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Geographic accessibility to primary care providers: Comparing rural and urban areas in Southwestern Ontario

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Key Messages

- Southwestern Ontario has slightly better geographic accessibility to primary care providers than the provincial average, but there remain areas with provider shortages.
- Primary care provider distribution is unequal across the urban-rural continuum, with lowest accessibility in rural and small population centres within the Census Metropolitan Area.
- There is a mismatch between the distribution of primary care providers and high proportions of seniors, necessitating many seniors to travel long distances to access health care.

This research examines geographical accessibility to primary care providers (PCPs) across urban and rural areas of Southwestern Ontario and examines variations in the distribution of PCPs in relation to the senior

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population (aged 65 years and older). Information about PCP practices was provided by the HealthForceOntario Marketing and Recruitment Agency. Population data were obtained from the 2016 Census of Canada. To calculate scores for accessibility to PCPs (i.e., PCPs/10,000 population), we applied the enhanced 2-step floating catchment area method with distance decay effect within a global service catchment of 30-minute drive time. A geospatial mapping approach revealed disparities in the distribution of PCPs with a pattern of higher spatial accessibility in or around major urban areas in Southwestern Ontario. Comparative analyses were performed in association with the seniors' population to identify how accessibility scores were mismatched with the population needs. The outcome of this study will assist researchers and health service planners to better understand the distribution of existing PCPs to address inequalities, particularly in rural areas.

Keywords: primary care, geography of health, inequalities, rural areas, senior population

L'accessibilité géographique aux services de soins primaires : une comparaison entre les secteurs ruraux et urbains dans le sud-ouest de l'Ontario

La présente recherche étudie l'accessibilité géographique des populations aux dispensateurs de soins primaires (DSP) dans les secteurs ruraux et urbains du sud-ouest de l'Ontario. Il s'agit aussi d'analyser les écarts dans la répartition des DSP par rapport à la population âgée (65 ans et plus). Sur le plan méthodologique, les informations concernant les pratiques des DSP ont été fournies par l'Agence de promotion et de recrutement ProfessionsSantéOntario. Pour leur part, les données sur la population proviennent du Recensement canadien de 2016. De plus, pour calculer les indices d'accessibilité aux DSP (c.-à-d., les DSP par population de 10 000), nous avons appliqué la méthode améliorée de zones de captage flottante en deux étapes avec effet de désintégration en fonction de la distance à l'intérieur d'un rayon global de 30 minutes en voiture. Ainsi, une technique de cartographie géospatiale a révélé des écarts dans la distribution des DSP avec un schéma spatial de haute accessibilité dans les principaux secteurs urbains du sud-ouest de l'Ontario ou à proximité de ceux-ci. En complément, des analyses comparatives ont été effectuées relativement à la population âgée dans le but de déterminer la façon dont les indices d'accessibilité étaient déphasés par rapport aux besoins de la population. Les résultats de la présente étude aideront les chercheurs et les planificateurs de soins de santé en Ontario à mieux comprendre la répartition des DSP existants afin de travailler à réduire les écarts, notamment dans les secteurs ruraux.

Mots clés : soins primaires, géographie de la santé, inégalités, secteurs ruraux, population âgée

Background

Canada, like other developed countries, faces challenges in the delivery of primary care across the urban-rural continuum. Primary care is the level of a health system that provides first point of access to health care services for all health-related needs and problems, providing person-focused care over time in a continuous and coordinated fashion (Primary Healthcare Planning Group 2011; Aggarwal and Hutchison 2012; Health Canada 2012). The *Canada Health Act* sets out the conditions for the provincial and territorial governments to provide reasonable access to medically necessary hospital and doctor services, including primary health care (Canada 1985). Despite having a universal health care system, many Canadians still experience difficulty in accessing primary care services (Reid et al. 2009; Paez et al. 2010; Crooks and Schuurman 2012; Shah et al. 2017; Kaur Khakh et al. 2019). A retrospective analysis of administrative health data in Ontario highlights that "just over two-thirds of primary care physicians provided comprehensive care in 2014/15, which indicates that traditional estimates of the primary physician workforce may be too high" (Schultz and Glazier 2017, E856). While 9.58 physicians per 10,000 population are identified as primary care providers (PCPs) in Ontario, only 6.03 physicians per 10,000 population are affiliated with a patient enrollment model (Schultz and Glazier 2017). This paper undertakes a comprehensive examination of how primary care services are distributed across Southwestern

Ontario (SWO), with a particular focus on understanding how the distribution is meeting the primary care needs of the senior population (i.e., people aged 65 years and older) and populations living in different geographic settings (i.e., the urban-rural continuum).

Contextual factors (e.g., place of residence, distance to facilities, and transport infrastructure) can serve as barriers or facilitators to accessing health care resources (Chan et al. 2006; Cinnamon et al. 2008; McDonald et al. 2017; Wang et al. 2017), which are in turn associated with health outcomes (Subramanian 2004; Holtz et al. 2014). Health care accessibility is inversely associated with distance or travel time and is sensitive to where people are located within a large metropolitan area (Guagliardo et al. 2004; Charreire and Combier 2009; Bauer et al. 2016; Shah et al. 2016; Gilliland et al. 2019) and/or across the urban-rural continuum (Cinnamon et al. 2008; McGrail and Humphreys 2015; McDonald et al. 2017; Shah et al. 2017). Even within urban areas, transportation is one of the most commonly cited barriers to primary care access (McColl et al. 2015; South East Local Health Integration Network 2015). In addition to contextual factors, health geographers also consider the compositional factors (e.g., sociodemographic characteristics of individuals living in a place) that can also influence health outcomes and accessibility to health care resources (Mohan 1998; Macintyre et al. 2002). For example, poor geographic accessibility to PCPs represents an even greater barrier in areas with a high population of seniors, as older adults are more likely to have mobility constraints than younger adults. Compositional factors are therefore also important to consider when developing policy and allocating resources.

