Canadian Journal of Rural Medicine
CJRM CMR
Journal canadien de la médecine rurale

Original Article
Article original

Rural–urban differences in use of health care resources among patients with ankle sprains in Ontario

Graydon Lucas, BSc
Department of Public Health Sciences, Queen's University, Kingston, Ont.

Iwona A. Bielska, PhD
Department of Public Health Sciences, Queen's University, Kingston, Ont.

Raymond Fong, MSc
Rouge Valley Health System; Department of Public Health Sciences, Queen's University, Kingston, Ont.

Ana P. Johnson, PhD
Department of Public Health Sciences, Queen's University; ICES–Queen's Health Services Research Facility, Kingston, Ont.

Correspondence to:
Ana Johnson,
ana.johnson@queensu.ca

This article has been peer reviewed.

Introduction: Ankle sprains can have a significant impact on the short- and long-term well-being of patients. We conducted a study to describe the demographic characteristics of people with an ankle sprain/dislocation treated at physicians' offices and emergency departments in Ontario, by rurality status; describe the use of health care services and the associated costs in this population, by rurality status; and investigate the relation between health care costs and rurality status by sex, age, income quintile and season of injury.

Methods: We obtained data on nonfracture injuries of the ankle, foot and toe (International Statistical Classification of Diseases and Related Health Problems, 10th revision, Canada diagnostic code S93) in Ontario between 2003 and 2011 from multiple databases linked through the Institute for Clinical Evaluative Sciences. We used the Rurality Index of Ontario (RIO) as a measure of the rurality level of communities. Demographic characteristics, use of health care services and physician billing costs were obtained and compared among 5 RIO categories.

Results: Data were available for 1 787 866 injury encounters. Patients in the most rural RIO category saw specialists least often and had the greatest number of emergency department visits. The mean cost for specialist visits was $141 in the most urban category and $157 in the most rural category ($p < 0.05$), and the corresponding mean costs for general practitioner visits were $37 and $18, respectively ($p < 0.001$).

Conclusion: The differences in use of health care resources between RIO categories may indicate a lack of access to specialist care in rural areas, thereby necessitating reliance on emergency care. These results may be useful in allocating future resources to better serve rural patients.

Introduction : Les entorses de la cheville peuvent avoir un effet important sur le bien-être à court et à long terme des patients. Notre étude avait trois objectifs : 1) décrire les caractéristiques démographiques des personnes traitées pour une entorse/luxation de la cheville dans un cabinet de médecin ou un service d'urgence en Ontario, par statuts ruraux; 2) décrire l'utilisation des services de santé et les coûts associés pour cette population, par statuts ruraux; 3) examiner le lien entre le coût des soins de santé et le statut rural selon le sexe, l'âge, le quintile de revenu et la saison au cours de laquelle la blessure est survenue.

Méthodes : Nous avons obtenu des données sur les blessures sans fracture de la cheville, du pied et de l'orteil (International Statistical Classification of Diseases and Related Health Problems, 10e révision, Canada code de diagnostic S93) en Ontario, entre 2003 et 2011, en interrogeant plusieurs bases de données par l'entremise de l'Institut de recherche en services de santé. Nous avons utilisé l'indice de ruralité de l'Ontario (IRO) pour mesurer le niveau de ruralité des localités. Nous avons comparé les données recueillies sur les caractéristiques démographiques, l'utilisation des services de santé et les coûts de facturation des médecins entre 5 catégories d'IRO.

Résultats : Des données étaient disponibles pour 1 787 866 consultations liées à une blessure. Les patients de la catégorie d'IRO la plus rurale consultaient des spécialistes

© 2018 Society of Rural Physicians of Canada

moins souvent et avaient le nombre le plus élevé de visites aux urgences. Le coût moyen des rendez-vous avec un spécialiste était de 141 $ dans la catégorie la plus urbaine et de 157 $ dans la catégorie la plus rurale ($p < 0,05$). Le coût moyen correspondant des rendez-vous avec un médecin généraliste s'élevait à 37 $ et à 18 $, respectivement ($p < 0,001$).

Conclusion : Les différences au chapitre de l'utilisation des ressources de soins de santé entre les catégories d'IRO pourraient indiquer un problème d'accès aux soins spécialisés en milieu rural qui créerait une dépendance à l'égard des soins d'urgence. Ces résultats pourraient s'avérer utiles à l'avenir pour l'allocation des ressources afin de mieux servir les patients des régions rurales.

