Patient clustering in primary care settings

Outcomes and quality of care

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Abstract

Objective To determine whether neighbours who share the same family physicians have better cardiovascular and health care outcomes.

Design Retrospective cohort study using administrative health databases.

Setting Ontario.

Participants The study population included 2,690,482 adult patients cared for by 1710 family physicians.

Interventions Adult residents of Ontario were linked to their family physicians and the geographic distance between patients in the same panel or list was calculated. Using distance between patients within a panel to stratify physicians into quintiles of panel proximity, physicians and patients from close-proximity practices were compared with those from more-distant-proximity practices. Age- and sex-standardized incidence rates and hazard ratios from cause-specific hazards regression models were determined.

Main outcome measures The occurrence of a major cardiovascular event during a 5-year follow-up period (2008 to 2012).

Results Patients of panels in the closest-proximity quintile lived an average of 3.9 km from the 10 closest patients in their panel compared with 12.4 km for the 10 closest patients of panels in the distant-proximity quintile. After adjusting for various patient and physician characteristics, patients in the most-distant-proximity practices had a 24% higher rate of cardiovascular events (adjusted hazard ratio=1.24 [95% CI 1.20 to 1.28], *P*<.001) than patients in the closest-proximity practices. Age- and sex-standardized all-cause mortality and total per patient health care costs were also lowest in the closest-proximity quintile. In sensitivity analyses restricted to large urban communities and to White long-term residents, results were similar.

Conclusion The better cardiovascular outcomes observed in close-proximity panels may be related to a previously unrecognized mechanism of social connectedness that extends the effectiveness of primary care practitioners.

Editor's key points

- Patients in the same family physician panel who live close to one another have, on average, better cardiovascular health outcomes, lower mortality, and lower total health costs.
- In terms of physicians, close-proximity panels had more female physicians, more international medical graduates, and larger roster sizes. In terms of patients, those in close-proximity panels were more likely to be female, be immigrants, live in low-income neighbourhoods, and be in poorer health.
- Patients in close-proximity quintiles visited their family physicians more often and received more preventive care.

Points de repère du rédacteur

- Les patients d'un même groupe de médecins de famille qui vivent à proximité les uns des autres ont, en moyenne, de meilleures issues en santé cardiovasculaire, une plus faible mortalité, et leurs coûts totaux en soins de santé sont moindres.
- Pour ce qui est des médecins, les groupes de plus proche proximité comptaient plus de femmes médecins et plus de diplômés internationaux en médecine, et avaient des listes de patients plus nombreuses. Du côté des patients, ceux qui étaient dans un groupe de plus proche proximité étaient plus susceptibles d'être des femmes ou des immigrants, de vivre dans des quartiers à faible revenu et d'être en moins bonne santé.
- Les patients des quintiles de plus proche proximité consultaient leur médecin de famille plus souvent et recevaient plus de soins préventifs.

Regroupement des patients en milieu de soins primaires

Résultats et qualité des soins

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Résumé

Objectif Déterminer si des voisins qui ont les mêmes médecins de famille ont de meilleurs résultats cardiovasculaires et sur le plan de la santé.

Type d'étude Une étude rétrospective de cohortes à l'aide de bases de données administratives sur la santé.

Contexte L'Ontario.

Participants La population à l'étude comptait 2 690 482 patients adultes soignés par 1710 médecins de famille.

Interventions Les résidents adultes de l'Ontario ont été corrélés à leurs médecins de famille, et la distance géographique entre les patients d'un même groupe ou d'une même liste a été calculée. En utilisant la distance entre les patients au sein d'un groupe pour stratifier les médecins en quintiles selon la proximité dans ce groupe, les médecins et les patients des pratiques de plus proche proximité ont été comparés à ceux des pratiques de moindre proximité. Les taux d'incidence selon l'âge et le sexe, et les modèles de régression des rapports de risque de causes particulières ont été déterminés.

Principaux paramètres à l'étude La survenue d'un événement cardiovasculaire majeur durant une période de suivi de 5 ans (de 2008 à 2012).

Résultats Les patients des groupes appartenant au quintile de la plus proche proximité vivaient en moyenne à 3,9 km des 10 patients les plus proches d'eux dans leur groupe, comparé à 12,4 km pour les 10 patients les plus proches dans le quintile de la moindre proximité. Après rajustements en fonction de diverses caractéristiques des patients et des médecins, les patients dans les pratiques de la proximité la plus distante avaient un taux d'événements cardiovasculaires de 24 % plus élevé (rapport de risque rajusté =1,24 [IC à 95 % de 1,20 à 1,28], p<,001) que les patients dans les pratiques de la plus proche proximité. La mortalité toutes causes confondues normalisée selon l'âge et le sexe, et le total des coûts en santé par patient étaient aussi les plus faibles dans le quintile de la plus proche proximité. Dans des analyses de sensibilité limitées à de grandes communautés urbaines et à des habitants à long terme blancs, les résultats étaient semblables.

