Chapter 12
Analyzing the Effect of Choice and Availability in Healthcare on Health Outcomes in Canada – A Pre-COVID-19 Environment

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Abstract This research hypothesizes that greater availability of healthcare services, and greater choice in healthcare facilities results in better health when controlling for a variety of socio-economic factors within the Canadian context. This research will model access to healthcare services using density of general and specialist physicians relative to population size, and the geographic density of healthcare facilities. Choice in healthcare is modeled by the number of healthcare facilities in each health region, when normalized by the population in that health region.

Various health outcomes will be used as benchmarks to test this hypothesis, including self- reported general health, self-reported mental health, influenza immunization rates, body mass index (BMI), and incidence of diabetes, cardiovascular disease and hypertension.

From the empirical results, choice in the healthcare system does not have an impact on the selected health outcomes. Increased availability of healthcare generally improves health outcomes, but this is dependent on the health outcome in question, and the provincial region being analyzed.

Keywords Health economics · Pre-COVID healthcare · Healthcare access · Health outcomes · Canadian healthcare · Pre-COVID Canadian healthcare

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12.1 Introduction

12.1.1 Overview of Healthcare in Canada

Healthcare in Canada is delivered via a publicly funded system that is paid by the taxpayer, but delivered via private entities. Access to primary health care services is intended to be available to all citizens and permanent residents across all socioeconomic groups with minimal upfront costs. Canada is fairly unique in the world due to the fact that it has a national health insurance system which assures access to all citizens, regardless of their ability to pay. As guided by the Canada Health Act, each province is responsible for administering healthcare under federal guidelines [20]. As a result, the provinces handle the administration and physician reimbursement for services. The provincial governments administer and deliver health services in divided geographic health regions. Health regions can be thought of as administrative areas defined by each provincial ministry of health.

The supply of healthcare and the associated wait times have been a significant issue of public interest, particularly in non-urban areas. Although government administered healthcare is theoretically available to all, there remains challenges in the utilization of services. Currently long wait times, lack of available physicians, rising population to physician ratios, and physician brain drain have contributed to a shortage of available services in Canada [17]. Coupled with geographic challenges in accessing distant healthcare facilities, it is clear that there are imperfections in the delivery of healthcare to all Canadians. In 2006, Canada's physician-to-population ratio ranked 26th among 28 developed nations that maintain universal access health care [17]. Additionally, 6.6% of Canadians reported being unable to find a family doctor in 2010 [17]. Nadeem [17] also suggests that lack of physicians in Canada is a serious problem negatively affecting the health of Canadians. In this context, this research aims to explore the relationship between choices and availability in healthcare and the resulting health outcomes in Canada.

12.1.2 Overview of Chapter

This research will use measures such as physician density and geographic distance to healthcare facilities as a proxy for availability of healthcare services. The density of healthcare facilities will serve as a proxy for choice. This research will attempt to examine the effect of availability and choice on health outcomes. It is hypothesized that greater availability of healthcare services, and greater choice in healthcare facilities results in better health when controlling for a variety of socio-economic factors. This research will examine the extent to which health outcomes are affected at the health region level, a finer level of analysis than current literature which examines health outcomes at the provincial level. Self-reported general health and self-reported mental health are used as direct indicators of health outcomes.

Other measures such as body mass index (BMI), influenza immunization, diabetes, cardiovascular disease, and hypertension will be used as proxies for health outcomes.

This research will begin by discussing the current literature on the topic both in Canada and in various other countries. The data and methodology will be discussed, and various empirical models will be presented to analyze the topic at hand. The empirical model results will be presented, and conclusions will be derived on whether greater availability and choice in healthcare results in better health outcomes when controlling for a variety of socio-economic factors.

12.1.3 Review of Literature

Although it is difficult to compare Canada's healthcare to other countries due to structural differences between the healthcare systems, analyzing the literature on healthcare systems in other countries can provide key insights on analyzing the Canadian system. Health economics in Canada is an emerging field of study, as recent problems within the healthcare system have gained the public focus.

The main focus in Canada has been towards the reduction of wait times for procedures and emergency department visits. A policy report by Barua et al. [3] illustrates that wait times in Canada is increasing rapidly and must be addressed to ensure timely access to healthcare services for a variety of procedures. A study by Kulkarni et al. [13] concluded that for patients who underwent cystectomy for bladder cancer in Ontario between 1992 and 2004, higher wait times for this procedure was associated with a lower overall survival rate. Similarly, a study by Jewett et al. [12] concluded that Canadian wait times for urological surgeries, such as for renal cancer, are beyond the recommended thresholds set by national and international expert bodies, thus resulting in overall poorer tumor control. Another study by Braybrooke et al. [4] showed that for posterior lumbar spinal surgery, a longer wait for surgery was associated with less improvement in outcome following surgery. Clearly wait times have an effect on certain health outcomes, and wait times are expected to be correlated with the public access to healthcare. It may be fair to hypothesize that increasing public access to healthcare services effectively increases healthcare supply, which may serve to reduce wait times and improve health outcomes.