INTRODUCTION

Ankle sprains are common injuries with a high incidence among children (age 12 yr or less) and adolescents (age 13–17 yr). A recent meta-analysis showed that the pooled cumulative incidence rates of ankle sprain for these age groups are 2.85 and 1.94 per 1000 exposures, respectively, compared to 0.72 for adults.[1] Females have a higher cumulative incidence rate of ankle sprains (13.6 per 1000 exposures) than males (6.94 per 1000 exposures).[1] Sports and other forms of physical activity significantly increase the risk of this injury, with 10%–30% of all sport injuries related to the ankle joint.[2]

Although ankle sprains are often viewed as benign, self-contained injuries, their effects can last for months or even years.[3] The physical limitations of these injuries have a high economic impact on society. Ankle sprains account for 7%–10% of all emergency department visits in the United States,[4] despite reports that up to two-thirds of people with ankle sprains do not seek treatment in an emergency department.[5] Studies from Belgium, the United Kingdom and the United States show that the cost of diagnosis and treatment of an ankle sprain ranges from $496 to $4720 (2013 Canadian dollars) depending on the severity of the sprain and the treatment.[6–9] Furthermore, it has been reported that as many as one-quarter of those who experience an ankle sprain miss school or work for more than 7 days.[10] However, Canadian data on this topic are lacking.

Despite the presence of a universal health care system in Ontario, differences exist in accessibility and quality of health care across the province.[11,12] Although the number of physicians providing services in rural areas is increasing,[12] there are still instances in which patients have to travel far distances and may receive less care, depending on their level of rurality.[11] Research has been conducted measuring use, including medication uptake,[13] care of chronic ischemic heart disease[14] and cardiac rehabilitation, based on rurality in Ontario.[15] To our knowledge, no studies have assessed the differences in use of health care resources by patients with musculoskeletal injuries based on rurality.

Therefore, the objectives of this study were to 1) describe the demographic characteristics of people with an ankle sprain or dislocation treated at physicians' offices and emergency departments in Ontario, by rurality status; 2) describe the use of health care services, including the number of family physician, specialist physician and emergency department visits and the associated costs, by patients with ankle sprains or dislocations, by rurality status; and 3) investigate the relation between health care costs and rurality status by sex, age, income quintile and season of injury.

METHODS

Data sources

We obtained aggregate data on medical encounters for nonfracture injuries of the ankle, foot and toe from multiple linked databases accessible through the Institute for Clinical Evaluative Sciences. These were identified with the use of International Statistical Classification of Diseases and Related Health Problems, 10th revision, Canada (ICD-10-CA)[16] diagnostic code S93, representing "dislocation, sprain and strain of joints and ligaments at ankle and foot level" (hereinafter referred to as an "injury"). The databases included the Canadian Institute for Health Information Discharge Abstract Database,[17] the Ontario Health Insurance Plan,[18] the National Ambulatory Care Reporting System[19] and the Registered Persons Database.[20] These data sets were linked by means of unique encoded identifiers and analyzed at the Institute for Clinical Evaluative Sciences. All encounters reported between Apr. 1, 2003, and Mar. 31, 2011, among Ontario residents covered by the Ontario Health Insurance Plan were included.

Study variables

Each injury record included information on the use of health care services and treatment costs for 6 months after the initial diagnosis date. Injury was the event of interest; therefore, a single patient with multiple ankle injuries could contribute numerous entries over the period under study as long as 6 months had elapsed between each event. The variables included in the aggregate data were patient sex, age and income quintile (determined from 2006 census data based on postal code of residence);[21,22] Rurality Index for Ontario (RIO) score;[23,24] season when the injury took place (defined by calendar date ranges); number of family physician, specialist physician and emergency department visits related to the injury; and the cost of physician visits, obtained from the Ontario Health Insurance Plan. Data from the Institute for Clinical Evaluative Sciences did not provide estimates for the direct costs related to the provision of care and costs of running the emergency department for treatment of an ankle sprain or dislocation. We estimated costs of running the emergency department (capturing nursing costs, material and overhead expenses of the hospital) using the Ontario Case Costing Initiative;[25] the cost amounted to $177.59 per injury. This amount included cost information on 19 different ICD-10-CM diagnostic codes, which together covered all variations of the S93 diagnostic code used in this study, from all years of Ontario Case Costing Initiative data available (2005–2011). All costs were adjusted for inflation and are presented in 2013 Canadian dollars.[26]