Many Canadian communities, particularly those in rural and remote areas, face challenges accessing primary care and retaining health care providers (e.g., nurse practitioners, doctors) (Canadian Institute for Health Information 2006). Rural communities are characterized by low population densities and large distances between destinations, which are typically associated with poorer access to health care services and higher cost per capita (Bosco and Oandasan 2016). Some rural communities in Canada lack access to basic primary care services due to a shortage of health care providers (Reid et al. 2009; Primary Healthcare Planning Group 2011; Lavergne and Kephart 2012; Health Council of Canada 2014; Bosco and Oandasan 2016). Rural residents are less likely to have a family physician (FP) or access to specialty physicians compared to urban residents (Sibley and Weiner 2011). In fact, while 20% of the Canadian population lives in rural communities, only 9.4% of FPs and 3% of specialist physicians are considered rural health professionals (Society of Rural Physicians of Canada 2008). While an increasing number of specialists work to meet the needs of highly intensive and technical hospitals in major urban centres, rural communities often rely on well-trained FPs who are able to deliver high quality, general, yet diverse primary care (Bosco and Oandasan 2016). Poorer access to PCPs in rural areas is a critical health policy issue in Canada, as disparities in health status also exist in rural areas where, for example, the prevalence of smoking and obesity are higher (Pong et al. 2009).

The unequal distribution of PCPs across Ontario's urban-rural continuum is compounded by the province's aging population who experience an increase in utilization of primary care (McDonald 2011). The 2016 Census of Canada reported almost 5.8 million seniors aged 65 years and older in Canada, or 16.9% of the country's population (Statistics Canada 2016). This was the first time in Canada that the population of seniors was higher than the population of children aged 14 years and younger. Population projections show that seniors will account for 25% of Canada's population by 2036 (Canadian Institute for Health Information 2011). This demographic shift has major impacts on the health care system, as people aged 65 years and older visit their FP three times more frequently than children under age 18 years (Canadian Institute for Health Information 2015). Seniors may also be more limited in their choice of health care providers than younger adults, due to increased likelihood of suffering from intrinsic and extrinsic mobility constraints (e.g., physical disabilities, lack of driver's license). Poorer access to primary care may lead to higher levels of chronic disease, consumption of more medication, and shorter life expectancy for rural seniors compared to their urban counterparts (Cinnamon et al. 2008).

The purpose of this study is to examine how the distribution of PCPs across SWO matches the potential needs of the senior population (i.e., people aged 65 years and older) and populations living in different geographic settings (i.e., the urban-rural continuum). This study has three specific objectives: (1) to identify the geographic accessibility to PCPs; (2) to examine variations in the geographic accessibility to PCPs across the

