Geographic access to optometry services across Canada: Mapping distribution, need and self-reported use

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Abstract

Background This research investigates the distribution of optometrists in Canada relative to population health needs and self-reported use of vision care services with a focus on identifying variation and poorly served health regions in order to gain a clearer understanding of geographic proximity of optometry services.

Methods Optometrist locations were gathered from resources provided by provincial regulatory bodies. A geocoding approach then converted these descriptive data into a set of geographic coordinates. Utilization of vision care services was extracted from the Canadian Community Health Survey (CCHS) 2013-2014 question regarding self-reported contacts with vision care providers. Data from the 2016 Statistics Canada census were used to create three population ‘need’ subgroups (65 years and over; low-income; and people aged 15 and over with less than a high school diploma). Optometrist-to-population ratios, expressed as number of providers per 10,000 people at the health region level, were then calculated. Cross-classification mapping compared optometrist distribution to self-reported use of vision care services in relation to need.

Results A total of 5,959 optometrists working across ten Canadian provinces were included in this analysis. The nationwide distribution of optometrists is variable across Canada and they are predominantly concentrated in densely populated urban areas. The mean ratio of optometrists across Canada was 1.70 optometrists per 10,000 people (range = 0.13 to 2.92). Out of 109 health regions (HRs), 26 were classified as low ratios, 51 HRs were classified as moderate ratios, and 32 HRs were high ratios. Thirty-five HRs were classified as low utilization, 39 HRs were classified as moderate, and 32 HRs as high utilization. HRs with a low optometrist ratio relative to eye care utilization and a high proportion of key sociodemographic characteristics are located throughout Canada and identified with maps indicating areas of likely greater need for optometry services.
Conclusion This research provides a nationwide overview of vision care provided by optometrists identifying gaps in geographic access relative to “supply” and “need” factors. This in-depth examination of variation in population accessibility to optometric services will be useful to inform workforce planning and policies at national, provincial, and health region levels.

Background

Primary health care (PHC) in Canada includes a variety of services from a range of health professionals providing comprehensive care and coordination with other levels of care. Access to PHC services is a considerable health delivery concern across Canada with important health policy implications. Some communities, particularly in rural and remote areas, do not have the same access to a range of primary health care professionals. Such differences in access to health services have negative consequences for best meeting population health needs. Geographic access to PHC services involves investigating the distribution of these services in relation to population health needs.[1-3] The increasing interest in geographic access to PHC services in Canada has focused predominantly on physicians, and dentists.[4-10] In relation to vision care services, the few studies in Canada to date have focused on either ophthalmologists only [11, 12] or combined distribution of ophthalmologists and optometrists.[13] Optometrists are identified as “independent primary health care providers and represent the front line of vision health” (CAO website) and practice in a diverse range of settings across Canada including private practice, community health centres, and hospitals. Research investigating vision care provider use (i.e. optometrist or ophthalmologist) based on a self-reported national survey in Canada, found that populations having high risk of vision loss may lack access to eye care services [14], socioeconomic characteristics may be barriers to eye service utilization among certain subgroups [15], and those without additional health insurance have
reduced use and access to eye care services.[16] However, having additional health care insurance does not necessarily result in equitable access to eye care services. Residents of countries with low densities of eye care professionals, for example, have reduced likelihood of vision service access, even among those with insurance.[17] Further, rural and remote residents face additional challenges due to longer travel distances to receive vision care.[18]

To date, there has been little work in Canada that has focused solely on investigating the distribution of optometry services relative to potential need and use. The aim of this research was to explore the distribution of optometrists in relation to population health needs and self-reported use of vision care services across Canada in order to identify potential gaps in geographic access relative to “supply” of and “need” for such factors. Specifically, this research: 1) identifies variation and poorly-served areas (i.e. health regions) to optometry services across Canada; 2) analyzes and maps the self-reported use of vision care services in relation to optometrist distribution; and 3) maps the patterns of spatial distribution of optometrists in relation to census-based socio-demographic characteristics (e.g. age, income, education).