Rurality Index for Ontario

We determined rurality using the RIO, a standard, normalized scale ranging from 0 to 100 that indicates a community/region's degree of rurality.[23,24] A community with a score of 1 is considered to be the least rural, and a score of 100 represents the most remote rural community in the province.[23,24] The RIO represents a community's relative access to health care and is increasingly being used as a determinant for eligibility for programs that offer incentives for physicians to live and work in rural areas.[23,24,27] The RIO scores for the communities of residence for the injury encounters were grouped into 5 categories: 0–3 (communities with advanced referral centres), 4–14 (larger communities, most with basic referral centres), 15–39 (communities with smaller populations), 40–74 (small rural communities located mostly in southern Ontario) and 75–100 (remote rural communities located mostly in the north).[23] The last 2 categories fulfill the Rural Physician Eligibility requirements of Health Force Ontario.[28]

Statistical analysis

We summarized the demographic characteristics of the injury encounters according to age, sex and income quintile for each of the 5 RIO categories. We determined the number of injuries seen by each health care option — general practitioner/family physician, other specialist physician or emergency department — for each of the RIO categories. We compared differences in proportions between multiple groups using Pearson χ^2 analyses. We performed statistical analyses of the differences between health care costs using analysis of variance (ANOVA) and the Kruskal–Wallis methods using SAS version 9.2 (SAS Institute). We used the Tukey studentized range test for multiple comparisons.

Ethics approval

This study was approved by the institutional review board at Sunnybrook Health Sciences Centre, and the Queen's University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board.

RESULTS

A total of 1 787 866 injury encounters for ICD-10-CA diagnostic code S93 were recorded between Apr. 1, 2003, and Mar. 31, 2011, in Ontario. The total costs billed by specialists and by general practitioners/family physicians during the study period were $64 million and $36 million, respectively. A further $116 million was spent on emergency department visits. The youngest patients (aged 14–24 yr) accounted for a greater proportion of injuries (24%–30%) than the oldest patients (55–64 yr) (14%–16%) (Table 1). Injuries were roughly uniformly distributed across income quintiles for the RIO categories 0–3, 4–14 and 40–74, but the categories 15–39 and 75–100 exhibited a higher proportion of injuries in the high-income quintiles than in the low-income quintiles. About 52% of all injuries involved female patients across all the RIO categories. There was a consistently smaller proportion of injuries in the winter season than in other seasons.

Resource use for each RIO category, summarized as the proportion of injuries with 1 or more visits to each of the health care options, is displayed in Figure 1. The proportion of injuries seen by a specialist was 25.9% in the most urban group, compared to 15.2% in the most rural group ($p < 0.01$,

Table 1: Cohort demographic characteristics by Rurality Index of Ontario category, 2003–2011

	RIO category*; no. (%) of injuries				
Characteristic	0–3 *n* = 838 634	4–14 *n* = 528 456	15–39 *n* = 248 271	40–74 *n* = 156 128	75–100 *n* = 16 377
Age, yr					
14–24	202 446 (24.1)	143 000 (27.0)	71 030 (28.6)	45 824 (29.4)	4903 (29.9)
25–34	155 231 (18.5)	95 968 (18.2)	38 755 (15.6)	23 482 (15.0)	2720 (16.6)
35–44	174 520 (20.8)	111 610 (21.1)	49 083 (19.8)	30 008 (19.2)	3040 (18.6)
45–54	178 797 (21.3)	105 638 (20.0)	51 442 (20.7)	31 991 (20.5)	3382 (20.6)
55–64	127 640 (15.2)	72 240 (13.7)	37 961 (15.3)	24 824 (15.9)	2334 (14.2)
Income quintile					
1 (lowest)	173 178 (20.6)	99 614 (18.8)	31 828 (12.8)	28 368 (18.2)	2340 (14.3)
2	172 591 (20.6)	100 935 (19.1)	40 071 (16.1)	32 865 (21.0)	2836 (17.3)
3	164 540 (19.6)	106 907 (20.2)	51 293 (20.7)	32 927 (21.1)	3303 (20.2)
4	159 760 (19.0)	114 199 (21.6)	64 401 (25.9)	32 740 (21.0)	3164 (19.3)
5 (highest)	168 565 (20.1)	106 748 (20.2)	60 677 (24.4)	29 227 (18.7)	4731 (28.9)
Sex					
Female	435 586 (51.9)	274 110 (51.9)	128 282 (51.7)	79 469 (50.9)	8477 (51.8)
Male	403 048 (48.1)	254 346 (48.1)	119 989 (48.3)	76 659 (49.1)	7900 (48.2)
Season					
Fall	200 098 (23.8)	130 317 (24.6)	60 156 (24.2)	38 517 (24.7)	4058 (24.8)
Spring	223 831 (26.7)	145 008 (27.4)	67 108 (27.0)	43 497 (27.8)	4400 (26.9)
Summer	230 121 (27.4)	151 878 (28.7)	69 541 (28.0)	45 277 (29.0)	4518 (27.6)
Winter	184 667 (22.0)	101 252 (19.2)	51 467 (20.7)	28 837 (18.5)	3400 (20.8)

