Title: Relationship between Family Physician Retention and Avoidable Hospitalization in the Province of Newfoundland and Labrador: a population-based cross-sectional study

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Abstract:

Purpose: Physician turnover, involving a physician leaving clinical practice in a specific area, may disrupt continuity of care leading to poorer health outcomes and greater healthcare utilization. The purpose of this study was to investigate the relationship between family physician retention and avoidable hospitalization.

Methods: A population-based cross-sectional study was conducted involving provincial health administrative data for residents of the province of Newfoundland and Labrador holding a provincial health card between 2001 and 2009. Five-year family physician retention was calculated by regional economic zone, and individuals within economic zones were divided into tertiles based on retention level. Hospitalization for ambulatory-care-sensitive conditions was compared among tertiles while adjusting for covariates.

Results: In 475,961 residents of the province, there was a negative relationship between retention and ambulatory-care-sensitive hospitalization where individuals from areas with moderate and low physician retention had 16.5% (95% confidence Interval (CI) 1.126-1.204) and 19.9% (95% CI 1.152-1.247) higher hospitalization rates respectively, compared to areas with high retention. No relationship was found when analysis was limited to seniors.

Conclusions: The current study suggests that high physician retention is associated with lower rates of hospitalization for ambulatory-care-sensitive conditions even after controlling for other factors. This is consistent with our hypothesis that physician turnover acts to disrupt continuity of care, resulting in higher hospitalization rates.

Key Words:

Physician retention/turnover, ambulatory-care-sensitive conditions, hospitalization, family physician

Abbreviation:

CI confidence interval

Introduction

Relational continuity of care with a primary care physician has been associated with better problem recognition[1] and preventive care,[2-4] improved patient satisfaction and treatment adherence,[5-9] as well as reduced health care utilization,[10-17] healthcare costs,[18-20] and mortality.[21-23] However, relatively little is known about the effects of a specific aspect of continuity of care, primary care physician turnover.[24] Physician turnover, which involves a physician leaving clinical practice in a specific area, may disrupt continuity of care by diminishing opportunities for establishing trusting physician-patient relationships and reducing the quality of communication and information needed for care.[25-27] Patients forced to change their family physician report low satisfaction with care and loss of trust,[28] while higher physician retention has been shown to be associated with better patient satisfaction and preventive care outcomes[25-27, 29] and may be associated with reduced health care utilization.

Although several studies have shown that higher continuity with a primary care physician is associated with reduced preventable hospitalizations for ambulatory care sensitive conditions,[15-16, 19, 30] we were unable to find any studies examining the relationship between physician turnover/retention and hospitalization. Studying the effects of retention is important because changes to health policy required to address this issue are different from those for continuity. In addition, measuring physician turnover or retention may offer a proxy measure for continuity of care when it is not possible to measure continuity at the individual level.

Newfoundland and Labrador has a long history of physician shortages, exacerbated by the out-migration of physicians. Between 2011 and 2015, NL had the second highest average annual net loss of physicians of all Canadian provinces and territories.[31] The goal of the present study was to investigate the

association between physician retention and hospitalization for ambulatory-care-sensitive conditions through linkage and analysis of health administrative data in Newfoundland and Labrador.

Methods

Setting

The study was set in the province of Newfoundland and Labrador with a population of 505,469 in the 2006 Statistics Canada Census. The study sample was distributed across 269 (91.5%) rural and 25 (8.5%) urban centres (census subdivisions).

Participants and Design

This is a population-based cross-sectional study using a cohort of individuals used in a prior analysis of effects of primary care reforms (unpublished) consisting of residents of the province who held a provincial health card between 2001 and 2009. Individuals who changed postal code or permanently left the province between 2001 and 2009 were excluded.

Data Sources and Procedure

Patient records including age, sex and postal code were obtained from the provincial health insurance registry. Records were linked to provincial hospital abstracts, physician claims and death records for the five-year period from 2005 to 2009 and information on family physician supply and retention was obtained from the Physician and Medical Practice Database, a longitudinal research dataset of physicians in Newfoundland and Labrador. Provincial databases containing hospital abstracts and death records are used for research and policy and planning and undergo rigorous data quality procedures.[32,33]

Data elements from abstracts are extracted and validated annually and have been found to be highly accurate and complete.[33,34] Physicians' claims data are generally considered to be complete given that the information collection is required for physicians to obtain payment for services.[35]

Postal code of residence was mapped to census dissemination areas (DA) (i.e. neighborhoods) using the Postal Code Conversion File,[36] and several co-variate variables were obtained from the 2006 Census, Statistics Canada at the dissemination area level including median household income, and proportions of individuals reporting high school completion, aboriginal identity and visible minority status.[37] In addition, the Postal Code Conversion File was used to map postal code of residence for each patient to one of 20 provincial economic zones[38] (See Appendix A).

Measures

Main predictor variable and outcome

Physician retention was the main predictor of interest and was defined as percentage of physicians practicing in a given economic zone at the start of 2005 who were still practicing in the same EZ at the end of 2009 (5-year retention).[39] Economic zones rather than communities were chosen to calculate retention because we felt this level of geography most accurately reflected accessibility to family physician care. Many communities in NL have a very small number of physicians practicing in them, and were in close proximity to other communities. When we calculated retention at the community level, the departure of one physician from a small area resulted in large changes in retention score which often did not reflect the real change in accessibility because of the close availability of physicians in nearby communities. The larger geography of the economic zones allowed us to more-accurately capture this accessibility.[38] (Appendix A).

Five-year physician retention values for each economic zone were then assigned to individuals based on postal code of residence, and individuals were grouped into tertiles based on their retention score. With patient as the unit of analysis, we examined the number of hospitalizations for an ambulatory-care-sensitive condition (including chronic, acute and vaccine-preventable conditions[40]), for individuals in each retention tertile. Conditions examined and codes used to define them were slight variations of those used in a previous Canadian study[40] and are included in Appendix B.

