate language and cultural skills (Caulford & Mayhew, 2014). Therefore, the unavailability and inaccessibility of mental healthcare in an area severely prevents people from accessing necessary treatment.

This study focuses on the inequitable accesses to mental healthcare across space because of the uneven distribution of healthcare providers. The term "access" refers to "the availability of services in a geographic area" (Nesbitt et al., 2014), and "spatial access" consists of two dimensions: accessibility, which demonstrates the relationship between the location of healthcare and the population who need services; and availability, which refers to adequate supply in terms of population demand. In most literature, availability is integrated into accessibility with a single measure to indicate the geographic variations in the distribution of healthcare services with regard to potential utilization.

Researchers indicate that rural residents have lower accessibility to psychologists, compared to those living in urban areas. In the U.S., accessibility to mental health treatment by residents in metropolitan areas is 1.5 times those living in rural areas (Fortney et al., 2010; Hauenstein, 2006). In Canada, a national study showed that the physician-to-population ratio for registered psychologists is 1/9,619 in rural areas, compared to a ratio of 1/2,195 in urban areas (McIlwraith & Dyck, 2002).

There are several factors related to the inequitable access to mental healthcare between rural and urban areas. Most literature suggests that people in rural areas might be more concerned with the confidentiality about their mental healthcare information (Townsend, 2011; Warner et al., 2005; Wakerman, 2008). In addition, some people are reluctant to access these services due to a lack of information or familiarity with them.

Due to the existing differences in accessibility to healthcare between different population groups, there is an increasing interest in studying accessibility to healthcare services and spatial variation. Geographic Information System (GIS) has provided people a convenient and inexpensive way to assess and visualize spatial accessibility. With the development of

mapping and analytical software, GIS software provides the capability to visualize and manipulate road network data, as well as calculating accessibility from various population points to healthcare services. With the integration of neighbourhood information, it is possible to identify the spatial pattern of unequal healthcare accessibility between different socioeconomic groups and communities.

4.3 Data

4.3.1 Measuring Spatial Accessibility to Mental Healthcare

Spatial accessibility measures usually consider the potential utilization of services, based on population size and location, healthcare resources, and travel impedance to healthcare. Data used to measure spatial accessibility to mental healthcare providers are summarized in Table 4.1. These include locations of mental health providers, population data, and the Toronto street network.

Table 4.1 A summary of data used for measuring accessibility to mental healthcare providers

Data	Description
Mental health physician	Data containing point locations of mental health providers in Toronto were used as the supply of mental healthcare.
Toronto street file	Road and street segments were used to construct Toronto road network for routing and calculating travel time from population to different locations of mental health providers.
Population	The number of people residing in the census tract was regarded as population demand that would require accessing to mental health providers.

Both mental health providers and Toronto street data were retrieved from DMTI Spatial Inc., which is Canada's leading location-based data product provider (Laliberte, 2014). The data of locations of mental health providers were preprocessed and filtered from a vector-based database of over one million business and recreational points. North American Industry Classification System (NAICS) code, which provides details about the activity of businesses, was applied to filter mental health physician data from other datasets of interest. Table 4.2 provides NAICS codes that refer to mental health professionals.

Generally, the primary healthcare (e.g. family doctor and general practitioner) is the first contact for most patients. However, those primary health care often focus on physical

health symptoms, often fail to diagnose mental health problems, or fail to prescribe with property treatment (Funk et al., 2008). Instead, people should access to mental healthcare services with regard to their mental disorder or health conditions. The two types of mental health providers employed in this study were: (a) mental health specialists or psychiatrist, and (b) mental health professional including psychologist, counselors and therapists. Psychiatrists are trained medical doctors and thus can proscribe medication. Their services are covered by health insurance, but a doctor referral is required beforehand. In contrast, Psychologists are graduates of a master or doctoral degree in psychology; counselors and therapists are usually social workers from a certain mental healthcare association. Therefore, mental health professionals cannot prescribe medication and their services are not covered by health insurance.

Table 4.2 Points of Interest (source: EPOI User Manual, 2013)

NAICS Code	Description
621112	Offices of physicians, mental health specialists
62133	Offices of mental health practitioners (except physicians)

DMTI Spatial Inc. also provides high quality street file data, which were attribute-rich with a number of informative features, including road direction, road name and type, speed limit, turning restriction, and route hierarchy. The information was useful for defining network attributes. For example, a one-way road could be identified based on road direction; travel time could be calculated given road length and speed limit. Based on road and rail classifications, only five classes of roads were included in the network. Table 4.3 lists road classes and corresponding descriptions.

Table 4.3 Road classes in the Toronto road network (source: DMTI Spatial, 2013)

Road Classes	Description
Expressway	Expressways and 400 series highways, e.g. Highway 401, Don Valley Parkway
Primary highway	Primary Highway, e.g. Highway 7, Highway 11
Secondary highway	Secondary Highways
Major road	Major road or Arterial road, e.g. Bayview Ave
Local Road	Subdivision road in a city or gravel road in a rural area

Population data were developed from two input files: the 2011 Census of Population (Statistics Canada, 2011), and spatial files of census tract and dissemination area boundaries. Centroids were used to represent the whole census tract and population. Since the population within an area is seldom evenly distributed, the population-weighted centroid was employed, which is a summary point of describing the spatially distributed grouping of population. Weighted centroids were generated based on population data at the dissemination area level, and they were calculated based on equations as follows (Luo & Wang, 2003):

$$x_c = \frac{\sum_{i=1}^{n_c} p_i x_i}{\sum_{i=1}^{n_c} p_i} \tag{4.1}$$

$$y_c = \frac{\sum_{i=1}^{n_c} p_i y_i}{\sum_{i=1}^{n_c} p_i} \tag{4.2}$$

where x_c and y_c were the coordinates of the population-weighted centroid of census tract c; p_i was the population of ith dissemination area within that census tract; x_i and y_i were the coordinates of ith dissemination area centroid; n_c was total number of dissemination areas within that census tract.

4.3.2 Evaluating Risk of Poor Mental Health

As highlighted from the conceptual model, material deprivation, social cohesion and crime were contributing factors in explaining mental health inequalities. Datasets used to evaluate the risk of poor mental health are summarized in Table 4.4.

Toronto crime statistics were retrieved from the University of Waterloo Geospatial Centre. Crime data, aggregated from the Uniform Crime Reporting Survey, included police-recorded violent crime and property crime at each census tract in Toronto in 2006. Crime rate was a widely used measure of the intensity of crime at different geographic scales. It was measured by the number of crime incidents in an area per thousand people at risk, which referred to the working and residential population in the area.

Deprivation data were drawn from the 2011 Census of Population. Canadian area-based material and social deprivation indices were developed to model how different social

inequalities affect people's health and wellbeing over the years (Townsend, 2011). Material deprivation measured lack of goods and conveniences and social deprivation reflected the fragility of social relationships in family and community (Pampalon et al., 2012). Six indicators were selected based on their known relationships to health and affinities with material and social deprivation: low education, unemployment, average income, the percentage of individuals living alone, the percentage of separated, divorced, or widowed individuals, and the percentage of single–parent families. The indicators were analyzed by a principle component analysis, and the first two main components were extracted: the first one combining factors of education, unemployment, and income was noted as material deprivation; the second one grouping factors of family and marital information was referred to as social deprivation.

Table 4.4 A summary of data used for evaluating the risk of poor mental health

Data	Description
Violent crime	The number of police-recorded violent crime, including physical assault, sexual assault, robbery, uttering threat, and criminal harassment
Property crime	The number of police-recorded property crime, including burglary, shoplifting, vehicle-related theft, and mischief
Material deprivation	The lack of goods and conveniences, this index included: proportion of the population with no high school diploma; average household income; unemployment rate
Social deprivation	The fragility of social relationships in the family, and the community, this index included: proportion of the population separated, divorced, or widowed; proportion of the population that lives alone; proportion of single–parent families

4.4 Methodology

In order to explore neighbourhood residents' spatial accessibility to mental healthcare providers, spatial accessibility measures were employed. In this study, two measures, namely, the gravity model and the two-step floating catchment area (2SFCA) method were adopted and compared. A GIS-based multi-criteria evaluation (MCE) analysis was applied to study residents' risk of poor mental health, taking neighbourhood crime and deprivation into account. To explore spatial variance of accessibility ratio with regard to the variance of risk score, an Exploratory Spatial Data Analysis (ESDA) was adopted. More specifically,

global and local spatial autocorrelation Moran's I statistics were employed to explore spatial dependence of accessibility ratios and risk scores. Clusters with high risk of poor mental health but low accessibility to mental healthcare were identified. Details of each stage of the methodology are described in the following sections.

4.4.1 Spatial Accessibility Measures

Due to the uneven distribution of inhabitants and mental healthcare facilities, people located at different locations may enjoy different accessibilities to mental healthcare providers. The simplest accessibility measure is the provider-to-population ratio, which refers to the total number of suppliers per 100,000 residents within a geographical area (Canadian Institute for Health Information, 2013). The ratio is one of the most popular measures of spatial accessibility, as it can be widely applied in bordered administrative areas, such as provinces, metropolitan areas, and health regions (Guagliardo, 2004). However, it does not account for the variance of accessibility within a certain area or travel distance between supplying healthcare providers and population demand.

Another commonly used method is travel impedance to the nearest provider, which measures the straight-line distance (Euclidean distance) from a population center to the nearest healthcare provider. The measure is widely applied in rural areas, where healthcare providers are limited. However, it is not applicable in urban areas, where an array of providers is located in similar distances away from population groups (Fyer et al., 1999). Thus, the measure does not account for all potential available healthcare providers among residents.

This study focuses on measuring spatial accessibility to mental healthcare by incorporating both space and time dimensions. Two advanced measures have emerged in recent healthcare studies: the gravity model and the 2SFCA method. Both measures were applied to model potential spatial access to mental healthcare in Toronto.

4.4.1.1 The Gravity Model

The gravity model was developed by Joseph and Bantock (1982) based on Newton's Law of Gravitation. It considers the potential interaction between healthcare providers and population groups by incorporating space-time constrains. The gravity model is described by the following equation (Geertman & Ritsema Van Eck, 1995):

$$A_i = \sum_{j=1}^{n} \frac{S_j}{D_j d_{ij}^{\beta}}$$

(4.3)

where A_i is the accessibility ratio at population point i, S_j is the supply or number of physicians at physician location j, d_{ij} is the travel impedance between physician j and population point i, β is the distance decay coefficient, and D_j is the demand at physician location j. Demand at each physician location can be calculated by the following equation:

$$D_j = \sum_{k}^{m} \frac{P_k}{d_{kj}^{\beta}}$$

(4.4)

where P_k is number of people at population point k, d_{kj} is the travel impedance between physician j and population point k.

Distance decay is a geographic term to describe how the spatial interaction is affected by travel distance and travel time. The value of coefficient β represents the relationship between "population-service interaction and distance" (Schuurman et al., 2010). In other words, the value of β is related to the willingness of people to travel a certain distance to access a service. A high value (e.g. β=2) increases the distance weight, indicating that people are not willing to travel a far distance to access a service, while a low value (e.g. β=1) shows that people tend to travel far to access a service (Black, 1973). In reality, the coefficient β should be calculated based on actual mental healthcare utilization (Wang, 2001), however the data is often not available. Accordingly, different β values were tested to measure the variance of spatial accessibility by the gravity model. Six values of β ranging from 1 to 2 with an increment of 0.2 were tested.

4.4.1.2 The Two-Step Floating Catchment Area Method

As an enhanced gravity model, a 2SFCA method was developed and widely applied in recent spatial accessibility studies. With the advantages of the gravity model, the 2SFCA method can also be interpreted as a special form of provider-to-population ratio. It combines two steps: the first step assesses "physician availability" for each physician location through the ratio of physicians to their population within a catchment area, and the second step sums up all physician ratios that fall within a catchment area for each resident group. The detailed procedures are as follows and described by Luo & Wang (2003).

Let N be the number of clinics of mental health physicians located in the region of interest. It is assumed that each clinic j ($j=1\sim N$) has its threshold travel time T_j, which is the maximum time that physicians of the clinic j can travel. Let (X_j, Y_j) be the coordinate of the location of clinic j, while the service area of clinic j is determined as follows:

$$C_j = \{(x, y) \textbf{ such that travel time from } (X_j, Y_j) \textbf{ is within } T_j\} \qquad (4.5)$$

Let M be the number of households located in the region of interest and the coordinate of the location of household i ($i=1\sim M$) is expressed as (X_i, Y_i). Household i is said to be included in the area of clinic j if travel time from clinic i is within T_j and it is described as $(X_j, Y_j) \in C_j$ (Note that household i is said to be not included in the area of clinic j if travel time from clinic i is not within T_j and it is described as $(X_j, Y_j) \notin C_j$).