RIO = Rurality Index of Ontario.
*0–3 = communities with advanced referral centres, 4–14 = larger communities, most with basic referral centres, 15–39 = communities with smaller populations, 40–74 = small rural communities located mostly in southern Ontario, 75–100 = remote rural communities located mostly in the north.[23]

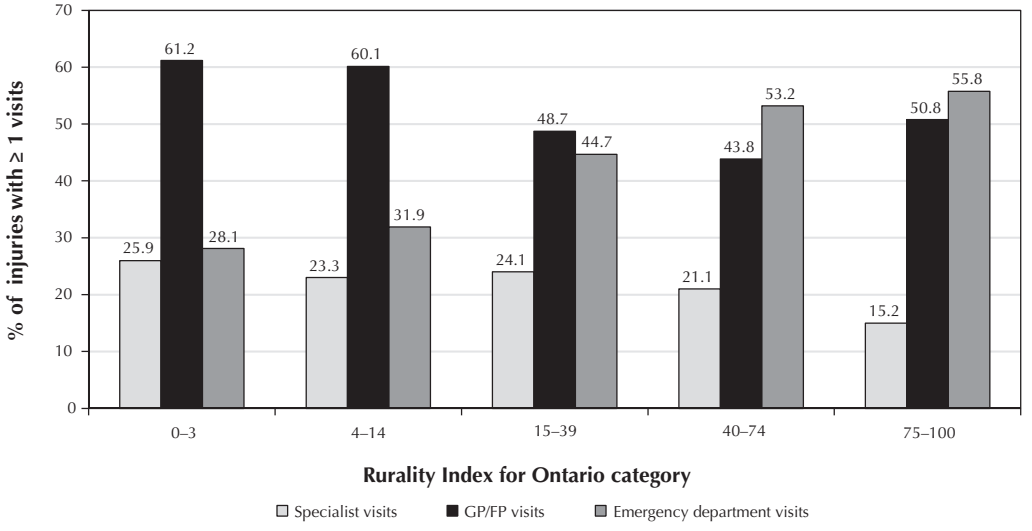


Fig. 1: Proportion of injuries seen by specialist physicians and general practitioners/family physicians (GPs/FPs) and at emergency departments in Ontario by Rurality Index for Ontario category, 2003–2011. 0–3 = communities with advanced referral centres, 4–14 = larger communities, most with basic referral centres, 15–39 = communities with smaller populations, 40–74 = small rural communities located mostly in southern Ontario, 75–100 = remote rural communities located mostly in the north.[23]

Pearson χ^2 test). The corresponding values for emergency department visits were 28.1% and 55.8% ($p < 0.001$, Pearson χ^2 test). The proportion of injuries seen by a general practitioner/family physician was 61.2% in the most urban group and 50.8% in the most rural group; however, the value for RIO category 76–100 was higher than that for category 40–75 (43.8%).

The mean cost per injury for general practitioner/family physician and specialist visits by RIO category are presented in Figure 2. These values represent the mean cost spent on an injury for all visits to the given health care option and exclude patients who did not receive any visits of that type. The mean cost for specialist visits was $141.19 in the most urban category, compared to $157.29 in the most rural category ($p < 0.05$, ANOVA). The corresponding values for general practitioner/family physician visits were $37.21 and $17.73 ($p < 0.001$, ANOVA). Detailed cost information on emergency department visits was not available in the data set.

We further assessed the relation between RIO category and the mean cost per injury for general practitioner/family physician and specialist visits after stratification by patient sex, age and income quintile, and season of injury (Fig. 3). For specialists, the mean cost per injury increased with increasing age for all RIO categories, the cost was statistically significantly higher for male patients than for female patients for all except the most rural category, and the cost was higher in the winter than in other seasons for all RIO categories. For general practitioners/family physicians, the mean cost per injury increased with increasing age for all RIO categories, and the cost in winter was significantly greater than that during other seasons only for the 2 most urban categories, by a small margin (in the RIO category 4–14, $34.50 in fall, compared to $36.11 in winter); there were no significant differences in costs between the sexes. The relation between RIO category and costs associated with general practitioner/family physician and specialist visits did not differ statistically across income quintiles. Overall, the patterns observed in the mean costs per injury for specialist visits, namely, higher costs with increased age, male sex and winter, were not observed in the mean costs for general practitioner/family physician visits.

