SPATIAL ACCESSIBILITY TO MENTAL HEALTH CARE IN THE CITY OF TORONTO

by

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Bachelor of Arts, McGill University, 2012

Master of Science, McGill University, 2016

A MRP presented to Ryerson University

in partial fulfillment of the requirements for the degree of

Master of Spatial Analysis

in the program of

Spatial Analysis

Toronto, Ontario, Canada, 2017

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Abstract

Mental illness refers to a wide range of disorders that affect mood, thinking and behaviour. One in five Canadians has mental health care needs, many of which are unmet (Smetanin et al., 2015). Within the City of Toronto, the provision of mental health care is delivered by over 100 public and private community service organisations and over 700 physicians with a psychiatric specialization - each providing community-based general or specialised care to residents in need. Research has shown that travel distance is an enabling factor of health service utilisation, thus equitable spatial access to services remains a key priority (Fleury et al., 2012). Using spatial quantitative methods, this study examines potential spatial accessibility to mental health services and specialist physicians within the City of Toronto, and levels of statistical association between access to care and prevalence of mental health crisis events. A wide range of datasets is analyzed including occurrence data for apprehensions under the Mental Health Act undertaken by the Toronto Police Service and the Canadian Marginalization Index. The enhanced two-step floating catchment area (E2SFCA) method is used to compute spatial accessibility to mental health services based four modes of transportation: driving, walking, cycling and public transit. Areas that are underserved by mental health specialists and mental health community services are identified and shown to have different income levels. This study provides spatial explicit patterns of accessibility to mental health services in Toronto, providing detailed data to inform planning and policy of mental health care delivery.

Acknowledgements

I am eternally grateful for the support and encouragement I have received from so many, without which completing this thesis would not have been possible.

I would like to extend my deepest gratitude to my supervisor, Professor Lu Wang for her unwavering support and guidance for the duration of my graduate experience at Ryerson. Special thanks are also due to Ian Williams and the Business Intelligence & Analytics team at the Toronto Police Service; their recommendations and insights have been invaluable.

Thanks are due to my Ryerson colleagues, students both in and outside of the department of Geography, that have journeyed alongside me in my academic endeavors. I am also indebted to my friends, thank you for your unreserved support and for cheering me on through trying times. Mariel, thank you for love and support, nakupenda.

To my dearest family, erokamano ahinya. You have been my loudest cheerleaders and my fondest friends, thank you Monique and Alfie for your encouragement, Mummy and Daddy I am indebted to you for your support since day one.

Deo gratias.

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1 Introduction

Mental illnesses are manifested in many forms affecting millions of people worldwide and accounting for 13% of the global burden of disease (Collins et al., 2011). Research has demonstrated that many mental or neurological disorders are without a cure and that effective forms of treatment and preventions are not always available to those in need resulting over a million deaths each year (Bertolote & Fleischmann, 2015). Collins et al. (2011) identify the integration of mental health services (MHS) into primary health care as a core challenge of mental health care that requires urgent action and investment. In the Canadian context, mental disorders affect just under 20% of people, however, mental health service utilization is only 9.5% nationally and 8.7% in the province of Ontario (Vasiliadis et al., 2005). In Canada, mental health care is delivered by family physicians (Collins et al., 2006; Fleury et al., 2008), psychiatric specialists working in private practices or hospitals, and by community services (Kates et al., 2011). Family physicians (FP) or general practitioners (GP) are the primary contacts for patients with mental illness (Collins et al., 2006; Fleury et al., 2008), and approximately one-third of visits to FPs are for mental health issues (Kates et al., 1997; Kates et al., 2011). However, many family physicians lack adequate access to mental health services or psychiatrists for patients with severe mental health conditions who require referrals or collaborative mental health care (Collins et al., 2006; Fleury et al., 2008; Rockman et al., 2004). Alongside a lack of funding and the culture of health care services, Kates et al. (2011) list geographic disparities in access to mental health care services as a barrier to collaborative mental health care in Canada. A lack of mental health literacy is another barrier to mental health care, Jorm (2012) finds that mental health literacy facilitates early intervention and treatment that improve mental health outcomes. Mental health community services are identified as a resource that improves mental health literacy, facilitating professional help seeking for person's suffering from mental illness (Kelly et al., 2007; Jorm, 2012). Beyond mental health literacy, geographic location (Sommers, 1989) and spatial accessibility (Fleury et al., 2011) have been identified as factors that influence mental health service utilization among patients with mental illness, and in turn mental health outcomes (Fortney et al., 1999). This study will focus on spatial accessibility to mental health services as it is a key factor in the fight against mental illness.

The area of study in this paper is the City of Toronto, the largest metropolitan area in Canada with a population of over 2.5 million people. The City of Toronto is a unique study area as it is an urban area with the highest population density in Canada and a high level of socioeconomic and cultural diversity (Statistics Canada, 2011). Within the City of Toronto, mental health care is delivered by over 100 public and private community services and by over 700 mental health specialists.

While mental health (MH) community services and mental health (MH) specialists are available in Toronto, there are thousands of individuals who experience severe mental health crises due to mental illness. In Toronto and across Canada, police have increasingly become first responders to mental health calls (Coleman and Cotton 2010; Coleman and Cotton 2016), and the Toronto Police Service is dispatched to over 20,000 calls for service annually related to a person in mental health crisis, 8,000 of which require an apprehension under the Mental Health Act. Unfortunately, some of these calls involve the application of lethal force by the police that resulted in the death of the person in crisis (Borum, 2000). These events prompted the creation of an independent review conducted by Frank Iacobucci for the Chief of the Toronto Police Service. The review titled 'Police Encounters with People in Crisis' (Iacobucci, 2014), often referred to as the Iacobucci Report had the mandate of reviewing the practices of the Toronto Police Service with respect to lethal force especially in encounters with 'persons who are or may be emotionally disturbed, mentally disturbed or cognitively impaired'. One of the findings highlights the need for mental health care to be delivered to the city's population through mental health services and mental health specialists to reduce the prevalence of severe mental health episodes that require police intervention.

This study seeks to quantify and provide an overview of spatial accessibility to two forms of mental health care in the City of Toronto while identifying any potential association between access to mental health care and the prevalence of mental health crisis events attended to by the police. To this end, this study aims to answer the following research questions:

1. How does spatial accessibility to mental health services vary in different neighbourhoods in the City of Toronto?
2. What is the relationship between spatial accessibility to mental health care and the prevalence of mental health crises?

3. Where are the under-serviced neighbourhoods in the City of Toronto, and what are their characteristics?

The research questions translate to two main research objectives. The first is to quantitatively measure the levels of spatial accessibility to mental health services for the dissemination areas (DAs) of the City of Toronto. The DA is the finest geographical area in the Canadian census and is chosen as the unit of measurement in order to improve the accuracy of findings and to generate results at the highest spatial resolution possible. The second research objective is to assess the relationship between access to mental health care and the prevalence of mental health crises attended to by the Toronto Police Service. While a causal link may not be established, exploring this objective will shed light on the role of geographical access to mental health service in mental health outcomes.

The main method used in the study is the enhanced two-step floating catchment area (2SFCA) method is used to analyze spatial accessibility to mental health services (Luo and Qi, 2009). The 2SFCA method is a specific type of the gravity-based spatial interaction model implemented in a GIS to calculate spatial accessibility to service locations scores for various geographic units (Guagliardo, 2004; Yang et al., 2006). The model calculated access (or accessibility) scores based on ratios of the abundance of health care resources to a population in demand within a specified travel distance or distance threshold. It systematically ascribes spatially explicit results of access scores, allowing for an understanding of how levels of access vary spatially at the local scale within a large study area (Bissonnette et al., 2012). Hotspot analysis is then used to identify statistically-significant spatial clusters of high and low accessibility to MHS and mental health crisis incidence. The association between mental health care access and mental health crisis events is analyzed by using correlation analysis.

The family of 2SFCA models have been used widely in previous studies that spatial access to healthcare, including mental health resources (Luo and Qi, 2009; Luo and Wang, 2003), healthcare services (Cao et al., 2016), and other public resources such as parks and child daycare centres (Lee and Hong, 2013; Fransen et al., 2015). Within the Toronto CMA region, past studies have used the 2SFCA method technique to explore access to primary care physicians (Harrington et al., 2012), primary health care (Bissonnette et al., 2012) and linguistically matched family

physicians (Wang and Roisman, 2011) for immigrants; however, no existing studies have explored access to mental health care specifically, a research gap that this paper seeks to fill. While access to mental health care has been explored in Montreal using the 2SFCA method (Ngui and Vanasse, 2012).

There are several key terms that are used throughout to paper that require definition. Mental health care service refers to mental health (MH) community services or mental health (MH) specialists that provide mental health care and/or information on mental health to patients or community members seeking treatment or information. Mental health community services refer to any public or private community-based service that provides support for persons in need of mental health care. Mental health community services include community-based centers that provide counselling, therapy and other services to outpatients; psychiatric hospitals with long and short-term inpatient mental health services and addiction support groups that offer treatment and withdrawal programs for individuals experiencing addiction. Mental health specialists, a term used interchangeably with mental health physicians refer to medical doctors who have a specialisation in psychiatry and are qualified to provide specialized care and prescribe medication to patients with a mental health illness. A mental health crisis refers to any incident that results in an apprehension that is carried out under the *Mental Health Act* law enforcement where the person in crisis has become a threat to themselves or others.

The structure of this paper is as follows, the literature review provides a comprehensive review of the theoretical and methodological contribution of academics on the theories of neighbourhood and health, social determinants of health and measures of accessibility to health care accessibility. The data and methodology section provides an overview of the data sources used in the study along with a comprehensive description of the methodological steps taken in the study. In the analysis results, section key results of the spatial accessibility model and bivariate association analysis are presented. The penultimate section is a discussion of the analysis results, in this section the limitations of the study are identified and next research steps are presented. The paper concludes with a summary of the research findings as they relate to the research questions.

2 Literature Review

This literature review will explore the concepts, theories and analysis techniques relevant to understanding the contributing factors of mental health and spatial accessibility to health care, including mental health care services. Specifically, this review explores the theoretical perspectives on the ‘social determinants of health' and ‘neighbourhood and health' in order to highlight the importance of access in health care. The notion of accessibility is then explained followed by a review of relevant studies of spatial accessibility in various contexts. The review concludes with a summary of methods that have been used to measure spatial accessibility to health care and identifies relevant gaps in the literature.

Social determinants of health

Health is a broad subject that encompasses both the physical and mental well-being of an individual or a population. As in most developed nations, Canada has a public health system that is designed to improve the health of the population by preventing and treating disease and illnesses. Nevertheless, inequalities in health status and health utilization have persisted and an increasingly ageing population will present future challenges to population health (Bryant et al., 2011). Traditionally, the response to health inequalities has been to combat disease and to improve the health systems. It is recognised in the literature, however, that health outcomes are determined and altered through a varied number of factors, known as social determinants of health (Marmot, 2005; Raphael, 2009). The definition provided by the United States Centers for Disease Control (USCDC) on the concept is ‘life-enhancing resources, such as food supply, housing, economic and social relationships, transportation, education, and health care, whose distribution across populations effectively determines length and quality of life'. Marmot (2005) and Braveman (2011) call for public policy to identify and address the social determinants of health as a vehicle for battling the rise of both infectious and non-infectious disease. Within the Canadian landscape of health care, policies that focus on the social determinants of health are seen as invaluable in reducing existing health inequalities (Bryant et al., 2011; Raphael, 2009). The social factors that impact the health of individuals that have been widely used in the Canadian context are as follows: income, education, unemployment, early child development, food insecurity, housing, social inclusion, race and gender (Bryant et al., 2011). Evidence of the socioeconomic gradient in mortality and health outcomes both regionally and globally point to

the causal links that exist between socioeconomic status and health (Berkman et al., 2014; Marmot, 2005). While each social determinants of health can be categorized separately, this body of literature has repeatedly drawn links between factors maintaining that they are interconnected and intersectional (Braveman, 2011). For example, an individual's level of educational attainment will have an impact on their employment prospects which in turn impact their level of income, all of which have an impact on health outcomes (Bryant et al., 2011; Ettner, 1996). Based on this evidence, health disparities within populations can be successfully reduced by focusing on the improvements to the conditions of life and work through strengthening housing, education, employment and housing policies (Marmot, 2005; Raphael, 2009).

The concept of 'social determinants of health' can be broadly applied to the discussion of mental health, however, there are social determinants that relate specifically to mental health (Compton and Shim, 2015). Social determinants of mental health are factors that increase or decrease the risk of mental illness and alter the impact mental illnesses when they occur (Compton and Shim, 2015). These determinants include social and economic circumstances such as household income, the level of educational attainment (Fryes et al., 2005) and social inclusion that play a role in the prevalence of mental disorders and depression (Allen et al., 2014; Sederer, 2016). Sederer (2016) identifies poor education, housing instability, unemployment (Paul and Moser, 2009) and limited access to health care among key determinants of mental disorders and depression. A recurring theme across the social determinants of mental health is social inequality, unequal opportunities that accumulate across every stage of life to impact mental health (Allen et al., 2014; Jensen et al., 2013). In the Canadian context, the Canadian Marginalization Index (CAN-Marg) was created as an area-based measure of marginalization (Matheson et al., 2012). The four dimensions of marginalization in CAN-Marg: residential instability, material deprivation, dependency and ethnic concentration, are closely related to the social determinants of mental health found in the literature. This is confirmed by the analysis of Matheson et al. (2012) revealed a significant association between material deprivation, residential instability and mental health outcomes as measured by the Canadian Community Health Survey (Béland, 2002). The city of Toronto is home to a large immigrant population, the latest National Household Survey reports that 48.6% of the population of Toronto are foreign-born immigrants (Statistics Canada, 2011). Given the ethnic and cultural diversity of the city of

Toronto, it is important to consider studies of immigrant mental health within the region. A mixed-methods analysis by Chadwick and Collins (2015) examined the relationship between self-perceived mental health and the availability of social support within urban environments in Canada. Their findings are consistent with the work by Dunn and Dyck (2000) that indicated a relationship between declining mental health status among immigrants with settlement challenges associated with social determinants such as employment, housing and social support networks. Later work by Blair and Schneeber (2013) uses the term ‘healthy immigrant effect' which attributed declining health in new immigrants with acculturation. Other recognized factors contributing to the healthy immigrant effect other than acculturation are the under-utilization of health services by immigrants and lack of information about the health care system (McDonald and Kennedy, 2004). Pertaining specifically to mental health, Kirmayer et al. (2011) identify the social status, employment and social exclusion as key social determinants of mental health among immigrants and refugees in Canada. It is evident that ethnocultural, linguistic (Wang and Roisman, 2011) and racial factors are important when considering the social determinants of health in the City of Toronto a multicultural urban setting with a large immigrant population (Zanchetta and Poureslami, 2006). For this study, however, race and ethnicity are not a research focus and all analysis is conducted on the general population.

In Canada, deinstitutionalization in recent decades has led to an increase in interactions between police and persons with mental illness (Cotton and Coleman, 2010; Lamb et al., 2002). In 2010, 7% to 30% of calls for police service involved a person who was mentally ill (Coleman and Cotton, 2010), thus, requiring collaboration between law enforcement and mental health services to reduce criminalization and high-risk encounters (Coleman and Cotton, 2016). In North America, it is common that contact between police and a person in mental crisis results in an arrest or apprehension both of which are considered high-risk encounters (Borum, 2000). Across Canada, under the Mental Health Act, police have the authority to apprehend a person who appears to be mentally ill and is a threat to themselves or others (Gray et al., 2008). For reasons of privacy, data pertaining apprehensions under the Mental Health Act have not been published (Personal communication, Toronto Police Service).

Neighbourhood and health

When discussing the study of health through a geographical lens, the concept of neighbourhood and health warrants specific mention, a critical review of multilevel studies found that evidence for neighbourhood effects on health are consistent (Pickett and Pearl, 2001). Neighbourhood and health are defined in the literature as the concept of how "features of neighbourhoods or residential environments may affect health" (Diez Roux and Mair, 2010), a concept that is discussed in-depth by Gatrell and Elliott (2014). In epidemiology, location and environmental characteristics are routinely considered as drivers of the occurrence and spread of disease, for example, the work by Snow (1855) is a highly regarded example of how location and space relate to the spread of diseases, by plotting the location of cholera deaths in a London neighbourhood, Snow was able to locate the water pumps that were contributing to the spread of the disease. Neighbourhood plays a crucial role in shaping health outcomes and healthcare access. Macintyre et al. (2002) outline five features of local areas that have the potential to influence health, they are: physical features such as air or water quality, the availability of healthy environments for housing, work and play; services provided to support daily life such as transportation, socio-cultural features that promote networks of community support and reputation that influence the self-esteem of residents. Of the features included, physical neighbourhood features and the availability of healthy environments are of high importance. A large body of research has explored the role that built environments play in obesity (Booth et al., 2005), studies have shown that built environments have the ability to encourage or hinder physical activity and healthy eating habits. Researchers have drawn a link between the lack of access to places where residents can be physically active recreationally and obesity rates (Sallis and Glanz, 2006; Gordon-Larsen et al., 2006). Booth et al. (2005) highlight proximity to available physical activity resources such as sidewalks, biking paths and recreational facilities as a neighbourhood feature that promotes physical activity, thus reducing obesity risk. A US study of adolescents by Gordon-Larsen et al., (2006) found that inequality in access to physical activity facilities was associated with decreased physical activity and increased obesity. Roux et al., (2001) found that neighbourhood characteristics had the potential to cause and sustain cardiovascular risk factors, their study controlled for personal socioeconomic indicators among study participants to highlight the effects of geographic location on health outcomes. Beyond chronic diseases, built environment impact health outcomes through situational opportunities and

exposure to communicable diseases particularly in poor quality housing where unsanitary lodging promotes the spread of disease (Cohen et al., 2003).