Most literature shows evidence that there is a positive effect on health outcomes when access to healthcare is increased. A study by Macinkko et al. [15] suggests that increased access to family physicians decreases infant mortality, mortality related to cancers, heart disease, and increases life expectancy across time periods and jurisdictions in the United States. Macinkko et al. [15] also concluded that an increase in one primary care physician per 10,000 population is associated with a reduction of mortality by 5.3% or 49 lives per 10,000 population. Another study by Roetzheim [22] concluded that higher dermatologist and family physician supply is associated with earlier detection of a melanoma – a deadly form of skin cancer which is lethal if not diagnosed early. Another study by Roetzheim [21] concluded that a higher supply of primary care physicians decreased the odds of late state diagnosis of colorectal cancer. However, there is some contradiction by other research. A thesis by Franz [8] examines the relationship between physician density in the United States and population health. Franz [8] concludes that there is insufficient evidence to claim that an increase in physician density would increase population health in the United States. A study by Arild and Tor Helge [1] examined the impact of economic conditions and access to primary health care on health outcomes in Norway. Arild and Tor Helge [1] rejected the significant relationship between mortality and the number of GPs per capita found in most previous studies in Norway. However, Arild and Tor Helge [1] found there is a significant effect of the composition of GPs, where an increase in the number of contracted GPs reduces mortality rates when compared with GPs employed directly by the municipality. There has been some research on the effect of specialist physicians compared to general physicians on health outcomes. A study by Baicker and Chandra [2] suggests that greater supply of specialist physicians is associated with higher costs and inadequate care. On the other hand, a study by Nash [18] showed that treatment of acute myocardial infarction (heart attack) by a cardiologist lowers risk of mortality than if treated by a general practitioner. This research will also examine the effect of specialist physicians on health outcomes in Canada.

A study of the structural economics and delivery of healthcare is also important in understanding access to healthcare services, which may affect health outcomes. In the United States, the managed care model is a healthcare plan or system that seeks to control medical costs by contracting with a network of providers, and by requiring preauthorization for visits to specialists. A thesis by Grefer [10] concluded that the density of physicians is negatively correlated with the prevalence of managed care facilities. These structural differences between healthcare systems make cross country comparisons difficult. Additionally, the structural supply of healthcare may be affected by exogenous factors. For example, a study by Correia and Veiga [7] found that geographic disparities in physician density are high, and appear to be due mainly to geographic income inequality.

This research is based on the work of Sarma and Peddigrew [23], which examines the extent to which the density of family physicians influences health outcomes in Canada. Sarma and Peddigrew [23] finds that increased density of physicians positively impacts self-reported health on the order of 2–4%. The analysis by Sarma and Peddigrew [23] is performed on a national and provincial basis, and provides some evidence that increasing density of physicians positively impacts health outcomes. This research continues the work of Sarma and Peddigrew [23] and analyzes health outcomes at a finer provincial and regional level, by examining individual health regions. This research also uses different metrics of health outcomes, and models various factors of choice and availability of healthcare not present in Sarma and Peddigrew [23].

12.2 Methodology and Data

This research hypothesizes that greater availability of healthcare services and greater choice in healthcare facilities results in better health when controlling for a variety of socio-economic factors. The determinants of access to health care are complex, and involve the interaction between the supply of healthcare services and the competition or demand for these services. Geographical factors which constrain access to healthcare services are important in determining whether an individual is able to reach locations that offer healthcare services. This research will model access to healthcare services using the density of general and specialist physicians, and the geographic density of healthcare facilities. Family physicians per 100,000 and specialist physicians per 100,000 are used as a proxy for density of physicians. The geographical density is determined from the number of healthcare facilities within 10, 20, 30, 50, and 100 km from the center of each health region. Choice in healthcare can be interpreted as the number of healthcare facilities that a person has access to, or alternatively as the number of competitors. It is another measure of healthcare supply, and is modeled by the total number of healthcare facilities in each health region, when normalized by population in that health region. This research examines the effects of choice and availability on health outcomes on a health region level.

The data for this research comes from the Canadian Community Health Survey (CCHS), performed by Statistics Canada. This is a cross-sectional survey that collects information related to health status, health care utilization and health determinants for the Canadian population. The survey contains large sample of respondents and is designed to provide reliable estimates at the health region level. Physician density at a provincial level is obtained from the Canadian Institute of Health Information (CIHI) reports that are available on their website. A list of healthcare facilities is sourced from DMTI Spatial Inc, using a product called Enhanced Points of Interest which is a national database of approximately 1 million Canadian business and recreational points of interest. This data was checked against official listing of healthcare facilities entitled Guide to Canadian health care facilities published by the Canadian Hospital Association [6]. Geographical data from Health Statistics Division of Statistics Canada provided boundaries for health regions in Canada. Using these sources, the various geographical density variables were generated.

Several measures of health outcomes were used, the two primary measures being self-reported general health and self-reported mental health. These ordinal measures ranged from 1 to 5, where 1 indicates health is poor, 2 if health is fair, 3 if health is satisfactory, 4 if health is good, and 5 if health is excellent. Various other measures that reflect health status were also used such as influenza immunization rates, body mass index (BMI), incidence of diabetes, cardiovascular disease and hypertension.

Many control variables that are probable in their effect on health status are also included in the model. Age and squared age are continuous variables used, as this is expected to be highly correlated with health status. Other controls include gender, marital status, education status, employment status, income, and geographic location. Gender and marital status is captured by a single dummy variable for that equals 1 if female or married respectively, and 0 otherwise. Educational status is captured by 3 dummy variables that represent 4 categories of education in the CCHS. These categories include individuals who graduated with post-secondary education, individuals with some post-secondary education who did not graduate, and individuals who graduated from high school. The reference or base category for education are individuals who did not graduate from high school. Employment status is a dummy variable that equals 1 if the person has been employed part-time or full-time within the past 3 months, 0 otherwise. Income is controlled via 4 dummy variables that control for 5 income categories in the CCHS. The base category is individuals whose household income is below 20,000. The remaining income categories are individuals whose household income is between \$20,000–\$39,999, \$40,000–\$59,999, \$60,000–\$79,999, and \$80,000+. Geographic differences were modeled using several dummy variables indicating the various health regions in Canada. Four provinces were analyzed in detail: Ontario, British Columbia, Quebec, and Nova Scotia. The health regions that served as base categories which were omitted in the model were Toronto, Vancouver, Montreal, and Zone 1 respectively. The choices of these omissions reflected the fact that these were the most populous health regions in each province.

