

# Primary Care Physician Panel Size and Quality of Care: A Population-Based Study in Ontario, Canada

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## ABSTRACT

**PURPOSE** The purpose of this study was to determine the relationship between the number of patients under a primary care physician's care (panel size) and primary care quality indicators.

**METHODS** We conducted a cross-sectional, population-based study of fee-for-service and capitated interprofessional and non-interprofessional primary health care practices in Ontario, Canada between April 2008 and March 2010, encompassing 4,195 physicians with panel sizes  $\geq 1,200$  serving 8.3 million patients. Data was extracted from multiple linked, health-related administrative databases and covered 16 quality indicators spanning 5 dimensions of care: access, continuity, comprehensiveness, and evidence-based indicators of cancer screening and chronic disease management.

**RESULTS** The likelihood of being up-to-date on cervical, colorectal, and breast cancer screening showed relative decreases of 7.9% ( $P < .001$ ), 5.9% ( $P = .01$ ), and 4.6% ( $P < .001$ ), respectively, with increasing panel size (from 1,200 to 3,900). Eight chronic care indicators (4 medication-based and 4 screening-based) showed no significant association with panel size. The likelihood of individuals with a new diagnosis of congestive heart failure having an echocardiogram, however, increased by a relative 8.1% ( $P < .001$ ) with higher panel size. Increasing panel size was also associated with a 10.8% relative increase in hospitalization rates for ambulatory-care-sensitive conditions ( $P = .04$ ) and a 10.8% decrease in non-urgent emergency department visits ( $P = .004$ ). Continuity was highest with medium panel sizes ( $P < .001$ ), and comprehensiveness had a small decrease ( $P = .03$ ) with increasing panel size.

**CONCLUSIONS** Increasing panel size was associated with small decreases in cancer screening, continuity, and comprehensiveness, but showed no consistent relationships with chronic disease management or access indicators. We found no panel size threshold above which quality of care suffered.

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## INTRODUCTION

Given the central role that primary health care plays in creating a sustainable health care system, improving access to high quality primary health care is an international priority.<sup>1</sup> Where physician resources are scarce, one way to achieve better population coverage and ensure that all individuals have a primary care physician is to promote larger panel sizes, defined as the number of patients under the care of a primary care provider. There is, however, a concern that quality may decline at larger panel sizes.<sup>2</sup> Establishing the "ideal" panel size for a primary care physician by striking a balance between population access and quality of care is a key objective for decision-makers and clinicians. Setting a maximum size or range, however, is challenging because quality of care can be influenced by a large number of patient, provider, and contextual factors.

Studies have reported significant correlations between larger panel sizes and shorter consultations,<sup>3</sup> fewer home visits,<sup>4,5</sup> and higher rates of referral to specialists.<sup>6</sup> Previous research conducted by members of our

team has also found an association between higher self-reported panel sizes and lower likelihood of providing high quality primary and secondary preventive care.<sup>7-9</sup> These findings help to identify potential problems with excessive panel sizes but are insufficient to define optimal panel size ranges.

Our objective was to investigate the relationship between panel size and a comprehensive set of primary care quality indicators using linked, population-based health administrative databases. Our approach was to allow the existing pattern of relationship to emerge, with no a priori assumptions about the shape of that relationship or whether there was a cut-off point across which performance would be compared. Our hypothesis was that the quality of patient care would drop as panel size increased.

## METHODS

We conducted a cross-sectional, population-based study of primary care services from April 1, 2008, to March 31, 2010 in the province of Ontario, Canada. The datasets used were linked using unique, encoded identifiers and analyzed at the Institute for Clinical Evaluative Sciences (ICES), a not-for-profit research institute. The databases used for this purpose are described in Supplemental Appendix 1, available at <http://www.annfammed.org/content/14/1/26/suppl/DC1>. This study was approved by the Bruyère Research Institute Ethics Board and by the Research Ethics Board at Sunnybrook Health Sciences Centre, Toronto, Canada.