Co-variates

Covariates found to be associated with health care utilization were included as control variables in the analysis. Charlson Comorbidity Index values were calculated for each individual using diagnostic codes contained in physician billing data [41] and were categorized into four levels (0,1-2,3-4, or 5+). The index was categorized into four categories because of a relatively small number of individuals with a higher number of co-morbidities. Including more than four categories was associated with only minimal improvement in predictive ability of the models (minimal reduction in the Akaike information criterion).

Income quintiles for each dissemination area were calculated as described in a previous study where they were found to be good predictors of health services use. [42] Percentages of individuals in DAs reporting high school completion, aboriginal identity and visible minority status were also calculated and rural-urban residence status by census subdivision (i.e. municipality) was determined from 2006 Census data. Dissemination area-level co-variates were assigned to individuals using 6-digit residential postal code. Census subdivisions were considered urban if they fell within a census metropolitan area or census agglomeration, and rural otherwise. [37]

The mean number of acute care hospital beds per 1000 residents (hereafter "beds per capita") was determined by assigning each census subdivision to the nearest acute healthcare facility using ArcGIS Version 10.3 geospatial software, Environmental Systems Research Institute, December 2014 and obtaining the number of acute care beds in each facility from the Guide to Canadian Healthcare Facilities, 2008-2009.[41] Distance to the nearest facility was calculated from the geographic center of each census subdivision. The mean number of family physicians per 1000 residents (hereafter "GPs per capita") was determined by obtaining the number of family physicians/general practitioners practicing in each economic zone by year in the study period from the Physician and Medical Practice Database and taking the mean. The beds per capita and GPs per capita variables used 2006 census population as denominators. Individuals were assigned census subdivision-level values for these two variables, as well as distance to nearest acute care facility, using postal code of residence.

Analysis

Means and proportions were calculated for outcomes and co-variates by retention tertile. We did not calculate inferential bi-variate comparison statistics (e.g. chi-squared or kruskal-wallis test) as the study was population-based and differences were actual differences. Multi-variate regression models were used to model the association of retention tertile with number of hospitalizations for ambulatory-care-sensitive conditions, for all ages as well as those age 65 years and older, while adjusting for co-variates. Factors were only included in the final analysis if $p<0.2$ in unadjusted analysis. The negative binomial model was used as analysis revealed the variance of hospitalizations (0.207) was larger than its mean (0.079) indicating presence of overdispersion, and the negative binomial model had better fit compared to Poisson based on a likelihood ratio test. [43] A sensitivity analysis excluding urban patients was also conducted due to high co-linearity between retention and rural-urban place of residence. All analyses were carried out using IBM SPSS Statistics Version 23, IBM Corporation, 2015.

Ethics

The research protocol was approved by the Newfoundland and Labrador Health Research Ethics Board.

Results

Figure 1 shows the flow of study exclusions. Individuals in economic zones 1 and 4, remote northern coastal areas in the Labrador region, were excluded from the analysis (n = 5266). The former had no family physicians while the latter had one family physician for only a portion of the observation period. Individuals dying before 2005 were also excluded as the current analysis was over a 5-year period from 2005-2009. Thus, the final study sample consisted of 475,691 individuals (Figure 1). The proportion of individuals with one or more hospitalizations for an ambulatory-care-sensitive condition was 5.3% with a total of 38,189 hospitalizations yielding an average ambulatory-care-sensitive hospitalization rate of 78.8 per 1,000 individuals. Mean retention percentage was 53.5 (SD 13.1) with range from 13.8% to 72.7%.

Table 1 presents exact proportions of patients falling into retention tertile groups as well as descriptive statistics for co-variates by tertiles. While there were some differences in these covariates across tertiles, the difference in the proportion of rural patients was particularly notable. Table 2 presents ambulatory-care-sensitive hospitalization rate per 1,000 by retention tertile showing a decrease in rate with higher retention scores.

Table 3 presents results of three multivariate negative binomial regression models showing factors associated with ambulatory-care-sensitive hospitalization for the entire sample (i.e. all ages), for those

65 years of age and older, as well for individual with rural place of residence only (i.e. with urban area excluded). Sex was excluded from the model because it was not a significant predictor in unadjusted analysis. After adjusting for co-variates, there was a negative relationship between retention and ambulatory-care-sensitive hospitalization where individuals in an economic zone with moderate physician retention had a 16.5% increase in ambulatory-care-sensitive hospitalization rate relative to high retention, and those with low retention had an even greater increase (19.9%) (Table 3). We see a similar, but slightly more-pronounced pattern in the analysis including only rural residents, however, no relationship was seen in the age-65+ analysis. In the multivariate analysis, all other co-variates were significant predictors of hospitalization for ambulatory-care-sensitive conditions except for beds per capita.

Interpretation

We examined the relationship between family physician retention and hospitalization rate for ambulatory-care-sensitive conditions from 2005 to 2009 in a population-based cohort from the Canadian Province of Newfoundland and Labrador. A negative relationship was found between family physician retention and hospitalization for ambulatory-care-sensitive conditions when controlling for other factors thought to affect hospitalization. While the association between continuity of care and ACSC hospitalization rate has been established in several studies,[13-14, 17] this is the first demonstration that physician retention is associated in a similar pattern.

Hospitalization rates for ACSCs were found to be similar to another Canadian study utilizing the same ACSCs.[44] We also found hospitalization rates for ACSCs to be higher in rural areas as well as in individuals with higher co-morbidity rates and lower household income, all of which have been reported in the

literature.[30, 45-49] The association between rurality and poor health has also been well documented [50-53] and likely explains at least part of the association we observed between this factor and hospitalization. Hospital bed availability is commonly higher in rural areas, [54] but the effect of rurality remained significant after including an adjustment for beds per capita. In addition to greater rates of morbidity in rural areas, services that help keep patients out of hospital such as home care may be more readily available in urban areas, contributing to lower hospitalization rates.

