Association Among Age, Sex, and Geographical Region with Health Care Utilization through the Ontario Telemedicine Network

by

Jessica Lowey

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Author's Declaration

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

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

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List of Abbreviations

APP= Alternative Payment Program

CA= Census Agglomeration

CCAC= Community Care Access Center

CIHI= Canadian Institute for Health Information

CMA= Census Metropolitan Area

CSD= Census Subdivision

FPA= Focused Practice Assessment

FP/GP= Family Medicine or General Practice

FY= Fiscal Year

HCU= Health Care Utilization

LHIN= Local Health Integration Network

MIZ= Metropolitan Influenced Zone

MMT= Methadone Maintenance Treatment

MOHLTC= Ministry of Health and Long Term Care

NR= North-rural

NU= North-urban

OHIP= Ontario Health Insurance Plan

OTN= Ontario Telemedicine Network

SD= Standard Deviation

SR= South-rural

SU= South-urban

VPN= Virtual private network

Chapter 1: Introduction/Overview

The Ontario Telemedicine Network (OTN) facilitates virtual health care services across all of Ontario. Founded in 2006, OTN has allowed patients to access specialized care that was once only accessible in urban settings.[1] The services that the services that OTN facilitates has impacted the health and quality of life of hundreds of thousands of residents in the province. It has been suggested that telemedicine decreases the patient's need to travel long distances to receive appropriate health care.[2,3] Traveling to medical appointments is time-consuming and poses many safety risks to those residing in Ontario, particularly for northern and rural residents.[2,3] Further, it can create issues of inequity (e.g., vehicle ownership), social disruption, and anxiety in the populations who must travel to seek health care. A lack of public transportation is another reason why patients and providers may choose to use telemedicine over in-person services.[4,5] The use of telemedicine services in the Ontario population is not well understood. Specifically, it is unknown how telemedicine service utilization varies between men and women, and among various age groups. It is also unknown how utilization rates within these age and sex groups differ by patient geography; and particularly in older adults, where there is growing familiarity and comfort with telemedicine technologies. To fill this knowledge gap, more research is needed to understand how telemedicine can be used to help older adults, especially those with chronic health conditions.[6] Thus, my thesis sought to determine what telemedicine services are utilized through OTN. More specifically, administrative billing data from April 2008 to March 2015 were analyzed to determine what age and sex groups are using telemedicine services most frequently and to further investigate these population utilization rates in a rural and urban context. This study is the first to examine the associations among age, sex and utilization of OTN services. The results show which OTN therapies were most sought out by Ontario patients in different age and sex groups and how

utilization rates vary by region and rurality. This study also examined whether telemedicine in Ontario is targeting particular demographics (i.e., if a clinical service area is being utilized by a particular age, sex, or regional group). Through dissemination and knowledge translation, this study hopes to inform rural, northern policy and decision-makers on the OTN utilization patterns of men and women in different age groups, and potentially providing justification on how funding resources should be allocated to improve the specialized health care services that are most needed in the community.

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Chapter 2: Background

2.1 Background Introduction

Chapter two provides background information on the challenges presented in the Canadian Health Care System, emphasizing the challenges present in rural and remote Canada. This chapter then introduces telemedicine: what it is, what services are available through telemedicine, and how telemedicine is to improve access to health care services to all people residing in its service area. Lastly, this chapter describes the Ontario Telemedicine Network and its contributions to the delivery of telemedicine services in the province of Ontario.

2.2 Challenges in the Canadian Rural Health Care System

Prior to the introduction of telemedicine technology and its benefits, it is important to describe barriers faced in rural communities, particularly within the rural health care system. This section will provide context and justification to why telemedicine was developed and what issues it aims to alleviate.

The health care that is available to people living in rural communities is unique and varies depending on degree of rurality (defined below), as well as the ability to access urban, regional health care centers.[1] Health care issues of concern by rural populations include, but are not limited to, physician recruitment and retention, the overall number of health care professionals (such as physicians, nurses, midwives, physiotherapists, dietitians, pharmacists, and psychologists), limited access to specialized health care, local facilities, aged equipment, support services, wait times, and travel required to access essential health care.

The definition of rural varies. For this thesis and review of the literature, the definition used will be Statistics Canada's definition: "A rural population is defined as a municipality residing outside

census metropolitan areas (CMAs) and census agglomerations (CAs)".[2] Census metropolitan areas, are defined as having a "built-up core population of at least 50,000 and a total population of over 100,000." Census agglomerations have a core population of at least 10,000, with a total population no more than 100,000.[2] Census subdivisions (CSDs) outside urban classifications (CMA and CA) are designated into one of four categories of metropolitan zones of influences (MIZ) that reflect their relationship with these metropolitan areas. These zones are labeled as strong, moderate, weak or no MIZ.[3] Strong MIZ include those CSDs with a "place of work flow (POW)" greater than 30%. Place of work flow represents the percentage of working population that commutes to a CA/CMA for work. Moderate MIZ include subdivisions with POW greater than 5%, up to 30%; weak MIZ are those CSDs with POW greater than 0%, up to 5% and no MIZ are those CSDs with a POW of 0% or suppressed (i.e., with a workforce less than 40 persons).[3]

As stated previously, there are many alternative definitions of rural based on the geographical area. Additional definitions of rural (based on geographical area) considered were: census rural (based on enumeration area codes); organization of economic co-operation and development (OECD) (based on census consolidated subdivision codes); Beale non-metropolitan regions (based on census division codes); and rural postal codes (based on Canada Post Geography).[4] The MIZ definition of rurality was chosen as this classification system takes into account commuting to larger urban centers. Because we are interested in defining rural as those areas that do not have quick, commuting access to specialized medical care services, we felt the definition of MIZ system would properly represent distance to large centres and therefore access to specialist medical care services.

A major health care issue faced by rural communities is the disproportionate number of physicians practicing in rural areas compared with central areas.[1] The Canadian Institute for Health

Information (CIHI) published a report in 2011 indicating that while approximately 20% of the population resides in rural Canada, only 14.6% of general practitioner/family physicians are in rural areas.[5] Further, in Northern Ontario, over 60% of all physicians were practicing general/family practitioners, while approximately 48% of physicians located in Southern Ontario were general/family practitioners.[6] Although there is a notable misdistribution of rural family physicians and rural Canadians, this skewed distribution is even more prominent for specialists practicing in rural Canada. Specialties such as emergency medicine, psychiatry, orthopedics, and obstetrics are predominantly located in urban centers.[1,7] Because of this, many people in rural areas must travel to a regional center to seek specialized care.

Specialty services require some form of infrastructure, access to facilities, equipment, and specialty trained staff, which may not be economically or logistically feasible for rural communities.[8] Data from Australia found that rural areas with population catchments of less than 10,000 appear to be too small to support the infrastructure for most specialty services and thus rely on resident primary care providers supported by specialist outreach services.[8] In contrast, larger catchment areas between 10,000 and 20,000 can support general surgeons; catchment areas of 20,000 to 60,000 can support resident specialist services in orthopedic surgery and pathology; centers with population catchment areas between 50,000 and 80,000 are large enough to include dermatology, emergency medicine, internal medicine, pediatrics, neurology, otolaryngology-head and neck surgery, palliative and rehabilitation services.[8]

In addition to infrastructure limitations, smaller communities face barriers around health care provider recruitment and retention. There is a large body of work on the factors that affect recruitment and retention of physicians. Factors often cited as contributing to poor physician recruitment and retention can be summarized into three broad categories: professional,

social/personal, and external/geographical factors.[9,10] Professional factors impeding recruitment and retention may include high perceived or actual workload and time spent on-call, less professional support, and fewer opportunities available for professional growth and development.[9,10] Personal/social factors include fewer opportunities (e.g., professional, educational, social) for oneself, spouses, family members (e.g., employment and fewer educational opportunities for children).[9,10] For instance, lack of quality amenities and schools for children, and employment opportunities for spouses and other family members may hinder physician recruitment and retention. Lastly, geographical factors contributing to physician recruitment and retention include overall living conditions in community, presence (and quality of) amenities and schools, social/recreational opportunities, safety, and access to rapid transport to urban centers.[10] These geographical factors can be positive factors to some and negative to others. For instance, some individuals may perceive typical rural, outdoor activities (e.g., hunting, fishing, and hiking) as a benefit of moving to these environments, while others may be indifferent to these activities or prefer activities that are more prevalent in urban, metropolitan communities (e.g., shopping, concerts, sporting events, theatres, museums). If a community experiences issues with health care professional recruitment and retention, it may lead to lower rates of health care service use, or stronger feelings around unmet health care needs among community members.

Individuals who use the health care system are more likely to feel their health care needs are being met. [11, 12] In 2014, 11.2% of Canadians aged 12 or older, or about 3.4 million people, reported that they did not receive sufficient health care when they felt they needed it.[13] When asked why, one-third of participants cited wait times as the reason.[13] For those who specifically require emergency care, long wait times are common, as there are only a limited number of qualified health care

professionals available to meet the needs of everyone. This is particularly true for those who reside in rural communities.[14, 15]

Longer waiting times for patients can in turn lead to health care professionals working longer hours to ensure all patient needs are met. Longer work days can lead to professional dissatisfaction and ultimately discontinuation of their practice in a rural community.[14] Long wait times are common in emergency care (minutes to days, especially in fly-in communities); inpatient rehabilitation (days), mental health services (days to months), residential and home care (days to months), diagnostic imaging (hours to days), and surgery (hours to years).[16-19]

2.3 Ontario Demographics

The large area and uneven distribution of the population across this geography has created health care disparities in sparsely populated geographical regions in Ontario—disparities that telemedicine has sought to address.

According to the 2011 census, there are approximately 13 million people living in Ontario.[20] The year 2011 was chosen because it lies midway between the 2008-2015 data years. This number reflects a provincial population growth of approximately 5.7% between 2006 and 2011, with a clear majority (98%) occurring within Ontario's 15 CMAs. Northern Ontario's population decreased between 2006 and 2011 and comprised 6.0% of the total provincial population based on the 2011 census findings.[20] This count excludes those who did not complete the census, which is estimated to be around 2.8% of the population (approximately 370,000 people).[20] Under-coverage is highest among young adult males between the ages of 18-34, especially in remote communities (e.g., First Nations communities).[20] There are 574 Census Subdivisions (CSDs) in Ontario. CSDs are geographical regions that correspond to municipalities, Indigenous reserves or unorganized

territories. The 2011 census, reported that over two-thirds (67.5%) of the Ontario population resided in the 25 most populous CSDs.[21]

According to 2011 census results, the median age of Ontarians was 44.0 years. With an increase in life expectancy and as baby boomers age, the fastest growth is occurring in the older age cohorts, specifically the '85 or over' followed by the '60-69' age cohorts. In addition, the youngest age cohort (age 0-14 years) continued to observe a proportional decline and now represents only 17% of the total population in the province.[22] The overall gender distribution in Ontario is relatively equal, with women marginally outnumbering men. There is a shift in gender distribution with age: there are substantially more women than men over the age of 65. Specifically, there is a 4:5 ratio of men to women in the '65 or older' age group and a 2:5 men to women ratio in the '90 or older' age group.[22] Based on the 2016 census, 2.8% of the Ontario population self-identified as Indigenous.[23] Fifteen percent of all self-identified Indigenous People in Ontario lived on reserves.[23] Of those residing on reserves, nearly all (99%) were First Nations. Most Indigenous Peoples of Métis (72%) or Inuit (82%) descent lived in urban areas.[23]

According to 2016 Ontario Census reports, 32% of working adults (25 to 64 years of age) had a university degree, 25% a college diploma, 6% a trade's certificate, 25% a high school diploma, and 10% had not completed high school.[24] These proportions slightly differed in the subsequent 2011 census reports; however, due to the voluntary nature of the Long Form National Household Survey, there may be a misrepresentation in the educational achievements reported. Although the findings of the 2011 National Household Survey should be interpreted with caution, the findings did show that urban centers tended to reflect those statistics observed in the 2016 census.

When compared with adults residing in urban centers, there is a larger prevalence of rural adults having only obtained a high school education or lower. For example, 20% of Ontario adult

residents from strong MIZ regions had reported their highest level of education to be less than high school.[25] In no MIZ regions, almost half of the adult residents (49%) indicated less than high school as their highest level of education. Lowest median income districts are found in rural areas and some city centers, whereas the highest median income districts are on CMA peripherals.[26] The proportion of Ontario adults that work and have an employment income decreases in those regions furthest from population centers. Based on 2011 census data, 70% of adults in remote (no MIZ) regions reported an employment income, compared with the 83% reported in urban, CMA/CA regions.[25] The highest education attained is correlated positively with the proportion of adults with an employment income. Average earnings as well as the percentage of full-time, full-year working adults in 2011 were higher in urban areas compared with rural areas.[25] Average earnings in urban regions were over $41,000 in 2011.[25] The average individual income decreased as the degree of rurality increased, with an average income of approximately $27,500 reported in remote, no MIZ Ontario regions.[25]

2.4 Clinical Telemedicine in Diagnosing and Treating Inhabitants of Rural Communities

Telemedicine attempts to mitigate the problems with equitable access to specialized health care shortages in rural populations. Telemedicine, sometimes more broadly referred to as telehealth or e-health, is the use of telecommunication to provide clinical health care to an individual in a different location from the health care provider.[27] Telemedicine can act as an alternative to and can augment in-person consultations. When introduced, the primary goals of telemedicine were to: improve underserved urban and rural health care by bringing urbanized primary, secondary and tertiary treatment to rural areas, diminish the need for patient transfer to distant regional centers, and provide physicians with education programs.[7] The long-term goals are to improve the health

outcomes of rural populations and to retain rural physicians by making them feel less professionally isolated.[7]

The ability to ease access to specialized care, through telemedicine, may diminish the effects of "distance decay," which describes the decrease in health care utilization (HCU) with increasing distance from regional centers.[43] Other issues that are resolved with telemedicine include reduced health care travel-related costs by limiting travel [7, 33, 38, 44, 48], and shorter wait times in the physician office.[7, 15, 38, 41] Lastly, telemedicine advances the technology available to rural health care professionals, which is important in recruiting and retaining physicians. Telemedicine technology may also reduce professional isolation felt by rural physicians and health care professionals.[7] For example, physicians and other health care professionals can use telemedicine technologies to initiate or enhance connection with an interdisciplinary team as a way to improve patient care, increase professional development and decrease feelings of professional isolation.

2.4.1 Drivers of Telemedicine Utilization

While the primary goal of telemedicine utilization is to improve health care in underserved areas, the need for telemedicine in such areas is overshadowed by other dimensions influencing access. Geographical influences of access and utilization include the ease of traveling to regional health care centers or facilities with telemedicine equipment.[28] Temporal influences of utilization include time required to receive the services and the perceived patient and provider costs associated with that allocated time to deliver medical services over telemedicine.[28]

The willingness of patients, providers and facilitators to use telemedicine technologies is a major driver for overall telemedicine utilization. In regard to patient demand driving utilization, one study found no evidence of uptake being driven by patient demand because public awareness of telemedicine is still minimal.[31] In cases when patients perceive telemedicine as positive and often

express disappointment that it is not more readily available, provider utilization and dissemination of telemedicine can be unexpectedly low.[28-30] Barriers to poor physician uptake of telemedicine include reimbursement, liability, technical challenges, and credentialing. [28-30] We know that provider interest is a key driver of telemedicine utilization.[31] In other words, future growth and adoption of telemedicine programs relies primarily on health care providers and their interest and acceptance of integrating telemedicine technologies into their daily practice. Although many health care providers are offered incentives to deliver care through telemedicine, these incentives alone may not outweigh the lack of provider interest and acceptance. Without a provider advocating for telemedicine, most patients will not have access to the services.

2.4.2 Telemedicine Services Available in other Jurisdictions

Several studies have examined the potential uses for telemedicine in both small and large-scale population settings.[27, 32-34] The most common uses for telemedicine are psychology, cardiology, dermatology, neurology, surgery and oncology, as these specialties are often not readily accessible in rural, underserved communities.[27] Telemedicine uses for cardiovascular-related illnesses include rural and remote monitoring of implantable cardiovascular devices, monitoring conditions such as hypertension and heart failure, and transferring ECG readings to specialized centers for interpretation.[32]

Psychiatric telemedicine has been shown to have positive results in the treatment of post-traumatic head injuries, depression, attention-deficit disorders, and eating disorders.[17, 33] Psychiatric telemedicine is also used for forensic and judicial purposes.[35] Psychiatry and other means of psychotherapy are rarely available in rural communities and telemedicine can be one way to bridge the gap, especially for individuals living with mental illness. [17, 33]

Intensive care (ICU) has also utilized telemedicine services and allowed health care professionals to make critical decisions using specialized equipment, bedside monitors, and microphones.[36] Tele-ICU has been associated with a significant decrease in ICU mortality and length of stay in the ICU.[36] Telemedicine can be used for diagnosing acute and chronic conditions in remote patients, through the transfer of diagnostic images, such as ultrasounds and echocardiograms, to regional centers, where specialists or sub-specialists can interpret the results.[37] Telemedicine technologies have been used to infer diagnoses of conditions such as sleep disorders[38], cardiovascular diseases[39], musculoskeletal injuries[37], pediatric neurological and congenital heart disorders[40], as well as acute trauma.[37]

Obstetrics is an important health care specialty that may not be readily available to women living in rural settings.[41] Pregnant and post-partum women travelling to seek obstetric care face difficulties and stressors such as fear of bad weather, costs for accommodations, separation from other children, and complications associated with travelling late in pregnancy.[41, 42] Fetal monitoring and prenatal screening can also be performed remotely using telemedicine technology through the transfer and interpretation of real-time ultrasound imaging by a specialist.[37] This further reduces the need to travel to regional centers to seek out the appropriate specialized care.[37]

Stroke is one of the leading causes of disability and death in Canada.[46] Strokes are treatable when intervention occurs immediately after the onset of a stroke. In rural areas, where there are no specialized stroke centers, appropriate treatment may not always be accessible.[47] To improve outcomes for rural stroke patients (particularly in ischemic strokes, caused by clots or blood vessel obstruction), rural hospitals began implementing telestroke systems. Telestroke allows rural hospitals to work with specialists at stroke centers to identify and treat stroke as well as determine if a patient transfer is required.[47] The safety and effectiveness of telestroke system treatment are

comparable to in-person stroke center treatment if treatment is given within three hours of having a stroke.[47]

Telemedicine technologies have substantial surgical applications. Telecommunication technology has provided telementoring, which allows for expert surgical mentors to watch remote surgeries and guide the remote mentee surgeon through the steps of the procedure.[48] This educational technique incorporates a spectrum of clinical events, including initial diagnosis, preoperative treatment, surgical interventions, and postoperative care. Telesurgery (or Robotic surgery), in contrast, allows for surgical interventions to be performed remotely with a surgical robot controlled by a distant, specialized operator.[49] Surgeons relay commands to endoscopes and robots, which in turn execute the desired surgical operations.[49] Implementing robotics to provide specialized health care remotely has been positively received by patients, caregivers, nurses and physicians.[40] It has been found to improve patient care, workload, job satisfaction and reduce the need for travel.[40] Both telementoring and telesurgery have been developed and implemented in gastrointestinal, urological, thoracic, gynecological and endocrine surgical interventions.[48] Telementoring is also widely used for vascular and neurological surgery.[48]

Telemedicine can also be used for monitoring and postoperative care. Telerehabilitation provides physiotherapy, speech pathology and occupational therapy for distant patients.[50] Telerehabilitation has been implemented for stroke,[51] chronic disease,[52, 53] orthopedic[54] and postoperative rehabilitation.[55] Telerehabilitation is currently presented as image-based (using videoconferencing) and sensor-based (using tilt switches, accelerometers, and gyroscopes to measure movement) rehabilitation.[50] More recently, virtual reality (VR) has been incorporated into rehabilitation practices. Rehabilitation specialists can manipulate VR to include rehabilitation concepts such as task repetition, feedback, and motivation to improve motor skills.[50] Lastly,

telemonitoring is the use of information technology to monitor a patient from a distant location. The purpose of monitoring varies widely, from home telemonitoring of chronic illness and disability, to monitoring of preoperative and postoperative patients.[56-58]

2.5 Telemedicine in Ontario: the Ontario Telemedicine Network

Founded in 2006, the Ontario Telemedicine Network (OTN) facilitates electronic communications between patients and providers, and among providers across Ontario.[59] OTN facilitates virtual care services across the province using a secure virtual private network. Health consultations take place within a designated OTN site, typically a health care facility (health center, hospital, nursing station, or long-term care facility) that is located within an hour's drive of the patient's residence.[44]

2.51 Clinical Services Currently Available over OTN

While the research conducted for this thesis focuses solely on the top therapeutic areas of care facilitated by OTN, there are an exceptional number of medical, educational and consulting services facilitated by OTN. Since its inception in 2006, the total number of services available has grown substantially. OTN facilitates two broad streams of services: patient care and professional development. OTN provides healthcare providers with opportunities for peer collaboration and professional development through a number of virtual services. The focus of this thesis is specific to the patient care services facilitated by OTN. There are three subdivisions of patient care: eConsult, eVisit, and eCare.[60] eConsult allows health care professionals to consult with specialists in 30 areas of care using a store-forward system.[60] For example, a physician residing in remote Ontario can send a patient's medical data over OTN's secure network to a clinical specialist practicing in an urban center. This specialist views these data and provides an expert opinion within days of receiving the information.[60] eVisit provides real-time video consultations between a patient and health care professional.[60] eVisit allows health professionals, in all therapeutic areas of care, across Ontario to connect with their patients to provide high quality care, reducing the need for patients to travel to access necessary care. The top therapeutic areas of care providing these eVisits include: Mental Health (defined as services provided by a general practitioner who specializes additionally in addiction medicine or mental health), Internal Medicine, Primary Care, Oncology, Surgery, Dermatology, Ophthalmology and Psychiatry.[61,62] Lastly, eCare provides electronic applications and devices to monitor patients, providing palliative and management care for patients at home.[60] This service allows patients, living with chronic illness or mobility issues to receive care from home, reducing the time spent in a hospital setting.[60]

2.52 Clinical Telemedicine Utilization over OTN

This next section describes the top clinical therapeutic areas of care facilitated over OTN. These clinical services are the main outcomes of interest in the research conducted for this thesis. The top therapeutic areas of care focused on for this research include: Family Practice or General Practice (FP/GP); Addiction Medicine (sub-category under FP/GP); Internal Medicine; Psychiatry; Dermatology; and Mental Health. A study recently published by O'Gorman et al. (2016) determined utilization rates of clinical telemedicine services through the Ontario Telemedicine Network.[63] Use of clinical telemedicine services, billed through OHIP are highest in urban areas that are geographically distant from Toronto, such as Thunder Bay, Ottawa, and Sudbury. The researchers found an 8-fold increase in patient visits facilitated over OTN from fiscal years 2008/09 to 2013/14.[63] In the most recent fiscal year investigated, rural patients comprised approximately 26% of the total clinical visits observed. When utilization rates per 1,000 people per year were calculated for each Ontario census subdivision, the mean utilization rate of OTN services was highest in rural (52% of total utilization) and urban Northern Ontario (32.1% of total utilization).[63] These rates were much higher than the mean utilization rates calculated in rural and urban southern geographical locations. This suggests that per capita use of clinical telemedicine services enabled by OTN is higher in locations distant from metropolitan areas.