Relating specifically to mental health, neighbourhood characteristics and features of the built environment have been shown to have a noticeable impact on mental health (Compton and Shim, 2015; Gifford and Lacombe, 2006; Wright and Kloos, 2007). Physical factors such as ambient noise (Lercher et al., 2002; Jackson et al., 2013) and socioeconomic factors such as social disorganization (Latkin and Curry, 2003; WHO, 2014), unemployment (McKee-Ryan et al., 2005; Paul and Moser, 2009) and social inequalities (Allen et al., 2014; Ross, 2000) are shown to be significant contributors to symptoms of depression, anxiety and other mental illnesses. Lercher et al. (2002) found that exposure to ambient noise was correlated to mental health among children; children living in neighbourhoods with higher levels of noise exposure from roads and highways showed poorer mental health when controlling for other potential factors, similar results have revealed among adults (Tzivian et al., 2015). Housing quality is another key dimension of the built environment, housing quality encompasses structural quality, indoor climatic conditions, cleanliness and housing type that all affect mental health (Evans et al., 2000; Evans et al., 2003; Gifford and Lacombe, 2006). The built environment of a neighbourhood may also create a barrier to or enable social inclusion and social support that have both been shown to improve mental well-being (Kim, 2010; Thoits, 2011; Wright and Stickley, 2013). Other researchers have explored how non-environmental risks such as neighbourhood disorder lead to poor mental health through increased alcohol consumption. Hill and Angel (2005) demonstrated how physiologically distressing neighbourhood contexts lead to increased alcohol consumption as a people consumed alcohol to cope with depression and anxiety. The response of heavy drinking can have the effect of exacerbating existing mental illness while increasing other health risks such as maternal alcohol use or elevated blood pressure that can contribute to negative health outcomes (Goodlett and Horn, 2001). Linking mental health stressors to overall health outcomes, Hill et al. (2005) propose that chronic stressors in a neighbourhood environment lead to physiological and physiological stress responses that in turn affect health. One example of a chronic stressor examined by Hill et al. (2015) is high levels of social disorder due to neighbourhood crime or physical disrepair; the link between the fear or crime, built environment and mental well-being has been established by others (Kim, 2010; Lorenc et al., 2012).

One key neighbourhood characteristic is proximity to health services, as distance can be an enabling factor in health service utilisation (Fleury et al., 2012). In their review of neighbourhood and health, Gatrell and Elliott (2015) ask how neighbourhood characteristics can affect access to health care resources. This question explores the concept of neighbourhood and health from the perspective of how a neighbourhood context can improve health outcomes by providing services to heal or eliminate chronic diseases. Research has broadly shown that access to primary health care does vary by neighbourhood residence, leading to health inequalities (Bell et al., 2013). Bell et al. (2013) identify access to primary health care as under-examined in the existing literature on neighbourhoods and health and examine access to primary health care in the city of Mississauga, Ontario.

Defining access to service

One of the key determinants of health and a major driving factor in improving health outcomes is access to service. Accessibility is a broad term that is comprised of many facets (Gulliford, 2002). In this research, the term accessibility is defined as the level of ease in obtaining appropriate and timely care from a mental health care provider, the Canadian Health Act defines accessibility as "reasonable access to needed and appropriate health services" (Statutes of Canada, 1985). The classic definition of access in health care literature is provided by Penchansky and Thomas (1981), defining access as the availability, accessibility, affordability, acceptability and accommodation of care to patients in need. Access to healthcare can be examined in both spatial and nonspatial terms. In their examination of accessibility to primary health care in Illinois, Wang and Luo (2004) consider both spatial and nonspatial factors. The nonspatial factors considered by Wang and Luo (2004) are based on a survey by Field (2000) that explored factors that could affect health care access. These nonspatial factors include census variables related to socioeconomic status, linguistic barriers and service awareness and transport mobility. The authors describe spatial factors as those pertaining to geographic barriers represented by geographical distance or travel time from a person in need to a provided health care service, other researchers have described spatial factors in similar terms (Ngui and Vanasse, 2012; Shah et al., 2016). As healthcare services are non-uniformly distributed in space, spatial accessibility varies over space (Ngui and Vanasse, 2012). Spatial access can be measured explicitly by units of distance or time, or by using spatial accessibility measures such as the two-

step floating catchment area method that uses ratio indexes to represented spatial access (Guagliardo, 2004). While spatial access is a salient factor in healthcare accessibility, nonspatial factors also play an important role in dictating levels of access, there is a multitude of nonspatial or nongeographic factors that enable or impede access to health care service (Wang and Luo, 2004). These nonspatial factors include: the financial affordability of health care services that may define whether an individual's ability to pay for required services (Gulliford, 2002), the quality and adequacy of service to provide both generalized and specialized care as required and other factors such as the language spoken by the physician or service worker providing care (Flores, 2006; Lasser et al., 2006). Within the diverse mosaic of the Greater Toronto Area several studies have included healthcare service language as a key variable in measuring accessibility to among immigrants (Wang and Roisman, 2012) and linguistic minorities in an urban context (Bissonnette et al., 2012).

Beyond spatial and nonspatial factors, the concept of accessibility can be categorized as either potential or revealed. Potential access is a concept that refers to the separation by distance, time or cost between services and the populations that need them. Potential access is calculated using theoretical models based on the location of healthcare services and demand for services (Cromley and McLafferty, 2011; Guagliardo, 2004). Revealed access is a different concept and signifies the actual use of said healthcare services, normally obtained from survey or interview (Luo and Qi, 2009; Luo and Wang, 2003). This distinction is important as potential access does not ensure the utilization of the services available as many external factors beyond those that have been mentioned can have an impact on whether an offered service is in fact used (Wang and Luo, 2005). This study will focus primarily on measuring potential spatial accessibility to mental health care services using analysis techniques that have been used extensively in the literature (Neutens, 2015).

Measures of potential spatial access

In the field of health geography, the two-step floating catchment area method (2SFCA), developed by Luo and Wang (2003) is widely accepted as an effective analysis technique for the measurement of spatial accessibility to healthcare service (McGrail, 2012). In a review by Neutens (2015) two-step floating catchment area analysis techniques were found to be the most frequently used accessibility metric in the context of primary care. The 2SFCA model takes as

input data locations of health care demand represented by census boundary population centroids and locations of health care supply represented by physicians, hospitals or other health care service providers. Conceptually, the 2SFCA method can be divided into several steps. In the first step, a service area or catchment area for each health care facility is defined in terms of census tract within a user-defined travel time or travel distance of the facility. Next, for each facility, a physician-to-patient ratio is calculated by dividing the number of physicians and the sum of the population within the facility service area. The second set of catchment areas are then calculated, this time defined as a threshold travel time or distance from a population location (represented by a census tract centroid), all the ratios for facilities within the catchment area are to summed to give a new. The final result is a map with a ratio value for each geographic unit that represents its level of potential spatial accessibility to health care service. A major limitation of the basic 2SFCA method is the use of circular floating catchment areas in the analysis, this method of analysis assumes uniform access to services within specified catchment areas where in reality transportation networks include barriers that may impede Euclidian travel to access healthcare resources. In addition to this limitation, the use of centroids makes the assumption that the population residing within a census boundary will always travel from the geographic centroid whereas patients are typically more uniformly spread within the area. Furthermore, the ratios assigned to each census tract represent an average of the physician-to-patient ratio for the service area and not the census tract specifically (Yang et al., 2006).

In spite of these recognized limitations, the 2SFCA method has been successfully applied in multiple studies. The 2SFCA method was applied in the Greater Toronto Area to model spatial accessibility of immigrants to culturally diverse family physicians (Wang and Roisman, 2011), in the United States to model patterns of end-stage disease and spatial access organ transplant centres (Cao et al., 2016) and analyze spatial accessibility to mental health facilities in a Canadian urban context (Ngui and Vanasse, 2012). In addition to these examples, the 2SFCA method has been successfully applied to model accessibility to food stores in southwest Mississippi (Dai and Wang, 2011), to child daycare centers in Belgium (Fransen et al., 2015) and urban parks in Daegu, Korea (Lee and Hong, 2013)

Both modified and enhanced versions of the classic 2SFCA method exist and have been applied in different contexts to address specific model customizations. Delamater (2013) modified the

original 2SFCA model in order to acknowledge the suboptimal distribution of health services within the study area. The enhanced two-step floating catchment area (E2SFCA) method was first introduced by Luo and Qi (2009) with the goal of producing more spatially explicitly shortage areas. In the E2SFCA method, different weights are applied to time travel zones to account for distance delay. This modification addresses the recognised weakness of the original 2SFCA method that assumes uniform access within specified catchment areas. Another proposed variation of the gravity-based spatial access models that have been discussed thus far is the three step floating catchment area (3SFCA) method presented by Wan et al. (2012). The authors believe that their approach is an improvement of the E2SFCA and the classic 2SFCA methods in its ability to more effectively identify health care shortage areas without overestimating demand. The additional step in the 3SFCA method is to divide the service site and population location catchments into subzones based on distance and assigning Gaussian weights when the physical-to-population ratios are combined. This step is able to account for competition effects or 'mutual interactions' by attributing higher weight to service sites that are closer to locations of service demand (Wan et al., 2012).

Summary

In summary, this literature review has explored the concepts of the 'social determinants of health' and 'neighbourhood and health' and related them to the study of mental health care and mental health service delivery. Previous research has shown that a wide range of social and economic factors, defined as social determinants of health, have a direct effect on the prevalence and treatment of mental illness. In the discussion of neighbourhood and health, this review has highlighted several neighbourhood characteristics, including the physical built environment and spatial access to care, that have a demonstrated impact on mental health. In light of this, the concept of spatial accessibility to health care has been introduced with a specific focus on measures of spatial accessibility to health care using GIS. The literature has shown that spatial accessibility to service is an important dimension of health care delivery and is instrumental in the fight for positive mental health outcomes.

3 Data and Methodology

In this section, data used and the methodological approach is presented. As the research objectives are descriptive in nature, the methodological approach will focus on the quantification and description of the current levels of spatial access to mental health services.

3.1 Data

The dataset used in this research is drawn from multiple sources and formats and are summarized in Table 1. There are two main sets of data that are required for analysis, the first set of data is used to calculate accessibility and the second set is used to relate the accessibility results to the prevalence of mental health crises and socioeconomic variables. To calculate potential spatial accessibility three datasets are required: locations of mental health services, locations of mental health service demand (i.e., population) and travel networks across which services are accessed by the population. Other important data sets include the prevalence of mental health crisis events provided by TPS and neighbourhood socioeconomic characteristics from 2011 Census and the 2006 Canadian Marginalization Index (Matheson et al., 2012). In the methodology section of this report, the interaction between these two main data set groups is described and justified in detail.

Data on mental health services

The mental health service supply locations are taken from two mental health care provision categories: community mental health services and physician specialists.
Community-based services that provide information, counselling, therapy, treatment, medication and other services, on an outpatient basis to the general population. The locations of these mental health community services are taken from a directory of community services provided through personal communication with 211 Toronto (2017), the directory is a tabular database that includes the name, location (postal code and geographic coordinates), service category, contact information, opening hours and other related information of over 2000 services. Mental health related community services are extracted from the directory using “mental health” as a key word for the service category.

The mental health specialists represent medical professionals from the psychiatric medical speciality that provides the diagnosis and treatment of mental disorders to patients that have received a referral from their family doctor or hospital. Patients with mental disorders requiring help from mental health specialists include those who have experienced a mental health crisis and have been apprehended under the MHA. The psychiatrists within the study area are located both in private clinics and public hospitals. This data is taken from the Canadian Medical Directory (2011) a database that provides the names, address, postal codes, contact information, specialization and other details of medical physicians in Canada. The subset of data used in this research is medical physicians that are listed as specializing in Psychiatry. For both the community mental health services and physician specialists' datasets, a full variable listing is provided in the appendix.

Service demand: potential mental health service users

Locations of mental health care demand are represented by dissemination area (DA) boundaries within the City of Toronto that includes sociodemographic data from the 2011 Canadian census. DAs are geographical units that have a total population of 400 to 700 people and are the smallest geographic unit used by the Canadian census (Statistics Canada, 2006). In this research, DAs serve as the primary unit of measurement for the analysis and results. The DA boundary shapefiles and census data are taken from the CensusPlus 2011 data set developed by Environics Analytics (2011). The census data selected for each DA include the total population above the age of 15 for the year 2011, and the proportion of the population above the age 15 that travel to work by car, bike, walking and public transit and other relevant variables. For a full listing of the census variables included in this dataset refer to the complete variable list in the appendix.

Mode of transport: travel networks

In order to execute the spatial accessibility analysis using the enhanced two-step floating catchment area method presented in the methodology, geospatial travel networks are required. The Toronto Centerline, Sidewalk Inventory, Toronto Bikeways and TTC Routes and Schedules data sets serve as the transportation network for the accessibility analysis and are sourced from the Toronto Open Data catalogue (City of Toronto, 2017). These four separate transport

networks are polyline shapefiles that depict roads, sidewalks, bikeways and public transit routes for four modes of transportation: driving, walking, biking and public transit. The Toronto Centerline is a data set of streets, walkways, rivers, railways, highways and administrative boundaries in the City of Toronto, each line segment has a feature code describing the classification it represents. The Sidewalk Inventory is a polyline shapefile from April 2015 that provides the location of sidewalks within the City of Toronto. The Sidewalk Inventory is based on both the Toronto Centerline data set and aerial photography from early 2015 that is used to determine the presence of sidewalks. The Toronto Bikeways dataset is an enhanced Toronto Centerline (TCL) dataset that contains an additional column indicating bikeways in the City of Toronto it was last updated on April 2017. The Toronto bikeways data contains information on bicycle lanes, signed bicycle routes, pathways and suggested bike routes on regular roads. The final network data set is the TTC Routes and Schedules data provided by the Toronto Transport Commission (TTC) that contains scheduling information for the City of Toronto public transit system. The data is published as a General Transit Feed Specification (GTFS) format and includes route definitions, transit stop locations, and schedules for all TTC buses, streetcars and trains.

Mental health crisis data

Mental health crisis data for the City of Toronto for the years 2014 to 2016 inclusive is provided by the Business Intelligence & Analytics Unit of the Toronto Police Service from their apprehensions databases. The MHA apprehension data provided only includes apprehensions that were executed under the Mental Health Care Act (Gray et al., 2008). The data on Mental health act (MHA) apprehension occurrences is available at the dissemination area level. For each MHA apprehension occurrence, two geographic locations are provided: the DA of the MHA apprehension location and where available the DA of the apprehended person's residential address.

Canadian Marginalization Index

The Canadian Marginalization Index is an area-based measure of socioeconomic status that is used in population health research (Matheson et al., 2012). The index was created to measure

four dimensions of marginalization: residential instability, material deprivation, dependency and ethnic concentration and is calculated by apply factor analysis to variables from the 2006 Canadian census. All dimensions with the exception of ethnic concentration are used in this study as they are related to the social determinants of mental health observed in the literature (Compton and Shim, 2015; Sederer, 2016).

Table 1. Summary of data

Dataset and year	**Data type**	**Source (year)**	**Spatial enabled?**
Mental health community service locations	Database	211 Toronto (2017)	Yes, via latitude/longitude coordinates
Mental health specialist locations	Database	Canadian Medical Directory (2011)	Yes, via latitude/longitude coordinates
City of Toronto - Dissemination Areas boundary file	Shapefile	CensusPlus 2011; SimplyMap	Yes
Toronto Centreline (TCL)	Shapefile	Geospatial Competency Centre (April 2017)	Yes
Sidewalk Inventory	Shapefile	Transportation Service, City of Toronto (April 2015)	Yes
Toronto Bikeways	Shapefile	Transportation Service, City of Toronto (April 2017)	Yes
TTC Routes and Schedules	GTFS	Toronto Transit Commission (June 2017)	Yes
Mental health crises (2014-2016 inclusive): - Call for service (emotionally distressed persons) by location - MHA Apprehensions by location - MHA Apprehensions by person's address	Database	Toronto Police Service (2017)	Yes, via dissemination area spatial ID number
Canadian Marginalization Index	Database	Centre for Urban Health Solutions at St. Michael's (2006); Matheson et al., 2012	Yes, via city of Toronto neighbourhoods

3.2 Methodology

The methodology of this study is separated into two sections: first the calculation of spatial accessibility to mental health services, and the second the measure of statistical association between levels of access to service and major mental health crises. The methodological steps detailed in this section are summarized in the schematic diagrams shown in Figure 1 and Figure 2.