Methods

This research is based on the number of optometrists per population (i.e. optometrist distribution ratio), eye services utilization (including optometrists and ophthalmologists), and population subgroups that may have higher health care needs (i.e. seniors population, low-income measures, and less education) (see Figure 1). The primary practice locations of optometrists in Canada were gathered from the provincial regulatory bodies. The Canadian Association of Optometrists (CAO) gathered primary practice information of optometrists for 2017 (i.e. six-digit postal codes) from seven provinces (British Columbia, Manitoba, New Brunswick, Ontario, Prince Edward Island, Quebec, Saskatchewan) whereas
data from the remaining three provinces (i.e. Alberta, Newfoundland and Labrador, Nova Scotia) was downloaded directly from each of the provincial regulatory college’s website. CAO was unable to provide optometrist information for three Territories due to unavailability of any licensing bodies to provide data. A set of geographic coordinates for primary practice locations were generated using postal code geocoding and Google Maps. Next, in order to aggregate data in various geographic scales, supporting attributes from other layers such as health region boundaries, census subdivision (CSD) geographic units were assigned to each location.

Geographic proximity of optometry services was measured in terms of the number of optometrists per 10,000 population at health region levels (i.e. optometrist distribution ratio). The number of optometrists extracted from the provincial regulatory bodies (December 2017 to July 2018) from either the 2017 or 2018 registration year combined with Census derived population figures were used for estimating optometrist ratios at a health region level. Information about utilization of eye care services (i.e. combination of optometrist or ophthalmologist) is based on the CCHS 2013-2014 that was accessed via Ontario Data Documentation, Extraction Service and Infrastructure (odesi) web-based data exploration, extraction, and analysis tool (https://odesi.ca/). The CCHS is a cross-sectional, nationwide, and self-reported household survey that was collected from persons aged 12 and over living in Canadian health regions except those living on a reserve or as fulltime member of the Canadian Forces. We used the following question to derive the information about utilization of eye care services at health regions: “CHP_Q06: [Not counting when you were an overnight patient, in the past 12 months/In the past 12 months], have you seen, or talked to: an eye specialist, such as an ophthalmologist or optometrist (about your physical, emotional or mental health)?” Unfortunately, the wording of the CHP question related to vision care services does not distinguish between optometrist or
ophthalmologist use. Comparative analyses of ratio and utilization variables in association
with population subgroups that usually have much higher health care needs was
performed. We focused on the following three population subgroups with potentially
higher needs: seniors (age 65 years and over), low-income, and lower educational
attainment. Information about these three variables were extracted from 2016 Census and
downloaded from the Statistics Canada website. The 2016 dissemination area (DA) census
data were used to prepare the following HR level variables: population 65 years and over,
low-income measures, and the population aged 15 and over with less than a high school
diploma. These variables were expressed as percentages.

Geospatial mapping methods that were used to analyze the patterns of optometrists per
10,000 population (i.e. ratio), self-reported eye care services utilization, and population
subgroups can be divided into three ways. First, optometrist practice locations were
associated with the different urban-rural classifications where we used statistical area
classification to categorize census subdivisions (municipalities) into metropolitan and
metropolitan influence zones (MIZs).[19] The MIZ classifies the CSDs outside census
metropolitan areas (CMAs) and census agglomerations (CA) into “four categories
according to the degree of influence (strong, moderate, weak, or no influence) that the
CMAs or CAs have on them.” [19] Second, optometrist ratios estimated at health regions
levels were mapped. This was done after converting ratio values into five categories
where a standard deviation (SD) classification approach was used (± 0.5 SD from the
mean value were used as a cut-off for demonstrating distribution of optometrists across
health regions). Third, a cross-classification technique was utilized to map the patterns of
spatial distribution of optometrists in relation to self-reported use of vision care services
and population subgroups. This was performed after separating optometrist ratio and self-
reported utilization of eye services into three classes, based on a standard deviation
classification scheme, as follows: low, moderate, and high. Similarly, the patterns of
spatial distribution of optometrists in relation to census-based socio-demographic
characteristics (i.e., seniors’ population, low-income measures, and lower educational
attainment) were mapped. A similar classification scheme was applied for converting the
percent of these population subgroups into three classes: low (< -1.5 SD; -1.5 to -0.50
SD), moderate (-0.5 to 0.5 SD), and high (0.50 to 1.5 SD, > 1.5 SD).