When investigating what health care specialties are most utilized through OTN technologies, O'Gorman et al. found that addiction and mental health services make up the majority (63%) of services utilized through the OTN network.[63] This aligns with telemedicine being used largely to provide mental health service to those patients in underserved and remote communities globally.[64-67] Clinical health services that have also incorporated telemedicine into practice include internal medicine, oncology, renal/nephrology, surgery, pediatrics, obstetrics/gynecology, stroke, and

rehabilitation. While there are over 39 clinical, educational and consultation telemedicine services currently offered through OTN, much of the clinical activity through the OTN, as well as other Canadian telehealth services, is only generated through the activity of three or four clinical services. According to the 2010 Canadian Telehealth Forum Pan-Canadian Telehealth Survey, mental health, internal medicine, oncology and renal/nephrology services made up 87% of the total services sought out through virtual care in Canada.[68] These utilization patterns reflect those patterns observed in Ontario, with the addition of general and family medicine, also yielding high utilization rates through OTN services.[63] It is important to note that OTN facilitated visits contributes the largest amount of data to the Pan-Canadian Survey, and thus hold a greater weight than administrative data provided by other provinces.

Addiction and mental health services make up a large proportion of the total clinical services facilitated over OTN. Previously reported, mental health and addiction services over OTN, account for approximately 63% of the total OTN clinical services sought out by patients in Ontario.[63] In comparison, it is estimated that 10% of all health services sought out by Canadians are for mental health reasons.[69] With over half of all completed clinical sessions over OTN attributable to mental health and addiction services, there appears to be an access gap in mental health services that is adequately filled by telemedicine technologies. The feasibility of providing these clinical services over telemedicine is likely due to the nature of services provided. Mental health and addiction clinical consultations rarely require physical touch from a physician, and as a result, physicians do not need to be in the same vicinity as their patient to provide treatment. Especially for physicians providing addiction medicine services such as MMT, there are huge, profitable incentives associated with integrating telemedicine technologies within their practice. While only 10% of total health care services are specific to mental health and addiction, statistics estimate that 20%

of all Canadians will personally experience mental illness at some point in their life.[70] More specifically, the Canadian Chronic Disease Surveillance System: Mental Illness in Canada, 2015 reported that 14.6% of Ontarians sought out mental health services in 2009-2010.[71] For many Canadians residing in rural and remote areas, there is a shortage or absence of mental health and addictions services and providers.[39] In addition to the burden of travelling to seek out mental health treatment, the negative stigma surrounding mental illness is another key reason why patients living with mental illness may choose not to make face-to-face contact with a therapist.[39] With high patient satisfaction of tele-mental health services, these services have the potential to connect underserved populations living with mental illness, and improve the stigma associated with seeking professional help for one's mental illness.[39]

2.6 Health Care Utilization, by Sex

2.61 Sex vs. Gender Definitions in Research

There is much confusion about sex and gender terminology. The terms are often used interchangeably.[72] The administrative data analyzed for this thesis provided patient sex (as indicated on the patient's health insurance policy (i.e., OHIP) card). This section clearly defines sex and how it differs from gender, as sex is one of the main factors investigated in this thesis. Sex refers to biological differences: chromosomes, hormonal composition, anatomy and internal and external sex organs.[72] Sex is often categorized as a binary variable, based on typical male (YX) and female (XX) sex chromosomal makeup.[73] The common binary understanding of sex (male/female) is limiting and under represents the presence of genetic variations of sex chromosomes, including XXX, XXY, XYY, and X.[73] In contrast, gender describes the characteristics that a society or culture define as masculine or feminine. While male and female sex distinctions are a biological fact spanning across cultures, gender and gender roles can be quite

different across varying cultures.[74-76] Gender roles can have a substantial influence on individual behaviour, specifically on dress codes, mannerisms, posture and ideations on what make us men and women.[74-76.] How gender roles can influence health care utilization is described later in this section.[74-76.]

While there is no specific information on sex utilization patterns of OTN services, there appear to be sex differences in Canadian health care utilization.[77] In a 2004 CIHI report, it was found that women were almost twice as likely to report the absence of a family doctor.[5] While this is true, it was also shown that women are more likely than men to report more frequent contact with a primary health care provider.[77] Older research shows that when compared with men, women use more physician services, have higher rates of acute illness, and require more reproductive care and long-term care over their lifespan.[78] In addition, the life expectancy of women in Canada is higher.[79] With a longer lifespan, women have more opportunity to seek out medical care. Although it is reported that Canadian women use health care services more frequently than Canadian men, the reasons for sex differences in health care utilization are not fully understood. In regard to contact with a general practitioner (GP), a study done in Denmark found that GP service utilization, in both men and women, was influenced by the presence of chronic morbidities, such as hypertension, diabetes, and angina pectoris as well as employment status.[80] The findings of this study found that a larger percentage of unemployed service users were female, while a larger proportion of male patients reported the presence of chronic morbidities.[80] While the higher presence of chronic health conditions would suggest that men would frequent GP services more so than women, it was instead found that women's use of services pertaining to female reproduction factors, such as use of postmenopausal hormone replacement therapy and pregnancy, play a predominant role in the sex variations observed in GP service utilization.[80]

The sex differences observed in health care utilization are not solely due to reproductive and pre- and post-natal health concerns. As fertility diminishes in women, concerns related to menopausal health and general age-related health concerns often increase.[81,82] Prolonged exposure to sex hormones, such as estrogen, has been associated with an increased risk of uterine and breast cancer.[83] The decrease in circulating estrogen levels increases the risk of developing cardiovascular disease (CVD)[84] and osteoporosis which also increases the risk of falls and fractures.[85, 86] In addition, menopause is directly associated with symptoms that reduce women's health and quality of life.[87] This includes vasomotor symptoms such as hot flashes, which affect a great number of women over the age of 50.[87] To reduce these acute vasomotor symptoms, many women resort to hormone replacement therapies (HRT). In a study done by the Women's Health Initiative, women taking combination HRT, estrogen and progestin, had a higher risk of breast cancer, pulmonary embolisms and stroke.[88] The increased risk of these conditions and diseases could help explain increases in oncology, cardiology, surgery, osteology, and general practitioner services accessed through in-person and virtual consultations by older Canadian women. It is also important to note that poorer health and more chronic diseases are highly associated with advanced age. Since women have a greater life expectancy than men (and thus make up a larger proportion of the Canadian population), increases in medical services in the older female population is expected.

While the research conducted in this thesis is specific to sex and health care utilization, it is also important to identify how gender plays a role in health care utilization in Canada. This is important to note as there are social and economic gender constructs that could help explain the observed "sex" differences in health status and health care utilization in Canada. The Public Health Agency of Canada found that education and income are important determinants of health and use of health

care services.[89] Specifically, women with lower education and income were more likely to report being smokers, overweight and living with conditions such as hypertension, diabetes and mood disorders than those women who have obtained university degrees or have a high household income.[90] Women with a lower socioeconomic status (SES) were also less likely to self-report favourable physical and mental health and less contact with a health care provider within the last year.[91] Higher rates of hospitalization have also been reported in women who are of lower SES.[90] While these trends are also present in men, the relationships were found to be stronger in women.

Some published studies and commentaries attempt to explain why men utilize medical services less than women. Men have a shorter life expectancy than women in Canada.[79] Men are more likely than women to engage in high-risk behaviours, such as alcohol consumption, smoking, non-medical illicit drug use, and being overweight.[91, 92] While the first and second leading causes of death in men and women are the same, the third leading causes of death in men and women are unintentional injury and chronic lower respiratory disease, respectively.[93, 94] Chronic illness and disease require more medical services than sudden death due to unintentional injuries. In addition, suicide was the seventh leading cause of death in males for 2013.[93] Among Canadians, regardless of age, four of every five suicides are male.[95] Higher suicide rates in men could be attributed to men seeking out less mental health care than women. Lower mental health service utilization in men can be due to several reasons including beliefs of masculinity and 'gender norms', negative stigma and stereotypes, and alternative coping mechanisms, such as substance abuse and violence to mask emotional problems.[95,96]

2.7 Health Care Utilization, by Age

In addition to patient sex, this thesis focuses on patient age, the medical care sought out by different age groupings over OTN and what factors are contributing to these utilization variations.

In 2014, data from the Canadian Community Health Survey indicated that unmet health care needs were lowest for those aged 12 to 19 and those aged 65 or older.[13] Rates of unmet health care needs were highest for those aged 20 to 54. Women were also more likely than men to report health care needs not being met.[13]

2.71 Youth Health Care Utilization

When looking at how health care is used by youth aged 12-24, researchers in Nova Scotia found that females within this cohort generally used health care services more frequently than males.[97] Youth from lower SES areas showed trends of lower utilization of general/family practitioner services, but higher utilization of specialized outpatient, emergency and acute inpatient services when compared with those youths from higher SES areas.[97] It was also found that, when compared with urban youth, rural youth used general/family physician, and emergency services less frequently, while specialized services were more frequently used. Health care in the areas of maternal diagnoses, mental health, diabetes and cancer comprised much of the services sought out by youth in Nova Scotia.[97]

2.72 Health Care Utilization in Older Adults

Many studies and reports published globally support findings that indicate health care service utilization rates tend to be highest for those patients aged 65 years or older.[98-101] Specifically, while only 15% of the Canadian population is made up of adults aged 65 years or older, 45% of national health care budgets are consumed by patients in this age group.[102] Age is significantly associated with health status, and the risk of ill health and disability increases with age. In 2006, 33% of Canadians aged 65 or older and 44% of Canadians 75 years of age or older were living with a disability.[98] Researchers in the United States have estimated that 20% of all adults are living with at least one chronic illness.[103] Among these, 80% are over the age of 65.[103] Chronic illnesses, such

as cancer, cardiovascular disease, chronic lower respiratory diseases and diabetes, impact the quality of life among those diagnosed and short-term or long-term hospitalization is often required for these individuals. Because of increasing rates of disability and chronic disease, the demand for health services is expected to increase as Canada's population ages.

When investigating the specific utilization patterns of older adults, researchers at Sunnybrook Health Sciences Center in Toronto found that general/family practitioner visits comprised the greatest number of physician services for adults at least 65 years of age.[104] The oldest cohort, patients aged 85 or older, used GP services more than the youngest age group (65-69 years of age).[104] Specialized health care services were the second most utilized service, particularly in men in the 75-84 age groups.[104] Among the study participants, an average of 7.7 chronic health conditions per patient was reported, with women having slightly more chronic health conditions than men.[104]

2.8 Summary

Rural and remote health care service and provider availability is limited, especially when compared with urban, regional centers. The introduction of telemedicine has been shown to improve health care service access for those residing in underserved and remote regions, particularly improving access to physicians who primarily, or solely, provide specialty services within large, urban centers. Currently, there is a gap in the research literature: does the demographic of patients utilizing telemedicine mimic the population trends present in general health care utilization?

More specifically, there is a great deal of information known about the unique utilization patterns with in-person care, it is unknown whether these patterns are also reflected in virtual, telemedicine service utilization. It is unlikely; however, because approximately two-thirds of the total health

services delivered through OTN are mental health-related services[63,105], which is not a reflection of the total proportion of health care accessed in Canada. In addition, it is important to determine what services are most frequently used by age and sex groups, as this knowledge will allow policy makers and stakeholders to prioritize programs and funds on developing the best virtual care services in the areas of care patients most frequently use.

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Chapter 3: Summary of Thesis

3.1 Justification for Study

There is a knowledge gap that currently exists around the patterns of telemedicine service utilization. It is well-documented that two-thirds of the total clinical health services facilitated through OTN are mental health-related services.[1,2] The demographic groups accessing these mental health-related services, in addition to other widely used clinical services, is not known. It is important to determine what services are most frequently used by age and sex groups, as this knowledge will allow policy makers and stakeholders to prioritize programs and funds on developing the best virtual care services in the areas of care that patients most frequently use. Further, it may also be meaningful to present the basic demographics of telemedicine users, as these variables may help to explain why these therapeutic areas of care are used most frequently and, conversely, what may be hindering service utilization.

3.2 Objectives

3.2.1 Primary Research Objective

My primary research objective is to determine the association between age, sex and health care utilization rates for services facilitated by the Ontario Telemedicine Network (OTN).

3.2.2 Secondary Research Objective

My secondary research objective is to determine if geographical region modifies the association between age, sex and health care service utilization.

3.3 Hypotheses

I hypothesize that health care service utilization through the OTN will be highest in the oldest age cohort, those individuals over the age of 65, followed by the middle age cohort (15-64) and lastly

the youngest age cohort (0-14). I also hypothesize that women will use telemedicine services more than men. Furthermore, stratification of the cohorts by the potential effect modifier, geographical region, will illustrate higher utilization rates within the older age cohort (aged 65 years or older) as well as the female age cohort, per 1,000 population in rural northern communities followed by rural southern communities.

3.4 Approach to Thesis

This thesis uses a manuscript-style layout to present the research results with the aim that the findings of this research will be disseminated in the form of journal publications. The next two chapters contain two manuscripts. Chapter four describes the utilization patterns of clinical telemedicine over OTN. Utilization patterns were described on an individual level (i.e. number of sessions per patient user) and on a population level (i.e. total counts and proportion of visits per 1,000-population) to determine the association between clinical telemedicine service usage over OTN and patient age, sex and regional sub-groups. Chapter five addresses the secondary objective, looking specifically at mental health and addiction services as the outcome of interest. Each manuscript includes a background, methods, results, discussion, and conclusion section. A comprehensive literature review was presented in Chapter two, and a general discussion is presented in Chapter six to discuss the findings and implications of both manuscripts.

3.5 Definition of Health Care Utilization

For the purpose of this thesis, two outcome measures were investigated. For chapter 4, the outcome was the number of visits participated in the population at risk (e.g., only female census data were used to calculate female utilization per 1,000-population at risk). For chapter 5, the outcome of interest was the number of visits per patient. The decision to measure different outcomes was to minimize redundancy in the two chapters. Furthermore, I felt it would be

beneficial to learn about how patient geography may influence the mean number of visits participated in by patients, especially in tele-mental health services facilitated over OTN, as many of these services have long wait times and are predominantly located in urban, metropolitan regions.

3.6 References

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Chapter 4: Characteristics and Utilization Rates of Clinical Telemedicine Patients

4.1 Abstract

Background: The Ontario Telemedicine Network (OTN) facilitates virtual health care services, specifically to those residing in rural communities where access to care is limited. This research explores the sex, age and regional characteristics of patients who have used OTN-facilitated clinical telemedicine services from 2008 to 2015.

Materials & Methods: A retrospective, population-based cohort study, using record-level administrative billing data and census data was employed. The study cohort includes all persons with an Ontario Health Insurance Plan (OHIP) claim covering medical services provided by medical doctors over OTN from April 1, 2008 to March 31, 2015. Health care utilization was determined from OHIP medical billing data with OTN listed as the service location. Specified medical service codes were organized into therapeutic areas of care and the top utilized specialties were reported. Univariate and descriptive statistics were used to determine sub-group distributions and proportions. Crude risk ratios were also calculated within each sub-group to compare utilization within region, age and sex groups.

Results: There were 913,329 completed patient sessions facilitated through the OTN from April 2008 to March 2015, providing care to 185,061 unique patients throughout the province. More females used mental health services (Risk Ratio (RR)= 2.08, 95% CI: 1.59, 2.74), and dermatology services (RR=1.46, 95% CI: 1.33, 1.61) when compared with males. When compared with individuals under the age of 25, those 65 or older were over 180 times more likely to use oncology services (RR=183.27, 95% CI: 105.41, 318.64) and 98% less likely to use addiction medicine services (RR=0.02, 95% CI: 0.01, 0.04). While not as pronounced, those 65 or older were over 12 times more likely to use the "other" services (RR=12.33; 95% CI: 9.53, 15.94) when compared

with individuals under the age of 25. Consistent with previous literature, the number of completed visits billed in all specialty services per 1,000-persons at risk was highest among patients residing in rural Northern Ontario.

Conclusion: This study provides a detailed description of telemedicine use in Ontario by sex, age, rurality, and specialty. While the majority of completed patient sessions through OTN are related to addiction medicine, the findings of this study highlight the variability of telemedicine usage by sex and age across the province. Based on the findings presented, increased efforts and resources could be used to increase male use of tele-mental health services, such as psychiatry and mental health services. Lastly, the increased visit proportions in older adults using therapeutic areas of care contained within the "other" category may warrant further research to determine which additional services are utilized by this age cohort.

4.2 Introduction/Background

Equity in access to necessary and appropriate health care services pose a major challenge to health care systems worldwide. Factors such as the ratio of health care professionals to patients, type of services available (i.e., urgent/non-urgent; specialty/general), wait times, and travel distance to care significantly impact health care access.[1,2] These issues are especially apparent in rural and remote regions where there are fewer practicing physicians relative to community members when compared with urban, metropolitan centers.[1,3-5] One major factor contributing to lower proportions of physicians practicing in rural and remote communities is the absence of resources and infrastructure necessary to support many specialized physicians.[6,7] Specialties such as emergency medicine, psychiatry, orthopedics, and obstetrics are predominantly located in urban centers.[2,8] Because of this, rural and remote residents must travel to regional centers to receive specialized care.[9,10]

Telemedicine attempts to resolve the problems with specialized health care shortages in rural populations. Telemedicine, sometimes more broadly referred to as telehealth or e-health, is the use of telecommunication to provide clinical health care to an individual residing in a location different from the health care provider.[11] It acts as an alternative to in-person consultations. When introduced, the primary goals of telemedicine were to improve rural health care by bringing urbanized primary, secondary and tertiary treatment to rural regions, diminishing the need for patient transfer to distant regional centers, and providing physicians in rural areas with education programs.[8] The long-term goals are to improve the health outcomes of rural populations and to retain rural physicians by making them feel less professionally isolated.[8]

The use of telemedicine is not well understood. Specifically, there is a great deal of information that is needed regarding telemedicine and how it differs from in-person clinical care. Previous

research has shown that the delivery and quality of care through telemedicine and in-person care is comparable.[12,13] Systematic review evidence also suggests that patient and provider satisfaction and the physician-patient relationship in telemedicine is similar to in-person care.[14,15] While there is a great deal of information known about the utilization patterns and drivers of in-person care, it is unknown whether these patterns and drivers are also reflected in telemedicine services.

In Canada, health care services, such as telemedicine, are funded through provincial and territorial health care insurance plans.[16] Within these provincial divisions, secure, virtual networks have been created to host publicly-funded telemedicine services. Currently, the largest Canadian telemedicine network is in the province of Ontario. The Ontario Telemedicine Network (OTN) mediates virtual health care services across the province. Founded in 2006, OTN was created through the merging of three provincial telemedicine networks.[17,18] Not only is OTN the largest telemedicine network in Canada, it has also become one of the most extensive telemedicine networks in the world.[17,18] In line with the global objectives of telemedicine, standardized utilization of clinical telemedicine over OTN is highest in remote and rural regions that are medically underserved.[19] Mental health and addiction telemedicine services also comprise over half of all clinical services facilitated over OTN, which is in line with national utilization patterns of telemedicine in Canada.[19-21] Because OTN facilitates virtually all clinical telemedicine sessions between physicians and patients with provincially-funded health care in Ontario, studying the utilization of clinical services over OTN has the potential to provide important insight on telemedicine uptake in the Ontario population as well as other similar populations.

While previous research has been sufficient in determining where and how telemedicine services are utilized in Ontario, research has yet to investigate who is utilizing the services. Specifically, no study has explored how clinical services via OTN have increased virtual health care access

within various sex and age groups residing in Ontario. The aim of this research was to describe the patient user population accessing OTN-facilitated clinical services. To achieve this, utilization patterns were described on an individual level (i.e., mean number of sessions per patient user) and on a population level (i.e. total counts and proportions per 1,000-population) to determine the association between clinical telemedicine service usage over OTN and patient age, sex and regional sub-groups.

4.3 Methods

Secondary data analyses were performed on data from the Ministry of Health and Long-Term Care (MOHLTC). The data provided were obtained under a data sharing agreement between the MOHLTC and the Centre for Rural and Northern Health Research – Laurentian University, and accessed through a remote virtual private network (VPN). Patient health numbers were de-identified by the MOHLTC. Ethical approval was obtained from the Lakehead University and Laurentian University Research Ethics Boards.

4.3.1 The Ontario Health Insurance Plan (OHIP) Billing Database

In Canada, health care services, such as telemedicine, are funded through provincial and territorial health care insurance plans.[16] The Ontario Health Insurance Plan (OHIP) is the Ontario province's health care plan.[16] OHIP funds medically-necessary health care services including appointments with primary care physicians, visits to walk-in clinics and some other health care providers, emergency room visits, surgeries and medical tests.[16] Clinical telemedicine services were identified using OTN-flagged OHIP administrative data. Ontario billing records are an effective, timely way to measure fee-for-service programs, such as telemedicine.[22,23] Because physicians must submit a claim for each telemedicine service they provide, the OHIP database captures comprehensive information on the clinical sessions facilitated over OTN. The data provided by

the MOHLTC contained all provincial fee-for-service clinical appointments billed to OHIP from April 1, 2008, to March 31, 2015. The data provided by the MOHLTC includes: a unique anonymous patient identifier code; patient's age in years at time of service, sex, and residence code; the month and year of the visit; geographical location of the service; physician specialty; diagnosis code; type of diagnosis code and fee (billing) code to identify the therapeutic area of care.

4.3.2 Patient Geography

Patient residence codes were matched with Statistics Canada's Census Subdivisions (CSDs), and then grouped into south-urban, south-rural, north-urban, and north-rural. North Ontario comprised the areas of North East Local Health Integration Network (LHIN) and North West LHIN, and South Ontario comprised the remaining area of the province.[24] Urban and rural classifications were determined using the geographical boundaries defined by the Statistics Canada's Statistical Area Classification System.[25] Specifically, patient residence codes matched to CSDs that corresponded to metropolitan areas (CMAs) and census agglomerations (CAs) were classified as urban. All residence codes corresponding to CSDs outside these areas were classified as rural.

4.3.3 Data Inclusion/Exclusion

The study cohort includes all persons with an OHIP-funded OTN claim covering medical services (successful, cancelled, etc.) provided by medical doctors from April 1, 2008 to March 31, 2015. Only provincially-funded health services were included in these analyses. Because of these restrictions, individuals whose clinical telemedicine services are federally funded were excluded from this study. Populations federally-funded include Indigenous populations (First Nations, Inuit, and Métis), eligible veterans, refugee protection claimants, members of the Canadian Forces and Royal Canadian Mounted Police, as well as inmates of federal penitentiaries.[16,26] Although clinical

telemedicine services are readily available and frequently used in most First Nation communities, accurate utilization rates are not captured in OHIP billing data. To avoid underestimating the incidence, especially in rural regions, all CSDs classified as First Nation communities (n=145), housing approximately 1% of the total Ontario population (n=186,825), were removed from the numerator and denominator counts prior to analysis.

4.3.4 Therapeutic Areas of Care Available through Telemedicine over OTN

Each OTN visit creates two or more distinct OHIP codes: one telemedicine encounter premium code and at least one specified health service code. The telemedicine premium codes were used to identify completed visits, and the specified health service codes were used to determine specialty utilization. Using the *Schedule of Benefits: Physician Services*, health service fee codes were organized into the therapeutic areas of care defined by MOHLTC.[27] The specialties with the highest utilization were reported. The remaining specialties were grouped into an "other" category.

During analyses, two additional areas of care were created: addiction medicine services and mental health services. Addiction medicine services were defined as either a focused practice assessment (FPA) specific to addiction medicine billed by a family and general practitioner (GP/FP) with the appropriate training in addiction (including methadone maintenance) medicine, or a fee code corresponding to smoking cessation.[27] Mental health services were defined as all GP/FP-billed events specific to primary mental health care, psychotherapy, or counselling.[27] The surgery outcome variable included all billed fee codes corresponding to anaesthesia, general surgery, cardiac surgery, plastic surgery and vascular surgery specialties.[27]

4.3.5 Analyses

All data were analyzed using SPSS software, version 24.0.[28] Because OHIP administrative data are not structured for research purposes, data variables (patient age, sex and geography; OHIP fee code classification; month and year of appointment) were first restructured and coded prior to analyses. Specifically, residence codes were assigned into one of the four regional groups (i.e., south/north; rural/urban) recoded as a categorical variable. Patient age, at the time of the first recorded appointment, was examined as a continuous and categorically-transformed variable. All specific medical fee codes were re-coded into a categorical variable with nine unique groups: eight each corresponding to one of the top therapeutic areas of care and one corresponding to the remaining 28 areas of care available through OTN.