3.2.1 Measurement of spatial accessibility to mental health services

The technique used to measure spatial accessibility to mental health services in the City of Toronto is the enhanced two-step floating catchment area (E2SFCA) method. The E2SFCA method is a variation of the 2SFCA method and was chosen for its ability to calculate accessibility scores for small area geographies for multiple modes of transportation across a large study area (Luo and Qi, 2009). The E2SFCA method takes as input three datasets, point locations that represent the mental health service supply, point locations that represented mental health service demand, and travel networks that depict the pathways that allow populations that require mental health care to travel to mental health service locations. The E2SFCA tool calculates the ratio of potential patients to physicians or community services, these ratios are calculated using user defined catchment areas based on travel distance that is input as a parameter. An additional input parameter for the E2SFCA method is a distance-decay function used by the tool to account for friction to travel with increased distance. The measurement of spatial accessibility to mental health services begins with the preparation of the raw input data and travel network building, next the prepared data are directed to the tool, when the tool is run accessibility scores are produced for each areal unit, finally statistical analysis and spatial statistics are performed on the results.

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \in D_r\}} P_k W_r}$$

Equation 1. Step one of the E2SFCA method

Presented as an equation, first step of the E2SFCA method is shown in Equation 1, where R_j is the weighted physician-to-population ratio within the catchment area, P_k is the population of area

k falling within the catchment j, S_j the number of physicians at location j and d_{kj} the travel time between k and j, and D_r the *r*th travel time zone in the catchment and W_r the distance weight that represents the distance decay of access to physician j.

$$A_i^F = \sum_{j \in \{d_{ij} \in D_r\}} R_j W_r$$

Equation 2. Step two of the E2SFCA method

The second step of the E2SFCA method is shown in Equation 2 where A_i represents the accessibility of the population at *i* to physicians, R_j is the physician-to-population ratio at physician *j* within the catchment of population *i*, and d_{ij} as the travel time between *i* and *j* (Luo and Qi, 2009).

Data preparation and network building

In the first step of the methodology, the mental health service supply locations are prepared for input. The mental health community service locations and mental health specialist locations were each aggregated by postal code, generating a point data layer with for each postal code location with integer fields indicating the number of mental health community services and the number of mental health specialists. Next, a geographic centroid was generated for each dissemination area feature (Figure of point centroids) and all census data including the population above the age of 15 from the source DA is joined to the centroid point. These DA centroids represent the points of service demand for each DA. Next, using ArcCatalog network datasets were built for the four modes of transportation. In a first step, the polyline files for each transportation network (roads, sideways, bikeways and public transit routes) were queried to only include the transportation lines relevant to the research question. For the TCL data set any centerlines that represented features on which automobiles cannot legally drive were removed, the features removed included private laneways, walking paths and coastline boundaries. Likewise, for the bikeways data set, features such as highways and expressways that do not allow cyclist access was removed, for the sidewalk data set any roadways with incomplete or no sidewalks were removed. For the public transit data set no public transportation routes were removed. Following this data cleaning step, taking as input the queried transportation polyline features unique network datasets were built for

each of the four modes of transportation. In the network data builds turns were modelled in the networks, however, travel directions were not set in order to allow for bi-directional travel in the accessibility model. The construction of network datasets provides the geometry data required to apply the distance-decay function and distance defined catchment areas used in the E2SFCA method tool.

Calculating accessibility

Using the USWFCA ArcGIS Add-In tool the accessibility scores for spatial access to mental health services are calculated for eight separate scenarios, the tool calculates Enhanced Two-Step Floating Catchment Area (E2SFCA) accessibility metrics based on user controlled input parameters and datasets. This tool has been successfully used by Frew et al. (2017) in measuring potential accessibility to primary health care. The tool takes as input a service supply data set representing the location of mental health service providers with a field selected to indicate the number of physicians or services at each location, the second input is a service demand data set representing the location of populations accessing services which are represented by DA centroids, the tool then takes as input a GIS network data set representing the travel pathways between points of service demand and supply, the user also indicates the travel distance in meters and selects a distance-decay function.

The parameters used for each scenario are shown in Table 2, the first four scenarios calculate accessibility scores to mental health community service locations for the four modes of transportation and the subsequent four scenarios calculate accessibility scores to MH specialists for the same for modes of transportation. The accessibility scores are calculated for MH community services and MH specialists separately as the two mental health service categories have different levels of non-spatial access. While mental health community services often are open to the public, psychiatrists (which are also referred to as mental health specialists) are medical professionals that require service users to receive a referral from a hospital or family physician. Previous studies of spatial accessibility to health care services base travel/distance thresholds from questionnaire surveys (Luo and Roisman, 2011) or an arbitrary threshold travel times ranging from 30 to 40 minutes (Luo and Wang, 2003; Lee, 1991). In this study for each mode of transportation different travel distances are used based on an estimated travel time of 10

minutes that has been used in other spatial accessibility studies (Langford and Higgs, 2006), this threshold was also chosen in order to limit travel within the City of Toronto and reduce edge effects. The distance used for driving and public transit is 5 kilometers (assuming an average speed of 30 kilometers per hour), a distance of 2 kilometers is used for biking (assuming an average speed of 12 kilometers per hour) and a distance of 1 kilometer for walking (assuming an average speed of 6 kilometers per hour). Across all scenarios, the demand population for each dissemination area is set as the population aged 15 years and above from the 2011 CensusPlus dataset. The distance-decay parameter is set at as a Gaussian distance decay with a bandwidth of 50.

Table 2. E2SFCA method tool parameters

<table>
<tr><th>Scenario Name</th><th>Service supply</th><th>Service demand</th><th>Network dataset</th><th>Travel distance (kilometres)</th></tr>
<tr><td>S1</td><td rowspan="4">Mental health community services (211 Toronto)</td><td rowspan="8">Total population aged 15 years and older (2011)</td><td>Roads</td><td>5</td></tr>
<tr><td>S2</td><td>Sidewalks</td><td>1</td></tr>
<tr><td>S3</td><td>Bikeways</td><td>2</td></tr>
<tr><td>S4</td><td>TTC Routes</td><td>5</td></tr>
<tr><td>D1</td><td rowspan="4">Mental health specialists</td><td>Roads</td><td>5</td></tr>
<tr><td>D2</td><td>Sidewalks</td><td>1</td></tr>
<tr><td>D3</td><td>Bikeways</td><td>2</td></tr>
<tr><td>D4</td><td>TTC Routes</td><td>5</td></tr>
</table>

Transformation of output data and weighting by mode of transportation

The accessibility scores for each of the eight scenarios are measured in ratios, in the case of scenarios D1 to D4 the unit of measurement is the ratio of mental health specialists to 10,000 people and for scenarios S1 to S4 the unit is the ratio of mental health community services to 10,000 people. The results for all scenarios were standardized using a Z-Score, the purpose of the standardization is to both allow for a comparison between access to the two different service

providers and to facilitate the combination of accessibility scores for the four modes of transportation. To perform the Z-score standardization, for each scenario the mean accessibility score for the City of Toronto was subtracted from each DA specific accessibility score and this result was divided by the standard deviation of the accessibility scores for the City of Toronto. The equation used is shown in Equation 3 below where $Access_i$ is the accessibility score for each unique DA, X is the average access score for the City of Toronto and Y_{sd} is the standard deviation of access scores for the City of Toronto.

$$Accessibility\ score\ (Z\ Score)_i = \frac{Access_i - \bar{X}}{Y_{sd}}$$

Equation 3. Z-Score standardization for accessibility scores

Following the Z-Score standardization of accessibility scores for all scenarios, combined accessibility scores were calculated for the two types of mental health service providers: mental health community services and mental health specialists. As the proportion of the population that utilize the four modes of transportation varies by DA, the combined accessibility scores for each dissemination area are weighted using mode of transportation census variables. By weighing access scores by the proportion of the population using each mode of transportation, more emphasis will be attributed to access scores for predominant forms of transportation resulting in a single accessibility score for each DA that combines the level of access for all four modes of transportation. The combined accessibility score is calculated by multiplying the proportion of the DA population using a mode of transportation by the standardized accessibility score for the mode of transportation, this is summed for all four modes of transportation to give the combined accessibility score and is calculated for each DA. The combined accessibility score is calculated for accessibility to mental health community services and access to mental health specialists (Equation 4), where *DRIV*, *WALK*, *BIKE*, *PUBT* are the proportion of the population above the age of 15 traveling to work by car, walking, cycling and public transit respectively.

$$\begin{aligned} &Combined\ Accessibility\ Score \\ &\quad = \left(DRIV * Access_{driving}\right) + \left(WALK * Access_{walk}\right) + \left(BIKE * Access_{bike}\right) \\ &\quad + \left(PUBT * Access_{transit}\right) \end{aligned}$$

Equation 4. Weighing accessibility scores by mode of transportation

3.2.2 Measurement of association between accessibility and mental health crises

Preparation of mental health crisis data

The data provided by the Toronto Police Service provides a count of mental health act apprehensions for each DA for the years 2014 to 2016, two counts are given for each DA, the number of MHA that take place in the DA and the number of MHA apprehensions for which the apprehended person is a resident of the DA. Both counts are standardized by population, each count is divided by the DA total population in 2011 and divided by three (3 years) to give the number of apprehension per capita per year (Equation 5). As with the accessibility scores, the population rated MHA apprehension rates by the location of apprehension and address of apprehended individual are standardized as Z-Scores. The average is taken of the MHA apprehension Z-Scores for each DA to give a mental health crisis score that represents the level of mental health crisis severity for that area.

$$Apprehension\ Rate = \frac{\sum MHA\ apprehensions\ (2014-2016)_{DA}}{3 * Population_{DA}}$$

Equation 5. Calculation of MHA apprehension rates

Analysis of accessibility scores and mental health crisis scores

The mental health service accessibility scores (to MH specialists and MH community services) were plotted on maps to reveal variation in levels of access in the study area. To measure of statistically significant spatial clusters in accessibility and mental health crisis in the City of Toronto the Getis-Ord Gi* statistic was calculated for each DA for three measures: combined accessibility to mental health community services, combined accessibility to mental health specialist and the mental health crisis score. To calculate this, the Hot Spot Analysis (Getis-Ord Gi*) tool within the spatial statistics toolbox of ArcMap was used. The tool returned statistically significant hotspots that represent clustering of high values and cold spots that represent the clustering of low values. The confidence level used was to define statistical significance was the 90% confidence interval, representing a p-value of equal to or less than 0.10. Additionally, summary statistics for accessibility and mental health crisis scores were calculated by Toronto neighbourhoods and municipal boundaries.

In order to measure the levels of spatial association between mental health crisis scores and accessibility scores, a local indicator of spatial autocorrelation (LISA) statistic was calculated (Equation 6). Using the Local Bivariate Moran's I analysis, levels of spatial autocorrelation were calculated for the six variable pairs listed in Table 3. Levels of association were calculated between mental health crisis scores and mental health care accessibility scores for both community services and mental health specialists. The accessibility scores used were the combined access scores, driving access scores and public transit access scores, as the main modes of transportation across the study area were by car or public transit.

$$I_i = z_i \sum_j w_{ij} z_j$$

Equation 6. Calculation of Local Bivariate Moran's I

Table 3. Variable pairs of Local Bivariate Moran's I analysis

Analysis Run	First Variable (X)	Second Variable (Y)
1	MHA Apprehension rate (persons address)	Combined Access$_{\text{(mental health community service)}}$
2	MHA Apprehension rate (persons address)	Driving Access$_{\text{(mental health community service)}}$
3	MHA Apprehension rate (persons address)	Public transit Access$_{\text{(community service)}}$
4	MHA Apprehension rate (persons address)	Combined Access$_{\text{(mental health specialist)}}$
5	MHA Apprehension rate (persons address)	Driving Access$_{\text{(mental health specialist)}}$
6	MHA Apprehension rate (persons address)	Public transit Access$_{\text{(mental health specialist)}}$

Note: All variables are standardized Z-Scores

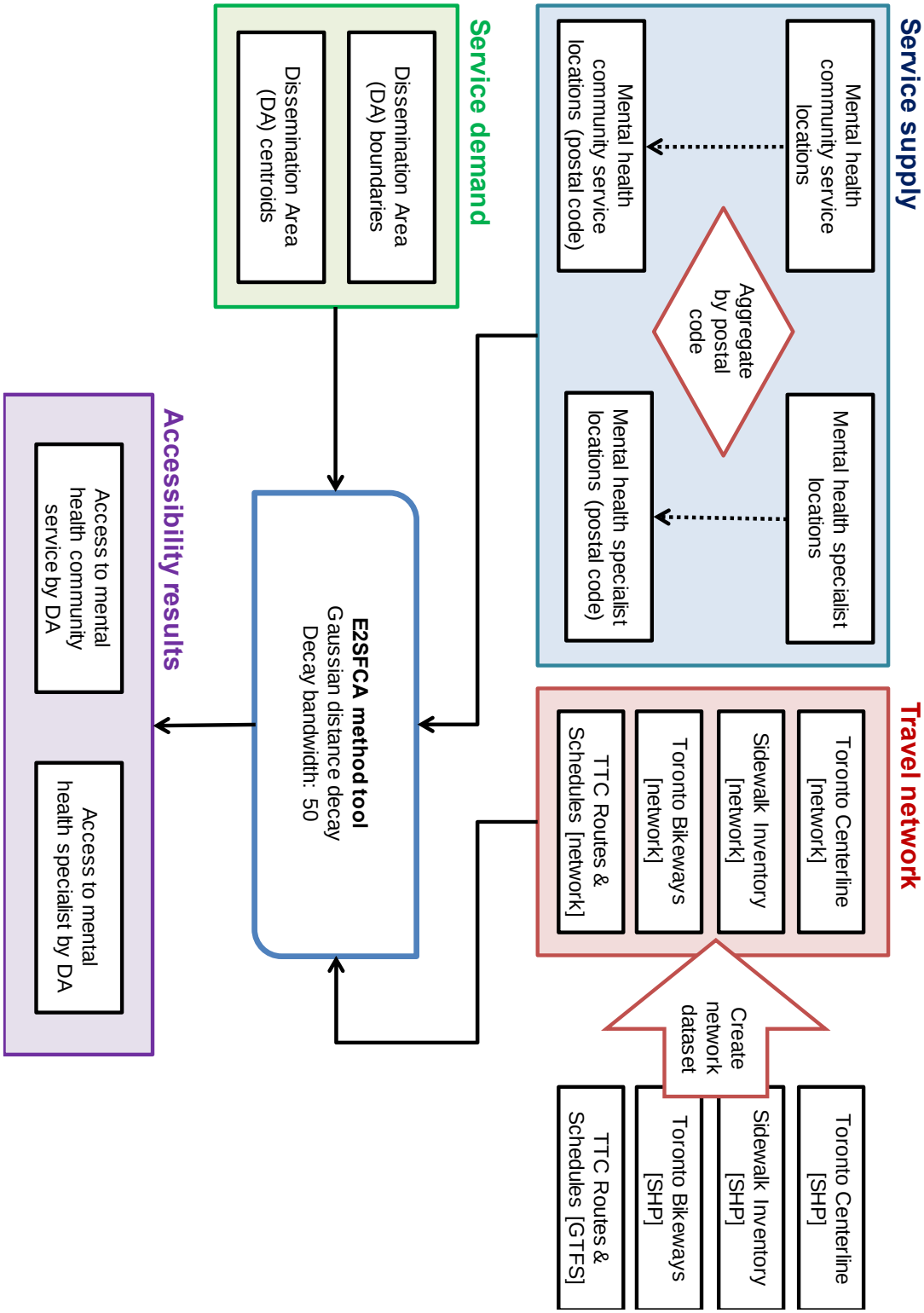

Figure 1. Methodology schematic: measuring spatial accessibility to mental health services

