Research

# Characteristics of primary care practices by proportion of patients unvaccinated against SARS-CoV-2: a cross-sectional cohort study

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## Abstract

**Background:** Variations in primary care practices may explain some differences in health outcomes during the COVID-19 pandemic. We sought to evaluate the characteristics of primary care practices by the proportion of patients unvaccinated against SARS-CoV-2.

**Methods:** We conducted a population-based, cross-sectional cohort study using linked administrative data sets in Ontario, Canada. We calculated the percentage of patients unvaccinated against SARS-CoV-2 enrolled with each comprehensive-care family physician, ranked physicians according to the proportion of patients unvaccinated, and identified physicians in the top 10% (v. the other 90%). We compared characteristics of family physicians and their patients in these 2 groups using standardized differences.

**Results:** We analyzed 9060 family physicians with 10 837 909 enrolled patients. Family physicians with the largest proportion (top 10%) of unvaccinated patients ($n$ = 906) were more likely to be male, to have trained outside of Canada, to be older, and to work in an enhanced fee-for-service model than those in the remaining 90%. Vaccine coverage (≥ 2 doses of SARS-CoV-2 vaccine) was 74% among patients of physicians with the largest proportion of unvaccinated patients, compared with 87% in the remaining patient population. Patients in the top 10% group tended to be younger and live in areas with higher levels of ethnic diversity and immigration and lower incomes.

**Interpretation:** Primary care practices with the largest proportion of patients unvaccinated against SARS-CoV-2 served marginalized communities and were less likely to use team-based care models. These findings can guide resource planning and help tailor interventions to integrate public health priorities within primary care practices.

Among people in Canada, concerns about risks and adverse effects are the top reasons for non-intent to receive a SARS-CoV-2 vaccine.[1] These trends are most commonly observed among communities that have low levels of trust and confidence in government because of deep histories of marginalization by institutions and harm, including being subjected to unethical medical procedures and experimentation.[2]

Family physicians can play an important role in increasing vaccine uptake through building vaccine confidence and debunking misinformation among their patients,[3,4] as many people in Canada consider family physicians as their most trusted source of vaccine information.[3,4] This requires that physicians first proactively identify vaccine-hesitant patients, and then have the necessary communication skills and capacity to engage in conversations that take time and may require several encounters.[5] Some family physicians may prioritize such work more than others or may have more capacity to undertake it. Successful partnerships between public health and primary care requires understanding of which practices are in most need of support.

We sought to evaluate characteristics of family physicians with the largest proportion of patients unvaccinated for SARS-CoV-2. We sought to describe these physicians, their practices, and their patients, and to explore characteristics associated with vaccination, with the goal of informing tailored supports that can leverage primary care to support vaccination or similar public health efforts.

## Methods

### Study design

We conducted a cross-sectional, population-based analysis using linked health administrative data in Ontario, Canada, to assess the characteristics of family physicians with the largest proportion of patients (aged ≥ 12 yr) unvaccinated for SARS-CoV-2, namely patients who had not received any doses of SARS-CoV-2 vaccine as of Nov. 1, 2021. We a priori defined this group as the 10% of physicians who had the highest proportion of unvaccinated patients in their practices, knowing that future efforts to support primary care practices in achieving public health priorities would need to focus on those with the greatest opportunity for improvement.

We compared the group of comprehensive-care family physicians who cared for the largest proportion of unvaccinated patients to the remaining 90% of comprehensive-care family physicians in the province. We used data as of Nov. 1, 2021, just before the Omicron wave of the COVID-19 pandemic. At that time, we were launching an intervention to support primary care physicians in encouraging uptake of SARS-CoV-2 vaccinations among their patients. We designed this study to provide baseline insights for a randomized trial of practice supports to improve vaccination rates (clinical trial no. NCT05099497).

### Setting

In Ontario, vaccination against SARS-CoV-2 began in December 2020 for priority groups; by May 2021, vaccines were available to everyone aged 12 years and older. In July 2021, people were eligible for their second dose using the shortened 28-day interval. Therefore by Nov. 1, 2021, everyone in the study cohort had the opportunity to have 2 doses. At the time of this study, SARS-CoV-2 vaccinations were freely available in Ontario in pharmacies, large public health immunization centres, and pop-up immunization clinics, as well as in a small number of primary care clinics. Furthermore, the vaccination of essential workers, their families, and other residents living in COVID-19 hotspots was accelerated and prioritized.[6]

Ontario has publicly funded health care for medically necessary physician and hospital services for permanent residents, without deductibles, and does not limit patients' choice of physician. Almost all primary care is delivered by family physicians; 85% of the population is enrolled with a family physician.[7]

### Study population

We included family physicians practising in a patient enrolment model, as opposed to a strictly fee-for-service model. In patient enrolment models, between 15% and 70% of payment for physicians is based on age- and sex-adjusted capitation.[8] The enrolment model is meant to reinforce a mutual commitment between patient and physician. Around 80% of family physicians in Ontario work in a patient enrolment model.