Conclusion Les meilleurs résultats cardiovasculaires observés dans les groupes de proche proximité pourraient être liés à un mécanisme de connexion sociale qui n'a pas été reconnu auparavant et qui augmente l'efficacité des professionnels des soins primaires.

Improved health outcomes are a virtue of organizational features at system,[1] practice,[2] provider,[3] and patient levels. Common examples in clinical family practice include patients helping other patients with transportation, patients sharing medical information, and patients assisting one another when they are sick. Nevertheless, we know little about how patients of a family practice self-organize.

Several studies have shown that close to half of patients rely on a recommendation from a family member, friend, neighbour, or coworker when choosing a new family physician.[4,5] Evidence suggests that word of mouth is more important than a convenient office location[6] and that a high level of satisfaction with one's physician often leads patients to recommend their own family physicians to others in their social networks.[7] When existing patients influence others to join the same practice, they create an informal network that is more connected than if they were to choose their physicians independently. This may be particularly important when they are neighbours, as individuals derive most support from members of their social network residing closest to them.[8-13]

In this study we used geospatial analysis to explore our hypotheses that patients cluster around their family physicians and that patients in closer-proximity panels have better cardiovascular and health outcomes. To our knowledge this association between patient clustering and health outcomes has never been studied at the provider and patient levels.

Methods

Study population

In this retrospective cohort study, we carried out a secondary analysis using data from the population-based CANHEART (Cardiovascular Health in Ambulatory Care Research Team) cohort, which comprises most adult residents in the province of Ontario.[14] This cohort was created at ICES in Toronto, Ont, using multiple health administrative data sets linked together by unique encoded identifiers.[14] ICES is an independent, not-for-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without individual consent, for health system evaluation and improvement. This study was approved by the Sunnybrook Health Sciences Centre Research Ethics Board in Toronto.

Individuals in the cohort were identified from the Ontario Registered Persons Database, which captures demographic information such as age, sex, and postal code for any person covered by the Ontario Health Insurance Plan (OHIP). All community-dwelling individuals aged 20 to 105 years as of January 1, 2008, who had resided in Ontario for at least the previous 2 years were included. A flow diagram detailing study cohort inclusion and exclusion criteria can be found in Appendix 1, available from **CFPlus**.* We followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for the reporting of observational studies.[15]

Ontario provides an ideal setting for this study because all necessary hospital and physician services for residents are covered under its medicare program and residents are free to choose their family physician. We restricted the study population to those without a history of cardiovascular disease before the cohort inception date of January 1, 2008. Individual cardiovascular risk factors and other information were obtained from various databases, described elsewhere.[14]

Practice panel

Each patient's primary family physician was identified through the Client Agency Program Enrolment database, which tracks patient enrolment to individual family physician panels. If patients were not formally enrolled, they were assigned to the panel of the physician with the highest costs in claims for core primary care services provided to the patient from 2006 to 2007 using the OHIP physician claims database. We restricted the sample to family physicians providing comprehensive primary care medicine, using the ICES physicians database, which contains demographic information and practice characteristics of all practising physicians in Ontario. We further restricted the data set to family physicians whose offices were in communities with populations of at least 10,000 and panel sizes between 1300 and 2000 patients.[16]

Panel proximity (predictor variable)

We measured the extent of geospatial clustering of patients within primary care panels by identifying the geographic location of individuals' residences using their 6-character postal codes, available from the Ontario Registered Persons Database. The last 3 characters denote a local delivery unit that often represents a single address, but may also represent a single side of a city block or a portion of a large building. We excluded patients with identical postal codes in an attempt to exclude family members living in the same home. We then calculated the distance between a patient's postal code and the 10 nearest postal codes of patients in the same panel. The panel's spatial proximity score was then determined as the mean of these distances for all patients in the practice panel. Based on these scores, practices were subsequently ranked into quintiles, chosen a priori, and compared on various health processes and outcome measures.

Outcomes

Our primary outcomes were hospital admission due to myocardial infarction or stroke and death due to

*Appendices 1, 2, 3, and 4 are available from **https://www.cfp.ca**. Go to the full text of the article online and click on the **CFPlus** tab.

ischemic heart disease or cerebrovascular disease during a 5-year follow-up period (2008 to 2012). Hospitalization information was obtained from the Canadian Institute for Health Information Discharge Abstract Database, and death-related information was obtained from the Ontario Registrar General Vital Statistics database.

