

Identifying Distinct Geographic Health Service Environments in British Columbia, Canada: Cluster Analysis of Population-Based Administrative Data

Identifier les différents environnements de services de santé en Colombie-Britannique, au Canada : analyse typologique des données administratives en fonction de la population



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Abstract

Definitions of “urban” and “rural” developed for general purposes may not reflect the organization and delivery of healthcare. This research used cluster analysis to group Local Health Areas based on the distribution of healthcare spending across service categories. Though total spending was similar, the metropolitan areas of Vancouver and Victoria were identified as distinct from non-metropolitan and remote communities, based on the distribution of healthcare spending alone. Non-metropolitan communities with large community hospitals and greater physician supply were further distinguished from those with fewer healthcare resources. This approach may be useful to other researchers and service planners.

Résumé

Les définitions d’« urbain » et de « rural » dans les contextes généraux ne s’appliquent pas nécessairement à l’organisation et à la prestation des services de santé. Dans le cadre de cette recherche, l’analyse typologique a servi pour étudier les régions sanitaires locales en fonction de la distribution et des dépenses de santé dans les différentes catégories de services. Bien que

les dépenses totales soient similaires, les régions métropolitaines de Vancouver et de Victoria sont considérées de façon distincte des communautés non métropolitaine et éloignées, et ce, uniquement en fonction de la distribution et des dépenses de santé. Les communautés non métropolitaines dotées de grands hôpitaux communautaires et d'un plus grand effectif de médecins se distinguent de celles où il y a moins de ressources en santé. Cette démarche peut être utile pour les chercheurs et les planificateurs des services de santé.

Background

An extensive body of literature has examined healthcare services across urban and rural contexts. Typically, areas are grouped according to urban and rural categories, and then measures of use, quality or outcomes are compared. Multiple definitions of urban and rural places exist in Canada (du Plessis et al. 2001). These use information on population size, density and/or distance or connectivity to large urban centres to classify areas. Definitions specific to healthcare policy have also been developed, and incorporate information on the location of healthcare resources (Kralj 2009; Leduc 1997; Olatunde et al. 2007; Rosenberg and Hanlon 1996). Of course, there are factors beyond supply or location of healthcare resources that shape utilization, including income, education and availability of transportation (Wilson 2004).

Rather than first classifying areas based on urban/rural definitions and/or supply of healthcare resources, and then comparing patterns of service use, the present analysis classifies areas based on service use directly. Using population-based data from the province of British Columbia (BC), areas that are similar with respect to the distribution of healthcare spending across categories of care are grouped. Population and health system characteristics of the grouped areas are then compared.

Methods

Data

This analysis used data on per capita healthcare spending across 89 Local Health Areas (LHAs) in BC, with populations ranging from under 4,000 (Kettle Valley) to over 300,000 (Surrey). LHAs are the smallest unit of geography commonly used in the context of healthcare in BC, and are nested within 16 Health Services Delivery areas and five Health Authorities. They represent geographic boundaries relevant to healthcare managers and policy makers, and are the smallest unit at which data can be accessed.

Average per capita spending, stratified by LHA, sex and age group, was obtained from the Health System Matrix, produced by the Modeling and Analysis Team, within the Health System Planning Division of BC's Ministry of Health. All services used by an LHA's residents are attributed to that LHA, regardless of where they were accessed. Analysis included the following administrative data sources, with spending subdivided into categories as indicated:

- *Medical Services Plan Fee-for-Service Payments to Physicians.* These were grouped into: GP services in office; GP services in hospital/other locations; medical specialist services provided in office; medical specialist services in hospital/other locations; surgical specialist services provided in office; surgical specialist services in hospital/other locations; pathology/laboratory services, all locations; and diagnostic imaging, all locations.
- *Hospital Discharge Abstract Database.* Hospital costs derived from Resource Intensity Weights (CIHI 2011a) were grouped into: medical care; day surgery; in-patient elective surgery; trauma and emergency surgery; and other, including obstetrics, gynecology, oncology, palliative care and pediatrics.
- *Home and Community Care.* Spending includes home/community supports provided by health authorities (nursing care, home support services, rehabilitation services, adult day care and public funding to Community Services for Independent Living clients) and residential care/assisted living (publicly funded support services provided in assisted living settings and residential care, including convalescent care, transition care and respite).
- *PharmaNet Pharmaceutical Spending.* Spending is the total value of prescription drugs dispensed from community pharmacies, including drugs paid for by PharmaCare, private extended health plans and patients.