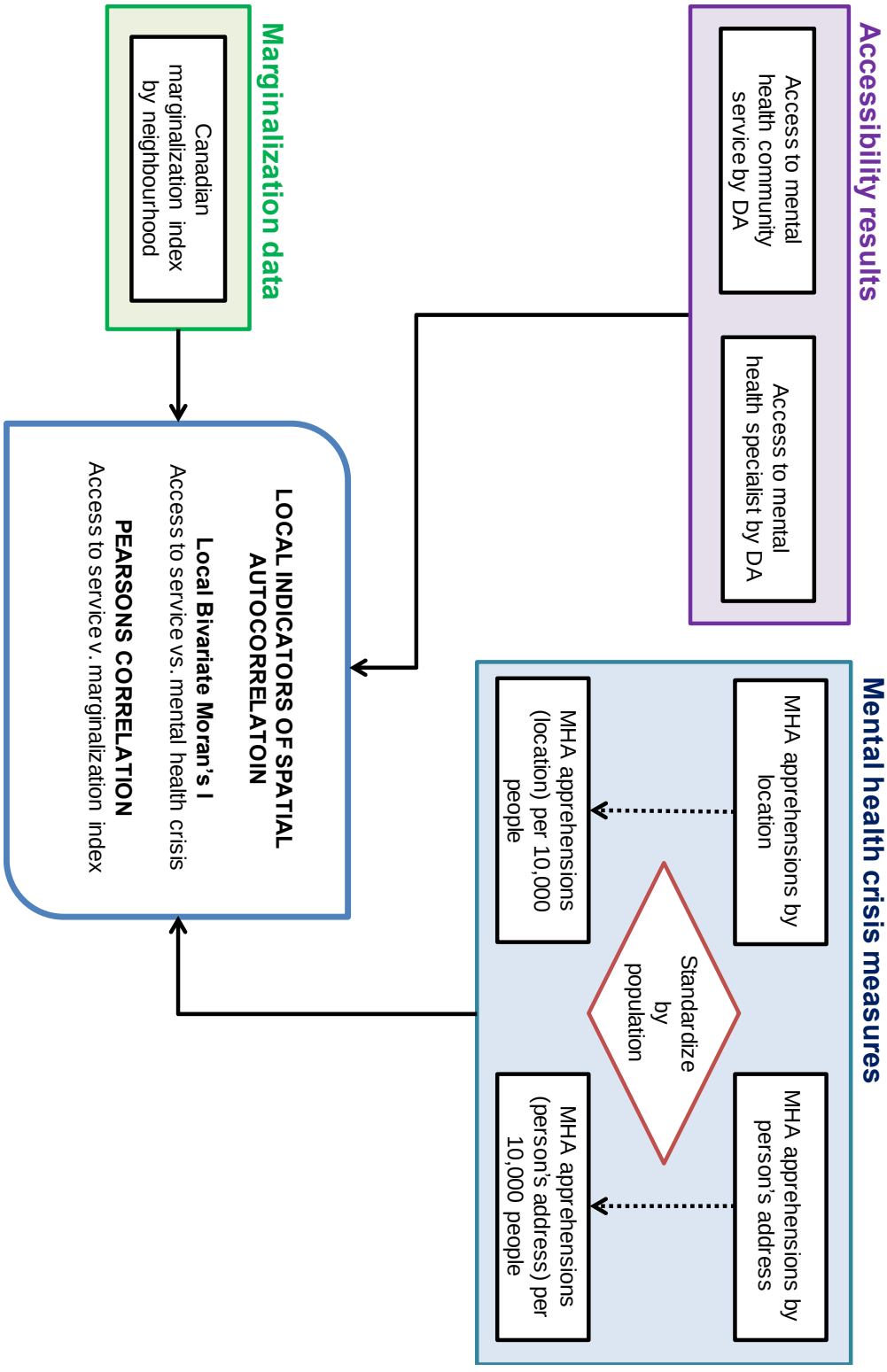

Figure 2. Methodology schematic: measuring association between accessibility, mental health crises and marginalization

4 Analysis results

This results section begins by describing the spatial distribution of mental health care services, population and mental health crisis events in the City of Toronto. It then presents the results for spatial accessibility to mental health community services and mental health specialists. The final subsection explores measures of association between access to mental health care and mental health crisis events using bivariate statistical analysis.

4.1 Spatial distribution of mental health care, population and mental health crises

Mental health community services

Within the city of Toronto, both mental health community services and mental health specialists are unevenly distributed and found primarily in areas of high population density (Figures 1 and 2). This study considered a total of 102 community-based MH services whose primary function is to provide mental health services to surrounding populations. As shown in Figure 3, mental health community services are mostly concentrated in the downtown core of the City of Toronto in middle and low-income neighbourhoods; more than 64% of mental health community services are located in the former municipality of Toronto where downtown neighbourhoods are found. The spatial clustering of mental health community services is confirmed by the nearest neighbour index result of 0.593. In the peripheral areas of the City of Toronto, community services can be found at major road intersections where the population density is higher. The average density of mental health community services in the City of Toronto is 0.16 services per km^2. The neighbourhoods with the highest density of mental health community services per square kilometre are the Church-Yonge Corridor (6.6 services per km^2), Niagara (5.8) and University (4.3), a full listing of mental health service density by neighbourhood can be found in the appendix.

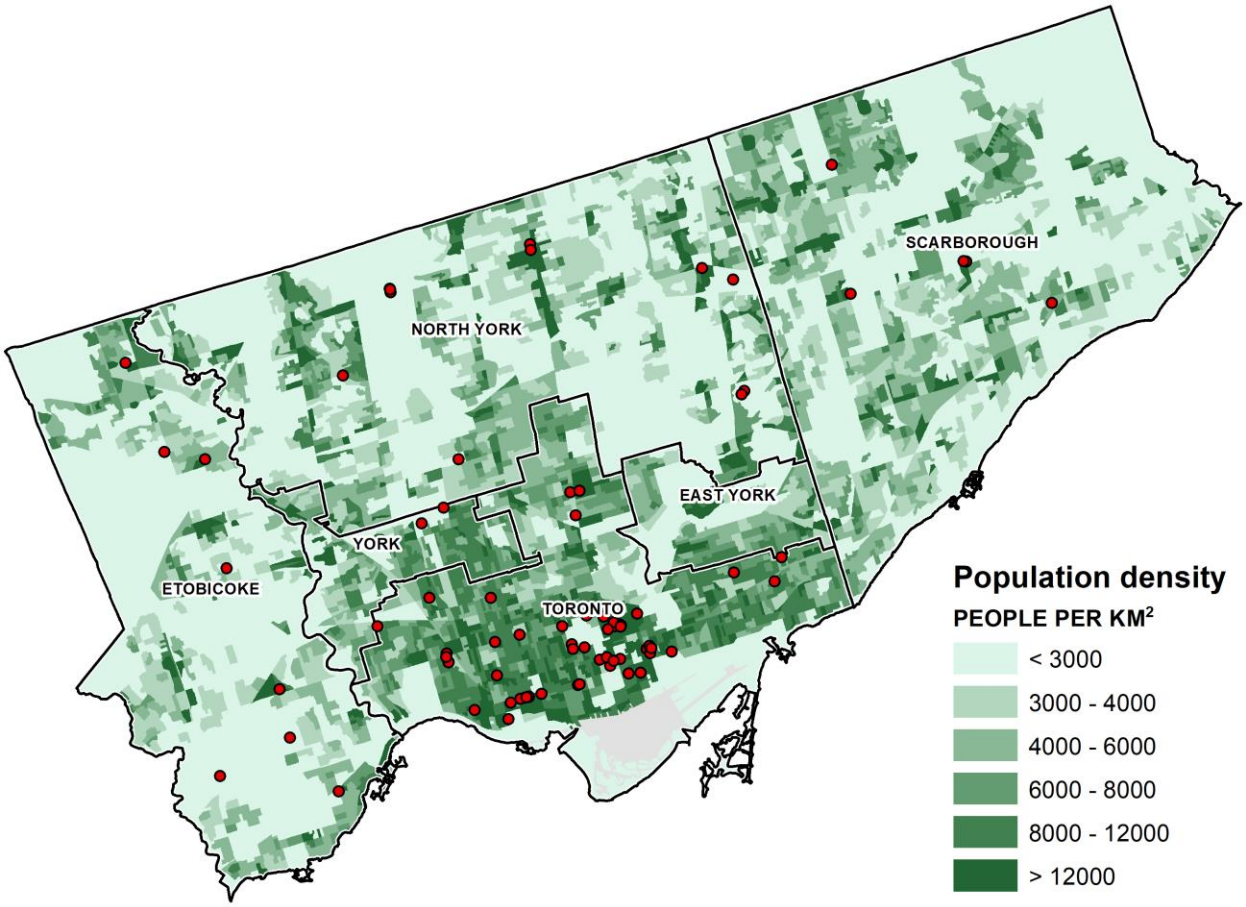

Figure 3. Location of mental health community services in the City of Toronto

Mental health specialists (Psychiatric physicians)

Similar to the mental health community services, the majority of mental health specialists are concentrated in the downtown core of the City of Toronto where there is a high density of hospitals and healthcare centres Figure 4. The nearest neighbour index of mental health specialists is 0.244 indicating a global spatial clustering of physician location. As shown in Figure 4, the downtown cluster of mental health specialists extends from King Street and northwards until Eglinton Avenue, bound on the east and west by Bathurst Street and Mount Pleasant Road, this area is known as the former municipality of Toronto. It is important to note that a high concentration of mental health specialists is located in the high-income neighbourhoods of Rosedale, Forest Hill and Casa Loma. There is a total of 718 mental health specialists in the study area, and over 40% of them are located in the downtown neighbourhoods of University, Bay Street Corridor, Kensington-Chinatown, Casa Loma, Annex and Church-Yonge Corridor, with the former municipality of Toronto accounting for 70.9% of all mental

health specialists. In the City of Toronto, the density of mental health specialists is 1.1 physicians per km^2. The highest density of mental health specialists is in the neighbourhoods of University, Bay Street Corridor and Kensington-Chinatown each with a density of above 30 mental health specialists per km^2.

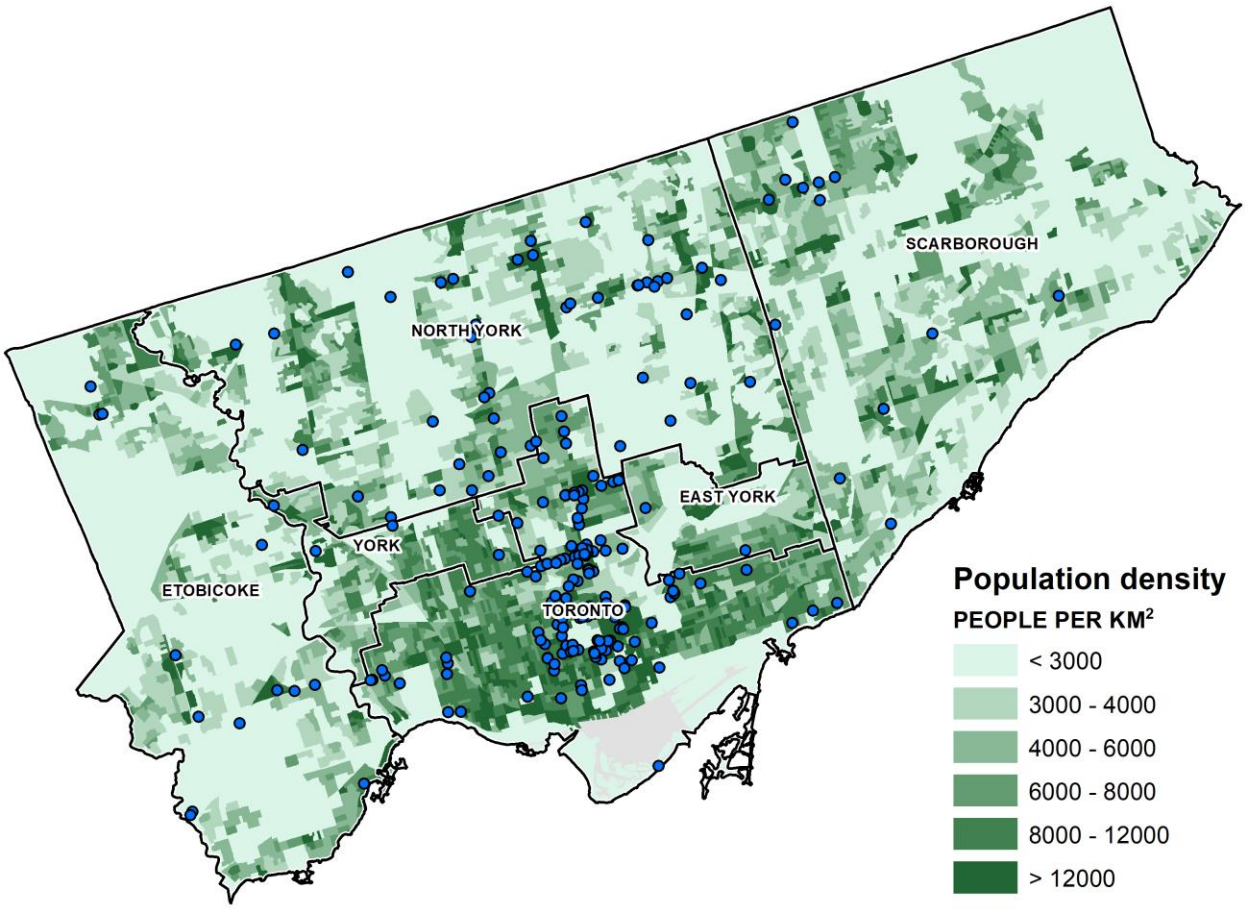

Figure 4. Location of mental health specialists in the City of Toronto

Population

The population of the City of Toronto in 2011 was 2,615,060 and is unevenly distributed, while the entire city has a population density of 4,119 people per km^2, the highest densities found in the downtown core. The former municipality of Toronto has a population density of 7,336 people per km^2, followed by York with a density of 6,175 people per km^2, the least densely populated municipality is Etobicoke (2,771 people per km^2). The distribution of the population in Toronto is shown in Figure 5.

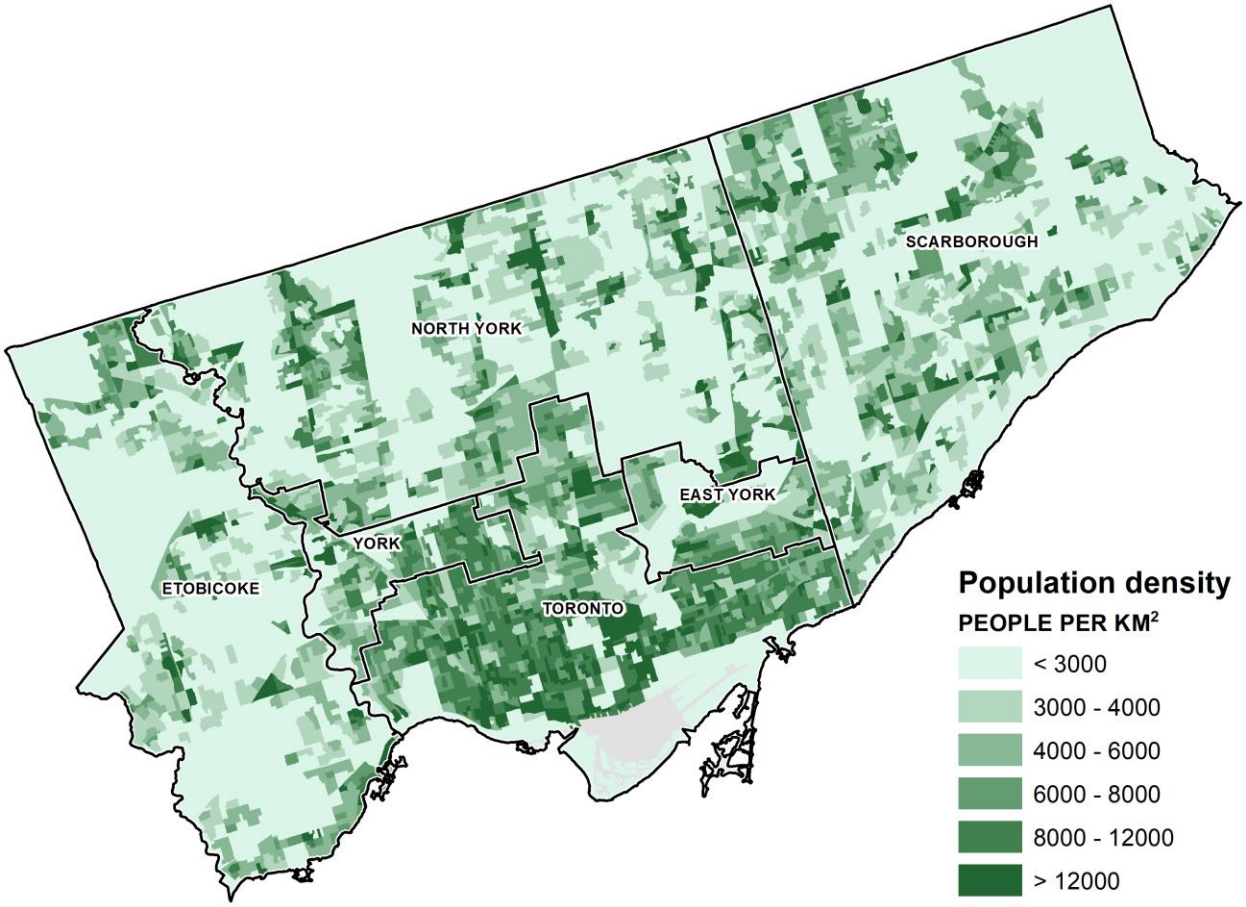

Figure 5. Population density in the City of Toronto

Mental health crises

For the period of 2014 to 2016, a total of 23,604 Mental Health Act (MHA) apprehensions were recorded by the Toronto Police Service within the City of Toronto. Among all MHA apprehensions, the location of apprehension by DA was recorded for all 23,604 and the residential address of the apprehended person by DA was recorded for 18,338 apprehensions

(76.1% of all apprehensions). For a total of 6,670 apprehensions (27.7% of all apprehensions) the individual apprehended under the MHA was apprehended in the same DA as their residential address. In 11,668 cases (49.4% of all apprehensions), the apprehension took place in a DA different from the individual's residential address – the average Euclidean distance between the DA of apprehension and DA of residence was 8.3 kilometres ranging from a minimum distance of fewer than 100 meters to a maximum distance of 34.8 kilometres. Personal communication with the Toronto Police Service revealed that over 50% of MHA apprehensions take place in a private dwelling or residential property. Table 4 summarizes key descriptive statistics of calls for service and apprehension rates by DA. Apprehension rates in by DA in the City of Toronto for the years of data provided range from 0 to over 1400 apprehensions per 10,000 persons with a mean of 32.58 apprehensions per 10,000 persons. Figure 6 displays the Z-Score of MHA apprehension rates by apprehension location across the City of Toronto.