Secondary outcomes and measures of care included all-cause mortality, annual number of visits to a family physician, periodic health examination rates, cancer screening rates, and diabetes processes of care. These were included because they are commonly used indicators in research, using health administrative databases to evaluate the quality of health care delivery in the primary care setting.[17,18] Information for these outcomes and processes of care were obtained from the Ontario Breast Screening Program database, the Ontario Diabetes Database, the Ontario Drug Benefit database, and an OHIP physicians claims database. We also examined total per capita health care costs in 2008, including costs associated with visits to emergency departments, hospitalizations, medications paid for through the Ontario Drug Benefit Plan, home care, and ambulatory care services provided by both primary care physicians and physicians from other specialties.

Statistical analysis

Descriptive statistics were calculated for baseline physician and patient characteristics and for each outcome and care measure. Incidence rates of the primary outcome were reported as events per 1000 person-years of follow-up. All outcomes and care measures were standardized to the age and sex structure of the overall study population. To examine relative rates of our primary outcome across quintiles, we used cause-specific hazard regression models that accounted for the competing risk of noncardiovascular death, sequentially adjusting for age and sex, patient factors (including traditional cardiac risk factors such as smoking, total cholesterol levels, high-density lipoprotein levels, hypertension, and diabetes), neighbourhood income and ethnicity, and proximity to a primary care physician.[19,20] This order was chosen a priori to adjust for potential confounding owing to known risk factors for cardiovascular disease. We treated proximity quintiles as a categorical covariate and used the first quintile as the reference group. To account for clustering of patients within panels, a frailty parameter or a cluster-specific random effect was used in all models.[21] Since cholesterol levels were not available for the entire cohort, we imputed these using multiple imputation with 5 data sets.[22]

Recognizing that the size and ethnic composition of communities in Ontario may influence our results, we also performed post hoc separate sensitivity analyses, restricting the data to physicians with offices in locations of community sizes greater than 500,000 and including predominantly White long-term residents by excluding immigrants who arrived in Ontario after 1984 and Chinese or South Asian residents identified from a validated surname algorithm.[23] Chinese and South Asian people compose 49% of racialized populations in Ontario and live primarily in urban communities.[24] ArcGIS version 10.2 software was used to calculate panel proximity and the model builder software was used to iterate the analysis from panel to panel. All other analyses used SAS, version 9.4.

Results

Our study included 2,690,482 adult patients cared for by 1710 family physicians providing comprehensive care in Ontario communities with populations of 10,000 or more over a total of 13,184,894 years of follow-up. Characteristics of physicians and their patients by panel proximity are outlined in **Tables 1** and **2**,[25] respectively. Panel proximity varied substantially across primary care providers in Ontario. Close-proximity panels had considerably more female physicians, more international medical graduates, and larger roster sizes. **Table 2** shows that patients in close-proximity practices were more likely to be female, be immigrants, live in low-income neighbourhoods, and be in poorer health.

Table 3 and Appendix 2 (available from **CFPlus***) present age- and sex-standardized and crude outcome rates, respectively. Cardiovascular event and all-cause mortality rates were lowest among patients in the closest-proximity practices and increased with each quintile of more distant spatial proximity. Patients in close-proximity quintiles generally visited their family physician more often and were more likely to have received a periodic health examination than patients in distant-proximity quintiles. Total health care costs were lowest in the closest-proximity quintile and increased progressively as proximity decreased.

Table 4 shows sequential modeling results. Across all analyses, as spatial proximity decreased, the risk of a cardiovascular event increased. In unadjusted analyses, the rate of a major cardiovascular event was 36% greater among patients in the most-distant-proximity quintile compared with patients in the closest-proximity quintile (hazard ratio=1.36, 95% CI 1.30 to 1.42). After adjusting for age, sex, cardiac risk factors, income, ethnicity, physician characteristics, and patient-to-physician distance, the major cardiovascular event rate among patients in most-distant-proximity practices was 24% greater than among those in the closest-proximity quintile (hazard ratio=1.24, 95% CI 1.20 to 1.28). In sensitivity analyses restricted to large urban communities and to White long-term residents, results were similar (Appendices 3 and 4, available from **CFPlus***).

