Exploratory Spatial Analysis of Osteoarthritis Patients in Alberta

Mina Nasr[1], Judy Seidel[1,2], Alka B. Patel[1,2], Rizwan Shahid[1,4], Claire Barber[1], Raj Sharma[3], Stefania Bertazzon[4], Nigel Waters[4], Sonia Vanderby[5], Peter Faris[6], Tom Briggs[7], Terry McDonald[8], and Deborah A. Marshall[1]

1 Community Health Sciences, University of Calgary, Calgary, AB, mina.nasr1@ucalgary.ca, cehbarbe@ucalgary.ca, dmarsha@ucalgary.ca
2 Applied Research and Evaluation Services, Alberta Health Services, Calgary, AB, judy.seidel@albertahealthservices.ca, alka.patel@albertahealthservices.ca, rizwan.shahid@albertahealthservices.ca
3 Surgery, University of Calgary, AB, rajrishi.sharma@ucalgary.ca
4 Geography, University of University of Calgary, AB, bertazzs@ucalgary.ca, nwaters@ucalgary.ca
5 University of Saskatchewan, Saskatoon, SK, sonia.vanderby@usask.ca
6 Research Priorities and Implementation, Alberta Health Services, Calgary, AB, peter.faris@albertahealthservices.ca
7 Planning and Performance, Alberta Health Services, Calgary, AB, tom.briggs@albertahealthservices.ca
8 Family Medicine, University of Alberta, Edmonton, AB, te2@ualberta.ca

Abstract

Equitable access to Osteoarthritis (OA) health services in Alberta is challenged by the geographic spread of the Alberta population coupled with variations in OA prevalence across the province. OA is a degenerative chronic condition affecting 10-15% of adults in Canada. Our goal was to determine geographic variations of patients with OA, considering their needs for access to specialty and non-specialty OA-related health services use in Alberta. To reveal the geographic variations, we used longitudinal administrative health records from which we identified 323,674 OA prevalence cohort cases in Alberta (April 1, 2012 – March 31, 2013). Our analysis showed significantly larger numbers of prevalence cases for women than men (p-value<0.001). There were significantly higher age- and sex-standardized OA prevalence rates per 1,000 population in rural remote areas, rural areas, satellite communities located on the periphery of the city of Edmonton (moderate metro areas), and in moderate urban areas in the centre. Our hot spot analysis results showed local hot spots in Alberta that were particularly consistent with already identified communities with high numbers of elderly patients, and patients with comorbidities and/or low socio-economic status. The specialty care weighted hot spot analysis showed slightly higher numbers of hot spots in communities from rural remote and rural south areas, compared to other areas where patients mostly used non-specialty health services. This information will help inform the distribution and delivery of healthcare resources to communities with high OA prevalence in Alberta.

Background and Relevance

Osteoarthritis (OA) is a degenerative chronic condition affecting 10-15% of adults in Canada (Bombardier et al., 2011). The incidence is expected to increase due to obesity and an aging population (Bombardier et al., 2011; Lidgren, 2003; O'Donnell, 2011; Räsänen et al., 2007). Improving the management of OA offers potential for increasing the appropriateness of care and reducing health system costs (Chowdhury, 2014; Health Council of Canada, 2012; Seidel, 2013). OA is managed mainly by primary care

providers and, in later stages of the disease, by orthopedic surgeons through total joint replacement (MacDonald et al., 2014; Räsänen et al., 2007; Wilson et al., 2008). The Canadian Medical Association (CMA) and Alberta Health Services (AHS) have a goal to achieve equitable access to care, with a focus on patients in rural/remote areas (Canadian Medical Association [CMA], 2013; Government of Alberta, 2008). Our overall goal is to inform health services planning by assessing geographic variations of patients with OA in Alberta, and their related health services use. Existing evidence is limited to age- and sex-standardized rates of OA prevalence and incidence (O'Donnell et al., 2011), which does not account for geographic variations of patients and their health services use. We assessed this variability using spatial analysis in Geographic Information System (GIS), including hot spot analysis to identify spatial hot and cold clusters of OA prevalence in Alberta, considering OA-related health services utilization.