Table 4. Descriptive statistics of mental health crisis (N=3685)

Statistic	Mental health CFS	MHA Apprehension by Location	MHA Apprehensions by persons address
Mean	177.58	32.58	28.38
Median	93.90	15.08	11.09
Standard Deviation	388.82	67.34	134.40
Minimum	0.00	0.00	0.00
Maximum	14145.14	1421.11	6921.12

Units: Events per year per 10,000 people

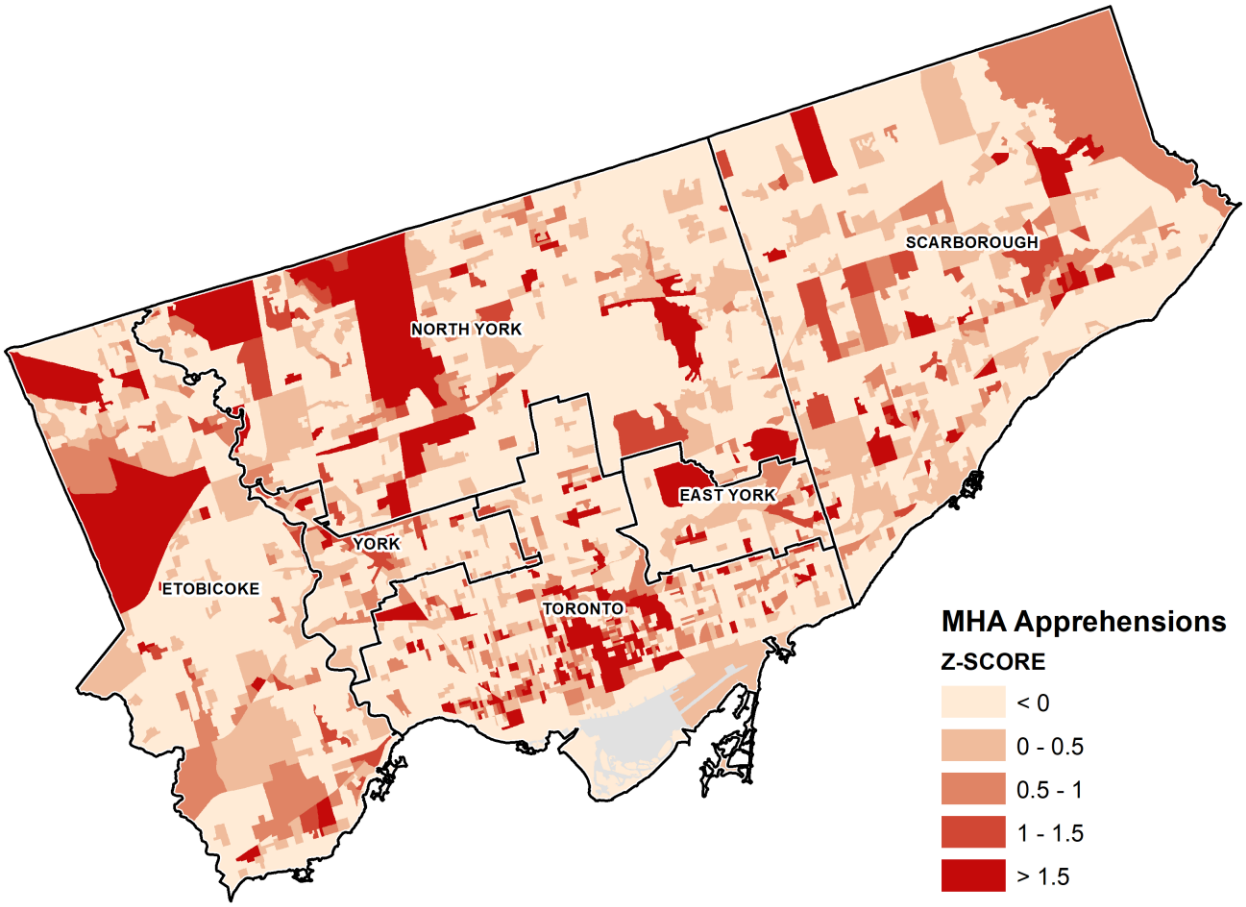

Figure 6. MHA Apprehension rates by apprehension location

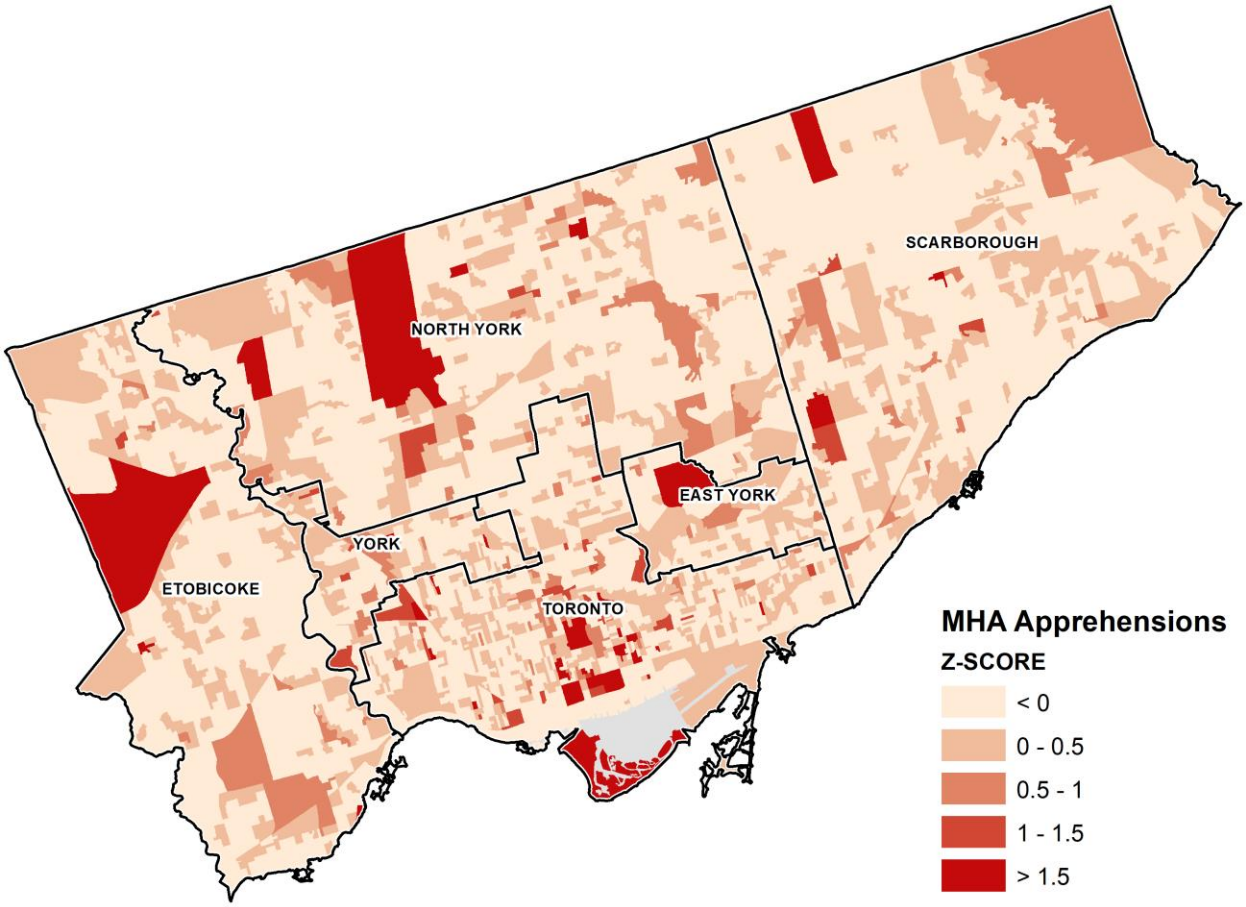

Figure 7. MHA Apprehension rates by person's address

Mental health act (MHA) apprehensions are used as a measure of mental health crises as they represent extreme events where an individual is apprehended to prevent themselves from causing harm to themselves or others (Gray et al., 2008). The spatial distribution of MHA apprehensions by location is shown in Figure 6, areas of high apprehension rates can be seen concentrated in downtown Toronto, East York, and central parts of North York and Scarborough. When compared to the MHA apprehension rates by location, the MHA apprehension rates by person's address are more concentrated in the core regions of the City of Toronto. The neighbourhoods with DAs showing highest rates of MHA apprehensions by person's address are found in the east end of the downtown core in the Bay Street Corridor, Church-Yonge Corridor and Moss Park. Other neighbourhoods of high MHA apprehension rates are Downsview in North York and the Junction area (Figure 7). This pattern is confirmed by the Getis-Ord Gi* hotspot analysis of the combined MHA apprehension rate data (Figure 8) that reveals hotspots of MHA apprehensions

in the downtown core, and the North York neighbourhoods of Downsview and Brookhaven. Pockets of cold spots where lower apprehension rates are found in parts of Etobicoke, Lawrence Park in North Toronto and the Agincourt North neighbourhood of Scarborough.

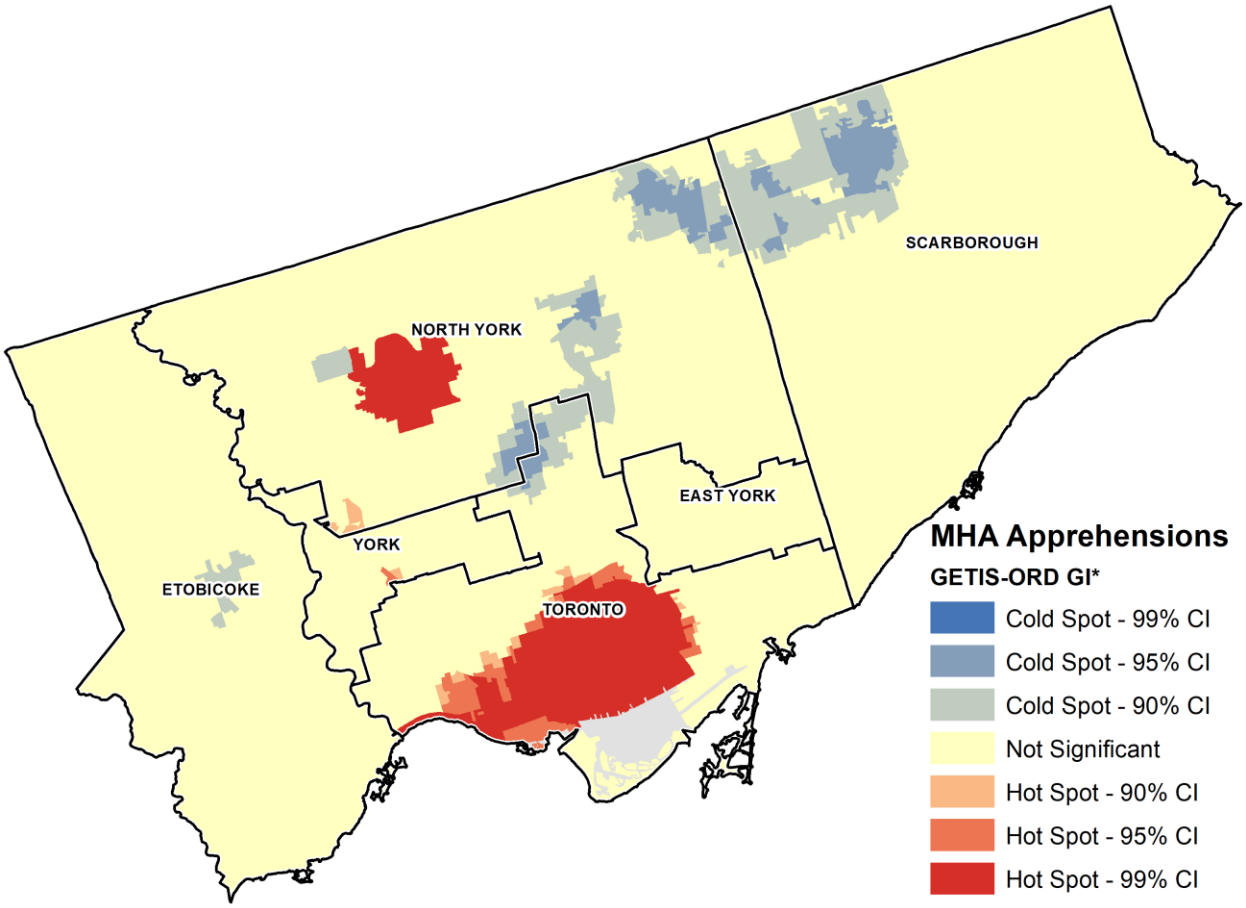

Figure 8. Hotspot map of MHA Apprehension rates by person's address

4.2 Accessibility to mental health community services

Using the E2SFCA method, accessibility scores are calculated for each DA to represent its ease to reach mental health community services based on different transportation modes and travel time thresholds. Descriptive statistics for spatial accessibility to mental health community services by mode of transportation by DA are shown in Table 5. For driving, the most common mode of transportation when travelling to work for Toronto residents, accessibility score varies from 0 to 2.87 services per 10,000 persons with a mean of 0.46 and a standard deviation of 0.57. The average levels of access are higher for biking and public transit with a mean accessibility

index of 0.48 and 0.49 services per 10,000 persons respectively, the highest average level of access is by walking with 0.53 services per 10,000 persons available. When interpreting these results, it is important to note that the distribution of accessibility scores is highly skewed for all modes of transportation (skewness ranging from 2.08 to 12.73).