The following software were used for mapping and data analysis (spatial and nonspatial):
ArcGIS Map, SPSS, and Microsoft Excel. A thematic mapping tool available in ArcGIS
software (ArcGIS Desktop version 10.5, ESRI, Redlands, CA) was used to prepare a set of
maps. Supporting datasets required for mapping were accessed by the research team
through the Geographical Information System (GIS) Library Services at the University of
Saskatchewan [20]. These datasets included a digital geographic boundary file for health
regions, demographic data, digital geographic file of the 2016 Canadian Census at various
geographic scales, and CanMap Postal Code Suite for geocoding purposes.

Results

This analysis is based on 5,959 optometrists working across Canada. As shown in Table 1,
we generated geographic locations using the following geocoding methods: postal code
geocoding (n = 5,835; 97.9%), and Google Maps (n = 114; 1.9%). There were 10
optometrists (0.17%) where address information was not provided, and these were
excluded from the analysis. Figure 2 presents the health region level distribution of
optometrists by relative rurality (based on MIZ). Out of the total sample of optometrists,
4750 (i.e., 79.7%) were located within urban census metropolitan or agglomeration areas
(CMAs; CAs). The remainder of optometrists were distributed within different MIZs: 668
(i.e., 11.2%) within strong MIZs; 103 (1.7%) within moderate MIZs; 427 (7.2%) within
weak/no MIZs. Optometrist provincial counts across different MIZs are shown in Appendix
1.
The average distribution of optometrists across 109 Canadian health regions was 1.70 optometrists per 10,000 people (range = 0.13 to 2.92) whereas the average proportion of eye care utilization by health regions was 41.87% (range = 32.11% to 51.77%; SD = 4.01). Optometrist ratios were mapped after converting into a categorical variable by following a standard deviation (SD) scheme where a ± 0.5 SD from the mean value was used as a cut-off for demonstrating distribution of optometrists across health regions. The first two categories (< - 1.5 SD; -1.5 to - 0.50 SD) indicate poor distribution of optometrists (i.e., lower category), the third category (-0.5 to 0.5 SD) moderate, and the last two (0.5 to 1.5 SD, > 1.5 SD) indicate higher geographical availability of optometry services. Regarding optometrist ratio per 10,000 people: out of 109 HRs, 26 were in the lower categories, 51 HRs in the moderate, and 32 HRs in the higher categories as seen in the sum of values given in the legend of Figure 3. Table 1 presents the province wide distribution of the total population (and HR counts) across the optometrist ratio categories (5-classes based on the standard deviation approach). About 9.2% of total population (i.e., 3.24 million) in 26 HRs from eight provinces (i.e. all except NS and PE) fall under the lower categories of optometrists per population ratios (i.e., < -1.5 SD; -1.5 SD to -0.50 SD).

Optometrist distribution patterns relative to utilization of eye care services demonstrates moderate-low optometrist availability in health regions with moderate-high utilization of eye care services (Figure 4) and in health regions with relatively higher percentage of population subgroups (higher than the national average) (Figures 5–7). Cross-classification between the ratio and use variables where 106 HRs were divided into nine category combinations (Figure 4). Health regions with low optometrist ratio values relative to the low utilization of eye care are located throughout Canada. There are nine HRs (8.5%) that fell within the high utilization-high distribution ratio combination (1 HR from each of NB,
QC, and SK, 6 from ON). Ten HRs (9.4%) from the following provinces were found to have a low utilization-low distribution ratio combination: 1 HR from each of NB, ON, and AB, 2 from each of BC, and NL, 3 from MB. Ten HRs (9.4%) fell within high utilization-low distribution ratio combination: 1 HR from each of NB, and AB, 2 from ON, 3 from SK). Eight HRs (7.5%) had a low utilization-high distribution ratio combination: 1 HR from ON, 3 from BC, and 4 from QC. Various other combinations with moderate utilization or distribution were found in 69 HRs distributed across all 10 provinces.