Discussion

We showed that in some family practices, patients, on average, live much closer to each other than in other

Table 1. Primary care physician characteristics*

CHARACTERISTIC	PATIENT PANEL PROXIMITY QUINTILE					
	1 (n=342)†	2 (n=342)	3 (n=342)	4 (n=342)	5 (n=342)	OVERALL (N=1710)
Patient proximity, km, mean (SD)	3.9 (0.6)	5.3 (0.3)	6.4 (0.3)	7.8 (0.6)	12.4 (3.7)	7.2 (3.4)
• Median (IQR)	4.0 (3.4-4.4)	5.3 (5.1-5.5)	6.4 (6.1-6.6)	7.7 (7.3-8.3)	11.4 (9.9-13.5)	6.4 (5.1-8.3)
Age, y, mean (SD)	53.4 (8.3)	53.1 (8.7)	52.2 (8.5)	52.6 (8.6)	52.2 (8.2)	52.7 (8.5)
Years in practice, mean (SD)	28.0 (8.7)	28.2 (8.8)	26.9 (8.7)	27.4 (9.0)	26.8 (8.5)	27.5 (8.7)
Male, n (%)	238 (69.6)	253 (74.0)	281 (82.2)	298 (87.1)	294 (86.0)	1364 (79.8)
Canadian medical graduate, n (%)	204 (59.6)	223 (65.2)	236 (69.0)	255 (74.6)	279 (81.6)	1197 (70.0)
Patients in panel, mean (SD)	1598 (194)	1583 (185)	1581 (183)	1554 (188)	1551 (189)	1573 (189)
Median patient-to-physician distance, km, mean (SD)	7.6 (3.7)	7.6 (4.1)	7.3 (5.5)	6.6 (3.9)	9.2 (15.6)	7.7 (8.0)
• IQR	(1.9-36.2)	(2.1-60.9)	(0.9-73.1)	(1.0-39.3)	(0.1-253.8)	(0.1-253.8)

IQR—interquartile range.
**P* values for differences between quintiles were all <.05, with the exceptions of age (*P*=.25) and years in practice (*P*=.14).
†Closest-proximity quintile.

family practices. We found that closer spatial proximity is associated with better cardiovascular health outcomes, lower mortality, and lower health care costs. The somewhat progressive gradient and consistency of the effect across quintiles suggest that the proximity of patients within a practice may be related to some phenomena that improve health.[26] Accounting for potential influences of community size and clustering of immigrants and ethnic groups, results were similar when we restricted our analyses to large urban communities and to predominantly White long-term residents. To our knowledge, this is the first study to demonstrate that patient proximity within a practice is associated with health outcomes.

The finding that females are more likely to be patients in closer-proximity practices than in more-distant-proximity practices is consistent with some of them possibly preferring a female physician and taking time to seek a neighbour's advice when searching for a physician.[27] Similarly, the finding that immigrants are more likely to attend close-proximity practices is consistent with them preferring a physician trained abroad who may speak their language and taking the time to seek a neighbour's advice when searching for a physician. Recently published studies demonstrate that social connectedness can have a substantial effect on physical and mental well-being.[16,28-33] In a 2016 systematic review, Valtorta et al found that poor social relationships were associated with a 29% increase in risk of incident coronary artery disease.[30]

Another interpretation of the findings is that patients in closer-proximity quintiles visited their family physicians more often and received more preventive care, although it seems unlikely that all improvement found in this study could be explained by better care. Patients living in geographic proximity within primary care practices may be embedded in communities in which they are supporting each other in ways that benefit their common health. A different possibility is that people who take greater care when selecting their family physician by consulting with their neighbours (who then belong to close-proximity practices) also take better care of themselves.

Strengths and weaknesses

The use of population-based health administrative data and our ability to reliably measure geographic proximity of patients within a panel are strengths of this study. Our regression models were able to account for neighbourhood income.

We were unable to consider confounding variables, such as family history of cardiovascular disease, the built environment, and lifestyle factors such as diet and physical activity. We were unable to confirm whether patients in a practice panel know or support one another. There was no literature to guide our choice of 10 as the number of patients living nearby.

Relevance

Further research is needed before attempting interventions to bolster or exploit spatial proximity in family practices. Our findings, if verified, would have relevance to how services are organized, how providers are remunerated, and how future research is conducted. Our work suggests health outcomes may depend in part on the way patients choose their family practitioners.