Table 5. Descriptive statistics of accessibility scores to mental health community services (N=3685)

Statistic	Access by driving	Access by walking	Access by biking	Access by public transit
Mean	0.46	0.53	0.48	0.49
Median	0.27	0.00	0.04	0.24
Standard Deviation	0.57	2.30	1.18	0.98
Minimum	0.00	0.00	0.00	0.00
Maximum	2.87	61.01	40.23	9.29
Skewness	2.08	12.55	12.73	6.22

Unit: Services per 10,000 people

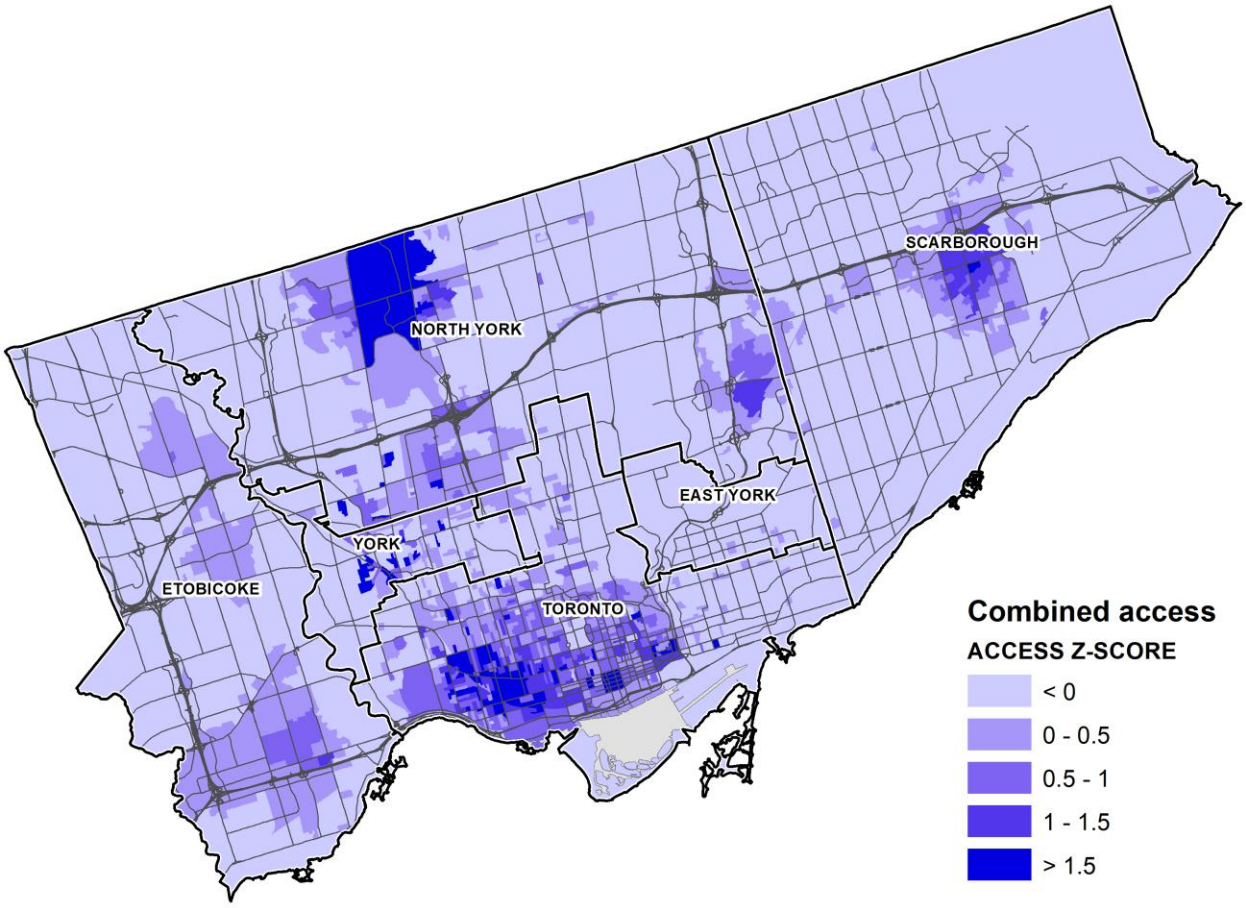

Figure 9. Combined access to mental health community services

Figure 9 shows the Z-scores for combined accessibility to mental health community services, the highest scores are found in the west end of downtown Toronto as well as the area of North York and downtown Scarborough. Across of the City of Toronto 71% of DAs had combined accessibility Z-scores of 0 or below, these DAs were mostly located in peripheral neighbourhoods in Scarborough, East York and Etobicoke. Getis-Ord Gi* hotspot analysis of the combined access scores for mental health community services show hotspots of high access to mental health community services in a large contiguous area in downtown core of Toronto extending northwest to the former municipalities of York and North York (Figure 10). Other statistically significant hotspots of high access can be found the periphery of the City of Toronto. These hotspots of well serviced mental health community service DAs are located in North York centred around the York University Heights and Bathurst Manor neighbourhoods, in Scarborough around the Woburn neighbourhood and in the Islington - City Centre West

neighbourhood of Etobicoke. Statistically significant cold spots are located in the former municipalities of Scarborough, North York, East York and some regions of Etobicoke.

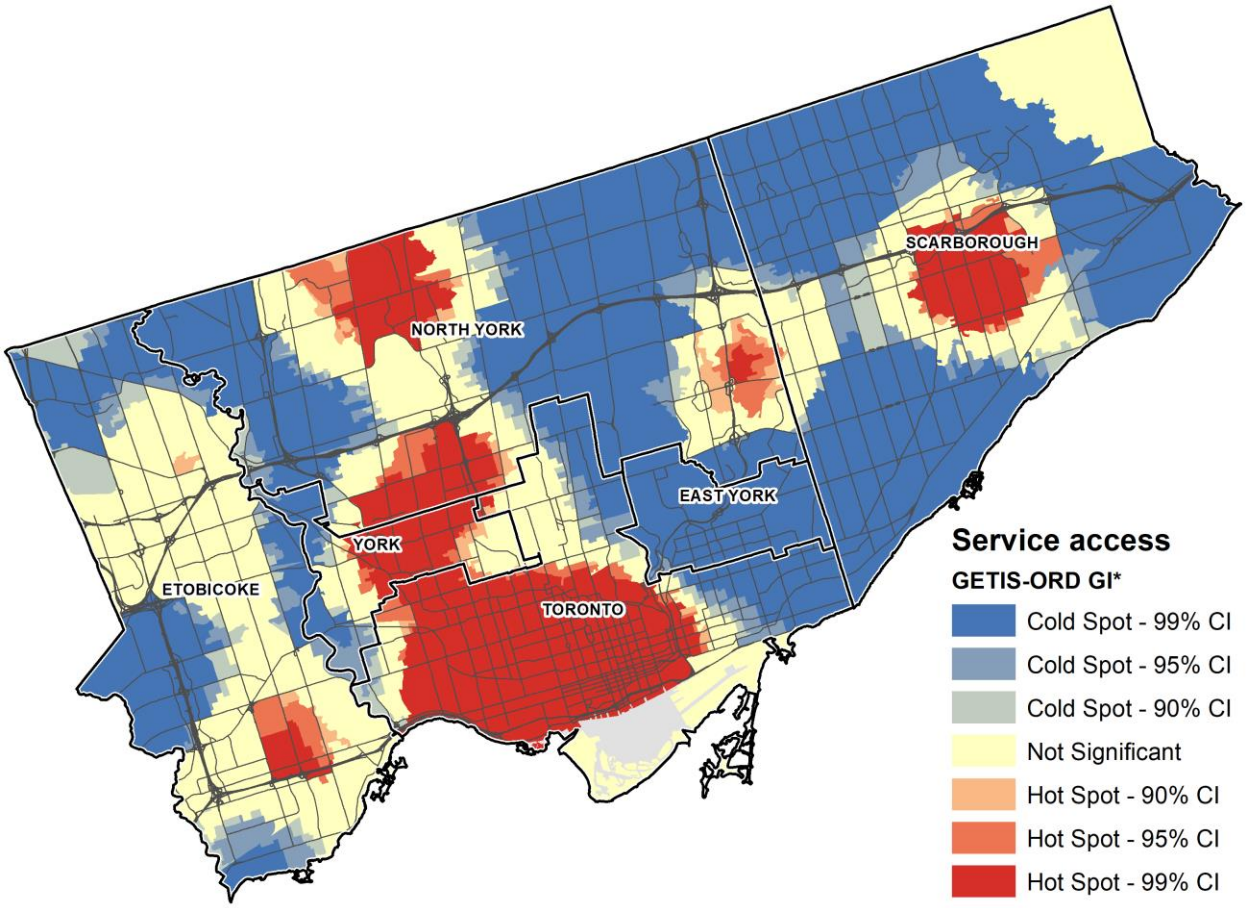

Figure 10. Hotspot map of combined access to mental health community services

4.3 Accessibility to mental health specialists

In the area of study, mental health specialists are more numerous and more evenly spread over space than mental health community services, as such, populations in the City of Toronto have higher levels of spatial access to mental health specialists than mental health community services. The output from the E2SFCA method tool produces for each DA a physician-to-population ratio that serves as a measure of potential spatial accessibility to mental health specialists. Descriptive statistics for spatial accessibility to mental health community services by mode of transportation are shown in Table 6. For driving, the most common mode of transportation, accessibility score varies from 0 to 23.69 with a mean of 3.16 and a standard

deviation of 4.48. The average levels of access are higher for biking and public transit with a mean access of 3.18 and 3.32 services per 10,000 persons respectively, the highest average level of access is by walking with 3.56 services per 10,000 persons available. As with the accessibility scores for mental health community services, these results were not normally distributed (skewness ranging from 2.28 to 9.49)

Table 6. Descriptive statistics of accessibility scores to mental health specialists (N=3685)

Statistic	Access by driving	Access by walking	Access by biking	Access by public transit
Mean	3.16	3.56	3.18	3.32
Median	1.39	0.00	0.79	1.58
Standard Deviation	4.48	13.82	5.86	5.74
Minimum	0.00	0.00	0.00	0.00
Maximum	23.69	242.89	50.55	61.85
Skewness	2.28	9.49	3.09	4.52

Units: Services per 10,000 people

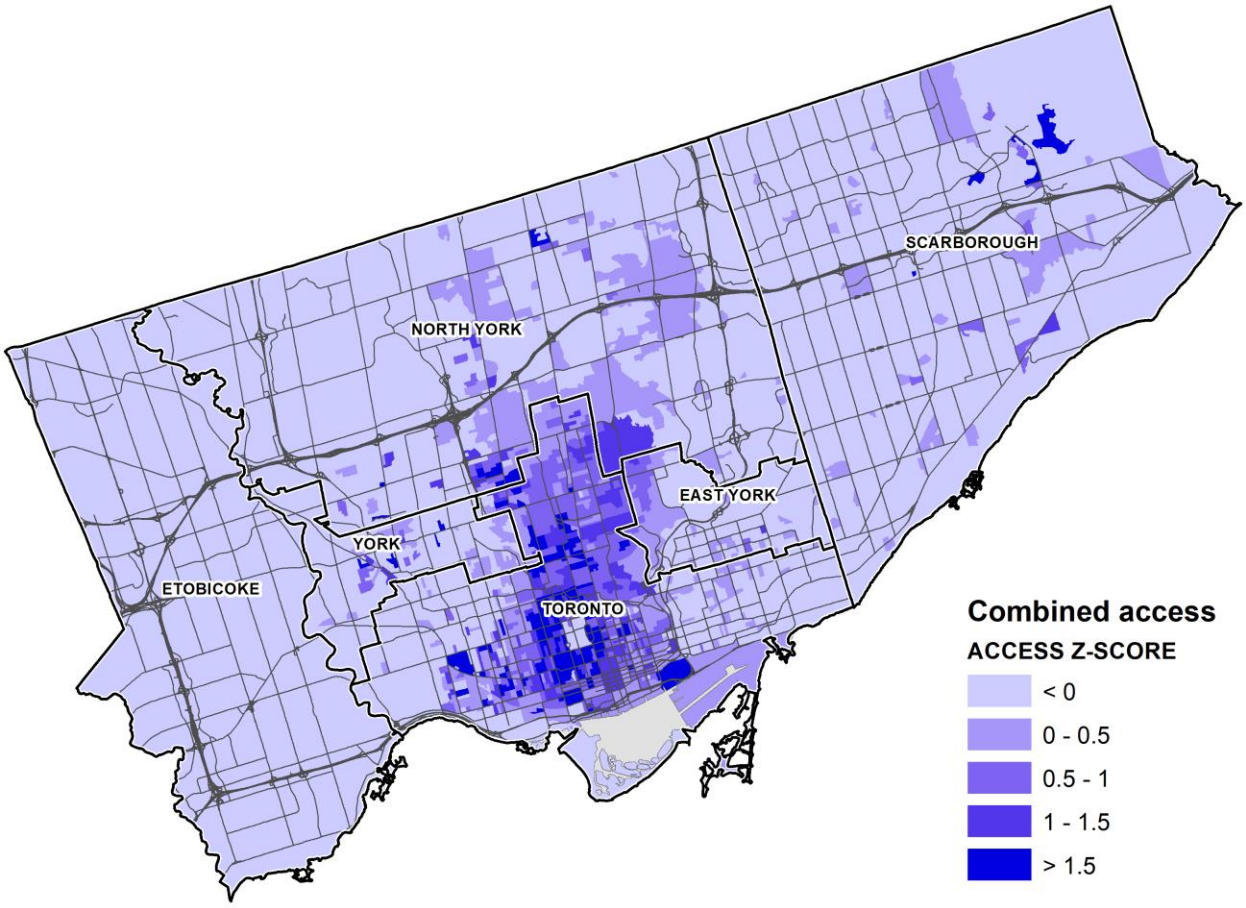

Figure 11. Combined access to mental health specialists

The spatial distribution of Z-scores for combined access to mental health specialists are shown in Figure 11, areas of high combined accessibility are spatially clustered in the former municipality of Toronto in a region that extends up towards the south of North York. The results from the Getis-Ord Gi* hotspot analysis of the combined access scores for mental health specialists show a sizeable contiguous hotspot of high access to mental health community services in the downtown core of Toronto (Figure 12). This hotspot that is statistically significant at the 90% confidence level is comprised of 928 DAs (25.2% of the City of Toronto) found within the former municipalities of Toronto, and parts of York, East York and North York. Statistically significant cold spots are mostly located in the former municipalities of Scarborough and Etobicoke, with 85%.12 and 88.2% of their DAs respectively classified as cold spots at the 99% confidence level. These indicate that Scarborough and Etobicoke extending to the west end of

North York are predominately underserviced in terms of combined access to mental health specialists.

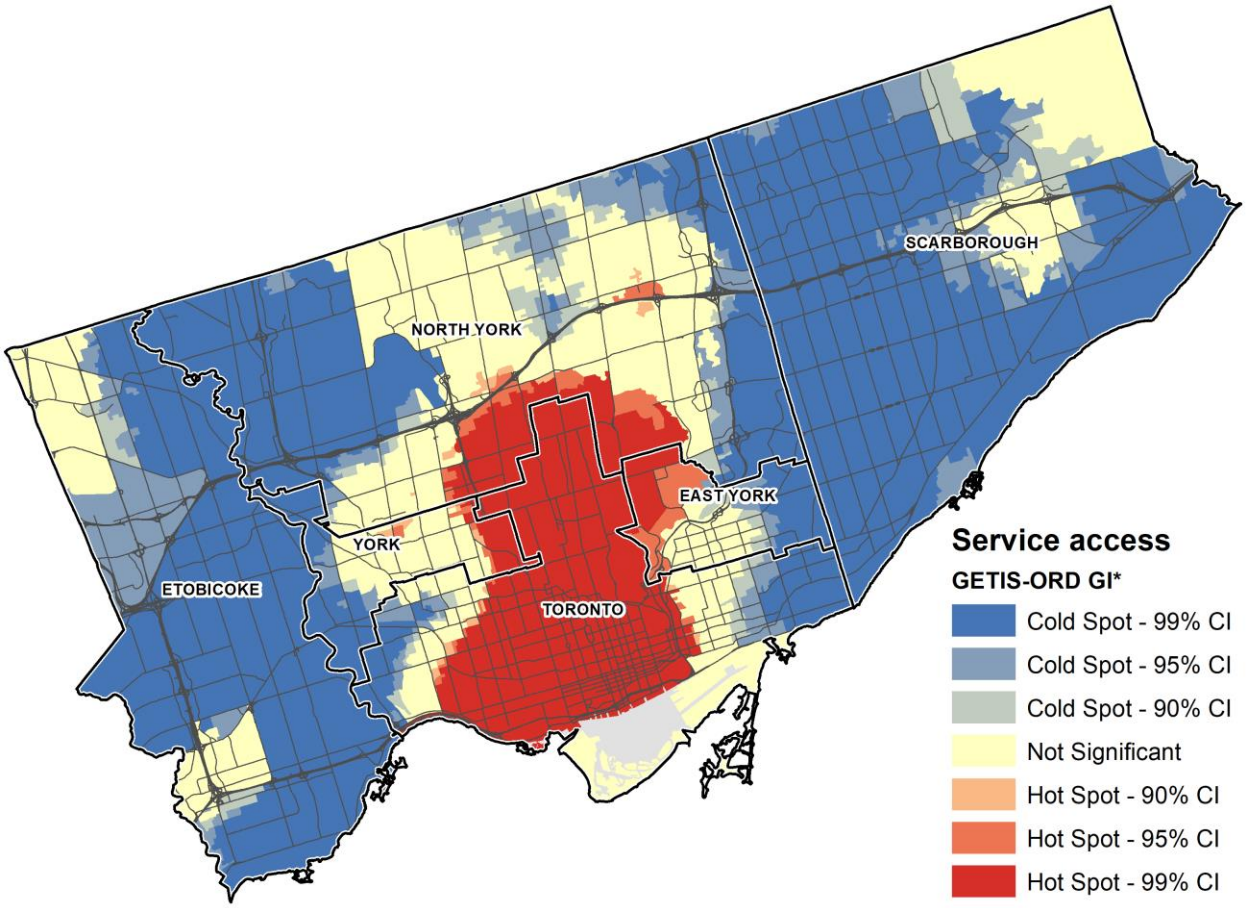

Figure 12. Hotspot map of combined access to mental health specialists

4.4 Measures of association: Bivariate analysis

Pearson's correlation analysis was applied as a first measure of association between accessibility to mental health care and mental health crises indicators. The Pearson's coefficient results show that there is no strong association between combined accessibility to MH specialists and MH community services and MHA apprehensions by person's address with no correlations above 0.2 or below -0.2. The only moderate positive correlations found were between access to mental health specialists and mental health community services (0.479). MHA apprehensions by person's address were very weakly correlated with accessibility to MH specialists (0.050**) and MH community services (0.054**).

