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TITLE: Trends in patient attachment to an aging primary care workforce: a population-based serial cross-sectional study in Ontario, Canada

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ABSTRACT

Purpose: Population aging is a global phenomenon. Resultant healthcare workforce shortages are anticipated. To ensure access to comprehensive primary care, which correlates with improved health outcomes, equity, and costs, data to inform workforce planning are urgently needed. We explored temporal trends in early career, mid-career, and near-retirement comprehensive primary care physician characteristics, the medical and social needs of their patients, and the workforce's capacity to absorb patients of near-retirement physicians.

Methods: We conducted a serial cross-sectional population-based analysis using health administrative data in Ontario, Canada, where most comprehensive primary care is delivered by family physicians (FPs) under universal insurance. We included all insured Ontario residents at three time points: 2008 (12,936,360), 2013 (13,447,365), and 2019 (14,388,566) and all Ontario physicians who billed primary care services (2008: 11,566; 2013: 12,693; 2019: 15,054). We examined the number and proportion of patients attached to near-retirement comprehensive FPs; the number and proportion of near-retirement comprehensive FPs; and the characteristics of patients and their comprehensive FPs.

Results: Patient attachment to comprehensive FPs increased over time. The overall FP workforce grew, but the proportion practicing comprehensiveness declined (2008: 77.2%, 2019: 70.7%), with shifts into limited scopes of practice across all career stages. Over time, an increasing proportion of the comprehensive FP workforce was near retirement age. Correspondingly, an increasing proportion of patients were attached to near-retirement physicians. By 2019, 13.9% of comprehensive FPs were 65 years or older, corresponding to 1,695,126 (14.8%) patients. Mean patient age increased, and near-retirement physicians served markedly increasing numbers of medically and socially complex patients.

Conclusions: The primary care sector faces capacity challenges as both patients and physicians age and fewer physicians practice comprehensiveness. Nearly 15% (1.7 million) of Ontarians may lose their comprehensive FP to retirement by 2025. To serve a growing, increasingly complex population, innovative solutions are needed.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our serial cross-sectional study uses large, population-level health administrative datasets to examine temporal trends in primary care supply and demand, in turn informing future workforce planning.
- By distinguishing between family physicians practicing comprehensive primary care and those who have narrowed their scope of practice, our methodology allows us to identify disparities between the presumed and actual primary care supply, and trends related to practice preferences among family physicians at all career stages.
- By linking the characteristics, including age and sex, of the primary care workforce to both the medical and social characteristics of the population served, our methodology facilitates a rich understanding of the resources needed by patients who may soon lose their FP to retirement, and the capacity to meet those needs among those who will remain in the workforce.
- Due to limitations in data availability for more recent years, our analyses predate the COVID-19 pandemic, which may have additional impacts on future supply and demand.
- Our analyses may underestimate the number of comprehensive FPs in rural areas due to practice patterns that may involve a large proportion of hospital-based services among some rural physicians.

INTRODUCTION

Primary care is the foundation of high-performing health care systems worldwide,[1] and can be defined by four core functions ("the 4 Cs") articulated by Starfield and others: first *Contact* access to the healthcare system, *Continuity* (long-term person-focused care), *Comprehensiveness* (meeting the majority of each patient's physical and mental health care needs, including prevention, acute care, chronic care, and multimorbidity care), and *Coordination* of care across the healthcare system, including specialty care, hospitals, home care, and community services and support.[1 2] Access to primary care is associated with improved health outcomes, improved health equity, and reduced health system costs.[3-9]

An essential enabler of primary care access is an adequate health human resource (HHR) supply, but many jurisdictions are grappling with current and impending shortages. For example, 14.5% (4.6 million) Canadians are without a primary care provider.[10] Virtually every country world-wide is experiencing population aging,[11] with a high burden of medical complexity[12-15] and a HHR workforce that is aging into retirement.[16-18] Concurrently, many countries, including Canada, the United Kingdom, and the United States, are experiencing challenges attracting incoming physicians to primary care as a specialty,[19-22] and among those who do, a declining proportion are providing primary care reflective of Starfield's "4 Cs" (hereafter referred to as "comprehensive primary care"); instead, primary care physicians are increasingly limiting their scope of work to subspecialized areas such as sports medicine, dermatology, or palliative care, or to episodic acute care settings, such as walk-in clinics.[23-29] Moreover, the concentration of women in primary care may further reduce HHR capacity, as women primary care physicians have been found to spend more time with patients[30] and receive more patient requests outside of appointments than men.[31 32]

In the context of an aging population and shifting workforce demographics, HHR planning requires an understanding of the needs of patients who will soon lose their primary care provider due to retirement, as well as an understanding of the capacity of the remaining and incoming workforce. To anticipate future workforce needs, previous studies often use high-level supply indicators such as number of primary care physicians, and high-level demand indicators such as patient visit rates and durations.[33-36] In-depth analyses tend to be limited to sub-jurisdictional populations, such as the neighborhood[36] or early career clinicians,[24] and do not directly link supply (individual clinicians) to demand (patients served by clinicians).

We conducted an in-depth exploration linking supply and demand at a health system planning level in Ontario, Canada. We examined temporal trends in early career, mid-career, and near-retirement primary care physician characteristics, the medical and social needs of patients attached to these physicians, and the workforce's capacity to meet the needs of patients of near-retirement physicians. We explored hypothesis-generating differences in gender-based workforce trends, including differences in care provision,[30 31] and trends around alternative practice models, such as team-based care. As Canadian healthcare planning and delivery are provincial jurisdiction, we focused on the province-level (Ontario). In Ontario, most comprehensive primary care is delivered by family physicians (FPs), most physician services and nearly all residents are covered by government insurance, and health services data are stored centrally in health administrative datasets.

METHODS

The use of data in this study was authorized under section 45 of Ontario's Personal Health Information Protection Act (PHIPA) and did not require review by a research ethics board or informed consent. This study followed the Strengthening the Reporting of Observational Studies

in Epidemiology (STROBE) reporting guideline.[37] Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Study Design, Population, and Data Sources

We conducted a serial cross-sectional population-level analysis using health administrative data housed at ICES. The study population included all registered Ontario residents covered by the Ontario Health Insurance Plan (OHIP) at three time points: March 31, 2008 (12,936,360), March 31, 2013 (13,447,365), and March 31, 2019 (14,388,566) and all Ontario physicians who billed primary care services (2008: 11,566; 2013: 12,693; 2019: 15,054).

Physician-level and patient-level data came from nine databases which were linked using unique encoded identifiers and analyzed at ICES (Supplement: eMethods).

Outcomes and Covariates

The primary outcomes were the number and proportion of patients attached to a near-retirement age comprehensive FP over three time points, and the number and proportion of near-retirement age comprehensive FPs over three time points. Based on previous literature finding the average Ontario FP retires at age 70.5 years (with women retiring on average 5 years earlier than men)[38] and accounting for the time needed to train new physicians,[39] three different "near-retirement" physician age cut-points were examined: ≥ 55 years, ≥ 65 years, and ≥ 70 years. Comprehensive FPs were defined by applying a previously validated algorithm described below in the Analysis section.[29]

We described the characteristics of both comprehensive FPs and their attached patients over the three time points. Physician characteristics served as exploratory indicators of both supply and, for near-retirement physicians, anticipated demand based on the populations of patients they

serve. Patient characteristics served as indicators of demand based on medical and sociodemographic complexity. Detailed data source, cohort, and covariate definitions can be found in the Supplement (eMethods).

Analysis

For our patient cohort, we created cross-sections of patients attached to comprehensive FPs at three time points: 2008, 2013, 2019.

We began by applying our previously validated algorithm for primary care physician attachment[40] to the population of OHIP-registered Ontario residents; identifying patients attached to a physician providing longitudinal primary care services based on billing codes and physician-level continuity of care (see Supplement eMethods – continuity of care). We removed patients seen at Community Health Centres because they cannot be attached to a specific physician, patients that the algorithm attached to non-FPs such as pediatricians and surgeons, and patients attached to a FP with missing covariates.

We next created the cohort of FPs linked to the attached patients we identified (2008, 2013, 2019). We stratified our patient and FP cohorts by physician practice type (scope). For this, we used a previously published algorithm for determining comprehensiveness of primary care practice, where physicians are identified as providing comprehensive care if more than half of their services were for core primary care and if these services fell into at least 7 of 22 activity areas.[29] This resulted in four groups of patients with attachments to four types of FP practice scopes: Comprehensive, Focused (for example, sports medicine or palliative care), Other, and those who worked less than 44 days/year. Focusing on the "comprehensive FP" group, we described the characteristics of these physicians and their patients.

Physician analyses were stratified by physician sex and physician age, including the three "near-retirement" cut-points. Proportions and means with standard deviations were reported for each time point (2008, 2013, 2019).

RESULTS

Patient Cohort

Excluding long-term care home residents, the population of OHIP-eligible Ontario residents in the patient cohort over time was 12,863,036 (2008), 13,371,946 (2013), and 14,312,309 (2019), of whom the following were attached to a comprehensive FP: 2008: n = 9,537,353 (77.3%); 2013: n = 10,398,003 (85.1%); 2019: n = 11,480,975 (86.1%) (Figure 1a).

Physician Cohort

The overall FP workforce grew from 9,944 physicians in 2008 to 13,269 in 2019 (Figure 1b). The proportion of FPs practicing comprehensive primary care declined from 77.2% in 2008 (n = 7,673) to 70.7% in 2019 (n = 9,377) (Supplement: eFigure 1).

eTable 1 stratifies comprehensive FP data by age and sex. The mean (SD) physician age remained relatively stable over time (2008: 50.3 (11.0) years; 2013: 51.4 (11.8) years; 2019: 49.7 (12.9) years). The mean age (SD) for female physicians was lower than for males at each time point (2008 male 53.0 (10.9) years, female 46.0 (9.7) years; 2013 male 54.7 (11.6) years, female 47.2 (10.6) years; 2019 male 53.1 (13.2) years, female 46.3 (11.6) years). Career stage (years in practice) closely followed physician age group for both males and females, and the youngest cohort (age <35) comprised an increasing proportion of the workforce over time, shifting from 7.7% in 2008 to 15.1% in 2019. The older cohorts were also found to comprise an increasing proportion of the workforce over time, and the absolute numbers of older physicians increased.

Among family physicians with patient attachments, a shift away from comprehensiveness and into other/focused scopes of practice was seen across all physician age groups, with the most pronounced shifts in the youngest and oldest physician groups (Supplement: eTable 2). Instead of comprehensive primary care, these FPs increasingly worked in focused or other scopes of practice. The proportion of FPs identified as practicing exclusively without patient attachments or in low-continuity ("walk-in clinic") settings fluctuated: 2008: 7.2% (n = 715), 2013: 4.9% (n = 558); 2019: 5.2% (n = 688) (Figure 1b).

Temporal Trends of Near-Retirement Comprehensive Family Physicians and their Patients

When looking at our three near-retirement cut-points (55+, 65+, 70+) over time, an increasing proportion of the comprehensive FP workforce was near retirement age (Figure 2). Correspondingly, an increasing proportion of patients were attached to near-retirement comprehensive FPs (Table 1). In the 55+ age group, the proportion of comprehensive FPs increased from 35.7% in 2008 to 38.2% in 2019. In 2019, this corresponded to 3,586 physicians and 4,935,992 (43.0%) patients (2019). In the 65+ group, the proportion increased from 10.0% in 2008 to 13.9% in 2019 (1,307 physicians, 1,695,126 (14.8%) patients). In the 70+ age group, the proportion increased from 4.6% in 2008 to 6.4% in 2019 (599 physicians, 666,000 (5.8%) patients).

Table 1. Characteristics of patients attached to near-retirement comprehensive family physicians over time, by near-retirement group

		Age 55+ Comprehensive FPs		Age 65+ Comprehensive FPs		Age 70+ Comprehensive FPs	
Patient Characteristics		N	%	N	%	N	%
OVERALL (N, % of all patients attached to all comprehensive FPs)	2008	3,571,661	37.5	690,642	7.2	214,861	2.3
	2013	4,676,625	45.0	1,399,119	13.5	419,172	4.0
	2019	4,935,992	43.0	1,695,126	14.8	666,404	5.8
Aged 65+ (N, % of patients attached to near-retirement physician group)	2008	597,707	16.7	136,394	19.8	45,414	21.1
	2013	846,974	18.1	298,545	21.3	95,833	22.8
	2019	1,003,769	20.3	402,430	23.7	176,473	26.5
Female patients (N, % of patients attached to near-retirement physician group)	2008	1,804,585	50.5	338,656	49.0	103,386	48.1
	2013	2,371,923	50.7	678,971	48.5	201,104	48.0
	2019	2,498,453	50.6	823,090	48.6	317,967	47.7
Rural patients (RIO score 40+) (N, % of patients attached to near-retirement physician group)	2008	233,045	6.5	48,860	7.1	14,323	6.7
	2013	292,357	6.3	88,311	6.3	20,294	4.8
	2019	274,099	5.6	83,691	4.9	33,545	5.0
Highest (4+) RUB (N, % of patients attached to near-retirement physician group)	2008	677,436	19.0	137,995	20.0	44,067	20.5
	2013	878,340	18.8	283,013	20.2	88,182	21.0
	2019	983,818	19.9	350,439	20.7	146,298	22.0
Highest (5+) annual core primary care visits (N, % of patients attached to near-retirement physician	2008	2,109,950	59.1	403,026	58.4	127,050	59.1
	2013	2,462,236	52.7	753,388	53.9	227,090	54.2
	2019	2,480,395	50.3	876,487	51.7	346,668	52.0

group)							
COPD (N, % of patients attached to near-retirement physician group)	2008	233,498	6.5	51,856	7.5	16,411	7.6
	2013	326,748	7.0	115,669	8.3	37,477	8.9
	2019	337,202	6.8	132,395	7.8	59,350	8.9
CHF (N, % of patients attached to near-retirement physician group)	2008	69,573	2.0	15,645	2.3	4,952	2.3
	2013	80,026	1.7	28,187	2.0	9,214	2.2
	2019	90,436	1.8	35,567	2.1	15,832	2.4
Diabetes (N, % of patients attached to near-retirement physician group)	2008	327,127	9.2	68,392	9.9	21,389	10.0
	2013	506,014	10.8	170,115	12.2	52,815	12.5
	2019	555,358	11.3	215,696	12.7	92,395	13.9
Frailty (N, % of patients attached to near-retirement physician group)	2008	66,559	1.9	14,875	2.2	4,964	2.3
	2013	98,490	2.1	33,005	2.4	10,794	2.6
	2019	114,085	2.3	43,032	2.5	18,597	2.8
Any mental health illness in last 2 years (N, % of patients attached to near-retirement physician group)	2008	825,520	23.1	166,257	24.1	51,802	24.1
	2013	979,987	21.0	311,771	22.3	96,543	23.0
	2019	1,022,523	20.7	355,911	21.0	150,153	22.5
Lowest income quintile (N, % of patients attached to near-retirement physician group)	2008	706,504	19.8	150,381	21.8	48,403	22.5
	2013	876,982	18.8	282,922	20.2	91,236	21.8
	2019	944,888	19.1	348,869	20.6	142,881	21.4
Highest housing instability quintile (N, % of patients attached to near-retirement physician group)	2008	761,397	21.3	165,525	24.0	54,275	25.6
	2013	934,472	20.0	295,059	21.1	92,653	22.2
	2019	1,031,506	20.9	374,322	22.1	155,859	23.4

Highest material deprivation quintile (N, % of patients attached to near-retirement physician group)	2008	736,903	20.6	163,835	23.7	52,733	24.9
	2013	1,045,136	22.4	338,012	24.2	112,097	26.9
	2019	926,043	18.8	352,849	20.8	145,084	21.8
Highest neighborhood ethnic concentration quintile (N, % of patients attached to near-retirement physician group)	2008	962,252	26.9	177,586	25.7	63,167	29.8
	2013	1,335,124	28.6	397,430	28.4	124,062	29.8
	2019	1,521,975	30.8	584,512	34.5	213,182	32.0
Recent immigrant (N, % of patients attached to near-retirement physician group)	2008	269,131	7.5	52,717	7.6	21,202	10.9
	2013	289,772	6.2	83,484	6.0	27,024	7.0
	2019	277,755	5.6	82,560	4.9	28,449	4.3

Interpretation of Table 1 rows:

Interpretation of the "Overall" category: For example, in 2019, 1,695,126 patients were attached to a comprehensive FP aged 65+. This represents 14.8% of all patients who are attached to a comprehensive FP.

Interpretation of each patient category: For example, in 2019, of the 666,404 patients attached to comprehensive FPs over the age of 70 years, 28,449 (4.3%) were recent immigrants

FPs: Family physicians

RIO: Rurality Index of Ontario

RUB: Morbidity, based on Resource Utilization Band

COPD: Chronic obstructive pulmonary disease

CHF: Congestive heart failure

Temporal Characteristics of Comprehensive Family Physicians and their Patients

Comprehensive FP Capacity/Workload

eTable 1 shows the mean (SD) roster size for the total population of comprehensive FPs remained consistent over time (2008: 1213 (927); 2013: 1272 (909); 2019: 1209 (837)). Male FPs had consistently larger roster sizes in each age group and at each time point. Both male and female FP roster sizes followed an inverted U pattern with FP age, with practice sizes starting and ending smaller at the extremes of FP age and peaking during mid-career. This pattern was observed at all three time points with older (65+) male and female physicians and younger (<35) male and female physicians caring for larger roster sizes over time.

Working full time equivalent (FTE) also followed an inverted U pattern according to FP age (eTable 1). Older physicians increasingly practiced FTE (2008: 58.4%, 2013: 67.0%, 2019: 72.6%). This was driven by an increasing proportion of female FTE comprehensive FPs. Among younger physicians, by 2019, females comprised the majority of FTE workforce (52.2% of FTE comprehensive FPs <35 years; 55.2% of FTE comprehensive FPs 35-44 years).

Mean (SD) annual core primary care visits provided per patient declined over time (eTable 1): 2008: 7.3 (3.1) visits; 2013: 6.5 (2.6) visits; 2019: 6.0 (2.3) visits. In most comprehensive FP age groups, male and females provided similar numbers of annual visits. Older physicians provided more annual visits compared with their younger counterparts.

In the patient cohort (Table 1), at all near-retirement physician cut-offs (55+, 65+, 70+), a declining proportion over time made a high number (5+) primary care visits in the preceding year, but these proportions remained consistently over 50% in all near-retirement groups and at each time point.

Comprehensive FP Practice Settings

A declining proportion of comprehensive FPs over time practiced in fee-for-service (FFS) models of care. Alternate payment plan models (APPs), specifically capitation/team-based models of care, were an increasingly common setting over time (Supplement: eFigure 2). In these APP models, physician compensation is primarily a lump sum payment per attached patient, with or without additional government funding for interdisciplinary health professional supports. In 2008, most comprehensive FPs worked in FFS-based models (76.6%), but by 2019, most practiced in APPs (55.4%). This shift was seen across all comprehensive FP age groups (Supplement: eTable 2). Correspondingly, an increasing proportion of patients were served in APP models: 2008: 26.5% (n = 2,526,116); 2013: 54.3% (n = 5,643,862); 2019: 61.5% (n = 7,064,109).

Over time, a stable majority of comprehensive FPs practiced in large urban and urban settings (Supplement: eTable 4A). After a decline in 2013, an increasing proportion and number practiced in rural/remote areas by 2019, but numbers did not return to 2008 levels (2008: 6.7%, n = 513; 2013: 5.1%, n = 410; 2019: 5.3%, 492). Trends around age and sex of rural comprehensive FPs resembled trends seen in the overall comprehensive FP population (Supplement: eTables 4B, 4C).

Patient complexity

The mean age (SD) of comprehensive FPs' patients increased over time (eTable 1): 2008: 33.5 (13.2) years; 2013: 36.5 (12.1) years; 2019: 38.1 (12.0) years. When stratified by physician age and sex, each physician age group served increasingly older patients. Male physicians cared for slightly older patients than did women in each physician age group and at each time point.

The number and proportion of patients aged 65 and older increased over time in each near-retirement group (Table 1). This number nearly quadrupled in the oldest (70+ years) FP group (2008: N = 45,414, 2019: N = 176,473).

Comprehensive FPs cared for a stable mean (SD) proportion of female patients over time (eTable 1) (2008:53.2% (12.9); 2013: 53.1% (12.5); 2019: 52.9% (12.0). Female comprehensive FPs had a greater proportion of female patients than male physicians at all time points and in all age groups. The overall proportion of female patients was higher in younger physician age groups at all time points, equalizing as physicians aged.

When examining the patient cohort by near-retirement physician age groups, the proportion of female patients also remained stable at each time point (Table 1), with slightly lower proportions of female patients in the oldest near-retirement group.

Over time, an increasing proportion of comprehensive FPs' practices were comprised of the highest morbidity patients (Resource Utilization Band (RUB) 4+): 2008: 16.5%; 2013: 18.1%; 2019: 19.8% (eTable 5). When stratified by comprehensive FP age and sex, older male physicians cared for higher proportions of the highest morbidity patients than did older female physicians in 2008 (65-69 years) and 2013 (65-69 years, 70+ years), but by 2019, males and females cared for similar proportions of highest morbidity patients within each and across all physician age groups.

Table 1 shows the number and proportion of highest morbidity patients attached to near-retirement physicians grew over time. By 2019, 983,818 patients in the highest morbidity patients were attached to a physician aged 55+, representing 19.9% of all patients attached to a 55+ physician. 350,439 were attached to a 65+ physician (20.7% of patients attached to a 65+

physician). 146,298 were attached to a 70+ physician (22.0% of patients attached to 70+ a physician), representing a tripling of the absolute number.

While proportions of patients with chronic illness (COPD, CHF, diabetes, frailty, mental illness) remained relatively stable over time, the absolute numbers increased markedly in each near-retirement group (Table 1).

The proportions and means of socially complex patients cared for within each comprehensive FP age and sex group increased over time for most indicators (eTable 5) and the number of higher social complexity patients increased markedly over time for most near-retirement groups (Table 1).

DISCUSSION

In our population-level serial cross-sectional analyses, the proportion of patients attached to a comprehensive FP in Ontario, Canada, grew over time. However, we found an increasing proportion of the comprehensive FP workforce is nearing retirement. Given the average FP retires at age 70.5 years,[38] we anticipate that by 2025, nearly 1.7 million Ontarians may lose their comprehensive FP to retirement, eroding gains made to date.

This number may be an underestimate for several reasons. First, half of all comprehensive FPs are now female, and female FPs retire on average 5 years earlier than males.[38] Second, a decreasing proportion of FPs are practicing comprehensive family medicine. This trend was seen across every physician age group, indicating practicing FPs are leaving comprehensive primary care earlier in their careers than in previous years while a smaller proportion of incoming FPs are choosing to enter comprehensive practice. Third, due to limitations in data availability for more recent years, our analyses predate the COVID-19 pandemic, and surveys from Ontario indicate

the pandemic has hastened retirement plans, with almost double the usual proportion of FPs closing their offices during the pandemic (3%, compared with the usual rate of 1.6%/year),[41] and one in five indicating an intention to retire within five years.[42]

Several other trends identified likely apply to other jurisdictions nationally and internationally and, when taken together, indicated limited capacity in the workforce to absorb the workload of near-retirement physicians. Comprehensive FPs cared for increasingly older groups of patients with increasing complexity over time. As of 2019, all physician age groups served similar proportions of complex patients, and near-retirement physicians cared for an increasing number and proportion of older patients with increasing medical and social complexities. Females, who comprised an increasing proportion of the comprehensive FP workforce, served similar proportions of highest morbidity patients but smaller roster sizes compared with males, which may reflect previous research finding women primary care physicians spend more time with and receive more requests from patients.[31 32] That said, both the oldest and youngest male and female comprehensive FP groups served increasingly larger rosters, and an increasing proportion of older (65+) physicians practiced FTE.

Ontario continues to add a net positive number of FPs to the workforce each year, but this number has declined from 453 in 2017 to 303 in 2020.[43] Over the past 7 years, a smaller proportion of medical school graduates ranked family medicine as their first choice discipline,[44] echoing trends in other jurisdictions including the United Kingdom and the United States.[20-22] The future supply of incoming FPs may therefore be inadequate to meet needs identified in our study, especially considering the 1.6 million Ontarians already without a regular primary care provider in our 2019 cohort.

Solutions to FP workforce shortages identified in the literature focus on addressing deterrents to the practice of comprehensive primary care, including perceived poor respect for primary care as a profession, inadequate compensation, inadequate training supports for developing and maintaining comprehensive skills, and inadequate administrative and interdisciplinary health supports to manage increasing patient complexity.[21 24 45-49] Our finding of a shift toward APP models underscores the desire among comprehensive FPs for financial stability and team-based supports. Further, we identified large numbers of patients with chronic diseases and complex social needs, all of which are highly amenable to team-based care.[50-52]

There are some limitations to our study. The FTE indicator is based on physician billings and excluded non-billable administrative time. Almost half of Canadian FPs report 10-19 hours per week of administrative tasks,[53] so the indicator may underestimate workload, and thus the number of FTE FPs. Rural FPs often practice in both primary care and hospital settings;[54] since the comprehensiveness algorithm is based on primary care billings,[29] it may underestimate the number of rural comprehensive FPs. Further, the rurality index scores and methodology have not been updated since 2008. Some physician analyses could not be fully stratified by both age and sex due to small cell sizes. Community Health Centre patients are not included and we did not examine other clinicians who may provide primary care; however, these clinicians are the main primary care source for only a small minority (approximately 1%) of Ontarians.[55 56] Finally, our analyses do not account for the rise of virtual care and its potential impact on capacity.[57-59]

CONCLUSIONS

Primary care faces many capacity challenges as physicians age into retirement and fewer choose to enter or remain in comprehensive practice. Incentives and supports are needed to grow the comprehensive FP workforce to serve a growing and increasingly complex patient population.