Total counts were determined for all completed clinical telemedicine visits, stratified by fiscal year and specialty service. Unique patient users were then identified to determine the total sum of users (and sum of patient visits per unique user), as well as the mean number (and standard deviation) of patient visits billed by physicians in each of the top clinical telemedicine specialty services.

Univariate, descriptive analyses were used to determine the distribution (counts) and proportion (per 1,000-patients) of telemedicine visits within patient sex, age group and geographic region categorical variables. Mean (and standard deviation) patient age was calculated for each speciality service area. Statistically significant differences in mean age were calculated using one-way ANOVA and the Tamhane post-hoc test for unequal variance.[45] Visit proportions were calculated by dividing the total number of visits within each of the top therapeutic areas of care by the total Ontario population at risk. This calculation included multiple visits per patient. The population data used to calculate proportions were obtained from 2011 Ontario Census data.[29] Negative binomial regression modelling was used to determine the main effects of patient sex, age sub-group and region on the number of completed telemedicine visits per patient.[46] An offset variable

was used to adjust for "population at risk" differences. This offset variable is the count of people (i.e., denominator data) in the specific age-sex-region category, using the 2011 Ontario Census data.[29] From the model, risk ratios (i.e., Exp(β)), with 95% confidence intervals, were used to compare utilization within subgroups.

4.4 Results

4.4.1 Descriptive Analyses of the Ontario Population

The Ontario census reported a total population of just over 12.8 million, excluding First Nations CSDs. Women comprise 51.3% of the population. The largest proportion of Ontarians were under the age of 25 years (30.3%), followed by 45 to 64 years of age (28.7%), 25 to 44 years of age (26.3%), and lastly ≥65 years of age (14.7%). The majority of Ontarians resided in Southern Ontario (94.2%; n=12,056,640), specifically in those regions defined as urban (84.9%; n=10,866,910). The north, rural-defined region had the smallest proportion of inhabitants, comprising two percent (n=233,820) of the total Ontario population.

4.4.2 Descriptive Analyses of all Complete and Incomplete OTN Visits

From 2008 to 2015, a total of 913,329 completed patient visits were billed through OHIP. In addition, there were 106,602 cancelled/ missed appointments, and 1,869 abandoned sessions due to technical difficulties. The number of completed telemedicine sessions increased by an order of magnitude from 2008/2009 FY to 2014/2015 FY (Figure 1). Within the top therapeutic areas of care, family practice and general practice (FP/GP) and internal medicine services had the highest number of recorded sessions during the 2008/2009 (n=7,183; n=4,383) and 2009/2010 (n=8,870; n=5,754) fiscal years, respectively. Addiction medicine had the highest total number of recorded

sessions, growing from 21,865 sessions during the 2010/2011 FY to 144,230 sessions during the 2014/2015 FY.

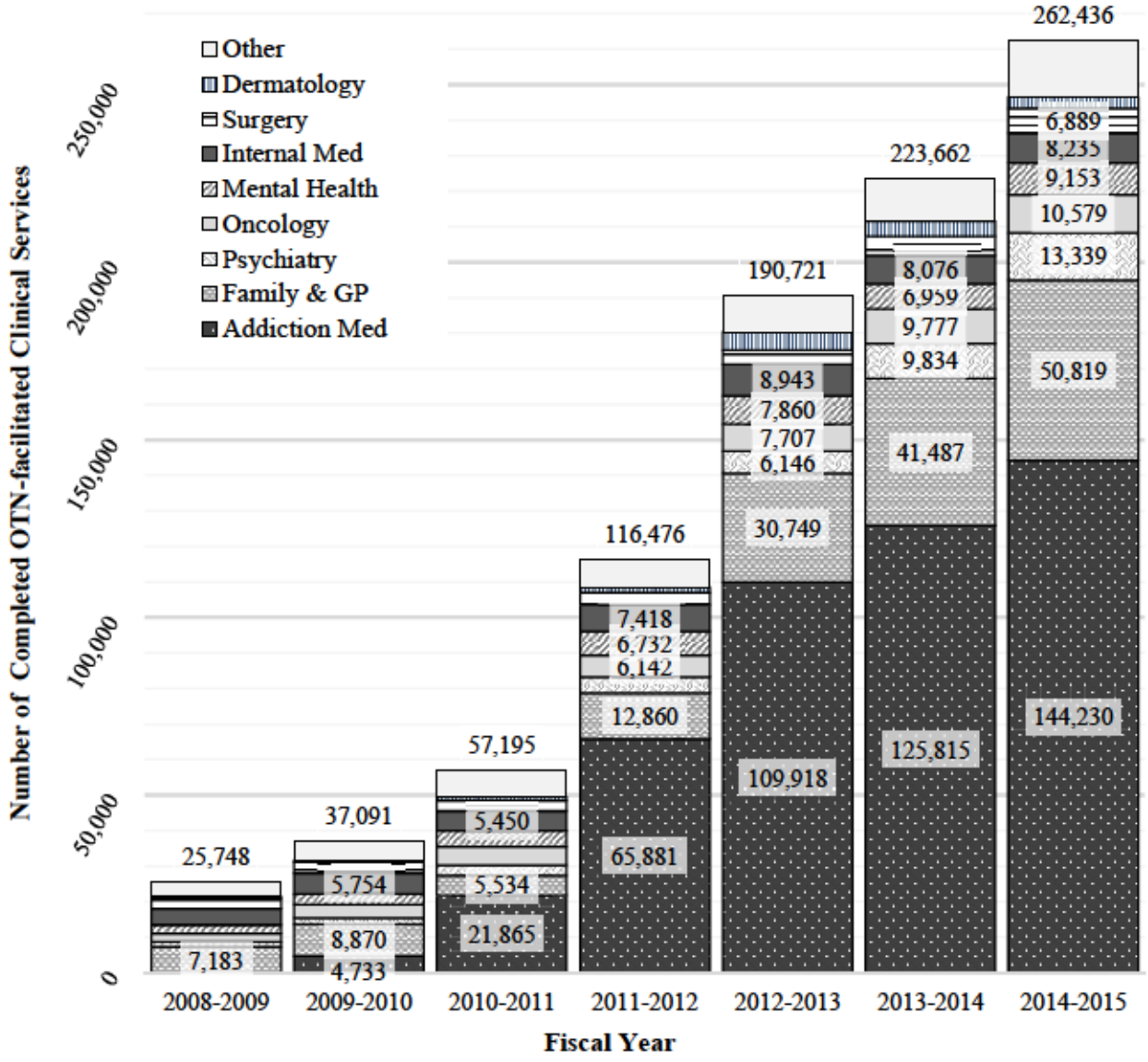

Figure 1: Number of clinical sessions facilitated over OTN from April 1, 2008 to March 31, 2015, stratified by top therapeutic area of care

As a whole, one visit per patient was most frequent, half of patients had 2 or fewer visits, and the maximum from April 1, 2008 to March 31, 2015 was 262 visits per patient (Figure 2). Almost all (94.20%) patients participating in dermatology telemedicine visits did so only once during the study period (Figure 3). In contrast, the vast majority (85.37%) of patients using telemedicine for addiction medicine participated in multiple visits during the study period. Of the specialties investigated, all but addiction medicine (median=12) and oncology (median=2) had a median of 1 visit per patient (Table 1).

Table 1: Therapy-specific descriptive (median, range, IQR) of OTN-facilitated physician-patient consultations from April 1, 2008 to March 31, 2015

	Median number of visits per patient	Range (Min-Max) number of visits per patient	Interquartile Range (25^{th} – 75^{th} percentile) of visits per patient
FP/GP	1	261 (1-262)	1 (1-2)
Addiction Medicine	12	165 (1-166)	29 (3-32)
Internal Medicine	1	42 (1-43)	1 (1-2)
Surgery	1	20 (1-21)	1 (1-2)
Oncology	2	63 (1-64)	4 (1-5)
Psychiatry	1	122 (1-123)	1 (1-2)
Dermatology	1	16 (1-17)	0 (1-1)
Mental Health	1	219 (1-220)	3 (1-4)
All Other Specialties	1	30 (1-31)	1 (1-2)

Note: Interquartile Range (IQR); Descriptive analyses based on the total number of completed sessions each individual patient user participated in within the top nine most common therapeutic areas of care

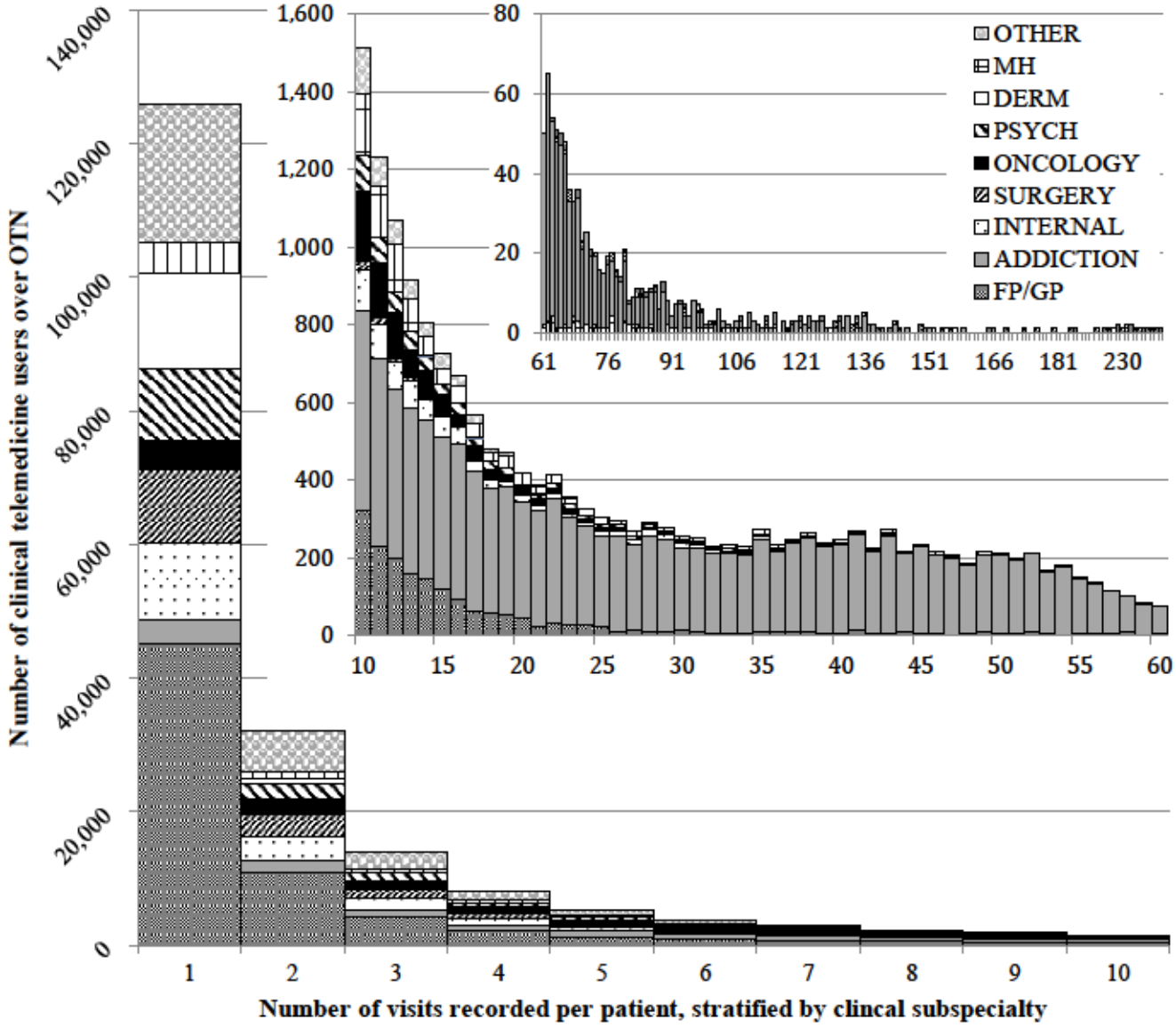

Figure 2: Total number of completed tele-mental visits per unique patient over OTN from April 1, 2008 to March 31, 2015, stratified by the top nine clinical therapeutic areas of care

Note: Family Practice and General Practice (FP/GP); Addiction Medicine (ADDICTION); Internal Medicine (INTERNAL) Psychiatry (PSYCH); Dermatology (DERM); Mental Health (MH); All other clinical subspecialties (OTHER)

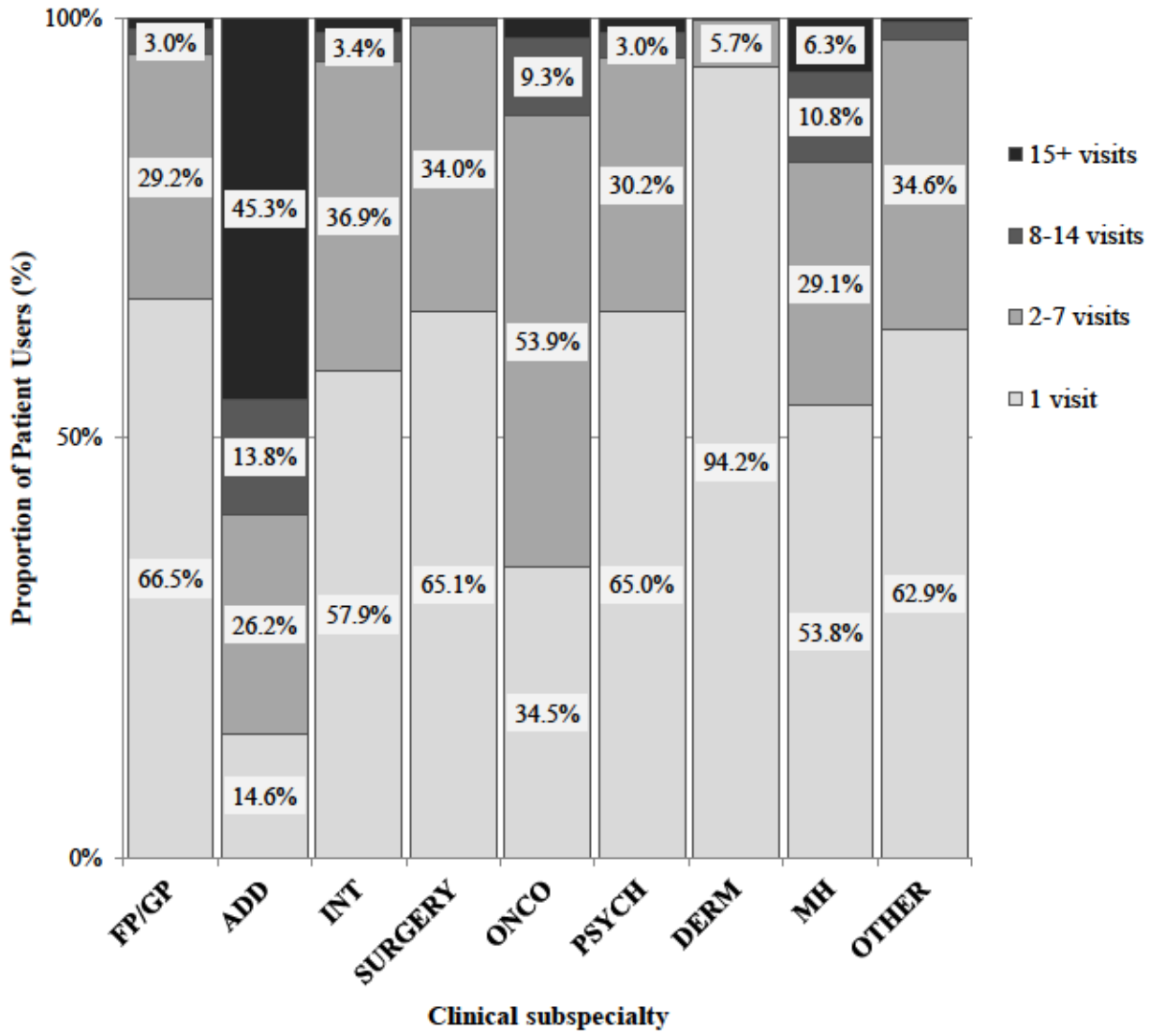

Figure 3: Utilization frequency of the top nine clinical subspecialty services by patients from April 1, 2008 to March 31, 2015

Note: Family Practice or General Practice (FP/GP); Addiction Medicine (ADD); Internal Medicine (INT) Surgery (SURG); Oncology (ONCO); Psychiatry (PSYCH); Dermatology (DERM); Mental Health (MH); All other clinical subspecialties (OTHER)

FP/GP services had the highest number of unique patient users, whereas addiction medicine services had the highest number of visits billed, as well as the largest mean and median number of visits per unique patient users (Tables 1 and 2).

Table 2: Therapy-specific population utilization counts of OTN-facilitated physician-patient consultations from April 2008 to March 2015

	Total N completed visits (% of total)	Unique Patient N[a] (Incidence proportion)[b]	Mean N of sessions per patient [c] (SD)
FP/GP	157,502 (17.2)	68,085 (0.53)	2.32 (6.16)
Addiction Medicine	472,442 (51.7)	24,457 (0.19)	18.60 (19.65)
Internal Medicine	48,259 (5.3)	19,757 (0.15)	2.44 (3.44)
Surgery	28,753 (3.1)	16,953 (0.13)	1.70 (1.38)
Oncology	45,776 (5.0)	12,372 (0.10)	3.69 (3.87)
Psychiatry	39,933 (4.4)	16,733 (0.13)	2.56 (4.93)
Dermatology	16,380 (1.8)	14,988 (0.12)	1.09 (0.54)
Mental Health	40,653 (4.5)	8,574 (0.07)	4.96 (9.72)
All Other Specialties	63,631 (7.0)	32,889 (0.26)	1.93 (1.94)

Note: Standard Deviation (SD); [a] Counts based on number of unique patient ID billed. Patients were only counted once within each specialty sub-category; [b] Incidence proportions based on 2011 census population data; [c] Average based on the total number of completed sessions each individual patient user participated in overall and within the top nine most common therapeutic areas of care

The greatest incidence of health care service visits per 1,000-persons was found in addiction medicine in both sexes, all four regions, and in the three youngest age groupings (Table 3). For those patients 65 years of age or older, the highest incidence of health care service visits per 1,000-persons was in oncology, followed by internal medicine.

Table 3: Total count and incidence (visits per 1,000-persons) of completed clinical telemedicine visits via OTN from April 2008 to March 2015, stratified by service specialty and patient characteristics

Characteristics		Completed Visits Count (Incidence per 1,000-population)[a]								
		FP/GP	Addiction Medicine	Internal Medicine	Surgery	Oncology	Psych-iatry	Derma-tology	Mental Health	All Other Services
Sex	Male	84,518 (13.55)	276,046 (44.24)	24,230 (3.88)	14,056 (2.25)	25,134 (4.03)	17,362 (2.78)	6,613 (1.06)	12,309 (1.97)	32,659 (5.23)
	Female	72,984 (11.12)	196,396 (29.92)	24,029 (3.66)	14,697 (2.24)	20,642 (3.15)	22,571 (3.44)	9,767 (1.49)	28,344 (4.32)	30,972 (4.72)
Age	≤ 24	32,861 (8.48)	96,136 (24.80)	2,278 (0.59)	1,292 (0.33)	312 (0.08)	10,564 (2.73)	3,743 (0.97)	2,214 (0.57)	3,673 (0.95)
	25-44	78,348 (23.24)	289,709 (85.93)	11,348 (3.37)	3,659 (1.09)	2,172 (0.64)	14,625 (4.34)	3,531 (1.05)	11,800 (3.50)	9,418 (2.79)
	45-64	36,683 (9.97)	85,111 (23.13)	20,619 (5.60)	12,445 (3.38)	16,026 (4.36)	11,709 (3.18)	5,023 (1.37)	21,869 (5.94)	23,565 (6.40)
	≥65	9,610 (5.12)	1,486 (0.79)	14,014 (7.47)	11,357 (6.05)	27,266 (14.53)	3,035 (1.62)	4,083 (2.18)	4,770 (2.54)	26,975 (14.38)
Region	South Urban	98,712 (9.08)	220,617 (20.29)	4,223 (0.39)	3,399 (0.31)	2,219 (0.2)	20,254 (1.86)	7,679 (0.71)	19,774 (1.82)	18,340 (1.69)
	South Rural	7,986 (6.71)	43,831 (36.84)	5,814 (4.89)	1,842 (1.55)	3,590 (3.02)	7,356 (6.18)	4,363 (3.67)	6,323 (5.32)	12,237 (10.29)
	North Urban	22,922 (45.20)	104,482 (206.01)	12,658 (24.96)	8,314 (16.39)	17,483 (34.47)	5,078 (10.01)	1,174 (2.31)	5,599 (11.04)	10,252 (20.21)
	North Rural	12,629 (53.93)	51,518 (220.02)	24,038 (102.66)	14,689 (62.73)	21,939 (93.69)	5,076 (21.68)	2,664 (11.38)	7,143 (30.51)	21,074 (90.00)
	Missing GEO[b]	15,253 (--)	51,994 (--)	1,526 (--)	509 (--)	545 (--)	2,169 (--)	500 (--)	1,814 (--)	1,728 (--)

Note: [a] Proportions based on 2011 census population data; [b] Missing GEO= patients that did not have a residence code included in billing information

Addiction medicine had the youngest patients, based on mean age, followed by psychiatry services (Figure 4 and Table 4). In contrast, oncology had the oldest patients, followed by surgery and internal medicine services.