The number of households included in the area of clinic j is denoted as $\#C_j$, and associated 'physician-to-population ratio' of C_j denoted by R_j, is computed as follows:

$$R_j = \frac{S_j}{\#C_j} \qquad (4.6)$$

where S_j is the number of physicians working in the clinic j.

Generally, some households are included in the area of more than one clinic. 'Accessibility' of household i, denoted by A_i, is computed as follows:

$$A_i = \sum_{j=1}^{N} R_j \cdot f_{c_j}((X_j, Y_j)) \qquad (4.7)$$

where $f_{c_j}((X_j, Y_j))$ is often called 'characteristics function' of set C_j and returns 1 if $(X_j, Y_j) \in C_j$ and 0 if $(X_j, Y_j) \notin C_j$).

The result of the 2SFCA method is significantly affected by the cut-off travel time T_j, which is also indeterminate. From previous studies, researchers have explored various cut-off times and found that a larger cut-off time (e.g. two hours) was applicable to remote areas, since the perceived travel time to access healthcare is longer than that in urban areas (Schuurman et al., 2010, Luo & Wang, 2003; Langford & Higgs, 2006). In contrast, a smaller cut-off time should be employed if the study is conducted in a densely populated metropolitan area. A cut-off time of 30-minute or less is widely applied in previous studies (Joseph & Bantock 1982; Langford & Higgs, 2006; Yang et al. 2006). Accordingly, in this study, six cut-off travel times were tested in order to explore the variance in spatial accessibility to mental healthcare services. These ranged from 5-minutes to 30-minutes with an increment of 5-minutes.

4.4.2 Multi-Criteria Evaluation for Assessing Risk of Poor Mental Health

To evaluate risk of poor mental health, a GIS-based MCE approach was adopted, which combined multiple related characteristics to produce a final risk map. MCE is a transformation of geographic information and spatial data into a decision through the process of combining multiple and conflicting criteria (Farkas, 2009). MCE applied in this study followed a series of steps to perform risk assessment. The first step was to determine the criteria and factors that relate to people's poor health. Then each factor was assigned a weight based on its degree of impact on mental health. A final estimate of risk at each location was calculated after aggregating all factors based on a weighted-sum procedure.

The Analytical Hierarchy Process (AHP) approach was adopted in this study, which was a structured process to deal with complex criteria based on a hierarchical framework (Zhou & Wu, 2012). The nature of AHP is the decomposition of a research problem into a hierarchy of criteria and sub-criteria. Based on the conceptual framework presented in Chapter 1 (Figure 1.1), two categories of criteria that affect people's mental health are crime and deprivation, which constituted the primary criteria considered for this analysis

as shown in Figure 4.1. Crime is subsequently comprised of violent crime and property crime categories, while deprivation is comprised of material deprivation and social deprivation categories. Figure 4.1 presents the hierarchical framework of criteria applied in this study to assess the risk of poor mental health.

Determining criteria weights is important for MCE, since criteria weights are vital in the calculations of the total scores for alternatives and for the purposes of decision-making. Pairwise comparison was implemented to determine the weight of each criterion. This entails that every two criteria were compared (e.g. pairwise) and that the relative importance could be scaled based on Table 4.5.
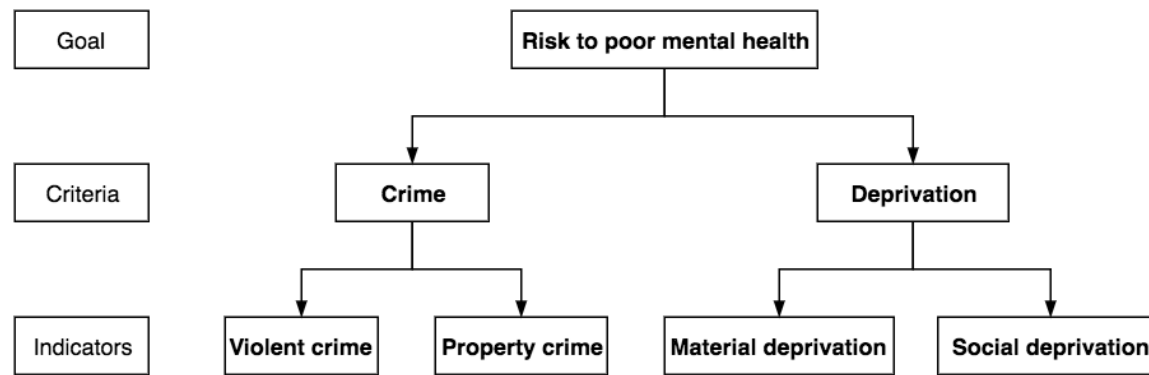
Figure 4.1 Hierarchy of criteria used to evaluate risk of poor mental health in Toronto

Table 4.5 Scales of relative importance applied for pairwise comparison (source: Saaty & Vargas, 1991)

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong or essential importance
7	Very strong or demonstrated importance
9	Extreme importance
2,4,6,8	Intermediate values
Reciprocals	Values for inverse comparison

The process of weight determination often involves the participation and compromise of stakeholders, decision makers, and expert groups. Therefore, the process is extremely time consuming when the decision maker cannot make an agreement on the importance of a

specific factor (Aldian & Taylor, 2005). The weights applied in this study were based on previous studies and related literature.

Both violent crime victimization and property crime victimization are significantly related to people's poor mental health (Norris et al., 1990; Teplin et al., 2005). However, compared to victimization from property crimes, violent crimes incur more negative effects on an individual's mental wellbeing (Freeman & Smith, 2014). Therefore, violent crime was considered to be more important in influencing an individual's mental health than property crime. Material deprivation and social deprivation are independently related with poor mental health (Fone et al., 2007). Therefore, both material and social deprivation were considered equally important in evaluating people's poor mental health. However, there is limited research available that incorporates crime and deprivation as explanatory variables and investigating their association with mental health.

Due to the uncertainty of assigning weights to crime and deprivation the AHP model, three scenarios were tested by applying different weights to the two criteria. The relative importance of sub-category criteria of crime and deprivation was retained for all scenarios. A detailed description of weights is provided in Appendix C. To compute the weight of each criteria from the results of pairwise comparison, a reciprocal pairwise comparison matrix A was created:

$$\text{A} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \tag{4.8}$$

Element a_{ij} in the matrix A refers to the relative importance of criterion i to criterion j, and the reciprocal a_{ji} equal $1/a_{ij}$, indicating the relative importance of criterion j to criterion i (Aldian & Taylor, 2005). The weight of each criterion can be calculated based on the eigenvector of the matrix A. Once weights of all criteria are calculated, the Consistency Ratio (CR) is used to verify whether the result is trustworthy and consistent in the judgment of large samples. CR is calculated by the following equation:

$$\text{CR} = \text{CI/RI} \tag{4.9}$$

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where CR refers to a Consistency Index that measures the closeness of the largest eigenvalue (λ_{max}) of the matrix A and the number of criteria (n), and RI refers to a Random Consistency Index based on the number of criteria n. RI is obtained from Table 4.6. CI is calculated by the following equation:

$$CI = (\boldsymbol{\lambda_{max}} - \boldsymbol{n})/(\boldsymbol{n} - \boldsymbol{1})$$ (4.10)

Table 4.6 Random Consistency Index (RI) (source: Saaty & Vargas, 1991)

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45

If CR <= 0.1, the matrix is consistent and acceptable. In contrast, if CR > 0.1, the matrix is inconsistent and untrustworthy, and the process should be repeated and weights revised.

The final risk was calculated based on the weighted-sum procedure (Yassine & Adel, 2011), which is a weighted linear combination of each criterion.

$$S = \sum \boldsymbol{w_i f_i}$$ (4.11)

where S is the risk score to poor mental health by MCE, w_i is the weight of criterion i, and f_i is the performance of each census tract on criterion i.

After aggregating all criteria, the risk of poor mental health was obtained for each census tract. A risk map was created by classifying the risk scores into risk groups.

4.4.3 Exploratory Spatial Data Analysis

In order to explore the spatial patterns of accessibility ratios and risk scores and to investigate the spatial association between them, an ESDA approach was employed as a quantitative approach to explore geographical features. Exploratory data analysis (EDA) approach is usually applied to non-spatial datasets and it involves a collection of descriptive statistics to explore the structure of a dataset, such as patterns and outliers (Haining et al., 1998). However, as an extension of EDA, ESDA involves a collection of techniques to examine spatially referenced data. The main functions of ESDA involve visualizing spatial distribution of data, identifying spatial outliers, detecting spatial clusters,

and exploring spatial association (Anselin, 1998).

In this study, spatial autocorrelation was employed to explore spatial pattern and clusters of accessibility ratios and risk scores. Spatial autocorrelation refers to the correlation among events of a single value with other values in nearby locations (Griffith, 2009). If a sample and its neighbours have similar values, they are considered to be spatially autocorrelated. Spatial autocorrelation is based on a null hypothesis, which indicates there is no spatial pattern existing among features, or the expected pattern is just complete spatial randomness (CSR). A global Moran's I test is employed to detect whether the null hypothesis should be accepted. The index I can be calculated from the following equation (Cliff & Ord, 1981):

$$I = \frac{N \sum_{i=1}^{n} \sum_{i=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^{n} \sum_{i=1}^{n} w_{ij}) \sum_{i=1}^{n} (x_i - \bar{x})^2} \qquad (4.12)$$

where N is the number of features, $\bar{x}$ represents the mean value of the features, x_i and x_j are the values of feature i and j, and w_{ij} indicates the distance-based weight between feature *i* and *j*.

Accordingly, the value of *I* ranges from -1 to +1. If the value is approximately near -1, the highly dispersed spatial pattern is detected. There is no spatial autocorrelation when the value is near 0. The spatial pattern is highly clustered when the value is near +1. Therefore, the global Moran's I is important when examining the overall spatial pattern of a dataset and for determining whether spatial autocorrelation exists, but local variations and clustering remain undetected. Therefore, local indices of spatial autocorrelation have been applied to detect areas with values that are both "extreme and geographically homogeneous", namely spatial clusters or spatial outliers (Oliveau & Guilmoto 2005).

The Local Indicators of Spatial Association (LISA) is often used to examine local autocorrelation, and it is considered to be the local equivalent of the global Moran's I test. LISA is also based on a null hypothesis of spatial randomness to examine the spatial association between each feature and its neighbours (Anselin, 1998). Therefore, for each feature at a particular location, LISA compares its value with its neighbours' and generates four types of spatial patterns: high values surrounded by neighbours with high values are

denoted as High-High; low values surrounded by neighbours with low values are denoted as Low-Low; high values surrounded by neighbours with low values are denoted as High-Low; low values surrounded by neighbours with high values are denoted as Low-High. The spatial patterns of High-High and Low-Low are spatially clustered as features are correlated with their neighbours. To visualize the spatial pattern, the four scenarios can be plotted on a map to show the exact locations of clusters and hot spots.

In this study, spatial autocorrelation helps to explore the spatial patterns of accessibility to mental healthcare and risk of poor mental health in Toronto. Both global Moran's I and LISA were employed to investigate whether spatial clusters exist in accessibility ratios and risk clusters, and whether there are coinciding locations and patterns of low accessibility and high risk in LISA maps.

4.5 Results

4.5.1 Spatial Accessibility Results

In order to explore spatial distribution of mental healthcare resources with respect to various population demands, spatial accessibility to mental healthcare was assessed in this study. Two key parameters were required when employing the gravity model and the 2SFCA method in this study. These are, (a) the distance decay coefficient β in the gravity model, and (b) the cut-off travel time threshold T_j in the 2SFCA method. To explore how different parameters would affect the results of accessibility ratios, standard deviation maps were developed to highlight the variance in spatial accessibility ratios. A sensitivity analysis compared the mean accessibility ratios and spatial variances of the two accessibility measures.

4.5.1.1 Spatial Accessibility by the Gravity Model

Figure 4.2 shows the spatial variance of accessibility to mental health providers in the City of Toronto using the gravity model with changes to the distance decay coefficient β. The accessibility ratios were grouped by the Standard Deviation Classification method in

ArcGIS, and the variance of accessibility ratios from the mean were clearly shown. For an easy comparison, one legend was applied in six maps: red was used for the highest accessibility, which was greater than 1.5 times the standard deviation from the mean score; dark green indicated a low accessibility, which was less than 1.5 times the standard deviation from the mean.