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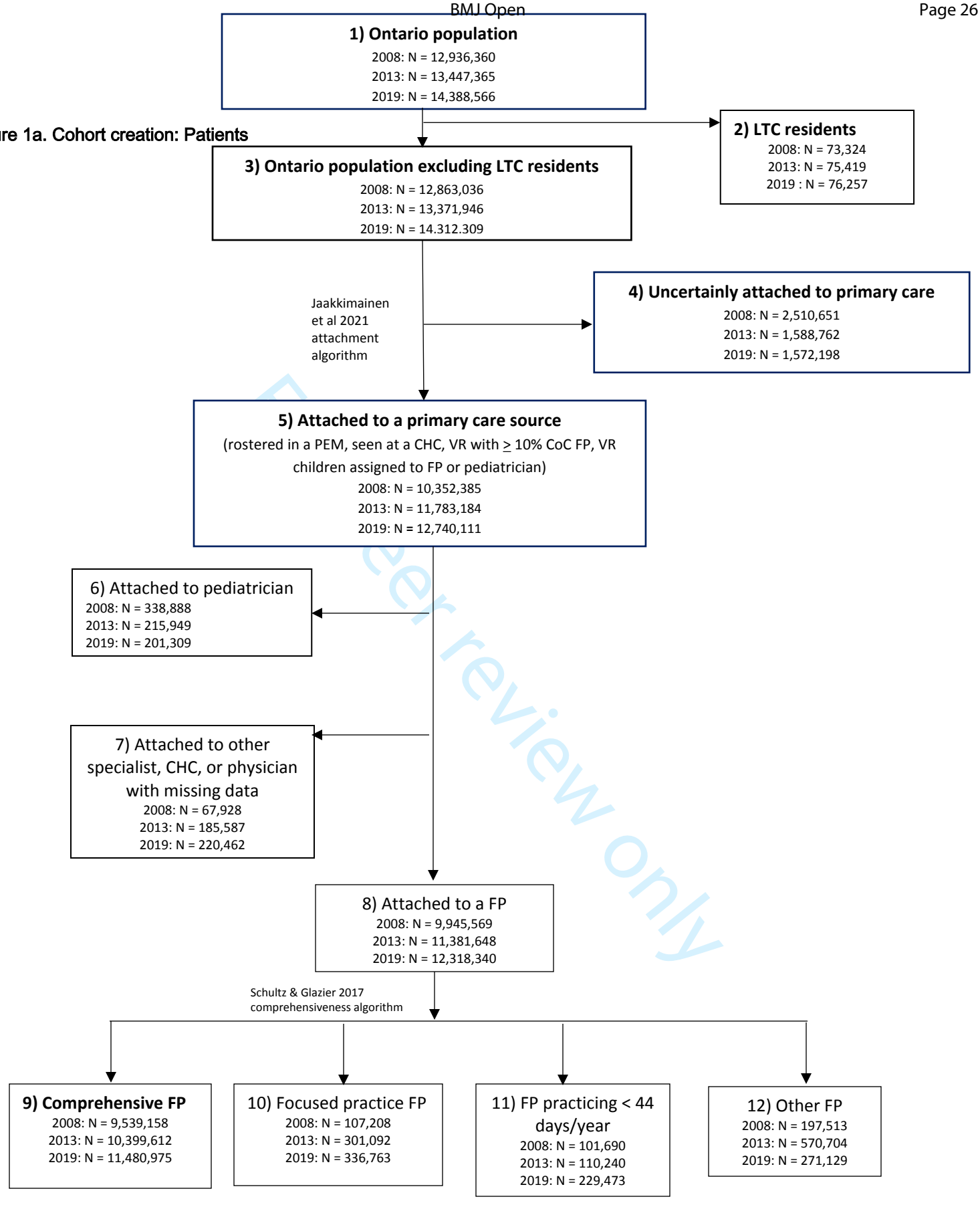
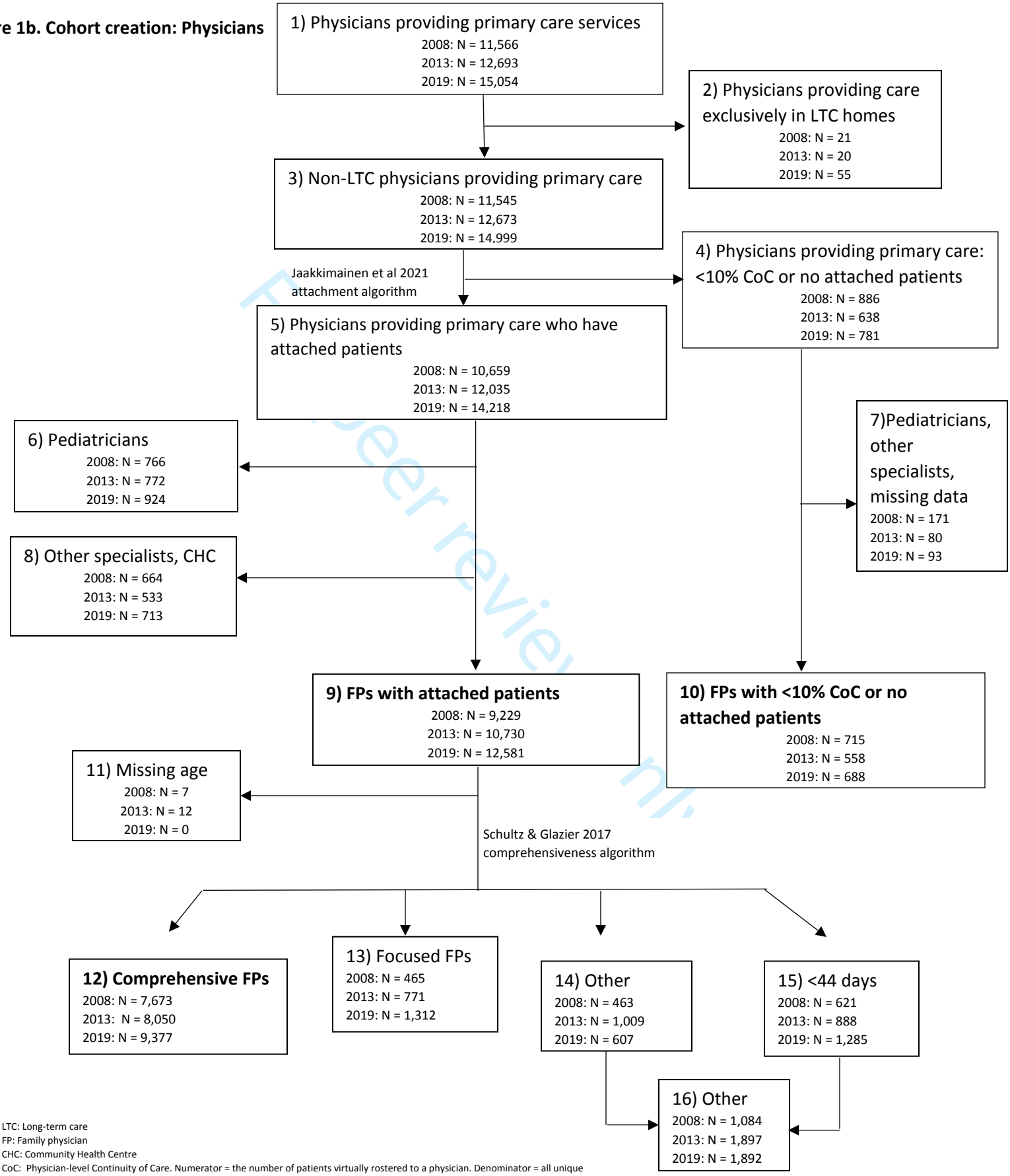
Figure 1a. Cohort creation: Patients



LTC: Long-term care home
FP: Family physician
CHC: Community Health Centre
VR: Virtually Rostered. Patient is considered VR to the physician with whom the majority of their primary care core visits were made over the preceding two-year period (Jaakkimainen et al 2021)
CoC: Physician-level Continuity of Care. Numerator = the number of patients virtually rostered to a physician. Denominator = all unique patients the same physician had seen over two years. Physician CoC ≤ 10% corresponds to low CoC. (Jaakkimainen et al 2021)
Comprehensive FP: Comprehensive scope of primary care practice. At least 50% of prior year's billings are for core primary care services in at least 7 different primary care activity areas (Schultz & Glazier 2017)
Focused FP: Narrowed scope of practice, such as sports medicine, palliative care, hospitalist
Other: Not comprehensive and not focused practice
<44 days: Worked less than 44 days/year

Figure 1b. Cohort creation: Physicians



LTC: Long-term care
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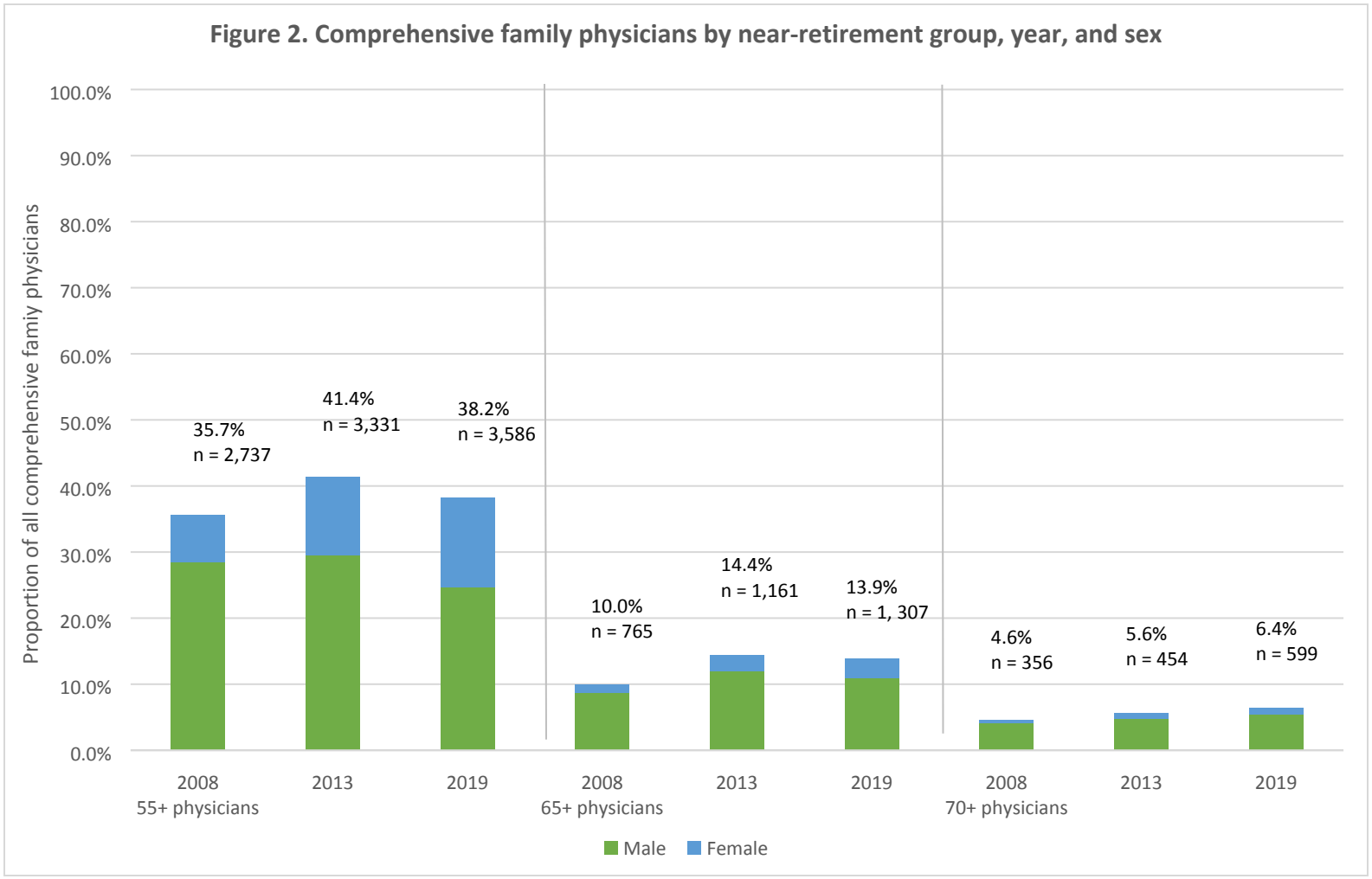


Total Ns (all comprehensive family physicians):

2008: 7,673

2013: 8,050

2019: 9,377

Table 1. Characteristics of patients attached to near-retirement comprehensive family physicians over time, by near-retirement group

		Age 55+ Comprehensive FPs		Age 65+ Comprehensive FPs		Age 70+ Comprehensive FPs	
Patient Characteristics		N	%	N	%	N	%
OVERALL (N, % of all patients attached to all comprehensive FPs)	2008	3,571,661	37.5	690,642	7.2	214,861	2.3
	2013	4,676,625	45.0	1,399,119	13.5	419,172	4.0
	2019	4,935,992	43.0	1,695,126	14.8	666,404	5.8
Aged 65+ (N, % of patients attached to near-retirement physician group)	2008	597,707	16.7	136,394	19.8	45,414	21.1
	2013	846,974	18.1	298,545	21.3	95,833	22.8
	2019	1,003,769	20.3	402,430	23.7	176,473	26.5
Female patients (N, % of patients attached to near-retirement physician group)	2008	1,804,585	50.5	338,656	49.0	103,386	48.1
	2013	2,371,923	50.7	678,971	48.5	201,104	48.0
	2019	2,498,453	50.6	823,090	48.6	317,967	47.7
Rural patients (RIO score 40+) (N, % of patients attached to near-retirement physician group)	2008	233,045	6.5	48,860	7.1	14,323	6.7
	2013	292,357	6.3	88,311	6.3	20,294	4.8
	2019	274,099	5.6	83,691	4.9	33,545	5.0
Highest (4+) RUB (N, % of patients attached to near-retirement physician group)	2008	677,436	19.0	137,995	20.0	44,067	20.5
	2013	878,340	18.8	283,013	20.2	88,182	21.0
	2019	983,818	19.9	350,439	20.7	146,298	22.0
Highest (5+) annual core primary care visits (N, % of patients attached to near-retirement physician group)	2008	2,109,950	59.1	403,026	58.4	127,050	59.1
	2013	2,462,236	52.7	753,388	53.9	227,090	54.2
	2019	2,480,395	50.3	876,487	51.7	346,668	52.0

COPD (N, % of patients attached to near-retirement physician group)	2008	233,498	6.5	51,856	7.5	16,411	7.6
	2013	326,748	7.0	115,669	8.3	37,477	8.9
	2019	337,202	6.8	132,395	7.8	59,350	8.9
CHF (N, % of patients attached to near-retirement physician group)	2008	69,573	2.0	15,645	2.3	4,952	2.3
	2013	80,026	1.7	28,187	2.0	9,214	2.2
	2019	90,436	1.8	35,567	2.1	15,832	2.4
Diabetes (N, % of patients attached to near-retirement physician group)	2008	327,127	9.2	68,392	9.9	21,389	10.0
	2013	506,014	10.8	170,115	12.2	52,815	12.5
	2019	555,358	11.3	215,696	12.7	92,395	13.9
Frailty (N, % of patients attached to near-retirement physician group)	2008	66,559	1.9	14,875	2.2	4,964	2.3
	2013	98,490	2.1	33,005	2.4	10,794	2.6
	2019	114,085	2.3	43,032	2.5	18,597	2.8
Any mental health illness in last 2 years (N, % of patients attached to near-retirement physician group)	2008	825,520	23.1	166,257	24.1	51,802	24.1
	2013	979,987	21.0	311,771	22.3	96,543	23.0
	2019	1,022,523	20.7	355,911	21.0	150,153	22.5
Lowest income quintile (N, % of patients attached to near-retirement physician group)	2008	706,504	19.8	150,381	21.8	48,403	22.5
	2013	876,982	18.8	282,922	20.2	91,236	21.8
	2019	944,888	19.1	348,869	20.6	142,881	21.4
Highest housing instability quintile (N, % of patients attached to near-retirement physician group)	2008	761,397	21.3	165,525	24.0	54,275	25.6
	2013	934,472	20.0	295,059	21.1	92,653	22.2
	2019	1,031,506	20.9	374,322	22.1	155,859	23.4
Highest material deprivation	2008	736,903	20.6	163,835	23.7	52,733	24.9

quintile (N, % of patients attached to near-retirement physician group)	2013	1,045,136	22.4	338,012	24.2	112,097	26.9
	2019	926,043	18.8	352,849	20.8	145,084	21.8
Highest neighborhood ethnic concentration quintile (N, % of patients attached to near-retirement physician group)	2008	962,252	26.9	177,586	25.7	63,167	29.8
	2013	1,335,124	28.6	397,430	28.4	124,062	29.8
	2019	1,521,975	30.8	584,512	34.5	213,182	32.0
Recent immigrant (N, % of patients attached to near-retirement physician group)	2008	269,131	7.5	52,717	7.6	21,202	10.9
	2013	289,772	6.2	83,484	6.0	27,024	7.0
	2019	277,755	5.6	82,560	4.9	28,449	4.3

Interpretation of Table 2 rows:

Interpretation of the "Overall" category: For example, in 2019, 1,695,126 patients were attached to a comprehensive FP aged 65+. This represents 14.8% of all patients who are attached to a comprehensive FP.

Interpretation of each patient category: For example, in 2019, of the 666,404 patients attached to comprehensive FPs over the age of 70 years, 28,449 (4.3%) were recent immigrants

FPs: Family physicians

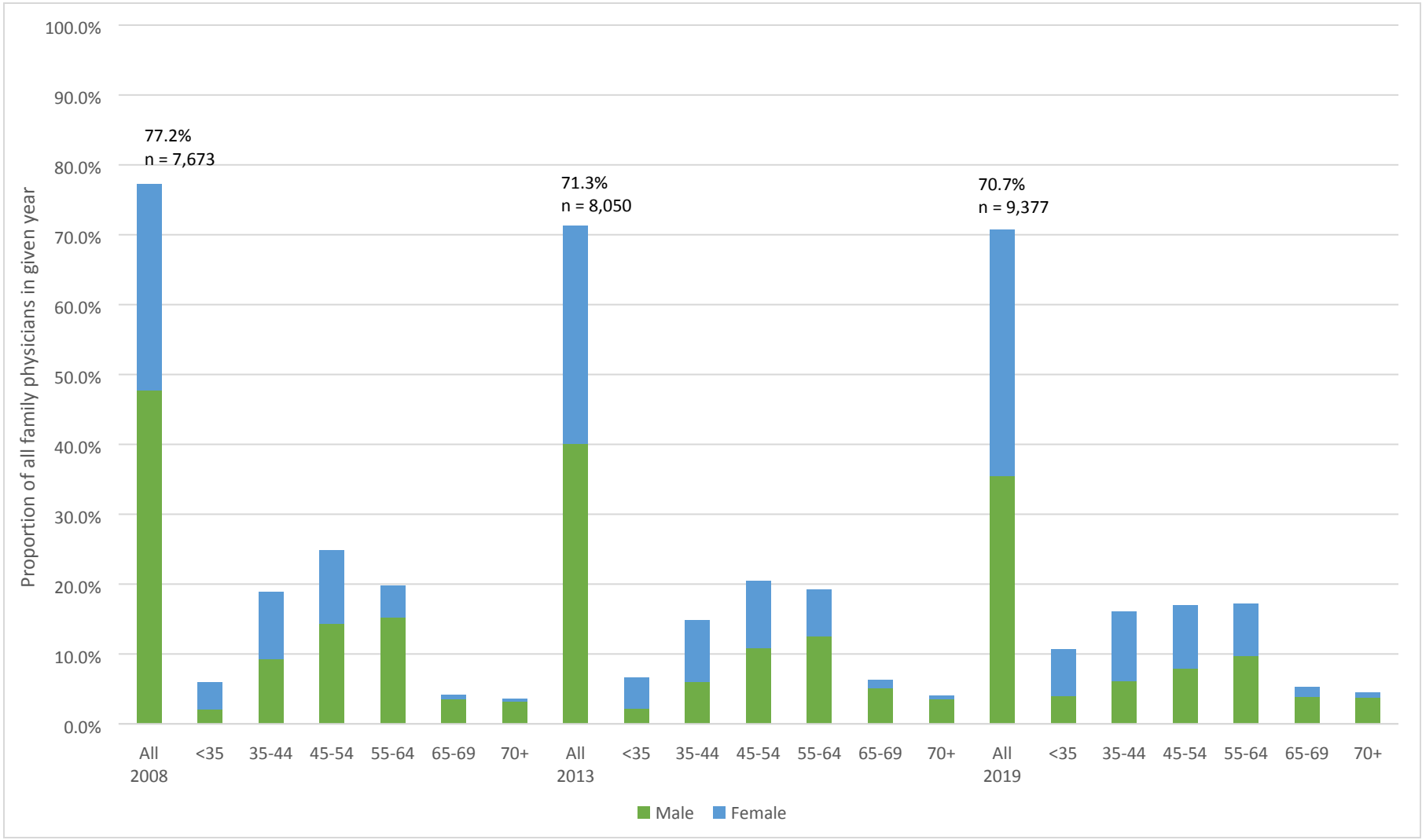
RIO: Rurality Index of Ontario

RUB: Morbidity, based on Resource Utilization Band

COPD: Chronic obstructive pulmonary disease

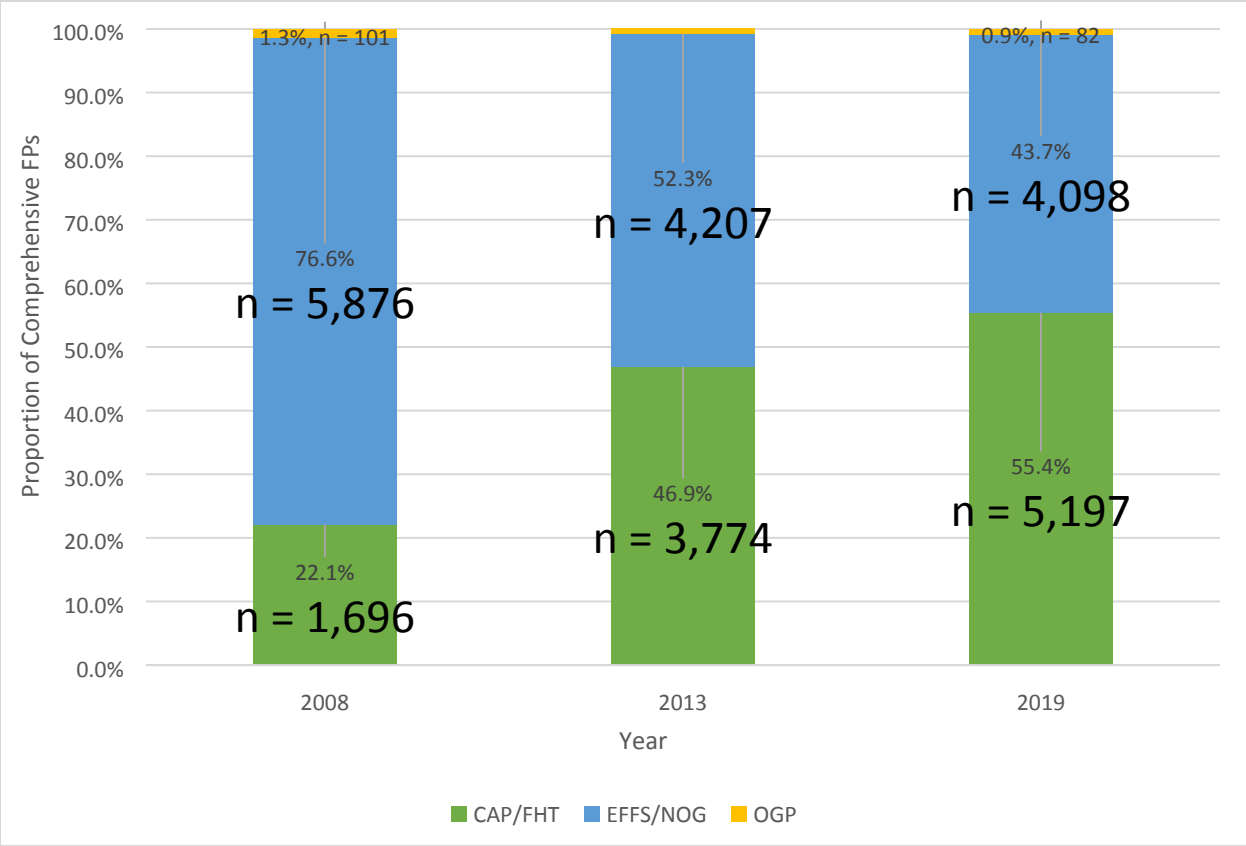
CHF: Congestive heart failure

eFigure 1. Proportion of family physicians practicing comprehensiveness by year, age, and sex



Total Ns (all family physicians): 2008: 9,944; 2013: 11,288; 2019: 13,269

eFigure 2. Proportion of comprehensive family physicians in various practice models by year



Total Ns (all comprehensive family physicians): 2008: 7,673; 2013: 8,050; 2019: 9,377

CAP/FHT: Alternate payment plan (APP) model where physician payments are mainly capitation(CAP)-based (annual amount per enrolled patient, adjusted for patient age and sex), with or without additional funding for interdisciplinary team members (Family Health Team(FHT)) such as nurse practitioners and social workers

EFFS/NOG: Fee-for-service payment models. EFFS = fee-for-service payments with enrolment requirements and some pay enhancements, such as higher payments for enrolled patients and bonus payments for meeting preventive care targets. NOG = No group; traditional fee-for-service payments with no enrolment requirements or payment enhancements.