Table 2. Baseline patient characteristics by panel proximity quintile*

CHARACTERISTIC	PATIENT PANEL PROXIMITY QUINTILE					
	1 (n=546,555)†	2 (n=541,332)	3 (n=540,733)	4 (n=531,296)	5 (n=530,566)	OVERALL (N=2,690,482)
Patient proximity, km, mean (SD)	3.9 (0.6)	5.3 (0.3)	6.4 (0.3)	7.8 (0.6)	12.5 (3.7)	7.1 (3.4)
• Median (IQR)	4.0 (3.4-4.4)	5.3 (5.1-5.5)	6.4 (6.0-6.6)	7.7 (7.3-8.3)	11.4 (9.9-13.5)	6.3 (5.1-8.2)
Age, y, mean (SD)	47.6 (16.4)	47.2 (16.4)	46.9 (16.3)	46.9 (16.5)	47.2 (16.8)	47.2 (16.5)
Male, %	45.3	47.0	48.7	49.6	48.8	47.9
Study follow-up time, y, mean (SD)	4.9 (0.5)	4.9 (0.5)	4.9 (0.5)	4.9 (0.6)	4.9 (0.6)	4.9 (0.6)
Immigrant, %	35.2	19.7	16.7	11.1	5.0	17.6
• <10 y in Ontario, %	14.4	8.8	7.9	5.5	2.5	7.8
• 10-20 y in Ontario, %	18.3	9.3	7.5	4.8	2.1	8.5
Ethnicity (among immigrants), %						
• Black	8.3	13.7	12.8	11.5	11.3	10.9
• East Asian	26.6	10.2	12.4	8.0	7.1	16.8
• Latin American	7.0	7.8	6.6	7.5	7.4	7.2
• South Asian	29.0	26.5	28.1	26.1	23.8	27.6
• Southeast Asian	9.2	9.7	7.5	7.5	5.8	8.6
• West Asian	5.4	10.4	11.4	12.1	8.6	8.7
• White Eastern European	10.1	14.5	12.9	15.5	15.2	12.6
• White Western European	3.6	6.1	7.2	10.5	19.5	6.6
• Unknown	0.9	1.1	1.1	1.3	1.3	1.0
Neighbourhood income quintile, %						
• 1 (lowest)	21.9	18.3	17.7	17.6	17.1	18.5
• 2	23.5	19.9	19.1	18.8	18.8	20.0
• 3	20.7	20.3	20.1	19.9	20.8	20.4
• 4	18.6	20.7	21.4	21.6	22.2	20.9
• 5	15.3	20.7	21.7	22.1	21.1	20.2
• Unknown	0.1	0.2	0.2	0.4	0.3	0.2
Current smoker or quit in past year, survey weight adjusted, %‡	17.3	19.6	23.0	24.5	25.7	22.0
Hypertension, %	26.6	25.0	24.2	24.5	25.3	25.1
Diabetes, %	11.8	9.9	9.1	8.8	8.5	9.6
Total cholesterol, mmol/L, mean (SD)§	5.05 (1.01)	5.10 (1.02)	5.11 (1.04)	5.10 (1.04)	5.15 (1.06)	5.10 (1.03)
HDL, mmol/L, mean (SD)§	1.45 (0.40)	1.46 (0.41)	1.45 (0.41)	1.44 (0.41)	1.45 (0.41)	1.45 (0.41)

HDL—high-density lipoprotein, IQR—interquartile range.
**P* value <.05 for differences between proximity quintiles on all characteristics.
†Closest-proximity quintile.
‡From a subpopulation of 32,518 respondents to the 2005 to 2012 cycles of the Canadian Community Health Survey.[25]
§From a subpopulation of 673,586 patients with testing performed at Dynacare Medical Laboratories.