At the neighbourhood level, the Pearson's correlation was used as a measure of association between access to mental health care and indicators from the Canadian Marginalization Index. The Pearson's correlation results in Table 7 show that both combined access to MH specialists (0.593**) and MH community services (0.482**) were positively correlated with residential instability an expected result as mental health care services were shown to be spatially clustered in areas of high population density. Combined access to MH specialists was shown to be moderately negatively correlated with material deprivation, (economic) dependency and general marginalization presenting a spatial mismatch between the location of MH specialists and neighbourhoods of low socioeconomic status. This finding is confirmed by literature as medical specialists in Toronto are concentrated in the downtown areas (Wang and Roisman, 2011) that are not considered low-income. Alternatively, combined access to MH community services is weakly positively correlated with material deprivation and marginalization, while these results are not significant at the 0.01 level they suggest that community services are located in neighbourhoods of lower socioeconomic status where mental health literacy is lower (Howard et al., 2006; Jorm, 2012). Combined access to MH community services was weakly negatively correlated with dependency, suggesting a mismatch between access to MH community services and the location of economically dependent populations. MHA apprehension rates by person's address were only significantly correlated with residential instability, a positive relationship (0.423**), with weak non-significant negative correlations to the remaining marginalization index dimensions.

Table 7. Pearson's correlation between neighbourhood characteristics, access scores and MHA apprehensions (N=140)

	Combined access to MH Specialists	Combined access to MH Community Services	MHA Apprehension by person's address
Residential Instability	.593**	.482**	.423**
Material Deprivation	-.343**	.129	-.112
Dependency	-.294**	-.232**	-.156
Marginalization Index	-.234**	.112	-.062

**. Correlation is significant at the 0.01 level (2-tailed).

The Local Moran's I bivariate analysis was utilized in order to investigate for spatial clustering of high-high, low-low, high-low and low-high variable pairs in DAs located in the City of Toronto. In this analysis, the first variable (Variable X) is the level of mental health crises (MHA apprehensions by person's address), and the second variable (Variable Y) describes, the level of combined spatial access to mental health care. For example, a DA categorized as High-High can be described as a DA within a cluster of DAs with a high MHA apprehension rate and high access to mental health care. Table 8 presents the key statistics for each variable pair, the overall the results show that there is not a strong spatial relationship between access to mental health care and level of mental health crises. Most DAs are classified as not holding a statistically significant relationship between the two variables $p < 0.10$), of the DAs that hold a statistically significant most show a high-high or low-low classification, indicating that there are many DAs with high levels of access and high levels of mental health crisis or low levels of access and low levels of mental health crisis. While the prevailing results are of the high-high or low-low classification there are some DAs classified as high-low which are spatial clusters of DAs that can be considered underserviced with a high level of mental health crises events, these DAs exist at similar levels for both the mental health community service data (6.05% of DAs) and mental health specialist data (6.12% of DAs). High-low DAs are underserviced areas in terms of access to mental health care as they represent neighbourhoods with a spatial mismatch between supply and need for MHS, the characteristics of these high-low (underserviced) DAs are discussed in the section that follows.

Table 8. Moran's I bivariate analysis

Analysis Run	Variable X	Variable Y	Moran's I	# of DAs in bivariate clusters				
				High-High	Low-Low	Low-High	High-Low	Not Significant
1	MHA Apprehension rate (by address)	Combined Access(community service)	0.044	186	865	331	223	2079
2		Driving Access(community service)	0.087	203	959	347	254	1921
3		Public transit Access(community service)	0.010	64	344	151	113	3012
4		Combined Access(mental health specialist)	0.052	185	866	391	225	2017
5		Driving Access(mental health specialist)	0.087	180	1098	358	292	1756
6		Public transit Access(mental health specialist)	0.031	108	465	212	139	2760

Table 9. Moran's I bivariate analysis: MHA apprehensions-combined access

Bivariate clusters	Combined Access to MH Community Service			Combined Access to MH Specialist		
	% of Toronto DAs	Population (%)	Average household income	% of Toronto DAs	Population (%)	Average household income
High-High *Adequately serviced – High demand*	5.0%	115,881 (4.4%)	$81,510	5.0%	121,145 (4.6%)	$124,716
Low-Low *Adequately serviced – Low demand*	23.5%	669,821 (25.6%)	$90,893	23.5%	682,451 (26.1%)	$79,019
Low-High *Well serviced*	9.0%	266,924 (10.2%)	$75,718	10.6%	297,438 (11.4%)	$121,566
High-Low *Underserviced*	6.1%	143,801 (5.5%)	$110,084	6.1%	153,274 (5.9%)	$86,753
Not Significant	56.4%	1,417,976 (54.2%)	$94,077	54.7%	1,360,095 (52.0%)	$84,851

Mental health community services

The bivariate local Moran's I results between MHA apprehension rate and combined spatial access to mental health community services are shown in Figure 13, clusters of DAs categorized as High-High and Low-High neighbour each other while Low-Low and High-Low DAs are clustered together spatially. Table 8 shows the weak relationship between MHA apprehensions and access to mental health community services (Moran's I = 0.04), this result indicates that there is no significant spatial association between combined access to mental health community services and mental health crises. DAs classified as High-High are located primarily in the in the downtown core of the former Municipality of Toronto, in the neighbourhood of York University Heights, North York and the neighbourhoods of Malvern, Woburn and Morningside, Scarborough. The underserviced DAs (High-Low) are found in throughout the former

municipalities of Scarborough, East York and North York in particular where the average household income is higher than all other categories ($110,084). The median household income for underserviced DAs is $80,879 with some DAs in the group of low-income (average household income below $50,000). These results suggest the neighbourhoods in the City of Toronto that are underserved in terms of accessibility to MH community services are predominately middle and high income, contrary to literature that identifies income as a contributor to health inequality (Subramanian and Kawachi, 2004; Bryant et al., 2011; Berkman et al., 2014). This result may be explained by the fact that MH community services are primarily located in middle and low-income neighbourhoods. Notable neighbourhoods that are under-serviced in access to mental health community services are Rouge (Scarborough), Humber Summit (North York) and the low-income neighbourhood of Weston (York).

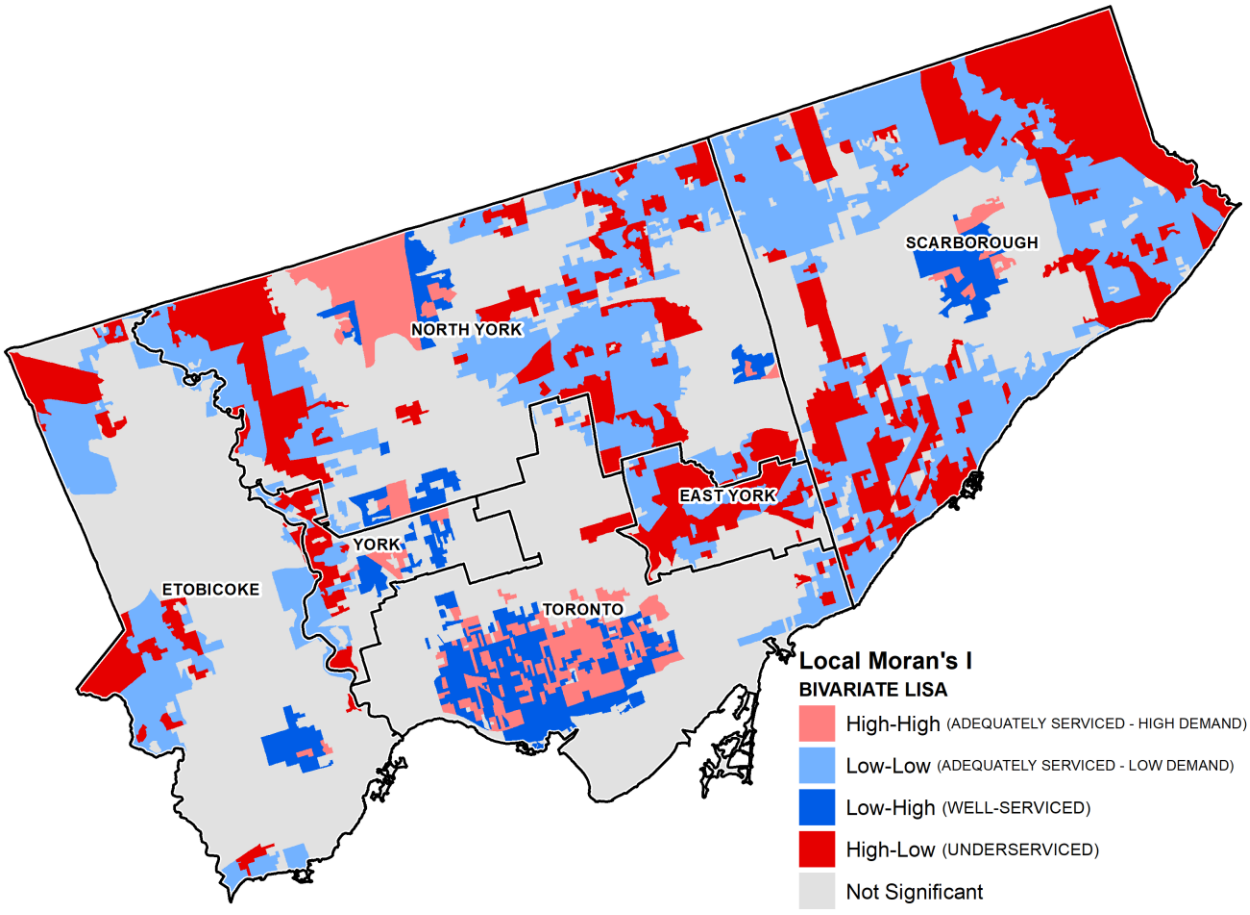

Figure 13. Moran's I cluster map: MHA Apprehensions v. Combined access to MH community services

Mental health specialists

The bivariate local Moran's I results between MHA apprehension rate and combined spatial access to mental health specialists are shown in Figure 14. Table 8 shows the weak relationship between MHA apprehensions and access to mental health specialists (Moran's I = 0.05), this result indicates that there is no significant spatial association between combined access to mental health specialists and mental health crises. The spatial distribution of clusters by DA differ slightly from the results produced for access to mental health community services, similar to the combined mental health specialists' accessibility results the High-High DAs where access to mental health care and mental health crisis events are spatial clustered can be found in the downtown core extending upward from the municipality of Toronto into York. The high-high adequately serviced DAs are located in close proximity to low-high DAs that are well-serviced and predominately high income (average household income $121,566). Low-high DAs are under-serviced as they are located in clusters of high mental health crisis and low access to mental health specialists. Underserviced DAs account for less than 6% of the City of Toronto population and are located in peripheral regions of Etobicoke, North York and Scarborough. As shown in Table 9 these underserviced DAs are the less affluent (average household income of $86,753 well-serviced DAs (average household income $121,566), the median household income of underserviced DAs is $75,549. The socioeconomic status of underserved DAs is in line with literature that concludes that social determinants such as income are related to health inequalities, including access to healthcare services (Wang and Luo, 2005). Notable underserviced low-income DAs are located in the neighbourhoods of Wexford/Maryvale and Dorset Park (Scarborough), Downsview (North York) and Weston (York).

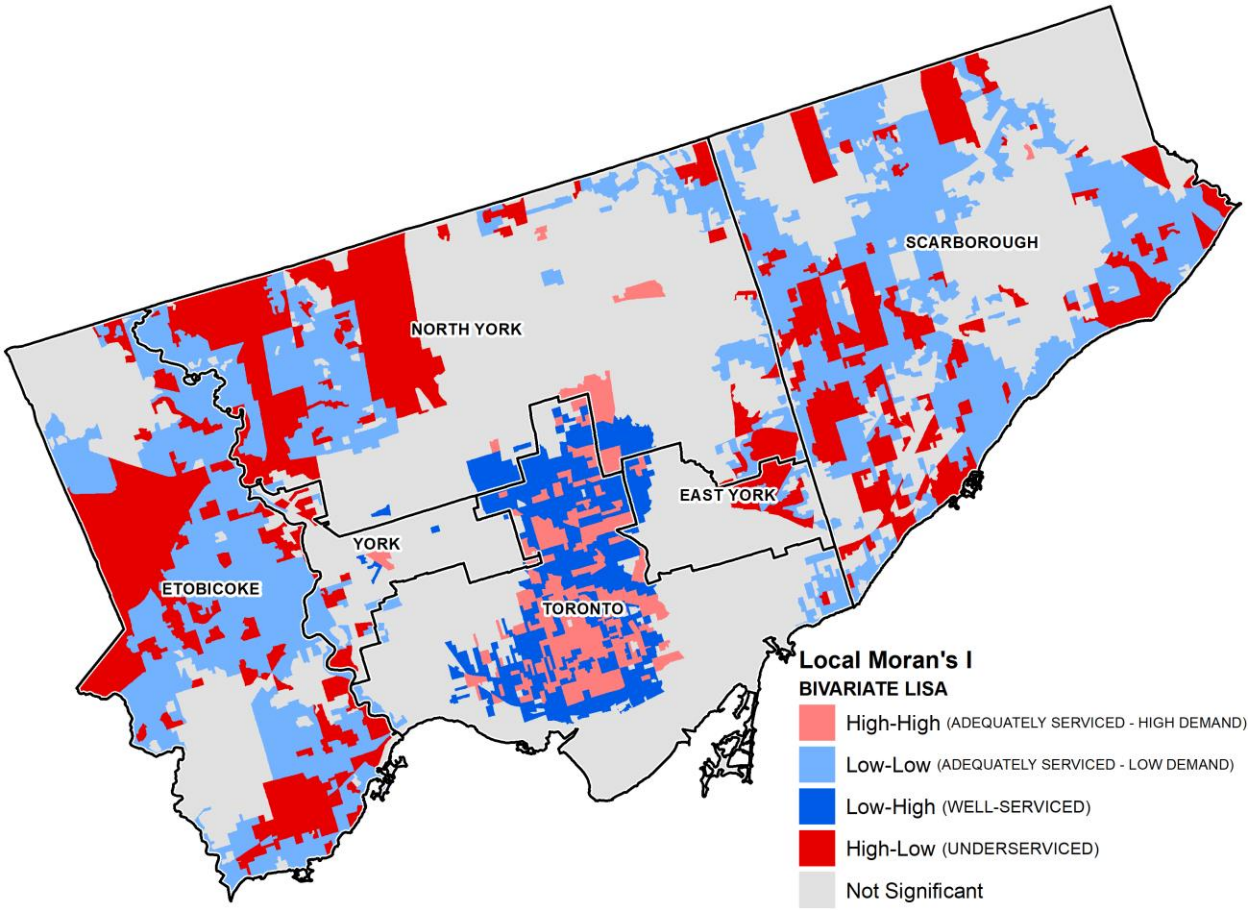

Figure 14. Moran's I cluster map: MHA Apprehensions v. Combined access to MH specialists

5 Discussion

Mental health is a fundamental aspect of public health in Canada, as mental illnesses have been shown to affect a significant proportion of the population (Kates et al., 2011; Vasiliadis et al., 2005). The health geography theory of neighbourhood and health holds that the spatial and non-spatial characteristics of an individual's neighbourhood of residence can have an impact on health outcomes, including mental health (Compton and Shim, 2015; Sederer, 2016). One key neighbourhood characteristic is potential spatial accessibility to mental health care, spatial accessibility is important as distance and travel time can work as either an enabler or barrier to the use of a mental health care service (Ngui and Vanasse, 2012). With equitable spatial access to mental health care, mental health outcomes in the general population can be improved as individuals and communities will be able to access the services and support that they need (Fleury et al., 2011; Sommers, 1989).

The purpose of this study is to use geospatial analysis techniques to measure potential spatial accessibility to mental health specialists and mental health community services for dissemination areas in the City of Toronto. This purpose was achieved by using the enhanced 2SFCA method (Luo and Qi, 2009) for four modes of transportation calculating a combined accessibility scores based on transportation data taken from the 2011 Census. In the second step of the analysis, the spatial accessibility results are analysed with mental health crisis data provided by the Toronto Police Service with the goal of measuring the association between spatial accessibility to mental health care and mental health crisis levels, which are taken to represent mental health care need. Under-serviced neighbourhoods with low levels of spatial access and high levels of mental health crises were identified and their characteristics described.

Key findings

This study has shown that mental health care services, both mental health community services and mental health specialists are clustered in the downtown core of the City of Toronto where population density is highest, leading to inequalities in accessibility across the study area. Hotspot analysis of the accessibility results revealed that high levels of access to mental health community services can be found in the downtown core as well as central areas of the peripheral former municipalities of Scarborough, North York and Etobicoke – other areas of the periphery

have lower levels of access especially in areas of low population density. In contrast, while there are more mental health specialists than mental health community services in the City of Toronto, MH specialists are clustered in the downtown core. As such, DAs of high combined accessibility to MH specialists are concentrated in the former municipality of Toronto and bordering regions of York, East York and North York. This study has also shown that mental health crises events (MHA apprehension) recorded by the Toronto Police Service are clustered in North York and the downtown core of the former municipality of Toronto. Although services are concentrated in the city core, the need for mental health services is found across all areas of the City of Toronto. When exploring the relationship between mental health care access and mental health this study demonstrates that there is a weak association between accessibility to both forms of mental health care and mental health crisis levels, this may be explained by non-normal distribution of the mental health crisis data. In spite of this, the Local Moran's I bivariate spatial analysis was successful in categorizing DAs based on their level of accessibility and mental health crises resulting in the identification of neighbourhoods that are underserved with regards to accessibility to mental health care when compared to mental health care need. The analysis was successful in revealing the detailed spatial variations in accessibility to mental health services. Spatially, under-serviced neighbourhoods for MH community services and MH specialists were distributed differently. Under-served neighbourhoods for mental health community services had a higher household income than those for mental health specialists. These findings show that access to neighbourhoods with a higher socioeconomic standing generally have greater spatial access to MH specialists than to MH community services, whereas less affluent neighbourhoods have an opposite relationship.