eTable 1. Practice characteristics of comprehensive family physicians

		<35 Years			35-44 Years			45-54 Years			55-64 Years			65-69 Years			70+ Years			Total Comprehensive FPs		
		Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F		M	F	Total	M	F
Comp. FPs N (%)	2008	592 (7.7)	211 (35.6)	381 (64.4)	1877 (24.5)	922 (49.1)	955 (50.9)	2467 (32.2)	1422 (57.6)	1045 (42.4)	1972 (25.7)	1522 (77.2)	450 (22.8)	409 (5.3)	347 (84.8)	62 (15.2)	356 (4.6)	319 (89.6)	37 (10.4)	7673 (100.0)	4743 (61.8)	2930 (38.2)
	2013	741 (9.2)	245 (33.1)	496 (66.9)	1666 (20.7)	674 (40.5)	992 (59.5)	2312 (28.7)	1227 (53.1)	1085 (46.9)	2170 (27.0)	1415 (65.2)	755 (34.8)	707 (8.8)	576 (81.5)	131 (18.5)	454 (5.6)	392 (86.3)	62 (13.7)	8050 (100.0)	4529 (56.3)	3521 (43.7)
	2019	1414 (15.1)	528 (37.3)	886 (62.7)	2135 (22.8)	806 (37.8)	1329 (62.2)	2242 (23.9)	1048 (46.7)	1194 (53.3)	2279 (24.3)	1290 (56.6)	989 (43.4)	708 (7.6)	519 (73.3)	189 (26.7)	599 (6.4)	505 (84.3)	94 (15.7)	9377 (100.0)	4696 (50.1)	4681 (49.9)
Years in pract. (mean (SD))	2008	6.0 (±2.3)	6.3 (±2.3)	5.9 (±2.2)	14.4 (±3.9)	14.7 (±3.8)	14.1 (±3.9)	23.7 (±4.2)	23.8 (±4.2)	23.5 (±4.2)	33.4 (±4.4)	33.6 (±4.2)	32.8 (±4.8)	41.3 (±3.0)	41.2 (±3.0)	42.0 (±3.2)	48.0 (±5.1)	48.0 (±4.9)	47.8 (±6.4)	24.6 (±11.4)	27.3 (±11.2)	20.2 (±10.1)
	2013	5.7 (±2.1)	5.4 (±2.1)	5.9 (±2.1)	13.8 (±4.2)	14.0 (±4.2)	13.7 (±4.1)	23.9 (±4.2)	23.9 (±4.0)	23.8 (±4.4)	33.2 (±4.4)	33.6 (±4.4)	32.5 (±4.5)	41.2 (±3.5)	41.1 (±3.4)	41.6 (±4.0)	48.7 (±4.9)	48.7 (±4.9)	49.0 (±4.9)	25.6 (±12.3)	28.8 (±12.1)	21.4 (±11.1)
	2019	5.8 (±2.0)	5.7 (±2.0)	5.8 (±1.9)	12.5 (±4.2)	12.5 (±4.4)	12.5 (±4.0)	23.7 (±4.7)	23.9 (±4.7)	23.5 (±4.6)	33.3 (±4.7)	33.4 (±4.5)	33.2 (±4.9)	40.8 (±3.6)	41.0 (±3.4)	40.3 (±4.0)	48.5 (±5.1)	48.4 (±5.3)	48.7 (±4.1)	23.7 (±13.4)	27.0 (±13.8)	20.3 (±12.0)
Roster size (mean (SD))	2008	638.3 (±622.5)	790.7 (±722.0)	553.9 (±542.7)	1131.8 (±873.2)	1323.5 (±981.3)	946.7 (±707.0)	1345.1 (±920.7)	1470.3 (±996.7)	1174.6 (±774.4)	1432.1 (±945.2)	1494.0 (±961.5)	1222.7 (±856.4)	1123.1 (±955.5)	1186.1 (±981.7)	770.7 (±701.1)	566.3 (±770.9)	584.9 (±785.4)	406.5 (±618.7)	1212.8 (±927.0)	1338.8 (±991.1)	1008.8 (±770.0)
	2013	620.0 (±605.9)	725.2 (±690.9)	568.0 (±552.6)	1152.8 (±836.0)	1348.6 (±935.1)	1019.7 (±732.6)	1407.1 (±927.1)	1567.8 (±1013.4)	1225.4 (±780.2)	1490.2 (±894.6)	1593.1 (±937.6)	1297.2 (±772.4)	1366.1 (±905.8)	1420.3 (±921.3)	1128.0 (±794.3)	898.1 (±895.7)	946.7 (±922.9)	591.1 (±622.7)	1272.1 (±909.2)	1425.0 (±975.2)	1075.4 (±773.4)
	2019	734.0 (±644.2)	834.7 (±712.0)	674.0 (±592.4)	1074.5 (±720.3)	1217.2 (±841.6)	987.9 (±620.1)	1394.8 (±876.2)	1529.3 (±946.5)	1276.7 (±791.2)	1405.6 (±847.2)	1531.6 (±902.2)	1241.1 (±738.3)	1434.4 (±900.5)	1502.5 (±932.8)	1247.6 (±777.3)	1098.0 (±804.3)	1125.7 (±815.1)	949.2 (±729.6)	1208.9 (±837.4)	1351.9 (±908.8)	1065.4 (±731.6)
Core PC visits (mean (SD))	2008	6.2 (±2.7)	6.2 (±2.8)	6.2 (±2.7)	7.3 (±4.2)	7.5 (±5.6)	7.2 (±2.3)	7.3 (±2.3)	7.4 (±2.5)	7.3 (±2.1)	7.7 (±2.6)	7.7 (±2.6)	7.7 (±2.4)	7.5 (±3.1)	7.6 (±3.2)	6.9 (±2.7)	6.8 (±3.5)	6.9 (±3.5)	6.2 (±2.9)	7.3 (±3.1)	7.4 (±3.5)	7.1 (±2.4)
	2013	5.3 (±2.3)	5.4 (±2.3)	5.3 (±2.3)	6.3 (±2.1)	6.2 (±2.2)	6.3 (±2.0)	6.5 (±2.4)	6.6 (±2.7)	6.4 (±2.0)	6.7 (±2.8)	6.8 (±3.2)	6.4 (±1.9)	6.9 (±2.4)	6.9 (±2.4)	7.0 (±2.3)	7.3 (±4.0)	7.5 (±4.2)	6.5 (±2.4)	6.5 (±2.6)	6.6 (±2.9)	6.3 (±2.1)
	2019	5.6 (±2.5)	5.5 (±2.6)	5.6 (±2.4)	6.0 (±2.5)	5.9 (±2.8)	6.0 (±2.4)	6.1 (±2.1)	6.1 (±2.3)	6.1 (±1.9)	6.1 (±2.1)	6.2 (±2.3)	6.0 (±1.8)	6.4 (±2.2)	6.5 (±2.3)	6.2 (±2.0)	6.7 (±3.0)	6.5 (±2.9)	7.2 (±3.1)	6.0 (±2.3)	6.1 (±2.5)	6.0 (±2.2)
Pt age (mean (SD))	2008	27.9 (±13.8)	29.4 (±14.0)	27.1 (±13.6)	31.7 (±11.7)	32.8 (±12.6)	30.5 (±10.7)	34.3 (±11.9)	35.4 (±12.5)	32.7 (±10.8)	36.7 (±13.1)	37.6 (±13.2)	33.7 (±12.2)	35.1 (±16.2)	36.0 (±16.1)	30.5 (±15.9)	28.2 (±18.5)	28.5 (±18.5)	25.5 (±17.8)	33.5 (±13.2)	34.9 (±13.8)	31.3 (±11.8)
	2013	28.2 (±13.7)	30.0 (±13.7)	27.4 (±13.6)	34.0 (±10.8)	35.0 (±11.6)	33.4 (±10.1)	36.4 (±10.7)	37.8 (±11.2)	34.8 (±9.9)	39.4 (±10.7)	40.5 (±11.1)	37.3 (±9.8)	40.9 (±12.6)	42.0 (±12.4)	36.3 (±12.7)	39.1 (±17.0)	39.7 (±17.1)	35.0 (±16.0)	36.5 (±12.1)	38.5 (±12.5)	34.0 (±11.2)
	2019	31.8 (±14.5)	33.5 (±14.2)	30.7 (±14.5)	36.4 (±10.9)	37.1 (±11.8)	36.0 (±10.3)	38.4 (±9.8)	39.4 (±10.6)	37.5 (±9.0)	40.6 (±10.5)	42.0 (±10.8)	38.7 (±9.8)	43.0 (±11.5)	43.9 (±11.6)	40.8 (±10.9)	43.3 (±14.3)	43.6 (±14.5)	41.2 (±13.1)	38.1 (±12.0)	40.0 (±12.3)	36.2 (±11.3)
Prop. Fem. Pts (mean (SD))	2008	55.7 (±15.1)	46.9 (±10.7)	60.7 (±14.9)	55.2 (±13.2)	46.2 (±7.5)	63.8 (±11.6)	54.3 (±13.0)	46.3 (±7.4)	65.3 (±10.9)	51.0 (±11.0)	46.8 (±7.0)	65.0 (±10.7)	49.5 (±11.1)	47.3 (±8.5)	61.5 (±15.7)	47.8 (±13.2)	46.7 (±11.1)	57.6 (±22.6)	53.2 (±12.9)	46.6 (±7.8)	64.0 (±12.1)
	2013	55.3 (±15.6)	47.8 (±13.7)	59.0 (±15.1)	55.1 (±12.1)	46.1 (±8.3)	61.2 (±10.4)	53.7 (±12.3)	45.6 (±7.4)	62.9 (±9.9)	52.4 (±12.1)	45.9 (±7.5)	64.7 (±9.3)	48.9 (±10.1)	45.9 (±7.2)	62.2 (±10.5)	49.6 (±12.2)	47.2 (±10.4)	64.8 (±11.9)	53.1 (±12.5)	46.1 (±8.3)	62.3 (±11.0)
	2019	54.3 (±13.7)	47.7 (±11.2)	58.2 (±13.6)	54.3 (±11.8)	45.0 (±8.2)	59.9 (±10.0)	53.5 (±11.2)	45.4 (±7.6)	60.6 (±8.9)	52.4 (±11.8)	44.8 (±7.8)	62.2 (±8.5)	49.9 (±11.7)	45.1 (±7.9)	63.0 (±10.2)	48.2 (±9.9)	45.9 (±8.1)	60.7 (±9.6)	52.9 (±12.0)	45.5 (±8.4)	60.4 (±10.3)
FTE (N (%))	2008	290 (49.0)	146 (50.3)	144 (49.7)	1210 (64.5)	754 (62.3)	456 (37.7)	1802 (73.0)	1173 (65.1)	629 (34.9)	1481 (75.1)	1209 (81.6)	272 (18.4)	239 (58.4)	220 (92.1)	19 (8.0)	114 (32.0)	107 (93.9)	7 (6.1)	5136 (66.9)	3609 (70.3)	1527 (29.7)
	2013	335 (45.4)	152 (45.4)	183 (54.6)	1073 (64.4)	556 (51.8)	517 (48.2)	1694 (73.3)	1014 (59.9)	680 (40.1)	1634 (75.3)	1156 (70.8)	478 (29.3)	474 (67.0)	415 (87.6)	59 (12.5)	189 (41.6)	177 (93.7)	12 (6.4)	5399 (67.1)	3470 (64.3)	1929 (35.7)
	2019	734 (51.9)	351 (47.8)	383 (52.2)	1401 (65.6)	628 (44.8)	773 (55.2)	1722 (76.8)	881 (51.2)	841 (48.8)	1681 (73.8)	1052 (62.6)	629 (37.4)	514 (72.6)	402 (78.2)	112 (21.8)	327 (54.6)	288 (88.1)	39 (11.9)	6379 (68.0)	3602 (56.5)	2777 (43.5)

Comp. FPs: Comprehensive family physicians; Pract.: Practice; PC: Primary care; Pt(s): Patient(s); Prop: Proportion; Fem: Female; FTE: Full-time equivalent

eTable 2. Family physicians in non-comprehensive (i.e., "focused" or "other") scopes of practice over time by physician

	<35 Years		35-44 Years		45-54 Years		55-64 Years		65-69 Years		70+
	N	% of all FPs	N	% of all FPs	N	% of all FPs	N	% of all FPs	N	% of all FPs	N
2008	217	2.2	463	4.7	397	4	286	2.9	84	0.8	102
2013	418	3.7	612	5.4	586	5.2	522	4.6	233	2.1	297
2019	561	4.2	677	5.1	563	4.2	654	4.9	323	2.4	426
Relative Change (2019/ 2008)		194%		109%		106%		171%		289%	
Absolute Change (2019 minus 2008)		2.05%		0.45%		0.25%		2.05%		1.59%	

ı age group

Years	Total - Focused/Other		Total - All FPs
% of all FPs	N	% of all FPs	N
1	1549	15.6	9,944
2.6	2668	23.6	11,288
3.2	3204	24.2	13,269
312%		155%	
2.18%		8.60%	

eTable 3. Comprehensive family physician practice model over time by physician age and sex

Year	Model	Age < 35						Age 35 - 44					
		Total	Total	Male		Female		Total	Total	Male		Female	
		N	%	N	%	N	%	N	%	N	%	N	%
2008													
	EFFS	243	41	91	43.1	152	39.9	1009	53.8	513	55.6	496	51.9
	CAP	56	9.5	*11 - 15		*43 - 47		167	8.9	70	7.6	97	10.2
	FHT	85	14.4	35	16.6	50	13.1	281	15	126	13.7	155	16.2
	NOG	198	33.4	69	32.7	129	33.9	389	20.7	202	21.9	187	19.6
	OGP	10	1.7	*1-5		*3 - 7		31	1.7	11	1.2	20	2.1
2013													
	EFFS	162	21.9	65	26.5	97	19.6	571	34.3	243	36.1	328	33.1
	CAP	108	14.6	*28 - 32		*76-80		361	21.7	*127 - 131		*229 - 233	
	FHT	186	25.1	64	26.1	122	24.6	461	27.7	183	27.2	*276 - 280	
	NOG	277	37.4	83	33.9	194	39.1	266	16	116	17.2	150	15.1
	OGP	8	1.1	*1-5		*3-7		7	0.4	*1-5		*2 - 6	
2019													
	EFFS	249	17.6	*103 - 107		*144 - 148		518	24.3	218	27	300	22.6
	CAP	341	24.1	124	23.5	217	24.5	597	28	193	23.9	404	30.4
	FHT	376	26.6	137	25.9	239	27	683	32	252	31.3	431	32.4
	NOG	437	30.9	157	29.7	280	31.6	316	14.8	133	16.5	183	13.8
	OGP	11	0.8	*3 - 7		*2 - 6		21	1	10	1.2	11	0.8

Percentages are column percentages

Ranges preceded by an asterisk (*) represent suppressed cells due to small cell sizes

EFFS: Enhanced fee-for-service. This is a fee-for-service payment model that requires patient enrollment and includes some pay enhancements, such as higher fee-for-service payments for enrolled p

CAP: Capitation. An alternate payment plan (APP) model where the majority of physician payments come from an annual amount for each enrolled patient adjusted for patient age and sex.

FHT: Capitation models with additional funding for interdisciplinary team members such as nurse practitioners and social workers.

NOG: No group. These physicians are paid via traditional fee-for-service, without any enrolment requirements or pay enhancements.

OGP: Other physician group types, typically serving a specific targeted population or geography (for example, rural/remote) with varying funding mechanisms.

Age 45 - 54						Age 55 - 64							
Total	Total	Male		Female		Total	Total	Male		Female		Total	Total
N	%	N	%	N	%	N	%	N	%	N	%	N	%
1410	57.2	796	56	614	58.8	1184	60	903	59.3	281	62.4	210	51.3
191	7.7	114	8	77	7.4	*128-132		104	6.8	*24 - 28		*30-34	
402	16.3	228	16	174	16.7	*276-280		228	15	*48 - 52		48	11.7
427	17.3	256	18	171	16.4	356	18.1	268	17.6	88	19.6	118	28.9
37	1.5	28	2	9	0.9	*20-24		19	1.2	*1-5		*1-5	
853	36.9	464	37.8	389	35.9	766	35.3	481	34	285	37.7	292	41.3
582	25.2	310	25.3	272	25.1	603	27.8	407	28.8	196	26	168	23.8
547	23.7	*266-270		*277 - 281		501	23.1	325	23	176	23.3	127	18
313	13.5	172	14	141	13	273	12.6	183	12.9	90	11.9	110	15.6
17	0.7	*11-15		*2 - 6		27	1.2	19	1.3	8	1.1	10	1.4
712	31.8	*348 - 352		*360-364		707	31	408	31.6	299	30.2	244	34.5
699	31.2	315	30.1	384	32.2	725	31.8	399	30.9	326	33	221	31.2
583	26	255	24.3	328	27.5	577	25.3	321	24.9	256	25.9	151	21.3
237	10.6	123	11.7	114	9.5	241	10.6	141	10.9	100	10.1	82	11.6
11	0.5	*3 - 7		*4-8		29	1.3	21	1.6	8	0.8	*6-10	

patients and bonus payments for preventive care targets.

Age 65 - 69						Age 70+						Total Sample	
Male		Female		Total	Total	Male		Female		Total	Total	Male	
N	%	N	%	N	%	N	%	N	%	N	%	N	%
174	50.1	36	58.1	142	39.9	129	40.4	13	35.1	4198	54.7	2606	54.9
*27 - 31		*1 - 5		7	2	7	2.2	0	0	583	7.6	337	7.1
*43-47		*1 - 5		17	4.8	*12-16		*1 - 5		1113	14.5	680	14.3
*94-98		*20 - 24		190	53.4	*163-167		*23 - 27		1678	21.9	1056	22.3
*1-5		0	0	0	0	0	0	0	0	101	1.3	64	1.3
218	37.8	74	56.5	173	38.1	149	38	24	38.7	2817	35	1620	35.8
146	25.3	22	16.8	75	16.5	*65-69		*6 - 10		1897	23.6	1091	24.1
114	19.8	13	9.9	55	12.1	*50-54		*1 - 5		1877	23.3	1007	22.2
88	15.3	22	16.8	151	33.3	124	31.6	27	43.5	1390	17.3	766	16.9
10	1.7	0	0	0	0	0	0	0	0	69	0.9	45	1
*163 - 167		*75 - 79		239	39.9	*190 - 194		48	51.1	2669	28.5	1437	30.6
176	33.9	45	23.8	165	27.5	146	28.9	19	20.2	2748	29.3	1353	28.8
109	21	42	22.2	79	13.2	71	14.1	8	8.5	2449	26.1	1145	24.4
64	12.3	22	11.6	112	18.7	93	18.4	19	20.2	1429	15.2	711	15.1
*3 - 7		*1-5		*1-5		*1-5		0	0	82	0.9	50	1.1

Female	
N	%
1592	54.3
246	8.4
433	14.8
622	21.2
37	1.3
1197	34
806	22.9
870	24.7
624	17.7
24	0.7
1232	26.3
1395	29.8
1304	27.9
718	15.3
32	0.7

eTable 4. Geographic Distribution of Comprehensive FPs

A. Comprehensive FPs by Geography

	Large Urban	Urban	Small Urban/Suburban	Rural/Remote	Total
2008					
N (% of Comprehensive FPs)	3,909 (51.1)	1,990 (26.0)	1,236 (16.2)	513 (6.7)	7,648 (100.0)
2013					
N (% of Comprehensive FPs	4,105 (51.1)	2,314 (28.8)	1,207 (15.0)	410 (5.1)	8,036 (100.0)
2019					
N (% of Comprehensive FPs	4,674 (50.0)	2,685 (28.7)	14,98 (16.0)	492 (5.3)	9,349 (100.0)

Note: Geographic data missing for: 2008 (25), 2013 (14), 2019 (28)

B. Rural (RIO 40+) Comprehensive FPs by Age Group

	<35 years	35-44 years	45-54 years	55-64 years	65-69 years	70+ years	Total
2008							
N (% of rural comprehensive FPs)	46 (9.0)	135 (26.3)	166 (32.4)	118 (23.0)	27 (5.3)	21 (4.1)	513 (100.0)
2013							
N (% of rural comprehensive FPs)	31 (7.6)	76 (18.5)	109 (26.6)	129 (31.5)	44 (10.7)	21 (5.1)	410 (100.0)
2019							
N (% of rural comprehensive FPs)	89 (18.1)	111 (22.6)	121 (24.6)	117 (23.8)	32 (6.5)	22 (4.5)	492 (100.0)

C. Rural (RIO 40+) Comprehensive FPs by Physicians Sex

	Male Physicians			Female Physicians			Total Rural	
	N	% of Rural Comprehensive FPs	% of all Comprehensive FPs	N	% of Rural Comprehensive FPs	% of all Comprehensive FPs	N	% of all Comprehensive FPs
2008	362	70.6	4.7	151	29.4	2	513	6.7
2013	268	65.4	3.3	142	34.6	1.8	410	5.1
2019	279	56.7	3	213	43.3	2.3	492	5.3

We were unable to stratify by both age and sex due to suppressed cells (cell sizes <6) in older age categories for male and female physicians in the rural category.

Large urban: Rurality Index of Ontario (RIO) score of 0

Urban: RIO score of 1-9

Suburban/Small Urban: RIO score of 10-39

Rural/remote: RIO score of 40+

All Comprehensive FPs	
N	% of all Comprehensive FPs
7648	6.7
8036	5.1
9349	5.3

eTable 5. Practice characteristics: Medical and social complexity of patients attached to comprehensive family physicians over time by physician age and sex

		<35 Years			35-44 Years			45-54 Years			55-64 Years			65-69 Years			70+ Years			TOTAL		
		Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Highest morbidity (RUB (4+))	2008	15.3	14.7	15.6	16.2	15.8	16.7	16.4	16.5	16.2	17.3	17.5	16.6	16.8	17.2	14.0	14.0	14.1	13.0	16.5	16.7	16.3
	2013	17.5	17.6	17.4	18.2	17.5	18.7	17.7	17.8	17.6	18.1	18.5	17.3	19.5	20.0	17.5	20.1	20.5	17.9	18.1	18.3	17.8
	2019	19.3	19.4	19.2	20.6	20.2	20.8	19.4	19.4	19.4	19.5	20.2	18.7	20.3	20.4	20.1	21.4	21.5	21.3	19.8	19.9	19.7
Lowest income quintile	2008	18.5	19.2	18.1	18.1	19.6	16.6	18.4	19.8	16.4	19.9	20.2	18.8	22.6	22.5	23.6	23.9	20.1	17.2	19.0	20.1	17.2
	2013	18.9	20.6	18.0	17.2	19.1	16.0	18.0	19.4	16.4	18.4	19.5	16.5	20.5	20.4	21.2	24.0	24.2	22.5	18.3	19.6	16.7
	2019	20.4	21.9	20.7	18.8	20.7	17.6	18.3	20.5	16.5	18.8	20.4	16.8	19.9	20.7	17.9	22.1	22.2	21.4	19.0	20.7	17.5
Highest housing instability quintile	2008	24.5	22.8	25.5	20.6	20.7	20.4	20.4	20.4	20.4	21.9	21.6	23.0	24.0	23.1	29.2	25.5	25.6	24.2	21.4	21.2	21.7
	2013	26.0	23.6	27.2	21.8	20.9	22.5	19.9	20.4	19.4	20.8	20.6	21.3	21.7	21.8	21.2	24.5	24.1	26.6	21.4	20.9	21.9
	2019	26.5	25.3	27.2	24.5	24.7	24.5	21.1	21.8	20.4	21.4	21.5	21.3	22.6	21.7	24.9	25.5	25.2	27.1	23.0	22.7	23.3
Highest material deprivation quintile	2008	18.6	19.8	17.9	17.4	19.3	15.5	18.2	20.1	15.6	20.5	21.3	18.1	23.7	23.9	22.4	25.7	26.2	21.3	19.0	20.6	16.4
	2013	22.9	24.6	22.0	20.5	22.1	19.4	21.2	22.9	19.3	21.4	22.6	19.2	23.7	23.2	25.7	29.2	29.4	27.8	21.5	22.8	19.9
	2019	18.2	19.7	17.3	17.3	19.9	15.8	17.0	19.3	15.0	18.1	19.8	15.9	19.7	20.9	16.7	21.8	22.1	19.9	17.8	19.8	15.9
Highest neighborhood ethnic concentration quintile	2008	27.4	30.8	25.5	27.5	28.4	26.5	26.0	26.1	25.9	27.2	26.3	30.4	28.0	26.4	37.2	32.6	32.8	30.7	26.9	26.9	27.0
	2013	29.9	31.1	29.2	28.6	29.2	28.2	27.9	29.2	26.6	27.2	27.2	27.3	27.7	25.5	37.3	33.0	32.0	39.4	28.0	28.1	28.0
	2019	26.0	26.6	25.7	25.8	27.2	25.0	28.5	29.2	27.8	27.0	26.8	27.3	33.2	33.7	31.9	32.1	30.9	38.5	27.4	28.3	26.7

Interpretation: For example, in 2008, within the group of comprehensive family physicians under the age of 35 years, 15.3% of patients in those practices had the highest level of morbidity (RUB 4+). When further stratified by physician sex, 14.7% of patients attached to male comprehensive family physicians belonged to the highest morbidity (RUB 4+) group.

RUB: Morbidity, based on Resource Utilization Band

eMethods. Data sources, cohort definitions, and variable definitions

We obtained study data from population-level, de-identified, linked health administrative databases housed at ICES. ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze healthcare and demographic data, without consent, for health system evaluation and improvement. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario. In 2018, the institute formerly known as the Institute for Clinical Evaluative Sciences formally adopted the initialism ICES as its official name. This change acknowledges the growth and evolution of the organization's research since its inception in 1992, while retaining the familiarity of the former acronym within the scientific community and beyond.

The dataset from this study is held securely in coded form at ICES. While legal data sharing agreements between ICES and data providers (e.g., healthcare organizations and government) prohibit ICES from making the dataset publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS (email: das@ices.on.ca). The full dataset creation plan and underlying analytic code are available from the authors upon request, understanding that the computer programs may rely upon coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

These datasets were linked using unique encoded identifiers and analyzed at ICES.

The index date for each covariate was the fiscal year-end for each time point: March 31, 2008, March 31, 2013, March 31, 2019.

Physician-level data came from the ICES Physician Database (age, sex, years in practice, practice specialty, practice type, full-time equivalence), the Primary Care Population database (geographic location, roster size, primary care model), and Ontario Health Insurance Plan (OHIP) billings (health services rendered). For physicians for whom birth month and date were missing, we imputed physician age based on birth year, with fiscal year end (March 31) as the index date. Physician gender is not available in ICES data, so physician sex was used instead, available as male and female.

Patient-level data came from the Registered Persons Database (age, sex, postal code, immigration status), the Client Agency Program Enrolment (CAPE) database (primary care enrolment model), the Community Health Centre database (CHC) (patients receiving health services at CHCs, which serve vulnerable patients), census data holdings (income quintiles and other marginalization indices), OHIP database (health services claims and associated diagnoses), Discharge Abstract Database linkages with OHIP (mental health diagnosis), and Johns Hopkins Adjusted Clinical Groups (frailty, resource utilization band).

Resource Utilization Bands (RUB): This was measured using the Johns Hopkins Adjusted Clinical Groups (ACG) Version 10.0. The RUB measure assesses expected health care use as a measure of patient complexity/morbidity.

Annual number of core primary care visits were based on activity billing codes for 22 primary care service types in the 12 months preceding the index date.

Rurality: We measured rurality using the practice postal code and the Rurality Index for Ontario (RIO) scoring methodology,[1] with the following categories: Large urban (score 0), Urban (score 1-9), Small Urban/Suburban (score 10–39), and Rural/Remote (score ≥ 40).

Full-time equivalency (FTE): FTE was calculated based on payments from all sources, with a 40th percentile cut-point corresponding with a FTE of 1.0.

Chronic diseases (COPD, CHF, Diabetes): These were measured using validated cohorts at ICES. The algorithm used to define cohorts varies slightly for each chronic condition, based on the original ICES algorithm for diabetes (i.e., two physician claims or one hospital admission with diabetes within two years). These disease cohorts are cumulative over time.

Frailty: This was measured using the Johns Hopkins Adjusted Clinical Groups (ACG) Version 10.0 frailty defining diagnoses indicator, which captures patients with multidimensional frailty at the population level and is based on 10 clusters of frailty defining dimensions: Malnutrition, dementia, impaired vision, decubitus ulcer, incontinence of urine, loss of weight, poverty, barriers to access to care, difficulty in walking, and falls. The indicator has been demonstrated to accurately identify patients with limitations in activities of daily living.

Mental illness: The case definition algorithm to identify patients with a mental health diagnosis over the last two years links two databases at ICES: The Discharge Abstract Databasae (DAD) and OHIP. It is based on having two physician billing claims in OHIP over 2 years or one hospitalization with one of the listed mental health service codes (ICD9/ICD10).

Marginalization: We assessed three dimensions of marginalization (residential instability, material deprivation, and neighborhood ethnic concentration) using the Ontario Marginalization Index,[2] a census-derived geographically-based index.

Physician-level continuity of care (CoC): The algorithm considers patients to be virtually attached a primary care physician if they received the majority of their primary care over the preceding 2-year period from a physician with greater than 10% physician-level continuity of care (CoC). Physician-level CoC is a visit-based measure of the proportion of an individual physician visits over all physician's visits over a two-year time period. The numerator is the number of patients virtually attached to a physician, and the denominator is all unique patients the same physician had seen over two years. If the physician CoC is less than or equal to 10%, then this physician had a low CoC.

References:

1. Kralj B. *Measuring 'Rurality' for Purposes of Health-Care Planning: An Empirical Measure for Ontario*.; 2009.

2. Matheson F, Moloney G, van Ingen T, Public Health Ontario. *2016 Ontario Marginalization Index: User Guide, 1st Revision*.; 2022. https://www.publichealthontario.ca/-/media/documents/o/2017/on-marg-

userguide.pdf?la=en

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

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7, Supplement (eMethods)
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	6-7, Supplement (eMethods)
Bias	9	Describe any efforts to address potential sources of bias	Figure 1a, 1b
Study size	10	Explain how the study size was arrived at	6-8, Figure 1a, 1b
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	7-8
		(*c*) Explain how missing data were addressed	7, Supplement (eTable 4)
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a
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	8, Figure 1a, 1b
		(b) Give reasons for non-participation at each stage	8, Figure 1a, 1b
		(c) Consider use of a flow diagram	Figure 1a, 1b

Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-16
		(b) Indicate number of participants with missing data for each variable of interest	Figure 1a, 1b, Supplement (eTable 4)
Outcome data	15*	Report numbers of outcome events or summary measures	8-16
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	8-16
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*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	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-17
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	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18
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	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The characteristics of patients attached to near-retirement family physicians: a population-based serial cross-sectional study in Ontario, Canada

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TITLE: The characteristics of patients attached to near-retirement family physicians: a population-based serial cross-sectional study in Ontario, Canada

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ABSTRACT

Objectives: Population aging is a global phenomenon. Resultant healthcare workforce shortages are anticipated. To ensure access to comprehensive primary care, which correlates with improved health outcomes, equity, and costs, data to inform workforce planning are urgently needed. We examined the medical and social characteristics of patients attached to near-retirement comprehensive primary care physicians over time, and explored the early- and mid-career workforce's capacity to absorb these patients.

Design: A serial cross-sectional population-based analysis using health administrative data.

Setting: Ontario, Canada, where most comprehensive primary care is delivered by family physicians (FPs) under universal insurance.

Participants: All insured Ontario residents at three time points: 2008 (12,936,360), 2013 (13,447,365), and 2019 (14,388,566) and all Ontario physicians who billed primary care services (2008: 11,566; 2013: 12,693; 2019: 15,054).

Outcome Measures: The number, proportion, and health and social characteristics of patients attached to near-retirement age comprehensive FPs over time; the number, proportion, and characteristics of near-retirement age comprehensive FPs over time. Secondary Outcome Measures: The characteristics of patients and their early- and mid-career comprehensive FPs.

