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Research paper

Measuring geographical accessibility to rural and remote health care services: Challenges and considerations

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ABSTRACT

This research is focused on methodological challenges and considerations associated with the estimation of the geographical aspects of access to healthcare with a focus on rural and remote areas. With the assumption that GIS-based accessibility measures for rural healthcare services will vary across geographic units of analysis and estimation techniques, which could influence the interpretation of spatial access to rural healthcare services. Estimations of geographical accessibility depend on variations of the following three parameters: 1) quality of input data; 2) accessibility method; and 3) geographical area. This research investigated the spatial distributions of physiotherapists (PTs) in comparison to family physicians (FPs) across Saskatchewan, Canada. The three-steps floating catchment areas (3SFCA) method was applied to calculate the accessibility scores for both PT and FP services at two different geographical units. A comparison of accessibility scores to simple healthcare provider-to-population ratios was also calculated. The results vary considerably depending on the accessibility methods used and the choice of geographical area unit for measuring geographical accessibility for both FP and PT services. These findings raise intriguing questions regarding the nature and extent of technical issues and methodological considerations that can affect GIS-based measures in health services research and planning. This study demonstrates how the selection of geographical areal units and different methods for measuring geographical accessibility could affect the distribution of healthcare resources in rural areas. These methodological issues have implications for determining where there is reduced access that will ultimately impact health human resource priorities and policies.

1. Introduction

Health services research is an interdisciplinary field of enquiry that examines how people access healthcare. Having optimal access to health services is important to help achieve the best health outcomes that include overall physical, social, and mental health status, as well as prevention of disease and disability. Poor access to healthcare services can affect individuals in many ways which can lead to unmet health needs. In Canada, there are growing concerns that the health system is not as responsive and accessible as it could be for some geographical regions (Johnson et al., 2008; Canada 2001). For example, many rural residents have poorer health, a shorter life expectancy, and higher rates of disability in comparison to those living in urban centers (Mitton et al., 2011; Romanow, 2002) and experience reduced access to health care services, such as physiotherapy (Gupta et al., 2011; Landry et al., 2009; Wilson et al., 2009; Bath et al., 2015).

The increasing interest in geographic access to health care services to determine under-served areas has focused almost exclusively on physician services in Canada to the

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detriment of understanding the full spectrum of primary health care (Guagliardo et al., 2004; Ngui and Apparicio, 2011; Bell et al., 2013, 2012; Sanders et al., 2013; Crooks and Schuurman, 2012). In particular, physiotherapists comprise the 6th largest health profession group in Canada (Canadian Institute for Health Information, 2014) and are uniquely qualified to assess, improve and maintain functional independence and physical performance as well as prevent or manage pain, physical impairments, disabilities and limits to participation in life activities (Cott et al., 2009,2011). Access to physiotherapy services, however, in comparison to other primary health care services such as family physicians and nurse practitioners, has received less research attention and seems to be under-recognized and under-valued (Barnes et al., 2012; Dufour et al., 2014). To date, there has been very little investigation into geographic-related barriers and associated technical challenges in measuring accessibility to physiotherapy and other primary health care services in rural and remote areas.

Geographic Information Systems (GISs) are frequently used to conduct complex geospatial computational tasks by integrating spatial and nonspatial attribute information (Pearce et al., 2006; Cromley and McLafferty, 2012; Engler-Stringer et al., 2013; Albert et al., 2005). Geographic dimensions of access to healthcare services that involve investigation of the distribution of these services in relation to population health need (Luo and Wang, 2003; Bissonnette et al., 2012) play a significant role in identifying and quantifying distribution of healthcare in underserviced areas. Currently, different GIS-based approaches are being applied to measure spatial aspects of healthcare accessibility in order to identify underserved and poorly served areas at the local scale (Bell et al., 2013; Cromley and McLafferty, 2012; Luo and Wang, 2003; Passalent et al., 2013; Sanders et al., 2013).

In health services research, accessibility to health care describes the fit between the users and health care system (Aday and Andersen, 1974; Cromley and McLafferty, 2012; Joseph and Phillips, 1984). Methods dealing with geographic accessibility estimation can be divided into two different groups (Cromley and McLafferty, 2012; Joseph and Phillips, 1984): (1) regional availability of health care services with the assumption that regional boundaries are impermeable (suitable for large regions, for example, census divisions/counties (Pong and Pitblado 2005; Fields et al., 2016), health areas (Thommasen and Thommasen 2001; Olatunde 2007), and utilization-based service areas (Shipman et al., 2010); and (2) methods based on the spatial interaction processes that manipulate supply and demand data at local scales using gravity models and kernel density estimations (Joseph and Phillips 1984; Luo and Wang 2003; Schuurman et al., 2010; Cromley and McLafferty 2012; McGrail 2012; Neutens 2015). For example, a three-steps floating catchment area (3SFCA) method, compared to a simple health care ratio, translates demand and supply factors for health care needs that are generated at local scales into an indicator of distribution of healthcare resources by involving both spatial proximity and relationships (Wang and Luo, 2005; Passalent et al., 2013; Delamater, 2013; Fransen et al., 2015; Bissonnette et al., 2012; McGrail, 2012). Largely, the process of geographical accessibility estimation depends on three aspects. First is related to the level and or type of input data. Secondly, it depends on the accessibility method (or spatial interaction processes). Lastly, geographical accessibility estimation is sensitive to units of analysis. Discrepancies in input data, choice of methods to estimate accessibility score, and selection of units of analysis can influence/affect the distribution of health care resources particularly in relation to rural and remote health services.