DISCUSSION

A smaller proportion of rural patients than urban patients saw specialists, whereas a higher proportion visited an emergency department; however, specialist visits were associated with higher costs than general practitioner/family physician visits. Specialist costs were also higher among male patients than female patients, among older patients and in the winter months. These trends were not observed to the same extent in general practitioner/family physician costs.

Most relevant to this study's objectives are the differences in resource use and cost in rural areas. In particular, the decreased proportion of injuries seen by a specialist and the increased proportion seen in the emergency department may indicate differences in accessibility to care. These differences may be due to a multitude of factors, including

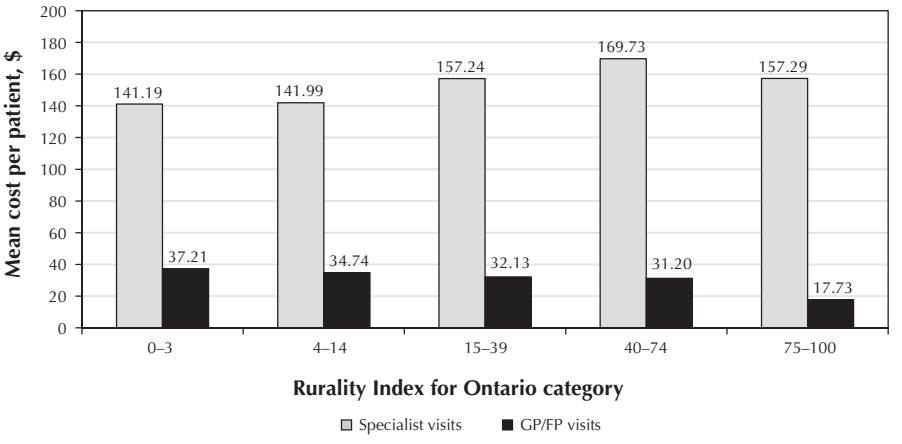


Fig. 2: Mean cost per injury for specialist and general practitioner/family physician (GP/FP) visits by Rurality Index for Ontario category. Injuries that did not require a visit were excluded from the mean calculation.