Contributions

By using a geospatial approach, this study produces new knowledge on spatial accessibility to mental health services in the City of Toronto at a high spatial resolution. Previous work examining access to mental health care in Toronto has focused on the use of qualitative survey methodologies to identify nonspatial barriers to access such as an inadequate number of mental health workers, limited mental health awareness and cultural stigma (Fenta et al., 2006; Sadavoy et al., 2004). As such, the spatial explicit accessibility results produced by this study are not comparable to any previous studies. Additionally, this study presents an assessment of spatial

accessibility to health services that combines multiple modes of transportation in the City of Toronto in order to account for variation in travel preferences. Traditionally, spatial accessibility studies measure levels of accessibility for a single or multiple travel distances across one sole transportation network (Guagliardo, 2004). By using multiple transportation networks and applying weights to accessibility scores based on transportation census variables, this study has generated a more accurate measure of accessibility that accounts for different transportation preferences (Fransen et al., 2015). Finally, these study analyzes accessibility scores calculated at the dissemination area level, a small areal unit that allows for increased accuracy in results compared to other studies of accessibility based on a census tract level of measurement providing access scores to small areal units across the City of Toronto (Bell et al., 2013; Wan et al., 2012). This study and its results provide valuable implications as they are successful in identifying areas with limited spatial accessibility to mental health care that require attention from health care decision-makers when considering the location of additional mental health care services. The findings of this study can contribute significantly to strategic planning for the creation of additional mental health care facilities in the region. This study reinforces the suitability of geospatial analysis for the measurement of access to general and mental health care service within an urban context (Ngui and Vanasse, 2012). The results and methodology of this study would be useful for public health initiatives that seek to increase mental health service utilization among the most vulnerable populations in the City of Toronto, the spatial accessibility scores can be used directly to inform strategic planning for the creation of new mental health community services in underserved areas.

Study limitations

The study has a number of possible limitations, the first is that the analysis only measures potential spatial accessibility to mental health care, as a result the accessibility results do not account for a myriad of factors that may influence the use of mental health care services. Language and cultural barriers (Wang and Roisman, 2011), user preference (Fransen et al., 2015) and cost of access, and attitudinal barriers (Sareen et al., 2007) are factors that are important but exist beyond the scope of this research. Research by Sadavoy et al. (2004) and Fenta et al. (2006) have identified limited awareness and a lack of language-diverse services as systematic barriers to accessing mental health services among ethnic immigrant populations of Toronto. Other study

limitations relate specifically to the methodology: while the City of Toronto is bordered on the east, west and north boundaries with other municipalities travel to mental health care beyond the city boundaries are not accounted for. Furthermore, the use of mental health care services within the City of Toronto by populations residing beyond the boundary is not included in the analysis. These edge effects result in an underestimation or overestimation of accessibility scores in DAs on the extremity of the study area. There are several assumptions within the enhanced 2SFCA method analysis that require identification: the travel distances used in this analysis are chosen arbitrarily and assume that individuals are not willing to travel beyond five kilometres to access a mental health service. When combining the access scores by mode of transportation there is an assumption that the travel habits of employed adults above the age of 15 years reflect the travel preferences of the entire population. Additionally, family physicians are not included in this study, the omission of family physicians is dues to the lack of knowledge regarding which family physicians are equipped to adequately treat mental health patients effectively (Collins et al., 2006; Fleury et al., 2008). For both MH specialists and MH community service locations in the accessibility model, attractiveness and capacity for service are considered to be equal. In doing so, there is no differentiation between the capacity of care between mental health care services. Other studies in the past have utilized additional service data to successfully incorporate measurements of attractiveness into the accessibility analysis (Luo, 2016). A final limitation of this study is that major mental health crisis events as measured by the Toronto Police Service are used as the sole measure of mental health crisis, this is largely due to the unavailability of mental health status data at the dissemination area largely due to privacy conerns.

Recommendations and next steps

While this study has progressed spatial accessibility research within the City of Toronto, several questions remain to be resolved. One potential avenue for further research is the question of how levels of potential spatial accessibility to mental health care relate to perceived level of access to mental health care. Through the use of surveys, data could be collected to better understand this as well as the major non-spatial factors that prevent access to mental health services. Further studies are required to establish a refinement of model parameters, information such as mode of transportation preferences and travel distances could also be collected using surveys to better inform the model parameters used in spatial accessibility modelling for mental health care.

Additional data on family physicians that are able to provide adequate mental health care and attractiveness data for the mental health community services would greatly improve the quality of the spatial accessibility model. With access to data from the Canadian Community Health Survey, dissemination area level data on mental health status and access to and perceived need for formal and informal services and supports would be sufficient to serve this current data gap. To address the issues of edges effects, I would recommend the expansion of the enhanced 2SFCA to the Toronto CMA while still focusing on the City of Toronto for analysis and presentation of the results.

Conclusion

This study demonstrated that the spatial distribution of mental health services in the City of Toronto is uneven, with low levels of spatial accessibility to services outside of the downtown core. This research has revealed that patterns of potential spatial accessibility mental health community services and mental health specialists are spatially clustered. The spatial distribution of mental health act apprehensions by the Toronto Police Service in the years 2014 to 2016 are concentrated in the most densely populated areas of the city of Toronto. The results of bivariate statistical and spatial analysis indicate a very weak association between levels of spatial accessibility to mental health services to mental health crises incidents. Neighbourhoods were identified that are appropriate candidates for further research as they are relatively underserved in access to general and acute mental health care with high per capita rates of mental health crisis events. Further research will be required to compare these findings with a community-based survey that explore the use of mental health care services in the City of Toronto by the most vulnerable populations.

Appendices

Appendix 1. Selected variable list - Toronto 211 database

Variable name	Full variable description
Agency Name	Agency name
Site Postal Code	Postal code of service location
Description	Full description of the service
Latitude	Location latitude coordinate, decimal degrees
Longitude	Location latitude coordinate, decimal degrees
DD code	Service category

Appendix 2. Selected variable list – Canadian medical directory

Variable code	Full variable description
Doctor_Num	Unique Doctor ID
Mail_Posta	Mailing Postal Code
CMD_Activi	Active Status
Specialtie	Specialties
Current_Sp	Current Specialization

Appendix 3. Selected variable list – CensusPlus 2011 Dissemination Areas

Theme	Variable code	Full variable name
Demographics	POP_2011	Population, 2011
	POP_15U	Total population aged 15 years and over
	AVG_INC	Average household Income (Current Year $)
Mode of Transportation	CAR_DRIV	% Labour Force by Mode of Transportation | Car, truck or van – as a driver
	CAR_PASS	% Labour Force by Mode of Transportation | Car, truck or van – as a passenger
	WALK	% Labour Force by Mode of Transportation | Walked
	BIKE	% Labour Force by Mode of Transportation | Bicycle
	PUBL_TRNS	% Labour Force by Mode of Transportation | Public Transit
Other	AREA	Area in square kilometres*

Note: AREA variable is not an original variable, calculated in ArcGIS using Calculate Geometry

SUMMARY TABLES BY NEIGHBOURHOOD

Appendix 4. Density of mental health services, mental health specialists and population by neighbourhood

Neighborhood	Mental health service density (services per km^2)		Population density (people per km^2)
	Specialists	Community services	
West Humber-Clairville (1)	0.24	0.03	1,118.77
Mount Olive-Silverstone-Jamestown (2)	0.00	0.21	6,943.29
Thistletown-Beaumond Heights (3)	0.00	0.00	2,975.95
Rexdale-Kipling (4)	0.00	0.00	4,205.22
Elms-Old Rexdale (5)	0.00	0.29	2,913.69
Kingsview Village-The Westway (6)	0.00	0.00	4,278.97
Willowridge-Martingrove-Richview (7)	0.18	0.36	3,860.25
Humber Heights-Westmount (8)	0.00	0.00	3,718.22
Edenbridge-Humber Valley (9)	0.00	0.00	2,722.70
Princess-Rosethorn (10)	0.00	0.00	2,166.79
Eringate-Centennial-West Deane (11)	0.23	0.00	2,178.67
Markland Wood (12)	0.00	0.00	3,532.35
Etobicoke West Mall (13)	0.00	0.00	6,111.39
Islington-City Centre West (14)	0.49	0.25	2,342.37
Kingsway South (15)	0.00	0.00	3,692.68
Stonegate-Queensway (16)	0.50	0.00	3,096.29
Mimico (includes Humber Bay Shores) (17)	0.14	0.14	3,781.19
New Toronto (18)	0.00	0.00	3,156.69
Long Branch (19)	0.00	0.00	4,250.45
Alderwood (20)	0.00	0.00	2,389.55
Humber Summit (21)	0.13	0.00	1,567.55
Humbermede (22)	0.00	0.00	3,560.68
Pelmo Park-Humberlea (23)	0.00	0.00	2,199.83
Black Creek (24)	0.29	0.00	6,415.48
Glenfield-Jane Heights (25)	0.00	0.00	6,062.76
Downsview-Roding-CFB (26)	0.13	0.07	2,300.90
York University Heights (27)	0.15	0.30	2,089.91
Rustic (28)	0.00	0.00	4,766.19
Maple Leaf (29)	0.00	0.00	4,033.22
Brookhaven-Amesbury (30)	1.43	0.00	5,077.51
Yorkdale-Glen Park (31)	0.50	0.50	2,455.47
Englemount-Lawrence (32)	3.14	0.00	6,311.98
Clanton Park (33)	1.46	0.00	3,546.06
Bathurst Manor (34)	1.05	0.00	3,232.62

Westminster-Branson (35)	2.74	0.00	6,970.88
Newtonbrook West (36)	0.43	0.43	4,905.47
Willowdale West (37)	0.00	0.00	5,145.59
Lansing-Westgate (38)	0.19	0.00	2,757.58
Bedford Park-Nortown (39)	0.54	0.00	4,199.43
St.Andrew-Windfields (40)	0.41	0.00	2,441.24
Bridle Path-Sunnybrook-York Mills (41)	3.70	0.00	976.81
Banbury-Don Mills (42)	0.20	0.00	2,682.33
Victoria Village (43)	0.21	0.63	3,602.82
Flemingdon Park (44)	0.00	0.00	8,896.94
Parkwoods-Donalda (45)	0.00	0.00	4,638.38
Pleasant View (46)	0.00	0.00	5,354.86
Don Valley Village (47)	0.48	0.00	6,368.11
Hillcrest Village (48)	0.00	0.00	3,298.01
Bayview Woods-Steeles (49)	0.00	0.00	3,305.10
Newtonbrook East (50)	0.49	0.00	4,023.79
Willowdale East (51)	0.60	0.00	8,966.88
Bayview Village (52)	3.49	0.00	3,424.50
Henry Farm (53)	1.92	0.77	4,346.98
O'Connor-Parkview (54)	0.00	0.00	3,667.43
Thorncliffe Park (55)	0.00	0.00	6,146.39
Leaside-Bennington (56)	0.21	0.00	3,580.54
Broadview North (57)	0.00	0.00	6,780.59
Old East York (58)	0.00	0.00	3,942.31
Danforth East York (59)	6.88	0.00	7,664.63
Woodbine-Lumsden (60)	0.00	0.00	6,764.01
Taylor-Massey (61)	0.00	0.00	15,263.71
East End-Danforth (62)	0.00	0.38	7,887.22
The Beaches (63)	0.83	0.00	5,879.38
Woodbine Corridor (64)	0.00	0.63	7,345.86
Greenwood-Coxwell (65)	0.00	0.60	8,415.30
Danforth (66)	2.66	0.00	8,365.11
Playter Estates-Danforth (67)	3.27	0.00	8,344.15
North Riverdale (68)	2.24	0.00	6,838.97
Blake-Jones (69)	0.00	0.00	8,229.39
South Riverdale (70)	0.00	0.00	2,671.11
Cabbagetown-South St.James Town (71)	1.41	0.00	8,488.53
Regent Park (72)	0.00	1.54	15,410.39
Moss Park (73)	1.41	3.54	11,529.05
North St.James Town (74)	18.95	2.37	42,235.48
Church-Yonge Corridor (75)	26.39	6.60	20,780.41
Bay Street Corridor (76)	36.70	2.19	10,599.06
Waterfront Communities-The Island (77)	0.40	0.27	5,759.13
Kensington-Chinatown (78)	33.43	0.66	12,122.32
University (79)	64.82	4.27	5,543.40

Palmerston-Little Italy (80)	2.80	0.70	9,616.67
Trinity-Bellwoods (81)	1.16	0.00	9,712.54
Niagara (82)	11.66	5.83	6,893.24
Dufferin Grove (83)	0.00	0.72	8,255.95
Little Portugal (84)	0.00	1.65	9,950.26
South Parkdale (85)	0.00	0.87	9,212.99
Roncesvalles (86)	1.98	1.32	9,928.25
High Park-Swansea (87)	3.94	0.19	4,082.66
High Park North (88)	0.00	0.53	11,335.18
Runnymede-Bloor West Village (89)	1.25	0.00	6,024.11
Junction Area (90)	0.00	0.38	5,302.78
Weston-Pellam Park (91)	0.00	0.68	8,191.58
Corso Italia-Davenport (92)	0.53	0.00	7,272.04
Dovercourt-Wallace Emerson-Junction (93)	0.00	0.00	9,280.63
Wychwood (94)	1.79	0.60	8,347.73
Annex (95)	9.65	0.00	10,423.79
Casa Loma (96)	20.59	0.00	4,914.78
Yonge-St.Clair (97)	23.19	0.00	10,008.57
Rosedale-Moore Park (98)	5.19	0.00	4,460.11
Mount Pleasant East (99)	2.90	0.00	5,156.19
Yonge-Eglinton (100)	5.47	1.22	6,434.67
Forest Hill South (101)	1.99	0.00	4,827.23
Forest Hill North (102)	0.00	0.00	7,841.02
Lawrence Park South (103)	1.24	0.00	4,677.52
Mount Pleasant West (104)	10.35	0.74	21,142.93
Lawrence Park North (105)	2.64	0.00	6,399.81
Humewood-Cedarvale (106)	1.07	0.00	7,564.37
Oakwood Village (107)	0.00	0.00	9,483.23
Briar Hill-Belgravia (108)	0.00	1.09	7,827.41
Caledonia-Fairbank (109)	0.00	0.00	6,376.36
Keelesdale-Eglinton West (110)	0.00	0.00	6,214.24
Rockcliffe-Smythe (111)	0.00	0.00	4,346.51
Beechborough-Greenbrook (112)	6.04	0.00	3,560.56
Weston (113)	0.39	0.00	7,162.59
Lambton Baby Point (114)	0.44	0.00	4,050.89
Mount Dennis (115)	0.47	0.00	6,174.55
Steeles (116)	0.00	0.00	5,540.35
L'Amoreaux (117)	0.97	0.00	6,231.59
Tam O'Shanter-Sullivan (118)	0.00	0.00	5,033.57
Wexford/Maryvale (119)	0.10	0.00	2,643.50
Clairlea-Birchmount (120)	0.13	0.00	3,337.89
Oakridge (121)	0.00	0.00	7,245.47
Birchcliffe-Cliffside (122)	0.33	0.00	3,658.74
Cliffcrest (123)	0.00	0.00	2,211.27
Kennedy Park (124)	0.84	0.00	4,756.14

Ionview (125)	0.00	0.00	6,737.28
Dorset Park (126)	0.00	0.17	4,037.88
Bendale (127)	0.27	0.00	3,741.46
Agincourt South-Malvern West (128)	0.00	0.00	2,818.06
Agincourt North (129)	0.00	0.00	4,114.51
Milliken (130)	0.43	0.11	2,888.79
Rouge (131)	0.00	0.00	1,221.68
Malvern (132)	0.00	0.00	5,076.07
Centennial Scarborough (133)	0.00	0.00	2,405.61
Highland Creek (134)	0.00	0.00	2,495.84
Morningside (135)	2.10	0.00	3,071.94
West Hill (136)	0.10	0.10	2,761.28
Woburn (137)	0.00	0.49	4,318.67
Eglinton East (138)	0.00	0.00	7,084.95
Scarborough Village (139)	0.00	0.00	5,371.57
Guildwood (140)	0.00	0.00	2,585.73

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