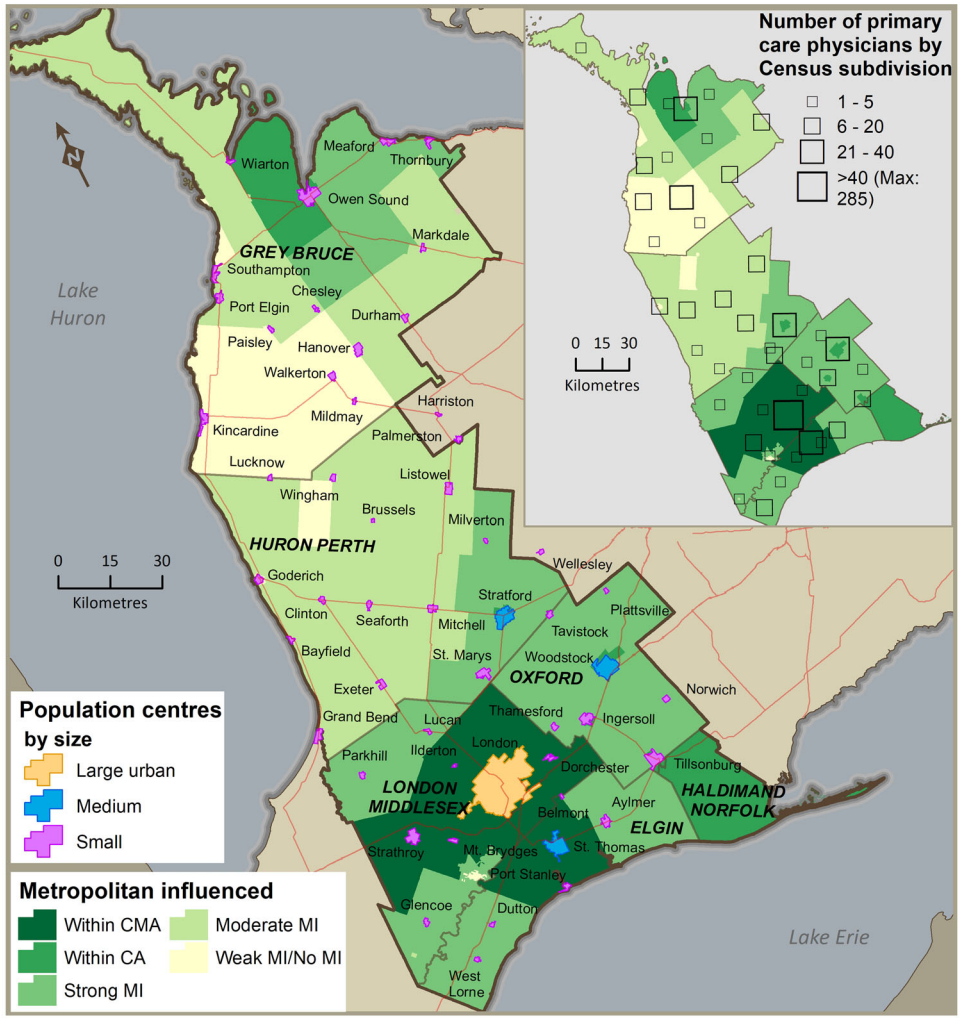


Figure 1
Study area map presenting two classification schemes: 1) Population Centres (POPCTR Class), and 2) Statistical Area Classification (SAC Type)

urban-rural continuum; and (3) to examine variations in the geographic accessibility to PCPs in relation to the population of seniors.

Methods

Data sources

The study area within SWO is equivalent to the area represented by the South West LHIN (Local Health Integration Network), which is one of 14 LHINs that are responsible for improving the integration and coordination of health services at a local level across Ontario. The South West LHIN spans an area of 21,639 square kilometres from Lake Erie to the Bruce Peninsula with a total population of nearly 1 million people (for study area map, see Figure 1).

The data used for this analysis were acquired from two key sources: HealthForceOntario Marketing and Recruitment Agency (HFO MRA) and the 2016 Census of Canada (for process flow chart, see Figure 2). HFO

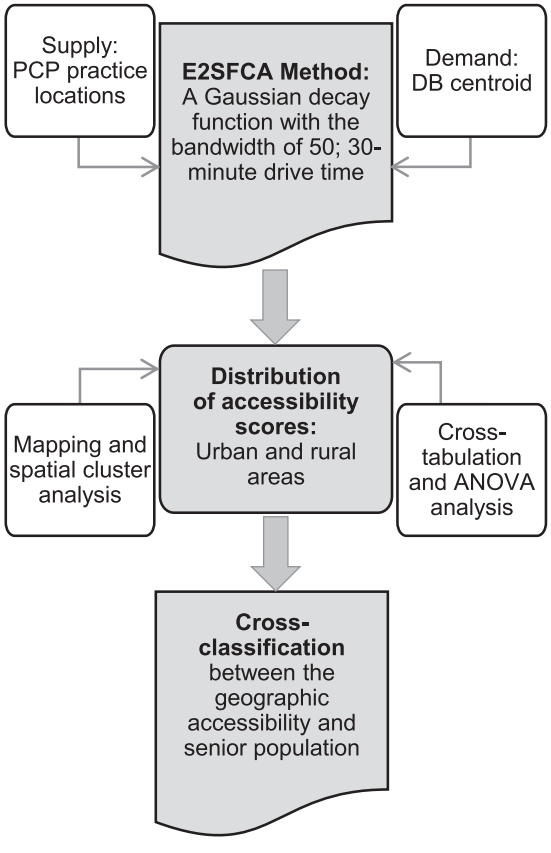


Figure 2
Process flow chart showing main components in the analysis.

MRA aims to ensure Ontarians have access to the right mix and number of health professionals, where and when they are needed (HealthForceOntario 2018). HFO MRA supplied data describing the FPs, general practitioners (GPs), and nurse practitioners (NPs) with practices within the SW LHIN and neighbouring LHINs. The data included address of practice, language in which they provide care, type of practice, and medical school graduation year. PCPs were included in our research database if they were physicians or NPs that have a comprehensive primary care practice and have a roster of enrolled patients for whom they provide ongoing primary care (as of July 2015). FPs that work solely in a hospital, walk-in clinic, or have a focused practice (e.g., psychotherapy) were excluded from this study.

The 2016 Census of Canada provided population counts for dissemination blocks (DBs) and information about the senior population for dissemination areas (DAs) throughout the South West LHIN. A DB is an area bounded on all sides by roads and/or other geographic boundaries (e.g., rivers), and is the smallest geographic unit for which population and dwelling counts are disseminated by Statistics Canada. A DA is a small geographic unit composed of one or more adjacent DBs, and is the smallest geographic unit for which sociodemographic data from the Canadian census are disseminated. To better understand the geographical context of how different areas within the South West LHIN are categorized along the urban-rural divide, this study classifies each DB and DA according to Statistics Canada's Population Centres (POPCTR Class) and Statistical Area Classification (SAC Type) based on the Census Sub-Division (CSD) they fall within (Williams and Kulig 2011; Statistics Canada 2018).