If the association is causal, the exact mechanism by which physician retention exert its effects on hospitalization is not fully understood, although quality of communication, comprehensiveness of physician knowledge about the patient as well as certain characteristics of the patient-provider relationship are thought to play a major role. Even if medical records and communication between providers are excellent, there are likely factors that are not typically recorded in patient charts that affect clinician and patient decision-making. These factors may only become apparent when a clinician and patient develop a lasting and trusting relationship. Other studies have shown a relationship between physician retention/turnover and improved patient satisfaction and higher rates of preventive services, although evidence is conflicting.[24-27, 29] Although we expected the relationship between physician retention and hospitalization to be more pronounced for seniors, no relationship was found for those 65 years and older. We felt GPs with improved retention would have a better understanding of the higher levels of social complexity and multi-morbidity in this population and, thus, have better ability to mitigate their effect on hospitalization. The lack of relationship in those ages 65 and older may be related to a higher likelihood of specialist and/or non-physician provider involvement in the care of individuals in this age group. Another unexpected result was the positive relationship observed between ACSC hospitalization and number of GPs in the region. A review of the literature, however, revealed that the small number of studies in this area have had mixed results, with studies reporting

results similar to ours, no relationship, or the expected inverse (i.e. negative) relationship.[55-59] In addition, a randomized controlled trial of Veterans Affairs Medical Centers in the United States found that patients receiving a greater amount of primary care after hospital discharge had higher rather than lower hospital re-admission rates.[60]

The main strengths of this study are its use of large administrative databases representing the provincial population allowing for comprehensive analysis as well as controlling for many factors affecting hospitalization for ambulatory-care-sensitive conditions. The study is limited by its cross-sectional design involving measurement of physician retention and hospitalization over the same time period, which allows for determination of an association between these two variables, but prevents us from making conclusions about causality. The observational study design may also be associated with possible residual confounding due to between-group differences in unknown or unmeasured variables, or the level of measurement of variables. An example of the latter is physician retention, which was calculated at the level of the provincial economic zone and can represent a fairly large geographic area. Although retention values in the current study provide an aggregate measure of retention within the economic zone, actual retention levels experienced by patients within different communities or neighborhoods within a given economic zone may be different depending on local physician migration patterns and access to physicians outside the economic zone of residence. Also, we were not able to measure other factors which may have affected outcomes such as disease severity or co-morbidities not captured within the Charlson Comorbidity Index index, lifestyle choices, motivation to seek care, treatment compliance, extent of care from specialist or non-physician providers, other access barriers, variation in physician practice patterns/hospital admission thresholds, or differences between regions in environmental factors such as pollution, poor housing or unhealthy working conditions.[55,59,61-62] In addition, although there were exclusions from the study sample such as individuals migrating outside

the province, they amounted to less than ten percent of the study population, and thus, were arguably associated with very little bias. Finally, although rention data was available on all family physicians in the province through the Physician and Medical Practice Database, physician utilization data (i.e. physician claims) in the province only included fee-for-service (FFS) physicians. Utilization data was unavailable for visits to the approximately 35% of physicians in the province who are non-FFS, most of whom were located in rural areas. Thus, determination of continuity of care patterns across the province was not possible and the Charlson co-morbidity score, which used diagnostic codes from physician claims, may have been underestimated for patients in rural areas.

In summary, the current study demonstrates that physician retention in a region is highly associated with hospitalization for ambulatory-care-sensitive conditions, a finding which will be of interest to clinicians and decision-makers. While this finding is likely explained at least in part by a reduction in continuity of care, it is also important because the policy response to this finding may be different. We argue that efforts should be made not only to improve continuity of care but also to minimize physician turnover in a region. Physician retention may also be an appropriate proxy for continuity of care when it is not possible to measure continuity at the individual level. Future research should examine additional factors affecting ambulatory-care-sensitive hospitalization rates not accounted for in this study, such as primary care use, other patient and physician characteristics, as well as environmental factors, in addition to involving different measures of retention/turnover and testing effects of retention on other important outcomes such as emergency department visits, health care costs and mortality. We also plan to investigate measuring retention at the emergency department catchment area level, thus more accurately capturing retention at a local level. In addition, more powerful longitudinal study designs where physician retention is shown to precede hospitalization would more effectively demonstrate a causal effect of physician retention on avoidable hospitalization.

Conflict of Interest Statement: None declared

REFERENCES

1. Gulbrandsen P, Hjortdahl, P, Fugelli P. General practitioners' knowledge of their patients' psychosocial problems: Multipractice questionnaire survey. BMJ (Clinical Research Ed.) 1997; 314(7086):1014-1018.

2. Mainous AG, Kern D, Hainer B, Kneuper-Hall R, Stephens J, Geesey, ME. The relationship between continuity of care and trust with stage of cancer at diagnosis. Family Medicine 2004; 36(1);35-39.

3. Gulliford MC, Naithani S, Morgan M. Continuity of care and intermediate outcomes of type 2 diabetes mellitus. Family Practice 2007; 24(3):245-251.

4. Fenton JJ, Franks P, Reid RJ, Elmore JG, Baldwin LM. Continuity of care and cancer screening among health plan enrollees. Medical Care 2008; 46(1):58-62.

5. Saultz JW, Albedaiwi W. Interpersonal continuity of care and patient satisfaction: A critical review. Ann Fam Med 2004; 2(5):445-451.

6. Kelly RB, Shank JC. Adherence to screening flexible sigmoidoscopy in asymptomatic patients. Medical Care 1992; 30(11):1029-1042.