Several models were constructed using regression analysis, where the dependent variables reflected health status. Self-reported general health, and self-reported mental health are ordered categorical variables, therefore an ordered logit model is employed. For dichotomous dependent variables, a logistical regression is employed. The results are presented as odds ratios for easier interpretation. Marginal effects were calculated, but not presented due space restrictions, and the limited value added after interpreting odds ratios. The analysis was performed in STATA software, and all regression results were weighted using the provided survey weights, and corrected for heteroscedasticity using the robust command in STATA. This option estimates the standard errors using the Huber-White sandwich estimators which compensate for heteroscedasticity, and erroneous observations that exhibit large residuals.

12.2.1 Body Mass Index (BMI)

Body mass index (BMI) is a measure of human body shape and is dimensionless quantity defined as the ratio between mass and height. The quantity is designed to be a simply measure that describes various levels of obesity. It assesses a person's body weight excess or deficiency relative to their height. Although commonly used, it does not account for weight deviations due to muscularity. According to the World Health Organization, the categorical descriptions for various ranges of BMI are given below (Table 12.1).

Table 12.1 BMI categories [26]

Category	BMI range
Very severely underweight	less than 15
Severely underweight	from 15.0 to 16.0
Underweight	from 16.0 to 18.5
Normal (healthy weight)	from 18.5 to 25
Overweight	from 25 to 30
Obese Class I (Moderately obese)	from 30 to 35
Obese Class II (Severely obese)	from 35 to 40
Obese Class III (Very severely obese)	over 40

The BMI ranges are based on the relationship between body weight and disease/death [25]. Therefore, individuals with higher BMI are at risk for many health conditions that are detrimental to health status. Some conditions of risk include: hypertension, diabetes, heart disease, stroke, sleep problems, and some types of cancers [19]. From the literature it is clear that BMI is very highly correlated with health status. Although control of an individual's BMI is ultimately dependent on each person, access to health professionals may have an educational effect, which may induce people to correct abnormally high BMI and its associated health issues. A healthcare provider can also assist individuals in performing this often-difficult task.

12.2.2 Alternate Measures of Health Status

Three common diseases are used as alternate measures of health status, as they are highly reflective of an individual's lifestyle choices [24]. Just as BMI is ultimately dependent on each individual, these three diseases are predominately caused or exacerbated by poor diet, inadequate exercise, and other negative health choices [24]. Similar to BMI, access to health professionals may have an educational effect, which may induce people to prevent or manage these diseases. The three conditions are: diabetes mellitus, hypertension, and cardiovascular disease.

Diabetes mellitus or simply diabetes is a group of metabolic diseases that involve a lack of control of blood sugar (glucose) due to a variety of physiological dysfunctions. Type 1 diabetes is an autoimmune condition where the body destroys insulin secreting cells in the pancreas, resulting in tissue degradation, ketoacidosis (acid blood), polyuria (abnormally high urine volume), polydipsia (increased thirst) and polyphagia (increased hunger) [24]. Type 2 diabetes is a general term for a family of diseases that result from insulin resistance, or an abnormal body response to insulin, and is associated with obesity, polyuria, and atherosclerosis (buildup of fatty plaque inside blood vessels) which leads to heart disease and stroke [24]. Based on the physiological effects of this disease, it is expected that both types of diabetes should decrease the health status of individuals who are inflicted.

Hypertension is another term for high blood pressure which is a chronic medical condition that causes the heart to work harder to pump blood throughout the body, and may increase risk for stroke, heart attacks, kidney disease, and shortened lifespan [24]. Hypertension is classified as either primary or secondary hypertension; about 90–95% of cases are categorized as primary hypertension which means high blood pressure with no obvious underlying medical cause [5]. Hypertension in most cases is easily manageable using various medications, weight loss, and food choices [24]. Treatment of minor to moderate hypertension is quite manageable with the assistance of a physician or healthcare provider.

Cardiovascular disease or heart disease is a family of diseases involving the circulatory system (heart, arteries, veins) [24]. There are many underlying causes of this disease, and both diabetes and hypertension are strong factors that influence the onset of cardiovascular disease. It is also one of the leading causes of death worldwide, but the death rate has been dropping in developing countries like Canada due to improvements in treatment [9]. This disease can partially be avoided by proper diet, adequate exercise, abstaining from smoking, and maintaining a healthy body weight under the guidance of a healthcare practitioner [24].

It is important to emphasize that in most cases type 2 diabetes and minor hypertension can be cured, particularly if diagnosed and managed early during the onset of the disease [24], therefore access to healthcare services is critical in managing these diseases.

12.2.3 Influenza Immunization

Influenza or the" flu" is a family of infectious viral diseases which causes chills, fever, sore throat, muscle pains, headache (often severe), coughing, weakness/ fatigue and general discomfort [16]. Most cases of influenza pass after a few days, but some individuals (particularly high-risk individuals) may develop life-threatening complications (such as pneumonia) which can cause death [11]. As a result, the Canadian Task Force on Preventative Health-care recommends annual influenza immunization for high-risk individuals and elderly individuals [14]. In this research, it is assumed that the incident of influenza immunization increases with greater availability and choice. Therefore, influenza immunization is expected to reflect choice and availability of this procedure.

12.2.4 Summary of Model Variables

The Table 12.2 below summarizes the different independent and dependent variables in the regression models.