Thus the results of GIS-based methods depend on various factors including choice of input data, geographical areal unit of analysis, and accessibility method. These methodological issues have implications for interpreting levels of accessibility to healthcare services and can impact decisions regarding health resource priorities and policies. The overarching aim of this research is to develop an understanding of key challenges and considerations in measuring geographical accessibility to rural healthcare services and to assess the extent to which these issues can influence the results. The objectives of this research are: (1) to compare GIS-based accessibility score and simple health care provider-to-population ratio for family physician (FP) and physiotherapy (PT) services across Saskatchewan, Canada; (2) to examine variation between the GIS-based accessibility scores for healthcare providers using two different census based areal units; and (3) to analyze spatial patterns of GIS-based accessibility scores by changing key paraments such as geographical catchment areas.

2. Methods

A geospatial cross-sectional exploratory approach was adopted to assess the variation in the geographic accessibility to healthcare services. This research examined access to family physician (FP) and physiotherapy (PT) services across the province of Saskatchewan, Canada using a variety of geographical methods (GIS-based accessibility score and simple health care provider-to-population ratio) and units of analysis (census subdivisions “CSDs” and census consolidated subdivisions “CCSs”).

The input data consisted of lists of physiotherapists and family physicians in Saskatchewan, collected via provincial regulatory bodies (i.e., Saskatchewan College of Physical Therapists and Saskatchewan College of Physicians and Surgeons) in 2013 and 2014, respectively. Only community-based services, outside of solely acute care settings, (i.e., physicians: family physicians, and physiotherapists involved in direct patient care in both public and private settings) were included in the analysis. An integrated geocoding approach was used to convert postal address/postal code information into a set of geographic coordinates (latitude and longitude) (Shah et al., 2014; Bell et al., 2012). The population locations of the Disseminaton Areas (DAs) provided by the Statistcs Canada are used to represent the point of population demand. The following reference datasets were used in building geocoding service: DMTI road network layer, and (2) multiple enhanced postal-code (MEP) points (DMTI Spatial 2014;2013).

To analyze the spatial distribution of health care services two different techniques were applied to estimate the provider-to-population ratios: (1) a GIS-based method; and (2) a simple container approach for the regional availability of healthcare resources. A GIS-based 3SFCA method (Luo, 2004; Bell et al., 2012, 2013; Bissonnette et al., 2012) was applied to estimate access scores for both FP and PT services separately. This method has been previously applied to health care services, food availability, and access to physical therapy and dental services (Shah and Bell, 2013; Engler-Stringer et al., 2014; Shah et al., 2015). The benefits of the GIS-based methods including the floating catchment area methods over simply provider-to-population ratios are widely published and well-acknowledged, however the simple provider-population ratio are being used for county level estimates (Fields et al., 2016). In the first step of this 3SFCA method, a provider-to-population ratio was calculated at the practice level. This was done by placing a buffer around each point of healthcare practice to select the points of populations (i.e., DA points) within its catchment. Secondly, the ratios from all provider points that are within a buffer around each point of population demand (i.e., DA) were summated. Thirdly, access ratio (score) was calculated by averaging the access ratios from all DAs (i.e., a result of the second step) falling within a areal unit used as a unit of analysis (CSD and CCS). This research used two different census based areal units (CSDs and CCSs as shown in Fig. 1 inset maps) that may have different meaning/significance for rural residents and planners to investigate the distribution patterns of PT and FP services as well as identify under-serviced areas. According to the Statistics Canada, the CSD is defined as municipalities or areas treated as municipal equivalents for statistical purposes whereas the CCS represents a group of adjacent municipalities or census subdivisions.[1] Based on the 2011 Canadian Census, there were 959 CSDS and 300 CCSs in Saskatchewan. This research did not include four CCSs (i.e., approximately 50 percent of the Saskatchewan land area with only 5.1 percent of the Saskatchewan population as highlighted in darker areas in main map of Fig. 1) and subsequent CSDs in the analysis due to their large geographic spread (area size >5000 square km). There are total 13 regional health authorities (RHA) in Saskatchewan where three RHA (Athabasca; Keewatin Yatthe; Mamawetan Churchill River) and some parts of Prince Albert Parkland and Kelsey Trail RHAs fall within one of these four CCSs (see Fig. 1).