Table 3. Age- and sex-standardized cardiovascular and health care outcomes*

	PATIENT PANEL PROXIMITY QUINTILE					
OUTCOME	1†	2	3	4	5	OVERALL
Major cardiovascular event incidence, per 1000 person-years (95% CI)	3.2 (3.1-3.3)	3.5 (3.4-3.5)	3.5 (3.4-3.6)	3.9 (3.8-3.9)	4.2 (4.1-4.3)	3.6 (3.6-3.7)
All-cause mortality, per 1000 person-years (95% CI)	5.8 (5.7-5.9)	6.5 (6.4-6.6)	6.6 (6.5-6.7)	7.1 (7.0-7.2)	7.6 (7.5-7.7)	6.7 (6.7-6.8)
No. annual visits to a family physician (2008-2012), mean (95% CI)	4.7 (4.7-4.7)	4.3 (4.3-4.3)	4.3 (4.3-4.3)	4.0 (4.0-4.0)	3.7 (3.7-3.7)	4.2 (4.2-4.2)
Periodic health examination (2008-2012), % (95% CI)	72.5 (72.2-72.7)	66.7 (66.5-66.9)	65.0 (64.8-65.2)	61.0 (60.8-61.3)	55.5 (55.3-55.7)	64.2 (64.1-64.3)
Cancer screening						
Cervical, n	234,101	223,245	216,916	204,790	202,237	1,081,289
• % up to date (95% CI)	68.5 (68.2-68.9)	70.0 (69.6-70.4)	69.1 (68.7-69.4)	68.1 (67.7-68.5)	67.3 (67.0-67.7)	68.7 (68.5-68.8)
Breast, n	84,125	80,351	76,737	74,548	76,632	392,393
• % up to date (95% CI)	67.4 (66.8-68.0)	67.6 (67.0-68.2)	67.3 (66.7-67.8)	67.1 (66.5-67.7)	66.9 (66.3-67.5)	67.2 (67.0-67.5)
Colorectal, n	140,417	128,322	129,617	128,523	130,865	657,744
• % up to date (95% CI)	40.9 (40.6-41.3)	41.1 (40.7-41.4)	41.9 (41.6-42.3)	39.6 (39.3-40.0)	38.8 (38.1-39.1)	40.5 (40.3-40.6)
Diabetes care						
• Patients with diabetes, n	56,624	46,350	42,860	40,069	38,714	224,617
• Eye examination (2008-2009), % up to date (95% CI)	64.2 (63.6-64.9)	66.3 (65.6-67.1)	67.2 (66.4-68.0)	68.6 (67.8-69.4)	69.5 (68.7-70.3)	66.9 (66.6-67.3)
• Cholesterol screening (2008-2009), % up to date (95% CI)	88.5 (87.7-89.2)	84.5 (83.6-85.3)	83.6 (82.7-84.5)	81.8 (80.9-82.6)	78.8 (77.9-79.7)	83.9 (83.5-84.2)
• HbA_{1c} test (2008-2009)	32.9 (32.4-33.4)	36.1 (35.6-36.7)	36.6 (36.0-37.2)	40.3 (39.7-40.9)	48.1 (47.4-48.8)	38.2 (38.0-38.5)
• HbA_{1c} test among those ≥65 years, n	21,974	17,458	15,675	15,138	15,334	85,579
• Oral hypoglycemic, % up to date (95% CI)	55.0 (54.0-56.0)	52.4 (51.4-53.5)	52.4 (51.3-53.5)	52.7 (51.6-53.9)	53.4 (52.2-54.6)	53.3 (52.9-53.8)
• ARB or ACEI, % up to date (95% CI)	62.7 (61.6-63.7)	62.6 (61.5-63.8)	62.9 (61.6-64.1)	63.8 (62.5-65.1)	63.2 (61.9-64.5)	63.0 (62.5-63.6)
• Statin, % up to date (95% CI)	56.8 (55.9-57.9)	55.2 (54.1-56.3)	55.4 (54.3-56.6)	54.3 (53.2-55.5)	52.6 (51.4-53.7)	55.1 (54.6-55.6)
Average annual health care costs per patient (2008), $, mean (SD)‡	13,171 (33,344)	13,458 (34,136)	13,243 (34,007)	13,629 (34,129)	14,321 (36,694)	13,561 (34,474)

ACEI—angiotensin-converting enzyme inhibitor, ARB—angiotensin II receptor blocker, HbA_{1c}—hemoglobin A_{1c}.
**P* value <.05 for differences between proximity quintiles on all outcomes except ARB or ACEI prescriptions (*P*=.21).
†Closest-proximity quintile.
‡Total health care costs are not age- and sex-standardized.