Results: Patient attachment to comprehensive FPs increased over time. The overall FP workforce grew, but the proportion practicing comprehensiveness declined (2008: 77.2%, 2019: 70.7%). Over time, an increasing proportion of the comprehensive FP workforce was near retirement age. Correspondingly, an increasing proportion of patients were attached to near-retirement physicians. By 2019, 13.9% of comprehensive FPs were 65 years or older,

corresponding to 1,695,126 (14.8%) patients. Mean patient age increased, and all physicians served markedly increasing numbers of medically and socially complex patients.

Conclusions: The primary care sector faces capacity challenges as both patients and physicians age and fewer physicians practice comprehensiveness. Nearly 15% (1.7 million) of Ontarians may lose their comprehensive FP to retirement between 2019 and 2025. To serve a growing, increasingly complex population, innovative solutions are needed.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our serial cross-sectional study uses large, population-level health administrative datasets to examine temporal trends in the needs of primary care patients who may soon lose their family physician to retirement, in turn informing future workforce planning.
- By distinguishing between family physicians practicing comprehensive primary care and those who have narrowed their scope of practice, our methodology allows us to identify disparities between the presumed and actual primary care supply.
- By linking the characteristics, including age and sex, of the comprehensive primary care workforce to both the medical and social characteristics of the population served, our methodology facilitates a rich understanding of the resources needed by patients who may soon lose their FP to retirement, and the capacity to meet those needs among those who will remain in the workforce.
- Our methodology allows us to identify trends related to practice preferences among family physicians that can be in turn applied to other data sources around primary care trainees and population growth.

- Limitations to this work include the following: i) our analyses predate the COVID-19 pandemic due to limited data availability for more recent years and, ii) the number of comprehensive FPs in rural areas may be underestimated due to rural physician practice patterns possibly involving a large proportion of hospital-based services.

INTRODUCTION

Primary care is the foundation of high-performing health care systems worldwide,1 and can be defined by four core functions ("the 4 Cs") articulated by Starfield and others: first *Contact* access to the healthcare system, *Continuity* (long-term person-focused care), *Comprehensiveness* (meeting the majority of each patient's physical and mental health care needs, including prevention, acute care, chronic care, and multimorbidity care), and *Coordination* of care across the healthcare system, including specialty care, hospitals, home care, and community services and support.[1, 2] Access to primary care is associated with improved health outcomes, improved health equity, and reduced health system costs.[3-9]

An essential enabler of primary care access is an adequate health human resource (HHR) supply, but many jurisdictions are grappling with current and impending shortages. For example, 14.5% (4.6 million) Canadians are without a primary care provider.[10] Virtually every country world-wide is experiencing population aging,[11] with a high burden of medical complexity[12-15] and a HHR workforce that is aging into retirement.[16-18] Concurrently, many countries, including Canada, the United Kingdom, and the United States, are experiencing challenges attracting incoming physicians to primary care as a specialty,[19-22] and among those who do, a declining proportion are providing primary care reflective of Starfield's "4 Cs" (hereafter referred to as "comprehensive primary care"); instead, primary care physicians are increasingly limiting their scope of work to subspecialized areas such as sports medicine, dermatology, or palliative care, or to episodic acute care settings, such as walk-in clinics.[23-29] Moreover, the concentration of women in primary care may further reduce HHR capacity, as women primary care physicians have been found to spend more time with patients[30] and receive more patient requests outside of appointments than men.[31, 32]

In the context of an aging population and shifting workforce demographics, HHR planning requires an understanding of the needs of patients who will soon lose their primary care provider due to retirement. To anticipate future need, previous studies often use high-level supply indicators such as number of primary care physicians, and high-level demand indicators such as patient visit rates and durations.[33-36] In-depth analyses tend to be limited to sub-jurisdictional populations, such as the neighborhood[36] or early career clinicians,[24] and do not directly link supply (individual clinicians) to demand (patients served by those clinicians).

We conducted an in-depth exploration linking supply and demand at a health system planning level in Ontario, Canada. We examined temporal trends in near-retirement primary care physician characteristics and the medical and social needs of patients attached to these physicians. We also examined early career and mid-career physician characteristics over time to understand this segment of the workforce's capacity to absorb the patients of near-retirement physicians. We explored hypothesis-generating differences in gender-based workforce trends, including differences in care provision,[30, 31] and trends around alternative practice models, such as interprofessional team-based care. As Canadian healthcare planning and delivery are within provincial jurisdiction, we focused on the province-level (Ontario). In Ontario, most comprehensive primary care is delivered by family physicians (FPs), most physician services and all permanent residents are covered by government insurance, and health services data are stored centrally in health administrative datasets.

METHODS

The use of data in this study was authorized under section 45 of Ontario's Personal Health Information Protection Act (PHIPA) and did not require review by a research ethics board or

informed consent. This study is reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.[37]

Study Design, Population, and Data Sources

We conducted a serial cross-sectional population-level analysis. De-identified physician-level and patient-level data came from nine databases which were linked using unique encoded identifiers and analyzed at ICES (Supplemental eMethods). The study population included all registered Ontario residents covered by the Ontario Health Insurance Plan (OHIP) at three time points: March 31, 2008 (12,936,360), March 31, 2013 (13,447,365), and March 31, 2019 (14,388,566) and all Ontario physicians who billed primary care services (2008: 11,566; 2013: 12,693; 2019: 15,054).

Outcomes and Covariates

The primary outcomes were the number, proportion, and characteristics of patients attached to a near-retirement age comprehensive FP over three time points, and the number, proportion, and characteristics of near-retirement age comprehensive FPs over three time points. Physician characteristics served as exploratory indicators of both existing supply and, for near-retirement physicians, anticipated demand based on the populations of patients they serve. Patient characteristics served as indicators of demand based on medical and sociodemographic complexity.

Based on previous literature finding the average Ontario FP retires at age 70.5 years (with women retiring on average 5 years earlier than men)[38] and accounting for the time needed to train new physicians,[39] three different "near-retirement" physician age cut-points were examined: $\geq$ 55 years, $\geq$ 65 years, and $\geq$ 70 years.

Comprehensive FPs were defined by applying a previously validated algorithm described below in the Analysis section.[29] Detailed data source, cohort, and covariate definitions can be found in the Supplemental eMethods.

Analysis

For our patient cohort, we created cross-sections of patients attached to comprehensive FPs at three time points: 2008, 2013, 2019.

We began by applying our previously validated algorithm for primary care physician attachment[40] to the population of OHIP-registered Ontario residents; identifying patients attached to a physician providing longitudinal primary care services based on billing codes and physician-level continuity of care (see Supplemental eMethods – continuity of care). We removed patients seen at Community Health Centres because they cannot be attached to a specific physician, patients that the algorithm attached to non-FPs such as pediatricians and surgeons, and patients attached to a FP with missing covariates.

We next created the cohort of FPs linked to the attached patients we identified (2008, 2013, 2019). We stratified our patient and FP cohorts by physician practice type (scope). For this, we used a previously published algorithm for determining comprehensiveness of primary care practice, where physicians are identified as providing comprehensive care if more than half of their services were for core primary care and if these services fell into at least 7 of 22 activity areas.[29] This resulted in four groups of patients with attachments to four types of FP practice scopes: Comprehensive, Focused (for example, sports medicine or palliative care), Other, and those who worked less than 44 days/year. The latter two practice categories were grouped

together as "Other". Focusing on the "comprehensive FP" group, we described the characteristics of these physicians and their patients.

Physician analyses were stratified by physician sex and physician age, including the three "near-retirement" cut-points. Proportions and means with standard deviations were reported for each time point (2008, 2013, 2019).

Patient and public involvement

None.

RESULTS

Patient Cohort

Excluding long-term care home residents, the population of OHIP-eligible Ontario residents in the patient cohort over time was 12,863,036 (2008), 13,371,946 (2013), and 14,312,309 (2019), of whom the following were attached to a comprehensive FP: 2008: n = 9,537,353 (77.3%); 2013: n = 10,398,003 (85.1%); 2019: n = 11,480,975 (86.1%) (Figure 1a).

Physician Cohort

The overall FP workforce grew from 9,944 physicians in 2008 to 13,269 in 2019 (Figure 1b, sum of boxes 8 and 9).

Supplemental eTable 1 stratifies comprehensive FP data by age and sex. Career stage (years in practice) closely followed physician age group for both males and females, and the youngest cohort (age <35) comprised an increasing proportion of the workforce over time, shifting from 7.7% in 2008 to 15.1% in 2019. The older cohorts were also found to comprise an increasing proportion of the workforce over time, and the absolute numbers of older physicians increased.

A shift away from comprehensiveness and into other/focused scopes of practice was seen, with the proportion of FPs practicing comprehensive primary care declining from 77.2% in 2008 (n = 7,673) to 70.7% in 2019 (n = 9,377) (Supplemental eFigure 1). This was driven by mid-career and near-retirement physician groups (age groups 45 and above) shifting away from comprehensiveness. Over time, the proportion of younger physicians (those under 45) practicing in focused or other scopes of practice remained stable, albeit in higher proportions than their mid-career counterparts. In the oldest age group, a large and increasing proportion practice in focused/other types of practice (Supplemental eTable 2).

Temporal Trends of Near-Retirement Comprehensive Family Physicians and their Patients

When looking at our three near-retirement cut-points (55+, 65+, 70+) over time, an increasing proportion of the comprehensive FP workforce was near retirement age (Figure 2). Correspondingly, an increasing proportion of patients were attached to near-retirement comprehensive FPs (Table 1). In the 55+ age group, the proportion of comprehensive FPs increased from 35.7% in 2008 to 38.2% in 2019. In 2019, this corresponded to 3,586 physicians and 4,935,992 (43.0%) patients (2019). In the 65+ group, the proportion increased from 10.0% in 2008 to 13.9% in 2019 (1,307 physicians, 1,695,126 (14.8%) patients). In the 70+ age group, the proportion increased from 4.6% in 2008 to 6.4% in 2019 (599 physicians, 666,000 (5.8%) patients).

Table 1. Characteristics of patients attached to near-retirement comprehensive family physicians over time, by near-retirement group

		Age 55+ Comprehensive FPs		Age 65+ Comprehensive FPs		Age 70+ Comprehensive FPs	
Patient Characteristics		N	%	N	%	N	%
OVERALL (N, % of patients attached to near-retirement physician group)	2008	3,571,661	37.5	690,642	7.2	214,861	2.3
	2013	4,676,625	45.0	1,399,119	13.5	419,172	4.0
	2019	4,935,992	43.0	1,695,126	14.8	666,404	5.8
Aged 65+ (N, % of patients attached to near-retirement physician group)	2008	597,707	16.7	136,394	19.8	45,414	21.1
	2013	846,974	18.1	298,545	21.3	95,833	22.8
	2019	1,003,769	20.3	402,430	23.7	176,473	26.5
Female patients (N, % of patients attached to near-retirement physician group)	2008	1,804,585	50.5	338,656	49.0	103,386	48.1
	2013	2,371,923	50.7	678,971	48.5	201,104	48.0
	2019	2,498,453	50.6	823,090	48.6	317,967	47.7
Rural patients (RIO score 40+) (N, % of patients attached to near-retirement physician group)	2008	233,045	6.5	48,860	7.1	14,323	6.7
	2013	292,357	6.3	88,311	6.3	20,294	4.8
	2019	274,099	5.6	83,691	4.9	33,545	5.0
Highest (4+) RUB (N, % of patients attached to near-retirement physician group)	2008	677,436	19.0	137,995	20.0	44,067	20.5
	2013	878,340	18.8	283,013	20.2	88,182	21.0
	2019	983,818	19.9	350,439	20.7	146,298	22.0
Highest (5+) annual core primary care visits (N, % of patients attached to near-retirement physician group)	2008	2,109,950	59.1	403,026	58.4	127,050	59.1
	2013	2,462,236	52.7	753,388	53.9	227,090	54.2
	2019	2,480,395	50.3	876,487	51.7	346,668	52.0
COPD (N, % of patients attached to near-retirement physician group)	2008	233,498	6.5	51,856	7.5	16,411	7.6
	2013	326,748	7.0	115,669	8.3	37,477	8.9
	2019	337,202	6.8	132,395	7.8	59,350	8.9
CHF (N, % of patients attached to near-retirement physician group)	2008	69,573	2.0	15,645	2.3	4,952	2.3
	2013	80,026	1.7	28,187	2.0	9,214	2.2
	2019	90,436	1.8	35,567	2.1	15,832	2.4
Diabetes (N, % of patients attached to near-retirement physician group)	2008	327,127	9.2	68,392	9.9	21,389	10.0
	2013	506,014	10.8	170,115	12.2	52,815	12.5
	2019	555,358	11.3	215,696	12.7	92,395	13.9

Frailty (N, % of patients attached to near-retirement physician group)	2008	66,559	1.9	14,875	2.2	4,964	2.3
	2013	98,490	2.1	33,005	2.4	10,794	2.6
	2019	114,085	2.3	43,032	2.5	18,597	2.8
Any mental health illness in last 2 years (N, % of patients attached to near-retirement physician group)	2008	825,520	23.1	166,257	24.1	51,802	24.1
	2013	979,987	21.0	311,771	22.3	96,543	23.0
	2019	1,022,523	20.7	355,911	21.0	150,153	22.5
Lowest income quintile (N, % of patients attached to near-retirement physician group)	2008	706,504	19.8	150,381	21.8	48,403	22.5
	2013	876,982	18.8	282,922	20.2	91,236	21.8
	2019	944,888	19.1	348,869	20.6	142,881	21.4
Highest housing instability quintile (N, % of patients attached to near-retirement physician group)	2008	761,397	21.3	165,525	24.0	54,275	25.6
	2013	934,472	20.0	295,059	21.1	92,653	22.2
	2019	1,031,506	20.9	374,322	22.1	155,859	23.4
Highest material deprivation quintile (N, % of patients attached to near-retirement physician group)	2008	736,903	20.6	163,835	23.7	52,733	24.9
	2013	1,045,136	22.4	338,012	24.2	112,097	26.9
	2019	926,043	18.8	352,849	20.8	145,084	21.8
Highest neighborhood ethnic concentration quintile (N, % of patients attached to near-retirement physician group)	2008	962,252	26.9	177,586	25.7	63,167	29.8
	2013	1,335,124	28.6	397,430	28.4	124,062	29.8
	2019	1,521,975	30.8	584,512	34.5	213,182	32.0
Recent immigrant (N, % of patients attached to near-retirement physician group)	2008	269,131	7.5	52,717	7.6	21,202	10.9
	2013	289,772	6.2	83,484	6.0	27,024	7.0
	2019	277,755	5.6	82,560	4.9	28,449	4.3

Interpretation of Table 1 rows:

Interpretation of the "Overall" category: For example, in 2019, 1,695,126 patients were attached to a comprehensive FP aged 65+. This represents 14.8% of all patients who are attached to a comprehensive FP.

Interpretation of each patient category: For example, in 2019, of the 666,404 patients attached to comprehensive FPs over the age of 70 years, 28,449 (4.3%) were recent immigrants

FPs: Family physicians

RIO: Rurality Index of Ontario

RUB: Morbidity, based on Resource Utilization Band

COPD: Chronic obstructive pulmonary disease

CHF: Congestive heart failure

Temporal Characteristics of Comprehensive Family Physicians and their Patients

Comprehensive FP Capacity/Workload

Supplemental eTable 1 shows the mean (SD) roster size for the total population of comprehensive FPs remained consistent over time (2008: 1213 (927); 2013: 1272 (909); 2019: 1209 (837)). Male FPs had consistently larger roster sizes in each age group and at each time point. Both male and female FP roster sizes followed an inverted U pattern with FP age, with practice sizes starting and ending smaller at the extremes of FP age and peaking during mid-career. This pattern was observed at all three time points. That said, male and female older (65+) physicians and younger (<35) physicians cared for larger roster sizes over time.

Working full time equivalent (FTE) also followed an inverted U pattern according to FP age (Supplemental eTable 1). Consistently, two thirds of the overall comprehensive FP workforce practiced FTE, with males comprising the majority of FTE physicians. Older physicians increasingly practiced FTE (age 65-69, 2008: 58.4%, 2013: 67.0%, 2019: 72.6%; age 70+, 2008: 32.0%, 2013: 41.6%, 2019: 54.6%), a trend that was driven by an increasing proportion of female FTE comprehensive FPs. Among younger physicians, by 2019, females comprised the majority of FTE workforce (52.2% of FTE comprehensive FPs <35 years; 55.2% of FTE comprehensive FPs 35-44 years).

Mean (SD) annual core primary care visits provided per patient declined over time (Supplemental eTable 1): 2008: 7.3 (3.1) visits; 2013: 6.5 (2.6) visits; 2019: 6.0 (2.3) visits. In most comprehensive FP age groups, male and females provided similar numbers of annual visits. Older physicians provided more annual visits compared with their younger counterparts.

In the patient cohort (Table 1), at all near-retirement physician cut-offs (55+, 65+, 70+), a declining proportion over time made a high number (5+) primary care visits in the preceding year, but these proportions remained consistently over 50% in all near-retirement groups and at each time point.

Comprehensive FP Practice Settings

A declining proportion of comprehensive FPs over time practiced in fee-for-service (FFS) models of care, with alternate payment plan models (APPs), specifically capitation and team-based models of care, becoming increasingly common (Supplemental eFigure 2). In these APP models, physician compensation is primarily a lump sum payment per attached patient, with or without additional government funding for support for interdisciplinary health professionals ("teams") such as nurses, nurse practitioners, social workers, and dietitians. In 2008, most comprehensive FPs worked in FFS-based models (76.6%), but by 2019, most practiced in APPs (55.4%) (Supplemental eFigure 2, Supplemental eTable 3). Correspondingly, an increasing proportion of patients were served in APP models: 2008: 26.5% (n = 2,526,116); 2013: 54.3% (n = 5,643,862); 2019: 61.5% (n = 7,064,109).

Over time, a stable majority of comprehensive FPs practiced in large urban and urban settings (Supplemental eTable 4A). Trends around age and sex of rural comprehensive FPs resembled trends seen in the overall comprehensive FP population (Supplemental eTables 4B, 4C).

Patient complexity

The mean age (SD) of comprehensive FPs' patients increased over time (Supplemental eTable 1): 2008: 33.5 (13.2) years; 2013: 36.5 (12.1) years; 2019: 38.1 (12.0) years. When stratified by physician age and sex, each physician age group served increasingly older patients. Male

physicians cared for slightly older patients than did females in each physician age group and at each time point.

The number and proportion of patients aged 65 and older increased over time in each near-retirement group (Table 1). This number nearly quadrupled in the oldest (70+ years) FP group (2008: N = 45,414, 2019: N = 176,473).

Over time, an increasing proportion of comprehensive FPs' practices were comprised of the highest morbidity patients (Resource Utilization Band (RUB) 4+): 2008: 16.5%; 2013: 18.1%; 2019: 19.8% (Supplemental eTable 5). Concordantly, as seen in Table 1, the number and proportion of highest morbidity patients attached to near-retirement physicians grew over time. By 2019, 983,818 patients in the highest morbidity category were attached to a physician aged 55+, representing 19.9% of all patients attached to a 55+ physician. 350,439 were attached to a 65+ physician (20.7% of patients attached to a 65+ physician). 146,298 were attached to a 70+ physician (22.0% of patients attached to 70+ a physician), representing a tripling of the absolute number.

While proportions of patients with chronic illness (COPD, CHF, diabetes, frailty, mental illness) remained relatively stable over time, the absolute numbers increased markedly in each near-retirement group (Table 1).

The proportions and means of socially complex patients cared for within each comprehensive FP age and sex group increased over time for most indicators (Supplemental eTable 5) and, concordantly, the number of higher social complexity patients increased markedly over time for most near-retirement groups (Table 1).

DISCUSSION

In our population-level serial cross-sectional analyses, the proportion of patients attached to a comprehensive FP in Ontario, Canada, grew over time. However, reflective of population-level workforce trends,[16] we found an increasing proportion of the comprehensive FP workforce is nearing retirement. Given the average FP retires at age 70.5 years,[38] we anticipate that between 2019 and 2025, nearly 1.7 million Ontarians may lose their comprehensive FP to retirement, eroding gains in primary care attachment made to date.[41]

This number may be an underestimate for several reasons. First, half of all comprehensive FPs are now female, and female FPs retire on average 5 years earlier than males.[38] Second, and aligned with previous research,[29] a declining proportion of FPs are practicing comprehensive family medicine. Third, only two thirds of comprehensive FPs are practicing full-time. Fourth, due to limitations in data availability for more recent years, our analyses predate the COVID-19 pandemic, and surveys from Ontario indicate the pandemic has hastened retirement plans, with almost double the usual proportion of FPs closing their offices during the pandemic (3%, compared with the usual rate of 1.6%/year),[42] and one in five indicating an intention to retire within five years.[43]

Several other trends we identified likely apply to other jurisdictions nationally and internationally and, when taken together, indicate limited capacity in the existing workforce to absorb the workload of near-retirement physicians. Reflective of a generally aging population, comprehensive FPs cared for increasingly older groups of patients with increasing medical and social complexity over time. Females, who comprised an increasing proportion of the comprehensive FP workforce, served smaller roster sizes than males, which may reflect that a lower proportion of female physicians practiced FTE compared with males. Hypotheses based on previous research include that women primary care physicians may spend more time with

patients, receive more requests outside of appointments from patients, and carry the majority of household responsibilities, including child care.[31, 32, 44] Of note, however, both the oldest and youngest male and female comprehensive FP groups served increasingly larger rosters, and an increasing proportion of older (65+) physicians practiced FTE, suggesting a significant workload among near-retirement FPs and limited capacity among early career FPs to absorb that workload.

Although modelling the incoming comprehensive FP workforce supply was outside of the scope of this study, data from other sources indicate concerning trends. While Ontario continues to add a net positive number of FPs to the workforce each year, this number has declined from 453 in 2017 to 303 in 2020.[45] Over the past 7 years, a smaller proportion of medical school graduates ranked family medicine as their first choice discipline,[46] echoing trends in other jurisdictions including the United Kingdom and the United States.[20-22] Demand created by population growth continues, and Canada recently announced a plan to welcome 1.45 million new immigrants between 2023 and 2025.[47] While some newcomers may add to the health workforce supply, it is unclear if, proportionally, this will be sufficient to meet demand, and concerns persist around the slow and difficult credentialing process for internationally trained physicians.[48, 49] The future supply of incoming FPs may therefore be inadequate to meet the needs identified in our study, especially considering the practice trends we identified and the 1.6 million Ontarians already without a regular source of primary care in our 2019 cohort.

Solutions to FP workforce shortages identified in the literature focus on addressing deterrents to the practice of comprehensive primary care, including perceived poor respect for primary care as a profession, inadequate compensation, inadequate training supports for developing and maintaining comprehensive skills, and inadequate administrative and interprofessional health

supports to manage increasing patient complexity.[21, 24, 50-54] Our finding of a shift toward APP models underscores the desire among comprehensive FPs for financial stability and the support of an interprofessional team. Further, we identified equity concerns that relate to the large numbers of patients with chronic diseases and complex social needs, all of which are highly amenable to team-based care.[55-57] Concerningly, as of 2019, we found that 47% of older (65+) physicians still practiced in the less popular FFS models of care, serving 761,648 patients; these FFS practices may be less desirable to incoming physicians looking to take over a retiring physician's practice.

In some jurisdictions, the response to primary care workforce shortages has included expanding the scope of practice for non-physician health professionals. For example, several provinces in Canada, including Ontario, now allow pharmacists to prescribe for minor common ailments. However, concerns have been raised around inadequate concurrent investments in comprehensive, team-based primary care (rather than episodic, siloed care), the disruption of continuity for those who do have primary care access, limited pharmacist training in clinical diagnosis, and the lack of high-quality evidence around cost-effectiveness and health outcomes.[58, 59] Both the U.S. and Canada have increased nurse practitioner- or physician assistant-led primary care. However, a recent U.S. study found that primary care delivered by non-physician practitioners was more costly than care delivered by physicians,[60] and accurate cost comparisons in Canada remain a challenge due to the lack of publicly available data on non-physician overhead spending.

There are some limitations to our study. The FTE indicator is based on physician billings, thereby excluding time spent on non-billable administrative work. Almost half of Canadian FPs report 10-19 hours per week of administrative tasks,[61] so the indicator may underestimate

workload, and thus the number of FTE FPs. Rural FPs often practice in both primary care and hospital settings;[62] since the comprehensiveness algorithm is based on primary care billings,[29] it may underestimate the number of rural comprehensive FPs. Further, the rurality index scores and methodology have not been updated since 2008 despite the significant population growth and municipal-level changes that have occurred since then. Some physician analyses could not be fully stratified by both age and sex due to small cell sizes. Community Health Centre patients are not included and we did not examine other clinicians who may provide primary care; however, these clinicians are the main primary care source for only a small minority (approximately 1%) of Ontarians.[63, 64] Finally, our analyses do not account for the rise of virtual care and its potential impact on capacity.[65-67]

CONCLUSIONS

Primary care faces many capacity challenges as physicians age into retirement and fewer choose to enter or remain in comprehensive practice. Incentives and supports are needed to grow the comprehensive FP workforce to serve a growing and increasingly complex patient population.

CONTRIBUTORS

Kamila Premji, Michael E Green, Richard H Glazier, and Bridget L Ryan conceived the study concept and design. Kamila Premji, Michael E Green, Richard H Glazier, Shahriar Khan, Susan E Schultz, Maria Mathews, Steve Nastos, Eliot Frymore, and Bridget L Ryan participated in the acquisition and interpretation of data. Kamila Premji, Shahriar Khan, Bridget L Ryan, Michael E Green, and Richard H Glazier contributed to the statistical analysis of the acquired data. Kamila Premji drafted the manuscript. All authors critically revised the contents of the manuscript, approved the final version to be submitted for publication, and agreed to be accountable for all aspects of the work with respect to its accuracy and integrity. Michael E Green and Richard H Glazier obtained funding to support this research. Eliot Frymire and Shahriar Khan provided administrative and technical support. Bridget L Ryan and Maria Mathews provided supervision for this project.

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Data availability statement: The data sets from this study are held securely in coded form at ICES. Data-sharing agreements prohibit ICES from making the data sets publicly available, but access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The complete data set creation plan, and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros unique to ICES.

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FIGURE LEGENDS

Figure 1a. Cohort creation: Patients.