To explore the key challenges and considerations in measuring geographical accessibility to rural family physician and physiotherapy services, this research used geospatial mapping to perform: (1) a comparison of GIS-based accessibility score and simple health care provider-to-population ratio; (2) an exploration of variation between the GIS-based accessibility scores for CCS and CSD areal units across family physicians and physiotherapists; and (3) analysis of spatial patterns of GIS-based accessibility scores at CCS for different geographical catchment areas for physiotherapists at 20 km, 25 km, 30 km and 35 km. There is no consensus on the catchment distances/areas for FPs and PTs (Allan 2014; McGrail and Humphreys, 2014). However, different methods and approaches have been applied to define the service area catchment in health services research including variable catchment sizes (Luo and Whippo, 2012), commuter-based proximity (Fransen et al., 2015) and distance decay within the catchment area (Delamater, 2013). In the current study, analyses are based on a 25 km catchment area, where a series of catchment areas ranging from 20 to 35 km (with a 5 km increment) was initially applied to first determine variability in spatial patterns of accessibility scores. The selection of 25 km for catchment areas was then based on the premise that catchment area should be greater than or at least equal to the average of the areal units of analysis (i.e., CCS: ave area = 1961 sq. km, SD = 15 527, Ave catchment 'radius' (assuming a circle) ≈ 25 km; CSD: ave area = 613 sq. km, SD= 8679, Ave catchment 'radius' (assuming a circle) ≈ 14 km) which should also take into account that individuals living in one municipality may travel to seek care in other municipalities.

This study uses comparative descriptive analysis in order to gain insights into the influence of geographic areal units in measuring geographical accessibility to health care services. To analyze variation across the accessibility scores for FP and PT services estimated at two geographic units (i.e., CSD and CCS), comparative analyses were performed in association with population groups with potentially high health care needs and those facing barriers in accessing health care services (such as geographic, socio-cultural and economic barriers) (Asanin and Wilson, 2008; Badley et al., 2015). The following variables were used for comparative analyses: (1) Low-income individuals below the after-tax low-income measure (LIM-AT), 2) Population aged 65+, (3) Population aged 15+ without certificate, diploma or degree, (4) Immigrants who came to Canada from 2001 to 2011, and 5) Aboriginal ethnicity. These need variables were derived at CSD and CCS levels from 2011 Population Census and National Household Survey (NHS) (Statcan, 2011b, 2011a). Selection of variables were based on prior research (Pampalon et al., 2012; Field, 2000; Andersen and Davidson, 2001; Asanin and Wilson, 2008) and data availability for both units of analysis (CSD and CCS). For example, the population 65+ variable represents the proportion of seniors age 65 and above (i.e., 148,730 which is 15.4% of SK population). Increased age is often associated with higher potential need for primary health care services (Canizares et al., 2014; Beaudet et al., 2013). To perform a comparative analysis, the full range of access scores was categorised into five manually defined classes, and then the proportions of these need variables were grouped within the access score category. The same procedure were repeated for all four set of access scores for FP and PT at CSD and CCS levels. The following software was used for mapping and data analysis (spatial and nonspatial): ArcGIS Map 10.3 (ESRI, Redlands, U.S.), Microsoft Office 2013 (MS Access and Microsoft Excel).

[1] http://www.statcan.gc.ca/pub/92-195-x/2011001/geo/ccs-sru/ccs-sru-eng.htm.