The accessibility maps by different β varying from 1 to 2 with an increment of 0.2 showed a consistent spatial pattern. Accordingly, people living in Downtown enjoyed the best accessibility, as all maps highlighted Downtown as the area with highest accessibility. Relatively poor accessibility occurred in the east and west areas of the city, namely in the Etobicoke and Scarborough regions. After comparing all of the accessibility maps, the map with coefficient β=1 showed the strongest spatial variance, while the map with β=2 exhibited the strongest spatial smoothing.

Figure 4.2 Standard deviation maps of spatial accessibility to mental health physicians calculated by the gravity model with changes to coefficient β

A weighted mean centroid was employed to compare the spatial variance in accessibility with changes to distance decay coefficient β. Similar to the population-weighted centroids, accessibility-weighted centroid is representative of the overall spatial distribution of spatial accessibility ratios. Each weighted mean centroid was calculated using a mean center function in ArcGIS software, from the *x* and *y* coordinates and the accessibility ratio of each census tract.

Figure 4.3 shows the locations of accessibility-weighted centroid with different values of coefficient β. The centroids were all located in one neighbourhood, Mount Pleasant West, which is situated in the central part of the city. Therefore, spatial distributions of accessibility ratios from the gravity model were consistent with changes made to coefficient β. They highlighted Downtown as enjoying the highest accessibility, while neighbourhoods in Etobicoke and Scarborough suffered from the lowest accessibility to mental healthcare.

Figure 4.3 Weighted centroids of the accessibility maps by different coefficient β from the gravity model

4.5.1.2 Spatial Accessibility by the 2SFCA method

As a comparison to the accessibility by the gravity model, the spatial distributions of accessibility by the 2SFCA method varied a lot with changes to cut-off travel times T_j. Figure 4.4 shows spatial accessibility ratios by the 2SFCA method, grouped by the Standard Deviation Classification method. Similarly, neighbourhoods in red were highlighted as high accessibility, while neighbourhoods in dark green were labeled as low accessibility.
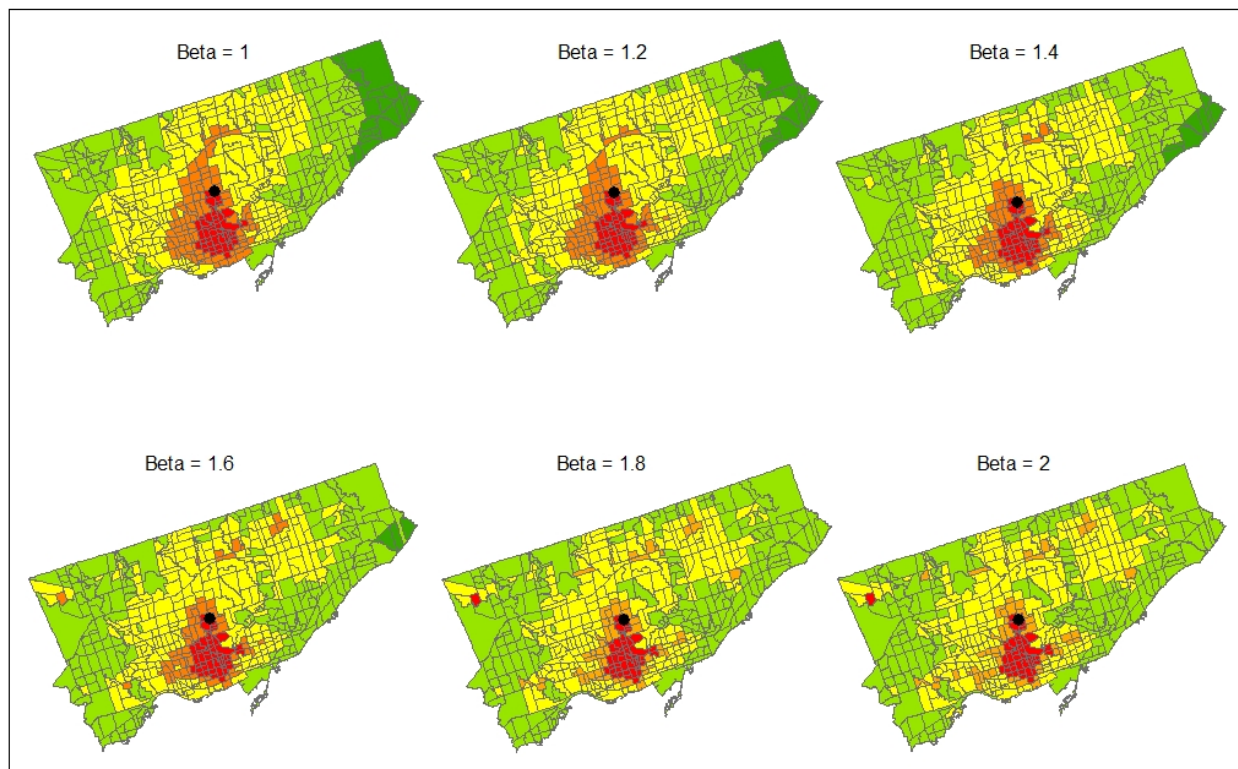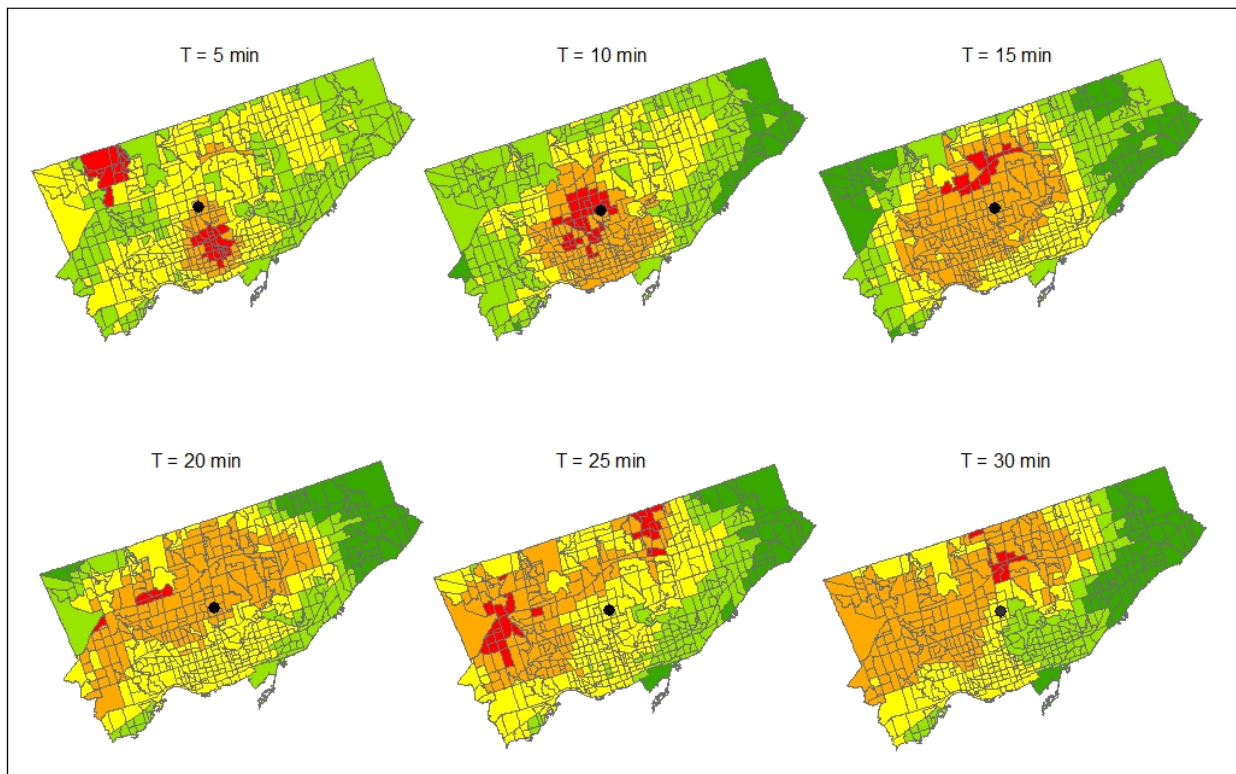

Figure 4.4 Standard deviation maps of spatial accessibility to mental health physicians calculated by the 2SFCA method with incremental changes to cut-off travel time

When T=5 min, Downtown and the northwest of the city enjoyed the highest accessibility. When T=10 min, more neighbourhoods were marked with high accessibility, and neighbourhoods in Midtown, North, and North York region enjoyed high accessibility. With the increment of the cut-off travel time T_j, areas that were marked as high accessibility shifted towards the northwest of the city. When d=30 min, neighbourhoods in North York

and the north of Etobicoke enjoyed high accessibility. However, the East End and Scarborough regions consistently suffered from poor accessibility, regardless of the cut-off travel time T_j.

In addition to different spatial distribution of accessibility ratios, different spatial variances of accessibility ratios were apparent. The map with coefficient $T_j=30$ min shows the strongest spatial variance, while the map with $T_j=5$ min shows the strongest spatial smoothing.

The centroid of each accessibility map by different cut-off threshold T_j was also calculated and mapped by ArcGIS software (shown in Figure 4.5). Similar to the centroids of accessibility by the gravity model, these centroids were located in central Toronto. However, they were located separately in three adjacent neighbourhoods, namely, Yonge Eglinton, Lawrence Park South, and Mount Pleasant East, indicating that the spatial distribution of accessibility ratios varied substantially with changes in the designated cut-off travel times T_j.

Figure 4.5 Centroids of the accessibility maps by different cut-off travel time thresholds from the 2SFCA method

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4.5.1.3 Comparison of the Two Accessibility Measures

In order to compare the two accessibility measures by different parameters, a sensitivity analysis was conducted by comparing the mean accessibility ratios and spatial variances of the results of two measures. Table 4.7 shows the mean accessibility ratios and the standard deviations for the two measures with changes to these parameters. There were several notable observations from the sensitivity analysis:

Table 4.7 Sensitivity analysis of the gravity model and the 2SFCA method with changes to distance decay coefficient β and cut-off travel time threshold T_j.

Gravity model			2SFCA method		
β coefficient	Mean of A	Standard deviation of A	Travel time T_j	Mean of A	Standard deviation of A
1.0	0.85	0.21	5	0.99	0.79
1.2	0.86	0.26	10	0.89	0.35
1.4	0.87	0.32	15	0.90	0.24
1.6	0.88	0.39	20	0.88	0.14
1.8	0.89	0.45	25	0.82	0.09
2.0	0.90	0.52	30	0.75	0.06

Note: A=Accessibility ratio per 1,000 people

(a)   Referring to the gravity model results, the mean accessibility ratios increased with the increment of distance decay coefficient β, and the variances of spatial distribution also increased according to the values of standard deviation. Therefore, a larger β coefficient indicates a higher spatial variance of accessibility. In reality, a large coefficient β is associated with people's reduced willingness to seeking mental healthcare by long travel times. Therefore, the spatial accessibility ratios vary substantially, since people tend to seek and favour healthcare services located nearby their residence.

(b)   By the 2SFCA method, the mean accessibility ratios decreased with incremental cut-off travel times, and the variance also decreased at the same time. Therefore, a large cut-off travel time reduced the variability of accessibility, contributing to stronger spatial smoothing. In other words, a smaller cut-off travel time was associated with a higher

spatial access to mental healthcare, and increased variability in spatial accessibility, since people tend to seek healthcare in their nearby locations.

(c)   The accessibility by a smaller β coefficient in the gravity model was equivalent to that of a larger cut-off travel time in the 2SFCA method. In this case, people were willing to travel far to access mental healthcare services, regardless of their locations as long as they were reachable within a reasonable travel time. In contrast, the effect of a larger β coefficient was comparable to that of a smaller cut-off travel time, when people tend to seek mental healthcare in their nearby locations. For example, the effect of coefficient β = 1.6 in the gravity model was similar to that of cut-off travel time T = 10 min in the 2SFCA method.