### Setting

Canada has a publicly funded universal health care system. In Ontario, all medically necessary physician, laboratory, and hospital fees are covered by the Ontario Health Insurance Plan (OHIP) for all 13 million permanent residents, and prescription medications are covered for those on social assistance and those who are aged 65 years or older. More than 80% of Ontarians receive care in 1 of 3 models: reformed fee-for-service, capitation/non-interprofessional team, and capitation/interprofessional team. In the fee-for-service model, patient enrollment is strongly encouraged, and physicians accrue a fee for each service they perform. In the capitation model, patient enrollment is an integral component of the compensation in that physicians receive a monthly allotment based on an age-sex adjusted formula for each patient enrolled in their practice. Approximately one-half of these capitated practices were funded by the Ontario Health Ministry to build interprofessional teams. Team composition varies across practices, but teams include non-clinical and clinical staff such as nurses, pharmacists, and social

workers who work alongside physicians in the practice. All 3 models offer physicians financial inducements for achieving quality goals. These include payments for achieving various thresholds of cancer screening and immunizations, incentives for completing flow sheets for diabetes and congestive heart failure, and bonus payments for after-hours care.

## Participants

### Physicians

We used the Corporate Provider Database to identify primary care physicians and attribute them to the model in which they were working on March 31, 2010. We limited the evaluation to generalists working in 1 of the 3 primary care models that serve the majority of Ontarians. Physicians were excluded if they were identified as specialists in the Ontario Physician Human Resource Database or were deemed to have a focused practice because they billed OHIP fewer than 8 of the 18 standard primary care fee schedule codes during the study period. Physicians with a prolonged absence from active practice (no billings for at least 8 consecutive weeks during the study period) were also excluded.

We obtained the age, sex, place of residency, training (Canadian and international), number of years since medical school graduation, practice size, number of years of experience working in their current payment model, and practice rurality for each physician from the Corporate Provider Database. Rurality was determined using the Rurality Index of Ontario (RIO),<sup>10</sup> which derives its measure from population density and availability of additional health services within the area. RIO ranges from 0 to 100, with higher numbers indicating greater rurality, and is commonly grouped into 3 categories: major urban (less than 10), urban (10 to 45), and rural (greater than 45).

### Panel Size

We defined panel size for each physician as the number of patients receiving their care from that physician. All patients formally enrolled under the care of a physician (86% of patients) as of March 31, 2010, as identified by the Client Agency Program Enrollment Tables were attributed to that physician's panel. The remaining patients, those not formally enrolled, were virtually rostered to the physician from whom they received the majority of their primary care services during the two-year study period, as determined by their costs.

Because the amount of time a physician worked in his or her clinic would considerably influence the number of patients for whom the physician would have the capacity to care for, and since we did not have a measure of work hours or full-time equivalent available in the health administrative data, we used small panel

size as a proxy. We hypothesized that part-time clinicians would be more likely to have smaller panels, and that by excluding physicians with the smaller panel sizes, we would have a more homogeneous population. Because approximately 25% of primary care physicians in Ontario report working part time, we excluded physicians with panel sizes less than 1,200 patients, which eliminated the lower tertile.

### Patients

We included patients with valid health care coverage (OHIP). Patient age and sex were obtained from the Registered Persons Database. We linked the postal codes to census data using the Postal Code Conversion File to determine residential patient income quintiles.<sup>11,12</sup> Immigration status was inferred based on when patients were issued their OHIP cards: if prior to 1998, they were considered long-term residents of the province, and if after 1998, they were considered recent registrants. Approximately 80% of recent registrants are immigrants from other countries, while the remainder are interprovincial migrants.<sup>13</sup> To measure patient complexity or burden of disease we used Resource Utilization Bands with a range from 0 to 5, derived from physician claims and hospital admissions using the Johns Hopkins Adjusted Clinical Groups (ACG) System.<sup>14</sup> We used the Ontario Diabetes Database,<sup>15</sup> Congestive Heart Failure registry,<sup>16</sup> and Ontario Asthma Surveillance Information System<sup>17</sup> to identify patients with these conditions. These databases are based on validated algorithms with high specificity for the target condition.

### Quality of Care Indicators

We relied on 16 indicators of primary care delivery covering 5 dimensions of care: cancer screening, chronic disease management, access, continuity, and comprehensiveness. Supplemental Appendix 2, available at <http://www.annfam.org/content/14/1/26/suppl/DC1>, provides the operational definition of the indicators and indicates whether financial incentives were available for each measure during the study period. Medication indicators were evaluated only in individuals aged 65 years and older because data were not available for other age groups.