Figure 1b. Cohort creation: Physicians

Figure 2. Comprehensive family physicians by near-retirement group, year, and sex

- **Figure 2 footnote:** Total Ns (all comprehensive family physicians):
  2008: 7,673
  2013: 8,050
  2019: 9,377

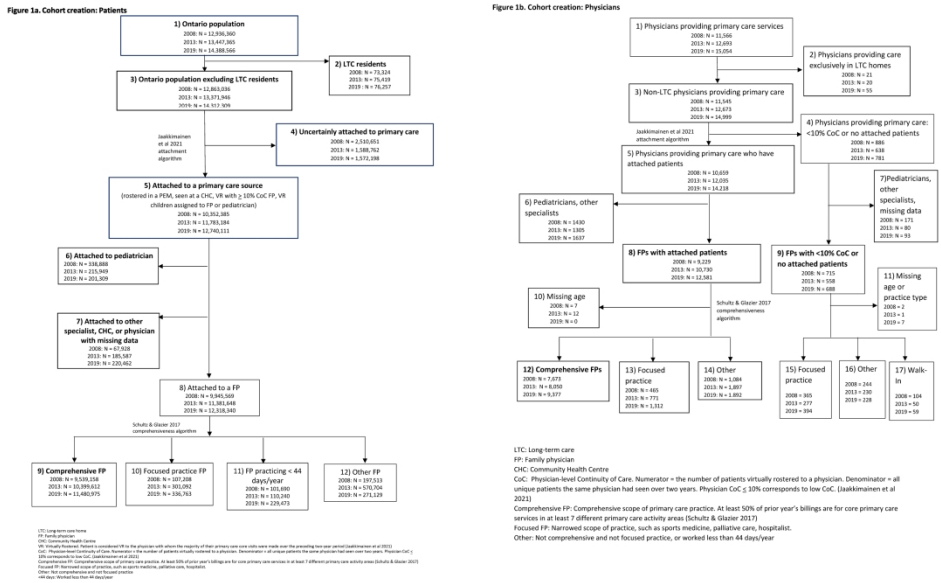
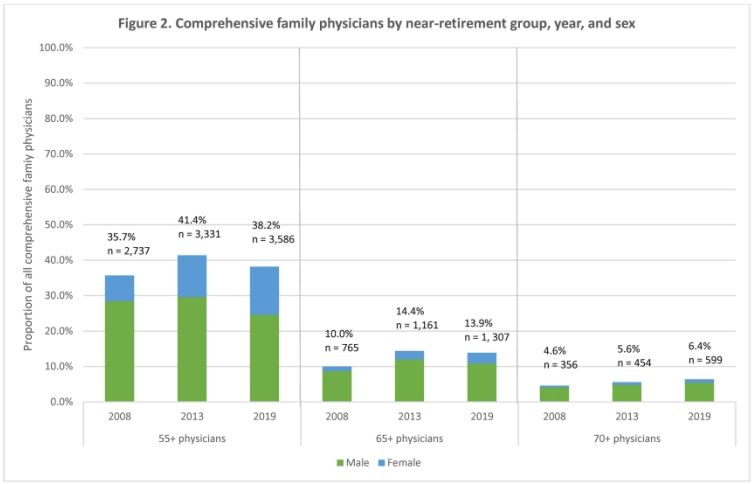


Figure 1a. Cohort creation: Patients. Figure 1b. Cohort creation: Physicians

431x279mm (300 x 300 DPI)



Total Ns (all comprehensive family physicians):
2008: 7,673
2013: 8,050
2019: 9,377

Comprehensive family physicians by near-retirement group, year, and sex

279x215mm (300 x 300 DPI)

Supplemental eMethods. Data sources, cohort definitions, and variable definitions

We obtained study data from population-level, de-identified, linked health administrative databases housed at ICES. ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze healthcare and demographic data, without consent, for health system evaluation and improvement. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario. In 2018, the institute formerly known as the Institute for Clinical Evaluative Sciences formally adopted the initialism ICES as its official name. This change acknowledges the growth and evolution of the organization's research since its inception in 1992, while retaining the familiarity of the former acronym within the scientific community and beyond.

The dataset from this study is held securely in coded form at ICES. While legal data sharing agreements between ICES and data providers (e.g., healthcare organizations and government) prohibit ICES from making the dataset publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS (email: das@ices.on.ca). The full dataset creation plan and underlying analytic code are available from the authors upon request, understanding that the computer programs may rely upon coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

These datasets were linked using unique encoded identifiers and analyzed at ICES.

The index date for each covariate was the fiscal year-end for each time point: March 31, 2008, March 31, 2013, March 31, 2019.

Physician-level data came from the ICES Physician Database (age, sex, years in practice, practice specialty, practice type, full-time equivalence), the Primary Care Population database (geographic location, roster size, primary care model), and Ontario Health Insurance Plan (OHIP) billings (health services rendered). For physicians for whom birth month and date were missing, we imputed physician age based on birth year, with fiscal year end (March 31) as the index date. Physician gender is not available in ICES data, so physician sex was used instead, available as male and female.

Patient-level data came from the Registered Persons Database (age, sex, postal code, immigration status), the Client Agency Program Enrolment (CAPE) database (primary care enrolment model), the Community Health Centre database (CHC) (patients receiving health services at CHCs, which serve vulnerable patients), census data holdings (income quintiles and other marginalization indices), OHIP database (health services claims and associated diagnoses), Discharge Abstract Database linkages with OHIP (mental health diagnosis), and Johns Hopkins Adjusted Clinical Groups (frailty, resource utilization band).

Resource Utilization Bands (RUB): This was measured using the Johns Hopkins Adjusted Clinical Groups (ACG) Version 10.0. The RUB measure assesses expected health care use as a measure of patient complexity/morbidity.

Annual number of core primary care visits were based on activity billing codes for 22 primary care service types in the 12 months preceding the index date.

Rurality: We measured rurality using the practice postal code and the Rurality Index for Ontario (RIO) scoring methodology,[1] with the following categories: Large urban (score 0), Urban (score 1-9), Small Urban/Suburban (score 10–39), and Rural/Remote (score ≥ 40).

Full-time equivalency (FTE): FTE was calculated based on payments from all sources, with a 40th percentile cut-point corresponding with a FTE of 1.0.

Chronic diseases (COPD, CHF, Diabetes): These were measured using validated cohorts at ICES. The algorithm used to define cohorts varies slightly for each chronic condition, based on the original ICES algorithm for diabetes (i.e., two physician claims or one hospital admission with diabetes within two years). These disease cohorts are cumulative over time.

Frailty: This was measured using the Johns Hopkins Adjusted Clinical Groups (ACG) Version 10.0 frailty defining diagnoses indicator, which captures patients with multidimensional frailty at the population level and is based on 10 clusters of frailty defining dimensions: Malnutrition, dementia, impaired vision, decubitus ulcer, incontinence of urine, loss of weight, poverty, barriers to access to care, difficulty in walking, and falls. The indicator has been demonstrated to accurately identify patients with limitations in activities of daily living.

Mental illness: The case definition algorithm to identify patients with a mental health diagnosis over the last two years links two databases at ICES: The Discharge Abstract Databasae (DAD) and OHIP. It is based on having two physician billing claims in OHIP over 2 years or one hospitalization with one of the listed mental health service codes (ICD9/ICD10).

Marginalization: We assessed three dimensions of marginalization (residential instability, material deprivation, and neighborhood ethnic concentration) using the Ontario Marginalization Index,[2] a census-derived geographically-based index.

Physician-level continuity of care (CoC): The algorithm considers patients to be virtually attached a primary care physician if they received the majority of their primary care over the preceding 2-year period from a physician with greater than 10% physician-level continuity of care (CoC). Physician-level CoC is a visit-based measure of the proportion of an individual physician visits over all physician's visits over a two-year time period. The numerator is the number of patients virtually attached to a physician, and the denominator is all unique patients the same physician had seen over two years. If the physician CoC is less than or equal to 10%, then this physician had a low CoC.

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Supplemental eTable 1. Practice characteristics of comprehensive family physicians

		<35 Years			35-44 Years			45-54 Years			55-64 Years			65-69 Years			70+ Years			Total Comprehensive FPs		
		Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F		M	F	Total	M	F
Comp. FPs N (%)	2008	592 (7.7)	211 (35.6)	381 (64.4)	1877 (24.5)	922 (49.1)	955 (50.9)	2467 (32.2)	1422 (57.6)	1045 (42.4)	1972 (25.7)	1522 (77.2)	450 (22.8)	409 (5.3)	347 (84.8)	62 (15.2)	356 (4.6)	319 (89.6)	37 (10.4)	7673 (100.0)	4743 (61.8)	2930 (38.2)
	2013	741 (9.2)	245 (33.1)	496 (66.9)	1666 (20.7)	674 (40.5)	992 (59.5)	2312 (28.7)	1227 (53.1)	1085 (46.9)	2170 (27.0)	1415 (65.2)	755 (34.8)	707 (8.8)	576 (81.5)	131 (18.5)	454 (5.6)	392 (86.3)	62 (13.7)	8050 (100.0)	4529 (56.3)	3521 (43.7)
	2019	1414 (15.1)	528 (37.3)	886 (62.7)	2135 (22.8)	806 (37.8)	1329 (62.2)	2242 (23.9)	1048 (46.7)	1194 (53.3)	2279 (24.3)	1290 (56.6)	989 (43.4)	708 (7.6)	519 (73.3)	189 (26.7)	599 (6.4)	505 (84.3)	94 (15.7)	9377 (100.0)	4696 (50.1)	4681 (49.9)
Years in pract. (mean (SD))	2008	6.0 (±2.3)	6.3 (±2.3)	5.9 (±2.2)	14.4 (±3.9)	14.7 (±3.8)	14.1 (±3.9)	23.7 (±4.2)	23.8 (±4.2)	23.5 (±4.2)	33.4 (±4.4)	33.6 (±4.2)	32.8 (±4.8)	41.3 (±3.0)	41.2 (±3.0)	42.0 (±3.2)	48.0 (±5.1)	48.0 (±4.9)	47.8 (±6.4)	24.6 (±11.4)	27.3 (±11.2)	20.2 (±10.1)
	2013	5.7 (±2.1)	5.4 (±2.1)	5.9 (±2.1)	13.8 (±4.2)	14.0 (±4.2)	13.7 (±4.1)	23.9 (±4.2)	23.9 (±4.0)	23.8 (±4.4)	33.2 (±4.4)	33.6 (±4.4)	32.5 (±4.5)	41.2 (±3.5)	41.1 (±3.4)	41.6 (±4.0)	48.7 (±4.9)	48.7 (±4.9)	49.0 (±4.9)	25.6 (±12.3)	28.8 (±12.1)	21.4 (±11.1)
	2019	5.8 (±2.0)	5.7 (±2.0)	5.8 (±1.9)	12.5 (±4.2)	12.5 (±4.4)	12.5 (±4.0)	23.7 (±4.7)	23.9 (±4.7)	23.5 (±4.6)	33.3 (±4.7)	33.4 (±4.5)	33.2 (±4.9)	40.8 (±3.6)	41.0 (±3.4)	40.3 (±4.0)	48.5 (±5.1)	48.4 (±5.3)	48.7 (±4.1)	23.7 (±13.4)	27.0 (±13.8)	20.3 (±12.0)
Roster size (mean (SD))	2008	638.3 (±622.5)	790.7 (±722.0)	553.9 (±542.7)	1131.8 (±873.2)	1323.5 (±981.3)	946.7 (±707.0)	1345.1 (±920.7)	1470.3 (±996.7)	1174.6 (±774.4)	1432.1 (±945.2)	1494.0 (±961.5)	1222.7 (±856.4)	1123.1 (±955.5)	1186.1 (±981.7)	770.7 (±701.1)	566.3 (±770.9)	584.9 (±785.4)	406.5 (±618.7)	1212.8 (±927.0)	1338.8 (±991.1)	1008.8 (±770.0)
	2013	620.0 (±605.9)	725.2 (±690.9)	568.0 (±552.6)	1152.8 (±836.0)	1348.6 (±935.1)	1019.7 (±732.6)	1407.1 (±927.1)	1567.8 (±1013.4)	1225.4 (±780.2)	1490.2 (±894.6)	1593.1 (±937.6)	1297.2 (±772.4)	1366.1 (±905.8)	1420.3 (±921.3)	1128.0 (±794.3)	898.1 (±895.7)	946.7 (±922.9)	591.1 (±622.7)	1272.1 (±909.2)	1425.0 (±975.2)	1075.4 (±773.4)
	2019	734.0 (±644.2)	834.7 (±712.0)	674.0 (±592.4)	1074.5 (±720.3)	1217.2 (±841.6)	987.9 (±620.1)	1394.8 (±876.2)	1529.3 (±946.5)	1276.7 (±791.2)	1405.6 (±847.2)	1531.6 (±902.2)	1241.1 (±738.3)	1434.4 (±900.5)	1502.5 (±932.8)	1247.6 (±777.3)	1098.0 (±804.3)	1125.7 (±815.1)	949.2 (±729.6)	1208.9 (±837.4)	1351.9 (±908.8)	1065.4 (±731.6)
Core PC visits (mean (SD))	2008	6.2 (±2.7)	6.2 (±2.8)	6.2 (±2.7)	7.3 (±4.2)	7.5 (±5.6)	7.2 (±2.3)	7.3 (±2.3)	7.4 (±2.5)	7.3 (±2.1)	7.7 (±2.6)	7.7 (±2.6)	7.7 (±2.4)	7.5 (±3.1)	7.6 (±3.2)	6.9 (±2.7)	6.8 (±3.5)	6.9 (±3.5)	6.2 (±2.9)	7.3 (±3.1)	7.4 (±3.5)	7.1 (±2.4)
	2013	5.3 (±2.3)	5.4 (±2.3)	5.3 (±2.3)	6.3 (±2.1)	6.2 (±2.2)	6.3 (±2.0)	6.5 (±2.4)	6.6 (±2.7)	6.4 (±2.0)	6.7 (±2.8)	6.8 (±3.2)	6.4 (±1.9)	6.9 (±2.4)	6.9 (±2.4)	7.0 (±2.3)	7.3 (±4.0)	7.5 (±4.2)	6.5 (±2.4)	6.5 (±2.6)	6.6 (±2.9)	6.3 (±2.1)
	2019	5.6 (±2.5)	5.5 (±2.6)	5.6 (±2.4)	6.0 (±2.5)	5.9 (±2.8)	6.0 (±2.4)	6.1 (±2.1)	6.1 (±2.3)	6.1 (±1.9)	6.1 (±2.1)	6.2 (±2.3)	6.0 (±1.8)	6.4 (±2.2)	6.5 (±2.3)	6.2 (±2.0)	6.7 (±3.0)	6.5 (±2.9)	7.2 (±3.1)	6.0 (±2.3)	6.1 (±2.5)	6.0 (±2.2)
Pt age (mean (SD))	2008	27.9 (±13.8)	29.4 (±14.0)	27.1 (±13.6)	31.7 (±11.7)	32.8 (±12.6)	30.5 (±10.7)	34.3 (±11.9)	35.4 (±12.5)	32.7 (±10.8)	36.7 (±13.1)	37.6 (±13.2)	33.7 (±12.2)	35.1 (±16.2)	36.0 (±16.1)	30.5 (±15.9)	28.2 (±18.5)	28.5 (±18.5)	25.5 (±17.8)	33.5 (±13.2)	34.9 (±13.8)	31.3 (±11.8)
	2013	28.2 (±13.7)	30.0 (±13.7)	27.4 (±13.6)	34.0 (±10.8)	35.0 (±11.6)	33.4 (±10.1)	36.4 (±10.7)	37.8 (±11.2)	34.8 (±9.9)	39.4 (±10.7)	40.5 (±11.1)	37.3 (±9.8)	40.9 (±12.6)	42.0 (±12.4)	36.3 (±12.7)	39.1 (±17.0)	39.7 (±17.1)	35.0 (±16.0)	36.5 (±12.1)	38.5 (±12.5)	34.0 (±11.2)
	2019	31.8 (±14.5)	33.5 (±14.2)	30.7 (±14.5)	36.4 (±10.9)	37.1 (±11.8)	36.0 (±10.3)	38.4 (±9.8)	39.4 (±10.6)	37.5 (±9.0)	40.6 (±10.5)	42.0 (±10.8)	38.7 (±9.8)	43.0 (±11.5)	43.9 (±11.6)	40.8 (±10.9)	43.3 (±14.3)	43.6 (±14.5)	41.2 (±13.1)	38.1 (±12.0)	40.0 (±12.3)	36.2 (±11.3)
Prop. Fem. Pts (mean (SD))	2008	55.7 (±15.1)	46.9 (±10.7)	60.7 (±14.9)	55.2 (±13.2)	46.2 (±7.5)	63.8 (±11.6)	54.3 (±13.0)	46.3 (±7.4)	65.3 (±10.9)	51.0 (±11.0)	46.8 (±7.0)	65.0 (±10.7)	49.5 (±11.1)	47.3 (±8.5)	61.5 (±15.7)	47.8 (±13.2)	46.7 (±11.1)	57.6 (±22.6)	53.2 (±12.9)	46.6 (±7.8)	64.0 (±12.1)
	2013	55.3 (±15.6)	47.8 (±13.7)	59.0 (±15.1)	55.1 (±12.1)	46.1 (±8.3)	61.2 (±10.4)	53.7 (±12.3)	45.6 (±7.4)	62.9 (±9.9)	52.4 (±12.1)	45.9 (±7.5)	64.7 (±9.3)	48.9 (±10.1)	45.9 (±7.2)	62.2 (±10.5)	49.6 (±12.2)	47.2 (±10.4)	64.8 (±11.9)	53.1 (±12.5)	46.1 (±8.3)	62.3 (±11.0)
	2019	54.3 (±13.7)	47.7 (±11.2)	58.2 (±13.6)	54.3 (±11.8)	45.0 (±8.2)	59.9 (±10.0)	53.5 (±11.2)	45.4 (±7.6)	60.6 (±8.9)	52.4 (±11.8)	44.8 (±7.8)	62.2 (±8.5)	49.9 (±11.7)	45.1 (±7.9)	63.0 (±10.2)	48.2 (±9.9)	45.9 (±8.1)	60.7 (±9.6)	52.9 (±12.0)	45.5 (±8.4)	60.4 (±10.3)
FTE (N (%))	2008	290 (49.0)	146 (50.3)	144 (49.7)	1210 (64.5)	754 (62.3)	456 (37.7)	1802 (73.0)	1173 (65.1)	629 (34.9)	1481 (75.1)	1209 (81.6)	272 (18.4)	239 (58.4)	220 (92.1)	19 (8.0)	114 (32.0)	107 (93.9)	7 (6.1)	5136 (66.9)	3609 (70.3)	1527 (29.7)
	2013	335 (45.4)	152 (45.4)	183 (54.6)	1073 (64.4)	556 (51.8)	517 (48.2)	1694 (73.3)	1014 (59.9)	680 (40.1)	1634 (75.3)	1156 (70.8)	478 (29.3)	474 (67.0)	415 (87.6)	59 (12.5)	189 (41.6)	177 (93.7)	12 (6.4)	5399 (67.1)	3470 (64.3)	1929 (35.7)
	2019	734 (51.9)	351 (47.8)	383 (52.2)	1401 (65.6)	628 (44.8)	773 (55.2)	1722 (76.8)	881 (51.2)	841 (48.8)	1681 (73.8)	1052 (62.6)	629 (37.4)	514 (72.6)	402 (78.2)	112 (21.8)	327 (54.6)	288 (88.1)	39 (11.9)	6379 (68.0)	3602 (56.5)	2777 (43.5)

Comp. FPs: Comprehensive family physicians; Pract.: Practice; PC: Primary care; Pt(s): Patient(s); Prop: Proportion; Fem: Female; FTE: Comp FPs practicing full-time equivalent

Supplemental eTable 2. Family physicians who are in non-comprehensive scopes of practice (i.e., focused, other, walk-in) over time by physician age group

	<35 Years			35-44 Years			45-54 Years			55-64 Years			65-69 Years			70+ Years			Total - Focused/Other/Walk-In		Total - All FPs
	N	% of all FPs	% of all FPs <35	N	% of all FPs	% of all FPs 35-44	N	% of all FPs	% of all FPs 45-54	N	% of all FPs	% of all FPs 55-64	N	% of all FPs	% of all FPs 65-69	N	% of all FPs	% of all FPs 70+	N	% of all FPs	N
2008	305	3.1%	34.0%	652	6.6%	25.8%	581	5.8%	19.1%	430	4.3%	17.9%	133	1.3%	24.5%	161	1.6%	31.1%	2262	22.7%	9,944
2013	503	4.5%	40.4%	755	6.7%	31.2%	708	6.3%	23.4%	615	5.4%	22.1%	278	2.5%	28.2%	366	3.2%	44.6%	3225	28.6%	11,288
2019	697	5.3%	33.0%	827	6.2%	27.9%	716	5.4%	24.2%	757	5.7%	24.9%	374	2.8%	34.6%	514	3.9%	46.2%	3885	29.3%	13,269
Relative Change (2019/ 2008)		171%	97%		95%	108%		92%	127%		132%	139%		211%	141%		239%	148%		129%	
Absolute Change (2019 minus 2008)		2.19%	-0.98%		-0.32%	2.14%		-0.45%	5.14%		1.38%	7.03%		1.48%	10.03%		2.25%	15.04%		6.53%	

Supplemental eTable 3. Comprehensive family physician practice model over time by physician age and sex

Year	Model	Age < 35 Total N	Age < 35 Total %	Age < 35 Male N	Age < 35 Male %	Age < 35 Female N	Age < 35 Female %	Age 35 - 44 Total N	Age 35 - 44 Total %	Age 35 - 44 Male N	Age 35 - 44 Male %	Age 35 - 44 Female N	Age 35 - 44 Female %	Age 45 - 54 Total N	Age 45 - 54 Total %	Age 45 - 54 Male N	Age 45 - 54 Male %	Age 45 - 54 Female N	Age 45 - 54 Female %	Age 55 - 64 Total N	Age 55 - 64 Total %	Age 55 - 64 Male N	Age 55 - 64 Male %	Age 55 - 64 Female N	Age 55 - 64 Female %	Age 65 - 69 Total N	Age 65 - 69 Total %	Age 65 - 69 Male N	Age 65 - 69 Male %	Age 65 - 69 Female N	Age 65 - 69 Female %	Age 70+ Total N	Age 70+ Total %	Age 70+ Male N	Age 70+ Male %	Age 70+ Female N	Age 70+ Female %	Total Sample Total N	Total Sample Total %	Total Sample Male N	Total Sample Male %	Total Sample Female N	Total Sample Female %
2008																																										
	EFFS	243	41	91	43.1	152	39.9	1009	53.8	513	55.6	496	51.9	1410	57.2	796	56	614	58.8	1184	60	903	59.3	281	62.4	210	51.3	174	50.1	36	58.1	142	39.9	129	40.4	13	35.1	4198	54.7	2606	54.9	1592	54.3
	CAP	56	9.5	*11 - 15		*43 - 47		167	8.9	70	7.6	97	10.2	191	7.7	114	8	77	7.4	*128-132		104	6.8	*24 - 28		*30-34		*27 - 31		*1 - 5		7	2	7	2.2	0	0	583	7.6	337	7.1	246	8.4
	FHT	85	14.4	35	16.6	50	13.1	281	15	126	13.7	155	16.2	402	16.3	228	16	174	16.7	*276-280		228	15	*48 - 52		48	11.7	*43-47		*1 - 5		17	4.8	*12-16		*1 - 5		1113	14.5	680	14.3	433	14.8
	NOG	198	33.4	69	32.7	129	33.9	389	20.7	202	21.9	187	19.6	427	17.3	256	18	171	16.4	356	18.1	268	17.6	88	19.6	118	28.9	*94-98		*20 - 24		190	53.4	*163-167		*23 - 27		1678	21.9	1056	22.3	622	21.2
	OGP	10	1.7	*1-5		*3 - 7		31	1.7	11	1.2	20	2.1	37	1.5	28	2	9	0.9	*20-24		19	1.2	*1-5		*1-5		*1-5		0	0	0	0	0	0	0	0	101	1.3	64	1.3	37	1.3
2013																																											
	EFFS	162	21.9	65	26.5	97	19.6	571	34.3	243	36.1	328	33.1	853	36.9	464	37.8	389	35.9	766	35.3	481	34	285	37.7	292	41.3	218	37.8	74	56.5	173	38.1	149	38	24	38.7	2817	35	1620	35.8	1197	34
	CAP	108	14.6	*28 - 32		*76-80		361	21.7	*127 - 131		*229 - 233		582	25.2	310	25.3	272	25.1	603	27.8	407	28.8	196	26	168	23.8	146	25.3	22	16.8	75	16.5	*65-69		*6 - 10		1897	23.6	1091	24.1	806	22.9
	FHT	186	25.1	64	26.1	122	24.6	461	27.7	183	27.2	*276 - 280		547	23.7	*266-270		*277 - 281		501	23.1	325	23	176	23.3	127	18	114	19.8	13	9.9	55	12.1	*50-54		*1 - 5		1877	23.3	1007	22.2	870	24.7
	NOG	277	37.4	83	33.9	194	39.1	266	16	116	17.2	150	15.1	313	13.5	172	14	141	13	273	12.6	183	12.9	90	11.9	110	15.6	88	15.3	22	16.8	151	33.3	124	31.6	27	43.5	1390	17.3	766	16.9	624	17.7
	OGP	8	1.1	*1-5		*3-7		7	0.4	*1-5		*2 - 6		17	0.7	*11-15		*2 - 6		27	1.2	19	1.3	8	1.1	10	1.4	10	1.7	0	0	0	0	0	0	0	0	69	0.9	45	1	24	0.7
2019																																											
	EFFS	249	17.6	*103 - 107		*144 - 148		518	24.3	218	27	300	22.6	712	31.8	*348 - 352		*360-364		707	31	408	31.6	299	30.2	244	34.5	*163 - 167		*75 - 79		239	39.9	*190 - 194		48	51.1	2669	28.5	1437	30.6	1232	26.3
	CAP	341	24.1	124	23.5	217	24.5	597	28	193	23.9	404	30.4	699	31.2	315	30.1	384	32.2	725	31.8	399	30.9	326	33	221	31.2	176	33.9	45	23.8	165	27.5	146	28.9	19	20.2	2748	29.3	1353	28.8	1395	29.8
	FHT	376	26.6	137	25.9	239	27	683	32	252	31.3	431	32.4	583	26	255	24.3	328	27.5	577	25.3	321	24.9	256	25.9	151	21.3	109	21	42	22.2	79	13.2	71	14.1	8	8.5	2449	26.1	1145	24.4	1304	27.9
	NOG	437	30.9	157	29.7	280	31.6	316	14.8	133	16.5	183	13.8	237	10.6	123	11.7	114	9.5	241	10.6	141	10.9	100	10.1	82	11.6	64	12.3	22	11.6	112	18.7	93	18.4	19	20.2	1429	15.2	711	15.1	718	15.3
	OGP	11	0.8	*3 - 7		*2 - 6		21	1	10	1.2	11	0.8	11	0.5	*3 - 7		*4-8		29	1.3	21	1.6	8	0.8	*6-10		*3 - 7		*1-5		*1-5		*1-5		0	0	82	0.9	50	1.1	32	0.7

Percentages are column percentages

Ranges preceded by an asterisk (*) represent suppressed cells due to small cell sizes

EFFS: Enhanced fee-for-service. This is a fee-for-service payment model that requires patient enrollment and includes some pay enhancements, such as higher fee-for-service payments for enrolled patients and bonus payments for preventive care targets.

CAP: Capitation. An alternate payment plan (APP) model where the majority of physician payments come from an annual amount for each enrolled patient adjusted for patient age and sex.

FHT: Capitation models with additional funding for interdisciplinary team members such as nurse practitioners and social workers.

NOG: No group. These physicians are paid via traditional fee-for-service, without any enrolment requirements or pay enhancements.

OGP: Other physician group types, typically serving a specific targeted population or geography (for example, rural/remote) with varying funding mechanisms.

Supplemental eTable 4. Geographic Distribution of Comprehensive FPs

A. Comprehensive FPs by Geography

	Large Urban	Urban	Small Urban/Suburban	Rural/Remote	Total
2008 N (% of Comprehensive FPs)	3,909 (51.1)	1,990 (26.0)	1,236 (16.2)	513 (6.7)	7,648 (100.0)
2013 N (% of Comprehensive FPs	4,105 (51.1)	2,314 (28.8)	1,207 (15.0)	410 (5.1)	8,036 (100.0)
2019 N (% of Comprehensive FPs	4,674 (50.0)	2,685 (28.7)	14,98 (16.0)	492 (5.3)	9,349 (100.0)

Note: Geographic data missing for: 2008 (25), 2013 (14), 2019 (28)

B. Rural (RIO 40+) Comprehensive FPs by Age Group

	<35 years	35-44 years	45-54 years	55-64 years	65-69 years	70+ years	Total
2008 N (% of rural comprehensive FPs)	46 (9.0)	135 (26.3)	166 (32.4)	118 (23.0)	27 (5.3)	21 (4.1)	513 (100.0)
2013 N (% of rural comprehensive FPs)	31 (7.6)	76 (18.5)	109 (26.6)	129 (31.5)	44 (10.7)	21 (5.1)	410 (100.0)
2019 N (% of rural comprehensive FPs)	89 (18.1)	111 (22.6)	121 (24.6)	117 (23.8)	32 (6.5)	22 (4.5)	492 (100.0)

C. Rural (RIO 40+) Comprehensive FPs by Physicians Sex

	Male Physicians			Female Physicians			Total Rural		All Comprehensive FPs	
	N	% of Rural Comprehensive FPs	% of all Comprehensive FPs	N	% of Rural Comprehensive FPs	% of all Comprehensive FPs	N	% of all Comprehensive FPs	N	% of all Comprehensive FPs
2008	362	70.6	4.7	151	29.4	2	513	6.7	7648	6.7
2013	268	65.4	3.3	142	34.6	1.8	410	5.1	8036	5.1
2019	279	56.7	3	213	43.3	2.3	492	5.3	9349	5.3

We were unable to stratify by both age and sex due to suppressed cells (cell sizes <6) in older age categories for male and female physicians in the rural category.