Methods and Data

We identified 323,674 OA cases in a prevalence cohort in 2012 – 2013 fiscal year (April 1, 2012 – March 31, 2013) of adult patients (age at incidence ≥ 18 years), using Public Health Agency of Canada validated OA case definition. The case definition is based on the International Classification of Diseases (ICD) 9th and 10th revisions diagnostic codes (715, M15-19) of at least one OA hospitalization, or at least two OA physician claims or ambulatory care visits to a physician or other health professional within 2 years, none on the same day (Lix et al., 2006). The data were extracted from AHS and Alberta Health (AH) longitudinal administrative health records from 1994 to 2013 fiscal years. OA Prevalence cohort refers to OA cohort patients who became OA incident while residing in Alberta and did not migrate out of the province or die between 1994 and 2013. The data variables used for this study were patients' characteristics (age at incidence, age in 2012 – 2013 fiscal year, sex), 6-digit postal codes of patients' residential locations, and patients' health services use (specialty care: rheumatologists, internal medicine specialists, and orthopedic surgeons; non-specialty care: general practitioners and physiotherapists). The first step of our data analysis included descriptive statistics and direct age- and sex-standardized OA prevalence rate calculations using Microsoft Excel and R software. The rates were calculated to determine OA distribution per 1,000 population for patients' age group in 2012 -2013 fiscal year (18–34, 35–44, 45–54, 55–64, 65–74, 75-84, 85+ years) by rural to urban geographic areas based on AHS geographic area classification into metro, moderate metro, urban, moderate urban, rural, rural centre, and rural remote areas shown in Figure 1 a-b (Alberta Health Services [AHS] & Alberta Health [AH], 2013). Alberta population registry data for the year 2013 weighted to the Statistics Canada population counts were used per sex, age group, and geographic area (Government of Alberta, 2015). Statistical significance of differences between standardized prevalence rates among geographic areas were assessed using the standardized rates ratio method (Boyle & Parkin, 1991). The second step of the analysis included spatial analysis conducted using ArcMap and GeoDa software. Postal Code Translator File (PCTF) and geographic areas shapefiles were used to geocode data, using patient-level data with 6-digit postal codes (AH, 2016; AHS & AH, 2013). We conducted spatial statistical analysis in GIS that is based on spatial dependency of the data and randomization assumption, i.e., evaluating whether the data are dispersed, clustered or random (Patel & Waters, 2012).

We conducted local indicators of spatial association (LISA), including (i) global spatial autocorrelation to determine the significance of data clustering, (ii) Anselin's local Moran's I to identify and visualize significance of spatial clusters and outliers, and (iii) Getis-Ord Gi*and Gi analytics for hot spot analysis to determine spatially significant communities (postal codes) with large numbers of patients that are clustered together (hot spots), and distinguish these from clusters of communities with small numbers of patients (cold spots) and no clustered areas (Anselin, 1995; Ord & Getis, 1995). For hot spot analysis, patient-level data were aggregated to the level of 6-digit postal codes, which was the highest resolution compared to the larger areas of 3-digit postal codes that are usually available with administrative data and the larger areas of Statistics Canada standard dissemination areas and local delivery units (LDU). These postal codes were population weighted (personal communication, AHS, 2016) and represents relatively accurate proxy for residential locations (Bow et al., 2004). Weighted hotspot analysis was also conducted based on health services use and numbers of years a patient used OA-related health services in Alberta. For this, we determined OA prevalence hot and cold spots, weighted by specialty and non-specialty OA-related healthcare use at patient-level. Our OA data included 19 years of health services utilization by OA patients, and this weighted hot spot analysis determined whether identified hot spots were more dominant with specialty or non-specialty care. We developed maps that show OA prevalence distributions in Alberta.

Results

Our results indicated that the age of patients with incident OA in Alberta is decreasing over time (median age in 2013 of 59 years vs 76 years in 1994) and adult females are 1.4 times more likely to have OA than adult males (p-value <0.001). These results are similar to national OA patterns in Canada (O'Donnell et al., 2011). Standardized OA prevalence rates per 1,000 population by the 20 geographic areas analyzed showed significantly higher rates for adult females (rate = 136) versus males (95) (p-value <0.001). The standardized prevalence rates were significantly higher in (i) rural remote areas, particularly those in the north-west (rate = 183), (ii) rural areas, particularly those in the north and south (135 and 150, respectively), (iii) satellite communities located on the periphery of the city of Edmonton (moderate metro) and moderate urban areas in the centre (133). In comparison, the rates were significantly lower or no significant differences were observed for metro, urban, and other rural/remote settings (Figure 1b). Hot spot maps identified local hot and cold spots in each of the above geographic regions. Specialty care weighted hot spot analysis showed slightly higher numbers of hot spots in local communities in rural remote and rural south areas than the non-specialty hot spots. Having compared these results with other sources (e.g., AHS) there is a strong indication that these spatial hot spots include elderly patients, and patients with comorbidities and/or patients with low socio-economic status.