We evaluated access and continuity indicators for all patients. Comprehensiveness was measured at the physician level. Cancer screening and chronic care indicators were evaluated in the subset of patients eligible for that care. For instance, colorectal cancer screening was assessed only in patients aged 50 to 74 years, while eye screening and hemoglobin A<sub>1c</sub> tests were assessed only in individuals with diabetes and aged 40 years and older.

## Analyses

### Statistical Methods

We conducted multilevel regressions to assess the relationship between panel size and each quality of care indicator, using generalized estimating equations to account for the clustering effect of patients within physicians. Panel size was the main independent variable, with each indicator in turn the dependent variable. We used negative binomial regressions for all indicators with count outcomes (access measures), logistic regressions for indicators of cancer screening and chronic disease management, and linear regressions for continuity and comprehensiveness. Because of the known strong influence of rurality on the use of hospital services, access regression analyses were carried out only for major urban regions (RIO <10). For all other models, the inclusion of the RIO index in the model was felt to be sufficient to account for any potential influence rurality might have on these indicators. Regressions were adjusted for all factors listed in Table 1 and the primary care model. Statistical significance was set at 0.05, and 95% confidence intervals were reported.

We used restricted cubic splines to optimize modeling of the relationship between panel size and each outcome variable. The curving functions of the cubic splines allow the existing pattern of the relationship between panel size and the outcome to emerge.<sup>18</sup> We chose to use 3 knots for our analyses after comparing the QICu (a goodness of fit measure) of 3-, 4-, 5-, and 7-knot splines as applied to our data because the higher knot numbers were unnecessary and overfitted the data. Statistical analyses were performed using SAS version 9.2 statistical software (SAS Institute). Restricted cubic spline regressions were implemented for each outcome with the "%daspline" SAS macro.<sup>19</sup> We used the regression coefficients to derive the estimated level of the quality indicator across panel sizes 1,200 to 3,900, setting the coefficients at their mean or mode, as appropriate.

## RESULTS

### Population

In total, 6,801 physicians operated in the 3 primary care models during the study period. From this group, 38 were removed due to prolonged absences and 373 because they were deemed to be specialists or primary care physicians with focused practices, leaving 6,390 physicians. Removing physicians with panel sizes less than 1,200 left 4,195 physicians serving a total patient population of 8.3 million people. The practices excluded due to low panel size did not differ markedly from the sample as a whole, with the exception that excluded practices were more likely to care for women

(56% vs 52%) and be rural (9.1% vs 3.3%). We also ensured that quality of care did not peak at panel sizes less than 1,200 by visualizing the relationship in the lower panel sizes (results not shown). Table 1 shows the patient profile across panel sizes. Physicians with larger panel sizes were more likely to be male, foreign trained, and work in urban practices. Immigrant patients and those from lower income quintiles were more likely to receive care from physicians with larger panel sizes.

## Adjusted Analyses

The relationship between panel size (at intervals of 300) and each indicator is shown in Table 2. Plots of the mean estimates of each indicator across panel size and the omnibus *P* value are displayed in Supplemental Appendix 3, available at <http://www.annfammed.org/content/14/1/26/suppl/DC1>. The omnibus *P* value represents the overall effect of the 2 panel-size cubic spline variables produced by the equation.