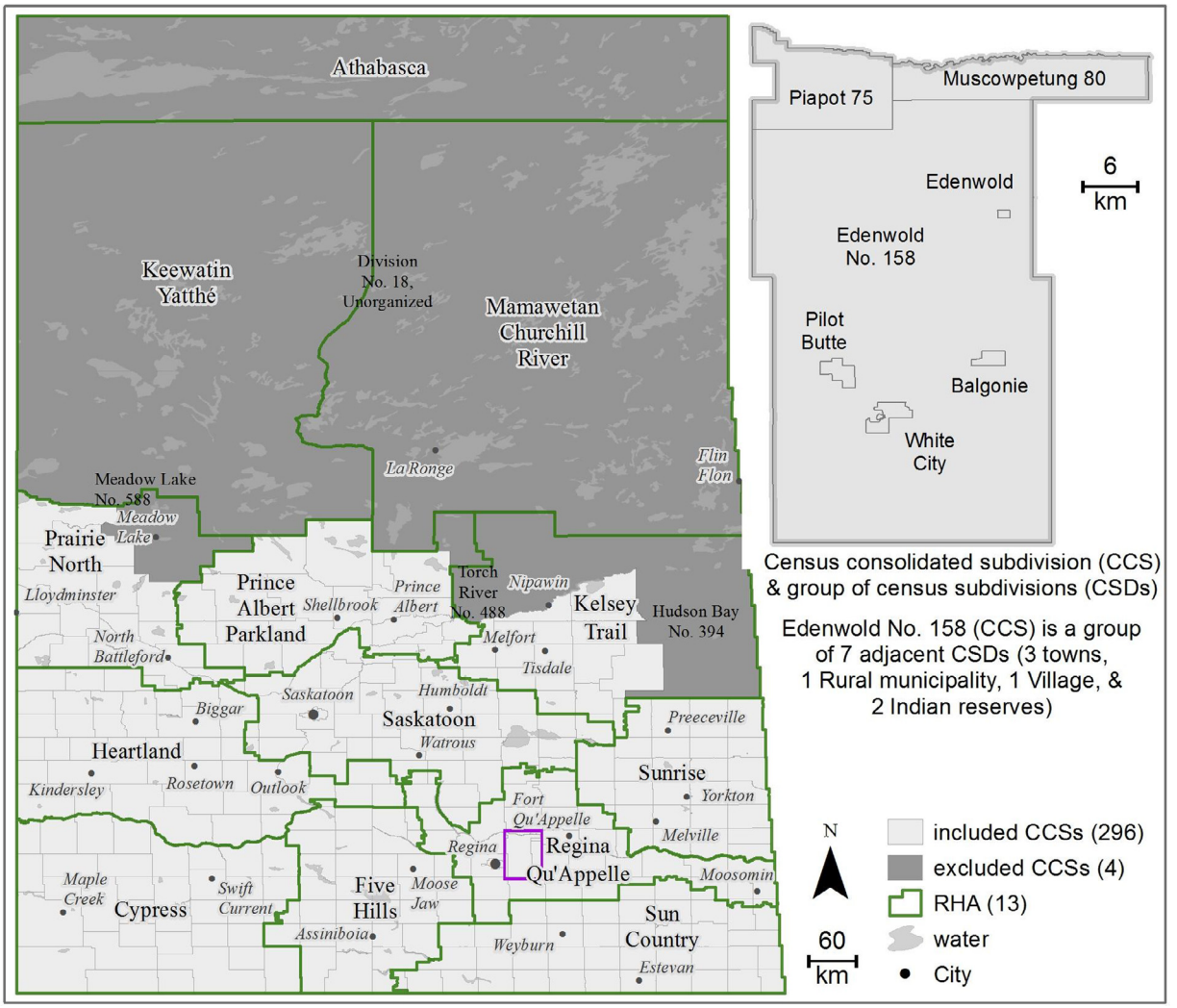

Fig. 1. Study area map: inset maps showing the difference between two areal units of analysis (CCS and CSD areal units). Note that darker areas on the main map are not included in the analysis.

2.1. Ethics approval

This study was approved by the (institutional) research ethics board (Biomedical Research Ethics Board (Bio #:13–02), University of Saskatchewan, Saskatoon, Saskatchewan).

3. Results

Overall, the research was focused on how different methods measuring geographical accessibility to rural and remote healthcare services could influence the distributions of FP and PT services and how different units of analysis could change these estimates. In brief, an accessibility score and health care provider-to-population ratio for both FP and PT services in Saskatchewan at both CCS and CSD areal units was calculated using a 25 km catchment and a set of maps showing the spatial distributions of these measures was produced. For the physiotherapy services (PTs; n = 558), only those who were involved in direct patient care in both public and private settings were included. In total, 982 family physicians were considered whereas physicians who were practicing in hospitals, working at non-practice locations (such as at academic institutions) or practicing outside the province were not included in the analysis (n = 189). Fig. 2 presents the CCS level accessibility score and health care provider-to-population ratio for both FP and PT services whereas Fig. 3 gives CSD level accessibility score for both FP and PT services. In all cases, in order to allow greater means of comparison between the health care providers groups and areal units, the access scores for FP and PT services (and healthcare provider-to-population ratios) are categorised into four manually defined classes (0.01–0.25; 0.26–0.50; 0.51–1.01; > 1.01) where the first class (0.01 to 0.25) indicates poorly-served municipalities. An additional class (i.e., less than 0.01, or in other words, no score in case of accessibility measures and no ratio