Five years of data were averaged (2004–05 to 2008–09) to ensure stable values in less populous LHAs. Spending was indirectly standardized using the age and sex distribution of the entire BC population (averaged over the five years of pooled data) as the standard population.

To capture health system characteristics within each area, individual-level data on patient age, sex, neighbourhood income and LHA of residence, as well as physician supply and hospital service delivery were obtained from the MSP registry file (British Columbia Ministry of Health 2011a), payment data (British Columbia Ministry of Health 2011b) and discharge abstract database (CIHI 2011b), accessed through Population Data BC and linked across the data sets using individual patient- and physician-specific study identification numbers. All inferences, opinions and conclusions drawn in this manuscript are those of the author, and do not reflect the opinions or policies of the Data Steward(s).

There are notable gaps in the available data, including services provided through the BC Cancer and Renal agencies, and some payments to physicians through alternate payment plans. Day surgeries performed on BC residents in Alberta are missing from the hospital data, though other acute care received by BC residents in Alberta is captured.

Hierarchical cluster analysis

The intent of this analysis was to identify groups of LHAs that have similar patterns of healthcare service use, measured as the distribution of spending across the categories of care described above. Hierarchical clustering starts from the point where each data point (in this case LHA) is a single “group,” and then successive linkages are made to minimize within group differences and maximize between group differences.

Age- and sex-adjusted LHA-level per capita spending for each category of care (15 total) was standardized with a mean of zero and standard deviation of one. Hierarchical clustering was done using Stata's cluster command and Ward's minimum variance method (minimizing the total within-cluster sum of squares) (StataCorp 2013).

To confirm the consistency and reliability of the cluster solution, the analysis was re-run using earlier years of data (2002/3–2003/4), an alternate clustering technique (k-means), as well as with alternate variable specification (collapsing or subdividing within categories, for example, subdividing home and community care services, or collapsing all physician services by specialty but not location of services).

Results

Cluster analysis revealed three very distinct high-level clusters, which are labelled metropolitan, non-metropolitan and remote. This was supported by the Calinski–Harabasz index in both Ward's and k-means clustering. A pictorial representation of the revealed clusters is provided with a dendrogram (Appendix 1, available at: <http://www.longwoods.com/content/24717>). This visually represents information about how LHAs are grouped. At the bottom of the figure, each LHA is treated as its own cluster. The LHAs are combined at various levels of similarity (joined by horizontal lines), until, at the top of the figure, the whole province is grouped together. The height of the lines gives information about the similarity of the clusters. Long vertical lines (for example, separating "metropolitan" and "remote" LHAs) indicate a distinct separation between clusters. Shorter lines (for example, separating "non-metropolitan" clusters (a) and (b) reflect clusters that are not as distinct).

All LHAs in the "metropolitan cluster" are located in densely populated urban areas in and surrounding Vancouver and Victoria. The "remote" LHAs are in isolated coastal and northern areas of the province. The "non-metropolitan" LHAs encompass the remaining area of BC outside the Lower Mainland and southern Vancouver Island (Figure 1). The next division in hierarchical clustering further subdivided non-metropolitan LHAs into two smaller clusters, labelled (a) and (b). These divisions were also confirmed by the k-means four-cluster solution.

Table 1 describes the distribution of average per capita spending across categories, by cluster. Metropolitan residents used the most physician services and were more likely to see physicians out of hospital. They also used more diagnostic and imaging services than non-metropolitan residents, and slightly more pharmaceuticals. Non-metropolitan residents had higher spending on GP services provided in hospital, as well as medical, day surgery and elective hospital services. Remote residents had very high use of hospital services and much lower use of other physician services. Looking within non-metropolitan areas, cluster (a) had slightly higher use of specialist services, laboratory, imaging and pharmaceuticals, and cluster (b) had higher use of GP services in hospital and medical hospital services. Despite these differences by categories of care, total per capita spending differed by less than 7% overall: \$68 between metropolitan and non-metropolitan LHAs, and \$153 between metropolitan and remote LHAs.