**Table 1. Patient, Physician, and Practice Characteristics Across Panel Size Ranges**

Characteristic	Panel Size					
	All	1,200-1,799	1,800-2,399	2,400-2,999	3,000-3,599	3,600+
<b>Physician profile</b>						
Physicians, No.	4,195	2,028	1,351	526	168	122
Age, median (IQR), y	53 (46-59)	51 (44-58)	54 (47-60)	55 (47-60)	54 (47-58)	52 (46-58)
Male, mean %	68.9	59.9	74.7	81.7	76.8	89.3
Foreign trained, mean %	26.9	22.7	27.4	34.2	41.1	39.3
Time since graduation, median (IQR), y	27 (20-34)	25 (18-33)	28 (21-35)	28 (22-35)	28 (21-33)	25 (19-33)
Practice group size, median (IQR), No.	16 (7-30)	15 (7-30)	16 (7-29)	18 (7-31)	17 (7-36)	18 (5-54)
Rurality: RIO index, median (IQR)	2 (0-8)	2 (0-10)	2 (0-8)	2 (0-6)	2 (0-8)	0 (0-3)
Rurality categories, %						
Major urban (RIO <10)	76.6	74.0	77.3	81.2	79.1	89.1
Minor urban (RIO 10-45)	20.4	21.8	20.2	17.4	20.9	10.9
Rural (RIO >45)	3.0	4.2	2.5	1.4	0.0	0.0
<b>Patient profile</b>						
Patients, No.	8,265,930	3,014,806	2,792,387	1,399,485	547,305	511,947
Proportion virtually rostered, %	12.7	13.6	11.5	12.5	13.0	13.5
Age, median (IQR)	41 (21-56)	41 (22-57)	41 (21-57)	40 (21-56)	38 (20-54)	37 (20-52)
0 to 18 y, %	21.5	21	21.1	21.7	23	23.5
19 to <65 y, %	63.9	63.4	63.7	64.3	64.9	65.9
≥65 y, %	14.6	15.7	15.2	14.1	12.1	10.6
Male, %	48.3	46.4	49.0	49.6	49.1	50.6
Recent immigrants, %	10.5	8.4	8.7	11.3	15.8	25.0
Rurality: RIO index, median (IQR)	2 (0-11)	2 (0-14)	2 (0-11)	2 (0-8)	2 (0-8)	0 (0-5)
Rurality categories, %						
Major urban (RIO <10)	73.5	70.5	72.9	76.0	76.6	84.0
Minor urban (RIO 10-45)	23.1	24.6	23.9	22.0	22.4	14.7
Rural (RIO >45)	3.4	4.9	3.2	1.0	1.0	1.2
Socioeconomic profile by income quintile (%)						
First (lowest)	18.0	16.6	17.3	18.7	22.0	24.3
Second	19.6	18.6	19.4	20.4	21.1	23.0
Third	20.5	19.9	20.6	21.3	20.9	21.3
Fourth	21.6	22.4	21.8	21.0	19.8	18.4
Fifth (highest)	20.3	22.5	20.9	18.6	16.2	13.0
Case mix: <sup>a</sup> Resource Utilization Bands (%)						
0 (lowest)	13.0	12.5	13.5	13.1	13.0	13.4
1	10.8	10.5	10.8	11.1	11.2	11.2
2	27.2	27.0	27.4	27.1	27.8	27.4
3	40.7	41.2	40.2	40.7	40.4	40.5
4	6.6	6.9	6.5	6.4	6.3	6.3
5 (highest)	1.7	1.8	1.7	1.6	1.4	1.3

IQR = interquartile range; RIO = Rurality Index of Ontario.

<sup>a</sup> The Resource Utilization Bands provide a measure of the health care resource requirements for individuals. The percentage distribution of patients across the 5 Resource Utilization Bands provides a measure of case mix for the population.