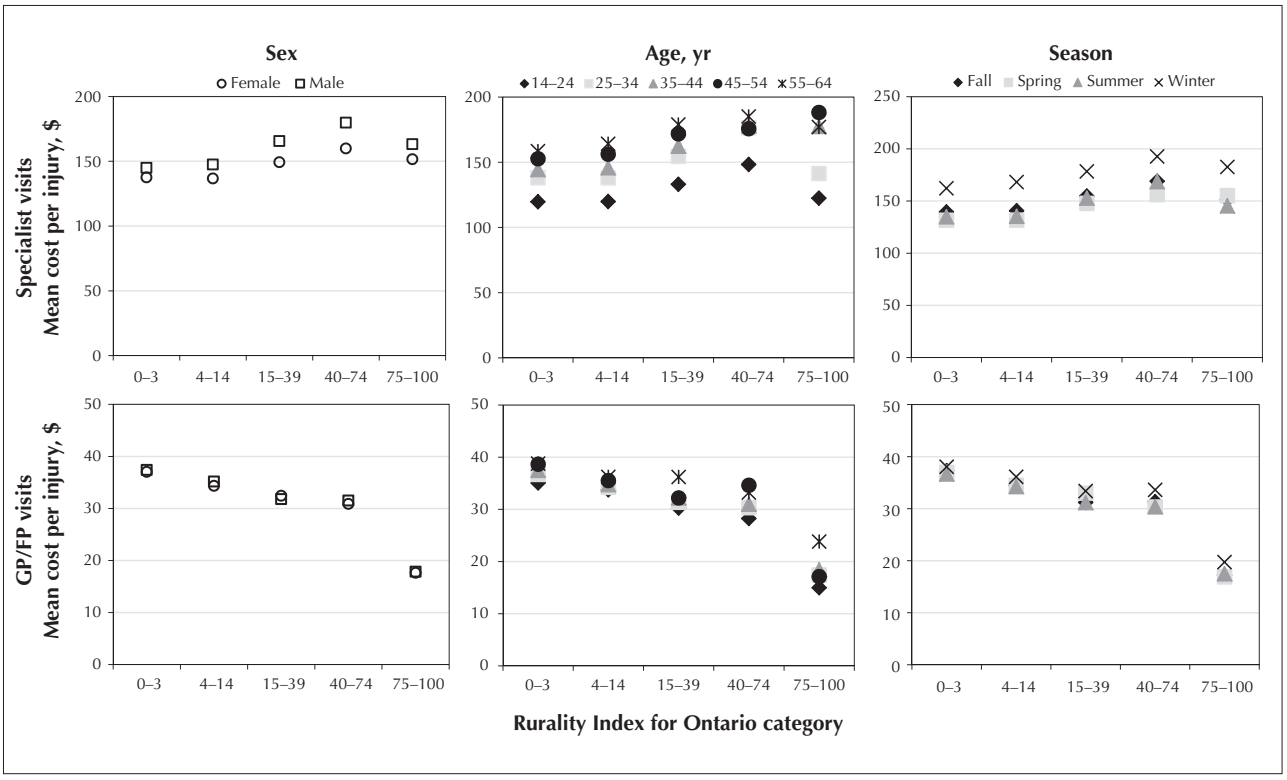


Fig. 3: Mean cost per injury for specialist and general practitioner/family physician (GP/FP) visits by Rurality Index for Ontario category and by sex, age and season of injury (2013 Canadian dollars).

physician shortages, the unavailability of sufficient options for after-hours care, long travel distances or the necessity of using complex modes of travel (for example, by air from remote northern communities). In terms of physician attachment, 2016 data showed that residents aged 16 years or more living in the North West Local Health Integration Network had the lowest proportion of people with a general practitioner/family physician or other primary care provider, at 84.3%.[29] In comparison, the provincial average was 94.3%.[29] The higher mean cost for specialist visits in more rural areas may indicate that rural patients are being referred to a specialist for more severe injuries than their urban counterparts, but such a hypothesis would need to be confirmed by a study assessing injury severity as well as costs at the individual level.

The demographic data observed are largely consistent with previous research. Specifically, a higher proportion of ankle sprains was observed in younger versus older patients[1] and in female versus male patients[4] across RIO categories. Numerous studies examining differences in access to health care resources between those residing in urban versus rural parts of Canada have been conducted. Previous research among populations of pregnant women, people with diabetes and people with heart failure showed that patients residing in rural or remote areas experienced more complications and adverse outcomes than those residing in urban centres.[30–32] Furthermore, Finkelstein[33] used population-based Ontario data to explore access to care in the province and found that people residing in urban areas incurred higher health care expenditures than those residing in rural settings, which may have been attributable to greater ease of access to care and, hence, higher use of health care services among urban residents. Although we did not investigate adverse outcomes, we did find that patterns of use of health care resources varied among patients residing in rural areas, with these patients using fewer general practitioner/family physician and specialist services than did urban dwellers.

Strengths and limitations

One of the main strengths of this study is the large sample (over 1.7 million injury encounters), which resulted in sufficient numbers of injury encounters in all 5 RIO categories. However, owing to the large sample, many relations that would not have been significant with smaller data sets were significant. It quickly becomes a lesson in recognizing the difference between statistical significance and clinical

importance. The analysis identified multiple areas of clinical importance, including a greater reliance on emergency department care among people residing in remote rural communities. From a patient perspective, this may indicate that those living in such communities have limited access to general practitioner/family physician services. From a health care system perspective, treating ankle sprains at the emergency department is more cost intensive than similar care provided by a general practitioner/family physician, as shown by our findings.

This study had several limitations, 1 of which was the case definition of ankle sprains. Because of the administrative nature of the data sets, these injuries were mostly coded as ICD-10-CA diagnostic code S93, which, in addition to ankle sprains, captures other nonfracture injuries to the foot and toe. Another limitation was the lack of a direct geographic variable to assess the underlying population demographic characteristics. In particular, this affected the conclusions that could be drawn from the finding that low-income people in rural areas accounted for a smaller proportion of injuries: the lowest income quintile in the most rural category accounted for only 14% of injuries instead of the expected 20%. The observed distribution of injuries may also have been confounded by the method used to assign income quintiles; connecting socioeconomic status from census data to forward sortation area codes has considerable limitations in rural populations and is prone to error.[34] Finally, using outside information from the Ontario Case Costing Initiative[25] for average emergency department costs allowed the calculation of an overall total attributable to injury care, although this also included indirect costs, whereas the general practitioner/family physician and specialist costs did not.