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FIGURE 1. Map of clusters and hospitals

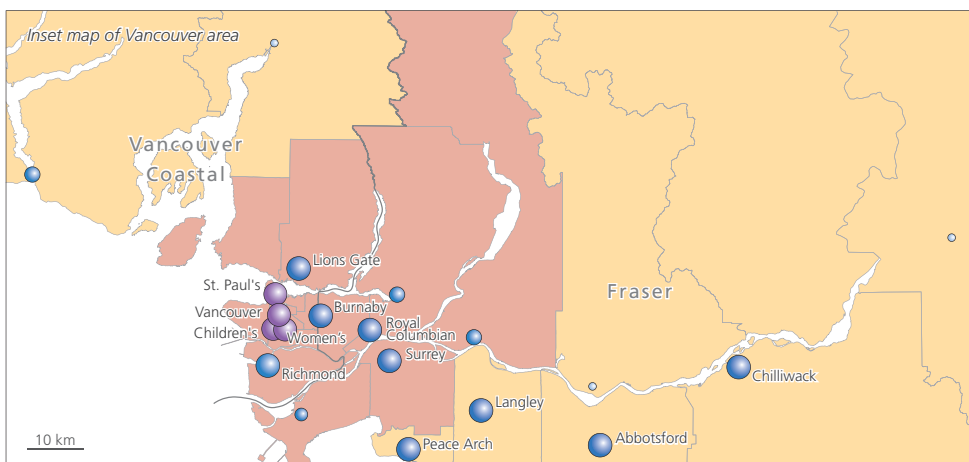


TABLE 1. Average per capita healthcare spending by cluster and percent distribution by category

	Metropolitan	Non-metropolitan		Remote
		a	b	
Total spending	\$2,424	\$2,356	\$2,358	\$2,271
Percentage of total spending by category				
Physician services				
GP office	5.9	5.5	5.1	1.4
GP hospital	1.7	2.9	3.7	1.6
Medical office	1.8	1.3	0.9	1.5
Medical hospital	2.6	1.4	1.0	1.3
Surgical office	0.6	0.6	0.5	0.5
Surgical hospital	4.2	4.1	3.1	4.4
Diagnostic services				
Laboratory/pathology	2.8	2.5	2.4	3.2
Diagnostic imaging	2.9	2.7	2.3	2.8
Hospital services				
Medical	9.7	11.3	14.9	25.7
Day surgery	2.7	3.1	2.8	3.7
In-patient elective surgery	3.4	4.4	4.2	5.0
Trauma/emergency	6.2	5.7	5.4	7.0
All other hospital	15.3	14.2	14.5	17.1
Home and community care	21.0	21.2	22.2	17.3
Pharmaceuticals	19.1	19.0	17.1	7.7

Table 2 describes population and health system characteristics by cluster. These variables were not included in the cluster analysis but help to understand factors that likely shape the spending patterns across categories. The majority of British Columbians live in metropolitan LHAs (58%) (Table 2). A higher percentage of metropolitan residents are female and a lower percentage are in the youngest and oldest age groups (though all spending was age–sex standardized prior to cluster analysis). A very high percentage of remote residents are in the lowest income quintile.

TABLE 2. Population and health system characteristics by cluster

	Metropolitan	Non-metropolitan		Remote
		a	b	
Number of LHAs included	20	37	24	8
Population, n (%)				
Cluster population	2,466,656 (58.0)	1,448,567 (34.0)	323,074 (7.6)	18,058 (0.4)

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TABLE 2. Continued

	Metropolitan	Non-metropolitan		Remote
		a	b	
Sex*				
Female	1,282,606 (51.1)	732,143 (50.7)	159,792 (49.3)	8,900 (48.0)
Age*				
0–19	449,082 (17.9)	271,993 (18.9)	66,101 (20.4)	4,184 (22.5)
20–39	676,882 (27.0)	350,956 (24.3)	80,955 (25.0)	4,762 (25.7)
40–59	805,771 (32.1)	432,984 (30.0)	99,809 (30.8)	5,720 (30.8)
60–79	443,646 (17.7)	298,405 (20.7)	63,129 (19.5)	3,271 (17.6)
80+	132,341 (5.3)	87,933 (6.1)	13,968 (4.3)	618 (3.3)
Income quintile*				
1 (highest)	477,675 (18.3)	322,603 (21.5)	66,493 (19.9)	717 (4.3)
2	493,406 (18.9)	322,382 (21.5)	70,513 (21.1)	914 (5.5)
3	528,686 (20.3)	305,227 (20.3)	64,558 (19.3)	2,094 (12.6)
4	549,503 (21.1)	276,490 (18.4)	62,711 (18.8)	4,388 (26.3)
5 (lowest)	556,982 (21.4)	275,611 (18.3)	69,752 (20.9)	8,542 (51.3)
Health system				
Physician supply (per 100,000 residents)				
GPs	118.0	132.2	134.9	165.5
Medical specialists	64.3	35.7	10.8	20.7
Surgical specialists	44.8	41.8	10.8	0.0
Laboratory specialists	9.3	8.8	3.8	0.0
Imaging specialists	3.2	3.3	0.3	0.0
Unknown specialty	27.0	21.1	20.4	51.7
Hospital facilities (total number of facilities within cluster) [§]				
Teaching	6	0	0	0
Large	8	8	0	0
Medium	4	10	6	0
Small	1	13	19	5
Other	4	2	0	0
Volume and complexity of hospital service delivery (for hospitalizations occurring within cluster, regardless of location of patient residence)				
Separations per 1,000 residents	258	294	218	262
Resource Intensity Weight (RIW) per 1,000 hospital separations	1,589	1,214	911	850