**Table 2. Estimated Performance Level in the Fully Adjusted Model for the Corresponding Panel Size**

Indicator	Panel size P value	Panel Size				
		1,200	1,500	1,800	2,100	2,400
<b>Cancer screening, % (95% CI)</b>						
Breast	<.001	64.6 (63.9-65.3)	64.2 (63.8-64.6)	63.8 (63.4-64.1)	63.4 (63.0-63.8)	63.1 (62.6-63.6)
Cervical	<.001	63.7 (62.9-64.5)	62.8 (62.3-63.2)	61.9 (61.5-62.3)	61.1 (60.5-61.6)	60.4 (59.8-61.0)
Colorectal	.01	45.6 (44.3-46.8)	44.6 (43.9-45.4)	43.8 (43.2-44.4)	43.2 (42.5-43.9)	42.9 (42.1-43.8)
<b>Chronic disease management, % (95% CI)</b>						
Diabetes						
Eye examination	.75	71.6 (71.1-72.2)	71.8 (71.4-72.1)	71.8 (71.6-72.1)	71.9 (71.6-72.2)	71.9 (71.6-72.3)
Lipid test	.59	62.8 (61.4-64.1)	63.0 (62.2-63.8)	63.1 (62.5-63.8)	63.3 (62.5-64.1)	63.5 (62.6-64.3)
HbA <sub>1c</sub> test	.11	39.7 (38.2-41.2)	39.3 (38.5-40.2)	39.0 (38.3-39.7)	38.6 (37.8-39.5)	38.3 (37.3-39.3)
Metformin	.24	89.1 (87.0-90.9)	88.5 (87.1-89.7)	87.9 (86.8-88.8)	87.4 (86.2-88.5)	87.0 (85.6-88.3)
ACEi/ARB	.19	73.3 (72.6-74.0)	73.5 (73.1-73.9)	73.7 (73.4-74.0)	73.9 (73.5-74.3)	74.0 (73.5-74.4)
Lipid-lowering agent	.66	69.7 (68.8-70.5)	69.8 (69.3-70.3)	69.9 (69.5-70.3)	70.0 (69.5-70.5)	70.1 (69.5-70.6)
Other						
CHF: ECHO	<.001	69.4 (67.3-71.3)	70.2 (69.0-71.4)	71.1 (70.2-72.0)	71.9 (70.8-72.9)	72.6 (71.4-73.7)
CHF: ACEi/ARB	.39	67.3 (65.1-69.3)	67.9 (66.6-69.2)	68.5 (67.5-69.4)	68.9 (67.7-70.0)	69.2 (67.9-70.4)
Asthma: Spirometry	.33	24.9 (22.7-27.3)	24.4 (23.0-25.9)	24.0 (22.9-25.1)	23.6 (22.4-24.9)	23.3 (21.9-24.7)
<b>Access &amp; Outcomes (RIO &lt;10), % (95% CI)</b>						
Admissions for ACSC	.04	12.0 (11.4-12.7)	12.2 (11.7-12.8)	12.4 (12.0-12.9)	12.6 (12.1-13.2)	12.8 (12.2-13.4)
ED visits, low triage	.004	19.5 (18.7-20.3)	19.0 (18.5-19.4)	18.5 (18.1-18.8)	18.1 (17.7-18.5)	17.8 (17.3-18.3)
<b>Physician, % (95% CI)</b>						
Continuity	<.001	78.0 (77.4-78.5)	78.6 (78.2-78.9)	79.1 (78.8-79.3)	79.3 (79.0-79.7)	79.3 (78.9-79.8)
Comprehensiveness	.03	66.5 (65.8-67.2)	66.6 (66.2-67.0)	66.7 (66.3-67.0)	66.7 (66.2-67.2)	66.5 (66.0-67.1)

ACEi = angiotensin-converting enzyme inhibitor; ACSC = ambulatory-care-sensitive conditions; ARB = angiotensin receptor blocker; CHF = congestive heart failure; ECHO = echocardiogram; ED = emergency department; HbA<sub>1c</sub> = glycated hemoglobin; RIO = Rurality Index of Ontario.

Note: Quality of care indicator performance levels are derived from regression coefficients set at their mean or mode across for panel size intervals. The P values given in the table are omnibus P value that represent the overall effect of the 2 panel-size cubic spline variables produced by the equation.

The likelihood of being up-to-date according to guideline requirements for cervical cancer screening decreased with increasing panel size by 5.0%, (from 63.7% to 58.7%), or a 7.9% relative difference ( $P < .001$ ). Breast and colorectal cancer screening showed a similar but less-pronounced association, with absolute and relative differences from peak to nadir of 3.0% and 4.6%, respectively for breast ( $P < .001$ ), and 2.7% and 5.9%, respectively, for colorectal cancer ( $P = .01$ ).

Only 1 of the 9 chronic disease indicators reflecting the guidelines for the management of the condition showed an association with panel size. The likelihood of individuals aged 40 years and over with congestive heart failure having an echocardiogram within 1 year of diagnosis increased by 6.1% (8.1% relative difference) across the range studied ( $P < .001$ ). Four medication and 4 screening test indicators showed no significant association.

The rate of non-urgent emergency department visits decreased from 19.5 to 17.4 visits per 100 patients per 2 years, a 10.8% relative difference (impact of small differences in the decimals not shown), across increasing panel size ranges ( $P = .004$ ), while the rate of hospitalization for ambulatory-care-sensitive condi-

tions increased by 1.25 admissions per 10,000 (relative difference 9.4%) over the range studied ( $P = .04$ ).

Continuity, which reflects the proportion of primary care visits made to the practice to which the patient is attached, showed a modest inverted U-shaped relationship with panel size. Patients were less likely to receive primary care services from the practice to which their physician belonged if their physician had smaller or larger panel sizes ( $P < .001$ ). The difference between the highest and lowest estimated continuity scores was 2.6% (relative difference 3.3%). We found a modest decrease in comprehensiveness, the proportion of 20 standard primary care services rendered, (1.6% absolute, and 2.4% relative difference) with increasing panel size ( $P = .03$ ).