When discussing the relation between RIO categories and differences in access to care, it is important to note that the RIO is partially determined by geographic distance to primary or advanced care centres.[23,24] People who have to travel farther for care have a greater burden in accessing care, which, in turn, affects measures of accessibility.[35] Differences in resource use between RIO categories will likely always exist; the question becomes whether we are satisfied with the current differences or whether change is needed to help bridge the gap. A review of the literature from Canada, the United States, Australia, New Zealand and the United Kingdom showed that people residing in rural locations do not always experience disadvantages in terms of their health status compared to those who reside in urban centres.[36] Future research should therefore focus on the large disparities observed, including the higher proportion of people from rural areas accessing emergency care for ankle injuries, to determine the impact of these findings.

CONCLUSION

The differences in use of health care resources between patients in different RIO categories may indicate a lack of access to general practitioner/family physician and specialist care for those residing in rural areas, thereby requiring these residents to rely on emergency services. In addition, the health care costs for treating ankle injuries among people from these areas tended to be higher than those for people in less rural areas, which indicates more resource-intensive injuries among the rural population. These results may be useful in allocating future resources to better serve rural patients.

REFERENCES

1. Doherty C, Delahunt E, Caulfield B, et al. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. *Sports Med* 2014;44:123-40.
2. Fong DTP, Hong Y, Chan LK, et al. A systematic review on ankle injury and ankle sprain in sports. *Sports Med* 2007;37:73-94.
3. Anandacoomarasamy A, Barnsley L. Long term outcomes of inversion ankle injuries. *Br J Sports Med* 2005;39:e14.
4. Waterman BR, Owens BD, Davey S, et al. The epidemiology of ankle sprains in the United States. *J Bone Joint Surg Am* 2010;92:2279-84.
5. Schappert SM, Rechtsteiner EA. Ambulatory medical care utilization estimates for 2007. *Vital Health Stat 13* 2011;13:1-38.
6. Cooke MW, Marsh JL, Clark M, et al. Treatment of severe ankle sprain: a pragmatic randomised controlled trial comparing the clinical effectiveness and cost-effectiveness of three types of mechanical ankle support with tubular bandage. The CAST trial. *Health Technol Assess* 2009;13:iii,ix-x,1-121.
7. Audenaert A, Prims J, Reniers GLL, et al. Evaluation and economic impact analysis of different treatment options for ankle distortions in occupational accidents. *J Eval Clin Pract* 2010;16:933-9.
8. Soboroff SH, Pappius EM, Komaroff AL. Benefits, risks, and costs of alternative approaches to the evaluation and treatment of severe ankle sprain. *Clin Orthop Relat Res* 1984;(183):160-8.
9. Nussbaum ED, Hosea TM, Sieler SD, et al. Prospective evaluation of syndesmotic ankle sprains without diastasis. *Am J Sports Med* 2001; 29:31-5.
10. de Bie RA, de Vet HC, van den Wildenberg FA, et al. The prognosis of ankle sprains. *Int J Sports Med* 1997;18:285-9.
11. Hospital births in Canada: a focus on women living in rural and remote areas. Ottawa: Canadian Institute for Health Information; 2013.
12. Supply, distribution and migration of Canadian physicians, 2011. Ottawa: Canadian Institute for Health Information; 2012.
13. Jandoc R, Mamdani M, Lévesque LE, et al. Urban–rural differences in the uptake of new oral bisphosphonate formulations. *Arch Osteoporos* 2016;11:11.
14. Tran C, Wijeysundera HC, Qui F, et al. Comparing the ambulatory care and outcomes for rural and urban patients with chronic ischemic heart disease: a population-based cohort study. *Circ Cardiovasc Qual Outcomes* 2014;7:835-43.