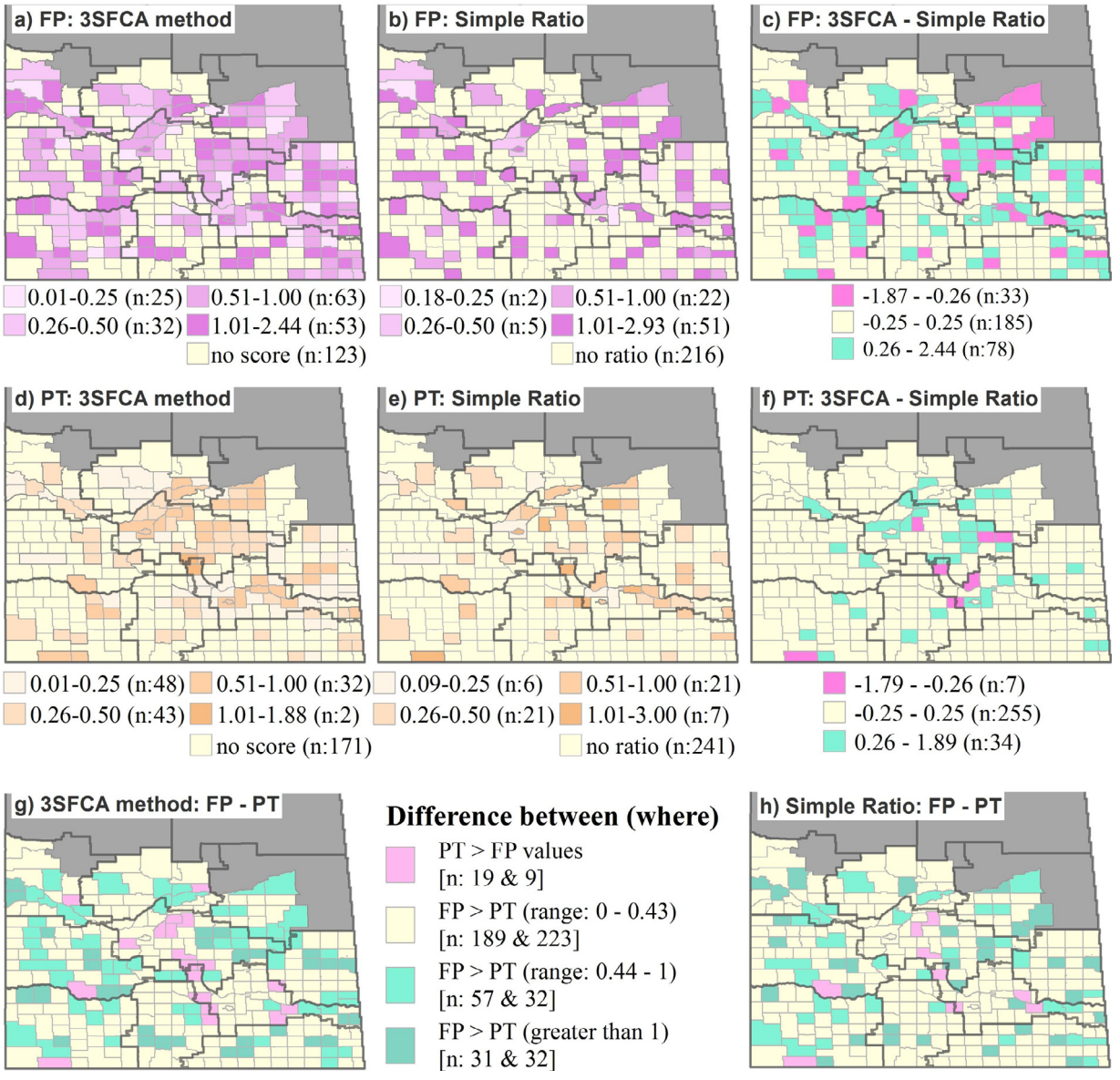

Fig. 2. Simple ratio and 3SFCA score (in terms of physician-to-population ratios) for both FP and PT services at CCS level across Saskatchewan. Note that number in parenthesis (n:) represents the geographic unit count. Health Regions (ST=Saskatoon; RQ=Regina Qu'Appelle; PA=Prince Albert Parkland; PN=Prairie North; SC=Sun Country; SR=Sunrise; FH=Five Hills; HL=Heartland; CY=Cypress; KT=Kelsey Trail; KY=Keewatin Yatthe, MC=Mamawetan Churchill River, and AT=Athabasca).

in case of simple ratio) is used to highlight municipalities with the following conditions: (1) those fall outside the catchment areas used in the 3SFCA method; and (2) without any healthcare provider to calculate simple ratio. This is done to emphasize: (1) a particular range of values, above or below threshold value such as one health care provider-per-1000 population—a measure that may be more meaningful to health planners, policy makers, and local residents; and (2) to allow greater means of comparison between the health care providers groups.

The differences between the 3SFCA and Simple Ratio values for FP and PT measures separtively are shown in Fig. 2 (see maps c and f, respectively) where all CCSs (i.e., municipalities; n= 296) are categorized into three classes. In all cases, where the difference is within the range of 0.25 health care providers-per-1000 population (or access score) indicates municipalities with no apparent change. Where the first measure is greater than the second measure with a margin of 0.25 scores and second measure is greater than the first measure with a margin of 0.25 scores indicate municipalities with an apparent change. The differences between FP and PT measures based on CCS scores (see, Fig. 2: maps g and h) are categorized into four classes. The first class indicates where the values of PT are greater