## DISCUSSION

### Main Findings

Within the panel size range studied, increasing panel size was associated with modest decreases in cancer screening, but we found no decrease in chronic disease management indicators. There was a small but notable inverted U relationship with relational continuity, and

Panel Size				
2,700	3,000	3,300	3,600	3,900
62.7 (62.2-63.3)	62.4 (61.8-63.0)	62.1 (61.4-62.9)	61.9 (60.8-62.9)	61.6 (60.3-62.9)
59.9 (59.3-60.6)	59.5 (58.7-60.3)	59.2 (58.1-60.3)	58.9 (57.4-60.5)	58.7 (56.6-60.7)
43.0 (42.1-43.9)	43.2 (42.1-44.2)	43.5 (42.1-44.9)	44.0 (42.1-45.9)	44.4 (42.0-46.9)
72.0 (71.6-72.3)	71.9 (71.5-72.4)	71.9 (71.4-72.4)	71.8 (71.2-72.5)	71.8 (70.9-72.7)
63.6 (62.7-64.5)	63.7 (62.6-64.8)	63.8 (62.4-65.3)	64.0 (61.9-65.9)	64.1 (61.4-66.6)
37.9 (36.9-39.0)	37.6 (36.3-38.9)	37.2 (35.5-38.9)	36.9 (34.6-39.2)	36.5 (33.6-39.5)
86.8 (85.3-88.1)	86.6 (85.1-88.1)	86.6 (84.9-88.2)	86.6 (84.5-88.5)	86.6 (84.0-88.9)
74.1 (73.6-74.6)	74.2 (73.7-74.7)	74.2 (73.6-74.9)	74.3 (73.5-75.1)	74.4 (73.3-75.4)
70.1 (69.6-70.7)	70.2 (69.5-70.8)	70.2 (69.4-71.1)	70.3 (69.1-71.4)	70.3 (68.8-71.7)
73.2 (72.0-74.4)	73.8 (72.5-75.1)	74.4 (72.8-75.9)	74.9 (72.9-76.8)	75.5 (72.9-77.8)
69.3 (67.9-70.6)	69.3 (67.8-70.7)	69.3 (67.5-71.0)	69.2 (66.9-71.4)	69.2 (66.3-71.9)
23.0 (21.5-24.6)	22.8 (21.2-24.4)	22.6 (20.8-24.4)	22.4 (20.3-24.6)	22.2 (19.6-25.1)
12.9 (12.3-13.5)	13.0 (12.4-13.7)	13.1 (12.4-13.8)	13.2 (12.4-14.0)	13.3 (12.3-14.3)
17.6 (17.1-18.2)	17.5 (16.9-18.1)	17.4 (16.8-18.1)	17.4 (16.6-18.3)	17.4 (16.3-18.5)
79.1 (78.7-79.6)	78.7 (78.1-79.2)	78.1 (77.4-78.8)	77.4 (76.5-78.3)	76.7 (75.6-77.9)
66.3 (65.7-66.9)	66.1 (65.4-66.7)	65.7 (65.0-66.4)	65.4 (64.5-66.3)	65.1 (64.0-66.1)

a negligible drop in comprehensiveness of care across the panel size range. The likelihood of having a hospitalization related to an ambulatory-care-sensitive condition increased with larger panel sizes, whereas the likelihood of making use of the emergency department for non-urgent issues dropped.

### Comparison With Other Studies

Findings of this study are in keeping with others reporting negative associations between panel size and cancer screening,<sup>8,20</sup> as well as with studies finding no associations with recommended chronic disease processes of care<sup>20</sup> and clinical outcome measures.<sup>21</sup> A possible explanation is that cancer-screening interventions are more time consuming because they necessitate a discussion of risks and benefits of screening and often the completion of a maneuver by the physician. Other time-consuming activities such as healthy lifestyle counseling and immunizations<sup>8,20</sup> have also been found to be negatively associated with higher panel sizes.

The literature shows that primary care physicians carrying larger panel sizes may be more likely to refer complex patients to specialists, who would then be more likely to adhere to guidelines.<sup>22</sup> Surprisingly, we

found the likelihood of undergoing an echocardiogram within 1 year of a congestive heart failure diagnosis showed a positive association with panel size. From our data, we are unable to determine whether higher rates of referral to specialists, greater experience and expertise, or both could have contributed to this pattern.