CSDs are classified using the POPCTR Class by first defining CSDs as rural when they have a population less than 1,000 people and/or a population density of less than 400 people per square kilometre. The remaining CSDs are then classified into three groups: large urban population centre (population of 100,000 or more); medium population centre (population between 30,000 and 99,999); and small population centre (population between 1,000 and 29,999) (see Figure 1). Each CSD is also classified into SAC Types by first categorizing them into two groups: census metropolitan area/census agglomeration (CMA/CA) and non-CMA/CA (Statistics Canada 2018). CSDs in the non-CMA/CA group are arranged into four metropolitan influence zones or "MIZ" (strong MI, moderate MI, weak MI, and no MI), based on their distance from the nearest CMA/CA (see Figure 1).

Data analysis

Enhanced 2-Step Floating Catchment Area method. A geospatial approach called the Enhanced 2-Step Floating Catchment Area (E2SFCA) method was employed to measure and analyze geographic accessibility to PCPs throughout the South West LHIN (Cromley and McLafferty 2012). Measuring geographic accessibility using the E2SFCA provides a ratio of supply (PCP locations) to demand (DB centroids) per 10,000 people for each DB in our study area, while considering the supply and demand

in neighbouring LHINs to account for edge effects. The E2SFCA method stems from the floating catchment area (FCA) approach that uses spatial interaction processes in the manipulation of supply and demand (Luo and Qi 2009). The FCA approach provides a unique platform for developing sophisticated methods and has been widely used for modelling spatial aspects of health care accessibility (Ngamini Ngui and Vanasse 2012; Bauer et al. 2016; Bauer et al. 2018). The E2SFCA method is a modification to the original 2-step floating catchment area (2SFCA) method by "addressing the problem of uniform access within the catchment by applying weights to different travel time zones to account for distance decay" (Luo and Qi 2009, 1100). More detailed information regarding the E2SFCA method is available elsewhere (Luo and Qi 2009; McGrail 2012; Langford et al. 2016).

The E2SFCA method was implemented in ArcGIS 10.3 with the Network Analyst extension by using an add-in tool developed by Langford et al. (2016). The PCP locations (supply) for the South West LHIN and neighbouring LHINs were generated using street address geocoding based on exact addresses provided by HFO MRA, using a street layer file as reference data (DMTI Spatial Inc. 2017). The demand points were represented by the centroids of each DB. In the first step, a PCP-to-population ratio was computed for each PCP location, where the number of PCPs at each location is divided by the population of all DBs within a threshold travel time of that location. Similar to Green et al. (2017), we used a 30-minute one-way drive time. A Gaussian decay function with a bandwidth of 50 within a global catchment area's defined drive time was used (Jordan et al. 2004). In the second step, a similar approach was applied to sum up the PCP-to-population ratio (i.e., accessibility score) at each population location (i.e., DB centroid), using all PCP locations that are within the 30-minute drive time from the DB location.

To analyze the distribution of geographic accessibility scores, we used a choropleth mapping approach with a standard deviation (SD) classification scheme (Figure 2). Accessibility scores were converted into five categories using a ±0.5 SD from the mean value as a cut-off: the first two categories (0.5 to 1.5 SD; >1.5 SD) have a higher geographic accessibility to PCPs; the third category (−0.5 to 0.5 SD) is indicative of moderate accessibility; and the last two categories (< −1.5 SD; −1.5 to −0.5 SD) are indicative of poor distribution of PCPs.

To further investigate the distribution patterns of geographic accessibility scores across the South West LHIN, a local indicator of spatial autocorrelation (LISA) statistic was used to identify local clusters of accessibility. LISA is a common way to measure local spatial association (i.e., local forms of Moran's I) (Anselin 2005). The Moran's I statistic indicates the presence of clusters, whereas Local Moran's I indicates the location of clusters and the type of spatial association. In this case, the association of the geographic accessibility scores for a particular DB is assessed with its adjacent DBs and the global average (Anselin 2005). The incremental spatial autocorrelation with a series of increasing window sizes (1 kilometre) was applied to detect spatial scales (i.e., distances) where the clustering is most significant. The results are presented on a map with DBs classified into five categories: 1) high-high, 2) low-low, 3) high-low, 4) low-high, and 5) not significant (NS). The high-high (or low-low) categories are presenting significantly high (or low) accessibility scores that are surrounded by high (or low) scores and indicate the presence of positive spatial autocorrelation. In contrast, the other two categories represent areas with significantly high (or low) scores that are surrounded by areas of low (or high) scores, while indicating negative spatial autocorrelation. More information on global and local measures of spatial autocorrelation can be found elsewhere (Wong and Lee 2005; Lloyd 2012).

Statistical and cross-tabulation analyses. Categorical variables were reported as percentages, and continuous variables were summarized using the mean and standard deviation. A cross-tabulation comparison was performed to analyze the distribution of geographic accessibility across two categorical variables (SAC Type and POPCTR Class) that divide the geographic areas in two different ways. A two-way analysis of variance (ANOVA) at a 5% level of significance was used to compare the mean geographic accessibility scores, and to test for an interaction effect between the two independent variables. Cross-tabulation and statistical analysis was performed using Excel's PivotTable function and SPSS software.

The geographic variation in the distribution of PCPs in relation to the senior population was evaluated using cross-classification between both variables. Geographic accessibility scores are

estimated at the DB level, whereas information about the population aged 65 and over is provided at the DA level. We assigned the percent of the seniors' population of the DAs to the individual DBs to use the full potential of local data, as the DBs nest within DAs. To perform a comparative analysis with the senior population, geographic accessibility scores were collapsed into a binary arrangement (below and above), where the LHIN average (0.5 standard deviation lower value to allow for uncertainty) was used as a cut-off to distinguish between the poor (below) and good (above) geographical accessibility areas (i.e., 5.4 PCPs per 10,000 population). The percent of the senior population was also collapsed into below and above the Ontario average. A cross-classification map between categories of geographic accessibility and the senior population was prepared to identify the mismatch in the distribution of PCPs in relation to health care needs.