Cross-classification between the ratios and socio-demographic characteristics (3 variables) were divided into nine category combinations are shown in Figure 5–7. Health regions with low optometrist ratios relative to the high percent of sociodemographic ‘need’ characteristics (Figure 5–7) are located throughout Canada. For example, in the case of seniors’ population (Figure 5), 11 HRs (8.5%) fell within the high percent of seniors’ population-high optometrist distribution ratio combination (2 HRs from each of NB, and QC, 3 from ON, 4 from BC). In the case of a low percent of seniors’ population-low optometrist distribution ratio combination, 11 health regions (9.4%) from the following provinces were found: 2 HRs from each of QC, MB, AB, and BC, and 3 from SK. High percent of seniors’ population-low optometrist distribution ratio values were found in 6 HRs (9.4%; 1 HR from each of NL, and BC, 2 from NB, and ON). Low percent of seniors’ population-high optometrist distribution ratio values were found in 10 HRs (7.5%; 1 HR from QC, 2 from each of SK, and AB, 5 from ON). Various other combinations with moderate percent of seniors’ population or distribution were found in 71 HRs.

Table 1 Total population with number of health regions across optometrist ratios using standard deviation (SD) classification scheme [population (HR count)]
### Optometrist Ratio (per 10,000 population) categorized using SD classification

| Canadian Provinces (from west to east) | Optometrist Ratio (per 10,000 population) | Total Population (HR count) |
|---------------------------------------|--------------------------------------------|-----------------------------|
|                                       | Low [< -1.5 SD] | Moderately low [-1.5 SD to -0.50 SD] | Moderate [-0.5 SD to +0.50 SD] | Moderately high [+0.5 SD to +1.5 SD] | High [> +1.5 SD] |
| British Columbia                      | 582,563 (4)       | 3,020,551 (8)                   | 965,085 (3)                      | 79,856 (1)                      | 4,648,055 (16) |
| Alberta                               | 903,389 (2)       | 291,112 (1)                     | 2,872,674 (2)                    |                                      | 4,067,175 (5)  |
| Saskatchewan                          | 35,453 (3)        | 151,741 (3)                     | 288,419 (5)                      | 622,739 (2)                      | 1,098,352 (13) |
| Manitoba                              | 199,821 (2)       | 192,061 (1)                     | 886,483 (2)                      |                                      | 1,278,365 (5)  |
| Ontario                               | 512,148 (4)       | 8,191,001 (20)                  | 4,133,395 (10)                   | 611,950 (2)                      | 13,448,494 (36) |
| Quebec                                | 30,329 (2)        | 2,328,266 (7)                   | 5,216,366 (8)                    | 589,400 (1)                      | 8,164,361 (18) |
| New Brunswick                         | 239,348 (3)       | 209,256 (1)                     | 298,497 (3)                      |                                      | 747,101 (7)    |
| Nova Scotia                           |                                      | 923,598 (4)                     |                                |                                      | 923,598 (4)    |
| Prince Edward Island                  |                                      | 142,907 (1)                     |                                |                                      | 142,907 (1)    |
| Newfoundland and Labrador             | 390,954 (2)       | 128,762 (2)                     |                                |                                      | 519,716 (4)    |
| Canada                                | 265,603 (7)       | 2,972,204 (19)                  | 16,410,355 (51)                  | 14,108,756 (28)                   | 1,281,206 (4)  |
|                                       |                                      | 35,038,124 (109)                |                                |                                      |                 |

SD=standard deviation; HR=health regions.