Table 12.2 Variable definitions

Variable	Definition
Dependent Variables	
Self-Perceived Health	=1 if general health is poor; =2 if general health is fair; =3 if general health is satisfactory; =4 if general health is good; =5 if general health is excellent
Self-Perceived Mental Health	=1 if general health is poor; =2 if general health is fair; =3 if general health is satisfactory; =4 if general health is good; =5 if general health is excellent
BMI	Body Mass Index (BMI) of respondent. Measure for human body health based on an individual's weight and height
High Blood Pressure	=1 if a respondent has high blood pressure; =0 otherwise
Diabetes	=1 if a respondent has diabetes; =0 otherwise
Heart Disease	=1 if a respondent has heart disease; =0 otherwise
Seasonal Flu Shot	=1 if a respondent had influenza immunization in past year; =0 otherwise
Independent Variables	
[Facilities within X km]	Vector: Number of healthcare facilities that fall within X km of gravity center of health region in which the respondent resides. X takes on values 10, 20, 30, 50, 100 km respectively
# of Facilities in H.R. Normalized	Density of healthcare facilities in each health region in which respondent resides
Family Physicians per 100,000	Number of general practitioners or family physicians per 100,000 population in the corresponding health region
Specialists per 100,000	Number of specialist physicians per 100,000 population in the corresponding health region
Age	Age of respondent in completed years
Age Squared	Squared Age
Female	=1 if female; =0 if male
Married	=1 if married; =0 if otherwise
Smoker	=1 if current and regular smoker; =0 if otherwise
Employed	=1 if employed full time or part time; =0 if other-wise
Educ: Graduated Post-Secondary	=1 if completed post-secondary education; =0 if otherwise
Educ: Some Post-Secondary	=1 if respondent has some post-secondary education, but not completed a degree/diploma; =0 if otherwise
Educ: Graduated Secondary	=1 if respondent graduated from secondary school; =0 if otherwise
Income: 20,000–39,999	=1 if household income is in the range of $20,000–39,999; =0 if otherwise
Income: 40,000–59,999	=1 if household income is in the range of $30,000–59,999; =0 if otherwise
Income: 60,000–79,999	=1 if household income is in the range of $60,000–79,999; =0 if otherwise
Income 80,000+	=1 if household income is above $80000, =0 if otherwise
[Provinces]	=1 if respondent lies in X province
[Health Regions]	=1 if respondent lies in X health region

12.2.5 Geographic Variables

As mentioned previously, a list of all healthcare centers was obtained from DMTI Spatial Inc, using a product called Enhanced Points of Interest. This includes hospitals, special care centers, nursing homes, and providers of group healthcare (groups of physicians). Using this data and geographic data from Health Statistics Division of Statistics Canada, the latitude and longitude of the gravity center of each health region and healthcare centers was extracted. The distance between the gravity center of each health region and each individual health center was calculated. Then this data was sorted to generate the number of health centers within various distances from the gravity center of each health region. Only the following distances were used in this analysis: 10, 20, 30, 50, and 100 km, as this provided sufficient data to model availability of healthcare services. Additionally, GIS software was used to calculate the number of healthcare facilities that are contained by the borders of each health region, and this was normalized by the population of the particular health region.

The analysis at the health region level was limited to 4 provinces: Ontario, British Columbia, Quebec, and Nova Scotia. This resulted from the improper use of the health region variable in the CCHS, as several health regions were improperly combined in the CCHS. A correction for issue using the GIS data is fairly complex, therefore provinces that exhibited this problem were omitted.

The Fig. 12.1 below shows the various health boundaries for Canada, and healthcare centers contained within each region. Clearly most health centers are located in populated areas close to the US border.

12.3 Empirical Results

This section presents the regression results performed in STATA. For self-reported health in Canada, analysis was performed at a granular level – that is province level geographic variables were employed. For the remaining models, the analysis was performed at the health region level. This section will summarize all regression results, please refer to the appendix for all the regression tables.

12.3.1 Self-Reported Health in Canada

The granular level model is intended to replicate the efforts of Sarma and Peddigrew [23] with updated data from 2010. The self-reported general health and self-reported mental health models were ordinal logistical models that took the form:

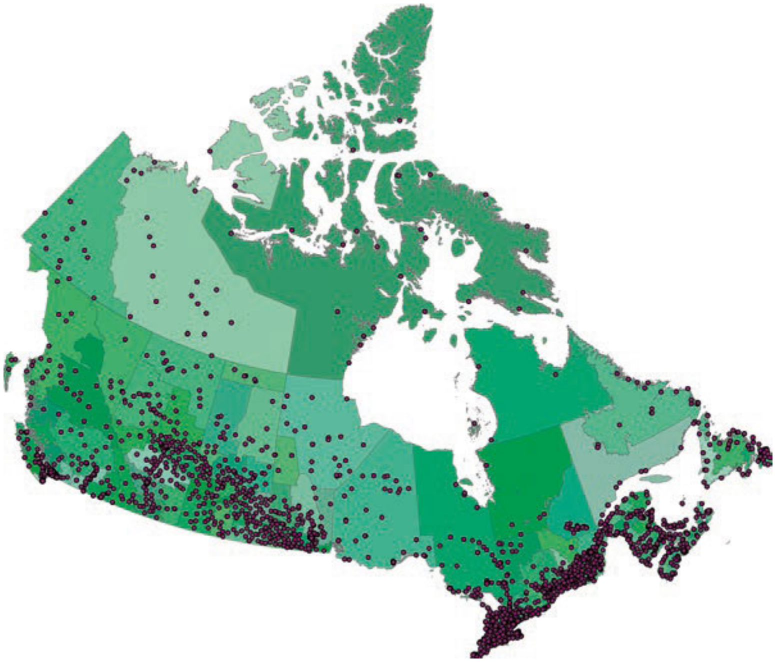

Fig. 12.1 Health regions and location of health centers in Canada

$$\begin{aligned}[\text{Self - Perceived Health}] &= \beta 0 + \beta 1 \text{Physician Density} + \beta 2 \text{Specialist Density} + \beta 3 \text{Age} \\ &+ \beta 4 \text{Age2} + \beta 5 \text{Female} + \beta 6 \text{Married} + \alpha [\text{Education}] + \gamma [\text{Income}] + \delta [\text{Province}]\end{aligned}$$