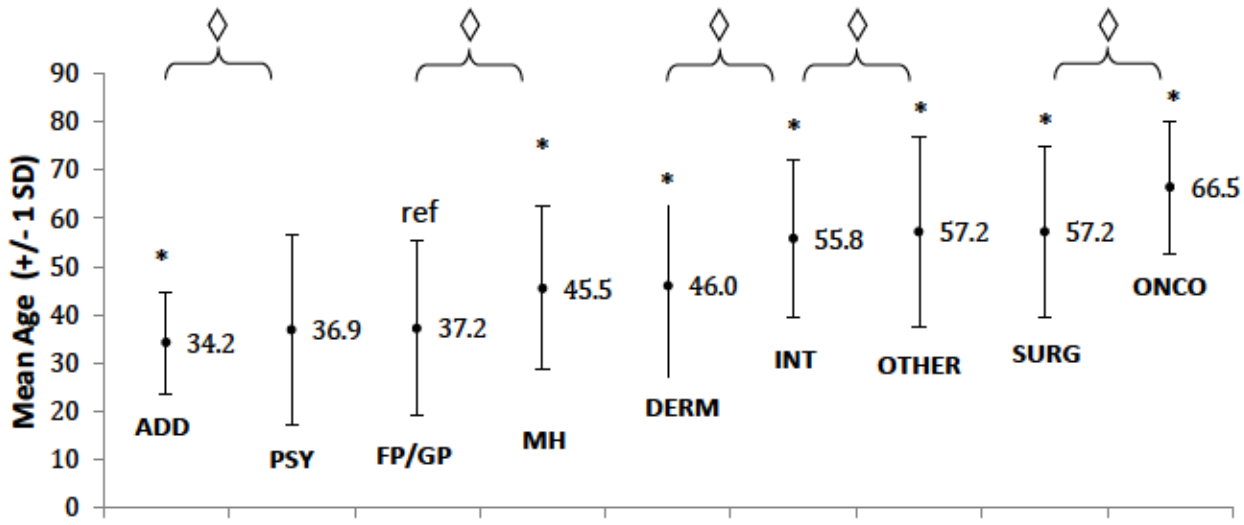

Figure 4: Mean Age (Standard Deviation) of patients participating in clinical telemedicine visits over OTN from April 1, 2008 to March 31, 2015 by service specialty

Note: Subspecialty differences in mean age determined with 95% confidence using Oneway ANOVA and Tamhane post hoc tests. Mean Age of FP/GP patients used as reference group (ref) to compare mean age across specialty groups;=Mean Age of specialty subgroup is different from the reference group at p<0.001; ◊ = Difference between groups is significant at p<0.001; Addiction Medicine (ADD); Psychiatry (PSY); Family Practice and General Practice (FP/GP); Dermatology (DERM); Mental Health (MH); Internal Medicine (INT); All remaining clinical subspecialties (OTHER); Surgery (SURG); Oncology (ONCO)*

Table 4: Median age and age ranges of patients participating in clinical telemedicine visits over OTN from April 1, 2008 to March 31, 2015 by service specialty

	Mean Age (SD)	Median Age (Min-Max Age)	Age IQR (25^{th} – 75^{th} percentile)
Addiction Medicine	34.2 (10.6)	32 (5 – 88)	26 – 41
Psychiatry	36.9 (19.8)	35 (2 – 98)	20 – 51
FP/GP	37.2 (18.0)	34 (0 – 102)	24 – 49
Mental Health	45.5 (16.9)	45 (3 – 97)	31 – 57
Dermatology	46.0 (23.6)	49 (0 – 102)	27 – 64
Internal Medicine	55.8 (16.3)	57 (4 – 103)	46 – 68
All Other Specialties	57.2 (19.7)	60 (0 – 102)	46 – 72
Surgery	57.2 (17.6)	59 (0 – 102)	48 – 70
Oncology	66.5 (13.7)	68 (0 – 99)	59 – 76

Note: Standard Deviation (SD); Interquartile Range (IQR)

Negative binomial regression models identified statistically significant risk ratios (RR) of use per 1,000 people in psychiatry (Female RR=1.33; 95% CI: 1.10, 1.62), dermatology (Female

RR=1.46; 95% CI: 1.33, 1.61), and mental health (Female RR=2.08; 95% CI: 1.59, 2.74) services facilitated over OTN, relative to males (Table 5). Using ≤24 years of age as the referent group, the greatest age-specific differences in RR were observed in oncology (≥65 RR=183.27; 95% CI: 105.41, 318.64), (45-64 RR=54.55 95% CI: 31.44, 94.62), and addiction medicine (≥65 RR=0.02; 95% CI: 0.01, 0.04) services. While not as pronounced, there was large age-specific differences in RR between the ≤24 years of age referent group and the ≥65 years of age group utilizing 'other' telemedicine services not specified (≥65 RR=12.33; 95% CI: 9.53, 15.94). Overall, when compared with the referent group (south-urban region), health care service visit incidence per 1,000-populations was greatest in north-rural regions, particularly in oncology (North-rural RR=561.64; 95% CI: 323.65, 974.62), (North-urban RR=189.11; 95% CI: 109.39, 326.93) and internal medicine (North-rural RR=265.27; 95% CI: 207.26, 339.51), (North-urban RR=68.10; 95% CI: 53.18, 87.21).

Table 5: Risk ratios and 95% confidence intervals comparing the main effects of patient sex, age grouping, and region on the incidence of visits participated in within the top nine clinical therapeutic areas of care: Ontario, April 1, 2008 – March 31, 2015

		Risk Ratio								
		FP/GP	Addiction Medicine	Internal Medicine	Surgery	Oncology	Psych-iatry	Derma-tology	Mental Health	All Other Services
Sex	Female	0.99 (0.79, 1.24)	0.77 (0.54, 1.10)	1.07 (0.90, 1.28)	1.06 (0.91, 1.24)	1.21 (0.81, 1.80)	1.33 (1.10, 1.62)	1.46 (1.33, 1.61)	2.08 (1.59, 2.74)	0.95 (0.79, 1.14)
	Male	1.00 (reference)								
Age Grouping (yrs)	≥65	0.72 (0.53, 0.99)	0.02 (0.01, 0.04)	11.42 (8.90, 14.65)	14.02 (11.23, 17.49)	183.27 (105.41, 318.64)	0.43 (0.32, 0.56)	1.83 (1.59, 2.10)	3.83 (2.58, 5.68)	12.33 (9.53, 15.94)
	45-64	1.09 (0.80, 1.49)	0.66 (0.40, 1.09)	9.28 (7.24, 11.89)	7.57 (6.06, 9.44)	54.55 (31.44, 94.62)	0.94 (0.71, 1.23)	1.20 (1.05, 1.37)	8.72 (5.88, 12.93)	5.61 (4.34, 7.23)
	25-44	2.66 (1.94, 3.63)	3.43 (2.08, 5.67)	6.29 (4.92, 8.04)	3.20 (2.56, 3.99)	8.49 (4.86, 14.82)	1.60 (1.22, 2.11)	1.07 (0.93, 1.22)	6.11 (4.14, 9.01)	3.11 (2.41, 4.01)
	≤24	1.00 (reference)								
Region	North Rural	8.01 (5.83, 11.02)	12.23 (7.36, 20.32)	265.27 (207.26, 339.51)	158.67 (127.23, 197.88)	561.64 (323.65, 974.62)	10.79 (8.19, 14.21)	15.55 (13.56, 17.83)	18.07 (12.29, 26.56)	51.66 (39.99, 66.72)
	North Urban	5.90 (4.31, 8.07)	8.53 (5.14, 14.14)	68.10 (53.18, 87.21)	43.41 (34.78, 54.18)	189.11 (109.39, 326.93)	4.61 (3.50, 6.08)	3.18 (2.77, 3.64)	7.27 (4.93, 10.72)	13.45 (10.40, 17.39)
	South Rural	0.82 (0.60, 1.11)	1.38 (0.83, 2.30)	10.72 (8.38, 13.72)	3.91 (3.14, 4.88)	13.97 (8.07, 24.17)	3.50 (2.66, 4.60)	5.00 (4.36, 5.73)	2.49 (1.69, 3.66)	5.28 (4.09, 6.80)
	South Urban	1.00 (reference)								

Note: Risk Ratio estimates obtained from negative binomial regression modelling the main effects of sex, age group, and region on the total number of visits participated in within the top nine therapeutic areas of care offered though telemedicine from April 2008 to March 2015; The offset variable adjusting for population at risk was based on 2011 census population data

4.5 Discussion

The total number of OTN sessions billed to OHIP from 2008/2009 to 2014/2015 Fiscal Year (FY), increased 10-fold, with different therapeutic areas of care experiencing differential growth. For instance, during the earlier 2008/2009 and 2009/2010 fiscal years, FP/GP and internal medicine accounted for nearly half of all telemedicine visits facilitated through OTN, forming 44.9%

(2008/2009) and 39.4% (2009/2010) of all billed sessions, respectively. In our dataset, service fee codes billed by a FP/GP specializing in addiction medicine were introduced in late 2009. By the end of the 2010/2011 FY, the number of billed addiction medicine appointments had tripled from the previous fiscal year to become the highest billed specialty service that year. Accounting for only 38% of all OHIP-billed sessions between 2010 and 2011, telemedicine appointments in addiction medicine have since accounted for over half of all billed sessions from 2011/2012 to 2014/2015.

Previous reports looking largely at OTN-facilitated telemedicine utilization have found an overwhelming majority of services specific to mental health and addiction services.[19,21] We found similar results in the total number of completed clinical telemedicine visits billed to OHIP. When focusing on the specific population using the services; however, our study found that FP/GP services had the highest number of unique patients, followed by addiction medicine, and internal medicine services. The high number of completed sessions billed per patient in addiction and mental health services can be explained by medical diagnoses and conditions that are being treated as well as the capacity of services that can be provided over telemedicine. For instance, most addiction medicine services are for patient visits corresponding to methadone maintenance treatment (MMT). There are only a small number of physicians who can prescribe methadone.[30] While initial dosages and dosing increases must be done in-person, MMT physician assessments during the stabilization treatment periods can be performed through telemedicine.[31] These appointments are frequent and can occur on a weekly basis.[31] A high frequency of addiction medicine visits provided over OTN was observed. Our study found that over half of all patients who used addiction medicine services over OTN participated in over seven visits (i.e., more than one visit per FY) over the seven-year study period. The integration of telemedicine technology in

addiction medicine allows for addiction-specializing FP/GP physicians to collaborate with rural and remote health care professionals and provide care to people with addictions.

In contrast, services such as tele-dermatology are largely performed using *Store and Forward*, where images are sent to a dermatologist who can provide professional recommendations, diagnoses and treatment plans for a patient.[32] Treatment plans can then be carried out by the local physician or nurse practitioner who initiated the telemedicine consult. In our study, almost all patients utilizing dermatology services over OTN did so only once during the seven year study period.

The greatest variations in per capita utilization were found in mental health services provided by a FP/GP physician: the proportion was 2.08 (95% CI: 1.59, 2.74) times greater in females than in males. Previous data collected by Statistics Canada shows that, in Canada, women report higher rates of mood disorders and generalized anxiety disorders when compared with men.[33] While these results are self-reported and do not ask whether individuals are seeking out medical care for a mental health disorder, these statistics may help explain the sex-specific medical care utilization patterns observed in our study. It is important to note that the rates of mental health-related disorders or illnesses are likely more equal between males and females than what self-reports show. For instance, recent findings from the Canadian Community Health Survey on mental health and well-being found that 10% of men experienced symptoms of the surveyed mental health disorders and substance dependencies, compared with 11% of women.[47] Higher female utilization in mental health services may be due to societal and cultural factors present in western societies that perceive mental illness as weak and non-masculine. Future research could focus on investigating the underlying factors and barriers contributing to the lower rates of mental health utilization over OTN in the male population.[47]

Oncology and surgery services available through telemedicine saw the oldest patients. The proportion of clinical oncology and surgery telemedicine visits billed per 1,000-population were 183 times greater and 14 times greater in patients 65 years of age or older than in patients under 25 of age years, respectively. These age variations could be largely due to the high prevalence of illness and disability in older adults, and the higher need for older adults to receive medical intervention provided by surgeons and oncologists.[34-39] In Canada, over 70% of all new cancer diagnoses are amongst individuals over the age of 60.[40] Just under half (49%) of all surgery-related hospitalizations in Canada are in patients over the age of 60.[41] Because these areas of care see high volumes of patients over the age of 60, it is not surprising that the mean patient age in these areas of care were higher than the other areas examined.

Addiction telemedicine services facilitated over OTN saw the youngest patients, with utilization peaking in the 25 to 44 years of age group. The proportion of clinical addiction telemedicine visits billed per 1,000-population was approximately 50 times greater in patients under the age of 25 than in patients 65 years of age or older. The proportion of clinical addiction telemedicine visits billed per 1,000-population was 3 times greater in patients from 25 to 44 years of age than in patients 25 years of age or younger. Our findings are reflective of national and global reports showing that addiction and substance abuse and treatment are highest in young adults, particularly those around the age of 25.[42,43]

As a whole, north-rural regions saw the highest proportion of clinical telemedicine visits per 1,000-persons. Regional (i.e., north versus south) variations (in per capita utilization) were most pronounced in oncology, internal medicine, and surgery, which are largely unavailable in smaller, rural communities. For instance, the proportion of oncology service telemedicine visits billed per 1,000-population was 561.64 (95% CI: 323.65, 974.62) times greater in the north-rural region than

in the south-urban region. These findings reflect previously published literature on Canada's telemedicine utilization.[19, 21]

Lastly, it is important to discuss the age group variations in proportion of clinical telemedicine visits contained within the "other" category per 1,000-persons. The higher visit proportions in older adults, 65 years of age or older, using therapeutic areas of care contained within the "other" category, when compared with the remaining three age groups suggest that there are a number of medical services offered through telemedicine that are serving the older adult population. Future analyses should be conducted to determine which additional services are utilized by this age cohort and the influence of patient sex and geographical region on the utilization of these older adult-driven medical services.

4.5.1 Limitations

The data used included only provincially-funded services. All federally-funded medical services were excluded from this dataset as utilization would have been underestimated. Thus OTN-facilitated patient visits of people living in First Nation communities were absent from our analyses. The exclusion of these populations likely resulted in an underestimation of the true utilization of clinical telemedicine services in the province, particularly in northern regions (i.e. where most First Nation communities are located). OHIP billing data provides a comprehensive data source that can be used to calculate telemedicine utilization rates within the remaining Ontario population. To be reimbursed for their telemedicine services, all physicians must use OTN and bill all clinical sessions as fee-for-service, with the possible exception of physicians who use alternative payment programs (APPs), such as salaries or hourly rates, and choose not to bill separately for telemedicine services. In Ontario, many physicians are paid through multiple payment models. In total, 99% of physicians practicing in Ontario received some payment through

fee-for-service and 56% received some payment through APPs.[44] Lastly, we used census data from the year 2011 to calculate incidence proportions of visits per 1,000 persons-at-risk. We assumed that the average Ontario population between 2008 and 2015 was roughly equal to the total and geography-specific population counts reported in the 2011 Census. This assumption may result in the over or underestimation of utilization.

4.6 Conclusions

The analyses presented in this paper provide a detailed description of telemedicine use in Ontario by sex, age, region and rurality. While the majority of completed patient sessions through OTN are related to addiction medicine, the findings of this study highlight the variability of telemedicine usage by sex and age across the province. Incidence of female visits per 1,000-persons was significantly higher for psychiatry, dermatology and mental health telemedicine services than male visits per 1,000-persons. Age differences were present in all clinical telemedicine services specialties studied, with the greatest differences observed in oncology (in favour of older adults) and addiction medicine (in favour of youth and young adults). North-rural regions saw the highest incidence of visits per 1,000-persons in all speciality areas studies, especially in oncology and internal medicine. Results provide insight for e-health networks, such as OTN, and local health networks on what services are being used and by whom. Based on the findings presented, increased efforts and resources could be used to increase male use of tele-mental health services, such as psychiatry and mental health services. Lastly, the increased visit proportions in older adults using therapeutic areas of care contained within the "other" category may warrant further research to determine which additional services are utilized by this age cohort.

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Chapter 5: Tele-Mental Health Visits vary with Patient Sex, Age, and Place of Residence

5.1 Abstract

Background: The Ontario Telemedicine Network (OTN) facilitates virtual health care services, specifically to those residing in rural and urban communities where access is limited. Of the clinical services used, over half are specific to mental health and addiction. Because providers of these services are predominantly located in urban, metropolitan centers, it is important to learn how service utilization by patient varies by region. This study aims to determine the association between patient age and sex and the number of OTN-facilitated tele-mental health visits per patient. The secondary objective was to determine how the associations of interest are modified by patient geography.

Materials: We conducted a retrospective, population-based cohort study, using record-level administrative billing and census data. The study cohort includes all persons with an OHIP-funded OTN claim covering tele-mental health services provided from April 1, 2008 to March 31, 2015. We used univariate and descriptive statistics to determine total visit counts, mean, and median number of visits per unique patient. Negative binomial regression modelling was used to determine the main effects and interactions between patient sex and age, and the number of patient tele-mental health care visits billed by physicians, modified by patient geographical region.

Results: In total, there were 46,002 Ontarians who participated in at least one tele-mental health consultation facilitated over OTN from 2008 to 2015, totaling 553,028 completed visits. The associations between age, sex, and number of tele-mental health visits per patient were modified by geographical region. While utilization trends were similar regardless of region, there was a greater increase in the number of visits billed per capita in the youngest male and female age cohorts, when compared with the oldest age cohort. In north-rural Ontario, the greatest risk ratio

(RR) was observed between male patients 25 to 44 years of age (RR=9.45; 95% CI: 7.81, 11.43), followed by females 25 to 44 (RR=8.52; 95% CI: 7.06, 10.28) and females under 25 years of age (RR=7.76; 95% CI: 6.34, 9.49) when compared with male patients 65 years of age or older (referent group). In contrast, the RR comparing these groups to the age-only referent group in southern regions showed the number of patient visits was greater in those 45 to 64 years of age when compared with those under the age of 25.

Conclusion: Patient geographical region modified the association among age, sex and tele-mental health service utilization. Overall, tele-mental health service use was driven by adults aged 25 to 44 years, for whom most visits were for addiction medicine. Future research could explore factors contributing to lower utilization in the youngest and oldest age cohorts and, if this is related to true underutilization, then develop and evaluate strategies to improve access and uptake of telemedicine services by physicians and underutilizing populations. Increasing equal mental health care access through telemedicine is crucial not only in Ontario, but in other areas worldwide afflicted by the growing demands to provide care for all those living with mental health and addiction disorders.

5.2 Introduction

Mental health disorders affect everyone, whether directly or indirectly, at some point in their lives.[1] In 2001, the World Health Organization estimated that 450 million people worldwide suffer from some form of mental or neurological disorder and that one-fourth will meet the criteria of a mental health disorder diagnoses at some point in their life.[2] The individual, societal and global burdens created by mental health disorders are significant. Past reports show that specific mental health-related disorders such as depression, drug and alcohol addiction (e.g., alcohol use), bipolar and panic disorders, and schizophrenia are among the leading causes worldwide of moderate and severe disability.[3,4]

The growing awareness and recognition of mental health and its associated disorders has resulted in increased demands for mental health services. This increase in demand has led to shortages of mental health services and providers. These shortages are even more prominent in rural and remote communities, where a lack of resources/infrastructure and low population catchment area make it challenging and unfeasible to permanently retain clinicians who specialize in mental health and addiction.[5] Thus, individuals residing in these communities must travel to urban centers to access these services.[5] In addition to the burden of travelling for treatment, the stigma surrounding mental illness is another key reason why patients living with mental health or addiction disorders may choose not to make face-to-face contact with a mental health professional.[5]

Tele-mental health was introduced in an attempt to improve access to mental health and addiction services for those patients in underserved communities globally.[6-9] Telemedicine, sometimes more broadly referred to as telehealth or e-health, is the use of telecommunication to provide clinical health care to an individual in a different location from the health care provider.[10] It acts as an alternative to or supplement to in-person consultations and has shown effectiveness in providing

services to individuals with mental health disorders.[11-12] The success of tele-mental health is largely due to mental health service providers relying primarily on verbal and nonverbal communications to treat patients, and not necessarily physical touch.

Because telemedicine technology can be easily integrated with mental health care, tele-mental health has become one of the most used telemedicine services today. In Canada, mental health and addiction services accounted for half (54%) of all clinical telemedicine appointments taking place between 2010 and 2011.[13] In the United States, mental health services and service providers have accounted for 70% to 95% of the total telemedicine-related insurance claims within the past decade.[14,15]

The Ontario Telemedicine Network (OTN) facilitates virtual health care services across the Canadian province of Ontario. Founded in 2006, OTN was created through the merging of three provincial telemedicine networks.[16] Between 2008 and 2014, OTN was able to facilitate over 650,000 clinical sessions, 63% of which were specific to mental health and addiction.[17] Today, OTN has become one of the largest telemedicine networks in the world.[18] The OTN's ability to facilitate a wide range of medical services over a vast geography provides opportunities for researchers, policymakers and stakeholders to learn more about how telemedicine is improving access to health care. This is especially true in the mental health field, where there is a growing demand for these limited services and providers. Learning more about who and how mental health services are used over OTN can lend positive insights into telemedicine usage trends in the Ontario population, and may generalize to similar jurisdictions with large rural, underserved populations.

Previous research shows that the greatest proportion of visits per capita are found in younger adults residing in rural, underserved communities.[19] While this is valuable information, it does not inform on the number and type of visits per patient, and whether or not the number of visits participated

in increases or decreases depending on the patient's place of residence. Thus, the purpose of this study was to determine the association between individual patient age and sex and utilization of tele-mental health services over OTN from 2008 to 2015. Additionally, we wanted to determine if the associations between age and sex and number of visits were modified by patient's place of residence.

5.3 Methodology

We conducted a retrospective cohort study using record-level, de-identified administrative data from the Ministry of Health and Long-Term Care (MOHLTC). The data were obtained under a data sharing agreement between the MOHLTC and the Centre for Rural and Northern Health Research - Laurentian University and accessed through a remote virtual private network (VPN). Ethical approval was obtained from the Lakehead University and Laurentian University Research Ethics Boards.

5.3.1 Ontario Health Insurance Plan (OHIP) Data

Clinical telemedicine services were identified using OTN-flagged OHIP administrative data. Ontario billing records are an effective, timely way to measure fee-for-service programs, such as telemedicine.[20,21] Because physicians must submit a claim for each telemedicine service they provide, the OHIP database captures comprehensive information on the clinical sessions facilitated over OTN. The data provided by the MOHLTC contained all provincial fee-for-service clinical appointments billed to OHIP from April 1, 2008 to March 31, 2015. The data provided by the MOHLTC included: a unique anonymous patient identifier code; patient's age in years at time of service, sex, and residence code; the month and year of the visit; location of the service; physician specialty; diagnosis code; and type of diagnosis code and fee (billing) code.

5.3.2 Patient Geographical Region

Patient residence codes were matched with Statistics Canada's Census Subdivisions (CSDs), and then grouped into south-urban, south-rural, north-urban, and north-rural. North Ontario comprised the areas of North East Local Health Integration Network (LHIN) and North West LHIN, and south Ontario comprised the remaining area of the province. Urban and rural classifications were determined using the geographical boundaries defined by the LHIN and Statistics Canada's Statistical Area Classification System, respectively.[22,23] Specifically, patient residence codes corresponding to metropolitan areas (CMAs) and census agglomerations (CAs) were classified as urban. All residence codes corresponding to CSDs outside these areas were classified as rural.

5.3.3 Mental Health via OTN

Each OTN visit creates two or more distinct OHIP codes: one telemedicine encounter premium code and at least one specified health service code. We identified all completed mental health-related service appointments facilitated over OTN from April 2008 to March 2015 using the specified health service codes. Using the Schedule of Benefits for physician services, health service fee codes were organized into therapeutic areas of care.[26] Of the ten most sought specialty telemedicine services, three are mental health-related: addiction medicine, psychiatry, and mental health services.[19] Addiction services were defined as either: 1) a focused practice assessment (FPA) specific to addiction medicine billed by a family or general practitioner (GP/FP) with the appropriate training in addiction (including methadone maintenance) medicine, or 2) a fee code corresponding to smoking cessation.[26] Psychiatry specialty services were defined as all events billed using psychiatry health service fee codes. Mental health services were defined as all GP/FP-billed events specific to primary mental health care, psychotherapy, or counselling.[26]

5.3.4 Data Inclusion/Exclusion

The study cohort includes all persons with at least one OHIP-funded OTN claim covering medical services from April 1, 2008 to March 31, 2015 in one of the three defined mental health areas of care. Demographic information at the time of first appointment was used for each patient.

Only provincially-funded health services were included in the OHIP data. The following federally funded populations were excluded from this study: Indigenous people (First Nations, Inuit, and Métis); eligible veterans; refugee protection claimants; members of the Canadian Forces or Royal Canadian Mounted Police; and inmates of federal penitentiaries.[24, 25]

5.3.5 Analyses

All data were analyzed using SPSS software, version 24.[27] Data variables (patient age, sex and geographical region; OHIP fee code classification) were re-coded before analyses. Using the unique patient identifier, total counts of completed patient appointments were summed. Univariate, descriptive analyses were performed on all categorically-transformed variables (therapeutic area of care, patient sex, age, and geographical region). Total number of unique tele-mental health users, total number of completed visits, and mean and median number of visits per patient within each group were calculated. Age was also analyzed as a continuous variable, with mean age and standard deviation presented. Incidence proportions were also calculated by dividing the total number of unique patients within each categorical strata by the total Ontario population at risk. The population data used to calculate proportions were obtained from 2011 Ontario Census data.[28] Crude means were also calculated describing the average number of tele-mental health visits per patient within each age, sex, and region strata.