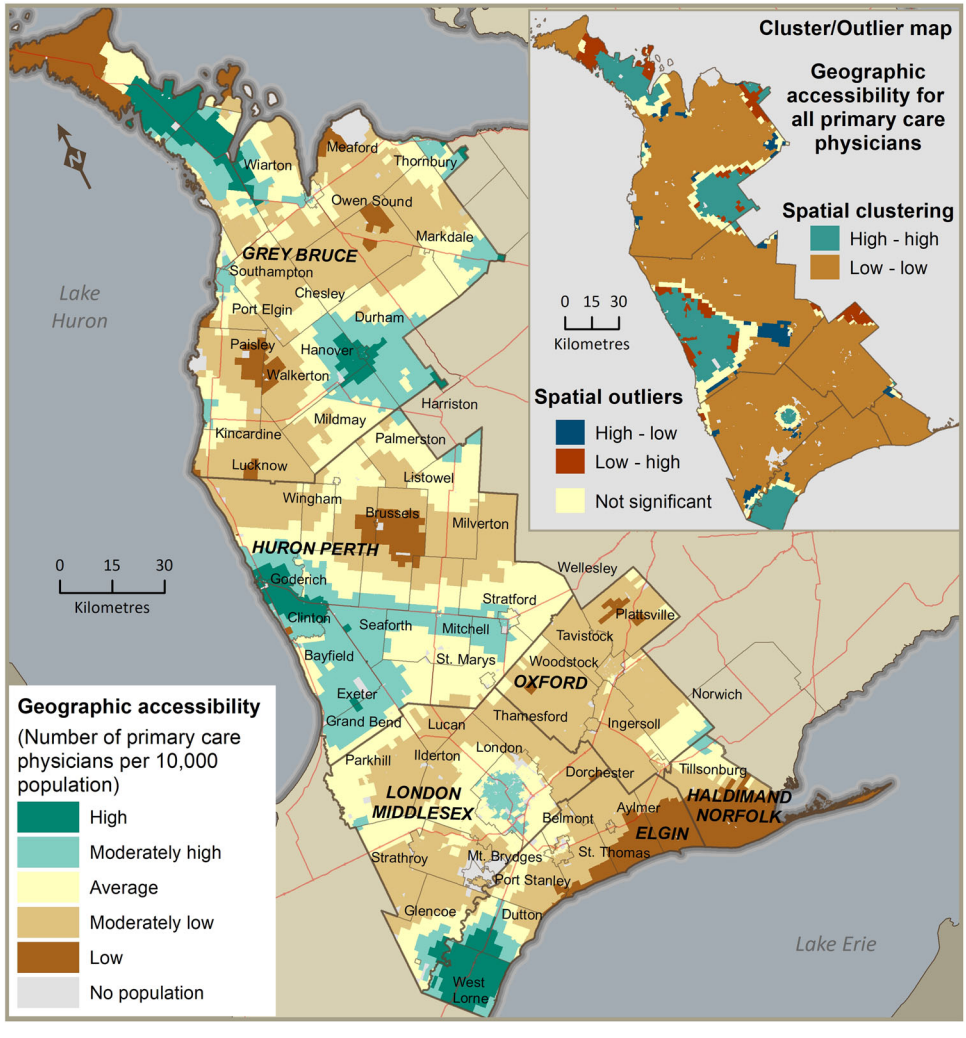


Figure 3
South West LHIN: 1) Geographic accessibility to PCPs at dissemination-block level; 2) Inset map highlighting the spatial clusters/outliers based on local indicators of spatial association

Results

In 2015, 892 (7.1%) of the province's 12,635 FPs practised within the area of SWO delineated by the boundaries of the South West LHIN (Ministry of Health & Long-Term Care 2012). There were 609 FPs providing comprehensive primary care (68.3%). The remaining 31.7% of FPs worked in alternative practice models including emergency medicine and inpatient hospitalist care. Eight NPs provided additional primary care capacity for a total of 617 PCPs practising within the SWO study area. FPs in rural communities often provide other medical care outside of the office setting, including emergency departments, inpatient clinics, as well as surgery, obstetrical, anesthesia, and long-term care coverage, which means they may not be working full-time providing primary care in the office setting.