### Discussion

This research provides an important overview of distribution patterns of vision care services provided by optometrists across Canadian health regions. Specifically, this work has identified variation and poorly-served health regions to optometry services across ten Canadian provinces in relation to self-reported use of vision care services, and census-based socio-demographic characteristics (i.e. seniors, lower income and education levels). Overall, there is an uneven distribution of optometrists across Canadian health regions. Across Canada, most optometrists are concentrated in densely populated areas of Calgary, Edmonton, Saskatoon, Regina, Southwestern Ontario (London), Central Ontario (except
Toronto), Ottawa, Montreal, and Fredericton. Canada’s most populous urban centres, Vancouver and Toronto, have moderate optometrist ratios (Figure 3). A few moderate-high optometrist concentration areas are located in Kelowna and Kootenay regions in British Columbia, Waterloo and Thunder Bay areas in Ontario, areas in and around Gatineau and Mon-Tremblant, Riviere-du-Loup in Quebec, Edmundston in New Brunswick (Figure 3). The majority of optometrists (n = 4750 or 79.7%) were located within urban centers consistent with distribution of physicians, nurses and physiotherapists [21]. The results of this study indicate health regions with low optometrist ratio values relative to the low utilization of eye care and relatively high percent of sociodemographic ‘need’ characteristic which are located throughout Canada. Our results align with what was found by Khan, Trope, Wedge [22] in Prince Edward Island where low vision care utilisation is attributed to barriers in accessing government-insured ophthalmologists. In previous studies on eye care services/utilization, different socio-demographic characteristics have been found to be related to distribution of optometry services. A further analysis of the Canadian Longitudinal Study on Aging [24] identified disparities in the utilization of eye care services in Canada with less educated populations (less than bachelor’s degree) and those with lower income less likely to use these services. For example, in an analysis of the Canadian Longitudinal Study on Aging, Aljied, Aubin, Buhrmann [23] reported that older age and income are critical factors for visual impairment. A study in Newfoundland and Labrador also found that low socioeconomic status (including lack of government insurance) and living in non-urbanized areas are related to the under-utilization of eye care providers.[24]

Ensuring adequate geographical distribution of health human resources and services is a key component of ensuring equitable access to health care.[25] Realized access is actual use of services, whereas potential access is linked to an individual’s perception of access
as well as other contextual and environmental factors, such as geographical distribution of services.[26] Our findings point out uneven distribution of optometrists relative to utilization and key socio-demographic indicators across Canadian health regions, suggesting that there are potential gaps in equitable access to care. It is important to note that optometrist-use data do not directly relate to population health need because those who need the service may not necessarily be able to access care for a variety of reasons. Access and use are not synonymous because an individual may need to overcome barriers that limit her or his access to a particular service in order to use it.[27] Furthermore, the health care needs of an individual do not necessarily reflect access to particular services, nor do health care needs consistently correlate with patterns of health care use.[28]

**Limitations and other considerations**

Interpreting the findings of this report should be viewed in light of limitations in data quality pertaining to optometrist location, utilization and other geographical factors. The optometrist ratios are most likely overestimated due to optometrist counts used for analysis instead of full-time equivalents. Optometrist practice locations are based on the postal code that may have some geographic uncertainty resulting in a potential misalignment with health regions. Self-reported utilization of vision care services is likely to be on the higher side as both optometrist and ophthalmologist providers are reported in CCHS and cannot be separated. In some cases, the CCHS data is available for groups of neighboring health regions only (primarily to increase the sample size). As of April 1, 2015, Nova Scotia has one Provincial Health Authority, with four management zones. These management zones are an aggregation of the nine former health authorities.

**Conclusion**

This research provides an overview of distribution patterns of vision care services.
provided by optometrists across Canadian health regions. The results show optometrists are located across Canadian health regions in a variety of rural and urban settings, with greater concentration in urban settings. However, there is considerable variation with a number of poorly-served health regions by optometry services identified across ten Canadian provinces relative to both self-reported use of vision care services, and census-based distribution of socio-demographic characteristics (i.e. seniors, lower income and education levels). This research identifies potential gaps in geographic access regarding “supply” of optometrist vision care services relative to socio-demographic “need” factors. These findings provide a better understanding of accessibility to eye care services provided by optometrists and can be used to inform workforce and service delivery policies and planning at national, provincial, and health region levels.