7. Safran DG, Taira DA, Rogers WH, Kosinski M, Ware JE, Tarlov AR. Linking primary care performance to outcomes of care. J Family Pract 1998; 47(3):213-220.

8. Hjortdahl P, Laerum E. Continuity of care in general practice: Effect on patient satisfaction. BMJ (Clinical Research Ed.) 1992; 304(6837):1287-1290.

9. Weyrauch, K. F. Does continuity of care increase HMO patients' satisfaction with physician performance? J Am Board Fam Pract 1996; 9(1):31-36.

10. Christakis DA, Wright JA, Koepsell TD, Emerson S, Connell FA. Is greater continuity of care associated with less emergency department utilization? Pediatrics 1996; 103(4 Pt 1):738-742.

11. Menec VH, Sirski M, Attawar D. Does continuity of care matter in a universally insured population? Health Serv Res 2005; 40(2):389-400.

12. Ionescu-Ittu R, McCusker J, Ciampi A, Vadeboncoeur AM, Roberge D, Larouche D, Verdon J, Pineault R. Continuity of primary care and emergency department utilization among elderly people. CMAJ 2007; 177(11):1362-1368.

13. Mainous AG, Gill JM. The importance of continuity of care in the likelihood of future hospitalization: Is site of care equivalent to a primary clinician? Am J Public Health 1998; 88(10):1539-1541.

14. Menec VH, Sirski M, Attawar D, Katz A. Does continuity of care with a family physician reduce hospitalizations among older adults? J Health Serv Res Policy 2006; 11(4):196-201.

15. Knight JC, Dowden JJ, Worrall GJ, Gadag VG, Murphy MM. Does higher continuity of family physician care reduce hospitalizations in elderly people with diabetes? Population Health Management. 2009; 12(2):81-86.

16. Starfield B, Chang HY, Lemke KW, Weiner JP. Ambulatory specialist use by nonhospitalized patients in us health plans: Correlates and consequences. J Ambulatory Care Manage. 2009; 32(3):216-225.

17. Nyweide DJ, Anthony DL, Bynum JPW, Strawderman RL, Weeks WB, Casalino LP, Fisher ES. Continuity of Care and the Risk of Preventable Hospitalization in Older Adults**.** JAMA Intern Med. 2013 Nov 11; 173(20):1-13.

18. Cornelius LJ. The degree of usual provider continuity for African and Latino Americans. Journal of Health Care for the Poor and Underserved. 1997; 8(2):170-185.

19. De Maeseneer, JM, De Prins L, Gosset C, Heyerick J. Provider continuity in family medicine: Does it make a difference for total health care costs? Ann Fam Med 2003; 1(3):144-148.

20. Hollander, M. J., Kadlec, H., Hamdi, R., & Tessaro, A. Increasing value for money in the Canadian healthcare system: New findings on the contribution of primary care services. Healthcare Quarterly. 2009; 12(4):32-44.

21. Wolinsky, F. D., Bentler, S. E., Liu, L., Geweke, J. F., Cook, E. A., Obrizan, M., et al. Continuity of care with a primary care physician and mortality in older adults. J Gerontol A Biol Sci Med Sci 2010; 65(4):421-428.

22. Worrall G, Knight J. Continuity of care is good for elderly people with diabetes: retrospective cohort study of mortality and hospitalization. Can Fam Physician. 2011 Jan; 57(1):e16-20.

23. Lustman A, Comaneshter D, Vinker S. Interpersonal continuity of care and type two diabetes. Prim Care Diabetes 2016 Jun; 10(3):165-70.

24. Ruhe M, Gotler RS, Goodwin MA, Stange KC. Physician and Staff Turnover in Community Primary Care Practice. J Ambulatory Care Manage 2004; 27(3):242–248

25. Pereira AG, Kleinman KP, Pearson SD. Leaving the practice: effects of primary care physician departure on patient care. Arch Intern Med 2003; 163(22):2733-2736.

26. Plomodon ME, Magid DJ, Steiner JF, MaWhinney S, Gifford BD, Shih SC, Grunwald GK, Rumsfeld JS. Primary Care Provider Turnover and Quality in Managed Care Organizations. Am J Manag Care 2007; 13(8):465-472.

27. Reddy A, Pollack CE, Asch DA, Canamucio A, Werner RM. The Effect of Primary Care Provider Turnover on Patient Experiences of Care and Ambulatory Quality of Care. JAMA Intern Med 2015; 175(7):1157-1162.

28. Kahana E, Strange KC, Meehan R, Raff L. Forced disruption in continuity of primary care: the patients's perspective. Sociological Focus 1997; 30(2): 177-186

29. Misra-Hebert AD, Kay R, Stoller JK. A review of physician turnover: rates, causes, and consequences. Am J Med Qual 2004; 19(2): 56-66.

30. Billings, J., Zeitel, L., Lukomnik, J., Carey, T. S., Blank, A. E., & Newman, L. Impact of socioeconomic status on hospital use in New York City. Health Affairs 1993; 12(1):162-173. 31. Canadian Institute for Health Information. Supply, Distribution and Migration of Canadian Physicians 2015. Ottawa: Canadian Institute for Health Information. 2016.

32. Clinical Database Management System (CDMS) Data Users Guide V.1.0. St. John's (NL): Newfoundland and Labrador Centre for Health Information; 2014.

33. NLCHI Mortality System Data Users Guide V.1.2. St. John's (NL): Newfoundland and Labrador Centre for Health Information; 2014.

34. Reabstracting 2001-2002 Clinical Data (Unpublished). St. John's (NL): Newfoundland and Labrador Centre for Health Information; (2004).