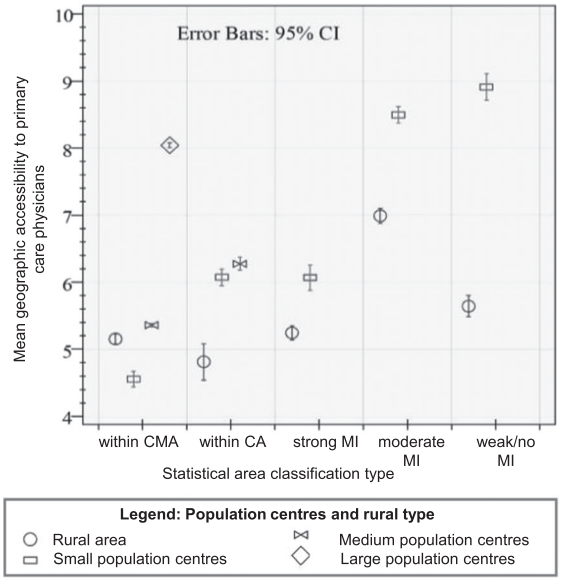
To address Objective 1, an E2SFCA method was used to estimate the DB geographic accessibility scores within SWO, the results of which are shown in Figure 3. The mean geographic accessibility score within SWO was 6.59 PCPs per 10,000 population (SD = 2.39), which is slightly higher than the provincial average of 6.03. An inset map prepared using a univariate Local Moran's I tool illustrates the significant local clusters/outliers of geographic accessibility scores (Moran's Index = 0.764; z-score = 1151; $P < .001$). An examination of the geographic distribution of the accessibility to PCPs and resulting Local Moran's I reveals an unequal distribution of PCPs across SWO.

When examining the distribution of accessibility in Figure 3, the cluster/outlier map highlights the trends across SWO. The high clustering of PCPs can be found in London, North of Wiarton, and areas around West Lorne, along the highway between Exeter and Goderich, as well as along the highway between Goderich and Stratford. These areas experience clustering as they are either urban (as the case of London), or are key locations for larger primary care clinics, such as Community Health Centres or Family Health Teams. Much of the rest of the study area experiences clustering of low accessibility, which stretches from the north to the south. There are still some outliers throughout this region, including the area just west of Stratford where high accessibility is surrounded by low accessibility areas. This is due to the relatively low population in this area but a high number of providers in Stratford.

Objective 2 is addressed with the results of the cross-tabulation analysis provided in Table 1, which presents mean accessibility scores (along with the proportion of the total population) for each cell of the cross-tabulation matrix between two urban-rural variables (SAC Type and POPCTR Class). These results are also displayed as an error bar plot of 95% confidence intervals (CI) around each mean accessibility score in Figure 4. Among the POPCTR Class categories (F = 1025; df = 3, $P < .001$), geographic accessibility for rural areas and medium population centres (about 39% of the total population) were comparatively lower than the other two

Table 1
Cross-tabulation between the urban-rural variables: mean geographic accessibility along with proportion of total population.

		Statistical Area Classification Type (SAC Type)				
Population Centre/Rural Area Class (POPCTR Class)	**Mean score [% of population]**	**Within CMA**	**Within CA (no cts)**	**Strong MI**	**Moderate MI**	**Weak MI/ No MI**
Rural area	**5.87**	5.15	4.81	5.24	6.99	5.64
	[27.20]	[4.57]	[2.48]	[9.89]	[8.00]	[2.25]
Small population centres (1,000 to 29,999)	**7.20**	4.55	6.07	6.07	8.50	8.91
	[20.70]	[2.65]	[5.38]	[4.40]	[5.55]	[2.71]
Medium population centres (30,000 to 99,999)	**5.97**	5.36	6.27			
	[11.88]	[4.39]	[7.50]			
Large urban population centres (100,000 or more)	**8.04**	8.04				
	[40.23]	40.23]				
South West LHIN	**6.59**	**6.84**	**5.87**	**5.44**	**7.48**	**7.00**
	[100]	**[51.83]**	**[15.36]**	**[14.29]**	**[13.55]**	**[4.96]**



Analysis of variance of geographic accessibility

Source	SS	*df*	MS	F	*p*
Corrected model	21773.1	12	1814.4	446.3	< .001
Intercept	386983	1	386983	95190	< .001
SACTYPE	10537.1	4	2634.3	647.9	< .001
POPCTR	12506.9	3	4168.9	1025.5	< .001
SACTYPE*POPCTR	2200.2	5	440	108.2	< .001
Error	52939.1	13022	4.1		
Total	640256	13035			
Corrected Total	74712.2	13034			

Figure 4
Error bar plot of accessibility scores for PCPs across two urban-rural variables.

categories (large and small population centres). About 40% of the total population within SWO lived in the city of London (the sole large urban centre) which had extremely high accessibility. The medium-sized population centres within the CMA category had comparatively poor accessibility. About 48% of the South West LHIN population lived in small population centres and rural areas, with 7.2 and 5.9 PCPs per 10,000 population, respectively. However, when these categories were analyzed across SAC Types, small population centres/rural areas that are part of CMA/CAs or in the strong metropolitan influence zones were in poor accessibility ($F = 648$; $df = 4$, $P < .001$). Furthermore, there was a statistically significant interaction between the effects of SAC Type and POPCTR Class ($F = 108$; $df = 5$, $P < .001$).

The city of London had comparatively high accessibility (mean: 8.04 PCPs per 10,000 population). There were three medium-sized population centres with mean values of 5.97 PCPs per 10,000 population that can be sub-divided into the population centre within the London CMA (St. Thomas) and separate census agglomerations (Woodstock and Stratford). In the case of small population centres (average of 7.20 PCPs per 10,000 population), there were relatively low accessibility levels in most located within CMA or strong MIZ compared to the centres located in moderate and weak influence zones. In the case of rural areas (average of 5.87 PCPs per 10,000 population), an examination of the accessibility to PCPs reveals low accessibility levels in most of the commuting zones, except moderate MIZ.