Table 4. Hazard ratios for a major cardiovascular event*

CHARACTERISTIC	MODEL, HAZARD RATIO (95% CI)						
	UNADJUSTED	+ AGE, SEX	+ TRADITIONAL CVD RISK FACTORS	+ INCOME QUINTILE	+ ETHNICITY	+ PHYSICIAN FACTORS	+ PHYSICIAN DISTANCE
Proximity quintile							
• 1 (reference)	NA	NA	NA	NA	NA	NA	NA
• 2	1.07 (1.03-1.12)	1.10 (1.05-1.14)	1.10 (1.06-1.13)	1.11 (1.08-1.15)	1.04 (1.01-1.08)	1.03 (1.00-1.07)	1.04 (1.00-1.07)
• 3	1.07 (1.03-1.12)	1.12 (1.07-1.17)	1.11 (1.07-1.15)	1.13 (1.09-1.17)	1.06 (1.03-1.10)	1.04 (1.01-1.08)	1.04 (1.01-1.08)
• 4	1.21 (1.16-1.26)	1.23 (1.18-1.29)	1.22 (1.19-1.26)	1.25 (1.21-1.29)	1.15 (1.12-1.19)	1.13 (1.10-1.17)	1.14 (1.10-1.18)
• 5	1.36 (1.30-1.42)	1.36 (1.30-1.42)	1.32 (1.28-1.37)	1.35 (1.30-1.40)	1.24 (1.20-1.28)	1.23 (1.19-1.28)	1.24 (1.20-1.28)
Female, (reference=male)	NA	0.56 (0.55-0.57)	0.64 (0.62-0.65)	0.63 (0.61-0.65)	0.63 (0.61-0.65)	0.63 (0.61-0.65)	0.63 (0.61-0.65)
Age (reference=60 to 69), y							
• 20-29	NA	0.02 (0.01-0.02)	0.04 (0.02-0.10)	0.03 (0.03-0.04)	0.03 (0.03-0.04)	0.19 (0.14-0.26)	0.17 (0.11-0.27)
• 30-39	NA	0.08 (0.07-0.08)	0.11 (0.08-0.14)	0.10 (0.09-0.10)	0.10 (0.09-0.11)	0.23 (0.19-0.29)	0.22 (0.15-0.30)
• 40-49	NA	0.27 (0.26-0.28)	0.32 (0.28-0.37)	0.30 (0.29-0.32)	0.31 (0.30-0.32)	0.45 (0.42-0.48)	0.43 (0.38-0.49)
• 50-59	NA	0.56 (0.54-0.58)	0.62 (0.55-0.69)	0.59 (0.57-0.61)	0.60 (0.58-0.62)	0.79 (0.76-0.82)	0.78 (0.74-0.82)
• 70-79	NA	2.08 (2.02-2.14)	2.16 (1.96-2.39)	2.09 (2.01-2.16)	2.09 (2.01-2.17)	2.50 (2.40-2.61)	2.50 (2.35-2.66)
• ≥80	NA	5.78 (5.62-5.94)	6.00 (5.41-6.64)	5.75 (5.53-5.98)	5.74 (5.53-5.96)	6.81 (6.51-7.12)	6.81 (6.39-7.24)
Smoking	NA	NA	1.81 (1.56-2.10)	1.78 (1.53-2.06)	1.74 (1.50-2.02)	1.67 (1.46-1.91)	1.68 (1.41-2.01)
Total cholesterol, per 1 mmol/L increase	NA	NA	1.15 (1.10-1.19)	1.14 (1.10-1.18)	1.14 (1.10-1.18)	1.17 (1.13-1.21)	1.16 (1.12-1.20)
HDL, per 1 mmol/L increase	NA	NA	0.62 (0.58-0.65)	0.62 (0.59-0.66)	0.63 (0.59-0.67)	0.66 (0.62-0.69)	0.65 (0.60-0.70)
Hypertension	NA	NA	1.54 (1.48-1.61)	1.52 (1.48-1.56)	1.51 (1.48-1.55)	1.80 (1.63-1.99)	1.75 (1.56-1.98)
Diabetes	NA	NA	1.46 (1.41-1.50)	1.43 (1.39-1.48)	1.44 (1.40-1.48)	1.53 (1.47-1.58)	1.52 (1.46-1.57)
Neighbourhood income quintile, (reference=5)							
1 (lowest)	NA	NA	NA	1.28 (1.23-1.34)	1.30 (1.25-1.36)	1.23 (1.17-1.28)	1.23 (1.19-1.28)
2	NA	NA	NA	1.17 (1.13-1.21)	1.18 (1.14-1.22)	1.12 (1.08-1.16)	1.13 (1.09-1.16)
3	NA	NA	NA	1.11 (1.07-1.15)	1.12 (1.08-1.16)	1.06 (1.03-1.10)	1.07 (1.03-1.11)
4	NA	NA	NA	1.03 (1.00-1.07)	1.04 (1.01-1.07)	0.99 (0.96-1.03)	1.00 (0.96-1.04)