Not only were the mean accessibility ratios and the standard deviation values similar when T = 10 minutes by the 2SFCA method and when β = 1.6 by the gravity model, the spatial distribution of their accessibility measures were also similar after examining their accessibility maps (Figure 4.6). Both results highlight Downtown and the central part of the city as high accessibility, while surrounding areas, including Etobicoke, Scarborough, and the north of the North York region, were marked as low accessibility. The accessibility weighted centroid in the case when T_j = 10 minutes by the 2SFCA method was very close to that when β = 1.6 by the gravity model. As shown in Figure 4.7, the centroids are approximately 240 meters apart, and located in two adjacent neighbourhoods in Central Toronto.

Although accessibility measured by the 2SFCA method when T_j = 10 min and the gravity model when β = 1.4 shared a certain number of similarities, they also had noticeable differences. A scatterplot shows the correlation of the accessibility ratios estimated by the two methods in Figure 4.8, where the x-axis indicates the accessibility ratios estimated by the 2SFCA method and the y-axis shows those by the gravity model. Theoretically, the points in the scatterplot should be close to the y=x (1:1) line, indicating that accessibility ratios by the two measures are equivalent. The accessibility ratios valued between 0.25 and 1.00 are located close to the 1:1 line, demonstrating that both measures are similar in areas with poor accessibility. However, the accessibility ratios by the two measures do not fall

around the 1:1 line, showing that the two measures are quite different for areas with high accessibility.
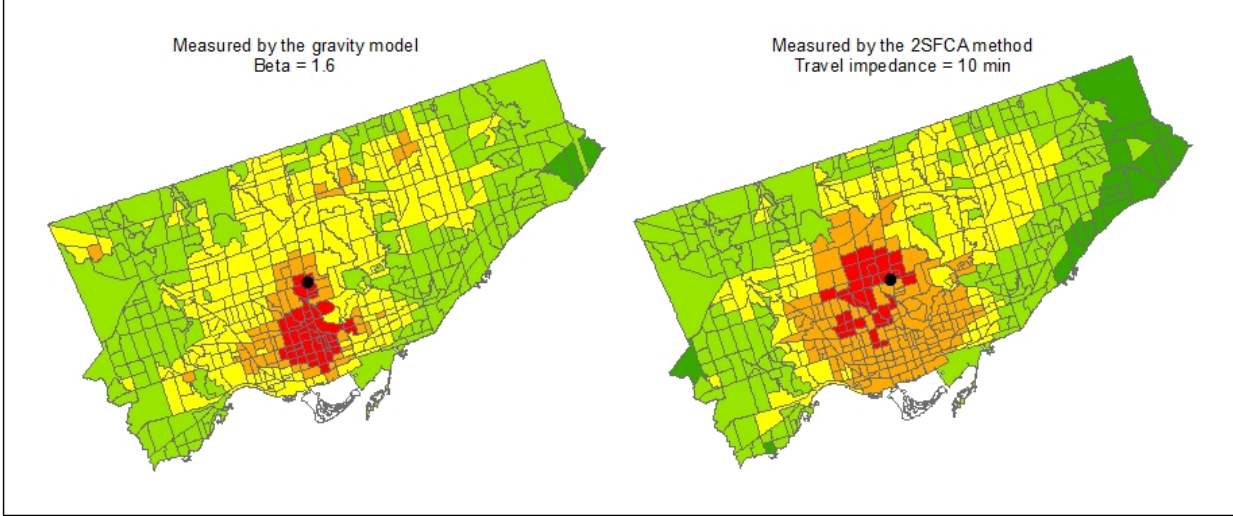

Figure 4.6 Standard deviation maps of accessibility measured by the 2SFCA when T = 10 minutes and by gravity model when β = 1.6
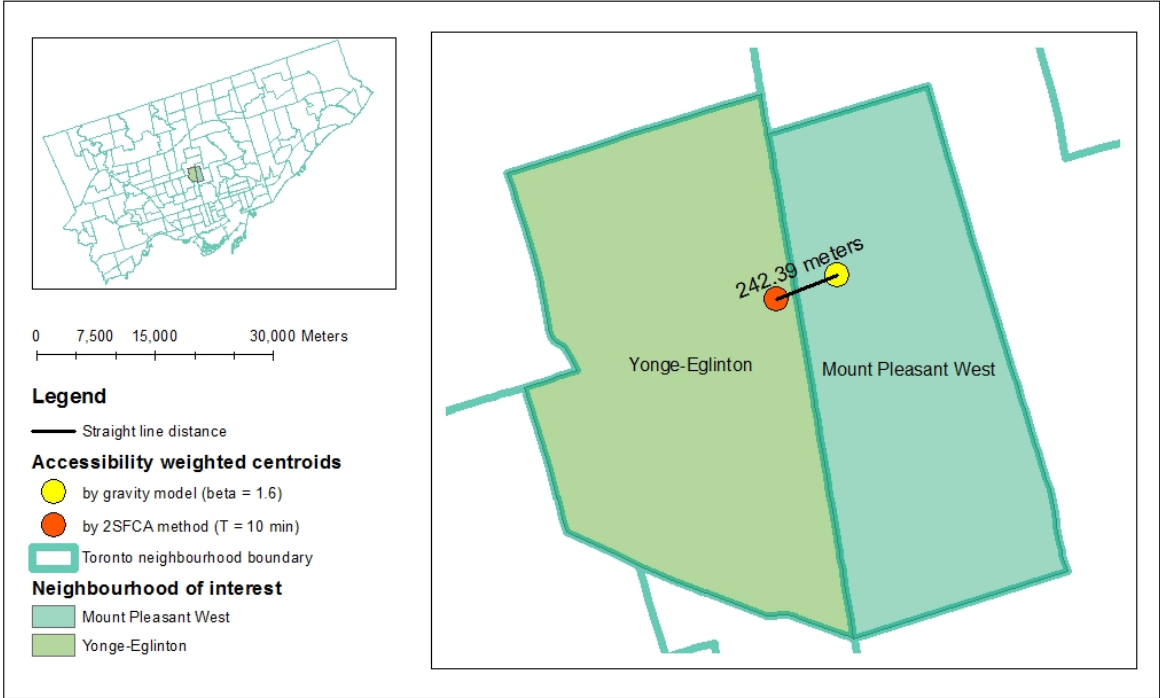
Figure 4.7 Centroids from the standard deviation maps by 2SFCA when T = 10 minutes and by gravity model when β = 1.6
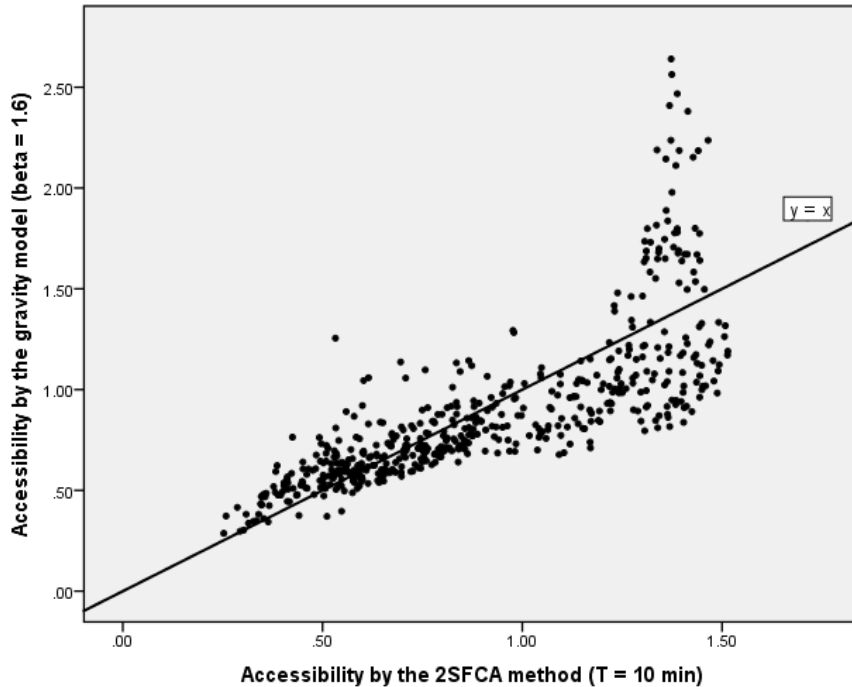
Figure 4.8 Scatter plot of accessibility by 2SFCA when T = 10 minutes compared with accessibility by the gravity model when β = 1.6

It is also interesting to note that the range of accessibility ratios calculated by the gravity model was larger than that calculated by the 2SFCA method. The maximum number of physicians that a thousand local residents can access was 2.6 when estimated by the gravity model, compared to 1.5 by the 2SFCA method. One of the possible explanations is the gravity model assumes that residents can access mental healthcare situated at any location, while the 2SFCA method considers care providers to be accessible only within a reasonable travel time.

Nevertheless, it is rather difficult to identify a "better" cut-off travel time that can generate a "better" accessibility result from different parameters. As earlier indicated, the value of β represents the willingness of people to travel across a certain distance to access a service. For instance, a high value could be employed to study accessibility to a pharmacy, as people are not willing to travel afar for this purpose. In contrast, research indicates that people are willing to travel afar to access health treatment (Guagliardo, 2004; Luo & Wang, 2003).

Therefore, the coefficient β valued at 1 is considered to be a better explanation of accessibility than β with other values in the gravity mode.

In addition, Lee (1991) has suggested that a 30-minute cut-off travel time is suitable for driving on primary roads and it is applicable for studies in urban areas and metropolitan areas. However, due to the lack of real traffic data, travel time between two points in the network may not be entirely realistic, since it does not consider delays due to traffic lights, road construction, and traffic jams. The distance of a 25-minute trip measured from the network without traffic was comparable to that of a 30-minute trip by Google Maps when taking traffic into account. Therefore, the accessibility generated by a 25-minute cut-off travel time was considered better than other cut-off time thresholds.

4.5.2 Evaluating the Risk of Poor Mental Health

A GIS-based multi-criteria evaluation (MCE) was adopted to evaluate the risk of poor mental health from crime and deprivation characteristics. It is notable that the factors had different units and scales. Therefore, data normalization was implemented before proceeding to aggregating the criteria. In this procedure, all criteria were normalized to the same scale, ranging from 0 to 1. Spatial autocorrelation of normalized criteria is shown in Figure 4.9. The global Moran's I index is a measure of spatial autocorrelation and cluster detection, and the value of I is in a range between negative one and positive one. When the value of I is close to positive one, the spatial autocorrelation is high positive, which shows a high clustered spatial pattern. It is evident that all criteria were spatial autocorrelated and that spatial clusters were present.

The LISA maps indicated the locations of clusters. Census tracts in red indicated the presence of a high cluster, while those in blue showed the evidence of a low cluster. Accordingly, High-High crime rates of both violent and property crimes were clustered in Downtown, while low crime rates were aggregated in Midtown and North York, and the northeast of the city. Spatial clusters of high material deprivation were located in York District, and northwest of North York region, while low material deprivation were

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clustered in the central part of the city and the south of Etobicoke. Clusters of high social deprivation were located in Downtown and Lakeshore of Etobicoke.
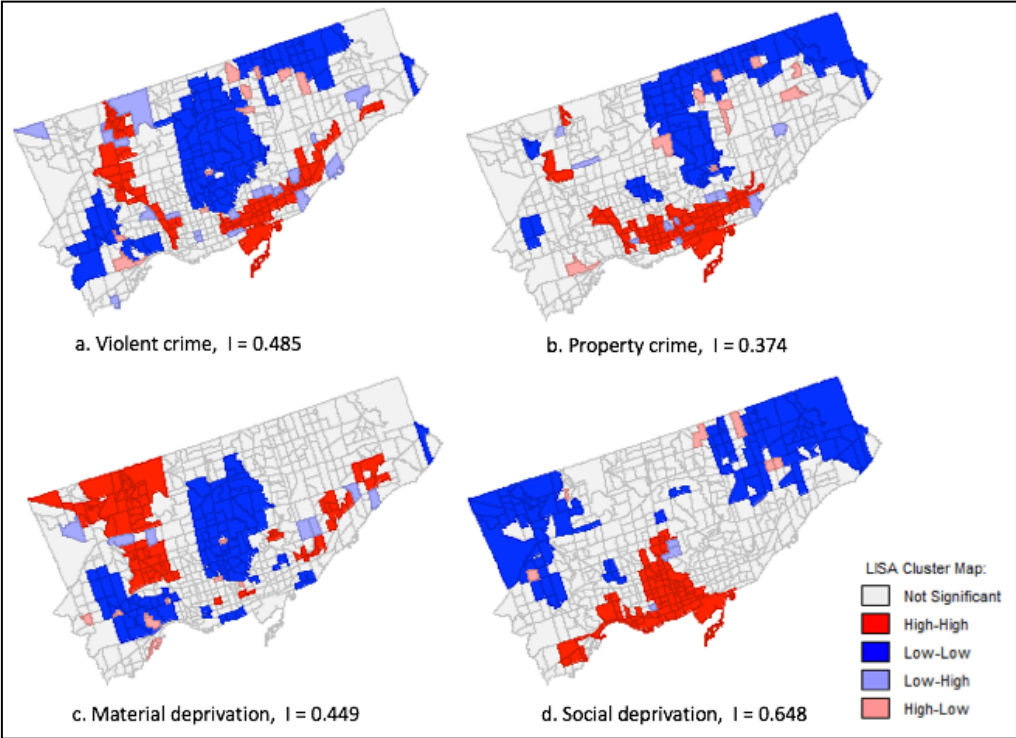
Figure 4.9 LISA cluster maps of (a) violent crime rate, (b) property crime rate, (c) material deprivation and (d) social deprivation