Large urban: Rurality Index of Ontario (RIO) score of 0

Urban: RIO score of 1-9

Suburban/Small Urban: RIO score of 10-39

Rural/remote: RIO score of 40+

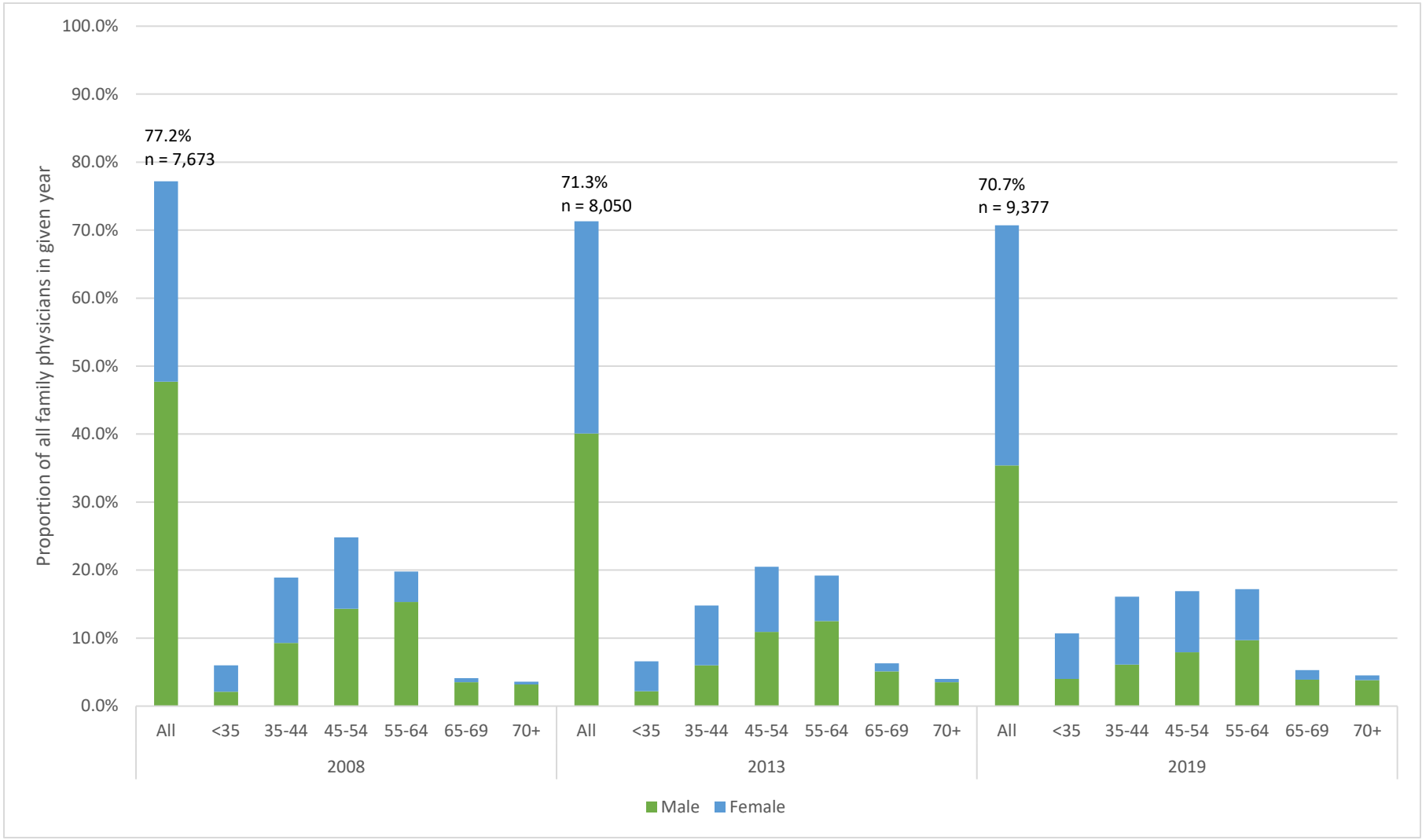
Supplemental eTable 5. Practice characteristics: Medical and social complexity of patients attached to comprehensive family physicians over time by physician age and sex

		<35 Years			35-44 Years			45-54 Years			55-64 Years			65-69 Years			70+ Years			TOTAL		
		Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Highest morbidity (RUB (4+))	2008	15.3	14.7	15.6	16.2	15.8	16.7	16.4	16.5	16.2	17.3	17.5	16.6	16.8	17.2	14.0	14.0	14.1	13.0	16.5	16.7	16.3
	2013	17.5	17.6	17.4	18.2	17.5	18.7	17.7	17.8	17.6	18.1	18.5	17.3	19.5	20.0	17.5	20.1	20.5	17.9	18.1	18.3	17.8
	2019	19.3	19.4	19.2	20.6	20.2	20.8	19.4	19.4	19.4	19.5	20.2	18.7	20.3	20.4	20.1	21.4	21.5	21.3	19.8	19.9	19.7
Lowest income quintile	2008	18.5	19.2	18.1	18.1	19.6	16.6	18.4	19.8	16.4	19.9	20.2	18.8	22.6	22.5	23.6	23.9	20.1	17.2	19.0	20.1	17.2
	2013	18.9	20.6	18.0	17.2	19.1	16.0	18.0	19.4	16.4	18.4	19.5	16.5	20.5	20.4	21.2	24.0	24.2	22.5	18.3	19.6	16.7
	2019	20.4	21.9	20.7	18.8	20.7	17.6	18.3	20.5	16.5	18.8	20.4	16.8	19.9	20.7	17.9	22.1	22.2	21.4	19.0	20.7	17.5
Highest housing instability quintile	2008	24.5	22.8	25.5	20.6	20.7	20.4	20.4	20.4	20.4	21.9	21.6	23.0	24.0	23.1	29.2	25.5	25.6	24.2	21.4	21.2	21.7
	2013	26.0	23.6	27.2	21.8	20.9	22.5	19.9	20.4	19.4	20.8	20.6	21.3	21.7	21.8	21.2	24.5	24.1	26.6	21.4	20.9	21.9
	2019	26.5	25.3	27.2	24.5	24.7	24.5	21.1	21.8	20.4	21.4	21.5	21.3	22.6	21.7	24.9	25.5	25.2	27.1	23.0	22.7	23.3
Highest material deprivation quintile	2008	18.6	19.8	17.9	17.4	19.3	15.5	18.2	20.1	15.6	20.5	21.3	18.1	23.7	23.9	22.4	25.7	26.2	21.3	19.0	20.6	16.4
	2013	22.9	24.6	22.0	20.5	22.1	19.4	21.2	22.9	19.3	21.4	22.6	19.2	23.7	23.2	25.7	29.2	29.4	27.8	21.5	22.8	19.9
	2019	18.2	19.7	17.3	17.3	19.9	15.8	17.0	19.3	15.0	18.1	19.8	15.9	19.7	20.9	16.7	21.8	22.1	19.9	17.8	19.8	15.9
Highest neighborhood ethnic concentration quintile	2008	27.4	30.8	25.5	27.5	28.4	26.5	26.0	26.1	25.9	27.2	26.3	30.4	28.0	26.4	37.2	32.6	32.8	30.7	26.9	26.9	27.0
	2013	29.9	31.1	29.2	28.6	29.2	28.2	27.9	29.2	26.6	27.2	27.2	27.3	27.7	25.5	37.3	33.0	32.0	39.4	28.0	28.1	28.0
	2019	26.0	26.6	25.7	25.8	27.2	25.0	28.5	29.2	27.8	27.0	26.8	27.3	33.2	33.7	31.9	32.1	30.9	38.5	27.4	28.3	26.7

Interpretation: For example, in 2008, within the group of comprehensive family physicians under the age of 35 years, 15.3% of patients in those practices had the highest level of morbidity (RUB 4+). When further stratified by physician sex, 14.7% of patients attached to male comprehensive family physicians belonged to the highest morbidity (RUB 4+) group.

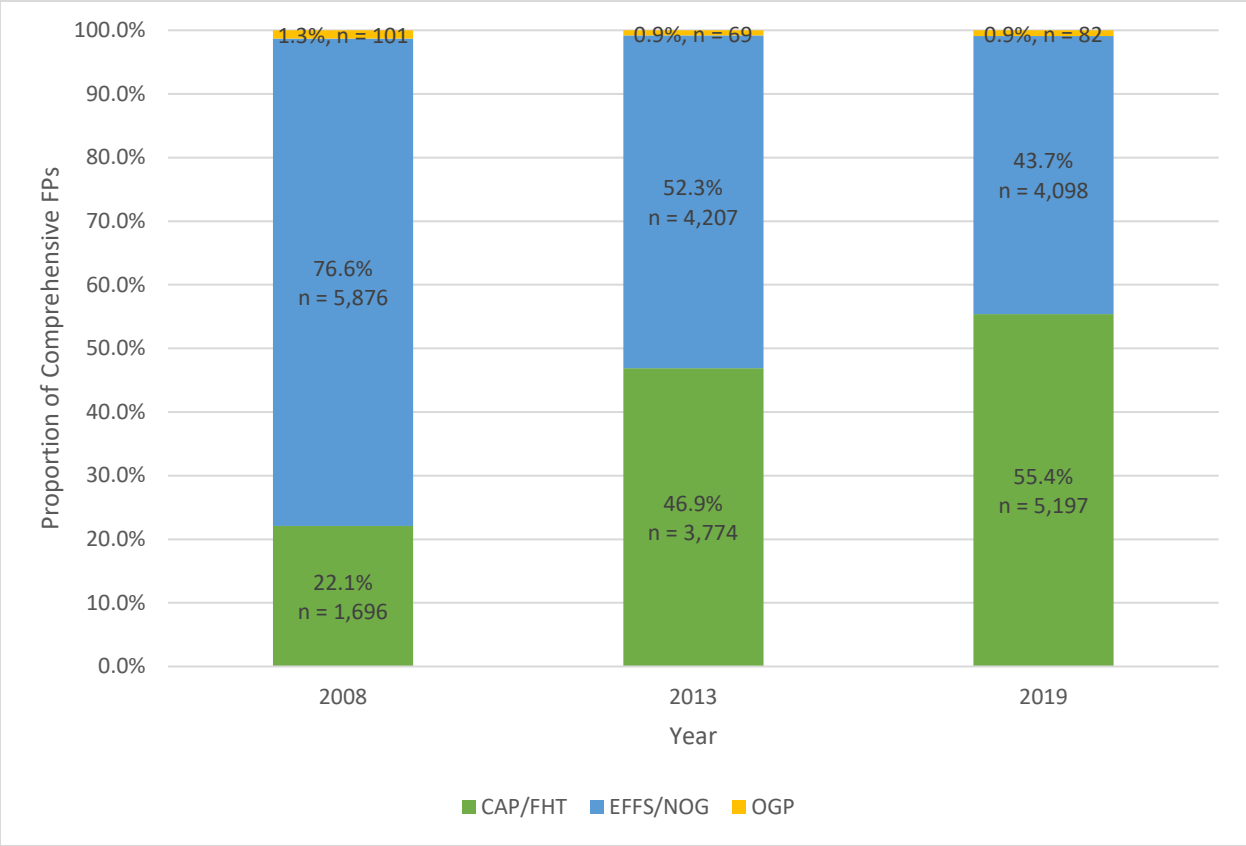
RUB: Morbidity, based on Resource Utilization Band

Supplemental eFigure 1. Proportion of family physicians practicing comprehensiveness by year, age, and sex



Total Ns (all family physicians): 2008: 9,944; 2013: 11,288; 2019: 13,269

Supplemental eFigure 2. Proportion of comprehensive family physicians in various practice models by year



Total Ns (all comprehensive family physicians): 2008: 7,673; 2013: 8,050; 2019: 9,377

CAP/FHT: Alternate payment plan (APP) model where physician payments are mainly capitation(CAP)-based (annual amount per enrolled patient, adjusted for patient age and sex), with or without additional funding for interdisciplinary team members (Family Health Team(FHT)) such as nurse practitioners and social workers

EFFS/NOG: Fee-for-service payment models. EFFS = fee-for-service payments with enrolment requirements and some pay enhancements, such as higher payments for enrolled patients and bonus payments for meeting preventive care targets. NOG = No group; traditional fee-for-service payments with no enrolment requirements or payment enhancements.

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

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9, Supplemental eMethods
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	7-9, Supplemental eMethods
Bias	9	Describe any efforts to address potential sources of bias	Figure 1a, 1b
Study size	10	Explain how the study size was arrived at	8-9, Figure 1a, 1b
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	7, Supplemental eTable 4
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a
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	9, Figure 1a, 1b
		(b) Give reasons for non-participation at each stage	9, Figure 1a, 1b
		(c) Consider use of a flow diagram	Figure 1a, 1b

Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-16
		(b) Indicate number of participants with missing data for each variable of interest	Figure 1a, 1b, Supplemental eTable 4
Outcome data	15*	Report numbers of outcome events or summary measures	9-16
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	9-16
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*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	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	17-18
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	19-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	19-20
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	21-22

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The characteristics of patients attached to near-retirement family physicians: a population-based serial cross-sectional study in Ontario, Canada

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The characteristics of patients attached to near-retirement family physicians: a population-based serial cross-sectional study in Ontario, Canada

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ABSTRACT

Objectives: Population aging is a global phenomenon. Resultant healthcare workforce shortages are anticipated. To ensure access to comprehensive primary care, which correlates with improved health outcomes, equity, and costs, data to inform workforce planning are urgently needed. We examined the medical and social characteristics of patients attached to near-retirement comprehensive primary care physicians over time and explored the early- and mid-career workforce's capacity to absorb these patients.

Design: A serial cross-sectional population-based analysis using health administrative data.

Setting: Ontario, Canada, where most comprehensive primary care is delivered by family physicians (FPs) under universal insurance.

Participants: All insured Ontario residents at three time points: 2008 (12,936,360), 2013 (13,447,365), and 2019 (14,388,566) and all Ontario physicians who billed primary care services (2008: 11,566; 2013: 12,693; 2019: 15,054).

Outcome measures: The number, proportion, and health and social characteristics of patients attached to near-retirement age comprehensive FPs over time; the number, proportion, and characteristics of near-retirement age comprehensive FPs over time. Secondary Outcome Measures: The characteristics of patients and their early- and mid-career comprehensive FPs.

Results: Patient attachment to comprehensive FPs increased over time. The overall FP workforce grew, but the proportion practicing comprehensiveness declined (2008: 77.2%, 2019: 70.7%). Over time, an increasing proportion of the comprehensive FP workforce was near retirement age. Correspondingly, an increasing proportion of patients were attached to near-retirement physicians. By 2019, 13.9% of comprehensive FPs were 65 years or older,

corresponding to 1,695,126 (14.8%) patients. Mean patient age increased, and all physicians served markedly increasing numbers of medically and socially complex patients.

Conclusions: The primary care sector faces capacity challenges as both patients and physicians age and fewer physicians practice comprehensiveness. Nearly 15% (1.7 million) of Ontarians may lose their comprehensive FP to retirement between 2019 and 2025. To serve a growing, increasingly complex population, innovative solutions are needed.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our serial cross-sectional study uses large, population-level health administrative datasets to examine temporal trends in the needs of primary care patients who may soon lose their family physician (FP) to retirement, in turn informing future workforce planning.
- By distinguishing between FPs practicing comprehensive primary care and those who have narrowed their scope of practice, our methodology allows us to identify disparities between the presumed and actual primary care supply.
- By linking the characteristics, including age and sex, of the comprehensive primary care workforce to both the medical and social characteristics of the population served, our methodology facilitates a rich understanding of the resources needed by patients who may soon lose their FP to retirement, and the capacity to meet those needs among those who will remain in the workforce.
- Our methodology allows us to identify trends related to practice preferences among FPs that can be in turn applied to other data sources around primary care trainees and population growth.

- Limitations of this work include that our analyses predate the COVID-19 pandemic, due to limited data availability for more recent years, and that the number of comprehensive FPs in rural areas may be underestimated due to rural physician practice patterns possibly involving a large proportion of hospital-based services.

INTRODUCTION

Primary care is the foundation of high-performing health care systems worldwide,1 and can be defined by four core functions ("the 4 Cs") articulated by Starfield and others: first *Contact* access to the healthcare system, *Continuity* (long-term person-focused care), *Comprehensiveness* (meeting the majority of each patient's physical and mental health care needs, including prevention, acute care, chronic care, and multimorbidity care), and *Coordination* of care across the healthcare system, including specialty care, hospitals, home care, and community services and support.[1, 2] Access to primary care is associated with improved health outcomes, improved health equity, and reduced health system costs.[3-9]

An essential enabler of primary care access is an adequate health human resource (HHR) supply, but many jurisdictions are grappling with current and impending shortages. For example, 14.5% (4.6 million) Canadians are without a primary care provider.[10] Virtually every country world-wide is experiencing population aging,[11] with a high burden of medical complexity[12-15] and a HHR workforce that is aging into retirement.[16-18] Concurrently, many countries, including Canada, the United Kingdom, and the United States, are experiencing challenges attracting incoming physicians to primary care as a specialty,[19-22] and among those who do, a declining proportion are providing primary care reflective of Starfield's "4 Cs" (hereafter referred to as "comprehensive primary care"); instead, primary care physicians are increasingly limiting their scope of work to subspecialized areas such as sports medicine, dermatology, or palliative care, or to episodic acute care settings, such as walk-in clinics.[23-29] Moreover, the concentration of women in primary care may further reduce HHR capacity, as women primary care physicians have been found to spend more time with patients[30] and receive more patient requests outside of appointments than men.[31, 32]

In the context of an aging population and shifting workforce demographics, HHR planning requires an understanding of the needs of patients who will soon lose their primary care provider due to retirement. To anticipate future need, previous studies often use high-level supply indicators such as number of primary care physicians, and high-level demand indicators such as patient visit rates and durations.[33-36] In-depth analyses tend to be limited to sub-jurisdictional populations, such as the neighborhood[36] or early career clinicians,[24] and do not directly link supply (individual clinicians) to demand (patients served by those clinicians).

We conducted an in-depth exploration linking supply and demand at a health system planning level in Ontario, Canada. We examined temporal trends in near-retirement primary care physician characteristics and the medical and social needs of patients attached to these physicians. We also examined early career and mid-career physician characteristics over time to understand this segment of the workforce's capacity to absorb the patients of near-retirement physicians. We explored hypothesis-generating differences in gender-based workforce trends, including differences in care provision,[30, 31] and trends around alternative practice models, such as interprofessional team-based care. As Canadian healthcare planning and delivery are within provincial jurisdiction, we focused on the province-level (Ontario). In Ontario, most comprehensive primary care is delivered by family physicians (FPs), most physician services and all permanent residents are covered by government insurance, and health services data are stored centrally in health administrative datasets.

METHODS

The use of data in this study was authorized under section 45 of Ontario's Personal Health Information Protection Act (PHIPA) and did not require review by a research ethics board or

informed consent. This study is reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.[37]

Study design, population, and data sources

We conducted a serial cross-sectional population-level analysis. De-identified physician-level and patient-level data came from nine databases which were linked using unique encoded identifiers and analyzed at ICES (Supplemental eMethods). The study population included all registered Ontario residents covered by the Ontario Health Insurance Plan (OHIP) at three time points: March 31, 2008 (12,936,360), March 31, 2013 (13,447,365), and March 31, 2019 (14,388,566) and all Ontario physicians who billed primary care services (2008: 11,566; 2013: 12,693; 2019: 15,054).

Outcomes and covariates

The primary outcomes were the number, proportion, and characteristics of patients attached to a near-retirement age comprehensive FP over three time points, and the number, proportion, and characteristics of near-retirement age comprehensive FPs over three time points. Physician characteristics served as exploratory indicators of both existing supply and, for near-retirement physicians, anticipated demand based on the populations of patients they serve. Patient characteristics served as indicators of demand based on medical and sociodemographic complexity.

Based on previous literature finding the average Ontario FP retires at age 70.5 years (with women retiring on average 5 years earlier than men)[38] and accounting for the time needed to train new physicians,[39] three different "near-retirement" physician age cut-points were examined: $\geq$ 55 years, $\geq$ 65 years, and $\geq$ 70 years.

Comprehensive FPs were defined by applying a previously validated algorithm described below in the Analysis section.[29] Detailed data source, cohort, and covariate definitions can be found in the Supplemental eMethods.

Analysis

For our patient cohort, we created cross-sections of patients attached to comprehensive FPs at three time points: 2008, 2013, 2019.

We began by applying our previously validated algorithm for primary care physician attachment[40] to the population of OHIP-registered Ontario residents; identifying patients attached to a physician providing longitudinal primary care services based on billing codes and physician-level continuity of care (see Supplemental eMethods – continuity of care). We removed patients seen at Community Health Centres because they cannot be attached to a specific physician, patients that the algorithm attached to non-FPs such as pediatricians and surgeons, and patients attached to a FP with missing covariates.

We next created the cohort of FPs linked to the attached patients we identified (2008, 2013, 2019). We stratified our patient and FP cohorts by physician practice type (scope). For this, we used a previously published algorithm for determining comprehensiveness of primary care practice, where physicians are identified as providing comprehensive care if more than half of their services were for core primary care and if these services fell into at least 7 of 22 activity areas.[29] This resulted in four groups of patients with attachments to four types of FP practice scopes: Comprehensive, Focused (for example, sports medicine or palliative care), Other, and those who worked less than 44 days/year. The latter two practice categories were grouped

together as "Other". Focusing on the "comprehensive FP" group, we described the characteristics of these physicians and their patients.

Physician analyses were stratified by physician sex and physician age, including the three "near-retirement" cut-points. Proportions and means with standard deviations were reported for each time point (2008, 2013, 2019).

Patient and public involvement

None.

RESULTS

Patient cohort

Excluding long-term care home residents, the population of OHIP-eligible Ontario residents in the patient cohort over time was 12,863,036 (2008), 13,371,946 (2013), and 14,312,309 (2019), of whom the following were attached to a comprehensive FP: 2008: n = 9,537,353 (77.3%); 2013: n = 10,398,003 (85.1%); 2019: n = 11,480,975 (86.1%) (Figure 1a).

Physician cohort

The overall FP workforce grew from 9,944 physicians in 2008 to 13,269 in 2019 (Figure 1b, sum of boxes 8 and 9).

A shift away from comprehensiveness and into other/focused scopes of practice ("non-comprehensive") was seen, with the proportion of all FPs practicing comprehensive primary care declining from 77.2% in 2008 (n = 7,673) to 70.7% in 2019 (n = 9,377) (Supplemental eFigure 1). This was driven by declining comprehensiveness among mid-career and near-retirement physician groups (age groups 45 and above). Over time, the proportion of younger physicians

(those under 45) practicing comprehensiveness was stable, albeit in lower proportions than their mid-career counterparts. In the oldest age group, a decreasing proportion practiced comprehensiveness (Supplemental eTable 1).

Supplemental eTable 2a and Supplemental eTable 2b focus specifically on the comprehensive FP workforce and stratify comprehensive FP data by age and sex. Career stage (years in practice) closely followed physician age group for both males and females, and the youngest cohort (age <35) comprised an increasing proportion of the comprehensive workforce over time, shifting from 7.7% in 2008 to 15.1% in 2019. The older cohorts were also found to comprise an increasing proportion of the comprehensive workforce over time, and the absolute numbers of older physicians increased.

Temporal trends for near-retirement comprehensive FPs and their patients

When looking at our three near-retirement cut-points (55+, 65+, 70+) over time, an increasing proportion of the comprehensive FP workforce was near retirement age (Figure 2). Correspondingly, an increasing proportion of patients were attached to near-retirement comprehensive FPs (Table 1). Between 2008 and 2019, FPs in the 55+ age group represented a growing proportion of all comprehensive FPs, increasing from 35.7% to 38.2%. In 2019, this corresponded to 3,586 physicians and 4,935,992 (43.0%) patients (2019). The proportion of comprehensive FPs in the 65+ group increased from 10.0% in 2008 to 13.9% in 2019 (1,307 physicians, 1,695,126 (14.8%) patients). the proportion of comprehensive FPs in the 70+ age group increased from 4.6% in 2008 to 6.4% in 2019 (599 physicians, 666,000 (5.8%) patients).

Table 1. Characteristics of patients attached to near-retirement comprehensive family physicians over time, by near-retirement group

		Age 55+ Comprehensive FPs		Age 65+ Comprehensive FPs		Age 70+ Comprehensive FPs	
Patient Characteristics		N	%	N	%	N	%
OVERALL (N, % of patients attached to near-retirement physician group)	2008	3,571,661	37.5	690,642	7.2	214,861	2.3
	2013	4,676,625	45.0	1,399,119	13.5	419,172	4.0
	2019	4,935,992	43.0	1,695,126	14.8	666,404	5.8
Aged 65+ (N, % of patients attached to near-retirement physician group)	2008	597,707	16.7	136,394	19.8	45,414	21.1
	2013	846,974	18.1	298,545	21.3	95,833	22.8
	2019	1,003,769	20.3	402,430	23.7	176,473	26.5
Female patients (N, % of patients attached to near-retirement physician group)	2008	1,804,585	50.5	338,656	49.0	103,386	48.1
	2013	2,371,923	50.7	678,971	48.5	201,104	48.0
	2019	2,498,453	50.6	823,090	48.6	317,967	47.7
Rural patients (RIO score 40+) (N, % of patients attached to near-retirement physician group)	2008	233,045	6.5	48,860	7.1	14,323	6.7
	2013	292,357	6.3	88,311	6.3	20,294	4.8
	2019	274,099	5.6	83,691	4.9	33,545	5.0
Highest (4+) RUB (N, % of patients attached to near-retirement physician group)	2008	677,436	19.0	137,995	20.0	44,067	20.5
	2013	878,340	18.8	283,013	20.2	88,182	21.0
	2019	983,818	19.9	350,439	20.7	146,298	22.0
Highest (5+) annual core primary care visits (N, % of patients attached to near-retirement physician group)	2008	2,109,950	59.1	403,026	58.4	127,050	59.1
	2013	2,462,236	52.7	753,388	53.9	227,090	54.2
	2019	2,480,395	50.3	876,487	51.7	346,668	52.0
COPD (N, % of patients attached to near-retirement physician group)	2008	233,498	6.5	51,856	7.5	16,411	7.6
	2013	326,748	7.0	115,669	8.3	37,477	8.9
	2019	337,202	6.8	132,395	7.8	59,350	8.9
CHF (N, % of patients attached to near-retirement physician group)	2008	69,573	2.0	15,645	2.3	4,952	2.3
	2013	80,026	1.7	28,187	2.0	9,214	2.2
	2019	90,436	1.8	35,567	2.1	15,832	2.4
Diabetes (N, % of patients attached to near-retirement physician group)	2008	327,127	9.2	68,392	9.9	21,389	10.0
	2013	506,014	10.8	170,115	12.2	52,815	12.5
	2019	555,358	11.3	215,696	12.7	92,395	13.9

Frailty (N, % of patients attached to near-retirement physician group)	2008	66,559	1.9	14,875	2.2	4,964	2.3
	2013	98,490	2.1	33,005	2.4	10,794	2.6
	2019	114,085	2.3	43,032	2.5	18,597	2.8
Any mental health illness in last 2 years (N, % of patients attached to near-retirement physician group)	2008	825,520	23.1	166,257	24.1	51,802	24.1
	2013	979,987	21.0	311,771	22.3	96,543	23.0
	2019	1,022,523	20.7	355,911	21.0	150,153	22.5
Lowest income quintile (N, % of patients attached to near-retirement physician group)	2008	706,504	19.8	150,381	21.8	48,403	22.5
	2013	876,982	18.8	282,922	20.2	91,236	21.8
	2019	944,888	19.1	348,869	20.6	142,881	21.4
Highest housing instability quintile (N, % of patients attached to near-retirement physician group)	2008	761,397	21.3	165,525	24.0	54,275	25.6
	2013	934,472	20.0	295,059	21.1	92,653	22.2
	2019	1,031,506	20.9	374,322	22.1	155,859	23.4
Highest material deprivation quintile (N, % of patients attached to near-retirement physician group)	2008	736,903	20.6	163,835	23.7	52,733	24.9
	2013	1,045,136	22.4	338,012	24.2	112,097	26.9
	2019	926,043	18.8	352,849	20.8	145,084	21.8
Highest neighborhood ethnic concentration quintile (N, % of patients attached to near-retirement physician group)	2008	962,252	26.9	177,586	25.7	63,167	29.8
	2013	1,335,124	28.6	397,430	28.4	124,062	29.8
	2019	1,521,975	30.8	584,512	34.5	213,182	32.0
Recent immigrant (N, % of patients attached to near-retirement physician group)	2008	269,131	7.5	52,717	7.6	21,202	10.9
	2013	289,772	6.2	83,484	6.0	27,024	7.0
	2019	277,755	5.6	82,560	4.9	28,449	4.3

Interpretation of Table 1 rows:

Interpretation of the "Overall" category: For example, in 2019, 1,695,126 patients were attached to a comprehensive FP aged 65+. This represents 14.8% of all patients who are attached to a comprehensive FP.