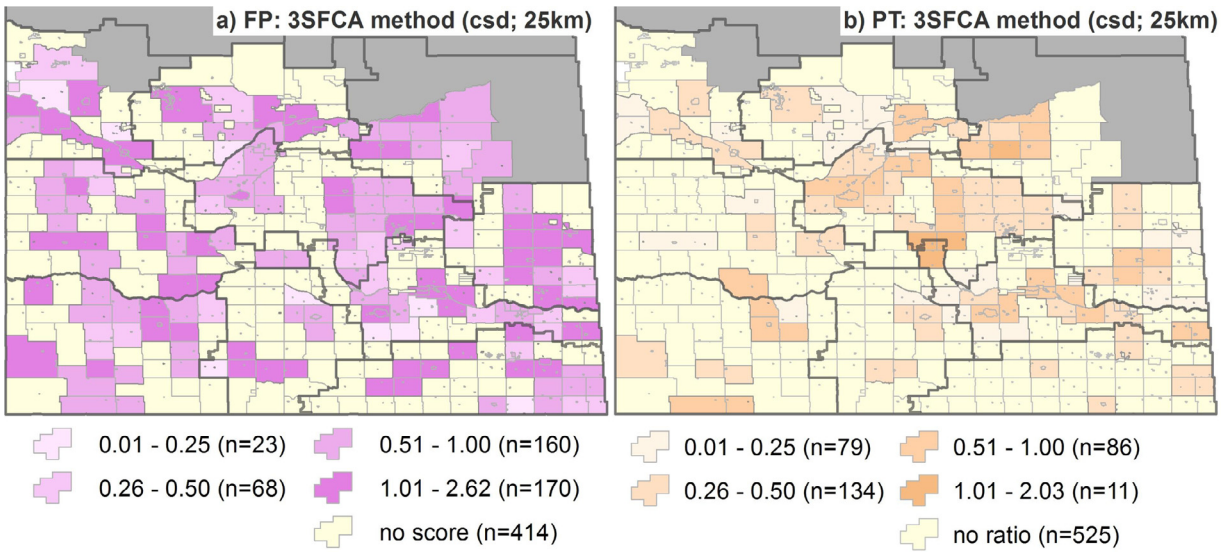

Fig. 3. CSD: 3SFCA method was applied to calculate the accessibility score for FPs and PTs.

then FP values. Rest of the three classes indicates where FP values are higher than PT. As we know that PT access score are poorer than FP (e.g., at Saskatchewan level, the Simple Ratio for FP and PT are 1.00 and 0.57 per 1000 population), The second class (range: 0 – 0.43) can be considered to level the difference. The last two classes (ranges: 0.44–1 and greater than 1) shows apparent changes in the FP scores over PT. Table 1 presents the results obtained from the comparative analysis of accessibility score (3SFCA method with 25 km catchment area) for FP and PT services across CSD (see Fig. 3) and CCS (see Fig. 2a and d) in association with population groups with potentially high health care needs. We used a cross tabulation analysis approach to present the percent of Saskatchewan population and sub-population groups (with potentially high health care needs) by four access categories (with an additional class less than 0.01, or in other words, no score) for FP and PT services and compare the results across both CSD and CCS areal units. Table 1 presented the proportions of the sub-population groups (need variables) within each access score category and repeated this procedure for all four access measures (FP-CSD, PT-CSD, FP-CCS, PT-CCS). When comparing the results of poor access scores (no access and <0.25 access categories together), there is a greater proportion of the Saskatchewan population for PT in comparison to FP in case of both areal units (CSD: 18.9% vs. 13.3% respectively; CCS: 14.8% vs. 9.6%, respectively). Fig. 4 presents the distributions of the accessibility scores for PT services at CCS level that were estimated using the following geographical catchment areas: 20 km, 25 km, 30 km and 35 km to analyze spatial patterns of GIS-based accessibility scores.

4. Discussion

This research is focused on two methodological considerations (i.e., accessibility techniques and unit of analysis) associated with the estimation of the geographical aspects of access to rural health care services provided by FP and PT. The differences between two measuring approaches (simple ratio and 3SFCA) and two census based areal units of analysis (CCS and CSD) were examined. The most obvious findings to emerge from the analysis is that the results could vary depending on the accessibility methods used and the choice of unit of analysis for measuring geographical accessibility for health care services. The results show a difference between the distributions of PT and FP services across measuring techniques and units of analysis. For example, for the difference between accessibility score for FP and PT as shown in Fig. 2g, there are only seven rural municipalities where geographic access to PT services (access scores) are found to be better than FP services. On the other hand, there are a large number of rural and urban municipalities (n = 129) (e.g., Moose Jaw, Swift Current, Regina, Prince Albert, and North Battleford) where geographic access to FP services (access scores) are better than those for PT services. There are a large number of units (i.e., CCSs) showing apparent change between the accessibility score and simple ratio in case of FP compared to PT as shown in Fig. 2c and f, respectively.

From the results presented in Table 1, Fig. 2 (a and d), and Fig. 3 (map a and b) respectively, it is apparent that there is a small difference between the CCS and CSD scores across FP and PT services. The difference in accessibility score due to unit of analysis is more critical in some classes such as in poorly-served (no score and <0.25; e.g., in case of FP accessibility score in comparison with total population). Such differences in accessibility measures could be linked to the modifiable areal unit problem (MAUP). Due to spatial aggregation issues, the MAUP can influence results in the following ways: (1) scale effect - the number of areal units used (Kwan and Weber, 2008; Schuurman et al., 2007; Smiley et al., 2010; Bell et al. 2013; Shah et al., 2014), and (2) zonation effect – the choice of aggregation or boundaries (Flowerdew et al., 2008; Stafford et al., 2008). In this research where

Table 1
Saskatchewan population and percent of socially disadvantaged groups by Accessibility Score (3SFCA method with 25 km catchment area): for family physician (FP) and Physiotherapy (PT) services across census subdivision (CSD) and consolidated census subdivision (CCS).