Weighting schemes for aggregating different criteria are detailed in Table C.4 in Appendix C. Due to the uncertainty of weights, three scenarios were considered by applying different weights to higher level criteria between crime and deprivation. The relative importance of criteria at the lower level was retained for all scenarios. The final risks to poor mental health from the MCE process are mapped based on different criteria aggregation scenarios (Figure 4.10). The risks to poor mental health were defined as five classes based on a Quantile classification scheme in ArcGIS software, so that each risk group contained an equal number of census tracts. All three maps show a clear spatial pattern of risk: population in the Lakeshore area and in York and Davenport districts suffered from high risk of poor mental health, while population located in Midtown, North York, and north Scarborough regions had a relatively low risk of poor mental health.
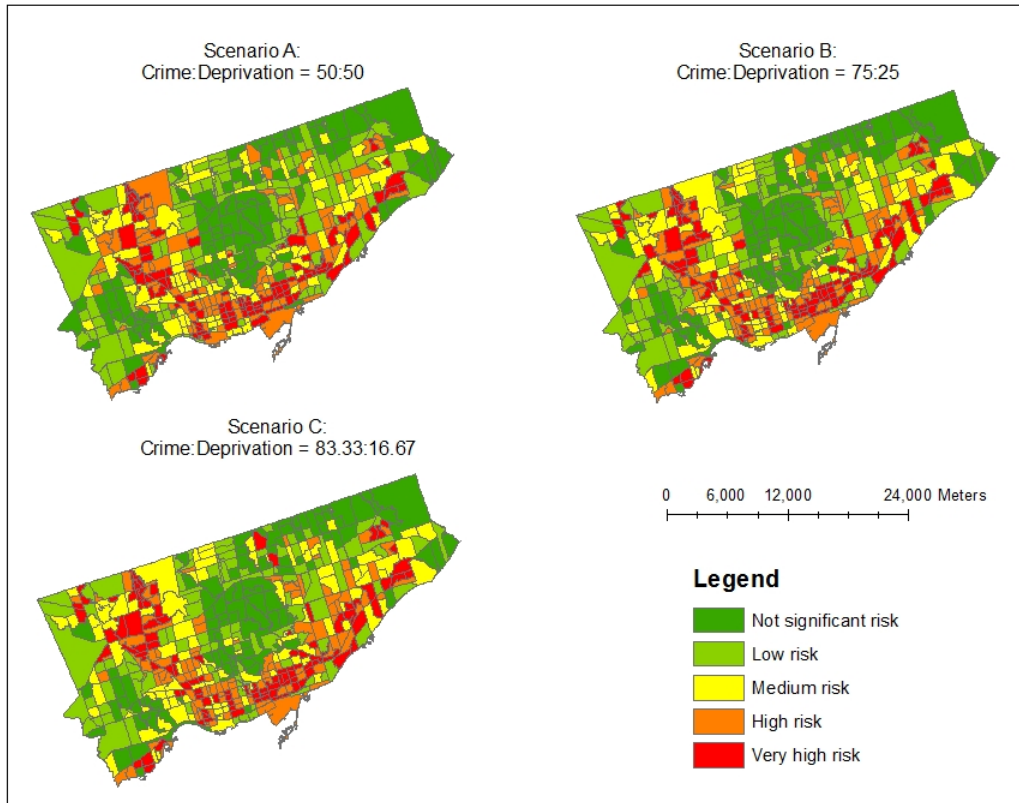
Figure 4.10 The risk of poor mental health by applying different weighting schemes to MCE criteria

A final risk map combining all different weighting scenarios is shown in Figure 4.11. The risk score of each census tract was calculated based on mean risk scores of three scenarios. The spatial distribution of risk scores is consistent with the outputs from MCE analysis: Downtown, Lakeshore in Etobicoke and Scarborough, and York District were highlighted as high risk of poor mental health, while Midtown, North York, Scarborough north and Etobicoke center were evaluated as low risk.
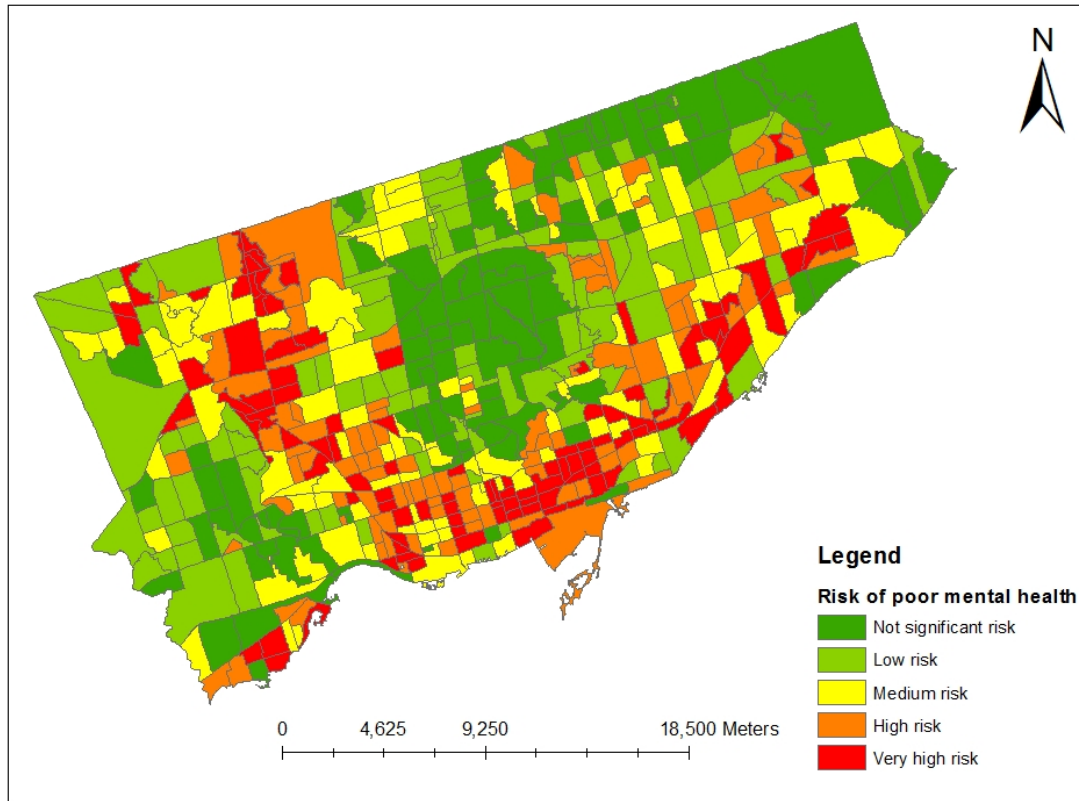
Figure 4.11 Risk of poor mental health aggregated from three MCE results.

4.6 Discussion

4.6.1 Comparison of the Gravity Model and the 2SFCA Method

Significant differences can be found after comparing the outputs by the gravity model and the 2SFCA method. The most significant disparity was different spatial variances of accessibility by the two measures. The gravity model consistently highlighted Downtown as high accessibility, regardless of values of coefficient β. The spatial patterns of accessibility by the 2SFCA method changed a lot with changes to cut-off travel time T_j. High accessibility ratios were clustered in Downtown when T_j was small, but high accessibility clusters shifted towards to the northwest of the city with the increase of value T_j.

The spatial locations of mental health providers were examined to help understand differences in spatial accessibility to mental healthcare estimated by the two measures. Figure 4.12(a) shows a map of mental health providers, which suggests that these

physicians were not evenly distributed throughout the city. The majority of physicians were concentrated in Downtown and Midtown, and only a few were located in Etobicoke and Scarborough. A hot spot detection technique was adopted to assess the spatial pattern of mental health physicians. Density analysis such as kernel density is commonly used to measure the concentration of a cloud of points. After running the "Kernel Density" tool in the Spatial Analyst toolbox in ArcGIS, the output of a "heat map" indicating the density of physicians is shown in Figure 4.14 (b). Accordingly, a group of physicians was closely and densely located in Downtown and Midtown, while another small group was concentrated in North York.

(a)   (b)
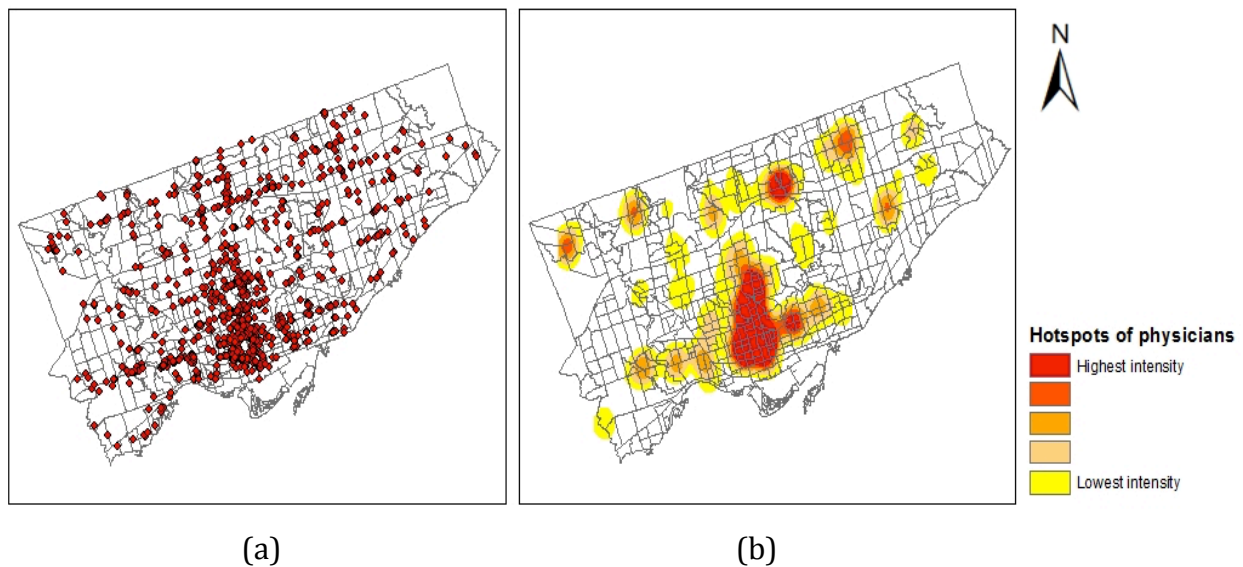
Figure 4.12 Hot spot detection for mental health physicians: (a) mental health physician location points; (b) kernel density estimation for hot spot detection of physician location.

The hot spots of physician locations may explain why Downtown was highlighted as high accessibility, since people living in Downtown have more access to mental health providers than people in other areas. In reality, a number of physicians are also located in the Greater Toronto Area outside the city, such as in Vaughan, Markham, and Brampton. Therefore, people living in North York and Etobicoke also enjoyed a high accessibility when the cut-off travel time was large, as they can either travel to Downtown or else drive to nearby cities to seek mental health treatments.

In addition to comparing different spatial patterns of accessibility ratios by the two measures, different spatial patterns by the 2SFCA method with the changes to the cut-off travel time were also evident. When a smaller cut-off travel time was applied, high accessibility occurred in Downtown, where mental health providers are concentrated. With increasing cut-off travel time, areas with highest accessibility shifted towards Etobicoke and North York, where people could drive to nearby cities, such as Brampton, Vaughan, and Mississauga, to seek mental healthcare. In contrast, the values of coefficient β in the gravity model did not affect the spatial patterns of accessibility, as the best accessibility consistently occurred in Downtown.