Figure 5 displays the cross-classification view of the geographic accessibility with the percentage of the senior population at the DB level after converting them into a binary arrangement (below and above the Ontario average of 16.7%) to address Objective 3. This system of category classification helps distinguish high and low priority areas for supply of primary care resources in accord with population health demand. For example, the "below-above" category indicates the DBs with poor or low accessibility to PCPs (i.e., below 5.4 PCPs per 10,000 population) and who have a higher percentage of senior residents. The majority of areas with low accessibility and higher percentage of seniors were located in areas closer to the city of London (see inset map) in the south and areas close to Owen Sound in the Grey Bruce sub-LHIN. In contrast, many of the high percentage senior areas of the city of London and close to Goderich in Huron Perth sub-LHIN had higher accessibility to PCPs.

Discussion

The purpose of this research was to examine the geographic distribution of PCPs across SWO and to better understand how this distribution matches both the needs of the population of seniors (aged 65 years and older) and the population living in different geographic settings. The geospatial mapping and

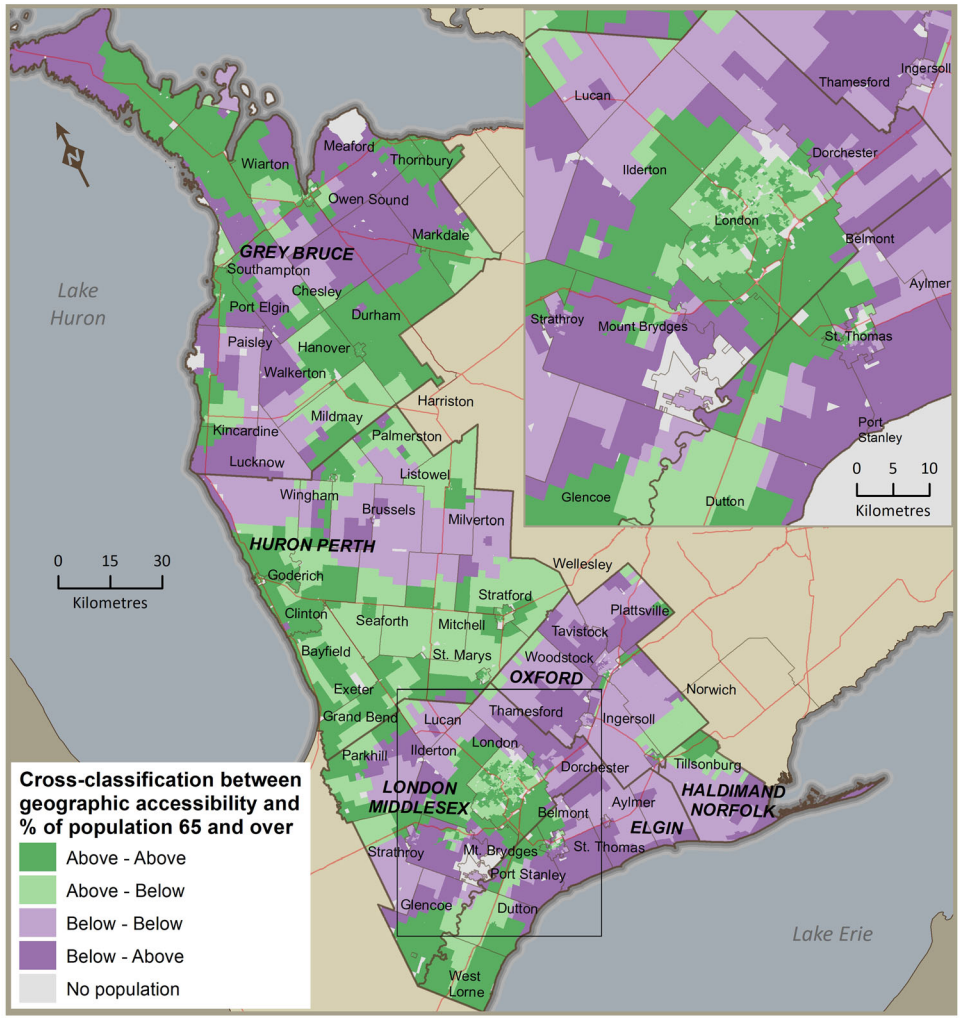


Figure 5
Distribution of cross-classifications between the geographic accessibility to PCPs and percent of population aged 65 and over

comparative analysis illustrate that geographic accessibility to PCPs was not equal across the South West LHIN, there was an unbalanced distribution of PCPs across the urban-rural continuum, and locations where there was high geographic accessibility to PCPs did not match the locations with high proportions of senior populations.

Overall, SWO had a slightly higher level of geographic accessibility to PCPs than the provincial average (i.e., 6.53 to 6.03 PCPs/10,000 population). There remain areas within the LHIN that have shortages in PCPs, which translates to lower levels of accessibility (e.g., rural areas, areas around the city of London). These gaps in access are not unique to SWO, and access to primary care has been a top policy concern for nearly two decades (Marchildon and Hutchison 2016). Evidence shows that a strong primary care system leads to a healthier population (Starfield et al. 2005). Accordingly, addressing inequality in accessibility to PCPs is a concern in Ontario (Canadian Institute for Health Information 2012; Gilliland et al. 2019) and around the world

(Hefford et al. 2005). Since the Alma-Ata declaration in 1978, primary care has been acknowledged as an essential foundation in achieving health for all (World Health Organization 2008), however decades of cost cutting and acute-care focus have eroded this foundation. Health systems around the world have perpetuated inequality through a lack of consideration for the social determinants of health and the critical role primary care can have in addressing them (Norbury et al. 2011). Further, patients are being sent home from the hospital sooner (and often sicker); patients are spending more time in the community where primary care holds an essential role. This version of primary care planning is complex and in order to be done effectively, must include input across sectors with multiple stakeholders (Sibbald et al. 2018). Historically, due to a variety of barriers, primary care has not been involved in system-level change (Skillman et al. 2017). However this is shifting, and PCPs are recognized as key partners for and drivers in system change (Snadden et al. 2019).