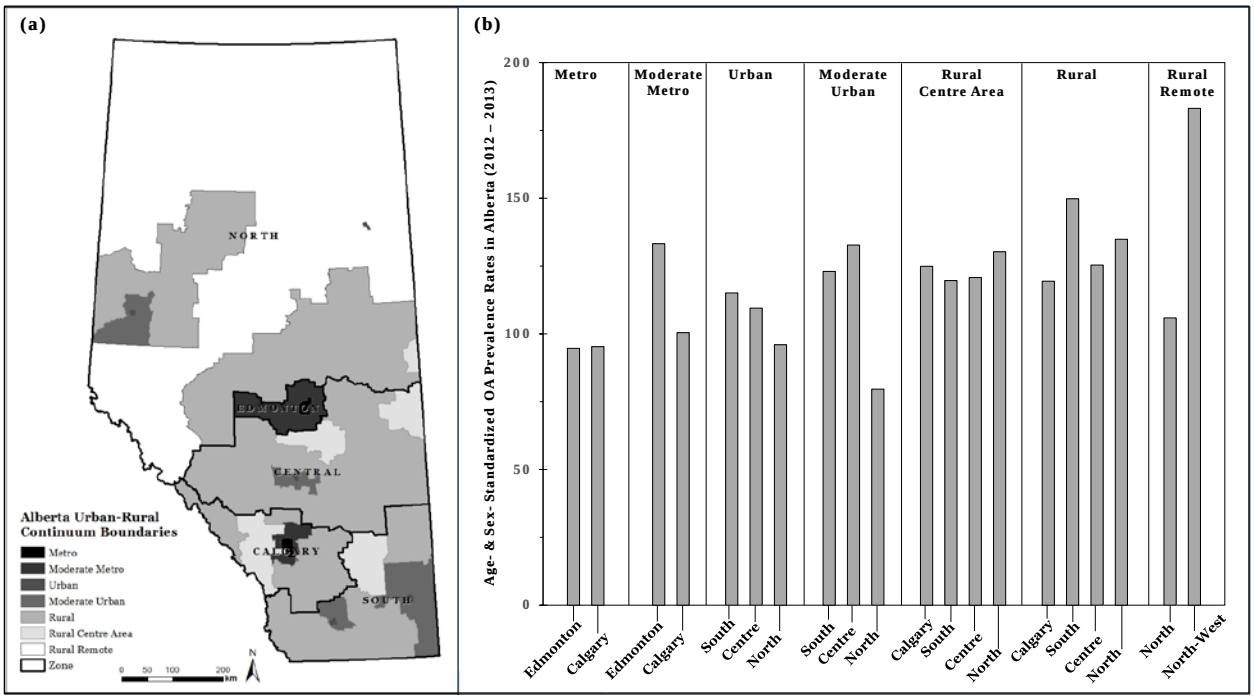

Figure 1. Geographic areas in Alberta. (a) standard urban to rural classification and zones, provided by Alberta Health Services (AHS). (b) Age- and sex-standardized OA prevalence rates per 1,000 population (2012 – 2013 fiscal year), by geographic area.

Conclusions

Our GIS spatial analysis showed that OA prevalence exhibits a geographic distribution which reflects the age and sex characteristics of the OA population with local hot spots of patients in Alberta. Lower numbers of hot spots based on non-specialty care weighted analysis confirmed the current evidence, which shows limited access to primary care in the urban periphery and rural communities (Shah et al., 2016; Starke et al., 2015). This information indicates a need for improving access to OA-related health services at the local level. The results of this study will help inform health services delivery and resource management, particularly the distribution of resources in areas of high and low OA prevalence. Our future work will address patients' needs for access to OA health services by including travel distance and time for patients with OA to access health services in Alberta and associated health outcomes and health resource use and cost.

References

Alberta Health. (2016). *Postal code translator file* (2016/05). Retrieved from Calgary, Alberta, Canada, Alberta Health Services database.

Alberta Health Services, & Alberta Health. (2013). *Official standard geographic areas*. Retrieved from Calgary, Alberta, Canada, Alberta Health Services database (2016/06).

Anselin, L. (1995). Local indicators of spatial association—LISA. *Geographical Analysis, 27(2),* 93-115.

Bombardier, C., Hawker, G., & Mosher, D. (2011). The impact of arthritis in Canada: today and over the next 30 years (Arthritis Alliance of Canada 2011/10). Retrieved from Arthritis Alliance of Canada: http://www.arthritisalliance.ca/images/PDF/eng/Initiatives/20111022_2200_impact_of_arthritis.pdf.