15. Shanmugasegaram S, Oh P, Reid RD, et al. Cardiac rehabilitation barriers by rurality and socioeconomic status: a cross-sectional study. *Int J Equity Health* 2013;12:72.
16. *International statistical classification of diseases and related health problems, 10th revision*. Ottawa: Canadian Institute for Health Information; 2009. Available: www.cihi.ca/en/icd_10_ca_vol1_2009_en.pdf (accessed 2014 Oct. 12).
17. Discharge Abstract Database (DAD) metadata. Ottawa: Canadian Institute for Health Information; 2016. Available: www.cihi.ca/en/types-of-care/hospital-care/acute-care/dad-metadata (accessed 2014 Oct. 12).
18. Schedule of benefits, physician services under the Health Insurance Act. Toronto: Ministry of Health and Long-Term Care; 2015. Available: www.health.gov.on.ca/english/providers/program/ohip/sob/physserv/sob_master20151221.pdf (accessed 2014 Oct. 12).
19. National Ambulatory Care Reporting System (NACRS) metadata. Ottawa: Canadian Institute for Health Information; 2016. Available: www.cihi.ca/en/types-of-care/hospital-care/emergency-and-ambulatory-care/nacrs-metadata (accessed 2014 Oct. 12).
20. Population grouping methodology. Ottawa: Canadian Institute for Health Information; 2010. Available: www.cihi.ca/sites/default/files/document/infosheet_popgroupmethod_en_web.pdf (accessed 2014 Oct. 12).
21. Institute for Clinical Evaluative Sciences. ICES data dictionary. 2016. Available: https://datadictionary.ices.on.ca/Applications/DataDictionary/Default.aspx (accessed 2016 Apr. 3).
22. Statistics Canada. Postal Code^{OM} Conversion File Plus (PCCF+). 2016. Available: www5.statcan.gc.ca/olc-cel/olc.action?ObjId=82F0086X&ObjType=2&lang=en&limit=0 (accessed 2016 Apr. 3).
23. Kralj B. Measuring rurality – RIO2008_BASIC: methodology and results. Toronto: Ontario Medical Association; 2009.
24. Kralj B. Measuring "rurality" for purposes of health-care planning: an empirical measure for Ontario. Toronto: Ontario Medical Association; 2000.
25. Ontario Case Costing Initiative. OCCI costing analysis tool. 2011. Available: https://hsimi.ca/occp/occpreports/Expire.aspx (accessed 2013 Mar. 14).
26. Bank of Canada. Inflation calculator. 2016. Available: www.bankofcanada.ca/rates/related/inflation-calculator (accessed 2016 Jan. 16).
27. RIO postal code look-up. Toronto: Ontario Medical Association; 2014. Available: https://application.oma.org/publicapp/nlp/nlpwf003.aspx (accessed 2014 Mar. 15).
28. Health Force Ontario. Rural physician eligibility requirements. 2014. Available: www.healthforceontario.ca/en/Home/Physicians/Training_%7C_Practising_in_Ontario/Locum/Rural_Family_Medicine_Locum_Program/Rural_Physicians/Eligibility (accessed 2014 Mar. 15).
29. Health Quality Ontario. System performance. Having a family doctor or other primary care provider. 2017. Available: www.hqontario.ca/System-Performance/Primary-Care-Performance/Having-a-Primary-Care-Provider (accessed 2017 Mar. 24).
30. Grzybowski S, Stoll K, Kornelsen J. Distance matters: a population based study examining access to maternity services for rural women. *BMC Health Serv Res* 2011;11:147.
31. Booth GL, Hux JE, Fang J, et al. Time trends and geographic disparities in acute complications of diabetes in Ontario, Canada. *Diabetes Care* 2005;28:1045-50.
32. Gamble JM, Eurich DT, Ezekowitz JA, et al. Patterns of care and outcomes differ for urban versus rural patients with newly diagnosed heart failure, even in a universal healthcare system. *Circ Heart Fail* 2011;4:317-23.
33. Finkelstein MM. Do factors other than need determine utilization of physicians' services in Ontario? *CMAJ* 2001;165:565-70.
34. Wilkins R. Use of postal codes and addresses in the analysis of health data. *Health Rep* 1993;5:157-77.
35. Soares NS, Johnson AO, Patidar N. Geomapping telehealth access to developmental-behavioral pediatrics. *Telemed J E Health* 2013;19:585-90.
36. Smith KB, Humphreys JS, Wilson MGA. Addressing the health disadvantage of rural populations: How does epidemiological evidence inform rural health policies and research? *Aust J Rural Health* 2008;16:56-66.

Disclaimer: This study was supported by the Institute for Clinical Evaluative Sciences (ICES), which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by the ICES or the MOHLTC is intended or should be inferred. Parts of this material are based on data and information compiled and provided by the Canadian Institute for Health Information (CIHI). However, the analyses, conclusions, opinions and statements expressed herein are those of the authors and not necessarily those of the CIHI.

Acknowledgment: The authors thank Marlo Whitehead and Susan Rohland at ICES Queen's for their assistance in aggregating and providing timely access to our data.

Competing interests: None declared.