The accessibility ratio obtained from the 2SFCA method can be interpreted directly. For instance, people living in a census tract with a score of 1 were exposed to twice the resources of those living in a census tract with a score of 0.5. However, the accessibility ratios derived from the gravity model cannot be interpreted in the same way, as there is a "tradeoff" between the number of physicians and travel impedance, according to the notion of the model (Luo & Wang, 2003). For example, the accessibility of a person to two physicians who are a 30-minute drive away does not equal the accessibility of that person to another physician who is 15 minutes away.

Therefore, the comparison indicates that significant disparities were found between the two accessibility measures. Ultimately, the 2SFCA method was considered to be a better measure than the gravity model. First, accessibility ratios were significantly overestimated by the gravity model, which considered residents as being able to access mental healthcare services situated at any location. Second, the results derived from the gravity model cannot be interpreted directly as physician-to-population ratios, which makes it difficult for healthcare facility planners to identify local areas and potentially locate and allocate mental healthcare providers.

4.6.2 Comparison of Risk and Accessibility Maps

Since the 2SFCA method performed better than the gravity model at measuring accessibility ratios, the spatial pattern of accessibility by the 2SFCA method when T = 25

min was compared to the spatial pattern of risk of poor mental health. Spatial autocorrelation of the accessibility ratios and the risk scores were examined. The global Moran's I index was significant for both the accessibility ratio (I = 0.905) and the risk score (I = 0.929), indicating the presence of spatial autocorrelation and the existence of spatial clusters.

The LISA maps show the locations of clusters with high accessibility ratios and high risk scores (Figure 4.13). Accordingly, spatial clusters of High-High accessibility ratios from the 2SFCA method were located in the northwest of the city and the northeast of the North York Region. These regions referred to areas with high accessibility to mental health providers. In contrast, Low-Low clusters were aggregated in the southwest of Downtown and most areas in Scarborough.

In conjunction with the accessibility ratio, the spatial pattern of risk of poor mental health was examined. Spatial clusters of High-High risk scores were located in Downtown and the York District, indicating that people residing in those areas were at high risk of poor mental health. In contrast, Low-Low clusters occurred mostly in Midtown, North York, Etobicoke center, and Scarborough north regions.

Results from LISA cluster maps indicated that the relatedness between the two spatial datasets of accessibility ratios and risk scores was relatively low. The spatial pattern of accessibility to mental healthcare differed from that of the mental health risk map. Specifically, only those census tracts in York District, which were evaluated as high risk, had high accessibility to mental healthcare.

In general, spatial patterns observed in the LISA maps of the two spatial datasets (accessibility to mental healthcare physicians and risk of poor mental health) were almost opposite in nature. Census tracts that were evaluated as high risk in Downtown were identified as having poor accessibility to mental healthcare. On the contrary, census tracts in North York and Etobicoke center were evaluated as low risk of mental health conditions but enjoyed high spatial accessibility to mental healthcare services.

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The findings provide an illustration of an "inverse care law", which indicates the mismatch between health care supply and population medical needs by Julian Tudor Hart (1971). He considered that services should be located where they are profitable and efficiency, instead of on the basis of population need (Ross, 2005). Since implemented in 1971, the principle was applied for the delivery of healthcare services in many countries, including U.S. (Vargas & Ronzio, 2002), U.K. (McLean et al., 2006), and Australia (Furler et al. 2002).

The inverse law should never exist in Canada, since Canadians are provided with socialized healthcare systems. Free healthcare could enable health equality and ensure everyone accesses to services. However, research indicates that inequity in accessibility to healthcare still exists among different SES classes in Canadian nowadays society (Ross, 2005; Lin et al., 2002). Particularly, people with low SES are exposed to less medical attention and healthcare resources.

Therefore, to ensure equitable access to mental healthcare, this study suggests that facility planners should focus on potentially locating more healthcare resources in the Downtown area. It is evident that the number of mental healthcare resources available in the Downtown area is not proportional to its population density, thus leading to a relative scarcity of mental healthcare services in this region relative to elsewhere in Toronto.
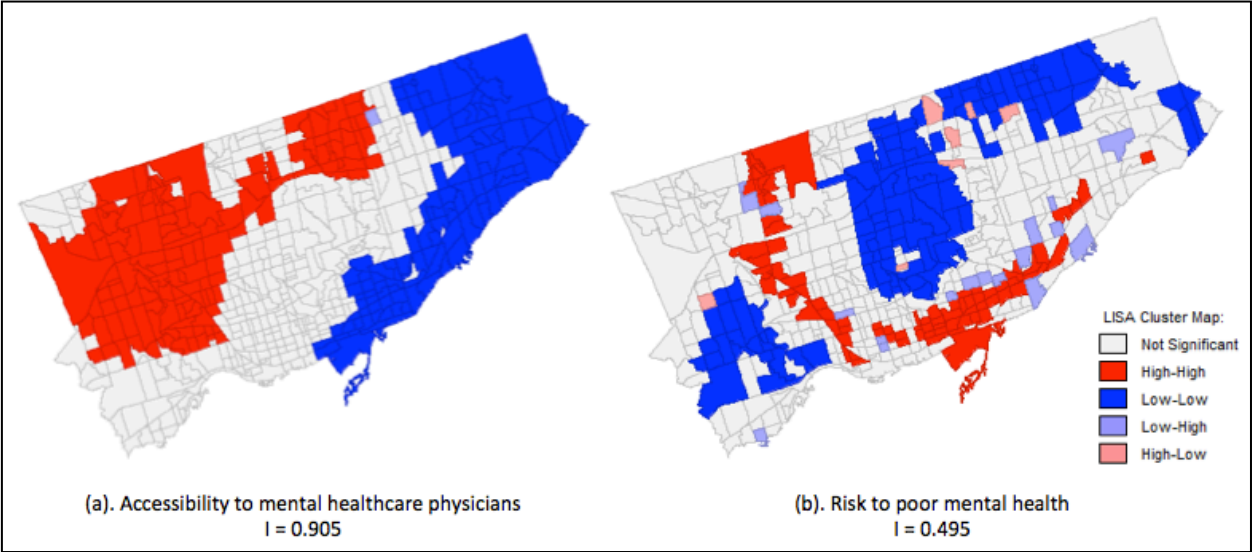

Figure 4.13 LISA cluster maps of (a) accessibility to mental healthcare, (b) risk of poor mental health

Therefore, the findings of this analysis of spatial accessibility and mental health risk can provide further insight into how inequities exist in the availability and distribution of mental healthcare services, identifying under-serviced areas and leading to suggestions that may ultimately improve access. Therefore, results from this study contributes to providing necessary spatial information for the healthcare facility planner to better locate and allocate healthcare resources based on the comparison of spatial accessibility map and risk map of poor mental health.

4.6.3 Limitations

4.6.3.1 Potential Improvement of the 2SFCA Method

Although the 2SFCA method performed better at measuring spatial accessibility to mental healthcare in Toronto, there are some limitations of this method. One of them is the artificial line between physicians who are accessible and inaccessible. For a single individual, access to mental healthcare may be viewed as dichotomous, since a location is deemed to be either accessible for inaccessible. However, for a group of diverse individuals, accessibility may be viewed as continuous, since accessibility may be based on various travel times and preferences (Luo & Wang, 2003). In addition, all physicians within the catchment area are considered to be equally accessible using this method, regardless of the actual travel impedance. Luo and Qi (2009) have developed an enhanced measure to address this problem by the idea of the gravity model. In their study, physicians were weighted differently based on their proximity to the population demand. Accordingly, each catchment area was divided into different travel time zones and different weights were assigned for each travel time zone.

Another significant limitation of the 2SFCA method is assuming a single mode of transportation, since travel time between physicians and population was measured by car travel time only. However, this is likely unrealistic in many areas, especially for people with low-income, those who cannot afford a car, and those living in Downtown Toronto who prefer modes of public transportation. Therefore, the 2SFCA method could be improved by dividing the entire population into sub-populations based on their preferred modes of

transportation. Different catchment areas could then be calculated with regard to the corresponding sub-populations.

Due to the unavailability of data on household car ownership, the multi-modes 2SFCA measure could not be employed in this study. However, it is certain that people living in Downtown would have lower car ownership and reliance on private transportation than people living in the suburbs or edge of the city. Travel times may differ significantly depending on the mode of transportation. In addition, the mean accessibility ratio by the single-mode 2SFCA method will be higher than that of a multi-model method, since more healthcare services are accessible when assuming everyone travels by car. For residents relying on public transit, access to mental healthcare is diminished to some degree, but this may differ by geographic region and traffic conditions.

In addition to spatial techniques that address geographic barriers between supply and demand, non-spatial characteristics could also potentially affect accessibility, including social class, race, sex, and household income. However, spatial and non-spatial factors are often studied independently. The 2SFCA method could be further improved by adding more details and characteristics of population groups who require such services. For example, a weight indicating the risk of poor mental health can be added to population demand. Accordingly, population with a high risk score could be assigned a larger weight, while those identified as low risk could be assigned with a smaller weight. Future studies could potentially incorporate risk scores into the 2SFCA method, so that multiple criteria can be considered.

4.6.3.2 Modifiable Areal Unit Problem

The modifiable areal unit problem (MAUP) is present among most spatial analysis studies involving aggregated datasets. MAUP refers to spatial aggregation error, since varying scales of data yield different results. In this study, a population-weighted centroid was computed as a proxy for spatial location of individuals of a census tract. Travel time from aggregated areal units to healthcare facilities could be different if such centroids were located differently.

Moreover, this study was conducted at the census tract level, since both crime and socioeconomic data were aggregated by census tract. Accessibility ratios were subsequently determined at the census tract level accordingly. Since the population centroid of a census tract is likely to be distant from its geographic centroid, weighted centroids were thus generated based on block-level population data in order to reduce aggregation errors.

4.6.3.2 Ecological fallacy

Ecological fallacy refers to the error when interpreting findings of individuals based on aggregated data of a group population. In this study, clusters of high accessibility ratios and high risk scores were calculated at the census tract level, rather than for single individuals residing in the area. Aggregated characteristics for zonal data may not accurately portray all individuals residing in an area. For example, if a census tract was deemed to have low accessibility to mental healthcare services, this does not mean that every resident in the census tract suffers from low accessibility. Similarly, if a census tract was identified as high risk of poor mental health, this did not imply that every resident in the census tract suffers from mental health problems.

Therefore, people living in an area with high risk of poor mental health, but low accessibility to mental healthcare, are not necessarily all in need of greater access to mental healthcare services. It is possible that individuals living in an area identified as low risk and high accessibility ratio at the census tract level may also require additional mental health treatments.

4.7 Conclusions

This study explores mental health status and spatial accessibility to mental healthcare by analyzing aggregate spatial data at the census tract scale. The spatial accessibility to mental health providers in Toronto was assessed based on two methods – the gravity model and the 2SFCA method. Both methods consider the potential interaction between healthcare providers and population demands within a reasonable travel time. The gravity model

identified high accessibility in the Downtown area, while the 2SFCA method indicated high accessibility concentrated in the Etobicoke north and North York regions.

Accessibility assessed by 2SFCA was considered to be a better solution, since the results can be directly interpreted as physician-to-population ratios, which was easier for healthcare facility planners to identify local areas and potentially locate and allocate mental healthcare services. However, a number of limitations were identified with the 2SFCA method and researchers have subsequently developed enhanced methods to address the existing drawbacks (e.g. Luo & Wang, 2003; Luo & Qi 2009). For example, physicians could be weighted differently based on their closeness to population demands, multiple transportation modes could be considered, and non-spatial factors of population groups can be incorporated to provide an improved measure of accessibility.

A risk map of poor mental health conditions was developed based on a multi-criteria evaluation methodology, thus identifying areas of potential need or demand for mental healthcare services. Crime and deprivation were identified as contributory factors to poor mental health. Areas with high risk of poor mental health were identified as being located in Downtown and York District, and low risk clusters were aggregated in North York, Etobicoke center, and Scarborough north regions. After comparing the risk and accessibility maps, Downtown census tracts with high risk of poor mental health but low accessibility to mental healthcare were identified.

In summary, this study highlights the varying accessibility to mental healthcare across the city of Toronto. Findings from this study suggest that existing mental healthcare facilities are not sufficient to serve residents' varying mental health needs. Downtown Toronto was identified as the area suffering the lowest accessibility and high risk of poor mental health compared to other regions. These findings provide valuable information for healthcare facility planners that can be used to improve access to mental healthcare, as well as improving overall mental health conditions within Toronto communities.