Hospital admissions for ambulatory-care-sensitive conditions, ostensibly an indirect measure of primary care systems' capacity to manage chronic conditions such as diabetes, congestive heart failure, and asthma,<sup>23</sup> increased across the panel size range studied. Estimates for these hospitalizations, however, had wide confidence intervals, and the findings should thus be interpreted with some caution. In contrast, the rate of emergency department visits for non-urgent conditions, often used as an indicator of poor access to primary care services,<sup>24,25</sup> was negatively associated with increasing panel sizes; patients of physicians

with larger panels had fewer emergency department encounters. The majority of studies assessing access have relied on measures of direct contact with the physicians, such as the number of yearly visits,<sup>26</sup> home visits,<sup>27</sup> and consultation times,<sup>3,26,28,29</sup> and showed consistently lower access associated with panel size. Another study evaluating emergency department visits as we did reported no association with panel size.<sup>30</sup>

We found a negligible decrease in the comprehensiveness of care and small changes in continuity of care across the panel size range we studied.<sup>31</sup> Continuity appeared optimized in the mid-range, showing a maximum gain of 2.6% in that range relative to the lowest measure. Since an ongoing and consistent relationship with the same primary care provider or practice over time is associated with better patient outcomes, especially for patients with chronic conditions, this difference may be of clinical relevance.<sup>32,33</sup>

### Strengths and Limitations

Our study estimated the association between panel sizes ranging from 1,200 to 3,900 and a broad spectrum of primary care quality indicators in more than 4,000 primary care physicians using a cross sectional,

population-based design relying on health administrative data. The study's multiple outcomes, though allowing us a comprehensive assessment of the potential role of panel size, were vulnerable to type I errors. For that reason, statistical significance, especially when weak, should be interpreted with caution. In addition, the precision of some estimates was lower, as reflected by the broader confidence intervals. As a result, it is possible that potentially meaningful differences across panel sizes could not be detected for some measures.

The analyses accounted for several factors potentially confounding the relationship of interest. We controlled for rurality because the limited availability of other health care services in rural areas can lead primary care physicians to take on a broader role in patients' care provision, consuming more of their time.<sup>34</sup> We accounted for the model in which care was provided because the remuneration structure is known to affect physician behavior<sup>35</sup> and because team composition can affect the practice's capacity to care for patients. We recognize, however, that many practices that did not receive funding to establish interprofessional teams would likely have included nurses, and that, in exceptional cases, some might have independently hired a complement of other health professionals. These practices would have remained attributed to the non-interprofessional group in the analyses. We accounted for the sex<sup>36-38</sup> and age<sup>39</sup> of the physician because these were found to be associated with quality of care in some studies. We used multiple factors to control for patient medical or social complexity, as complex patients require more time per visit and more visits per year.<sup>40,41</sup> Socioeconomic status and immigration, however, were determined by proxy measures. We also cannot exclude the possibility that some unmeasured and unaccounted-for factor may be contributing to the observed associations.

Importantly, we did not have access to some parameters that could have helped us explain our findings. For example, we didn't know whether physicians with larger panel sizes worked longer hours to accommodate the increased demands of a larger practice.<sup>26</sup> We also had no data on physicians' attitudes and behaviors, and have limited information on practice organizational structure and context.

## CONCLUSION

Because the observed differences in quality of care associated with panel size were modest, and especially because all showed apparent gradual changes over the panel size range studied, with no evidence of a threshold or shoulder beyond which quality dropped, our findings do not support policy measures such as

thresholds or caps that reduce payments to physicians with large panel sizes.

We postulate that physicians who take on larger patient panels may be able to do so without compromising care quality because some personal or practice characteristics allow them to provide effective and efficient care. Characteristics such as physician communication style,<sup>42,43</sup> better organizational climate,<sup>44,45</sup> and systematic improvements in practice access<sup>46</sup> are reported to promote efficiency and/or quality. We need to better understand what makes some practices high performing and what factors support greater efficiency. Building on this work, our team is undertaking a survey of Ontario primary care practices to understand their organizational structure and study the relationship of organizational factors with quality measures. Subsequent research should also include practice-based observations and qualitative studies that allow a more in-depth understanding about efficient high-performing practices.

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**Key words:** primary health care; workload; quality indicators; panel size

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