The density variables for general physician density and specialist density are found to be statistically insignificant. This deviates from Sarma and Peddigrew [23] which found that an additional general physician per 100,000 persons increased the odds of reporting better health status by 0.2%, and an additional specialist per 100,000 persons increase the odds of reporting better health by 0.1%, ceteris paribus. We do find that holding all things constant that increased age decreases the likelihood of reporting excellent general health by 10%, and mental health by approximately 25%. Relative to incomes below $20,000, incomes above $40,000 appear to increase the likelihood of reporting both general and mental health by at least 40%. Being female increases the probability of reporting excellent general health by 9.1% but decreases the probability of excellent mental health status by 12%. The effect of marriage is only significant in the case of mental health, where it increases the odds of reporting mental health by 21%.

Similar to the findings on income, education is found to have a strongly positive effect on health status at high significance levels. Relative to people who did not graduate high school, it is found that the odds of reporting better general health are increased by 77% for post-secondary graduates, 34% for people with some post-secondary education, and 27.6% for people who graduated from high school. Similarly, the odds of reporting better mental health increased by 53% for post-secondary graduates, 25% for people with some post-secondary education, and 36% for people who graduated from high school. Employed individuals are 20.5% more likely to report better general health, and 17.4% more likely to report better mental health.

Provincial variables appear to limited in their significance. However, it is found that residents of Quebec are 17.7% more likely to report better general health, and 27.8% more likely to report better mental health. Residents of Manitoba are 22% less likely to report excellent general health, and 29% less likely to report excellent mental health. Perhaps intra-provincial cultural differences or the differences in the delivery of healthcare may be at play, and this could be the subject of further research.

At the granular level, it is found that variables which reflect availability of healthcare are statistically insignificant, and only socio-economic factors play a role in reporting excellent general and mental health.

12.3.2 Self-Reported General Health

Self-reported general health was analyzed at the regional level using an ordered logistical regression model as follows. Additional variables that reflect choice and availability of healthcare services are included that were not in Sarma and Peddigrew [23].

$$\begin{aligned}&[\text{Self - Perceived General Health}] = \beta 0 + \beta 1 \text{Physician Density} + \beta 2 \text{Specialist Density}\\&\quad + \beta 3 \text{Age} + \beta 4 \text{Age2} + \beta 5 \text{Female} + \beta 6 \text{Married} + \alpha [\text{Education}] + \gamma [\text{Income}]\\&\quad + \delta [\text{Health Region}] + \beta 7 \text{Number of Facilities in Health Region Normalized}\\&\quad + \beta 8 \text{Has Doctor} + \zeta [\text{Density of Health Facilities}] + \beta 9 \text{Smoker}\end{aligned}$$

The density variables which are general physicians per 100,000 population and specialists per 100,000 population are found to be statistically insignificant in all provinces. Similarly, the density of healthcare facilities (number of facilities within X km), is not found to be significant across any of the provinces. Therefore, measures of availability of healthcare do not play a role in affecting self-reported general health. In the province of Ontario, the variable reflecting choice (number of facilities in each health region normalized by population) is significant, but has no effect on the odds of reporting better health status.

Many socioeconomic factors are found to significantly affect general health. In the province of Ontario, increasing education affected health status in a quasi-exponential fashion. Relative to individuals who did not graduate from high school, the odds of reporting better general health increased by 22% for high school graduates, 26.3% for individuals with some post-secondary education, and 63.2% for post-secondary graduates. Similarly, it was found that higher income increased the odds of reporting better general health. Being employed increased the odds of reporting better general health by 18.3%. A similar trend for education, income, and employment was found across in the other provinces. Another interesting fact revealed from the model, is that across all 4 provinces the odds of reporting better health decreases by approximately 38% for smokers.

In Ontario, living in the Haliburton-Kawartha-Pine Ridge District Health Unit decreases the odds by approximately 55% of reported excellent general health status, relative to Toronto. Similarly, living in Peel Region decreases the odds of reporting excellent general health by 42%. In contrast, living in the Oxford County Health Unit increases the odds of reported better general health by nearly 50%. In British Columbia, no such geographical health region effects were found to be significant relative to individuals living in Vancouver. In Quebec, living in Region du Saguenay, Region de la Capitale Nationale, and Region de la Montrgie increases the odds of reporting better general health by 88%, 29.7%, and 35.3% respectively (relative to Montreal). In Nova Scotia, residents of Zone 2 have decreased odds of reporting better general health by nearly 40%, relative to Zone 1.