Interpretation of each patient category: For example, in 2019, of the 666,404 patients attached to comprehensive FPs over the age of 70 years, 28,449 (4.3%) were recent immigrants.

FPs: family physicians. RIO: Rurality Index of Ontario. RUB: morbidity, based on resource utilization band. COPD: chronic obstructive pulmonary disease. CHF: congestive heart failure.

Temporal characteristics of comprehensive FPs and their patients

Comprehensive FP capacity/workload

Supplemental eTable 2b shows the mean (SD) roster size for the total population of comprehensive FPs remained consistent over time (2008: 1213 (927); 2013: 1272 (909); 2019: 1209 (837)). Male FPs had consistently larger roster sizes in each age group and at each time point. Both male and female FP roster sizes followed an inverted U pattern with FP age, with practice sizes starting and ending smaller at the extremes of FP age and peaking during mid-career. This pattern was observed at all three time points. That said, male and female older (65+) physicians and younger (<35) physicians cared for larger roster sizes over time.

Working full time equivalent (FTE) also followed an inverted U pattern according to FP age (Supplemental eTable 2b). Consistently, two thirds of the overall comprehensive FP workforce practiced FTE, with males comprising the majority of FTE physicians. Older physicians increasingly practiced FTE (age 65-69, 2008: 58.4%, 2013: 67.0%, 2019: 72.6%; age 70+, 2008: 32.0%, 2013: 41.6%, 2019: 54.6%), a trend that was driven by an increasing proportion of female FTE comprehensive FPs. Among younger physicians, by 2019, females comprised the majority of FTE workforce (52.2% of FTE comprehensive FPs <35 years; 55.2% of FTE comprehensive FPs 35-44 years).

Mean (SD) annual core primary care visits provided per patient declined over time (Supplemental eTable 2b): 2008: 7.3 (3.1) visits; 2013: 6.5 (2.6) visits; 2019: 6.0 (2.3) visits. In most comprehensive FP age groups, male and females provided similar numbers of annual visits. Older physicians provided more annual visits compared with their younger counterparts.

In the patient cohort (Table 1), at all near-retirement physician cut-offs (55+, 65+, 70+), a declining proportion over time made a high number (5+) primary care visits in the preceding year, but these proportions remained consistently over 50% in all near-retirement groups and at each time point.

Comprehensive FP practice settings

A declining proportion of comprehensive FPs over time practiced in fee-for-service (FFS) models of care, with alternate payment plan models (APPs), specifically capitation and team-based models of care, becoming increasingly common (Supplemental eFigure 2). In these APP models, physician compensation is primarily a lump sum payment per attached patient, with or without additional government funding for support for interdisciplinary health professionals ("teams") such as nurses, nurse practitioners, social workers, and dietitians. In 2008, most comprehensive FPs worked in FFS-based models (76.6%), but by 2019, most practiced in APPs (55.4%) (Supplemental eFigure 2, Supplemental eTable 3). Correspondingly, an increasing proportion of patients were served in APP models: 2008: 26.5% (n = 2,526,116); 2013: 54.3% (n = 5,643,862); 2019: 61.5% (n = 7,064,109).

Over time, a stable majority of comprehensive FPs practiced in large urban and urban settings (Supplemental eTable 4A). Trends around age and sex of rural comprehensive FPs resembled trends seen in the overall comprehensive FP population (Supplemental eTables 4B, 4C).

Patient complexity

The mean age (SD) of comprehensive FPs' patients increased over time (Supplemental eTable 2b): 2008: 33.5 (13.2) years; 2013: 36.5 (12.1) years; 2019: 38.1 (12.0) years. When stratified by physician age and sex, each physician age group served increasingly older patients. Male

physicians cared for slightly older patients than did females in each physician age group and at each time point.

The number and proportion of patients aged 65 and older increased over time in each near-retirement group (Table 1). This number nearly quadrupled in the oldest (70+ years) FP group (2008: N = 45,414, 2019: N = 176,473).

Over time, an increasing proportion of comprehensive FPs' practices were comprised of the highest morbidity patients (Resource Utilization Band (RUB) 4+): 2008: 16.5%; 2013: 18.1%; 2019: 19.8% (Supplemental eTable 5). Concordantly, as seen in Table 1, the number and proportion of highest morbidity patients attached to near-retirement physicians grew over time. By 2019, 983,818 patients in the highest morbidity category were attached to a physician aged 55+, representing 19.9% of all patients attached to a 55+ physician. 350,439 were attached to a 65+ physician (20.7% of patients attached to a 65+ physician). 146,298 were attached to a 70+ physician (22.0% of patients attached to 70+ a physician), representing a tripling of the absolute number.

While proportions of patients with chronic illness (COPD, CHF, diabetes, frailty, mental illness) remained relatively stable over time, the absolute numbers increased markedly in each near-retirement group (Table 1).

The proportions and means of socially complex patients cared for within each comprehensive FP age and sex group increased over time for most indicators (Supplemental eTable 5) and, concordantly, the number of higher social complexity patients increased markedly over time for most near-retirement groups (Table 1).

DISCUSSION

In our population-level serial cross-sectional analyses, the number and proportion of patients attached to a comprehensive FP in Ontario, Canada, grew over time. However, reflective of population-level workforce trends,[16] we found an increasing proportion of the comprehensive FP workforce is nearing retirement. Given the average FP retires at age 70.5 years,[38] we anticipate that between 2019 and 2025, nearly 1.7 million Ontarians may lose their current comprehensive FP to retirement.

This number may be an underestimate. Half of all comprehensive FPs are now female, and female FPs retire on average 5 years earlier than males.[38] Further, due to limitations in data availability for more recent years, our analyses predate the COVID-19 pandemic, and surveys from Ontario indicate the pandemic has hastened retirement plans, with almost double the usual proportion of FPs closing their offices during the pandemic (3%, compared with the usual rate of 1.6%/year),[41] and one in five indicating an intention to retire within five years.[42]

Although modelling the future capacity of the comprehensive FP workforce was outside the scope of this study, several findings from this study may help inform such modeling. Aligned with previous research,[29] a declining proportion of FPs are practicing comprehensive family medicine. Two thirds of comprehensive FPs are practicing full-time. Reflective of a generally aging population, comprehensive FPs cared for increasingly older groups of patients with increasing medical and social complexity over time. Females, who comprised an increasing proportion of the comprehensive FP workforce, served smaller roster sizes than males, which may reflect that a lower proportion of female physicians practiced FTE compared with males.

Modeling may also consider other variables not examined in this study, such as the net number of FPs added to the workforce each year (in Ontario, this has averaged 333 per year over the last 10 years (2013-2022)[43]), the ranking of family medicine as first choice discipline by medical

school graduates (in Ontario and other jurisdictions, this has declined in recent years[20-22, 44]), and population growth.[45]

Solutions to FP workforce shortages identified in the literature focus on addressing deterrents to the practice of comprehensive primary care, including perceived poor respect for primary care as a profession, inadequate compensation, inadequate training supports for developing and maintaining comprehensive skills, and inadequate administrative and interprofessional health supports to manage increasing patient complexity.[21, 24, 46-50] Our finding of a shift toward APP models underscores the desire among comprehensive FPs for financial stability and the support of an interprofessional team. Further, we identified equity concerns that relate to the large numbers of patients with chronic diseases and complex social needs, all of which are highly amenable to team-based care.[51-53] Concerningly, as of 2019, we found that 47% of older (65+) physicians still practiced in the less popular FFS models of care, serving 761,648 patients; these FFS practices may be less desirable to incoming physicians looking to take over a retiring physician's practice.

In some jurisdictions, the response to primary care workforce shortages has included expanding the scope of practice for non-physician health professionals. For example, several provinces in Canada, including Ontario, now allow pharmacists to prescribe for minor common ailments. However, concerns have been raised around inadequate concurrent investments in comprehensive, team-based primary care (rather than episodic, siloed care), the disruption of continuity for those who do have primary care access, limited pharmacist training in clinical diagnosis, and the lack of high-quality evidence around cost-effectiveness and health outcomes.[54, 55] Both the U.S. and Canada have increased nurse practitioner- or physician assistant-led primary care. However, a recent U.S. study found that primary care delivered by

non-physician practitioners was more costly than care delivered by physicians,[56] and accurate cost comparisons in Canada remain a challenge due to the lack of publicly available data on non-physician overhead spending.

There are some limitations to our study. The FTE indicator is based on physician billings, thereby excluding time spent on non-billable administrative work. Almost half of Canadian FPs report 10-19 hours per week of administrative tasks,[57] so the indicator may underestimate workload, and thus the number of FTE FPs. Rural FPs often practice in both primary care and hospital settings;[58] since the comprehensiveness algorithm is based on primary care billings,[29] it may underestimate the number of rural comprehensive FPs. Further, the rurality index scores and methodology have not been updated since 2008 despite the significant population growth and municipal-level changes that have occurred since then. Some physician analyses could not be fully stratified by both age and sex due to small cell sizes. Community Health Centre patients are not included and we did not examine other clinicians who may provide primary care; however, these clinicians are the main primary care source for only a small minority (approximately 1%) of Ontarians.[59, 60] Finally, our analyses do not account for the rise of virtual care and its potential impact on capacity.[61-63]

CONCLUSIONS

Primary care faces many capacity challenges as physicians age into retirement and fewer choose to enter or remain in comprehensive practice. Incentives and supports are needed to grow the comprehensive FP workforce to serve a growing and increasingly complex patient population.

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Data availability statement: The data sets from this study are held securely in coded form at ICES. Data-sharing agreements prohibit ICES from making the data sets publicly available, but access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The complete data set creation plan, and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros unique to ICES.

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FIGURE TITLES

Figure 1. Cohort creation: Patients (a) and physicians (b)

Figure 2. Comprehensive family physicians by near-retirement group, year, and sex
Total Ns (all comprehensive family physicians) for 2008, 2013, and 2019 are 7,673, 8,050, and 9,377, respectively.

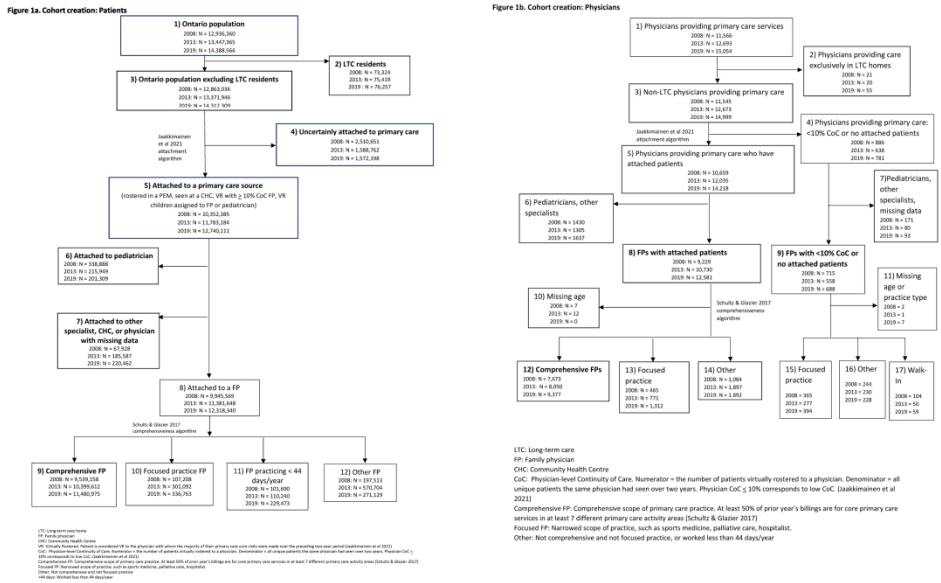

Figure 1a. Cohort creation: Patients. Figure 1b. Cohort creation: Physicians

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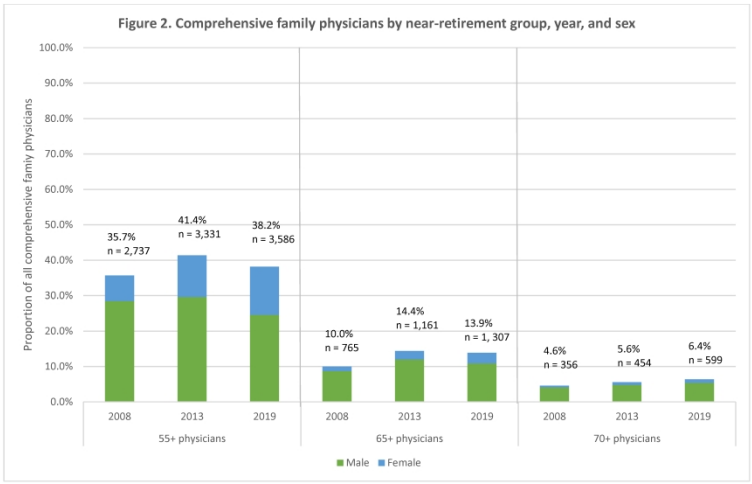

Total Ns (all comprehensive family physicians):

2008: 7,673

2013: 8,050

2019: 9,377

Comprehensive family physicians by near-retirement group, year, and sex

279x215mm (600 x 600 DPI)

Supplemental eMethods. Data sources, cohort definitions, and variable definitions

We obtained study data from population-level, de-identified, linked health administrative databases housed at ICES. ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze healthcare and demographic data, without consent, for health system evaluation and improvement. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario. In 2018, the institute formerly known as the Institute for Clinical Evaluative Sciences formally adopted the initialism ICES as its official name. This change acknowledges the growth and evolution of the organization's research since its inception in 1992, while retaining the familiarity of the former acronym within the scientific community and beyond.

The dataset from this study is held securely in coded form at ICES. While legal data sharing agreements between ICES and data providers (e.g., healthcare organizations and government) prohibit ICES from making the dataset publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS (email: das@ices.on.ca). The full dataset creation plan and underlying analytic code are available from the authors upon request, understanding that the computer programs may rely upon coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

These datasets were linked using unique encoded identifiers and analyzed at ICES.

The index date for each covariate was the fiscal year-end for each time point: March 31, 2008, March 31, 2013, March 31, 2019.

Physician-level data came from the ICES Physician Database (age, sex, years in practice, practice specialty, practice type, full-time equivalence), the Primary Care Population database (geographic location, roster size, primary care model), and Ontario Health Insurance Plan (OHIP) billings (health services rendered). For physicians for whom birth month and date were missing, we imputed physician age based on birth year, with fiscal year end (March 31) as the index date. Physician gender is not available in ICES data, so physician sex was used instead, available as male and female.

Patient-level data came from the Registered Persons Database (age, sex, postal code, immigration status), the Client Agency Program Enrolment (CAPE) database (primary care enrolment model), the Community Health Centre database (CHC) (patients receiving health services at CHCs, which serve vulnerable patients), census data holdings (income quintiles and other marginalization indices), OHIP database (health services claims and associated diagnoses), Discharge Abstract Database linkages with OHIP (mental health diagnosis), and Johns Hopkins Adjusted Clinical Groups (frailty, resource utilization band).

Resource Utilization Bands (RUB): This was measured using the Johns Hopkins Adjusted Clinical Groups (ACG) Version 10.0. The RUB measure assesses expected health care use as a measure of patient complexity/morbidity.

Annual number of core primary care visits were based on activity billing codes for 22 primary care service types in the 12 months preceding the index date.

Rurality: We measured rurality using the practice postal code and the Rurality Index for Ontario (RIO) scoring methodology,[1] with the following categories: Large urban (score 0), Urban (score 1-9), Small Urban/Suburban (score 10–39), and Rural/Remote (score ≥ 40).

Full-time equivalency (FTE): FTE was calculated based on payments from all sources, with a 40th percentile cut-point corresponding with a FTE of 1.0.

Chronic diseases (COPD, CHF, Diabetes): These were measured using validated cohorts at ICES. The algorithm used to define cohorts varies slightly for each chronic condition, based on the original ICES algorithm for diabetes (i.e., two physician claims or one hospital admission with diabetes within two years). These disease cohorts are cumulative over time.

Frailty: This was measured using the Johns Hopkins Adjusted Clinical Groups (ACG) Version 10.0 frailty defining diagnoses indicator, which captures patients with multidimensional frailty at the population level and is based on 10 clusters of frailty defining dimensions: Malnutrition, dementia, impaired vision, decubitus ulcer, incontinence of urine, loss of weight, poverty, barriers to access to care, difficulty in walking, and falls. The indicator has been demonstrated to accurately identify patients with limitations in activities of daily living.

Mental illness: The case definition algorithm to identify patients with a mental health diagnosis over the last two years links two databases at ICES: The Discharge Abstract Databasae (DAD) and OHIP. It is based on having two physician billing claims in OHIP over 2 years or one hospitalization with one of the listed mental health service codes (ICD9/ICD10).

Marginalization: We assessed three dimensions of marginalization (residential instability, material deprivation, and neighborhood ethnic concentration) using the Ontario Marginalization Index,[2] a census-derived geographically-based index.

Physician-level continuity of care (CoC): The algorithm considers patients to be virtually attached a primary care physician if they received the majority of their primary care over the preceding 2-year period from a physician with greater than 10% physician-level continuity of care (CoC). Physician-level CoC is a visit-based measure of the proportion of an individual physician visits over all physician's visits over a two-year time period. The numerator is the number of patients virtually attached to a physician, and the denominator is all unique patients the same physician had seen over two years. If the physician CoC is less than or equal to 10%, then this physician had a low CoC.

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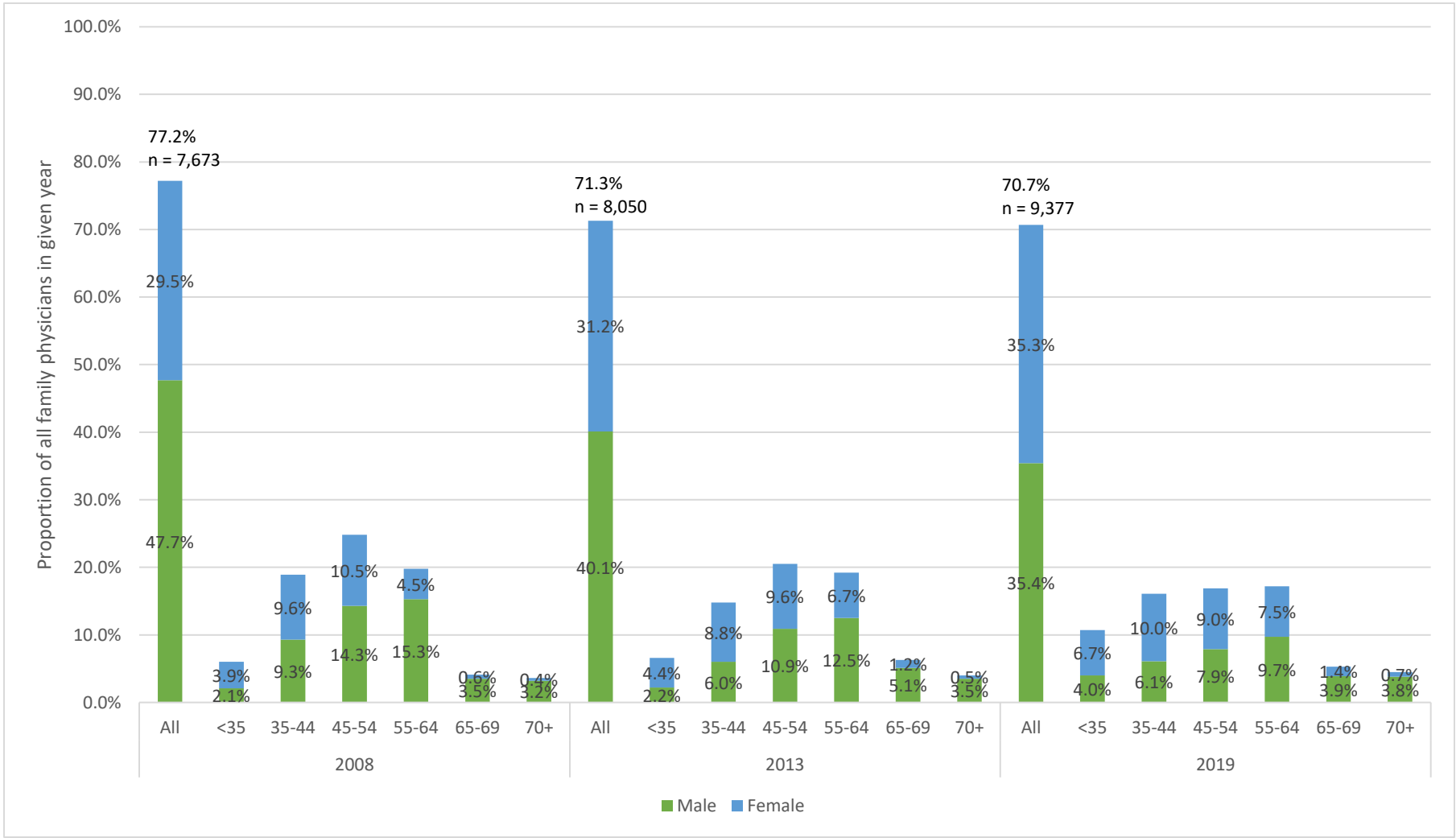
Supplemental eFigure 1. Proportion of all family physicians practicing comprehensiveness by year, age, and sex



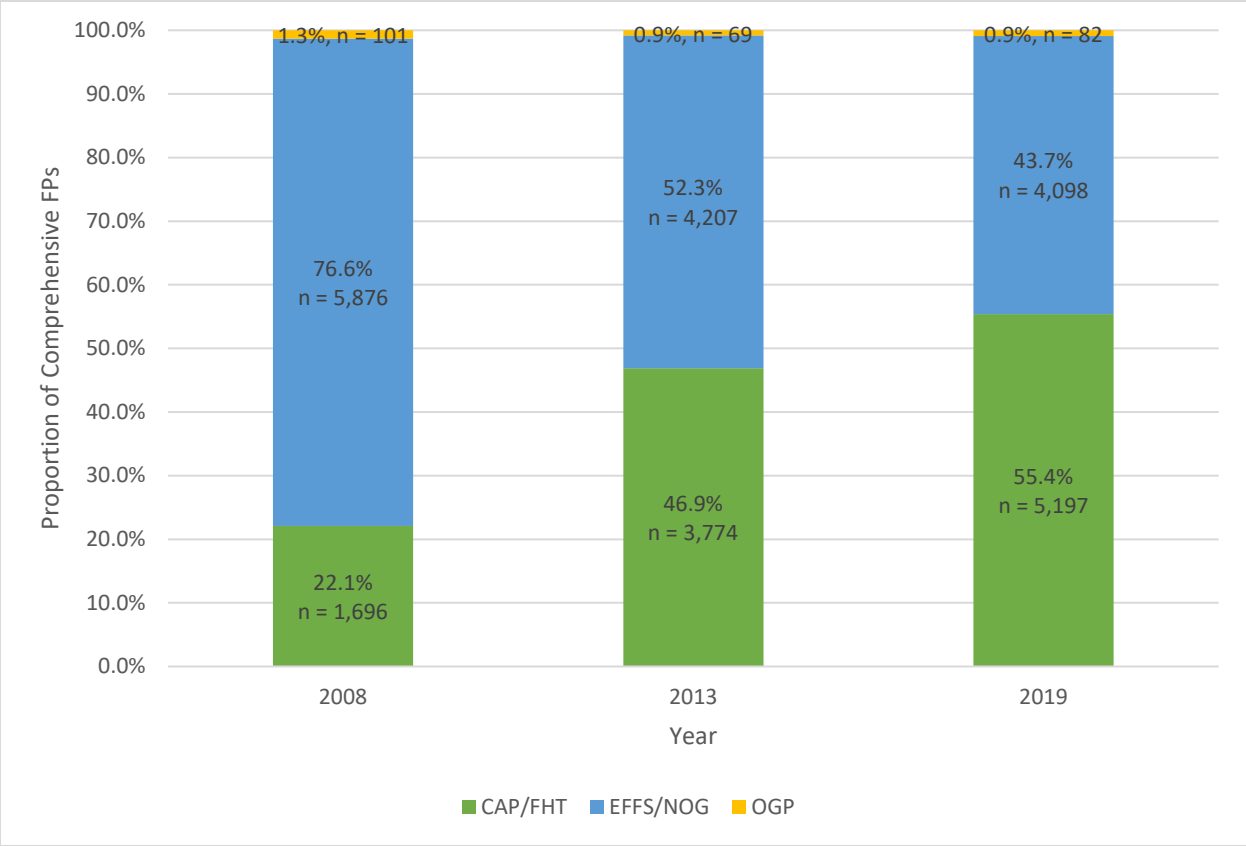
Total Ns (all family physicians): 2008: 9,944; 2013: 11,288; 2019: 13,269

Missing age for the age stratifications by year: 2008 = 9; 2013 = 13; 2019 = 7

Example of interpretation for bars labeled “All”: Of all family physicians in the 2008 cohort, 29.5% are females practicing comprehensiveness.

Example of interpretation for age-stratification bars: Of all family physicians in the 2008 cohort, the proportion who were female, under age 35 years, and practicing comprehensiveness is 3.9%.

Supplemental eFigure 2. Proportion of comprehensive family physicians in various practice models by year



Total Ns (all comprehensive family physicians): 2008: 7,673; 2013: 8,050; 2019: 9,377

CAP/FHT: Alternate payment plan (APP) model where physician payments are mainly capitation(CAP)-based (annual amount per enrolled patient, adjusted for patient age and sex), with or without additional funding for interdisciplinary team members (Family Health Team(FHT)) such as nurse practitioners and social workers

EFFS/NOG: Fee-for-service payment models. EFFS = fee-for-service payments with enrolment requirements and some pay enhancements, such as higher payments for enrolled patients and bonus payments for meeting preventive care targets. NOG = No group; traditional fee-for-service payments with no enrolment requirements or payment enhancements.