Negative binominal regression modelling was used to determine whether or not patient geography modified the association between the number of tele-mental health visits and patient age and sex.[35] Model 1 assessed the main effects of age, sex, and region on the number of completed tele-mental

health visits per patient over OTN from April 2008 to March 2015. Model 2 included the main effects as well as the interaction terms for age, sex, and region. To determine if geographical region did modify the associations, we assessed the statistical significance of the interaction terms in the model using the negative 2 log-likelihood test.[36]

5.4 Results

5.4.1 Descriptive Information on Tele-Mental Health Patients

To avoid underestimating the incidence, especially in rural regions, all CSDs classified as First Nation communities (n=145), housing approximately 1% of the total Ontario population (n=186,825), were removed (from the numerator and denominator) prior to analysis. In total, 46,002 (3.59 patient users per 1,000-population) Ontarians participated in 553,028 completed mental health visits facilitated over the OTN from April 1, 2008 to March 31, 2015 (Table 1). Over half of all physician-billed tele-mental health services occurred during the last two fiscal years 2013/14 and 2014/15 (figure 1). The majority of completed tele-mental health visits were specific to addiction medicine (85.43%). Patients had a mean age of 37.3 years and just over half were male (53.5%). Approximately half of all patients (46.3%) were between 24 and 44 years of age. The majority of patients resided in Southern Ontario with 51% residing within south-urban and 13% residing in south-rural regions. Approximately 46% of patients (n=21,028) used only one of the three tele-mental health services, namely addiction medicine services, which comprised 67% of the total.

Table 1: Demographic Information of tele-mental health service users and total number of completed visits billed to OHIP from April 1, 2008 to March 31, 2015

Characteristics		Unique Tele-Mental Health Users (Incidence per 1,000-persons[b])	Total number of completed visits (%)	Mean number of visits per patient (SD)
Total N patients		46,002 (3.59)	553,028	12.02 (17.57)
Sex	Male	24,620 (3.95)	305,717 (55.3)	12.41 (17.67)
	Female	21,382 (3.26)	247,311 (44.7)	11.57 (17.46)
Mean Age (SD)	37.3 (16.2)			
Age Categories	0-24	10,477 (2.70)	109,865 (19.9)	10.49 (16.68)
	25-44	21,311 (6.32)	315,640 (57.1)	14.81 (18.79)
	45-64	11,277 (3.06)	118,238 (21.4)	10.49 (16.78)
	65+	2,937 (1.57)	9,285 (1.7)	3.16 (7.06)
Patient Geography	South Urban	23,505 (2.16)	260,425 (47.1)	11.08 (17.22)
	South Rural	5,942 (4.99)	57,510 (10.4)	9.68 (15.83)
	North Urban	7,213 (14.22)	115,141 (20.8)	15.96 (18.39)
	North Rural	5,655 (24.15)	63,694 (11.5)	11.26 (17.39)
	Missing	3,687 (0.31)	56,258 (10.2)	15.26 (19.40)
Type of Service [a]	Addiction Medicine	21,028 (1.64)	371,785 (67.2)	17.68 (18.20)
	Psychiatry	15,681 (1.22)	37,526 (6.8)	2.39 (4.61)
	Mental Health	5,639 (0.44)	33,222 (6.0)	5.89 (11.65)
	Multiple	3,654 (0.29)	110,495 (20.0)	30.24 (26.61)

Note: Age and Geographical Region of patient was based on information provided during the first visit; [a]*Number of patients who participated in addiction medicine only, psychiatry only, mental health only or multiple (Patients who participated in more than one of the tele-mental health sub-services);* [b] *Incidence proportions per 1,000 population-at-risk used 2011 census population data in the denominator.*

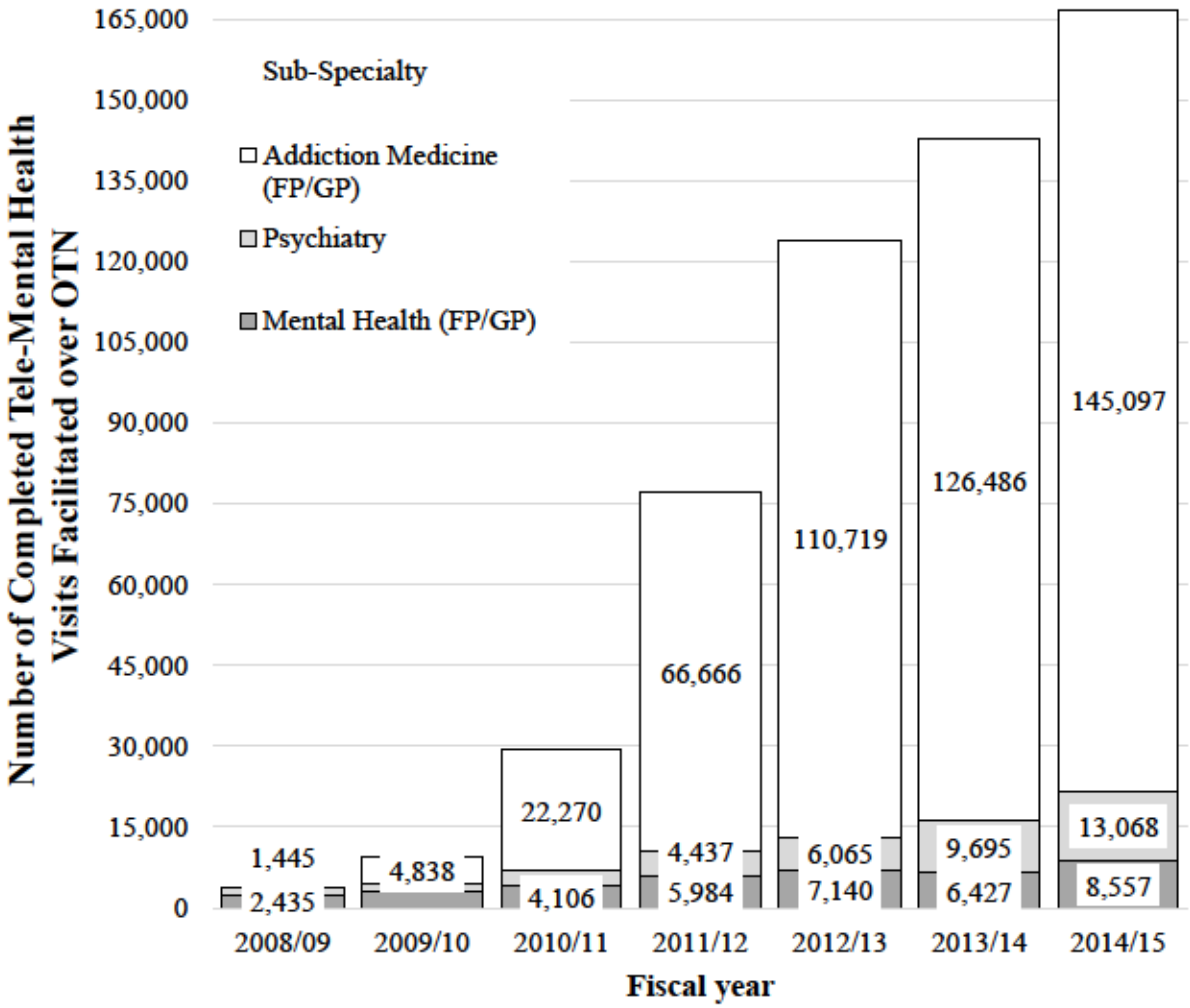

Figure 1: Number of tele-mental health sessions facilitated over OTN from April 1, 2008 to March 31, 2015

One-third of all patients (36.01%) had one completed tele-mental health visit billed to OHIP during the seven-year study period (Figure 2). Over one-third (37.89%) had seven or more completed visits billed to OHIP during the study period.

Of those who participated in at least seven tele-mental health clinical visits: 19.45% were under 25 years of age at the first time of visit, 56.81% were between 25 and 44 years of age; 22.06% were between 45 and 64 years of age, and 1.68% were 65 years of age or older. Of those patients

who had at least seven completed tele-mental health visits over the seven-year study period, Northern regions saw the greatest proportion of patients under 45 years of age: 81.21% in north-urban; 79.25% in north-rural; 74.22% in south-urban; and 73.17% in south-rural Ontario.

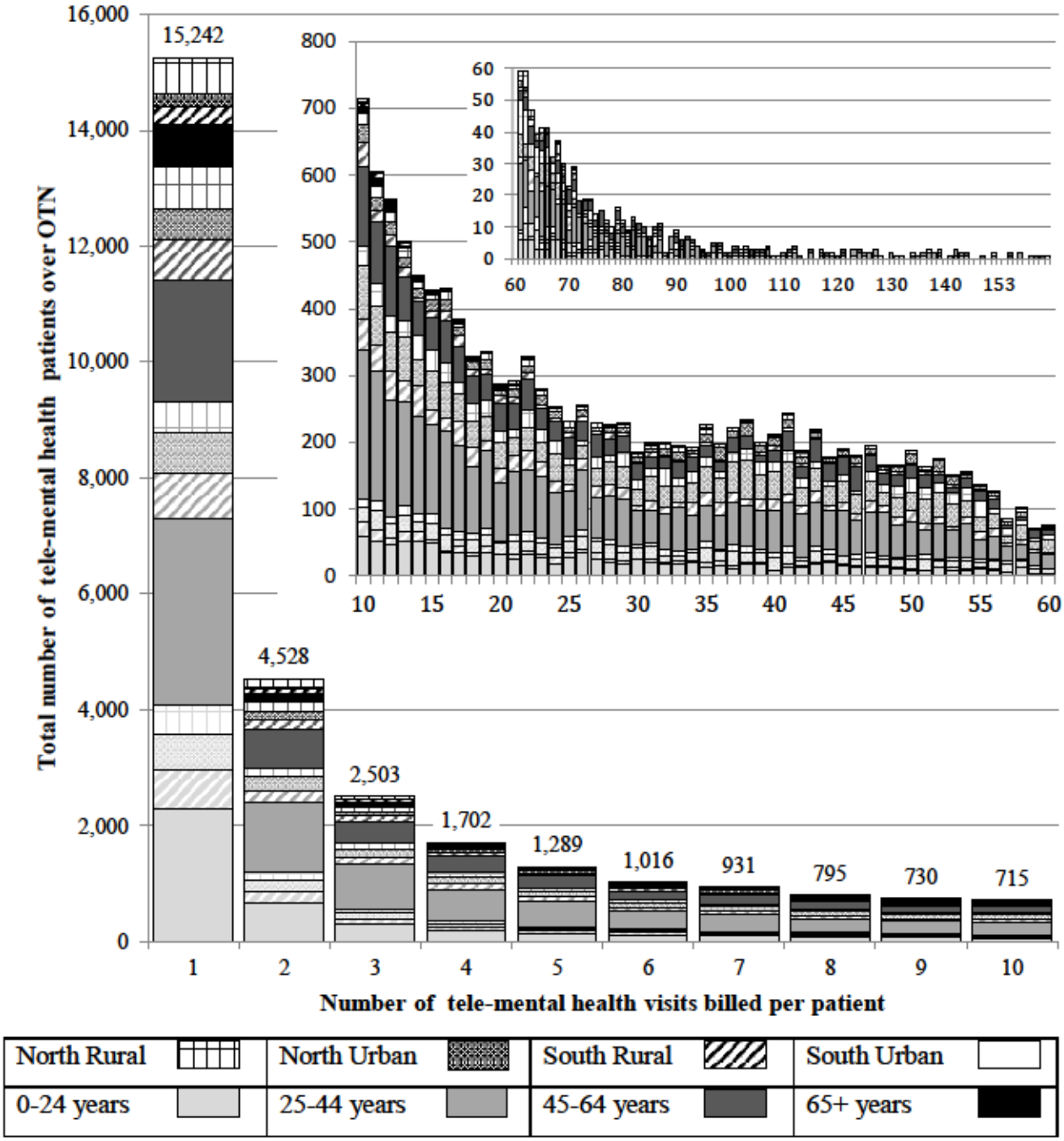

Figure 2: Total number of completed tele-mental visits per unique patient over OTN from April 1, 2008 to March 31, 2015, stratified by patient age group and region

The median number of completed visits per patient was highest among male patient users 25 to 44 years of age, followed by females within this age grouping (table 2) The lowest mean number of completed visits per patient was found in older adults 65 years of age or older.

Table 2: Median number (25^{th} – 75^{th} percentile) of completed clinical tele-mental health visits per patient over OTN calculated from April 2008 to March 2015, stratified by patient sex, age group and geographical region

		Median number of completed visits per patient (Q_1—Q_3)			
Age Grouping	Sex	Region			
		South-Urban	South-Rural	North-Urban	North-Rural
≤ 24	Male	2 (1 – 9)	2 (1 – 6)	3 (1 – 20)	2 (1 – 10)
	Female	2 (1 – 8)	2 (1 – 6)	7 (1 – 31)	3 (1 – 24)
25-44	Male	5 (1 – 19)	6 (1 – 23)	14 (3 – 35)	9 (2 – 29)
	Female	4 (1 – 16)	3 (1 – 15)	9 (2 – 34)	5 (1 – 28)
45-64	Male	3 (1 – 13)	2 (1 – 10)	7 (1 – 27)	2 (1 – 6)
	Female	3 (1 – 10)	2 (1 – 7)	2 (1 – 14)	1 (1 – 6)
≥65	Male	1 (1 – 2)	1 (1 – 2)	1 (1 – 2)	1 (1 – 2)
	Female	1 (1 – 3)	1 (1 – 3)	1 (1 – 2)	1 (1 – 2)

Note: Region (north/south; rural/urban classifications based on geographic parameters defined by the Local Health Integration Networks and Statistics Canada's Statistical Area Classification System; 75^{th} percentile (Q_3); 25^{th} percentile (Q_1)

The mean number of completed visits per patient was highest among male patient users 25 to 44 years of age, followed by females within this age grouping (table 3) The lowest mean number of completed visits per patient was found in older adults 65 years of age or older, particularly those residing in the rural, Northern Ontario region.

Table 3: Mean number (standard deviation) of completed clinical tele-mental health visits per patient over OTN calculated from April 2008 to March 2015, stratified by patient sex, age group and geographical region

		Mean Number of completed visits per patient (SD)			
Age Grouping	Sex	Region			
		South-Urban	South-Rural	North-Urban	North-Rural
≤ 24	Male	9.15 (16.04)	7.56 (13.96)	12.32 (16.17)	8.88 (13.99)
	Female	8.55 (15.92)	6.62 (11.77)	17.30 (19.68)	14.45 (19.37)
25-44	Male	13.63 (18.66)	14.81 (18.42)	19.65 (18.02)	17.60 (19.29)
	Female	12.54 (18.02)	11.62 (16.83)	18.17 (19.55)	15.87 (19.72)
45-64	Male	11.15 (17.40)	9.86 (17.02)	15.52 (17.71)	8.16 (16.08)
	Female	9.38 (15.24)	7.69 (15.26)	11.54 (17.36)	8.02 (15.48)
≥65	Male	3.24 (6.52)	2.71 (4.73)	2.58 (6.10)	1.86 (3.51)
	Female	4.37 (9.92)	3.45 (6.38)	2.94 (7.38)	2.66 (6.03)

Note: Region (north/south; rural/urban classifications based on geographic parameters defined by the Local Health Integration Networks and Statistics Canada's Statistical Area Classification System; Standard deviation (SD)

5.4.2 Patient Geography as an Effect Modifier of Individual Tele-Mental Health Service Utilization

All -2log likelihood (-2LL) scores were statistically significant ($p < 0.001$). However, the region-stratified model had smaller -2LL scores (95.1% decrease), which suggests a better fit to the data and that patient geography does statistically modify the associations observed between patient age, patient sex, and the number of tele-mental health visits per patient. When compared with the referent group (65 years or older, males), the greatest risk ratios (RR) were observed in patients residing in rural, Northern Ontario (Table 4). Specifically, the number of completed individual patient visits participated in by males and females 25 to 44 years of age were 9.45 (95% CI: 7.81, 11.43) and 8.52 (95% CI: 7.06, 10.28) times greater than the referent group in the rural region of Northern Ontario (table 4).

Table 4: Interaction effects of patient sex and age grouping on tele-mental health utilization in Ontario (stratified by patient geographical region) modelled using negative binomial regression: April 1, 2008 – March 31, 2015 (Model 2)

Model Term		β	Standard Error (β)	P value	Risk Ratio Exp(β)	95% Confidence Interval
Constant		1.177	0.078	< 0.001		
SOUTH URBAN						
Female	≤ 24	0.97	0.08	< 0.001	2.64	(2.23, 3.11)
	25-44	1.35	0.08	< 0.001	3.87	(3.30, 4.54)
	45-64	1.06	0.08	< 0.001	2.89	(2.45, 3.41)
	≥ 65[b]	0.30	0.10	0.003	1.35	(1.11, 1.65)
Male	≤ 24	1.04	0.08	< 0.001	2.82	(2.39, 3.32)
	25-44	1.44	0.08	< 0.001	4.20	(3.59, 4.92)
	45-64	1.23	0.08	< 0.001	3.44	(2.92, 4.04)
	≥ 65[b]	0	--	--	1.0	--
SOUTH RURAL						
Female	≤ 24	0.89	0.14	< 0.001	2.45	(1.87, 3.21)
	25-44	1.46	0.13	< 0.001	4.29	(3.31, 5.57)
	45-64	1.04	0.14	< 0.001	2.84	(2.18, 3.71)
	≥ 65[b]	0.24	0.16	0.13	1.28	(0.93, 1.75)
Male	≤ 24	1.03	0.14	< 0.001	2.79	(2.13, 3.66)
	25-44	1.70	0.13	< 0.001	5.47	(4.23, 7.08)
	45-64	1.29	0.14	< 0.001	3.64	(2.78, 4.78)
	≥ 65[b]	0	--	--	1.0	--
NORTH URBAN						
Female	≤ 24	1.90	0.11	< 0.001	6.70	(5.35, 8.39)
	25-44	1.95	0.11	< 0.001	7.04	(5.65, 8.78)
	45-64	1.50	0.12	< 0.001	4.47	(3.55, 5.63)
	≥ 65[b]	0.13	0.15	0.39	1.14	(0.85, 1.53)
Male	≤ 24	1.56	0.12	< 0.001	4.77	(3.81, 5.99)
	25-44	2.03	0.11	< 0.001	7.62	(6.11, 9.49)
	45-64	1.79	0.12	< 0.001	6.01	(4.78, 7.56)
	≥ 65[b]	0	--	--	1.0	--
NORTH RURAL						
Female	≤ 24	2.05	0.10	< 0.001	7.76	(6.34, 9.49)
	25-44	2.14	0.10	< 0.001	8.52	(7.06, 10.28)
	45-64	1.46	0.10	< 0.001	4.31	(3.53, 5.25)
	≥ 65[b]	0.36	0.12	0.004	1.43	(1.12, 1.82)
Male	≤ 24	1.56	0.11	< 0.001	4.77	(3.86, 5.89)
	25-44	2.25	0.10	< 0.001	9.45	(7.81, 11.43)
	45-64	1.48	0.10	< 0.001	4.38	(3.57, 5.36)
	≥ 65[b]	0	--	--	1.0	--

a. Female was used as the referent group for sex; b. ≥65 was used as a referent group for age

5.5 Discussion

Based on the -2 log likelihood tests comparing the aggregate and region-stratified interaction models, we found that patient geography statistically modified the sex and age variations in the number of tele-mental health visits observed, per patient, in the Ontario population. Regardless of region, patients between 25 and 44 years participated in the greatest number of visits, when compared with the remaining three age groupings. The referent group, males 65 years of age or older, had the lowest number of visits per patient when compared with all other age group and sex cohorts, with the exception of north-urban and south-rural regions where there was no statistically significant difference between male and female patients 65 years of age or older. Our multivariable analyses looked at tele-mental health as one broad service, which combined addiction medicine and mental health services provided by both FP/GPs and Psychiatrists. Our descriptive findings show that the majority of patients sought tele-mental health services specific to addiction medicine. When comparing our results with Statistics Canada reports, Statistics Canada reports show that addiction and substance abuse rates are higher in youth and young adults under the age of 45 and lower in adults over 45 years of age.[29] Higher prevalence in these populations may explain why these groups had a higher risk of tele-mental health service use.

In the south regions, the three youngest male age groups saw a greater number of visits per patient than females within the same age cohort. In north regions, particularly rural, Northern Ontario, these sex differences were not as prominent. Regional sex differences could be partially due to the types of mental health and addiction services being used by patients in the four regions. In Canada, male rates of self-reported substance abuse disorders are higher than female rates.[29] In contrast, women report higher rates of mood disorders and generalized anxiety disorders when compared with men.[29] While it cannot be confirmed in the parameters of this study, one reason for sex

differences in the number of patient visits billed regionally could be that addiction services require more visits per patient than other mental health services and are being sought more by south-residing male patients. Future research could benefit from further dividing tele-mental health services into several subservices (i.e., addiction medicine, psychiatry and mental health) to see if patient geography continues to modify the observed associations between patient sex and age, and the number of visits billed by telemedicine patient users.

Alternatively, research has shown that one significant reason why there are large regional variations in tele-mental health service use is the uptake of methadone maintenance treatments (MMTs), such as opioid agonist therapy (OAT), by patients residing in Southern Ontario.[37] While telemedicine was originally developed to service those residing in medically underserved rural and remote regions, telemedicine hubs are also being established in urban regions to increase the efficiency of specialized physicians to service multiple clinic locations. From 2008 to 2014, 78% of all patients who received OAT and/or received a mental health diagnosis via telemedicine resided in Southern Ontario.[37] Additional research also found that 77% of all patients who predominantly used telemedicine for OAT in 2011 and 2012 resided in urban Ontario.[38]

While the patient-specific factors described may help explain why there are sex and age variations in the number of visits per patient, it is likely that FP/GP or specialist (e.g., psychiatrist) uptake and acceptance, as well as availability of telemedicine technologies are contributing to the utilization rates of telemedicine services, such as tele-mental health.[39,40] Future research should first determine if these telemedicine-specific factors are confounding the age- and sex-variations observed before comparing our results to in-person mental health service utilization trends.

When looking at the interactive effects of age and sex on tele-mental health service use in patients under the age of 25, there was a higher mean and median number of visits by females, when compared with males residing in Northern Ontario. In contrast, sex differences in the number of visits were non-significant in patients under the age of 25 residing in southern regions. Future research could focus on determining what factors, if any, are contributing to the differences in male and female utilization of tele-mental health service usage, particularly in rural, underserved regions.