Chapter 5. Thesis Conclusions

5.1 Summary of Main Findings

This thesis has outlined a conceptual social model of health that highlights the roles that criminal victimization and deprivation can play in affecting people's health and quality of life. Based on Routine Activity Theory and social Disorganization theory, this thesis first investigated the roles of socio-economic and neighbourhood characteristics in affecting the occurrence of crime incidents. Since victimization is always associated with injury and trauma, the health of neighbourhood residents was explored. The relationships between victimization and victims' physical and mental health were examined, as well as those between fear of crime and neighbourhood residents' psychological health. Since public mental health is most likely to be compromised as an impact of crime, residents' spatial accessibility to mental healthcare and the geographic equity of healthcare providers were explored.

Two standalone manuscripts were involved in this thesis to address the three research objectives. The first two objectives were addressed in the first study, which aimed at exploring crime and its impacts on public wellbeing at the individual level in Toronto neighbourhoods. The study involved a questionnaire survey administrated to Toronto neighbourhoods with an aim of collecting information about respondents' previous crime experiences and their impacts on individual health and daily life. Findings from the survey indicated that both violent and property crimes had direct impacts on victims' psychological health, based on their reported feelings of stress, anxiety, and panic attacks. In addition, fear of crime was prevalent among victims and people in the neighbourhood. Fear of crime was found to also directly influence quality of life, affecting psychological wellbeing and physical functioning.

Questionnaire survey results subsequently point towards a significant impact of crime on mental or psychological health in addition to physical health effects. This may consequently place a demand on mental healthcare systems for providing victim support services. Availability and accessibility of mental healthcare services for victim support is

important from a health policy and social services perspective. The third research objective was thus addressed by the second study, which explored spatial accessibility to mental healthcare providers in Toronto. Two spatial accessibility measures were accounted, namely, the gravity model and the 2SFCA method. Risk of poor mental health was also evaluated based on the conceptual social model of health, which considered crime and deprivation to be contributory factors. Findings from this study suggest that existing mental healthcare facilities are not sufficient to serve residents with varying mental healthcare needs. Downtown Toronto was highlighted as an area with high risk of poor mental health conditions but low accessibility to mental healthcare. Such findings could potentially inform healthcare facility planners to better locate and allocate resources with the city of Toronto.

In general, this thesis explores the health of victims of crime based on a conceptual social model. Findings indicate that residents' mental health and psychological wellbeing are significantly affected by crime in selected Toronto neighbourhoods, but existing mental healthcare facilities are not sufficient to serve residents with varying mental healthcare needs, especially those living in Downtown areas.

5.2 Thesis Contributions

In general, this thesis is valuable as follows:

First, the crime-health questionnaire survey contributes to current police-recorded crime statistics, since it explored respondents' varying crime experiences and their impacts on health and wellbeing. Since not all victims or witnesses of crime are likely to report incidents to the police, aggregate crime data do not necessarily reflect actual neighbourhood crime rates. For example, the rate of physical assaults from official police records was greater than that of any type of property crime recorded, while survey respondents reported more incidents of property crime than violent crime. In addition, the impact of crime on physical and psychosocial health can be captured in a victim survey,

which cannot be fully investigated based on official aggregated datasets available on health and crime conditions in an area.

Second, findings of the thesis contribute to providing information necessary for Toronto Police Department and health promotion services. This research serves as a case study in which the links between neighbourhood, crime and health were explored. Since neighbourhood has significant contextual effects on victimization, maintaining or monitoring neighbourhoods in a well-ordered condition may eliminate further vandalism or crime occurrence. In addition, strengthening neighbourhood social cohesion in deprived neighbourhood may improve public mental health. Findings from the accessibility study would help healthcare facility planners to better locate and allocate resources, as well as improving public accessibility to mental health.

Finally, the study of spatial accessibility has highlighted the importance of GIS and spatial techniques in medical geography research. First, GIS was used to perform complex spatial data tasks, such as creating road networks and calculating accessibility to mental health physicians. Second, accessibility ratios were mapped over the entire city, which enabled spatial patterns and clusters to be detected. Third, spatial and non-spatial information were integrated and compared in a GIS environment. Therefore, GIS techniques and spatial methods contribute to the advancement of studies related to public health and wellbeing.

5.3 Future Work

Both studies in this thesis can be further improved and expanded. In particular, the questionnaire survey can be distributed to more neighbourhoods throughout the city. Additional questions could be added pertaining to the utilization of Victim Support services or mental healthcare services. More types of crime could be explored, including "white-collar" crimes, since this may be prevalent in particular neighbourhoods of socioeconomic status. In addition, the study of the relationships between health and crime can be compared to the previous study conducted in Sheffield, United Kingdom by Tan and Haining (2009). Comparison between different geographic localities can further the

understanding of the links between health and crime, and the generalizability of this study's findings.

As for spatial accessibility measures, two improvements can be made in future studies. First, although the 2SFCA method was considered in this study to be the best method for assessing urban residents' spatial accessibility, limitations to this method exist. In order to address methodological limitations, an enhanced 2SFCA method could potentially be adopted, which take residents' closeness to healthcare providers, multiple modes of transportation, and non-spatial barriers of accessibility into account. Second, the study area can be expanded to the Greater Toronto Area (GTA) so that accessibility to mental healthcare services in rural areas can be considered and compared with that in urban areas.

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Appendix A - Survey Questionnaire

*** Question colour code legend:
No colour = same questions retained from the 2006 survey conducted in Sheffield, UK (Tan, 2008)
Grey = new or modified questions in 2015 survey conducted in Toronto, Canada

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SECTION A: This section deals with your personal experiences of crime and how this may have affected your quality of life and wellbeing.

1. Have you personally been a victim of crime in the past 5 years?   □ Yes   □ No

2. If 'No', please skip to Section B (Question 9, Page 3).
   If 'Yes', please give brief details of the crimes you have personally been a victim of below:

   a. Type of crime:
      Please indicate how many occurrences (e.g. 1, 2, 3) in each time period.

Crime	Approximate time and number of occurrences				
	Less than 1 mth ago	1 to less than 6 mths ago	6 mths to less than 1 yr ago	1 to less than 3 yrs ago	3 to 5 yrs ago
Breaking and entering	(e.g.1,2,3)				
Physical assault					
Robbery					
Sexual violation					
Theft of credit card					
Vehicle-related theft					
Other forms of theft					
Uttering threats					
Vandalism					
Other (please list):					

   b. Where did the crime(s) indicated in Question 2 (a) occur?
      Please indicate the number of cases (e.g. 1, 2, 3) in each category.

Crime	Occurred in your neighbourhood	Occurred in the Downtown area	Occurred in other parts of Toronto	Occurred in another city (please specify)
Breaking and entering	(e.g.1,2,3)			
Physical assault				
Robbery				
Sexual violation				
Theft of credit card				
Vehicle-related theft				
Other forms of theft				
Uttering threats				
Vandalism				
Other (please list):				

c. Were the crime(s) reported to the police?
    Please indicate the number of cases (e.g. 1, 2, 3) in each category.

Crime	Were any of the cases reported to the police? (e.g.1,2,3)	Did the police ever visit your home to take a statement?	Did you ever have to go to court to give evidence?
Breaking and entering			
Physical assault			
Robbery			
Sexual violation			
Theft of credit card			
Vehicle-related theft			
Other forms of theft			
Uttering threats			
Vandalism			
Other (please list):			

d. If any of the crimes were not reported to the police, please briefly indicate the reason(s).

    _____

3. Did you feel it was necessary to take any special medical steps as a result of being a victim of crime?
    (tick as many as appropriate)
    □ I had to go to hospital once   □ I had to go to hospital several times
    □ I took medication to help me with anxiety   □ I went to my doctor/G.P.
    □ I took medication to help me with pain   □ I received counselling
    □ I took medication to help me with sleeping problems   □ I didn't take any medical treatment
    □ Any other steps (please explain) _____

4. Have you experienced any of the following as a result of being a victim of crime? (tick as appropriate)

	Often	Sometimes	Rarely	None
Feelings of stress (including anger)				
Panic attacks				
Depression				
Sleeping difficulties				
Loss (or increase) of appetite				
Alcohol consumption (started/increased)				
Smoking (started/increased)				
Dependence on prescription medication				
Reduced attendance at work				
Lack of confidence				
Other symptoms (please list):				

5. In what ways, if any, has your behaviour changed as a result of becoming a victim of crime?
    (tick as many as appropriate)
    □ I avoid going out alone whenever possible   □ I avoid going out after dark if possible
    □ I avoid certain areas/streets/places   □ I have had new locks fitted
    □ I only travel by certain means (e.g. car/taxi)   □ I have changed my phone number
    □ I have moved house/changed address   □ I stay at home as much as possible
    □ I have had security lights/alarms fitted   □ I am planning to move house/area
    □ Any other steps (please explain) _____

6. What, if any, physical injuries/ill health effects have you sustained as a result of being a victim of any of the previously mentioned crimes?

_____

_____

7. After being a victim of crime:
   a. Did you seek/receive help from a neighbour/friend/church/family member? □ Yes □ No
   b. Did you seek/receive help from Victim Support? □ Yes □ No
      (i) If yes, what Victim Support services did you receive? _____
   c. Did you seek/receive any other form(s) of help? □ Yes □ No
      (i) If yes, what other form(s) of help did you receive? _____

8. How would you summarize the impact of being a victim of crime upon your day-to-day life and health? (e.g. how has it affected your confidence, your pattern of activities, where and when you go out and about, your quality of life and health)

SECTION B: This section deals with your general anxieties about crime levels in the area where you live and its impact on your quality of life.*

Note: Even if you may not have been a victim of crime before, we would still like to hear your views. Please answer the remaining questions of this survey, regardless of whether or not you have been a victim of crime.

9. In the neighbourhood where you currently live, do you know anyone who has been a victim of crime during the last 6 months? □ Yes □ No
   a. If 'No', please skip to Question 11 (Page 4).
   b. If 'Yes':
      (i) How many of these people/victims are your immediate family members? _____
      (ii) How many of these people/victims are your closely related friends or colleagues? _____
      (iii) How many of these people/victims do you not personally know? _____

10. Please indicate the crime incidents you are aware of (excluding your own crime experiences), which have occurred in your current neighbourhood of residence within the last one year.
    (indicate the number of cases when possible)

Crime	Approximate time and number of occurrences			
	Less than 1 mth ago	1 to less than 6 mths ago	6 mths to less than 1 yr ago	More than 1 yr ago
Breaking and entering	(e.g.1,2,3)			
Physical assault				
Robbery				
Sexual violation				
Theft of credit card				
Vehicle-related theft				
Other forms of theft				
Uttering threats				
Vandalism				
Other (please list):				

11. Which, if any, of the following problems have you ever experienced as a result of *experiencing crime or feelings related to the fear of crime* in your neighbourhood of residence? (tick as appropriate)

	Often	Sometimes	Rarely	None
Feelings of stress (including anger)				
Panic attacks				
Depression				
Sleeping difficulties				
Loss (or increase) of appetite				
Alcohol consumption (started/increased)				
Smoking (started/increased)				
Dependence on prescription medication				
Reduced attendance at work				
Lack of confidence				
Other symptoms (please list):				

12. What, if any, of the following steps have you taken because of *fear of crime* in your neighbourhood of residence? (tick as many as appropriate)

□ I avoid going out alone whenever possible   □ I avoid going out after dark if possible
□ I avoid certain areas/streets/places   □ I have had new locks fitted
□ I only travel by certain means (e.g. car/taxi)   □ I have changed my phone number
□ I have moved house/changed address   □ I stay at home as much as possible
□ I have had security lights/alarms fitted   □ I am planning to move house/area
□ Any other steps (please explain) _____

13. Have you heard of Victim Support services before?   □ Yes   □ No

a. If 'Yes', what kind of Victim Support services are you aware of? (tick as many as appropriate)

□ Criminal justice information and support   □ Pre-court preparation
□ Emotional support and short-term counseling   □ Other (please describe) _____

b. If 'Yes', how did you become aware of these Victim Support services? (tick as many as appropriate)

□ Internet   □ Television
□ Newspaper   □ Radio
□ Friends, relatives, acquaintances   □ Passer by
□ Community center, shopping center   □ Other (please describe) _____

SECTION C: Finally, in order to help us to analyze responses from this questionnaire, we would like to ask you a few questions about your background (please tick or fill in as appropriate).