*Missing information on sex for 1,794 individuals, on age for 127,895 and income for 69,609. [§]Hospitals were classified by peer group (academic, large, medium and small community) according to the Canadian Institute for Health Information's methodology (CIHI 2013).

Although population characteristics vary, what more clearly differentiate the identified clusters are the health system resources available. Not surprisingly, metropolitan LHAs have more total physicians per capita and particularly more medical and surgical specialists (Table 2). Though these physicians see patients from across the province, they may be more accessible to metropolitan residents. All of the province's teaching hospitals are located within the metropolitan cluster. The high average Resource Intensity Weight (RIW) per hospital separation among metropolitan hospitals reflects their role as tertiary care centres, seeing complex patients from across the province. Non-Metropolitan cluster (a) can be distinguished from (b) by the fact that it has relatively greater physician supply (especially specialists), and is the location of all large community hospitals outside metropolitan LHAs.

When examining cluster stability by altering variable specifications, years of data and clustering technique, a handful of LHAs changed assignment, mostly between the two non-metropolitan clusters (a) and (b), but the overall cluster structure was robust to these changes in analysis.

LHAs along the Alberta border were grouped together within the non-metropolitan (b) cluster. This may, in part, reflect missing data on Alberta day surgeries, but this assignment has good face validity and these areas are similar in other characteristics as well. Missing data from BC Cancer and Renal agencies are not expected to have influenced results, as these are province-wide agencies responsible for planning services for patients in all included LHAs.

Discussion

The face validity of this clustering exercise is remarkably high. It groups areas that are similar in their geography and access to healthcare resources, though only information on healthcare spending was included. The primary distinction revealed by cluster analysis is between the metropolitan areas, including Vancouver and Victoria in the southwest, and the remainder of the province. This is important as many urban/rural definitions group much smaller "urban" centres along with the largest metropolitan areas (du Plessis et al. 2001). Results also highlight that very remote communities, though representing a small proportion of the total population, are distinct.

For comparison with Figure 1, Appendix 2 (available at: <http://www.longwoods.com/content/24717>) shows the Statistical Area Classification (SAC) groupings of Census Subdivisions (CSDs) overlaid with LHA boundaries (Statistics Canada 2015). The SAC approach groups CSDs according to whether they are part of a Census Metropolitan Area (CMA, population of at least 100,000) or Agglomeration (population of at least 10,000), and then categorizes the remaining areas by "metropolitan influence," based on the commuting flow of the employed labour force. CSD and LHA boundaries differ, but it is notable that clustering based on healthcare spending still yields generally similar groupings to the SAC approach: LHAs identified as remote in clustering correspond to weakly or not metropolitan influenced CSDs; LHAs in non-metropolitan (b) correspond to weakly or moderately metropolitan influenced CSDs; and LHAs in non-metropolitan (a) include strongly metropolitan influenced areas,

Census Agglomerations and the CMAs outside of Vancouver and Victoria (Kelowna and Abbotsford-Mission). For healthcare-related analysis, the SAC classification system is an improvement over binary urban–rural definitions (du Plessis et al. 2001), though it still does not identify Vancouver, Victoria and immediately surrounding areas as distinct.

This approach to categorizing areas based on cluster analysis may be useful to other researchers and healthcare system managers, either to classify health regions or to check if other definitions of urban and rural correspond adequately to observed patterns of use. More accurately describing how health system composition and organization differ across regions is important to craft policies that are appropriate to different settings.

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