12.3.3 Self-Reported Mental Health

Self-reported mental health was analyzed at the regional level using an ordered logistical regression model as follows.

$$\begin{aligned}&[\text{Self - Perceived Mental Health}] = \beta 0 + \beta 1\,\text{Physician Density} + \beta 2\,\text{Specialist Density}\\&+ \beta 3\,\text{Age} + \beta 4\,\text{Age2} + \beta 5\,\text{Female} + \beta 6\,\text{Married} + \alpha[\text{Education}] + \gamma[\text{Income}]\\&+ \delta[\text{Health Region}] + \beta 7\,\text{Number of Facilities in Health Region Normalized}\\&+ \beta 8\,\text{Has Doctor} + \zeta[\text{Density of Health Facilities}] + \beta 9\,\text{Smoker}\end{aligned}$$

The density variable denoting general physicians per 100,000 population played an unusual but statistically significant role in the province of Nova Scotia. Residents of Nova Scotia were 0.5% less likely to report better mental health status for an additional general physician per 100,000 population. Mental health was also affected by the density variable for specialist physicians per 100,000 population in three out of four provinces. The odds increased by 0.9% in Ontario, 0.8% in British Columbia, and 0.9% in Nova Scotia for reporting better mental health with an additional specialist physician per 100,000 population. The density of healthcare facilities (number of facilities within X km), was not found to be significantly and affect mental health outcomes in any of the provinces. The number of facilities in each health region normalized by population also did not play a role in affecting mental health outcomes. It is clear that only in some cases did the measures for healthcare availability play a role increasing mental health outcomes.

Socioeconomic factors mirrored their effects to self-reported general health. As expected, increased income and education increased the odds of reported better mental health. Unique to mental health, being female actually decreased the odds of reporting better mental health by 12.5%, 12.4%, 23.6%, and 23.5% in Ontario, British Columbia, Quebec, and Nova Scotia respectively. Being married also increases the odds of reporting better mental health by 17.6%, 17.1%, 18.5%, and 17.1% in Ontario, British Columbia, Quebec, and Nova Scotia respectively. In each of the four provinces the odds of reporting better mental health decreases by approximately 23% for smokers.

Regional effects of health regions were sparse and mostly insignificant for the most part. Residents of the Sudbury and District Health Unit in Ontario were 36% less likely to report better mental health relative to the base category of Toronto. In contrast, Quebec residents of Region de la Capital Nationale, Region de l'Abitibi-Tomiscamingue, Region de la Cote-Nord, Region de la Gaspsieles-de-la-Madeleine and Region de la Montrgie are more likely to report better mental health by 39.5%, 37.8%, 103.9%, 51.2% and 36.0% relative to Region de Montreal.

12.3.4 Body Mass Index

BMI was analyzed at the regional level using a normal least squares regression corrected for heteroscedasticity. The model takes the form:

$$\begin{aligned}\text{BMI} = {} & \beta 0 + \beta 1 \text{Physician Density} + \beta 2 \text{Specialist Density} + \beta 3 \text{Age} + \beta 4 \text{Age2} \\ & + \beta 5 \text{Female} + \beta 6 \text{Married} + \alpha \left[\text{Education}\right] + \gamma \left[\text{Income}\right] + \delta \left[\text{Health Region}\right] \\ & + \beta 7 \text{Number of Facilities in Health Region Normalized} + \beta 8 \text{Has Doctor} \\ & + \zeta \left[\text{Density of Health Facilities}\right] + \beta 9 \text{Smoker}\end{aligned}$$

The density variable for general physicians per 100,000 population was found to be statistically significant, but roughly decreased BMI by only 0.025 for a unit increase in density across all four provinces. This effect is not significant from viewpoint of health, as the change in BMI is too small. Similarly, the density of healthcare centers and number of facilities per health region exhibited statistical significance across the provinces, but had a non-significant effect on BMI from a health viewpoint.

Socioeconomic factors had a very interesting effect on this health outcome. As expected, a unit increase in age resulted in greater BMI by approximately 1.4 across the provinces. Interesting to note that smoking and being female decreased BMI by approximately 0.5 and 1.6 respectively across the provinces. This suggests that BMI is an imperfect measure of health outcome, and may not be suited to cross-gender comparisons. In particular, it may not capture the health consequences of smoking. It is also interesting to note that education played very little role in reducing BMI until individuals reached a very high level of education. Across the provinces, BMI decreased by roughly 0.6 only when individuals achieved post-secondary education. Lesser amounts of education had much small coefficients, and were found to be statistically insignificant. Income levels were not found to be statistically significant in their effect on BMI.

There were some regional effects of health regions that are notable. In Ontario the residents of the City of Ottawa Health Unit and Oxford County Health Unit exhibited lower BMI by 0.757 and 1.345 respectively (relative to Toronto). The odds of general health in Oxford County Health Unit were previously found to be greater, suggesting that residents of this health unit are healthier than residents of other regions. In British Columbia, residents of Fraser North, Fraser South, Richmond, and North Shore were found to have significantly lower BMI relative to residents of Vancouver. Similarly in Quebec, residents of Region du Bas-Saint-Laurent, Region du Saguenay Lac-Saint-Jean, Region de la Capitale Nationale, Region de la Mauricie et du Centre- du-Quebec and Region de l'Outaouais were found to have significantly lower BMI relative to Region de Montreal. In Nova Scotia, residents of Zone 2 were found to have an increased BMI by 2.292 relative to residents of Zone 1.

12.3.5 Alternate Measures of Health

Three alternate measures of health include: diabetes, cardiovascular disease, and hypertension. These were measured at the regional level using a logistical regression model as follows:

$$\begin{aligned}\text{Health Measure} = {} & \beta 0 + \beta 1 \text{Physician Density} + \beta 2 \text{Specialist Density} + \beta 3 \text{Age} \\ & + \beta 4 \text{Age2} + \beta 5 \text{Female} + \beta 6 \text{Married} + \alpha \left[\text{Education}\right] \\ & + \gamma \left[\text{Income}\right] + \delta \left[\text{Health Region}\right] \\ & + \beta 7 \text{Number of Facilities in Health Region Normalized} + \beta 8 \text{Has Doctor} \\ & + \beta 9 \text{Facilities within10km} + \beta 10 \text{Smoker}\end{aligned}$$

In Ontario, an additional general physician per 100,000 population decreased the odds of reporting diabetes and hypertension by 3.1% and 2.6% respectively. In contrast, an additional specialist physician per 100,000 population increased the odds of reporting hypertension by 1%. In Quebec and Nova Scotia, it was found that an increase in general physician density decreased the odds of diabetes by 2.5%. No other statistically significant effects were found for physician density or specialist density. The choice variable – number of facilities in health region normalized by population – did not affect any alternate health outcomes, nor was it statistically significant.