35. Segovia, J., & Edwards, A. C. (2001). *Newfoundland panel on health and medical care medical care utilization 1992-9 : Final report*. St. John's, NL: Division of Community Medicine, Faculty of Medicine, Memorial University of Newfoundland.

36. Postal Code Conversion File (PCCF) 2009. Ottawa (ON): Statistics Canada; 2009. (Catalogue No. 92-153-XCB).

37. 2006 Census Dictionary. Ottawa (ON): Statistics Canada; 2007. (Catalogue no. 92-566-XWE).

38. Newfoundland and Labrador Statistics Agency, Department of Finance. Economic Zones, Newfoundland and Labrador [map]. Government of Newfoundland and Labrador; 2011. Available from: http://www.stats.gov.nl.ca/Maps/pdfs/EZ_NL.pdf (Accessed July 17, 2017).

39. Alameddine M, Laporte A, Baumann A, O'Brien-Pallas L, Mildon B, Deber R. 'Retention' and 'inflow' as proxy measures of the relative attractiveness of various sub-sectors of nursing employment. Soc Sci Med. 2006 Nov; 63(9):2310-9.

40. Lavoie JG, Forget EL, Prakash T, Dahl M, Martens P, O'Neil JD. 2010 Have investments in on-reserve health services and initiatives promoting community control improved First Nations' health in Manitoba? Soc Sci Med 2010; 1(4):717-24.

41. Sundararajan V, Henderson T, Perry C, Muggivan A, Quan H, Ghali WA. New ICD-10 version of the Charlson Comorbidity Index predicted in-hospital mortality. J Clin Epidemiol 2004 Dec; 57(12):1288-94.

42. Guide to Canadian healthcare facilities 2008-2009 : volume 16 Canadian Healthcare Association. Ottawa, ON: CHA Press; 2008.

43. Booth JG, Casella G, Friedl H, et al. Negative-binomial loglinear mixed models. Stat Model 2003; 3: 179–191.

44. Lavoie JG, Forget EL, Dahl M, Martens PJ, O'Neil JD. Is it worthwhile to Invest in Homecare? Healthcare Policy 2011 May; 6(4):35-48.

45. Billings J, Anderson GM, Newman LS. Recent findings on preventable hospitalizations. Health Aff 1996; 15:239-249.

46. McConnochie KM, Roghmann KJ, Liptak GS. Socioeconomic variation in discretionary and mandatory hospitalization of infants: An ecologic analysis. Pediatrics 1997;99:774-784.

47. Cloutier-Fisher D, Penning MJ, Zheng C, Druyts EB. The devil is in the details: trends in avoidable hospitalization rates by geography in British Columbia, 1990-2000. BMC Health Serv Res 2006 Aug; 6:104.

48. Roos LL, Walld R, Uhanova J, Bond R. Physician Visits, Hospitalizations, and Socioeconomic Status: Ambulatory Care Sensitive Conditions in a Canadian Setting. Health Serv Res 2005 Aug; 40(4):1167–1185.

49. Agha MM, Glazier RH, Guttmann A. Relationship between social inequalities and ambulatory care-sensitive hospitalizations persists for up to 9 years among children born in a major Canadian urban center. Ambul Pediatr 2007 May-Jun; 7(3):258-62.

50. Summary Report: How Heathy Are Rural Canadians? An Assessment of Their Health Status and Health Determinants. Ottawa (ON): Canadian Institute for Health Information; 2006.

51. Badgley RF. Social and Economic Disparities Under Canadian Health Care. Int J Health Serv 1991; 21 (4):659–671.

52. Mansfield CJ, Wilson JL, Kobrinski EJ, Mitchell J. Premature Mortality in the United States: The Roles of Geographic Area, Socioeconomic Status, Household Type, and Availability of Medical Care. Am J Public Health 1999 Jun; 89(6):893–898.

53. Pampalon R. Health Discrepancies in Rural Areas in Quebec. Soc Sci Med 1991; 33(4):355–360.

54. Finch LE, Christianson JB. Rural hospital costs: an analysis with policy implications. Public Health Rep. 1981 Sep-Oct; 96(5):423-33.

55. Laditka JN, Laditka SB, Probst JC. More may be better: evidence of a negative relationship between physician supply and hospitalization for ambulatory care sensitive conditions. Health Serv Res 2005 Aug; 40(4):1148-66.

56. Krakauer, H., I. Jacoby,M. Millman, and J. E. Lukomnik. 'Physician Impact on Hospital Admission and on Mortality Rates in the Medicare Population. Health Services Res 1996 Jun; 31(2):191–211.

57. Ricketts, T. C., R. Randoph, H. A. Howard, D. Pathman, and T. Carey. 2001. Hospitalization Rates as Indicators of Access to Primary Care. Health and Place 2001 Mar; 7(1):27–38.

58. Parchman, L., and S. Culler. Primary Care Physicians and Avoidable Hospitalizations. Journal of Family Practice 1994 Aug; 39(2):123–9.

59. Schreiber, S., and T. Zielinski. 1997. The Meaning of Ambulatory Care Sensitive Admissions: Urban and Rural Perspectives. J Rural Health 1997 Fall; 13(4):276–84.

60. Weinberger, M., Oddone, E., & Henderson, W. Does increased access to primary care reduce hospital admissions? N Engl J Med 1996 May; 334(22):1441 -1447.

61. Komaromy, M., N. Lurie, D. Osmond, K. Vranizan, D. Keane, and A. B. Bindman. 1996. Physician Practice Style and Rates of Hospitalization for Chronic Medical Conditions. Medical Care 1996 Jun; 34(6):594–609.

62. Donaldson, M., Yordy, K., Lohr, K., & Vanselow, N. (Eds.). Primary care: America's Health in a New Era. Washington DC: National Academy Press, Institute of Medicine; 1996.