When examining age and sex utilization differences by region, the number of visits per patient was generally greater in northern regions, when compared with southern regions. Older adults residing in the Northern Ontario regions; however, had fewer visits per patient. In these northern regions, there was much more visits per patient for the 45 to 64 age group relative to the 65 years of age or older age group. In the north-urban region, male and female patients in the 45 to 64 years of age had a 6.0-fold and 4.5-fold higher number of tele-mental health visits per patient when compared with males 65 years of age or older, respectively. In contrast, in south-urban Ontario, male and female patients in the 45 to 64 years of age group had only 3.4-fold and 1.3-fold higher number of tele-mental health visits per patient when compared with males 65 years of age or older, respectively. In 2012, the Canadian Survey on Disability found that those who report mental health and addiction disabilities are, on average, younger than those who report other disabilities.[30] Although the study population is younger, there is still a significant number of older adults reporting mental health and addiction disabilities in Canada. Specifically, 66.2% of all reported mental health and addiction disabilities are amongst adults 45 years of age or older.[30] Compared with national reports, our results found that Ontarians utilizing OTN-facilitated mental health services are younger. Only one-third (30.9%) of tele-mental health service users (23.1% of all

visits) were at least 45 years of age. This could suggest that while older adults report higher incidences of mental health and addiction disability, they are less likely to seek out clinical care. Alternatively, our results suggest that tele-mental health services are more sought after by youth and young adults, whereas older adults and seniors may prefer to utilize in-person services. Future research and efforts could determine factors (e.g., stigma, culture, concurrent health disorders) contributing to higher and lower tele-mental health service use in older adults. Improving senior access to mental health services through telemedicine is important as the population continues to age, particularly in those residing in underserved and remote regions. It is also important to note that the reasoning for tele-mental health utilization (i.e., mental health disorder/illness being treated) are not addressed. In conjunction with research around tele-mental health service utilization patterns, further research is also needed to determine the underlying factors leading to the development of telemedicine service use, and how these issues can be resolved within a specific age or sex group.

5.5.1 Limitations

The data used included only provincially-funded services. All federally-funded medical services were excluded from this dataset as utilization would have been grossly underestimated. Thus OTN-facilitated patient visits in First Nation communities were absent from our analyses. Additionally, due to the limitations of this dataset, clinical consultations with other health care professionals (e.g. nurses, occupational therapists, physical therapists) are also excluded. The exclusion of these populations and non-physician provided services likely resulted in an underestimation of the true incidence and utilization of clinical telemedicine services in the province, particularly in northern regions (i.e. where the majority of First Nation communities are located). Apart from the missing data from federally-funded patients, OHIP billing data

provides a comprehensive data source that can be used to calculate telemedicine utilization rates within the remaining Ontario population. To be reimbursed for their telemedicine services, all physicians must use OTN and bill all clinical sessions as fee-for-service, with the possible exception of physicians who use alternative payment programs (APPs), such as salaries or hourly rates. In Ontario, many physicians are paid through multiple payment models. [32] In total, 99% of physicians practicing in Ontario received some payment through fee-for-service and 56% received some payment through APPs.[32]

It is important to note that our study is unable to provide causal inferences. Specifically, we cannot conclude, given the limitations of the study design and data source chosen, that patient age and sex have an effect on tele-mental health service utilization. We can infer, however, that there are indeed statistically significant correlations between patient age and sex and the number of tele-mental health visits participated in. Further, our results found significant age and sex-specific variations of telemedicine use within the four regional strata. However further confirmatory studies are required in order to conclude that patient geography is in fact an effect modifier of telemedicine utilization.

Due to the limitations of the dataset, a number of confounding factors were not controlled for in the analysis. Variable such as physical activity level, smoking and alcohol use, education level, marital status, income/employment status may have biased the relationship between patient sex and age and tele-mental health service use. These variables may also have biased the age and sex variations observed within the four geographical areas studied. For instance, rural communities typically have lower income and higher unemployment rates than urban communities.[33] Individuals living in rural communities also tend to have lower education levels, higher rates of smoking, alcohol consumption and physical inactivity than those residing in urban

communities.[33] Because these factors are also associated with lower mental health status[34], these variables may have confounded the associations found between patient age and sex, and the variations induced by patient geography.

5.6 Conclusion

Patient sex and age are associated with utilization of tele-mental health care provided over OTN. These associations were modified by the patient's geographical region. The associations (i.e., risk ratios) comparing age, sex and the number of tele-mental health visits in per patient were not as significant in southern, metropolitan areas. These results suggest that more northern, less densely populated regions use virtual care services more frequently than other regions. However, given the age differences observed in this region, higher service use is driven by adults 25 to 44 years of age (particularly using addiction medicine telemedicine services). Future research and efforts could benefit from determining patient and physician-specific factors contributing to lower utilization in the youngest and oldest age cohorts and determine strategies to improve access for these populations. Increasing equal mental health care access through telemedicine is crucial in not only Ontario, but in other regions worldwide afflicted by the growing demands to provide care for all those living with mental health and addiction disorders.

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Chapter 6: Discussion

6.1 Overview of Findings

The primary objective of this thesis was to determine the association between age and sex and utilization of health care services facilitated by the Ontario Telemedicine Network. The secondary objective was to determine if patient geography modified the association between age and sex and clinical telemedicine service utilization (specifically tele-mental health services). The majority of completed patient sessions through OTN are specific to mental health and addiction medicine. Sex-specific per capita utilization differences were present in psychiatry, dermatology and mental health telemedicine services, where the number of female visits per 1,000-persons was significantly higher than male utilization. Age differences were present in all clinical telemedicine service specialties studied, with the greatest differences observed in oncology and addiction medicine. North-rural regions saw the highest number of visits per 1,000-persons in all speciality areas studied, especially in oncology and internal medicine.

When looking at the interaction between age and sex on tele-mental health service use, young adults between 25 and 44 years of age participated in a greater number of tele-mental health visits per patient than the reference group (male patients, 65 years of age or older). Older adults in all regions participated in significantly fewer number of tele-mental health visits, when compared with the remaining three age groupings. Only male patients, 65 years of age or older residing in north-rural and south-urban participated in fewer tele-mental health visits per patient when compared with females 65 years of age or older residing in these respective regions (no significant differences were observed between these groups in south-rural and north-urban regions).

6.2 Justification of Population verses Individual Visit Utilization Outcome Measures

In Chapter 4, the outcome of interest was population utilization of clinical telemedicine. The first paper attempted to illustrate and describe how these services are impacting health care in different patient populations and make suggestions for where the services may be lacking (e.g., in children and youth residing in underserved rural and urban regions). In Chapter 5, the outcome of interest was individual utilization of clinical tele-mental health service use. The decision to measure health care service utilization on an individual level was motivated by the desire to provide some insight into whether or not tele-mental health services are able to provide long-term, continuity of care, and are not simply providing a substitution for a single clinical consultation/appointment. Especially in mental health and addiction, which are largely chronic, long-term disorders and diseases, I felt it was important to look at telemedicine's ability to provide means for clinicians to connect with patients and provide treatment, follow-up/maintenance treatment. Further, I wanted to determine if there was a correlational relationship between patient residency and the number of tele-mental visits participated in. For those residing in rural, underserved regions, where telemedicine may be providing the sole treatment option locally, I wanted to determine if the greater need for telemedicine was reflected in the actual number of visits billed per patient (i.e., higher mean number of visits per patient in rural regions). If patient geography did not significantly correlate with patient utilization, I wanted to be able to present this as well as suggest reasoning that could help explain these findings.

6.3 Justification of Mental Health Focus

In total, 36 therapeutic areas of care (available through telemedicine over OTN) were identified and coded from the dataset. Of the top eight, three were related to mental health and addiction. The second objective of this thesis was to determine if patient geography modified the

associations between patient sex/age and the number of tele-mental health visits per patient. In order to determine whether or not a variable is an effect modifier, two models need to be compared: one where only the aggregate (i.e., not stratified by patient geography) interaction between sex and age on the outcome (i.e., telemedicine utilization) are looked at, and a second model including the interaction terms, stratified by patient geography. To include these models for all clinical services would not be feasible in the constraints of one paper. For this reason, I decided to only select one, broad area (i.e., mental health, psychiatry and addiction medicine) to focus on when answering the second objective.

6.4 Main Findings

6.4.1 Relationship between Patient Sex and Clinical Telemedicine Utilization

In chapter 4, statistically significant sex differences were observed in three of the eight specialty services studied: psychiatry, dermatology and mental health services. Our findings showed that the proportion of psychiatry visits from April 2008 to March 2015 by the female Ontario population was 1.33-fold (95% CI: 1.10, 1.62) greater than the proportion of visits by male patients. The proportion of dermatology visits by the female Ontario population was 1.46-fold (95% CI: 1.33, 1.61) greater than the proportion of visits by male patients. Lastly, the proportion of psychiatry visits by the female Ontario population was 2.08-fold (95% CI: 1.59, 2.74) greater than the proportion of visits by male patients. These findings reflect the hypothesis that female utilization would be higher than male utilization. Addiction medicine service use per capita, measured as the incidence proportion of visits, was higher in males than in females (RR=0.77 (95% CI: 0.54, 1.10)); however, these differences were not statistically significant. A previous report from Statistics Canada shows that women in Canada report higher rates of mood disorders and generalized anxiety disorders when compared with men.[1] While these reports are based on

self-reported and do not ask whether or not individuals are seeking out medical care for a mental health disorder, these statistics may help explain the sex differences observed in our study. When examining the use of dermatology in a population, there is not a great deal of information on the age and sex differences present in tele- and in-person dermatology health care service utilization. A 2016 study showed that women are more likely than men to be diagnosed with a skin or skin-related condition (i.e. connective tissue diseases) and men are more likely than women to be diagnosed with skin-related cancer.[2] Because tele-dermatology is not a full substitute for in-person consults, one reason for the slight differences in sex utilization observed in our results (favouring utilization in women) could be that men requiring a dermatology referral may be seeking out care for a more urgent skin condition, such as skin cancer, and thus require the use of in-person services or telemedicine services not billed using fee codes classified under dermatology (e.g., services billed using oncology fee codes).

6.4.2 Relationship between Patient Age and Clinical Telemedicine Utilization

In chapter 4, age had a statistically significant effect on the risk ratios comparing the incidence proportion of visits billed per 1,000-persons (using the youngest age grouping as the reference group) for all nine therapeutic areas of care investigated. Age had the greatest influence on oncology services— older adults 65 years of age or older had a 183.27-fold (95% CI: 105.41, 318.64) greater risk in service use than children and youth under 25 years of age—as well as addiction services—young adults 25 to 44 years of age had a 160.81-fold (95% CI: 96.63, 267.61) greater risk in service use than older adults over the age of 65. The hypothesis that utilization would be highest in those over the age of 65 was supported for internal medicine, surgery, oncology and dermatology services, but not for the remaining four areas of care. Specifically, the crude incidence proportions of addiction medicine, psychiatry, and FP/GP visits

per 1,000-population were highest in those 25 to 44 years of age (addiction medicine: 86 visits per 1,000-population; psychiatry: 4.3 visits per 1,000-population; FP/GP: 23 visits per 1,000-population); the proportion of mental health visits per 1,000-population was highest in those 45 to 64 years of age (6 visits per 1,000-population).

In 2012, the Canadian Survey on Disability found that those who report mental health and addiction disabilities are, on average, younger than those who report other disabilities.[3] although this report uses a younger population (i.e. 15 years of age or older), 66.2% of all reported mental health and addiction disabilities are amongst adults 45 years of age or older.[3] Compared with these reports, our results in chapter 5 found that Ontarians utilizing OTN-facilitated mental health services are younger, with approximately two-thirds (69.1%) of patient users under the age of 45. Furthermore, 77.0% of all completed tele-mental health visits (billed to OHIP) were with patient users under the age of 45. This could suggest that while older adults report higher incidences of mental health and addiction disability, they are less likely to seek clinical care. Alternatively, tele-mental health services may be sought more by youth and young adults, whereas older adults and seniors may prefer to use in-person services.

FP/GP patients were younger than patients accessing other clinical services over OTN (i.e., oncology, internal medicine and surgery). This could be due to a number of reasons. Firstly, older adults, specifically those over the age of 65, may utilize more in-person FP/GP services as they are more likely to have a long-established, trusting relationship with a local FP/GP.[4, 5] Furthermore, younger adults (20 to 34 years of age) are less likely to report having a primary care provider than any other age group [5], and thus may be more inclined than older age cohorts to use primary care services over OTN.

6.4.3 Relationship between Patient Geographical Region and Clinical Telemedicine Utilization

In Chapter 4, patient geography had the greatest influence on oncology billed-services available through OTN-facilitated telemedicine. Rural cancer patients face numerous challenges in receiving care. In addition to treatment, support providers, transportations barriers, financial issues and limited access to clinical trials are also large barriers that exist for cancer patients.[3] Oncology telemedicine in Ontario services largely play a role in follow-up care.[6] Specifically, tele-oncology can substitute in-person appointments relating to: test results, symptom/medication review, capturing vital signs, viewing skin lesions and wound healing, and discussions of future care (over OTN or in-person at a peripheral clinical or urban/regional cancer centre).[31] While telemedicine cannot be fully integrated into all facets of cancer care, it can be used to reduce the need to travel to receive oncology care and decrease the burden felt on both patients and physicians providing care to rural patients.

6.4.4 Patient geographical region as an effect modifier of tele-mental health utilization

A notable relationship affected by patient geography was the relationship between patient sex and age on the number of tele-mental health visits by those under the age of 25. When compared with the referent group (male ≥65) within each respective region, males under the age of 25 participated in a 7.76-fold (95% CI: 6.34, 9.49) (north-rural) and 6.70-fold (95% CI: 5.35, 8.39) (north-urban) greater number of visits per patient, whereas females under the age of 25 only participated in a 4.77-fold (95% CI: 3.81, 5.99) (north-rural) and 4.77-fold (95% CI:3.86, 5.89) (north-urban) greater number of visits per patient. Reports from a provincial student drug use and

health survey found that female youth are more likely than male youth to report poor mental health and seek mental health counselling.[7] Female youth are also more likely than male youth to experience suicidal thoughts and attempt suicide.[7] These factors, in addition to the unique socio-economic factors present in rural and remote communities (e.g., social isolation, low income)[8], may explain why there was a higher risk in tele-mental health service use observed in female youth when compared with male youth in Northern Ontario.

As discussed in chapter two, a major health issue faced by rural and remote communities is the inability to support specialized clinicians in areas such as oncology, psychiatry, addiction medicine. If rural individuals require specialized medical services unavailable in their community, the only option (in addition to telemedicine) would be to drive to the closest regional or urban centre. In contrast, individuals residing in metropolitan areas, particularly those in Southern Ontario, have the added luxury of being in close proximity to multiple health care professionals and health centres offering specialized medical services. The decrease in health care access options in individuals residing in northern Ontario (particularly in rural, Northern Ontario) may be the reason for the higher number of patient visits in these regions. Although results of chapter five suggest patient geography to be a statistically significant effect modifier of the relationships between patient age grouping and sex and the number of tele-mental health visits per patient, it is important to note that physical geography is unlikely the only factor contributing to the modification of these relationships. In other words, these results alone do not infer causality and we cannot conclude that patient geography is a "true effect modifier". Unique socio-economic differences present in each of these geographies could also explain the relationship differences observed. These factors will be discussed in greater detail in section 6.5.1 (internal validity).

6.5 Epidemiological Implications

6.5.1 Internal Validity

Internal validity is the acceptability of comparisons and inferences made in a research study. It is the degree to which the results observed are truly due to the nature of the associations and not due to methodology or uncontrolled alternative variables.[9] Internal validity increases as the level of confounding, measurement error, and other biases decrease. In this study, the primary concern for internal validity comes from uncontrolled confounding factors, misclassification bias and selection bias.

Confounders are external, unaccounted for variables that correlate (positively or negatively) with both the dependent variable and the independent variable.[10] Confounding factors affect the research variables so that the yielded results do not reflect the true relationship between the variables of interest.[10] Variables that have been shown to have an influence on both the independent and dependent variable in this thesis are ethnicity, socio-economic factors (e.g., income, education), health status, and presence of physician-patient relationships.[11]. For instance, factors such as low income, low educational attainment, unemployment, and social isolation have been associated with low mental health status. Social isolation has been shown to have an effect on mental disorder prevalence in older adults (i.e. low isolation associated with lower risk of mental disorder prevalence).[11] Higher levels of education appear to have a protective effect against lower levels of self-reported mental health and mental health disorder prevalence.[12] The association between education and self-reported mental health appears to have a greater impact on the female population than the male population .[12] Given that many of these confounding factors were not controlled for in the analyses of this thesis, causal inferences cannot be made

about the quantitative relationships between age and sex and telemedicine utilization as well as the modifying effects of patient geography on the relationships found within the study results.

It is important to discuss how social determinants of health can confound the relationships between patient age, sex, residency and utilization of medical services (i.e., telemedicine utilization in Ontario). Social determinants of health are determinants of health relating to social and economic factors.[25] Social determinants of health such as social support, social status, coping skills, and education likely confound the relationship between age-sex-region and telemedicine service utilization (and health service use in general). For instance, one study found that MIZ-defined communities were more likely use FP/GP services and less likely to report using specialist physician services.[26] Most of these rural-urban differences were reduced or eliminated when controlled for social demographic factors such as marital status (i.e., social support), education, ethnic origin, income adequacy, and occupation class.[26] While this was specific to in-person medical service use, these confounding factors likely exist when examining telemedicine utilization trends. Lower socioeconomic status (SES) in Ontario is associated with a lower likelihood of accessing quality health care.[27] For instance a greater proportion of men and women living in the richest Ontario urban communities received cancer screening tests (i.e., colorectal and cervical cancer screening tests) than those men and women living in the poorest urban communities.[27] Low income has been found to correlate with low health status, particularly as age increases.[28, 29, 30] Research has found that older adults with low income are twice as likely to report having poor health when compared with older adults with mid to high incomes. [28, 29] There are also known relationships between mental health status (i.e., rate of mental illness) and income, where the rate of mental illness is higher in Ontarians with lower

income. [27] Additionally, there has been increases observed in the percentage of low-income Canadians (and not high-income Canadians) who rate their mental health status as poor/fair.[31]

The presence of social supports appears to play a role in health service utilization. For instance, social supports play a key role in mental health and addiction-related disorders and illnesses. People who are clinically depressed report lower levels of social support (e.g., fewer friends and relatives, less contact and satisfaction with friends, relatives and spouses) than people who are not currently depressed.[32, 33] The lack of support and feeling of loneliness can increase the risk of self-harm and substance use problems.[34] While a lack of social support may contribute to a poorer mental health and thus a greater use of mental health-related services, having a strong, positive support system may also lend to seeking out mental health services in populations struggling with mental health disorders (i.e., encouraging one to seek help).

Factors largely cited as facilitating or hindering telemedicine uptake in a population include availability of technologies and services, and physician uptake and acceptance of telemedicine. These factors may be potential confounders that were not controlled for within the parameters of this thesis.

Physician uptake and acceptance of telemedicine could potentially be measured using the current data available in this study. Within the administrative claims data, there are unique de-identified codes assigned for each physician providing the medical services, as well as the physician's residency code. Using this data, additional analyses could explore the number of physicians within each therapeutic area of care providing fee-for-service clinical telemedicine services and the location of these physicians. If there are gaps in geography and the number of physicians per capita offering the services, additional resources and efforts could be implemented to encourage

and incentivize physicians to consider using or increasing usage of telemedicine services in their practice.

Internal validity could have been improved if potential confounding factors had been controlled. Variables such as physical activity level, smoking and alcohol use, education level, marital status, income/employment status may have biased the relationships between patient sex and age and tele-mental health service use. These variables may also have biased the modifying effects of patient geography observed. For instance, people in rural communities have lower income and higher unemployment rates than urban communities.[8] Individuals living in rural communities also tend to have lower education levels, higher rates of smoking, alcohol consumption and physical inactivity than those residing in urban communities.[8] Because these factors are also associated with lower mental health status[13], these variables could be confounding the modifying effects of patient geography (likely away from the null). It is likely; however, these factors are not true confounders, but rather part of the causal pathway that explains why regional variations were observed in this study.

Misclassification bias is a type of measurement error.[14] There are two types of misclassification bias: non-differential and differential. Non-differential misclassification occurs when all study groups or variable categories have the same level of error.[14] In contrast, differential misclassification occurs when one group or variable category is more likely than the remaining groups/categories to be misclassified.[14] Of these two sub-classes, the risk ratios calculated in chapter 4 were more likely affected by non-differential misclassification bias. The effects of non-differential misclassification would bias the calculated estimates towards the null. When coding the data provided by the MOHLTC, all fee codes were assigned to a therapeutic area of care objectively based on the Physicians Schedule of Fee.[15] This resource is used by physicians when

submitting a service claim to OHIP. All fee codes listed in the dataset, were assigned to one of the 34 Physician Specialty Codes. Within FP/GP, sub-groups were created: addiction medicine and mental health, increasing the number of physician specialty codes to 36 for this study. Once fee codes were assigned one of the 36 Physician Specialty codes, some codes were combined to create one group. For instance, seven surgical specialty codes were grouped to create one 'surgery' therapeutic area of care grouping. Because the assigning of fee codes was done by one individual, assumptions and subjective assignment of codes to a particular therapeutic area of care were avoided as much as possible. The splitting and aggregating of areas of care was not systematically defined in the literature and thus may have been subjected to non-differential misclassification bias. More specifically, there were additional service fee codes classified under FP/GP that could have also been separated from this general service group and assigned to a more specialized medical service. Consequently, the seven-year incidence proportion of visits specified as FP/GP over OTN may be overestimated, while specialized medical or surgical care services (classified under FP/GP) provided over OTN may be underestimated.

Non-differential misclassification bias may have also been introduced through the decision to use administrative claims data. To determine the specialized therapeutic area of care health service fee codes listed in the claims data was re-coded into one of the 36 areas of care defined in the study. The validity of using administrative billing data to determine medical service utilization over telemedicine has not been assessed. Medical service data in Canada is generated indirectly through the physician fee-for-service reimbursement claims, and all fee-for-service appointments are recorded.[23] Within the claim, there is a patient diagnostic code as well as a health service fee code. While the diagnostic code could provide better insight into a patient's medical diagnosis (and potentially the reason for the telemedicine visit), these codes are not validated by the

MOHLTC (as they do not impact the amount reimbursed to the physician). In contrast, the health service fee codes do not provide complete insight into the medical diagnosis of a patient, but are carefully audited (and validated) by the MOHLTC as these codes directly impact the amount a physician is reimbursed.[23] While there is a potential for misclassification (i.e., by the claiming physician) of health service fee codes, it is likely minimal (especially when compared with diagnostic codes) and would not greatly impact the results and internal validity of this study.

It is also important to acknowledge the potential for differential misclassification bias in the two sub-groups created from the FP/GP therapeutic area of care: addiction medicine and mental health. The addiction medicine therapeutic area of care was created to better illustrate the importance of telemedicine in treating substance abuse disorders and its role in methadone maintenance treatment. This group was based on four focused practice assessment (FPA) health service fee codes (see **Appendix A Table 1**). Addiction medicine FPA service fee codes correspond to "assessments rendered by a GP/FP with addition training and/or experience in addiction medicine (including methadone)."[15] The Mental Health sub-category used in this study was based on fourteen health service fee codes corresponding to assessments provided by a GP/FP in primary mental health care (individual), counselling (individual, group, relatives), and psychotherapy (individual, group, family) (see **Appendix A Table 1**) The creation of these two FP/GP sub-groups have not been previously validated and may not contain all medical services provided by a GP/FP specific to addiction medicine and mental health. These groups, however have been used in previous research.[24]

Measurement errors should also be addressed regarding patient age and patient geographical region. Patient age and geography group designation was based on the information obtained during first time appointments. This may result in visit proportions that are overestimated in the

younger age cohorts. Further, individuals may be moving to different regions during the seven-year study period, and while the first appointment may have taken place in one region, the remaining completed visits participated in by a patient may have taken place in a different region.