Bow, C. J. D., Waters, N. M., Faris, P. D., Seidel, J. E., Galbraith, P. D., Knudtson, M. L., Ghali, W. A. & the APPROACH Investigators. (2004). Accuracy of city postal code coordinates as a proxy for location of residence. *International Journal of Health Geographics, 3(1),* 1.

Boyle, P., & Parkin, D. (1991). Statistical methods for registries. *Cancer Registration: Principles & Methods, 95,* 126-158.

Canadian Medical Association. (2013). *Position statement: ensuring equitable access to care: strategies for Ggvernments, health system planners, and the medical profession.* Retrieved from Canadian Medical Association policies: https://www.cma.ca/Assets/assets-library/document/en/advocacy/PD14-04-e.pdf.

Chowdhury, T. (2014). *Chronic disease management and primary care in Alberta (*Institute for Public Economics 2014/05). Retrieved from University of Alberta, Department of Economics, Institute for Public Economics: https://era.library.ualberta.ca/files/b4q77fr36n/Chowdhury,Tapan%20Chronic%20Disease%20Management%202014-05-30.pdf.

Government of Alberta. (2008/05). One Provincial Board to Govern Alberta's Health System. *News Release.*

Government of Alberta. (2015). *Adjusted population estimates*. Retrieved from Alberta Health, Surveillance & Assessment Branch, Interactive Health Data Application: http://www.ahw.gov.ab.ca/IHDA_Retrieval/.

Health Council of Canada. (2012). *Self-managementsupport for Canadians with chronic health conditions: a focus for primary health care* (Health Council of Canada 2012/05). Retrieved from Toronot, Ontario, Canada, Health Council of Canada: http://www.selfmanagementbc.ca/uploads/HCC_SelfManagementReport_FA.pdf.

Lidgren, L. (2003). Bone and Joint Decade and the global economic and healthcare burden of musculoskeletal disease. *The Journal of Rheumatology, 67,* 4-5.

Lix, LM, De Coster, C, & Currie, R. (2006). *Defining and validating chronic diseases: an administrative data approach* (Manitoba Centre for Health Policy 2006/07). Retrieved from University of Manitoba, Faculty of Medicine, Department of Community Health Sciences: http://mchp-appserv.cpe.umanitoba.ca/reference/chronic.disease.pdf.

MacDonald, K. V., Sanmartin, C., Langlois, K., & Marshall, D. A. (2014). Symptom onset, diagnosis and management of osteoarthritis. *Health Reports, 25(9),* 10.

O'Donnell, S., Lagacé, C., McRae, L., & Bancej, C. (2011). *Life with arthritis in Canada: a personal and public health challenge* (2011/06, 31). Ottawa, Ontario, Canada, Public Health Agency of Canada, Centre for Chronic Disease Prevention and Control, Chronic Disease Surveillance and Monitoring Division.

Ord, J. K., Getis, A. (1995). Local spatial autocorrelation statistics: distributional issues and an application. *Geographical Analysis, 27(4),* 286-306.

Patel, A., & Waters, N. (2012). Using geographic information systems for health research: *INTECH Open Access Publisher, 16,* 303-320.

Räsänen, P., Paavolainen, P., Sintonen, H., Koivisto, A.-M., Blom, M., Ryynänen, O.-P., & Roine, R. P. (2007). Effectiveness of hip or knee replacement surgery in terms of quality-adjusted life years and costs. *Acta Orthopaedica, 78(1)*, 108-115.

Seidel, J. E. (2013). *Development of functional geographic areas and related components for health services planning, Alberta Health Services*. Interviewer (2013/11): University of Calgary, Department of Community Health Sciences and the O'Brien Institute for Public Health.

Shah, T. I., Bell, S., & Wilson, K. (2016). Spatial accessibility to health care services: identifying under-serviced neighbourhoods in Canadian urban areas. *PLoS ONE 11(12)*: e0168208. doi:10.1371/journal.pone.0168208.

Starke, R., Spenceley S., Caffaro, M., Sansregret, B., Garbutt, A., Dupres, K., & Robbin, C. (2015). *Underestanding the Concerns and Challenges of Albertans Who Live in Rural and Remote Communities* (Rural Health Services Review Final Report 2015/03). Retrieved from Government of Alberta, Rural Health Services Review Committee: http://www.health.alberta.ca/documents/Rural-Health-Services-Review-2015.pdf

Wilson, N. A., Schneller, E. S., Montgomery, K., & Bozic, K. J. (2008). Hip and knee implants: current trends and policy considerations. *Health Affairs, 27(6)*, 1587-1598.