14. Please tell us about yourself:

a. Gender: □ Female   □ Male

b. Age category: □ Under 18 yrs   □ 46-65 yrs
                    □ 18-30 yrs   □ 66-85 yrs
                    □ 31-45 yrs   □ Over 85 yrs

c. Marital status: □ Single   □ Married or long term partner
                      □ Widowed   □ Separated or divorced

d. Family status:
      □ Living alone   □ Living with someone else *most* of the time
      □ Living with someone else *sometimes*   □ Living with someone else *all* of the time

e. Disability status: Do you have a disability?   □ Yes □ No
      (i) If 'yes', do you have a physical disability?   □ Yes   □ No

f. Type of residential dwelling/housing structure:
      □ Single-detached house   □ Duplex (one above the other)
      □ Semi-detached house (side by side) □ Apartment with 5 or more stories
      □ Townhouse or row house   □ Apartment with fewer than 5 stories
      □ Other (please describe) _____

g. Are you:
      □ a Canadian-born citizen   □ in Canada on a work visa
      □ a Landed immigrant   □ in Canada on a student visa
      □ a Refugee   □ a Visitor
      (i) If you were not born in Canada, in which country were you born? _____

h. Ethnic origin/race (based on Statistics Canada classifications):
      □ White   □ Latin American   □ Korean
      □ Chinese   □ Filipino   □ Japanese
      □ South Asia   □ Arab/West Asian   □ Aboriginal
      □ Black   □ Southeast Asian   □ Multiple minorities
      □ Other _____

i. Education completed:
      □ No certificate, diploma or degree   □ Apprenticeship or trades certificate or diploma
      □ High school certificate or equivalent □ University certificate/diploma below Bachelor's level
      □ College, CEGEP or other non-   □ University certificate, diploma or degree at Bachelor's
         university certificate or diploma   level or above

j. Current employment status:
      □ Full-time employment   □ Unemployed, seeking work
      □ Part-time employment   □ Unemployed, not seeking work
      □ Self-employed   □ Student
      □ Temporary or contract employment

k. Annual household income (total before tax and other deductions):
      □ Under $20,000   □ $60,000 to $79,999
      □ $20,000 to $39,999   □ $80,000 or more
      □ $40,000 to $59,999

l. Household information (include yourself in the household's adult count):
      How many adults live in your household (18 years of age or older)? _____
      How many children live in your household (under 18 years of age)? _____

m. Are you the head of household or primary householder?   □ Yes   □ No
      If 'No', what is your relationship to the head of household? _____

15. Please tell us about the neighbourhood in which you currently reside:

a. Do you OWN or RENT your residence?   □ Own   □ Rent

b. How long have you been living at this address or neighbourhood?
      □ Less than 6 months   □ 3 year to less than 5 years
      □ 6 months to less than 1 year   □ 5 year to less than 10 years
      □ 1 year to less than 3 years   □ 10 years and over

c. Please indicate the types of concerns that you have about your current neighbourhood of residence, related to personal and community safety, physical and natural environment, and social health and wellness.
(please tick for each category)

	Very concerned	Somewhat concerned	Not concerned	Not sure
Noise				
Speeding				
Traffic				
Bicycle lanes				
Sidewalks				
Graffiti				
Littering				
Cigarette butts				
Street lighting				
People being drunk or rowdy				
Illegal drug activity				
Unkempt housing property				
Inoperable vehicles				
Other (please specify):				

d. This question relates to walkability and accessibility. How long does it take for you to get from your home to the nearest businesses or facilities listed below, if you walked to them?
(please tick for each business or facility)

	1-5 min	6-15 min	16-30 min	31+ min	Not sure
Bar/club/pub					
Coffee shop					
Grocery/convenience store					
Motel					
Liquor store					
Pharmacy/drug store					
Shopping mall					
Bank/check cashing service					
Community center					
Hospital/walk-in clinic					
Police station					
Public transit stop/station					
Public school					
Victim services					
Your job or school					

e. Do you know your neighbours?
　　□ Yes, I know most or all of them　　　　　　□ Yes, I know a few (one or two)
　　□ Yes, I know many of them (three or more)　　□ No, not at all

For **Questions15 (f), (g) and (h)**, *please circle a number on the relative scale indicating your agreement with the statements below:*

f. You are living in a populated area:

$$1 \quad 2 \quad 3 \quad 4 \quad 5$$

Strongly Disagree　　　　Neutral　　　　Strongly Agree

125
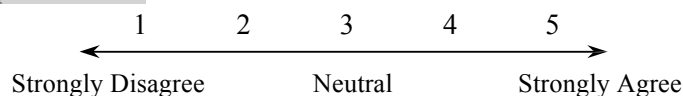
g. You speak to other people when you are walking in your neighbourhood of residence:

            1   2   3   4   5
    Strongly Disagree   Neutral   Strongly Agree

h. Your neighbourhood of residence is a place where neighbours help each other:
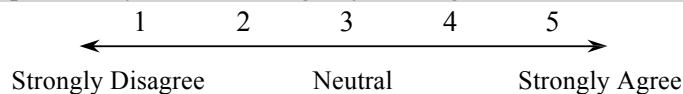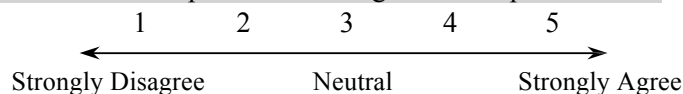
            1   2   3   4   5
    Strongly Disagree   Neutral   Strongly Agree

i. Are you a member of a Neighbourhood Watch program?   □ Yes   □ No

    (i) If 'Yes', what types of actions do you take when you are involved in the Neighbourhood Watch
        activities? (tick as many as appropriate)
        □ Recognize and report crimes and suspicious activities
        □ Protect yourself, your family, and your property
        □ Protect your neighbours' family and property
        □ Identify crime and disorder in your area and work with the police to solve them
        □ Other (please describe) _____

    (ii) If 'No', why are you not a member? _____

j. To give us a general idea of the location of your current neighbourhood of residence, please indicate
    (note that this does not provide information about your household location)*:

    (i) Your postal code (e.g. N2L 3G1):   _____
   (ii) The region in which you currently live in (e.g. North York, Vaughan):   _____

    *Each postal code is associated with a geographic area of approximately 19 households according to
    Statistics Canada, but the number can range from zero to 10,000 households. Therefore, no individual
    household identification information is collected.*

For **Questions 15 (k) and (l)**, please circle a number on the relative scale below:

k. In summary, how would you assess the risk of crime in your neighbourhood of residence in comparison to
    surrounding areas?

                    1   2   3   4   5
    Low risk   High risk
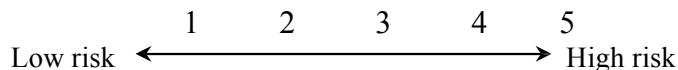
l. What is your perception of the risk of crime in the City of Toronto, in general?

                    1   2   3   4   5
    Low risk   High risk
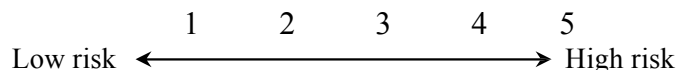
16. a. Would you like to receive a summary report of the outcomes of this survey?   □ Yes   □ No
        (If 'Yes', a summary report of the results of this study will be e-mailed to you when the study is completed,
        anticipated by September 2015)

    b. Would you like to be entered in a prize draw for a $50 Tim Horton's gift card? □ Yes   □ No

    If 'Yes' to either Questions 16 (a) or (b), please provide your email address: _____

PLEASE NOTE:
If you have answered the paper questionnaire, **DO NOT** submit an online questionnaire.

If completing a paper questionnaire, please return your completed questionnaire in the stamped return-
addressed envelope provided to the following address within **three weeks** after receipt:

Yiou Gao
19-131 Sheldon Dr.
Cambridge, ON N1R 9Z9

If you have any questions or concerns about this study, please contact Yiou Gao at y83gao@uwaterloo.ca.
Thank you for your participation!

Appendix B - Values of the Chi-Squared Probability (source: Pearson, 1990)

df	0.995	0.975	0.20	0.10	0.05	0.025	0.02	0.01	0.005	0.002	0.001
				X^2: Probability (Critical Value)							
1	0.000	0.000	1.642	2.706	3.841	5.024	5.412	6.635	7.879	9.550	10.828
2	0.010	0.051	3.219	4.605	5.991	7.378	7.824	9.210	10.597	12.429	13.816
3	0.072	0.216	4.642	6.251	7.815	9.348	9.837	11.345	12.838	14.796	16.266
4	0.207	0.484	5.989	7.779	9.488	11.143	11.668	13.277	14.860	16.924	18.467
5	0.412	0.831	7.289	9.236	11.070	12.833	13.388	15.086	16.750	18.907	20.515
6	0.676	1.237	8.558	10.645	12.592	14.449	15.033	16.812	18.548	20.791	22.458
7	0.989	1.690	9.803	12.017	14.067	16.013	16.622	18.475	20.278	22.601	24.322
8	1.344	2.180	11.030	13.362	15.507	17.535	18.168	20.090	21.955	24.352	26.124
9	1.735	2.700	12.242	14.684	16.919	19.023	19.679	21.666	23.589	26.056	27.877
10	2.156	3.247	13.442	15.987	18.307	20.483	21.161	23.209	25.188	27.722	29.588

Appendix C - Weighting Schemes of the Multi-Criteria Evaluation

Table C.1 Highest level criteria ranking

Highest level	Scenario A	Scenario B	Scenario C
Crime	50%	75%	83.33%
Deprivation score	50%	25%	16.67%

Table C.2 Second level criteria ranking - Crime

Crime	Violent crime	Property crime	Weight
Violent crime	1	7	87.5%
Property crime		1	12.5%

Table C.3 Second level criteria ranking - Deprivation

Deprivation	Material	Social	Weight
Material	1	1	50%
Social		1	50%

Table C.4 Final weights of each criterion at three scenarios

Criterion	A	B	C
Violent crime	43.75%	65.63%	72.91%
Property crime	6.25%	9.37%	10.42%
Material deprivation	25.00%	12.5%	8.34%
Social deprivation	25.00%	12.5%	8.33%

Appendix D - Socio-demographic statistics from survey and 2011 census data

Socio-demographic information	Survey	Toronto	Canada
Gender			
Female	65.3%	52%	51%
Male	34.7%	48%	49%
Age			
Under 18 yrs	0.5%	18.7%	20.6%
18-30 yrs	7.5%	17.5%	15.7%
31-45 yrs	23.6%	22.5%	19.9%
46-65 yrs	53.8%	26.9%	29.1%
66-85 yrs	14.6%	12.3%	12.8%
Over 85 yrs	1%	2.1%	1.9%
Marital Status			
Single	16.2%	33.7%	28%
Married or long term partner	69%	51.1%	57.7%
Widowed	3%	5.7%	5.7%
Separated or divorced	11.7%	9.5%	8.6%
Family Status			
Living alone	14.2%	12.9%	11.2%
Living with someone else	85.8%	87.1%	88.8%
Lone Parent Family			
Yes	3.6%	12.3%	10.3%
No	96.4%	87.7%	89.7%
Type of residential dwelling/housing structure			
Single-detached house	35.9%	26.2%	55%
Semi-detached house (side by side)	47%	6.9%	4.9%
Townhouse or row house	15.7%	5.8%	5.9%
Duplex (one above the other)	1.5%	4.3%	5.3%
Citizenship			
Canadian-born citizen	80%	48.9%	78.3%
Landed immigrant	20%	48.6%	20.6%
Ethnic Origin			
White	84.3%	50.9%	80.9%
Visible minority	15.7%	49.1%	29.1%
Education Completed[1]			
No certificate, diploma or degree or high school diploma or equivalent	6.5%	41.6%	45.7%
Postsecondary certificate or diploma below bachelor level	22.6%	25.5%	33.5%
Postsecondary certificate or diploma at bachelor level or higher	70.9%	32.9%	20.9%
Employment Status			
Employed	74.5%	58.3%	60.9%
Unemployed[2]	6.4%	9.3%	7.8%
Not in the labor force	20.4%	35.7%	34%
Annual household income			
Under $20,000	3.2%	39.1%	36%
$20,000 to $39,999	7%	24.6%	26.4%
$40,000 to $59,999	13%	15.4%	17.5%
$60,000 to $79,999	17.3%	8.6%	9.4%
$80,000 or more	59.5%	12.4%	10.7%

Note: [1]Toronto and Canada education data was retrieved from NHS, whose sample is total population aged 15 years and over

[2]Unemployment rate was calculated by dividing #unemployed by total # in the labour force