Selection bias is systematic error resulting from a study population not being chosen at random, resulting in the likelihood that particular members in the population were excluded at higher rates than others in the population.[16] This research utilized all OTN-billed OHIP data available between 2008 and 2015. While sample size is a major strength of this study, there were certain populations that were excluded from the analyses. Firstly, OHIP administrative billing data does grossly underestimate the number of telemedicine patients residing in First Nations communities as many of the individuals living on a First Nations reserve have federally-funded health care, not provincial. This research sought to determine if patient age and sex influenced clinical service utilization and how patient geography modified these effects. Thus, the results shown through our analyses may not be the "true" incidence of provincial utilization of telemedicine services. Individuals who identified as Indigenous (First Nations, Métis, Inuit) made up 2.4% of the total population of Ontario.[17] Of this population, one-fifth live on a reserve. An additional one-fifth live in rural Ontario.[18] Census reports show that Indigenous populations are, on average, younger than non-Indigenous populations.[17] Approximately, 42% of the provincial Indigenous population was 24 years of age or younger, compared with 30% of the non-Aboriginal population.[17] This demographic difference means our results may underestimate the incidence proportions of younger adults utilizing telemedicine services, especially in FP/GP, psychiatry and addiction medicine services, where higher visit incidence proportions were observed in younger adults.

Secondly, there were 10,113 patients (5.5% of the total sample population) that did not have a residence code associated with their billed OTN session and; therefore, patient geographical region could not be determined for these individuals. There was no missing information on patient sex and age. In order to ensure the same population was used in both the crude and adjusted incidence proportion calculations, these individuals were also excluded from the analyses. These individuals were included in the univariate, descriptive analyses. For five of the nine outcomes measured, individuals with no listed residence code comprised less than five percent of the total population who used clinical OTN services. While not included in the results, **Appendix B Table 2** includes a table with demographic information on this population and the number of visits billed within each categorical variable. Of those with missing geographical region, the majority of visits were specific to addiction medicine (68.4%) and FP/GP (20.1%) services over OTN. In these outcomes, the majority of FP/GP (82.5%) and addiction medicine (82.6%) visits were with patients between 25 and 65 years of age. Separate analyses were conducted calculating the proportion of visits participated in by the total population at risk. All proportions were below five visits per 1,000 persons, and thus the exclusion of these visits would not have greatly affected the age and sex effects observed in the studies.

6.5.2 External Validity

In epidemiological research, external validity refers to the extent to which study results can be generalizable to other situations, populations or time periods outside the study sample.[38] The sample selected for study greatly impacts the external validity. Chapter 4 used population-based data to calculate visit incidence proportions over a seven-year period. The data provided by the MOHLTC included all fee-for-service clinical OTN events between a physician and a patient covered through OHIP. Physicians must use OTN in order to be reimbursed by the province for

all clinical services they provide, with the possible exception of some salaried physicians or those who receive compensation through alternative physician compensation models (APPs). In total, 99% of physicians practicing in Ontario received some payment through fee-for-service and 56% received some payment through APPs.[16]

As previously described, OHIP administrative billing data does grossly underestimate the number of telemedicine patients residing in First Nations communities. This is because the vast majority of individuals residing in these CSDs have health insurance that is federally funded. As described above, there are slight population differences between Aboriginal populations and non-Aboriginal populations that need to be considered. Thus, analyzing provincial insurance plan data to answer my research question allows my findings to be strongly generalizable to the Ontario population, with the exception of First Nations communities.

This study examined the use of clinical OTN services over a seven-year period: April 1, 2008 to March 31, 2015. Although this dataset included information on the month and year of each clinical appointment, the decision to calculate the seven-year visit incidence proportion of visits per 1,000 population "at risk", and not annual rates of use, stemmed largely from the fact that the denominator data available was specific to the census population of Ontario in 2011. While the 2011 census population is sufficient for determining the incidence rate in 2011, it may underestimate or overestimate utilization rates in the remaining study years. Because data combines information from seven years, it is important to ensure these results are not interpreted and generalized as annual usage, as this would result in an inflated perception of how popular these virtual services are (when in reality only one percent of the province has accessed these services over the past seven years). To generalize these findings to reflect approximate annual prevalence (i.e. proportion of visits per 1,000-persons per year), one could divide the seven-year

rates by seven to get a sufficient approximation. Although the annual number of visits increased (and thus annual incidence likely increased), the effects of age and sex on utilization patterns would likely remain consistent, regardless of year or years examined. This is because the sex and age utilization patterns observed in our results are fairly in line with patterns observed in health care utilization as a whole. The effects of patient geography on telemedicine utilization are also likely consistent across time periods. This is because telemedicine has always benefitted those underserved regions where health care access is limited.

It is important to note that our findings do not reflect service use during the earlier years of telemedicine adoption. They also cannot be used to predict future use of telemedicine in the Ontario population. OTN has grown substantially since its inception in 2006 and will continue to grow with the advancement and acceptance of technologies and its growing integration into the health care system. For example, the results found in Chapter five are not generalizable to mental health and addiction telemedicine utilization prior to 2010. When looking at the annual counts of completed visits presented in chapter 4, OTN-facilitated addiction medicine services were not billed to OHIP prior to November 2009. Taking this into account, it is likely that the effects of patient sex, age, and geography on mental health-related telemedicine utilization differ before and after the inclusion of OTN-facilitated addiction medicine services. This hypothesis is largely based on our results, which found that age and sex differences in mental health and addiction service use were driven largely by addiction medicine visits (which were driven largely by male patients 25 to 44 years of age). Without this group, it is likely that the age and sex effects on number of tele-mental health visits per patient would not have been as pronounced.

We are unaware of any research surrounding the utilization patterns and incidence of clinical telemedicine in the Canadian population. While there is little known information available, our

results may provide insight into the prevalence in the Canadian population as a whole. Ontario makes up nearly 40% of the country's total population.[19] In Canada, there are over 1,000 communities that have telemedicine systems in place.[20] When looking at telemedicine usage in Canada during the same time period as this study, approximately 54% of all clinical telemedicine sessions in Canada were specific to mental health (which included addiction medicine, general mental health, psychiatry, psychology and psychometry).[20] Internal medicine (15%) and oncology (13%) had the second and third highest session counts.[20] While the distribution of specialty services usage does vary by province and territory, the top clinical services utilized in Canada are relatively similar to the top clinical services in Ontario.

Unlike national reports, we found that FP/GP and Surgery were also highly utilized by individuals in Ontario. The proportion of Ontarians residing in rural regions is also similar to the proportion of all Canadians residing in rural regions. The 2011 Census showed that approximately 14% of all Ontario residents lived in rural Ontario.[43] These reports also showed that approximately 19% of the total Canadian population lived in rural regions in 2011.[21] While only one-fifth of the Canadian population resides in rural Ontario, Praxia reported that roughly half of all clinical telemedicine sessions in Canada were rural clinical sessions.[20] While there may be a difference between the types of therapies/services most sought in Ontario and Canada, it is likely that patient geography will remain a significant effect modifier of the incidence of Canadian clinical telemedicine use.

Because our study included the majority of the Ontario population living off-reserve, our findings may be generalizable to other developed countries with similar health care systems, socioeconomic statuses, and large geographical regions (with large variations in population density). The findings of this study may be generalizable to developed countries such as the

United States and Australia, which also have large populations and spanning geographical regions.

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Chapter 7: Ethical Considerations

University Research Ethics Board approval was required from both Lakehead University and Laurentian University before secondary analysis could begin. Originally, ethics exemption was obtained from Lakehead University. Due to the nature of the non-disclosure agreement signed between the researcher and the MOHLTC, a full REB review was required from both institutions for this thesis. The letters of REB approval from both Laurentian and Lakehead are included in **Appendix C**.

Upon obtaining REB approval and completing all appropriate agreement documents, the data was released by the MOHLTC. All data was anonymized by replacing the patient's name, address and OHIP number with a unique identifier. Although identifying information was removed, there is still a risk of identifying patients and facilitators, particularly those in small remote communities where only a small number of sessions are occurring.

Some individuals who receive medical care through OTN could be part of a vulnerable population, but these populations are not specifically targeted in this study. As previously described, Indigenous patients who access care in First Nations communities are not included, as their care is billed federally to Health Canada. To prevent the identification of patients contained within the database, all patient utilization is presented in aggregate and individual patient information is not reported. Subgroup with a cell count smaller than five patients were repressed from all publications. Electronic files are stored on a secure server housed at Laurentian University. As outlined in the non-disclosure agreement, files were only accessible through one desktop at Lakehead University. A VPN connection was used on this device with the server housed at CRaNRH in Sudbury. All analyses were conducted and saved on the server.

Chapter 8: Strengths, Limitations and Relevance

8.1 Strengths

This study uses the census and administrative population-based data of Ontario residents to determine the utilization patterns of telemedicine services delivered through the Ontario Telemedicine Network. The large dataset used (containing just under one million OTN-flagged visits) allowed for analyses to be conducted with sufficient power to detect even slight differences within the groups. The dataset also allowed inclusion of specialty fee codes in addition to the OTN fee code, allowing for therapeutic areas of care to be investigated, and not just general telemedicine usage.

8.2 Limitations

OHIP billing data is collected for administrative purposes and is not structured for the purpose of research. Because these data only include provincially-funded services, all federally-funded medical services would not be contained within this dataset. Thus OTN-facilitated patient visits in First Nation communities are grossly underestimated in this dataset. The exclusion of these populations also limits the generalizability of the research findings to off-reserve populations residing in Ontario. Additionally, due to the limitations of this dataset, clinical consultations with other health care professionals (e.g. nurses, occupational therapists, physical therapists) are also excluded.

As described in the previous chapter, census data were used to calculate seven-year incidence proportions of visits per 1,000 persons-at-risk and subsequent risk ratios. To use this data, we assumed that the average Ontario population between 2008 and 2015 was equal to the total and geography-specific populations reported in the 2011 Census. Additionally, the denominator data

does not take into account changes in populations due to immigration and emigration out of the province. Further, patient residency was based off of residency recorded during first visit. If a patient had moved within the seven-year study period, it would not be accounted for in the current study.

Lastly, this study examined the incidence of the Ontario population using any of the top eight therapeutic areas of care at least once during the seven-year study period. However, conclusions cannot be made regarding the illness or condition that is warranting the use of a clinical telemedicine appointment. For example, while we can assume that all patients utilizing addiction medicine services were doing so because they were seeking care for an illness or condition relating to addiction, we cannot be completely certain based on the information available (and its accuracy). With the data provided by the MOHLTC, it was possible to categorize therapeutic area of care using patient diagnostic codes as opposed to billing fee-codes. Using patient diagnostic codes; however, would have posed greater risks of non-differential misclassification bias. For example, a diagnostic code corresponding to cancer does not mean that all services sought out by this patient will be specific to cancer, especially if there are several side effects and/or co-morbidities associated with a particular disease and diagnosis. At this time, we chose to focus on identifying services utilized, not the diagnoses motivating the appointment, and thus using billing fee codes made more sense. The risk of misclassification and statistical error are thus quite low. Services used through OTN should yield less misclassification error than diagnostic data, as I am only interested in identifying services used, not the diagnosis made during the appointment. Physicians are ultimately responsible for using the correct code, but they do have some choice and some codes pay better than others. OHIP looks for code inconsistencies

in a visit and physicians need to correct these errors. Physicians can be subjected to random audits, which emphasize the importance of billing preference and accuracy.

8.3 Relevance to Public Health/ Health Sciences

The use of telemedicine services in Ontario is not well understood. This thesis provides a detailed description of telemedicine use in Ontario by sex, age, rurality and region. The results show that, like in-person services, the clinical services facilitated over OTN are diverse and provide care to the specific age/sex demographic groups that require its services/therapies the most. Telemedicine has the ability to provide services relevant to the needs of both young (by offering FP/GP, mental health and dermatology services) and old (by offering services such as oncology, surgery and internal medicine). These findings also show the importance of telemedicine in Northern Ontario, particularly rural, Northern Ontario. These results show that telemedicine use, via OTN, is increasing over time, particularly in patients residing in Northern Ontario, where speciality services are sparse or non-existent.

The findings were linked with census population demographics which allowed for the per captia reporting of what specific areas of care are or are not being used by patients in the four regions of Ontario. The findings contained within the two paper manuscripts will positively impact OTN providing the organization with quantitative insights into how their network is being used and by whom.

This study positively impacts knowledge mobilization through the publishing of a peer-review paper, conference presentations and reports, and is readily available to the general public, researchers and policy-makers. These findings provide insight regarding what OTN services are still needed, and which services may require modifications to better reflect those age, sex and geographical groups frequenting the services.

Based on my findings, I recommend that future research should be directed towards determining what factors are contributing to the age and sex differences observed in tele-mental health services. Improving awareness and promotion (in both the general population and physician providers) of these services may be warranted if there are factors associated with a lower utilization. Ensuring proper access to these services is greatly needed for both youth and older adults, particularly those residing in underserved, socially-isolating rural communities. With the growing concern around the high rates of addiction in not only Ontario, but the remaining Canadian population, providing services, such as MMT, therapy and counselling may provide relief for health care professionals by reducing their need to travel to treat patients; the province by potentially reducing health care costs; and the general population who may be directly or indirectly affected by addiction and/or mental health disorders.

It may also be beneficial for future efforts to focus on increasing utilization of telemedicine to older adults, and thus future research could determine any additional services predominantly used by older adults (that were grouped into the "other" outcome group) to see how health care access can be improved to the aging population of Ontario.

Chapter 9: Conclusion

9.1 Summary of Findings

To our knowledge, this is the first study that examines the characteristics of patients who have participated in at least one clinical telemedicine session in the province of Ontario. These research findings provide insight into who is using the services and the quantity to which these services are being used by patients. Our findings were able to introduce knowledge on whether or not clinical telemedicine services are targeting specific age groups, sex groups, or regional divisions. Our research was also able to describe how different therapeutic areas of care are accessed by patients in the Ontario population and show the age and sex variations present in clinical telemedicine usage in provincially-funded patients.

When looking at overall results, there were notable age differences in the majority of top eight therapeutic areas of care offered over OTN. Of the eight services, three were related to mental health and addiction services, and two were specific to primary care (FP/GP and internal medicine). The remaining medical services found to be most sought by patients were speciality services (i.e. oncology, surgery and dermatology) that are available primarily in Census metropolitan areas and census agglomeration regions only. Unlike mental health and addiction services via telemedicine, the top clinical services provided via telemedicine provided by specialists in oncology and surgery are generally pre-operative and post-operative in nature (e.g. providing follow-up care remotely via Telemedicine to a patient following in-person treatment). Mental health and addiction services not only provide pre- and post-treatment services, but also have the capacity to provide diagnoses and treatment plans via telemedicine. Overall, utilization (determined by calculating visit incidence proportions per 1,000-persons) was significantly higher in rural, underserved regions and lowest in south-urban regions. The youngest users were

observed in addiction medicine services and the oldest users were observed in oncology services over OTN. Addressing the influence of patient sex on telemedicine utilization, most services saw no clinically significant differences between males and females using the services between 2008 and 2015 (especially when compared with the utilization differences between age groups). There were, however, notable differences between male and female visit proportions in mental health, psychiatry and dermatology (where higher female incidence) were observed.

When looking at mental health-specific telemedicine services specifically, individual older adult utilization (i.e., number of visits per patient) was significantly lower than the remaining age groupings, regardless of region. The low utilization of tele-mental health services in older adult males in the north-rural and north-urban regions resulted in greater RR to be observed in the remaining male and female age groupings, particularly those 25 to 44 years of age. Lastly, there were notable differences observed between north-residing males and females under the age of 25, where the number of visits per patient was significantly greater in males than in females.

9.2 Implications

Our study was able to examine telemedicine utilization patterns. While telemedicine technologies are well established and the quality of care provided is comparable to in-person care, adoption of telemedicine is still relatively low in the general population of Ontario, particularly in rural and urban Southern Ontario. While this study does not provide answers as to why adoption may be low, nor does it suggest ways to improve uptake of particular services, this study does provide insight on what populations are using particular services. Specifically, 1) what services are most used by older adults, 2) what services are most used by children, youth and young adults, and 3) what services are most used by males and females. Health disparities are not identical throughout the province of Ontario. Ontarians residing in rural and remote

regions of Ontario do not have the same access to specialized care services when compared with those residing in urban centers. Particularly in services such as addictions and mental health, where physical contact is not necessary to provide treatment, telemedicine provides means for patients in underserved regions to access non-emergent, but still necessary, care that may otherwise have not been accessed.

This research project describes the patient population utilizing clinical telemedicine services over the OTN, specifically looking at age and sex-specific utilization. The findings of this thesis illustrate that telemedicine has successfully increased access to over 185,000 unique individuals (half of which reside in rural Ontario) and facilitated over 900,000 successful clinical events from April 2008 to March 2015. While these results do not provide practical impacts that will result in drastic policy changes in OTN, they do inform decision and policy-makers within organizations such as OTN, the Ministry of Health and Long-Term Care (MOHLTC), Local Health Integration Networks (LHIN) and Community Care Access Centres (CCAC). Specifically, these results increase knowledge and understanding of telemedicine utilization within the province and within the four regional divisions. Policy- and decision-makers will be better informed about who is utilizing specific clinical services over OTN and can allocate resources accordingly to reflect the usage of services in specific groups and geographical regions. For example, our study results show that oncology services over OTN have high rates of use in older adults over the age of 65 and in rural, Northern Ontario. North-rural CCACs and LHINs can assess how tele-oncology is used in their local communities. If utilization is low or non-existent, these organizations can increase awareness of tele-oncology to health care professionals and provide incentives that may promote increased usage and availability of these services in a community. Particular services, such as surgical follow-up, mental health and psychiatry, and store-forward dermatology, could create

conversation and motivate change in how telemedicine is used in a community, particularly a small rural town that does not have direct access to these services.

9.3 Future Directions

Future research can also stem from the findings of this thesis. Future research could focus specifically on the older adult population and what clinical services have the highest utilization rates in this population. Several national and provincial sources emphasize how telemedicine has impacted clinical care specific to mental health and addiction services. While these clinical areas are important, our results show that these services are under-utilized in older adults when compared with the other services accessed by this population. Furthermore, this age group saw a high visit proportion of use in the '*All Other Services'* outcome category. Therefore, future research should focus on analyzing the services contained within this grouped, 'others' category to determine which services have the highest utilization rates in older adults, particularly those residing in remote and underserved regions.

Appendix A: Data Manipulation

Appendix A Table 1: Designation of Speciality Service Fee Codes, listed alongside a OTN-flagged B-Code to a) the corresponding therapeutic area of care and b) the groupings representing the outcomes of interest for this thesis (top eight therapeutic areas of care)

	a. Therapeutic Area of Care (TAC)	b. Categorical Variable given to all*	Fee Codes Contained within each Category	Comments
1	Family Practice and Practice in General	1= FP/GP	('A001A'=1) ('A003A'=1) ('A004A'=1) ('A005A'=1) ('A006A'=1) ('A007A'=1) ('A008A'=1) ('A112A'=1) ('A888A'=1)('A901A'=1) ('A903A'=1) ('A904A'=1) ('A905A'=1) ('A911A'=1) ('A912A'=1) ('A933A'=1) ('A937A'=1) ('A945A'=1) ('A947A'=1) ('A967A'=1) ('E079A'=1) ('G005A'=1) ('G313A'=1) ('G420A'=1) ('G489A'=1) ('G590A'=1) ('K002A'=1) ('K003A'=1) ('K008A'=1)('K006A'=1) ('K016A'=1) ('K022A'=1) ('K023A'=1) ('K026A'=1) ('K028A'=1) ('K029A'=1) ('K030A'=1) ('K032A'=1) ('K035A'=1) ('K036A'=1) ('K037A'=1) ('K071A'=1) ('K072A'=1) ('K090A'=1) ('K091A'=1) ('K121A'=1) ('K124A'=1) ('K682A'=1) ('K683A'=1) ('K684A'=1) ('K705A'=1) ('K706A'=1) ('K707A'=1) ('K708A'=1) ('K709A'=1) ('K730A'=1) ('K888A'=1) ('K889A'=1) ('K708A'=1) ('K709A'=1) ('K730A'=1)	
2	Surgery	4= Surgery	('A013A'=2) ('A014A'=2) ('A015A'=2) ('A016A'=2) ('C012A'=2) ('C015A'=2)('A093A'=4) ('A094A'=4) ('A095A'=4) ('A096A'=4) ('A935A'=4) ('C092A'=4) ('C095A'=4) ('C124A'=4)('A033A'=9) ('A034A'=9) ('A035A'=9) ('A036A'=9)('A643A'=10) ('A644A'=10) ('A645A'=10) ('A646A'=10) ('A043A'=19) ('A044A'=19) ('A045A'=19) ('A046A'=19) ('A063A'=23) ('A064A'=23) ('A065A'=23) ('A066A'=23) ('C069A'=23) ('A083A'=27) ('A084A'=27) ('A085A'=27) ('A086A'=27) ('C089A'=27) ('Z095A'=27) ('A173A'=34) ('A174A'=34) ('A175A'=34) ('A176A'=34)	Anaesthesia, Cardiac Surgery, General Surgery, General Thoracic Surgery, Neurosurgery, Plastic surgery, vascular surgery, orthopaedic surgery
3	Cardiology	9= Other	('A601A'=3) ('A603A'=3) ('A604A'=3) ('A605A'=3) ('A606A'=3) ('A608A'=3) ('A675A'=3) ('C605A'=3) ('G180A'=3) ('G283A'=3) ('G307A'=3) ('G321A'=3)	

4	**Dermatology**	**7= Dermatology**	('A020A'=6) ('A023A'=6) ('A024A'=6) ('A025A'=6) ('A026A'=6)	
6	**Endocrinology & metabolism**	**9= Other**	('A151A'=7) ('A153A'=7) ('A154A'=7) ('A155A'=7) ('A156A'=7) ('A158A'=7) ('A255A'=7) ('A760A'=7)	
7	**Gastroenterology**	**9= Other**	('A411A'=8) ('A413A'=8) ('A414A'=8) ('A416A'=8) ('A418A'=8) ('A415A'=8) ('G510A'=8)	
8	**Geriatrics**	**9= Other**	('A071A'=12) ('A073A'=12) ('A074A'=12) ('A075A'=12) ('A076A'=12) ('A078A'=12) ('A375A'=12) ('A770A'=12) ('A775A'=12) ('C770A'=12)	
9	**Oncology (medical and radiation)**	**5=Oncology**	('A441A'=16) ('A443A'=16) ('A444A'=16) ('A446A'=16) ('A445A'=16) ('A448A'=16) ('C445A'=16) ('G281A'=16) ('G345A'=16) ('G348A'=16) ('G359A'=16) ('G375A'=16) ('G381A'=16) ('G382A'=16) ('G388A'=16) ('G512A'=16) ('A340A'=30) ('A345A'=30) ('A745A'=30) ('A341A'=30) ('A343A'=30) ('A346A'=30) ('A348A'=30) ('A765A'=30) ('C346A'=30) ('X310A'=30) ('X312A'=30) ('X313A'=30)	
10	**Infectious Disease**	**9= Other**	('A275A'=14) ('A460A'=14) ('A461A'=14) ('A463A'=14) ('A464A'=14) ('A465A'=14) ('A466A'=14) ('A468A'=14)	
11	**Internal Medicine**	**3= Internal Medicine**	('A130A'=15)('A131A'=15) ('A133A'=15) ('A134A'=15) ('A135A'=15) ('A136A'=15) ('A138A'=15) ('A435A'=15) ('C134A'=15) ('C135A'=15) ('C138A'=15) ('C143A'=15) ('C435A'=15) ('G202A'=15) ('G212A'=15) ('G380A'=15) ('K045A'=15) ('Z135A'=15)	
12	**Haematology**	**9= Other**	('A611A'=13) ('A613A'=13) ('A614A'=13) ('A615A'=13) ('A616A'=13) ('A618A'=13) ('A655A'=13) ('G098A'=13) ('G100A'=13) ('G271A'=13) ('G379A'=13) ('G700A'=13)	
13	**Nephrology**	**9= Other**	('A161A'=17) ('A163A'=17) ('A164A'=17) ('A165A'=17) ('A166A'=17) ('A168A'=17) ('G009A'=17)	
14	**Neurology**	**9= Other**	('A113A'=18) ('A180A'=18) ('A181A'=18) ('A183A'=18) ('A184A'=18) ('A185A'=18) ('A186A'=18) ('A188A'=18) ('A385A'=18) ('C180A'=18) ('C185A'=18) ('G547A'=18) ('G549A'=18) ('K001A'=18) ('W183A'=18) ('W184A'=18)	
15	**Obstetrics & Gynecology**	**9= Other**	('A203A'=21) ('A204A'=21) ('A921A'=21) ('A205A'=21) ('A206A'=21) ('P003'= 21) ('P004'=21) ('P005'=21)	