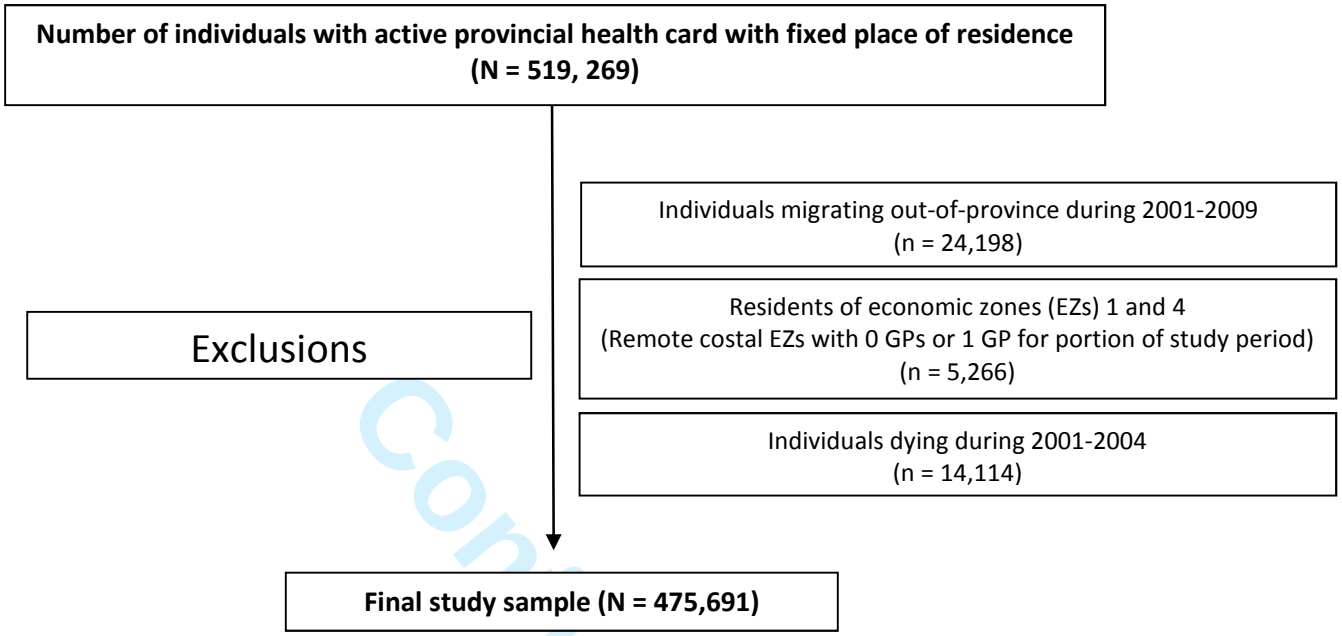

Figure 1: Study Exclusions

Table 1: Descriptive Statistics of Patients by Retention Tertile, Province of Newfoundland and Labrador (2005-2009)

Variable	Physician Retention Tertile			Total
	Low	Moderate	High	
N (% of total)	152,758 (31.8)	147, 399 (30.6)	175, 534 (36.5)	475,691
Sex [n (%)]				
Male	76,520 (50.1)	74,095 (50.3)	87,193 (49.7)	237,808 (50.0)
Female	76,231 (49.9)	73,299 (49.7)	88,326 (50.3)	237,856 (50.0)
Age [mean (SD)]	37.8 (22.6)	38.5 (23.3)	34.9 (23.6)	36.9 (23.3)
(median)	39.0	40.0	36.0	38.0
Income quintile				
Q1 (Lowest)	30,072 (20.1)	28,787 (19.8)	48,714 (27.9)	107,573 (22.9)
Q2	26,797 (18.0)	36,615 (25.1)	32,342 (18.5)	95,754 (20.4)
Q3	28,805 (19.3)	31,032 (21.3)	28,996 (16.6)	88,833 (18.9)
Q4	28,272 (18.9)	27,741 (19.0)	32,104 (18.4)	88,117 (18.8)
Q5 (Highest)	35,309 (23.7)	21,547 (14.8)	32,362 (18.5)	89,218 (19.0)
Rural-urban				
Rural	152,758 (100.0)	95,094 (64.5)	35,986 (20.5)	283,838 (59.7)
Urban	0 (0.0)	52,305 (35.5)	139,548 (79.5)	191,853 (40.3)
CCI Score				
0 conditions	108,662 (71.1)	96,419 (65.4)	115,160 (65.6)	320,241 (67.3)
1-2 conditions	24,821 (16.2)	27,605 (18.7)	33,506 (19.1)	85,932 (18.1)
3-4 conditions	10,981 (7.2)	12,200 (8.3)	14,255 (8.1)	37,436 (7.9)
5+ conditions	8,294 (5.4)	11,175 (7.6)	12,613 (7.2)	32,082 (6.7)
High School Diploma [mean (SD)]	57.7 (13.8)	61.4 (12.2)	74.8 (13.5)	65.2 (15.2)
Visible Minority [mean (SD)]	1.0 (2.0)	0.48 (1.5)	1.9 (3.4)	1.2 (2.6)
Aboriginal Identity [mean (SD)]	6.0 (14.3)	2.5 (4.2)	3.7 (8.2)	4.1 (9.9)
Distance to nearest acute care facility (km) [mean (SD)]	28.6 (30.4)	26.4 (27.9)	9.0 (13.5)	20.7 (26.2)
Beds per capita [mean (SD)]	2.2 (1.2)	2.8 (1.1)	3.1 (1.0)	2.7 (1.2)
GPs per capita [mean (SD)]	1.7 (0.56)	1.6 (0.23)	1.4 (0.16)	1.6 (0.37)

Notes: 1) Variables may not equal total N due to small number of individuals with missing data for some variable
2) For High School Diploma, Visible Minority and Aboriginal Identity data represent 'Mean percentage within dissemination area' for that retention tertile.