Table 4 *continued on page 679*

Table 4 *continued from page 678*

CHARACTERISTIC	MODEL, HAZARD RATIO (95% CI)						
	UNADJUSTED	+ AGE, SEX	+ TRADITIONAL CVD RISK FACTORS	+ INCOME QUINTILE	+ ETHNICITY	+ PHYSICIAN FACTORS	+ PHYSICIAN DISTANCE
Ethnicity (reference=White long-term resident)							
• East Asian	NA	NA	NA	NA	0.49 (0.46-0.53)	0.63 (0.57-0.70)	0.61 (0.54-0.70)
• Black	NA	NA	NA	NA	0.76 (0.68-0.86)	0.86 (0.78-0.96)	0.86 (0.77-0.95)
• Latin American	NA	NA	NA	NA	0.86 (0.76-0.97)	0.93 (0.83-1.04)	0.93 (0.83-1.04)
• South Asian	NA	NA	NA	NA	0.96 (0.91-1.01)	0.92 (0.88-0.97)	0.93 (0.88-0.98)
• Southeast Asian	NA	NA	NA	NA	0.75 (0.67-0.84)	0.89 (0.80-0.98)	0.88 (0.79-0.98)
• West Asian or Arab	NA	NA	NA	NA	0.78 (0.70-0.87)	0.91 (0.82-1.00)	0.90 (0.81-1.00)
• White Eastern European	NA	NA	NA	NA	0.89 (0.81-0.98)	0.93 (0.85-1.01)	0.93 (0.85-1.01)
• White Western European	NA	NA	NA	NA	0.79 (0.69-0.89)	0.92 (0.83-1.03)	0.92 (0.82-1.02)
Canadian medical graduate	NA	NA	NA	NA	NA	0.98 (0.96-1.00)	0.98 (0.95-1.00)
Male physician	NA	NA	NA	NA	NA	1.18 (1.14-1.22)	1.17 (1.13-1.21)
Physician age, per y increase	NA	NA	NA	NA	NA	1.00 (1.00-1.01)	1.00 (1.00-1.01)
Years in practice, per y increase	NA	NA	NA	NA	NA	1.00 (1.00-1.01)	1.00 (1.00-1.01)
Median patient-to-physician distance, per km increase	NA	NA	NA	NA	NA	NA	1.00 (0.99-1.00)

CVD—cardiovascular disease, HDL—high-density lipoprotein, NA—not applicable.
*From cause-specific hazards models.

If this is true, it would be important for patients to have this freedom of choice. Jurisdictions where this is the case should keep it and jurisdictions such as the United Kingdom and the United States should move to increase patient choice of provider. However, freedom to choose one's family physician depends on the supply of them available. There were periods before and during the study when the freedom of many patients to choose their family doctor was constrained by a lack of supply.

Our research suggests a new mechanism to explain the primary care paradox[34] and why it is that family practice is so powerful compared with non–family physician specialists in improving the health of the population. Patients of other specialists are often referred by primary care providers from large catchment areas, so patients seeing many kinds of medical specialists may be less likely to consult with their neighbours about whom to see, and so patients of these specialists may be less likely to know each other or be in a position to help each other.

Pay-for-performance bonuses and capitation are now features of many payment systems for family physicians. Considering the finding that female physicians and international medical graduates are more likely to have close-proximity panels, this could mean they may be better paid in part owing to a feature of practice organization. However, more research is needed.

Conclusion

Closer spatial proximity of patients in a family physician's panel is associated with better cardiovascular outcomes and lower costs of care. Further research is needed to better understand the types of support,[35] if any, that patients receive from other patients in the same panel. A survey of patients asking if they know

neighbours who are also patients in their family physician's practice, how they came to know them, and if and how they help each other would be next steps.

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Contributors

Dr William Hogg conceived of the study, oversaw the approach to the analysis, and drafted the paper. **Dr Jack Tu** seconded his research staff to the project, contributed to the planning of the analysis, and critically reviewed the paper. **Dr Ahmed Kotb** contributed to study conception, analysis oversight, and drafting of the paper. **Peter Gozdyra** performed the geospatial analyses and critically reviewed the paper. **Atul Sivaswamy** performed the remaining analyses and critically reviewed the paper. **Dr Jiming Fang** provided advice about the statistical methods and critically reviewed the paper. **Anna Chu** contributed to the planning of the analysis and critically reviewed the paper. **Dr Claire E. Kendall** helped interpret the data and provided guidance in the writing of the manuscript.

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Competing interests

Atul Sivaswamy, **Dr Jiming Fang**, and **Dr William Hogg** had full access to all the data in the study. **Dr William Hogg** was not paid by a pharmaceutical company or other agency to write this article and had the final responsibility for the decision to submit for publication. The analyses, opinions, results, and conclusions reported in this article are those of the authors and are independent of ICES; the funding sources; the Canadian Institute for Health Information; Cancer Care Ontario; and Immigration, Refugees and Citizenship Canada. No endorsement by ICES; the Ontario Ministry of Health and Long-Term Care; the Canadian Institutes of Health Research; the Canadian Institute for Health Information; Cancer Care Ontario; or Immigration, Refugees and Citizenship Canada is intended or should be inferred.

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