16	**Ophthalmology**	**9= Other**	('A233A'=22) ('A234A'=22) ('A235A'=22) ('A236A'=22) ('A250A'=22)('A253A'=22) ('G425A'=22) ('G435A'=22) ('G450A'=22) ('G526A'=22) ('G529A'=22) ('G530A'=22) ('G817A'=22) ('G818A'=22)	
17	**Paediatrics**	**9= Other**	('A260A'=25) ('A261A'=25) ('A262A'=25) ('A263A'=25) ('A264A'=25) ('A265A'=25) ('A266A'=25) ('A565A'=25) ('A661A'=25) ('A665A'=25) ('K122A'=25) ('K123A'=25)	
18	**Physical Medicine and Rehabilitation**	**9= Other**	('A310A'=26) ('A311A'=26) ('A313A'=26) ('A315A'=26) ('A316A'=26) ('A318A'=26) ('A425A'=26) ('A510A'=26) ('A511A'=26) ('A515A'=26) ('C312A'=26) ('C315A'=26) ('C318A'=26) ('C515A'=26) ('G456'=26) ('H313A'=26)	
19	**Psychiatry**	**6=Psychiatry**	('A190A'=28) ('A191A'=28) ('A192A'=28) ('A193A'=28) ('A194A'=28) ('A195A'=28) ('A196A'=28) ('A197A'=28) ('A198A'=28) ('A395A'=28) ('A695A'=28) ('A795A'=28) ('A895A'=28) ('C190A'=28) ('C192A'=28) ('C193A'=28) ('C196A'=28) ('C198A'=28) ('C895A'=28) ('K187A'=28) ('K188A'=28) ('K189A'=28) ('K191A'=28) ('K192A'=28) ('K193A'=28) ('K195A'=28) ('K196A'=28) ('K197A'=28) ('K198A'=28) ('K199A'=28) ('K200A'=28) ('K204A'=28) ('K205A'=28) ('K630A'=28) ('W895A'=28)	
20	**Respiratory Disease**	**9= Other**	('A470A'=31) ('A471A'=31) ('A473A'=31) ('A474A'=31) ('A475A'=31) ('A476A'=31) ('A478A'=31) ('A570A'=31) ('A575A'=31) ('C470A'=31) ('C475A'=31) ('C476A'=31)	
21	**Rheumatology**	**9= Other**	('A480A'=32) ('A481A'=32) ('A483A'=32) ('A484A'=32) ('A485A'=32) ('A486A'=32) ('A488A'=32)	
22	**Urology**	**9= Other**	('A353A'=33) ('A354A'=33) ('A355A'=33) ('A356A'=33) ('A365A'=33) ('C355A'=33) ('C356A'=33) ('C935A'=33) ('G010A'=33) ('G475A'=33) ('G477A'=33) ('G900A'=33)	
23	**Addiction Medicine**	**2= Addiction Medicine**	('A680A'=35) ('A957A'=35) ('K039'=35) ('K680A'=35)	
24	**Other (Clinical Immunology, Genetics, Nuclear**	**9= Other**	('A621A'=5) ('A623A'=5) ('A624A'=5) ('A625A'=5) ('A626A'=5) ('A628A'=5) ('A223A'=11) ('A225A'=11) ('A226A'=11) ('A325A'=11) ('K044A'=11) ('K222A'=11) ('K223A'=11) ('A635A'=20) ('A638A'=20) ('A243A'=24) ('A244A'=24) ('A245A'=24) ('A246A'=24) ('G145A'=24) ('A335A'=29) ('G342A'=29) ('G372A'=29)	

	Medicine, Otolaryngology, Diagnostic and Therapeutic Radiology)			
25	**Mental Health**	**8= Mental Health**	('K004'=36) ('K005A'=36) ('K007A'=36) ('K012A'=36) ('K013A'=36) ('K014A'=36) ('K015A'=36) ('K019A'=36) ('K020A'=36) ('K024A'=36) ('K025A'=36)('K033A'=36) ('K040A'=36) ('K041A'=36)	
**** Variables 1-8 correspond to top 8 therapeutic areas of care and 9 combines all other therapeutic areas of care***				

Appendix B: Additional Chapter 4 & 5 Analyses

Chapter 4: Test of Homogeneity of Variances: Oneway ANOVA comparing mean patient age within the top nine therapeutic areas of care facilitated through OTN

Appendix B Table 1: Test of Homogeneity of Variances: Patient Age (dependent variable) by top therapeutic area of care (independent variable)

		Levene Statistic	df1	df2	Sig.
Patient Age (continuous)	Based on Mean	1812.95	8	214799	< .001
	Based on Median	1646.22	8	214799	< .001
	Based on Median and with adjusted df	1646.22	8	196415.890	< .001
	Based on trimmed mean	1783.52	8	214799	< .001

Note: Variances are not equal if significance (Sig.) < 0.05

Chapter 4: Additional negative binomial regression analyses examining age as a continuous variable.

Appendix B Table 2: Risk ratios comparing the main effects of patient sex, age (continuous), and region on the proportion of visits participated in within the top nine clinical subspecialty services: Ontario, April 1, 2008 – March 31, 2015

		Risk Ratio								
		A. FP/GP	B. Addiction Medicine	C. Internal Medicine	D. Surgery	E. Oncology	F. Psych-iatry	G. Derma-tology	H. Mental Health	I. All Other Services
Sex	Female	0.92	0.75	1.07	1.15	1.32	1.35^{+}	1.40^{++}	2.31^{+}	0.88
	Male	1.00 (ref.)								
Age (Continuous)		0.99^{+}	0.91^{++}	1.04^{++}	1.05^{++}	1.10^{++}	0.98^{++}	1.01^{++}	1.02	1.04^{++}
Region	N. Rural	**7.77**$^{++}$	**11.26**$^{++}$	283.39^{++}	197.20^{++}	690.27^{++}	11.49^{++}	15.05^{++}	17.12^{++}	57.56^{++}
	N. Urban	5.56^{++}	**14.43**$^{++}$	67.83^{++}	32.62^{++}	152.06^{++}	4.84^{++}	3.07^{++}	6.41^{++}	13.69^{++}
	S. Rural	0.79	1.62	12.31^{++}	3.92^{++}	15.32^{++}	3.52^{++}	4.94^{++}	2.74^{+}	5.72^{++}
	S. Urban	1.00 (ref.)								

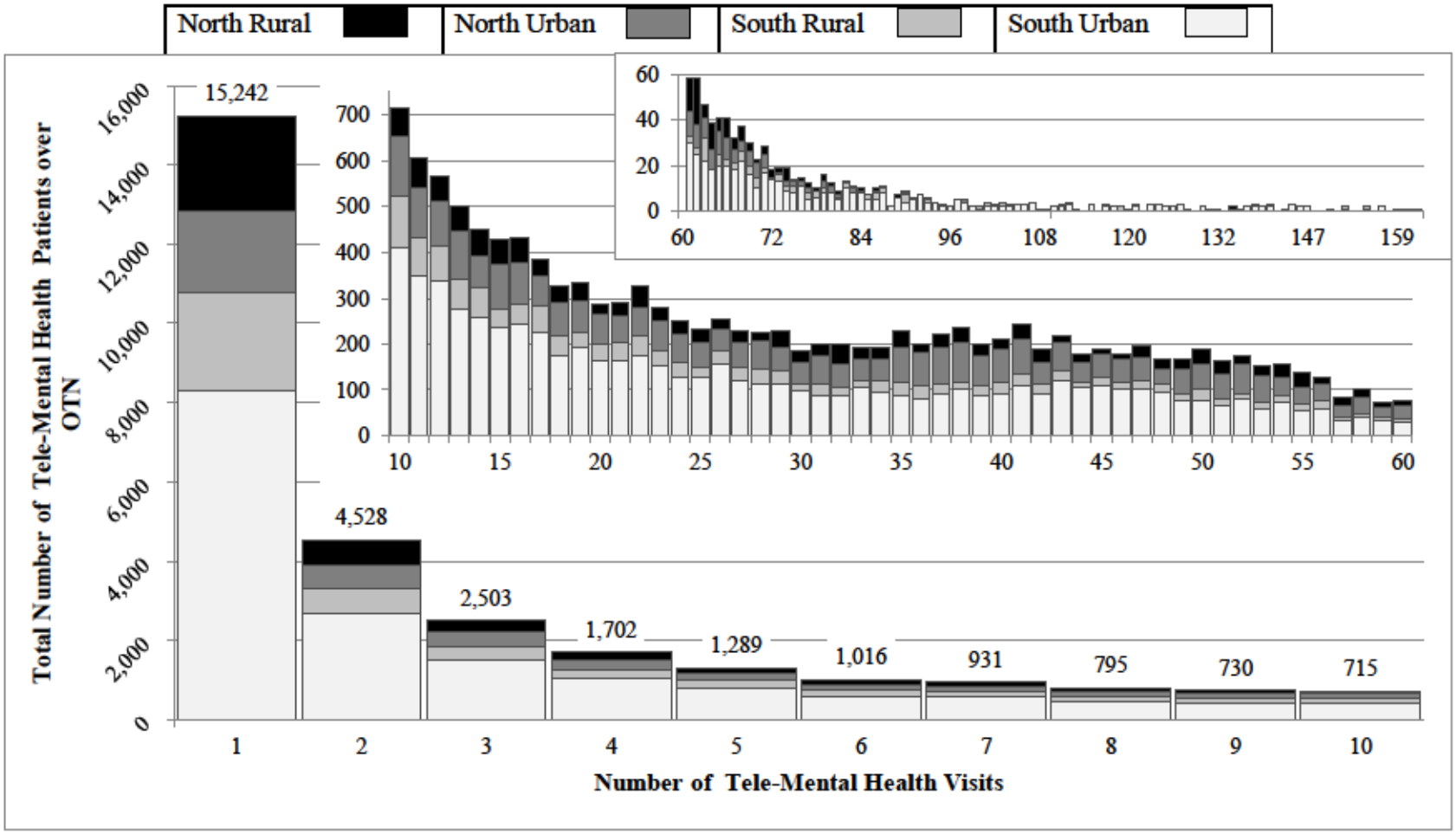
Note: Risk Ratio estimates obtained from negative binomial regression modelling the main effects of sex, region and age (as a covariate) on the total number of visits participated in within the top clinical telemedicine subspecialty services from April 2008 to March 2015; Proportion denominators based on 2011 census population data; $^{+}$Risk Ratio is significant at $p<0.05$; $^{++}$Risk Ratio is significant at $p<0.001$

Appendix B Table 3: Descriptive counts (visit proportion per 1,000-persons) of all completed telemedicine visits in the top speciality service areas, where 'Missing Geography' was listed for patient users from April 1, 2008 to March 31, 2015

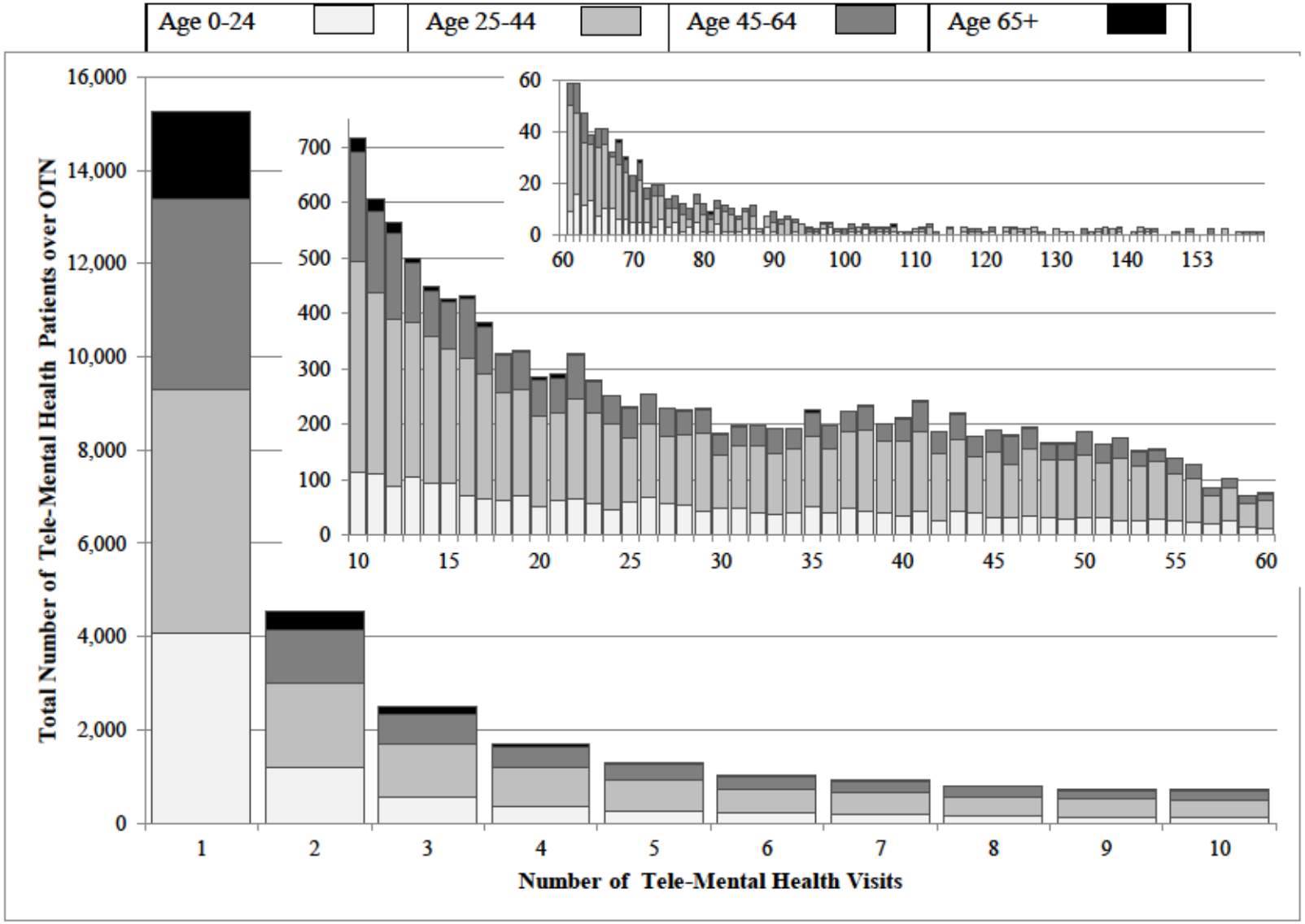
		A. FP/GP	B. Addiction Medicine	C. Internal Medicine	D. Surgery	E. Oncology	F. Psychiatry	G. Dermatology	H. Mental Health	I. All Other Services
Total		15,253 (1.19)	51,994 (4,06)	1,526 (0.12)	509 (0.04)	545 (0.04)	2,169 (0.17)	500 (0.04)	1,814 (0.14)	1,728 (0.13)
Sex (%)	Male	9,947 (1.59)	30,634 (4.91)	733 (0.12)	250 (0.04)	299 (0.05)	1,161 (0.19)	226 (0.04)	729 (0.12)	838 (0.13)
	Female	5,306 (0.81)	21,360 (3.25)	793 (0.12)	259 (0.04)	246 (0.04)	1,008 (0.15)	274 (0.04)	1,085 (0.17)	890 (0.14)
Age (%)	≤24	2,303 (0.59)	8,862 (2.29)	106 (0.03)	25 (0.01)	3 (0.00)	514 (0.13)	100 (0.03)	150 (0.04)	106 (0.03)
	25-44	8,794 (2.61)	32,229 (9.56)	596 (0.18)	107 (0.03)	7 (0.00)	956 (0.28)	112 (0.03)	719 (0.21)	301 (0.09)
	45-64	3,777 (1.03)	10,728 (2.92)	591 (0.16)	239 (0.06)	231 (0.06)	590 (0.16)	170 (0.05)	839 (0.23)	727 (0.20)
	≥65	379 (0.20)	175 (0.09)	233 (0.12)	138 (0.07)	304 (0.16)	109 (0.06)	118 (0.06)	106 (0.06)	594 (0.32)

Chapter 5: Additional figures: age- and region-specific histograms

Appendix B Figure 1: Total number of completed tele-mental visits per unique patient over OTN from April 1, 2008 to March 31, 2015, stratified by patient region



Appendix B Figure 2: Total number of completed tele-mental visits per unique patient over OTN from April 1, 2008 to March 31, 2015, stratified by patient age grouping



Chapter 5: Additional negative binomial regression analyses: Model 1 with age as a categorical variable and Models 1 and 2 with age as a continuous variable

Appendix B Table 4: Goodness-of-Fit Test using -2 Log Likelihood statistic comparing the fit of Model 1 (non-stratified) and Model 2 (stratified) with age as a categorical variable

Region	Model 1 -2LL [a b] (p-value)	Model 2 -2LL (p-value)	Model 1 - Model 2
South urban		160668.44 (<0.001)	
South rural		38603.85 (<0.001)	
North urban		54054.37 (<0.001)	
North rural		37428.99 (<0.001)	
Total	319,896.94 (<0.001)	290,755.65	29,141.29

Note: a. Information criteria are in smaller-is-better form; b. The log likelihood is based on a scale parameter fixed at 1

Appendix B Table 5: Interaction estimates of age group and sex modelled using negative binomial regression: Ontario, April 1, 2008 – March 31, 2015 (Model 1)

Model Term		β	Standard Error (β)	P value	Relative Risk	95% Confidence Interval
Constant		0.95	0.05	< 0.001		
Female	≤ 24	1.45	0.05	< 0.001	4.26	(3.86, 4.71)
	25-44	1.69	0.05	< 0.001	5.39	(4.90, 5.93)
	45-64	1.27	0.05	< 0.001	3.55	(3.22, 3.93)
	≥ 65[b]	0.34	0.06	< 0.001	1.40	(1.24, 1.58)
Male	≤ 24	1.30	0.05	< 0.001	3.67	(3.32, 4.06)
	25-44	1.77	0.05	< 0.001	5.85	(5.32, 6.43)
	45-64	1.47	0.05	< 0.001	4.34	(3.93, 4.74)
	≥ 65[b]	0	--	--	1.0	--

a. Male was used as the referent group for sex; b. ≥65 was used as a referent group for age; c. South-urban was used as the referent for region; North-rural=NR, North-urban=NU, South-rural=SR, South-urban=SU

Appendix B Table 6: Interaction effects of patient sex and Age (continuous) on tele-mental health utilization (not stratified by patient geographical region) modelled using negative binomial regression: Ontario, April 1, 2008 – March 31, 2015

Model Term	β	Standard Error (β)	P value	Relative Risk	95% Confidence Interval
Sex* Age					
Male	-0.014	0.001	< 0.001	0.99	(0.98, 0.99)
Female	-0.012	0.001	< 0.001	0.99	(0.99, 0.99)

a. Female was used as the referent group for sex; b. ≥65 was used as a referent group for age; c. South-urban was used as the referent for region; North-rural=NR, North-urban=NU, South-rural=SR, South-urban=SU

Appendix B Table 7: Goodness-of-Fit Test using -2 Log Likelihood statistic comparing the fit of Model 1 (non-stratified) and Model 2 (stratified) with age as a categorical variable

Region	**Model 1 -2LL [a b] (p-value)**	**Model 2 -2LL (p-value)**	**Model 1 - Model 2**
South urban		161896.06 (<0.001)	
South rural		39252.51 (<0.001)	
North urban		54664.13 (<0.001)	
North rural		38075.29 (<0.001)	
Total	295311.55 (<0.001)	293887.99	1423.56

Note: a. Information criteria are in smaller-is-better form; b. The log likelihood is based on a scale parameter fixed at 1

Appendix B Table 8: Interaction effects of patient sex and Age (continuous) on tele-mental health utilization (stratified by patient geographical region) modelled using negative binomial regression: Ontario, April 1, 2008 – March 31, 2015

Model Term	β	Standard Error of β	P value	Relative Risk exp(β)	95% Confidence Interval for RR
Sex* Age					
South Urban					
Female	-0.008	0.001	< 0.001	0.992	(0.990, 0.994)
Male[a]	-0.004	0.001	< 0.001	0.996	(0.994, 0.997)
Sex* Age					
South Rural					
Female	-0.013	0.002	< 0.001	0.987	(0.984, 0.990)
Male[a]	-0.007	0.002	< 0.001	0.993	(0.990, 0.997)
Sex* Age					
North Urban					
Female	-0.014	0.001	< 0.001	0.986	(0.984, 0.988)
Male[a]	-0.011	0.001	< 0.001	0.989	(0.987, 0.991)
Sex* Age					
North Rural					
Female	-0.030	0.001	< 0.001	0.971	(0.968, 0.974)
Male[a]	-0.031	0.001	< 0.001	0.969	(0.967, 0.972)

a. Female was used as the referent group for sex; b. ≥65 was used as a referent group for age; c. South-urban was used as the referent for region; North-rural=NR, North-urban=NU, South-rural=SR, South-urban=SU

Appendix C: Ethics Approvals

C.1 Laurentian University Ethics REB approval

APPROVAL FOR CONDUCTING RESEARCH INVOLVING HUMAN SUBJECTS
Research Ethics Board – Laurentian University

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

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

Name of Principal Investigator and school/department	John Hogenbirk, Wayne Warry, Jessica Lowey (added) CRaNHR (Laurel O'Gorman removed)
Title of Project	Telemedicine utilization by age, sex and rurality of patients in Northern and Southern Ontario
REB file number	2015-10-10
Date of original approval of project	November 06, 2015
Date of approval of project modifications or extension *(if applicable)*	November 10, 2016
Final/Interim report due on: *(You may request an extension)*	November, 2017
Conditions placed on project	

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

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

Congratulations and best wishes in conducting your research.

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

C.2 Lakehead University Ethics REB approval

Lakehead UNIVERSITY

Research Ethics Board
t: (807) 343-8283
research@lakeheadu.ca

February 10, 2017

Principal Investigator: Dr. Vicki Kristman
Co-Investigator(s): W. Warry, J. Hogenbirk, H. Moeller
Student: J. Lowey
Faculty of Health and Behavioural Sciences
Department of Health Sciences
Lakehead University
955 Oliver Road
Thunder Bay, ON P7B 5E1

Dear Dr. Vicki Kristman and Research Team:

Re: REB Project #: 131 16-17 / Romeo File No: 1465631
Granting Agency: N/A
Agency Reference #: N/A

On behalf of the Research Ethics Board, I am pleased to grant ethical approval to your research project titled, "Age and Sex Influences on Health Care Utilization Through the Ontario Telemedicine Network".

Ethics approval is valid until February 10, 2018. Please submit a Request for Renewal to the Office of Research Services via the Romeo Research Portal by January 10, 2018 if your research involving human participants will continue for longer than one year. A Final Report must be submitted promptly upon completion of the project. Access the Romeo Research Portal by logging into myInfo at:

https://erpwp2.lakeheadu.ca/

During the course of the study, any modifications to the protocol or forms must not be initiated without prior written approval from the REB. You must promptly notify the REB of any adverse events that may occur.

Best wishes for a successful research project.

Sincerely,

Dr. Lori Chambers
Chair, Research Ethics Board

/tm