Variable	PHC	Unit	Accessibility Score (per-1000 population)				
			no score	<0.25	0.26–0.50	0.51–0.10	>1.01
Percent (%) of the Saskatchewan population across professions and census units							
a. Population 2011 [count = 980,486]	FP	CSD	13.3	1.4	4.0	14.9	66.4
		CCS	9.6	3.5	5.1	19.1	62.7
	PT	CSD	18.9	5.6	16.5	58.6	0.3
		CCS	14.9	10.4	14.7	59.9	0.1
Percent (%) of the total group population across professions and census units	**PHC**	**Unit**	**Accessibility Score (per-1000 population)**				
			No score	<0.25	0.26–0.50	0.51–0.10	>1.01
b. Population age 65 and over [count = 148,730]	FP	CSD	14.7	1.2	4.8	16.5	62.9
		CCS	11.2	3.5	5.2	20.4	59.7
	PT	CSD	22.2	5.1	19.2	53.2	0.3
		CCS	18.0	10.1	17.4	54.4	0.2
c. Low income individuals [count = 99,455]	FP	CSD	6.4	0.4	2.0	11.1	80.2
		CCS	4.5	1.7	2.9	13.4	77.5
	PT	CSD	9.4	3.1	14.4	73.1	–
		CCS	7.7	5.4	13.8	73.1	–
d. Population 15 + without certificate, diploma or degree [count = 144,025]	FP	CSD	12.8	0.6	3.6	14.1	68.9
		CCS	7.3	3.8	5.1	18.7	65.1
	PT	CSD	17.5	4.7	17.8	59.9	0.1
		CCS	12.5	10.3	16.6	60.5	–
e. Immigrants who came Canada from 2001 to 2011 [count = 32,275]	FP	CSD	2.2	–	0.2	6.1	91.5
		CCS	1.8	0.3	0.3	6.5	91.1
	PT	CSD	2.9	2.6	7.3	87.2	–
		CCS	2.7	2.8	7.0	87.5	–
f. Aboriginal status population [count = 104,130]	FP	CSD	19.6	0.1	4.5	8.0	67.8
		CCS	7.2	6.4	8.0	14.0	64.4
	PT	CSD	24.3	4.4	12.2	59.1	0.1
		CCS	13.8	14.8	11.7	59.7	–

two different inter-related geographical units are used, the possibility of a MAUP scaling effect could not be ignored, highlighting the significance of choosing an appropriate unit of analysis at local scales that are pertinent to planning purposes. This research has also considered age, income, education, immigration and ethnicity variables as a proxy for the social determinants of health and potential health care needs in understanding the associated technical challenges in measuring accessibility to health care services in rural and remote areas and compared the results across both CSD and CCS areal units. A large proportion of this population with potentially high health care needs (e.g., population age 65 and over, low income, recent immigrants and aboriginal status/ethnicity) has reduced access to PT services particularly in rural and remote municipalities in comparison to FP services (see, Table 1). Further discussion of these factors is beyond the scope of this paper, but has been explored elsewhere (Shah et al., 2015). Further, comparison of the proportion of population with potentially high health care needs across both CSD and CCS areal units highlights observable differences when using different units of analysis. For example differences can be seen in the distribution of poorly-served access categories (i.e., no score and <0.25), in the proportion of the population age 65 and over (in case of FP, CSD: 15.9%, and CCS: 14.7%; in case of PT, CSD: 27.3% and CCS: 28.1%).

From Fig. 4 it can also be seen that by increasing catchment area in the 3SFCA method, more municipalities are moving from the no score class to the '0.0 to 0.25'class. Thus it can be argued that the basic parameters for GIS-based methods need to be set carefully by considering actual patient travel behavior (Allan, 2014; Paez et al., 2010), and by carefully planning the analytical strategy to be used, relative to questions being asked, and the measureable units of the population(s) being considered.

In health geography, input data quality can influence the results for geographic accessibility to health care services in a number of ways (Shah et al., 2014; Jacquez, 2012; McLafferty et al., 2012; Guagliardo, 2004; Cromley and Albertsen, 1993). A considerable amount of literature has been published on the input data quality issues/challenges related to the following types: incomplete data for generating location, positional uncertainty (normally due to different geocoding methods/converting polygon data to centroid) (Bell et al. 2012; Guagliardo 2004), selection of health care professions working in multiple sites (primary, secondary, or and tertiary practice settings) either within or across health regions (Albert et al., 2005; Cromley and Albertsen, 1993). In our case, the input data can be classified into two categories after considering the nature of data sources and potential type of positional uncertainty. The first category is related to supply data location such as health care providers' practice locations that are generated using an integrated geocoding process. In cases where health care professionals are working in multiple sites, this