In all provinces, increased age raised the likelihood of reporting diabetes and hypertension by over 100%, but did not have a significant effect on cardiovascular disease. In each of the provinces, being female cut the odds of reporting diabetes and cardiovascular disease in half, and hypertension by approximately 25%.

Increased education tended to significantly decrease the odds of reporting any of the 3 conditions, but the results were not consistently statistically significant. Increased incomes above $80,000 tended to decrease the likelihood of reporting diabetes and hypertension by approximately 60% and 50%, across all four provinces. Being employed decrease the odds of reporting diabetes and cardiovascular disease by roughly 36% and 32% in each of the four provinces.

Regional effects of health regions were significant in quite a few cases. In the case of Ontario, the base health region was Toronto. Relative to Toronto, residents of the District of Algoma Health Unit were 67% less likely to report hypertension. In Brant County Health Unit, residents were less likely to report diabetes, cardiovascular disease, and hypertension by 71.4%, 75.6%, and 63.7% respectively. In contrast residents of Haliburton-Kawartha-Pine Ridge District Health Unit were a whopping 607% more likely to report cardiovascular disease and 27.5% more likely to report hypertension. Residents of Chatham-Kent Health Unit were less likely report diabetes and hypertension by 57% and 51% respectively. Residents of the Leeds, Grenville and Lanark District Health Unit, were less likely to report hypertension by 52%. Residents of Middlesex- London Health Unit were less likely to report diabetes and cardiovascular disease by 68.2% and 83.7% respectively. Residents of North Bay Parry Sound District Health Unit and Oxford County Health Unit were found to be less likely to report diabetes by 58.2% and 77.8% respectively. Note that residents of Oxford County Health Unit reported lower BMI and were more likely to report better general health. Residents of Simcoe Muskoka District Health Unit were 50.3% less likely to report diabetes. In British Columbia base category for health regions was Vancouver. Relatively to Vancouver, residents of East Kootenay were 56.4% less likely to report hypertension. Residents of Okanagan were less likely to report diabetes and cardiovascular disease by 58.5% and 76.7% respectively. Residents of Thompson/Cariboo and South Vancouver Island were found less likely to report cardiovascular disease by 84.7% and 77% respectively. Residents of North Shore/Coast Garibaldi were less likely to report both cardiovascular disease and hypertension by 81.1% and 60% respectively. In the province of Nova Scotia, the base category was Zone 1. Relative to Zone 1, residents of Zone 5 were 144% more likely to report hypertension, and residents of Zone 6 were 119% more likely to report diabetes.

12.3.6 Influenza Immunization

Influenza immunization was also analyzed at the regional level and employed a logistical regression model as follows:

$$\begin{aligned}&\text{Influenza Immunization} = \beta 0 + \beta 1\,\text{Physician Density} + \beta 2\,\text{Specialist Density} + \beta 3\,\text{Age}\\&+\beta 4\,\text{Age2} + \beta 5\,\text{Female} + \beta 6\,\text{Married} + \alpha\left[\text{Education}\right] + \gamma\left[\text{Income}\right] + \delta\left[\text{Health Region}\right]\\&+\beta 7\,\text{Number of Facilities in Health Region Normalized} + \beta 8\,\text{Has Doctor}\\&+\zeta\left[\text{Density of Health Facilities}\right] + \beta 9\,\text{Smoker}\end{aligned}$$

An additional general physician per 100,000 population was not found to be statistically significant across any of the four provinces. However, an additional specialist per 100,000 population increases the odds of receiving influenza immunization in Ontario, British Columbia, and Nova Scotia by 5.5%, 6%, and 7% respectively. The density of healthcare facilities – number of facilities within X km – was not found to be significant across any of the provinces. The number of facilities in each health region normalized by population also did not play a role in affecting the odds of receiving the influenza immunization.

Socioeconomic factors played less of a role in affecting the odds of receiving the influenza immunization when compared to other measures of health status, as not very many socioeconomic variables were significant. Being female in Ontario, British Columbia, and Nova Scotia decrease the odds of receiving the influenza immunization by about 40–45%. Age, education, employment, and income were not found to have a statistically significant effect.

Regional effects of health regions showed extreme results in each of the provinces. In Ontario relative to Toronto, residents of Halton Regional Health Unit and Windsor-Essex County Health Unit were many times more likely to receive the influenza immunization. In contrast, residents of Huron County Health Unit and The Eastern Ontario Health Unit were many times less likely to receive the influenza immunization. Regional effects in British Columbia were difficult to analyze, as many observations predicted failure perfectly, or exhibited collinearity. This occurred because variables for each health region were zero every time influenza immunization was also zero. In Quebec, residents of the Region de la Capitale Nationale were more than 9 times more likely to receive influenza immunization relative to residents of Montreal. Note that from previous sections, residents of Region de la Capitale Nationale were also more likely to report better mental and general health outcomes. In Nova Scotia, residents of Zone 2 were much less likely to receive the immunization relative to Zone 1.