Our study found inequality in the distribution of PCPs across the South West LHIN, and an unequal balance of PCPs across the urban-rural continuum. While the urban centres had the highest ratios of PCPs to population, rural areas and population centres within the CMA had some of the lowest accessibility of PCPs in the region. In contrast, areas outside of the CMA and CA defined as rural and/or small population centres had relatively high accessibility. These results are consistent with those of Sibley and Weiner (2011) who found that residents of small cities not adjacent to major centres were most likely to have a regular medical doctor, whereas people residing in most rural communities were less likely to have a regular medical doctor. Similar trends are seen across the country and have been attributed to "a significantly wider scope of practice and need to maintain competence in different clinical areas despite having higher workloads, inaccessibility of CME, having no professional back up and limited specialist consultation" (Malko and Huckfeldt 2017).

Despite the high PCP-to-population ratios, the number of PCPs actually providing care in these rural and small population centre communities away from metropolitan influence zones is overestimated, as many PCPs provide other health services (e.g., emergency room doctors, specialists, service to long-term care). To understand how these additional roles influence primary care supply, the Ontario Ministry of Health and Long-Term Care needs to provide a definition of a PCP full-time equivalent, to allow better system-level planning and to recruit physicians to the locations of greatest need in order to fill the gaps and increase accessibility.

The results of cross-classification analysis reveal that low accessibility areas existed in relation to higher proportions of senior population. These were most prominent in the north, northwest, and south, surrounding the city of London. While there were various clusters of seniors throughout the region, the lowest accessibility for seniors appeared to be in two out of the five sub-regions. Within the other three regions, there were pockets of low accessibility for their senior populations. These findings suggest a discrepancy between the distribution of PCPs and the residence of the senior population in the region. Previous research has observed similar patterns of mismatch between the supply of FPs and clusters of seniors (Vogt 2016; Shah et al. 2017). However, our results highlight a slightly more pronounced trend that most of the areas with low accessibility to PCPs and a higher share of the senior population were located close to large and medium population centres. The lack of access to health services means that many seniors needing treatment may be required to travel less than ideal distances to access health care. Typically, this means travelling to the nearest urban centre (Cinnamon et al. 2008), which can lead to increased emergency department use regardless of a patient's place of residence in rural or urban areas (Ionescu-Ittu et al. 2007). New models of team-based primary care are part of the solution to this challenge. In Ontario, Family Health Teams have been implemented in an effort to improve access to allied health providers, as well as more frequent and ready access to a PCP. Other solutions such as training more physicians from rural areas and targeting international medical graduates have been suggested to improve access to primary care (Mathews et al. 2008), however these solutions are not often specific to meeting the needs of senior populations. More research is needed to understand primary care and health system planning targeted at rural dwelling seniors.

Limitations

A few limitations need to be considered when interpreting the results of our study. The PCPs'

locations were accurate as of 2015 when the information was collected to run the analysis, but as new PCPs open practices and existing PCPs move or retire, levels of geographic accessibility will also change. Another study limitation is the lack of a clear and consistent definition of full-time equivalent. In some areas, a full-time equivalent PCP is well defined by the number of hours per week spent in primary care. Unfortunately, Ontario has yet to define this, thus the analysis considers each PCP a full-time position, which means that PCPs who split their time between family practice, as a specialist, or in a hospital or clinic, are counted the same as those who spend 50 hours a week with their own PCP patients. This is especially important to understand when examining the results in small communities that do not have as many hospitalists and specialists to cover the area, thus increasing the responsibilities of PCPs outside of their practice.

Conclusions

The study findings suggest that there were significant geographic differences across the South West LHIN in the level of accessibility to PCPs. The resultant geographic accessibility scores revealed inequalities in the distribution of PCPs, particularly in rural communities located in the commute zones surrounding the urban areas. Further, there was a discrepancy in the South West LHIN between the distribution of PCPs and the population aged 65 years and over. These findings help us understand the distribution of comprehensive PCPs within a geographic region in Ontario and provide insight into which areas need increased primary care services. By supporting patients closer to their home, and earlier in their disease trajectories, we are able to meet patient need and reduce system inefficiencies.

Access to comprehensive primary care is essential for improved health outcomes; more work is needed to better align services with need in rural populations (Pampalon et al. 2010). This could include enhancing support for new and existing rural PCPs, or reconsidering medical school curricula as it relates to rural clinical work (Bosco and Oandasan 2016). Accessibility measures are an important policy tool for managing health care provision and reducing health inequality. To understand the accessibility dynamic on a local scale, future research should assess geographic accessibility on a regular basis and in context with socioeconomic factors such as income and education levels. Such information can be shared efficiently and in a timely way using web-mapping and/or mobile mapping with physicians, particularly those who are newly graduated or those interested in changing their practice locations, and even with individuals who are looking for nearby services.

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