Abbreviations

CA: Census agglomeration; CAO: Canadian association of optometrists; CHP: Contacts with health professionals; CMA: Census metropolitan areas; CCHS: Canadian community health survey; CSD: Census subdivisions; CT: Census tract; DA: Dissimilation areas; DB: Dissemination block; FTE: Full-time-equivalent; GIS: Geographical Information Systems; HA: Health authority; HR: Health regions; HU: Health unit; MEP: Multiple enhanced postal codes; MIZ: Metropolitan influence zone; PHC: Primary health care; RSTs: Rural and small towns; RHA: Regional health authority; SES: Socioeconomic status; SAC: Statistical area classification; SD: Standard deviation.

Declarations

Ethics approval and consent to participate

Ethical exemption was obtained from the Behavioral Research Ethics Board of the University of Saskatchewan.
CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIAL

The data that support the findings of this study are available from Statistics Canada (Government of Canada). The CCHS related data can be downloaded from the ODES1 website (Ontario Data Documentation, Extraction Service and Infrastructure; https://search1.odesi.ca/#/).

COMPETING INTERESTS

The authors declare that they have no competing interests.

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AUTHORS’ CONTRIBUTIONS

TS, BB, RL and SM contributed to the design and analysis of the study. TS and BB conducted the geospatial mapping and statistical analysis. TS constructed the maps, and all others provided feedback. TS and BB wrote the first draft of the manuscript, and all authors participated in providing editorial advice. All authors interpreted the results and thoroughly revised the manuscript. All authors read and approved the final manuscript.

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Figures
Figure 1

Data sources
Optometry clinic locations (individual optometrist) and census subdivisions (CSDs) within census metropolitan areas (CMAs), Census Agglomerations, and within different metropolitan influenced zones (MIZs) across Canadian provinces (main map); inset map of eastern provinces (A) inset map of Southern Ontario (B), and inset map of British Columbia (C). Labels: BC=British Columbia;
AB=Alberta; SK=Saskatchewan; MB=Manitoba; ON=Ontario; QC=Quebec;
NB=New Brunswick; PE=Prince Edward Island; NS=Nova Scotia; NL=Newfoundland and Labrador; YT=Yukon Territory; NT=Northwest Territory; NT=Nunavut Territory.

Figure 3

Distribution of optometrists across Canadian health regions in the form of number
of optometrists per 10,000 population (Optometrist Ratio) across Canadian provinces (main map); inset map of eastern provinces (A) inset map of Southern Ontario (B), and inset map of British Columbia (C). Labels: BC=British Columbia; AB=Alberta; SK=Saskatchewan; MB=Manitoba; ON=Ontario; QC=Quebec; NB=New Brunswick; PE=Prince Edward Island; NS=Nova Scotia; NL=Newfoundland and Labrador; YT=Yukon Territory; NT=Northwest Territory; NT=Nunavut Territory.

Figure 4

Cross-classification map of optometrist per 10,000 population (Ratio) with self-reported utilization of eye services; Labels: BC=British Columbia; AB=Alberta; SK=Saskatchewan; MB=Manitoba; ON=Ontario; QC=Quebec; NB=New Brunswick; PE=Prince Edward Island; NS=Nova Scotia; NL=Newfoundland and Labrador; YT=Yukon Territory; NT=Northwest Territory; NT=Nunavut Territory. L=low; M=moderate; H=high
Figure 5

Cross-classification map of optometrist per 10,000 population (Ratio) with seniors population; Labels: L=low; M=moderate; H=high

Figure 6

Cross-classification map of optometrist per 10,000 population (Ratio) with low-income families; Labels: L=low; M=moderate; H=high
Figure 7

Cross-classification map of optometrist per 10,000 population (Ratio) with population without high school education; Labels: L=low; M=moderate; H=high