12.4 Discussion, Conclusions, and Future Research

12.4.1 Discussion and Future Research

There are some methodological problems in using ordinal choices in survey data. There are no precise differences between the ordinal choices, and the relative differences between each ordinal choice is unclear. It may also be the case the ordinal variables do not capture the wide range of health status reported by individuals. It may also be the case an ordinal ranking of health status is in appropriate, and it makes sense to partition the outcomes into a dichotomous variable. Further investigation is required to prove that this is the case.

The density of healthcare facilities – number of facilities within X km – was calculated from the gravity center of each health region. That is, the shape of each health region was mathematically averaged to find the center of each health region.

In rare instances, for irregularly shaped health regions, this resulted in the gravity center being outside the borders of the health region. Therefore, it is also important to emphasize, that the gravity center is substantially different from the geographic center of most health regions. This limitation may have served to skew results for this variable, particularly for irregular shaped health regions in rural areas.

The CCHS did not adequately represent the health regions as defined by Health Canada and the various provincial ministers. Often several health regions defined by the provincial ministries would be amalgamated into one large health region in the CCHS. This led to issues in generating the geographic variables used in the models, thus any provinces that caused issues was removed from the analysis. The provinces of Saskatchewan, Manitoba, PEI, Newfoundland exhibited this issue to varying levels of extent. Alberta recently restructured its health boundaries, which created significant mismatch between the new health boundaries and regions in the CCHS. Also, the CCHS combined the northern territories, while excluding Nunavut.

In order to ensure that the CCHS data sufficiently represented the covered population accurately, the models were all weighted using the included probability weights. The weights represented the inverse of the probability of each observation being sampled. However, standard survey techniques of calculating reliable variance estimates were not employed at this time due to the lack of availability of replicate weights in the dataset. Further study should employ variance estimation methods such as: Taylor Linearization, balanced repeated replication (BRR), jackknife, or bootstrap. The variance estimation methods coupled with the corresponding replicate weights allow us to obtain much more accurate standard errors of the estimates in the CCHS. This may significantly change the inference of many variables, and provide greater insight into the question of the effect of availability and choice on health outcomes. Although these variance estimation methods are built into STATA, they are not compatible with complex survey data where weighting needs to be applied.

Finally, there is myriad of factors that are unaccounted for given the limited availability of data on this subject. Assuming the population is not genetically homogeneous, genetic factors between groups of individuals between regions can result in radically different health outcomes.

Quality of care can vary significantly between regions, particularly in urban vs. rural areas, where higher standard facilities may only be available in urban areas. Unobserved socioeconomic factors may also play a role, as well as other unaccounted for factors.

12.4.2 Conclusions

This research initially hypothesized that greater availability of healthcare services and greater choice in healthcare facilities results in better health when controlling for a variety of socioeconomic factors. The research modeled access to healthcare services using density of physicians and specialists, and the geographic density of healthcare facilities. Choice in healthcare was modeled as the number of healthcare facilities that a person has access to, which is the number of facilities in each health region normalized by population. The analysis was performed at the regional level in four provinces: Ontario, British Columbia, Quebec, and Nova Scotia.

Based on the various models constructed in this research, the indicator of choice – number of facilities in each health region normalized by population was found to be either statistically insignificant, or too small to realistically affect health outcomes. The indicator of availability of healthcare – the density of healthcare facilities – was also found to be statistically insignificant, or too small to realistically affect health outcomes. The indicators of availability of healthcare services – density of general physicians and specialist physicians – were found to affect health outcomes only in the case of certain health outcomes. Therefore, the results can be summarized by the various health outcomes as follows:

Self-Reported General Health
At the provincial level and the health region level, the density variables for general physician density and specialist density are found to be statistically insignificant. Socioeconomic factors dominate in explaining effects on self-reported general health.

Self-Reported Mental Health
In Nova Scotia, it was found that increased physician density decreased the likelihood of reported better mental health outcomes by 0.5%. Increased density of specialist physicians increased the odds of better mental health by 0.9% in Ontario, 0.8% in British Columbia, and 0.9% in Nova Scotia. Socioeconomic factors also played a strong role in explaining mental health.

BMI
Physician density decreased BMI by 2.5% in all four provinces, but this change is too small to make a real-world difference in health. Specialist density was not found to have any effect on BMI. Socioeconomic factors played less of a role in explaining BMI.

Diabetes, Cardiovascular Disease, and Hypertension
In Ontario increased general physician density decreased the odds of reporting diabetes and hypertension by 3.1% and 2.6% respectively. Specialist physician density increased the odds of reporting hypertension by 1%. In Quebec and Nova Scotia, it was found that increased general physician density decreased the odds of diabetes by 2.5%. No other statistically significant effects were found for general physician density or specialist density. Socioeconomic factors played a strong role in explaining these health outcomes.

Influenza Immunization
Increased general physician density was statistically insignificant across all 4 provinces, but increased specialist physician density increased the odds of receiving the influenza immunization in Ontario, British Columbia, and Nova Scotia by 5.5%, 6%, and 7% respectively.

Therefore, it is clear from the results, that choice in healthcare does not have an impact on the chosen health outcomes. Increased availability of healthcare generally improves health outcomes, but this is dependent on the health outcome in question, and the provincial region being analyzed.

Finally, regional effects of living in a particular health region did reveal some slight trends. From the various models, it appears that residents of Oxford Country and Region de la Capitale Nationale exhibit better health outcomes over a variety of measures. Relative to Toronto residents, residents of Oxford County Health Unit were found to be less likely to report diabetes by 58.2%, had a lower BMI by approximately 1.345, and 50% more likely to report better general health. Similarity, residents of Region de la Capitale National (relative to Montreal) were 26.7% more likely to report better general health, 39.5% more likely to report better mental health, reported lower BMI, and were nine times more likely to receive an influenza immunization.

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