Table 2: Adjusted Hospitalization Rates for Ambulatory-care-sensitive Conditions by Physician Retention Tertile over a Five-year period, Province of Newfoundland and Labrador (2005-2009)

Variable	Physician Retention Tertile			All Patients
	Low	Moderate	High	
Number of hospitalizations per 1,000	89.7	88.5	61.0	78.8

Table 3: Factors Associated with Hospitalizations for Ambulatory-care-sensitive Conditions, Province of Newfoundland and Labrador (2005-2009)

	Rate Ratio (95% confidence interval)		
	All ages	Age 65+	Rural Residence Only
Physician Retention			
Q1 (Lowest)	1.199 (1.152-1.247)	1.047 (0.968-1.133)	1.232 (1.168-1.299)
Q2	1.165 (1.126-1.204)	1.001 (0.943-1.075)	1.198 (1.135-1.265)
Q3 (Highest) (Ref.)	1.000	1.000	1.000
Age*	0.999 (0.998-0.999)	1.008 (1.004-1.011)	1.002 (1.001-1.003)
Income quintile			
Q1 (Lowest)	1.212 (1.162-1.264)	1.177 (1.084-1.277)	1.178 (1.118-1.241)
Q2	1.166 (1.121-1.214)	1.135 (1.049-1.228)	1.131 (1.076-1.188)
Q3	1.133 (1.088-1.179)	1.070 (0.989-1.159)	1.116 (1.062-1.172)
Q4	1.145 (1.101-1.190)	1.165 (1.077-1.261)	1.165 (1.110-1.221)
Q5 (Highest) (Ref.)	1.000	1.000	
Residence status			
Rural	1.198 (1.157-1.365)	1.302 (1.217-1.393)	-----
Urban (Ref.)	1.000	1.000	
CCI Score			
0 conditions	0.086 (0.083-0.089)	0.113 (0.104-0.123)	0.093 (0.090-0.098)
1-2 conditions	0.267 (0.258-2.276)	0.430 (0.405-0.457)	0.290 (0.279-1.303)
3-4 conditions	0.396 (0.382-0.411)	0.580 (0.549-0.614)	0.423 (0.404-0.441)
5+ conditions (Ref.)	1.000	1.000	1.000
High School Diploma*	0.991 (0.990-0.992)	0.990 (0.987-0.991)	0.990 (0.989-0.991)
Visible Minority*	0.993 (0.987-0.998)	0.992 (0.982-1.002)	0.981 (0.972-0.990)
Aboriginal Identity*	1.006 (1.005-1.007)	1.006 (1.003-1.009)	1.007 (1.006-1.008)
Distance to nearest acute care facility*	0.998 (0.997-0.998)	0.998 (0.997-0.999)	0.997 (0.997-0.998)
Beds per capita*	1.000 (0.990-1.010)	0.998 (0.980-1.016)	1.003 (0.992-1.014)
GPs per capita*	1.363 (1.318-1.409)	1.261 (1.175-1.352)	1.346 (1.300-1.394)

Notes: 1) Analysis excludes n = 7989 individuals with missing data for one or more co-variates (less than 1% of individuals)
2) The rate ratios are equal to the exponent of the regression co-efficient and are adjusted for all other variables in the table.
3) * indicates variable was include in continuous form in the final models.

Appendix A: Information on Provincial Economic Zones

Provincial economic zones (EZs) were created through a government initiative in the mid-1990s and were managed by Regional Economic Development Boards providing institutional structure for regional economic development in the province. Table A1 below presents population by EZ.

Table A1: Population by Provincial Economic Zone, Newfoundland and Labrador, 2006

Economic Zone	Population
1	3,120
2	9,660
3	9,176
4	2,591
5	1,817
6	8,833
7	9,251
8	40,805
9	21,807
10	9,120
11	14,264
12	26,431
13	7,927
14	47,243
15	28,060
16	21,585
17	39,982
18	7,869
19	187,508
20	8,420
Province	505,469

Source: Statistics Canada Census, 2006

Appendix B: ICD Codes for Ambulatory-care-sensitive Conditions

Classification of Conditions	Condition	ICD-9 AND 1CD-10-Codes
Chronic Conditions	Asthma	**ICD-9 493** **ICD-10-CA J45**
	Angina	**ICD-9** 411, 413 **ICD-10-CA** I20, I23.82, I24.0, I24.8, I24.9 Excluding cases with the following surgical procedures**: CCP 01.01-01.39, 07.24, 14.01-14.83,14.88-16.82,16.89-21.82, 21.89-29.7, 29.82-34.81, 34.89-41.81, 41.83-43.82, 43.84-45.84, 45.88-46.88,46.90-48.91, 48.99-50.79, 50.91-50.93, 50.96-52.81, 52.89-63.95, 63.97-64.96, 64.98-66.83, 66.89-67.84, 67.89-69.82, 69.89-71.96, 71.98-72.95, 72.97-75.81, 75.89-80.83, 80.89-88.81, 88.89-92.69, 92.80-97.82, or 97.89-98.99 CCI 1.^,2.^,5.^ (i.e. any procedure from CCI section 1, 2, 5)
	Heart Failure and pulmonary edema	**ICD-9** 428, 518.4 **ICD-10-CA** I50, J81, I11.0 Excluding cases with the following surgical procedures**: CCP 48.1, 49.5, 48.02, 48.03, 49.71, 49.72,49.73,49.82, 49.86 CCI 1.IJ.50, 1.IJ.57.GQ, 1.HZ.85, 1.IJ.76, 1.HB.53, 1.HD.53, 1.HZ.53, 1.HB.55, 1.HD.55, 1.HZ.55, 1.HB.54, 1.HD.54
	Convulsion & Epilepsy	**ICD-9** 345, 780.3, 642.6 **ICD-10-CA** G40, G41, R56, O15
	Diabetes with complications	**ICD-9** 250.0, 250.1, 250.2, 250.3, 250.4, 250.5, 250.6, 250.7, 250.8, 250.9 **ICD-10-CA** E10.1, E10.6, E10.7, E10.9, E11.0, E11.1, E11.6, E11.7, E11.9, E13.0, E13.1, E13.6, E13.7, E13.9, E14.0, E14.1, E14.6, E14.7, E14.9
	Hypertension	**ICD-9** 401.0, 401.9, 402.0, 402.1, 402.9 **ICD-10-CA** I10.0, I10.1, I11 Excluding cases with the following surgical procedures**: CCP 48.1, 49.5, 48.02, 48.03, 49.71, 49.72, 49.73, 49.82, 49.86 CCI 1.IJ.50, 1.IJ.57.GQ, 1.HZ.85, 1.IJ.76, 1HB.53 1.HD.53, 1.HZ.53, 1.HB.55, 1.HD.55, 1.HZ.55,
	COPD	**ICD-9** 491, 492, 494, 496 **ICD-10-CA** J41, J42, J43, J44, J47
	Pneumonia	**Pneumonia (only when a secondary diagnosis of COPD is present)** **ICD-9** 480, 481, 482, 483, 484, 485, 486 **ICD-10-CA** J12, J13, J14, J15, J16, J18
	Bronchitis	**Acute Bronchitis (only when a secondary diagnosis of COPD is present)** **ICD-9** 466.0 **ICD-10-CA** J20