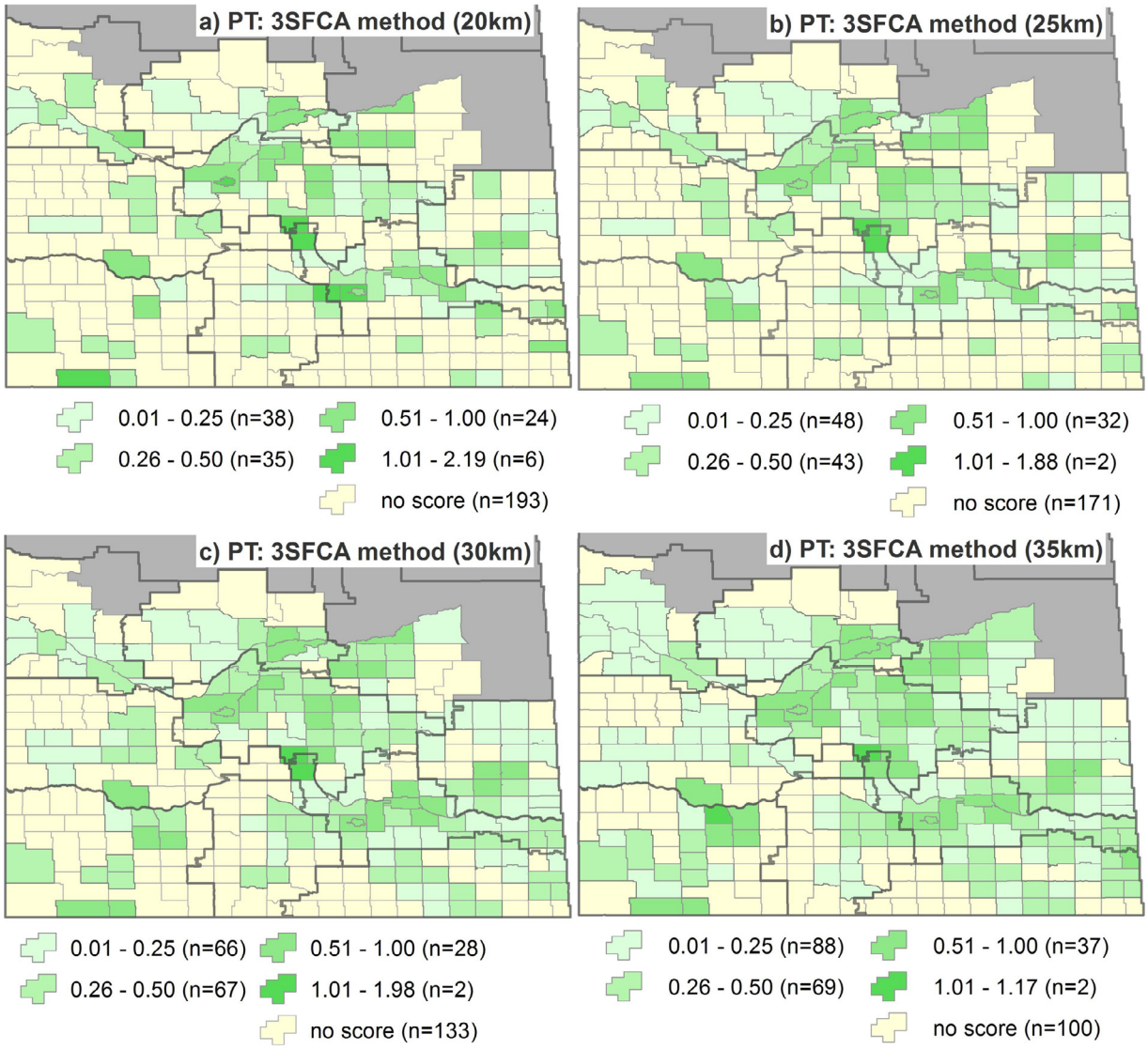

Fig. 4. Catchment area size: measuring geographical accessibility to PT services at CCS level using 20 km, 25 km, 30 km, and 35 km catchment areas.

research has selected their primary location for geocoding for subsequent estimation of provider-to-population ratios (Albert et al., 2005; Badley et al., 2015). The second category deals with the population health care need (demand) that are represented by centroids of census geographic areas. These centroids were generated by Statistics Canada's Spatial Data Infrastucture in an effort to ensure that representative point coordinates are not placed in a body of water (Statcan, 2011c). In both cases, some points for input data may have some positional errors, which could influence the accessibility scores.

5. Conclusions

Measuring accessibility to rural and remote healthcare services is not without technical challenges. The results of GIS approaches vary considerably depending on choice of input data, geographical area unit of analysis, and accessibility method. These methodological issues have implications for determining levels of accessibility to healthcare services (or where there is reduced access) that can impact decisions regarding health human resource decisions and policies related to rural and remote health service accessibility. Our findings not only provide researchers, decision makers, and health planners with a more nuanced understanding of the distribution of healthcare services at local levels but can also shed light on the technical challenges and difficulties associated with each approach.

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