Supplemental eTable 1. Comprehensive family physicians by physician age

	<35 years					35-44 years					45-54 years					55-64 years					65-69 years					70+ years					All					
	Comp	Noncomp	Total	% of <35 FPs who are comp	% of all FPs who are comp and <35	Comp	Noncomp	Total	% of 35-44 FPs who are comp	% of all FPs who are comp and 35-44	Comp	Noncomp	Total	% of 45-54 FPs who are comp	% of all FPs who are comp and 45-54	Comp	Noncomp	Total	% of 55-64 FPs who are comp	% of all FPs who are comp and 55-64	Comp	Noncomp	Total	% of 65-69 FPs who are comp	% of all FPs who are comp and 65-69	Comp	Noncomp	Total	% of 70+ FPs who are comp	%of all FPs who are comp and 70+	Comp	Noncomp	Total - all FPs	Missing age	Total - all including missing	% of all FPs who are comp
2008	592	305	897	66.0%	6.0%	1877	652	2529	74.2%	18.9%	2467	581	3048	80.9%	24.8%	1972	430	2402	82.1%	19.8%	409	133	542	75.5%	4.1%	356	161	517	68.9%	3.6%	7673	2262	9935	9	9944	77.2%
2013	741	503	1244	59.6%	6.6%	1666	755	2421	68.8%	14.8%	2312	708	3020	76.6%	20.5%	2170	615	2785	77.9%	19.2%	707	278	985	71.8%	6.3%	454	366	820	55.4%	4.0%	8050	3225	11275	13	11288	71.3%
2019	1414	697	2111	67.0%	10.7%	2135	827	2962	72.1%	16.1%	2242	716	2958	75.8%	16.9%	2279	757	3036	75.1%	17.2%	708	374	1082	65.4%	5.3%	599	514	1113	53.8%	4.5%	9377	3885	13262	7	13269	70.7%
Relative Change (2019/2008)				101.5%	179.0%				97.1%	85.2%				93.6%	68.1%									86.7%	129.7%				78.2%	126.1%						91.6%
Absolute Change (2019 minus 2008)				1.0%	4.7%				-2.1%	-2.8%				-5.1%	-7.9%									-10.0%	1.2%				-15.0%	0.9%						-6.5%

Comp: Comprehensive FPs

Noncomp: Non-comprehensive FPs

Supplemental eTable 2a. Comprehensive family physicians by physician age and sex

		<35 Years			35-44 Years			45-54 Years			55-64 Years			65-69 Years			70+ Years			Total Comprehensive FPs		
		Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F		M	F	Total	M	F
Comp. FPs N (%*)	2008	592 (7.7)	211 (35.6)	381 (64.4)	1877 (24.5)	922 (49.1)	955 (50.9)	2467 (32.2)	1422 (57.6)	1045 (42.4)	1972 (25.7)	1522 (77.2)	450 (22.8)	409 (5.3)	347 (84.8)	62 (15.2)	356 (4.6)	319 (89.6)	37 (10.4)	7673 (100.0)	4743 (61.8)	2930 (38.2)
	2013	741 (9.2)	245 (33.1)	496 (66.9)	1666 (20.7)	674 (40.5)	992 (59.5)	2312 (28.7)	1227 (53.1)	1085 (46.9)	2170 (27.0)	1415 (65.2)	755 (34.8)	707 (8.8)	576 (81.5)	131 (18.5)	454 (5.6)	392 (86.3)	62 (13.7)	8050 (100.0)	4529 (56.3)	3521 (43.7)
	2019	1414 (15.1)	528 (37.3)	886 (62.7)	2135 (22.8)	806 (37.8)	1329 (62.2)	2242 (23.9)	1048 (46.7)	1194 (53.3)	2279 (24.3)	1290 (56.6)	989 (43.4)	708 (7.6)	519 (73.3)	189 (26.7)	599 (6.4)	505 (84.3)	94 (15.7)	9377 (100.0)	4696 (50.1)	4681 (49.9)

*The "%" in the "Total" columns represents the proportion of all comprehensive FPs who belong to that age group. The "%" in the "M" and "F" columns represents the proportion who are male or female within that age group.

Supplemental eTable 2b. Practice characteristics of comprehensive family physicians by physician age and sex

		<35 Years			35-44 Years			45-54 Years			55-64 Years			65-69 Years			70+ Years			All Comprehensive FPs		
		Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F		M	F	All	M	F
Years in pract. (mean (SD))	2008	6.0 (±2.3)	6.3 (±2.3)	5.9 (±2.2)	14.4 (±3.9)	14.7 (±3.8)	14.1 (±3.9)	23.7 (±4.2)	23.8 (±4.2)	23.5 (±4.2)	33.4 (±4.4)	33.6 (±4.2)	32.8 (±4.8)	41.3 (±3.0)	41.2 (±3.0)	42.0 (±3.2)	48.0 (±5.1)	48.0 (±4.9)	47.8 (±6.4)	24.6 (±11.4)	27.3 (±11.2)	20.2 (±10.1)
	2013	5.7 (±2.1)	5.4 (±2.1)	5.9 (±2.1)	13.8 (±4.2)	14.0 (±4.2)	13.7 (±4.1)	23.9 (±4.2)	23.9 (±4.0)	23.8 (±4.4)	33.2 (±4.4)	33.6 (±4.4)	32.5 (±4.5)	41.2 (±3.5)	41.1 (±3.4)	41.6 (±4.0)	48.7 (±4.9)	48.7 (±4.9)	49.0 (±4.9)	25.6 (±12.3)	28.8 (±12.1)	21.4 (±11.1)
	2019	5.8 (±2.0)	5.7 (±2.0)	5.8 (±1.9)	12.5 (±4.2)	12.5 (±4.4)	12.5 (±4.0)	23.7 (±4.7)	23.9 (±4.7)	23.5 (±4.6)	33.3 (±4.7)	33.4 (±4.5)	33.2 (±4.9)	40.8 (±3.6)	41.0 (±3.4)	40.3 (±4.0)	48.5 (±5.1)	48.4 (±5.3)	48.7 (±4.1)	23.7 (±13.4)	27.0 (±13.8)	20.3 (±12.0)
Roster size (mean (SD))	2008	638.3 (±622.5)	790.7 (±722.0)	553.9 (±542.7)	1131.8 (±873.2)	1323.5 (±981.3)	946.7 (±707.0)	1345.1 (±920.7)	1470.3 (±996.7)	1174.6 (±774.4)	1432.1 (±945.2)	1494.0 (±961.5)	1222.7 (±856.4)	1123.1 (±955.5)	1186.1 (±981.7)	770.7 (±701.1)	566.3 (±770.9)	584.9 (±785.4)	406.5 (±618.7)	1212.8 (±927.0)	1338.8 (±991.1)	1008.8 (±770.0)
	2013	620.0 (±605.9)	725.2 (±690.9)	568.0 (±552.6)	1152.8 (±836.0)	1348.6 (±935.1)	1019.7 (±732.6)	1407.1 (±927.1)	1567.8 (±1013.4)	1225.4 (±780.2)	1490.2 (±894.6)	1593.1 (±937.6)	1297.2 (±772.4)	1366.1 (±905.8)	1420.3 (±921.3)	1128.0 (±794.3)	898.1 (±895.7)	946.7 (±922.9)	591.1 (±622.7)	1272.1 (±909.2)	1425.0 (±975.2)	1075.4 (±773.4)
	2019	734.0 (±644.2)	834.7 (±712.0)	674.0 (±592.4)	1074.5 (±720.3)	1217.2 (±841.6)	987.9 (±620.1)	1394.8 (±876.2)	1529.3 (±946.5)	1276.7 (±791.2)	1405.6 (±847.2)	1531.6 (±902.2)	1241.1 (±738.3)	1434.4 (±900.5)	1502.5 (±932.8)	1247.6 (±777.3)	1098.0 (±804.3)	1125.7 (±815.1)	949.2 (±729.6)	1208.9 (±837.4)	1351.9 (±908.8)	1065.4 (±731.6)
Core PC visits (mean (SD))	2008	6.2 (±2.7)	6.2 (±2.8)	6.2 (±2.7)	7.3 (±4.2)	7.5 (±5.6)	7.2 (±2.3)	7.3 (±2.3)	7.4 (±2.5)	7.3 (±2.1)	7.7 (±2.6)	7.7 (±2.6)	7.7 (±2.4)	7.5 (±3.1)	7.6 (±3.2)	6.9 (±2.7)	6.8 (±3.5)	6.9 (±3.5)	6.2 (±2.9)	7.3 (±3.1)	7.4 (±3.5)	7.1 (±2.4)
	2013	5.3 (±2.3)	5.4 (±2.3)	5.3 (±2.3)	6.3 (±2.1)	6.2 (±2.2)	6.3 (±2.0)	6.5 (±2.4)	6.6 (±2.7)	6.4 (±2.0)	6.7 (±2.8)	6.8 (±3.2)	6.4 (±1.9)	6.9 (±2.4)	6.9 (±2.4)	7.0 (±2.3)	7.3 (±4.0)	7.5 (±4.2)	6.5 (±2.4)	6.5 (±2.6)	6.6 (±2.9)	6.3 (±2.1)
	2019	5.6 (±2.5)	5.5 (±2.6)	5.6 (±2.4)	6.0 (±2.5)	5.9 (±2.8)	6.0 (±2.4)	6.1 (±2.1)	6.1 (±2.3)	6.1 (±1.9)	6.1 (±2.1)	6.2 (±2.3)	6.0 (±1.8)	6.4 (±2.2)	6.5 (±2.3)	6.2 (±2.0)	6.7 (±3.0)	6.5 (±2.9)	7.2 (±3.1)	6.0 (±2.3)	6.1 (±2.5)	6.0 (±2.2)
Pt age (mean (SD))	2008	27.9 (±13.8)	29.4 (±14.0)	27.1 (±13.6)	31.7 (±11.7)	32.8 (±12.6)	30.5 (±10.7)	34.3 (±11.9)	35.4 (±12.5)	32.7 (±10.8)	36.7 (±13.1)	37.6 (±13.2)	33.7 (±12.2)	35.1 (±16.2)	36.0 (±16.1)	30.5 (±15.9)	28.2 (±18.5)	28.5 (±18.5)	25.5 (±17.8)	33.5 (±13.2)	34.9 (±13.8)	31.3 (±11.8)
	2013	28.2 (±13.7)	30.0 (±13.7)	27.4 (±13.6)	34.0 (±10.8)	35.0 (±11.6)	33.4 (±10.1)	36.4 (±10.7)	37.8 (±11.2)	34.8 (±9.9)	39.4 (±10.7)	40.5 (±11.1)	37.3 (±9.8)	40.9 (±12.6)	42.0 (±12.4)	36.3 (±12.7)	39.1 (±17.0)	39.7 (±17.1)	35.0 (±16.0)	36.5 (±12.1)	38.5 (±12.5)	34.0 (±11.2)
	2019	31.8 (±14.5)	33.5 (±14.2)	30.7 (±14.5)	36.4 (±10.9)	37.1 (±11.8)	36.0 (±10.3)	38.4 (±9.8)	39.4 (±10.6)	37.5 (±9.0)	40.6 (±10.5)	42.0 (±10.8)	38.7 (±9.8)	43.0 (±11.5)	43.9 (±11.6)	40.8 (±10.9)	43.3 (±14.3)	43.6 (±14.5)	41.2 (±13.1)	38.1 (±12.0)	40.0 (±12.3)	36.2 (±11.3)
Prop. Fem. Pts (mean (SD))	2008	55.7 (±15.1)	46.9 (±10.7)	60.7 (±14.9)	55.2 (±13.2)	46.2 (±7.5)	63.8 (±11.6)	54.3 (±13.0)	46.3 (±7.4)	65.3 (±10.9)	51.0 (±11.0)	46.8 (±7.0)	65.0 (±10.7)	49.5 (±11.1)	47.3 (±8.5)	61.5 (±15.7)	47.8 (±13.2)	46.7 (±11.1)	57.6 (±22.6)	53.2 (±12.9)	46.6 (±7.8)	64.0 (±12.1)
	2013	55.3 (±15.6)	47.8 (±13.7)	59.0 (±15.1)	55.1 (±12.1)	46.1 (±8.3)	61.2 (±10.4)	53.7 (±12.3)	45.6 (±7.4)	62.9 (±9.9)	52.4 (±12.1)	45.9 (±7.5)	64.7 (±9.3)	48.9 (±10.1)	45.9 (±7.2)	62.2 (±10.5)	49.6 (±12.2)	47.2 (±10.4)	64.8 (±11.9)	53.1 (±12.5)	46.1 (±8.3)	62.3 (±11.0)
	2019	54.3 (±13.7)	47.7 (±11.2)	58.2 (±13.6)	54.3 (±11.8)	45.0 (±8.2)	59.9 (±10.0)	53.5 (±11.2)	45.4 (±7.6)	60.6 (±8.9)	52.4 (±11.8)	44.8 (±7.8)	62.2 (±8.5)	49.9 (±11.7)	45.1 (±7.9)	63.0 (±10.2)	48.2 (±9.9)	45.9 (±8.1)	60.7 (±9.6)	52.9 (±12.0)	45.5 (±8.4)	60.4 (±10.3)

FTE (N (%)*)	2008	290 (49.0)	146 (50.3)	144 (49.7)	1210 (64.5)	754 (62.3)	456 (37.7)	1802 (73.0)	1173 (65.1)	629 (34.9)	1481 (75.1)	1209 (81.6)	272 (18.4)	239 (58.4)	220 (92.1)	19 (8.0)	114 (32.0)	107 (93.9)	7 (6.1)	5136 (66.9)	3609 (70.3)	1527 (29.7)
	2013	335 (45.4)	152 (45.4)	183 (54.6)	1073 (64.4)	556 (51.8)	517 (48.2)	1694 (73.3)	1014 (59.9)	680 (40.1)	1634 (75.3)	1156 (70.8)	478 (29.3)	474 (67.0)	415 (87.6)	59 (12.5)	189 (41.6)	177 (93.7)	12 (6.4)	5399 (67.1)	3470 (64.3)	1929 (35.7)
	2019	734 (51.9)	351 (47.8)	383 (52.2)	1401 (65.6)	628 (44.8)	773 (55.2)	1722 (76.8)	881 (51.2)	841 (48.8)	1681 (73.8)	1052 (62.6)	629 (37.4)	514 (72.6)	402 (78.2)	112 (21.8)	327 (54.6)	288 (88.1)	39 (11.9)	6379 (68.0)	3602 (56.5)	2777 (43.5)

Comp. FPs: Comprehensive family physicians; Pract.: Practice; PC: Primary care; Pt(s): Patient(s); Prop: Proportion; Fem: Female; FTE: Comp FPs practicing full-time equivalent

*For the covariate "FTE", the ”%” in the “Total” columns represents the proportion of all comprehensive FPs in that age group who are FTE. The “%” in the “M” and “F” columns represents the proportion of FTE physicians in that age group who are male or female.

Supplemental eTable 3. Comprehensive family physician practice model over time by physician age and sex

Year	Model	Age < 35						Age 35 - 44						Age 45 - 54						Age 55 - 64						Age 65 - 69						Age 70+						Total Sample					
		Total	Total	Male		Female		Total	Total	Male		Female		Total	Total	Male		Female		Total	Total	Male		Female		Total	Total	Male		Female		Total	Total	Male		Female		Total	Total	Male		Female	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
2008																																										
	EFFS	243	41	91	43.1	152	39.9	1009	53.8	513	55.6	496	51.9	1410	57.2	796	56	614	58.8	1184	60	903	59.3	281	62.4	210	51.3	174	50.1	36	58.1	142	39.9	129	40.4	13	35.1	4198	54.7	2606	54.9	1592	54.3
	CAP	56	9.5	*11 - 15		*43 - 47		167	8.9	70	7.6	97	10.2	191	7.7	114	8	77	7.4	*128-132		104	6.8	*24 - 28		*30-34		*27 - 31		*1 - 5		7	2	7	2.2	0	0	583	7.6	337	7.1	246	8.4
	FHT	85	14.4	35	16.6	50	13.1	281	15	126	13.7	155	16.2	402	16.3	228	16	174	16.7	*276-280		228	15	*48 - 52		48	11.7	*43-47		*1 - 5		17	4.8	*12-16		*1 - 5		1113	14.5	680	14.3	433	14.8
	NOG	198	33.4	69	32.7	129	33.9	389	20.7	202	21.9	187	19.6	427	17.3	256	18	171	16.4	356	18.1	268	17.6	88	19.6	118	28.9	*94-98		*20 - 24		190	53.4	*163-167		*23 - 27		1678	21.9	1056	22.3	622	21.2
	OGP	10	1.7	*1-5		*3 - 7		31	1.7	11	1.2	20	2.1	37	1.5	28	2	9	0.9	*20-24		19	1.2	*1-5		*1-5		*1-5		0	0	0	0	0	0	0	0	101	1.3	64	1.3	37	1.3
2013																																										
	EFFS	162	21.9	65	26.5	97	19.6	571	34.3	243	36.1	328	33.1	853	36.9	464	37.8	389	35.9	766	35.3	481	34	285	37.7	292	41.3	218	37.8	74	56.5	173	38.1	149	38	24	38.7	2817	35	1620	35.8	1197	34
	CAP	108	14.6	*28 - 32		*76-80		361	21.7	*127 - 131		*229 - 233		582	25.2	310	25.3	272	25.1	603	27.8	407	28.8	196	26	168	23.8	146	25.3	22	16.8	75	16.5	*65-69		*6 - 10		1897	23.6	1091	24.1	806	22.9
	FHT	186	25.1	64	26.1	122	24.6	461	27.7	183	27.2	*276 - 280		547	23.7	*266-270		*277 - 281		501	23.1	325	23	176	23.3	127	18	114	19.8	13	9.9	55	12.1	*50-54		*1 - 5		1877	23.3	1007	22.2	870	24.7
	NOG	277	37.4	83	33.9	194	39.1	266	16	116	17.2	150	15.1	313	13.5	172	14	141	13	273	12.6	183	12.9	90	11.9	110	15.6	88	15.3	22	16.8	151	33.3	124	31.6	27	43.5	1390	17.3	766	16.9	624	17.7
	OGP	8	1.1	*1-5		*3-7		7	0.4	*1-5		*2 - 6		17	0.7	*11-15		*2 - 6		27	1.2	19	1.3	8	1.1	10	1.4	10	1.7	0	0	0	0	0	0	0	0	69	0.9	45	1	24	0.7
2019																																										
	EFFS	249	17.6	*103 - 107		*144 - 148		518	24.3	218	27	300	22.6	712	31.8	*348 - 352		*360-364		707	31	408	31.6	299	30.2	244	34.5	*163 - 167		*75 - 79		239	39.9	*190 - 194		48	51.1	2669	28.5	1437	30.6	1232	26.3
	CAP	341	24.1	124	23.5	217	24.5	597	28	193	23.9	404	30.4	699	31.2	315	30.1	384	32.2	725	31.8	399	30.9	326	33	221	31.2	176	33.9	45	23.8	165	27.5	146	28.9	19	20.2	2748	29.3	1353	28.8	1395	29.8
	FHT	376	26.6	137	25.9	239	27	683	32	252	31.3	431	32.4	583	26	255	24.3	328	27.5	577	25.3	321	24.9	256	25.9	151	21.3	109	21	42	22.2	79	13.2	71	14.1	8	8.5	2449	26.1	1145	24.4	1304	27.9
	NOG	437	30.9	157	29.7	280	31.6	316	14.8	133	16.5	183	13.8	237	10.6	123	11.7	114	9.5	241	10.6	141	10.9	100	10.1	82	11.6	64	12.3	22	11.6	112	18.7	93	18.4	19	20.2	1429	15.2	711	15.1	718	15.3
	OGP	11	0.8	*3 - 7		*2 - 6		21	1	10	1.2	11	0.8	11	0.5	*3 - 7		*4-8		29	1.3	21	1.6	8	0.8	*6-10		*3 - 7		*1-5		*1-5		*1-5		0	0	82	0.9	50	1.1	32	0.7

Percentages are column percentages

Ranges preceded by an asterisk (*) represent suppressed cells due to small cell sizes

EFFS: Enhanced fee-for-service. This is a fee-for-service payment model that requires patient enrollment and includes some pay enhancements, such as higher fee-for-service payments for enrolled patients and bonus payments for preventive care targets.

CAP: Capitation. An alternate payment plan (APP) model where the majority of physician payments come from an annual amount for each enrolled patient adjusted for patient age and sex.

FHT: Capitation models with additional funding for interdisciplinary team members such as nurse practitioners and social workers.

NOG: No group. These physicians are paid via traditional fee-for-service, without any enrolment requirements or pay enhancements.

OGP: Other physician group types, typically serving a specific targeted population or geography (for example, rural/remote) with varying funding mechanisms.

Supplemental eTable 4. Geographic Distribution of Comprehensive FPs

A. Comprehensive FPs by Geography

	Large Urban	Urban	Small Urban/Suburban	Rural/Remote	Total
2008 N (% of Comprehensive FPs)	3,909 (51.1)	1,990 (26.0)	1,236 (16.2)	513 (6.7)	7,648 (100.0)
2013 N (% of Comprehensive FPs	4,105 (51.1)	2,314 (28.8)	1,207 (15.0)	410 (5.1)	8,036 (100.0)
2019 N (% of Comprehensive FPs	4,674 (50.0)	2,685 (28.7)	14,98 (16.0)	492 (5.3)	9,349 (100.0)

Note: Geographic data missing for: 2008 (25), 2013 (14), 2019 (28)

B. Rural (RIO 40+) Comprehensive FPs by Age Group

	<35 years	35-44 years	45-54 years	55-64 years	65-69 years	70+ years	Total
2008 N (% of rural comprehensive FPs)	46 (9.0)	135 (26.3)	166 (32.4)	118 (23.0)	27 (5.3)	21 (4.1)	513 (100.0)
2013 N (% of rural comprehensive FPs)	31 (7.6)	76 (18.5)	109 (26.6)	129 (31.5)	44 (10.7)	21 (5.1)	410 (100.0)
2019 N (% of rural comprehensive FPs)	89 (18.1)	111 (22.6)	121 (24.6)	117 (23.8)	32 (6.5)	22 (4.5)	492 (100.0)

C. Rural (RIO 40+) Comprehensive FPs by Physicians Sex

	Male Physicians			Female Physicians			Total Rural		All Comprehensive FPs	
	N	% of Rural Comprehensive FPs	% of all Comprehensive FPs	N	% of Rural Comprehensive FPs	% of all Comprehensive FPs	N	% of all Comprehensive FPs	N	% of all Comprehensive FPs
2008	362	70.6	4.7	151	29.4	2	513	6.7	7648	6.7
2013	268	65.4	3.3	142	34.6	1.8	410	5.1	8036	5.1
2019	279	56.7	3	213	43.3	2.3	492	5.3	9349	5.3

We were unable to stratify by both age and sex due to suppressed cells (cell sizes <6) in older age categories for male and female physicians in the rural category.

Large urban: Rurality Index of Ontario (RIO) score of 0

Urban: RIO score of 1-9

Suburban/Small Urban: RIO score of 10-39

Rural/remote: RIO score of 40+

Supplemental eTable 5. Practice characteristics: Medical and social complexity of patients attached to comprehensive family physicians over time by physician age and sex

		<35 Years			35-44 Years			45-54 Years			55-64 Years			65-69 Years			70+ Years			TOTAL		
		Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Highest morbidity (RUB (4+))	2008	15.3	14.7	15.6	16.2	15.8	16.7	16.4	16.5	16.2	17.3	17.5	16.6	16.8	17.2	14.0	14.0	14.1	13.0	16.5	16.7	16.3
	2013	17.5	17.6	17.4	18.2	17.5	18.7	17.7	17.8	17.6	18.1	18.5	17.3	19.5	20.0	17.5	20.1	20.5	17.9	18.1	18.3	17.8
	2019	19.3	19.4	19.2	20.6	20.2	20.8	19.4	19.4	19.4	19.5	20.2	18.7	20.3	20.4	20.1	21.4	21.5	21.3	19.8	19.9	19.7
Lowest income quintile	2008	18.5	19.2	18.1	18.1	19.6	16.6	18.4	19.8	16.4	19.9	20.2	18.8	22.6	22.5	23.6	23.9	20.1	17.2	19.0	20.1	17.2
	2013	18.9	20.6	18.0	17.2	19.1	16.0	18.0	19.4	16.4	18.4	19.5	16.5	20.5	20.4	21.2	24.0	24.2	22.5	18.3	19.6	16.7
	2019	20.4	21.9	20.7	18.8	20.7	17.6	18.3	20.5	16.5	18.8	20.4	16.8	19.9	20.7	17.9	22.1	22.2	21.4	19.0	20.7	17.5
Highest housing instability quintile	2008	24.5	22.8	25.5	20.6	20.7	20.4	20.4	20.4	20.4	21.9	21.6	23.0	24.0	23.1	29.2	25.5	25.6	24.2	21.4	21.2	21.7
	2013	26.0	23.6	27.2	21.8	20.9	22.5	19.9	20.4	19.4	20.8	20.6	21.3	21.7	21.8	21.2	24.5	24.1	26.6	21.4	20.9	21.9
	2019	26.5	25.3	27.2	24.5	24.7	24.5	21.1	21.8	20.4	21.4	21.5	21.3	22.6	21.7	24.9	25.5	25.2	27.1	23.0	22.7	23.3
Highest material deprivation quintile	2008	18.6	19.8	17.9	17.4	19.3	15.5	18.2	20.1	15.6	20.5	21.3	18.1	23.7	23.9	22.4	25.7	26.2	21.3	19.0	20.6	16.4
	2013	22.9	24.6	22.0	20.5	22.1	19.4	21.2	22.9	19.3	21.4	22.6	19.2	23.7	23.2	25.7	29.2	29.4	27.8	21.5	22.8	19.9
	2019	18.2	19.7	17.3	17.3	19.9	15.8	17.0	19.3	15.0	18.1	19.8	15.9	19.7	20.9	16.7	21.8	22.1	19.9	17.8	19.8	15.9
Highest neighborhood ethnic concentration quintile	2008	27.4	30.8	25.5	27.5	28.4	26.5	26.0	26.1	25.9	27.2	26.3	30.4	28.0	26.4	37.2	32.6	32.8	30.7	26.9	26.9	27.0
	2013	29.9	31.1	29.2	28.6	29.2	28.2	27.9	29.2	26.6	27.2	27.2	27.3	27.7	25.5	37.3	33.0	32.0	39.4	28.0	28.1	28.0
	2019	26.0	26.6	25.7	25.8	27.2	25.0	28.5	29.2	27.8	27.0	26.8	27.3	33.2	33.7	31.9	32.1	30.9	38.5	27.4	28.3	26.7

Interpretation: For example, in 2008, within the group of comprehensive family physicians under the age of 35 years, 15.3% of patients in those practices had the highest level of morbidity (RUB 4+). When further stratified by physician sex, 14.7% of patients attached to male comprehensive family physicians belonged to the highest morbidity (RUB 4+) group.

RUB: Morbidity, based on Resource Utilization Band

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

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9, Supplemental eMethods
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	7-9, Supplemental eMethods
Bias	9	Describe any efforts to address potential sources of bias	Figure 1a, 1b
Study size	10	Explain how the study size was arrived at	8-9, Figure 1a, 1b
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	7, Supplemental eTable 4
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a
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	9, Figure 1a, 1b
		(b) Give reasons for non-participation at each stage	9, Figure 1a, 1b
		(c) Consider use of a flow diagram	Figure 1a, 1b

Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-16
		(b) Indicate number of participants with missing data for each variable of interest	Figure 1a, 1b, Supplemental eTable 4
Outcome data	15*	Report numbers of outcome events or summary measures	9-16
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	9-16
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*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	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	17-18
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	19-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	19-20
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	21-22

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.