	Anemia	**Iron Deficiency Anemia** ICD-9 280.0, 280.1, 280.8, 280.9 **Other deficiency anemia** ICD-9 281.0, 281.1, 281.2, 281.3, 281.4, 281.8, 281.9 **ICD-10-CA** D50.0, D50.1, D50.8, D50.9
Vaccine-preventable conditions	Diptheria	**ICD-9 032** **CD-10-CA** A36.0, A36.1, A36.2, A36.3 A36.8, A36.9
	Hemophilus Influenza type B	**ICD-9** 320.0 **ICD-10-CA** G00.0
	Hepatitis A	**ICD-9** 070.0, 070.1 **ICD-10-CA** B15.0, B15.9
	Hepatitis B	**ICD-9** 070.2, 070.3 **ICD-10-CA** B16.0, B16.1, B16.2, B16.9
	Influenza	**ICD-9** 487 **ICD-10-CA** J10.0, J10.1, J10.8, J11.0, J11.1, J11.8
	Measles	**ICD-9** 055 **ICD-10-CA** B05.0, B05.1, B05.2, B05.3, B05.4, B05.8, B05.9
	Meningococcal al disease (meningitis)	**ICD-9 036** **ICD-10-CA** A39.0, A39.1, A39.2, A39.3, A39.4, A39.5,A39.8, A39.9
	Mumps	**ICD-9** 072 **ICD-10-CA** B26.0, B26.1, B26.2, B26.3, B26.8,B26.9
	Pertussis	**ICD-9** 033 **ICD-10-CA** A37.0, A37.1, A37.8, A37.9
	Pneumococcal	**ICD-9** 038.2, 041.2, 320.1, 481, 567.1, 711.0 **ICD-10-CA** A40.3, G00.1, J13 Only counted 481 (ICD-9) and J13 (ICD-10) if COPD was not a secondary condition.
	Poliomyelitis	**ICD-9** 045 **ICD-10-CA** A80.0, A80.1, A80.2, A80.3, A80.4, A80.9
	Pulmonary/other tuberculosis	**ICD-9** 011-018 **ICD-10-CA** A15, A16, A17, A18, A19
	Rubella	**ICD-9** 056 **ICD-10-CA** B06.0, B06.8, B06.9
	Tetanus	**ICD-9 037** **ICD-10-CA A35**
Acute Conditions	Dental Conditions	**ICD-9** 521, 522, 523,525, 528 **ICD-10-CA** K02, K03, K04, K05, K06, K08, K09.8, K09.9, K12, K13
	Cellulitis	**ICD-9** 681, 682, 683, 686 **ICD-10-CA** L03, L04, L08, L44.4, L88, L92.2, L98.0, L98.3 Excluding cases with the following surgical procedures ** CCI codes 1 1.RM.87, 1.RM.89, 1.RM.91, 5.CA.89.CK, 5.CA.89.DA, 5.CA.89.GB, 5.CA.89.WJ, 5.CA.89.WK
	Pelvic Inflammatory Disease	**ICD-9 614,** **ICD-10-CA N70, N73, N99.4** Exclude males and cases with a hysterectomy procedures**: CCI codes: 1 1.RM.87, 1.RM.89, 1.RM.91,

		5.CA.89.CK, 5.CA.89.DA, 5.CA.89.GB, 5.CA.89.WJ, 5.CA.89.WK
	Gastroenteritis & Dehydration	**ICD-9** 558.9, 276.5 **ICD-10-CA** K52.2, K52.8, K52.9, E86.0, E86.8
	Severe Ear, Nose and Thoat (ENT) infections	**ICD-9** 382, 462, 463, 465, 472.1 **ICD-10-CA** H66, H67, J02, J03, J06, J31.2 Exclude otitis media cases with a myringotomy procedure**: CCI codes: 1.DF.53.JA-TS
* "Secondary diagnosis" refers to a diagnosis other than most responsible ** Code may be recorded in any position. Interventions coded as cancelled, previous and "abandoned after onset" are excluded		

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a

		meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses √
Discussion		
Key results	18	Summarise key results with reference to study objectives √
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias √
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence √
Generalisability	21	Discuss the generalisability (external validity) of the study results √
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based √