### Data sources

We used routinely collected administrative data from the Ontario Health Insurance Plan (OHIP) database for physician claims; the Registered Persons Database, which is Ontario's health care registry for OHIP-eligible patients; the Client Agency Provider Enrolment tables for patients in primary care enrolment models; the Corporate Provider Database for physicians in patient enrolment models; and the ICES Physician Database for physician characteristics. We used the COVaxON database, Ontario's central point-of care SARS-CoV-2 vaccine management system and database for the entire province. We also used sociodemographic data from the 2016 Canadian Census. Finally, we used the Immigration Refugee and Citizenship Canada (IRCC) Database, which includes people with landed immigrant or permanent resident status at any time from 1985 to 2014,[9] to identify recent immigrants, defined as those identified who had immigrated to Canada within the 10 years before Nov. 1, 2021.

These data sets were linked using unique encoded identifiers and analyzed at ICES, an independent, nonprofit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze deidentified health care and demographic data, without the need for explicit consent, for health system evaluation and improvement.

A review of Canadian studies of data quality in administrative databases revealed that demographic and clinical data have high levels of completeness and are reliable.[10] Data used in this study relied on administrative fee codes for physician payments and, despite small differences in completeness of billing between capitation and fee-for-service practices, the data were sufficiently complete. A small proportion (< 5%) of health services would not have been captured in our data (e.g., interactions with salaried professionals such as nurse practitioners).[10] Nevertheless, we are confident that the data are sufficiently comprehensive and valid for this study.

### Physician and patient characteristics

For primary care physicians, we collected data on sex, years practising medicine, country of graduation, and total OHIP billings. Practice characteristics included primary care enrolment model (enhanced fee for service, blended capitation, blended capitation with an interprofessional family health team), roster size and payment via fee for service.[11] An explanation of funding models and Ontario's patient enrolment model can be found in Appendix 1, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.230816/tab-related-content. We calculated SARS-CoV-2 vaccination coverage among enrolled patients. We also looked at quality-of-care indicators including screening for colorectal and cervical cancer, and diabetic care (e.g., at least 1 test of low-density lipoprotein cholesterol in the previous 2 years).

Patient demographics included age, sex, public health unit, distance to the rostered physician's location, and recent immigration status. We also included existing comorbidities (i.e., hypertension, congestive heart failure, diabetes, asthma, and chronic obstructive pulmonary disease) and SARS-CoV-2 vaccination.

We used postal codes at the neighbourhood level, linked to census data to assign income quintiles, marginalization quintiles, and rurality scores. We used Matheson's Canadian Marginalization Index[12,13] to assign marginalization quintiles for 4 components of marginalization — dependency, residential instability,

material deprivation, and ethnic concentration — and presented these as a summary score. We assigned rurality categorically into urban areas (score 0–9), small towns (score 10–44), and rural areas (score ≥ 45) according to the Rurality Index of Ontario.[14] Variables on health care use included continuity of care (i.e., percentage of primary care visits to the rostered physician, using a 2-year look-back) and any virtual visits in the previous 6 months. We assessed overall health care use using the Johns Hopkins Adjusted Clinical Group, determining resource utilization bands over the previous 2 years, with 0 being no health care use (no comorbidity) and 10 being the highest expected use (high comorbidity).[15]

### Statistical analysis

We calculated the proportion of unvaccinated patients enrolled to physicians and then analyzed patient and physician characteristics, stratified by physicians in the top 10% of unvaccinated patients in their practices and the remaining 90%. We calculated standardized differences and considered differences of 0.1 or greater noteworthy.[16]

We used random-effects logistic regression models to evaluate variables associated with patient vaccination status. We entered covariates into the model based on what has been shown in the literature to affect preventive care, namely patients' age, sex, neighbourhood income, neighbourhood ethnic diversity, comorbidity, rurality, and recent immigration status, and physicians' age, sex, and enrolment model.[17–20] We used the clustering of patients within physicians as a random effect. We ran separate models including patients of all physicians, those enrolled with physicians in the top 10% of unvaccinated patients, and those enrolled with physicians in the remaining 90%. The model for all patients included physician group (top 10% or remaining 90%) as a covariate.

We conducted 2 sensitivity analyses. The first defined the top decile as those with the largest number — rather than the largest proportion — of unvaccinated patients, compared with the remaining 90%. The second analysis compared physicians in the top 20% of unvaccinated patients enrolled with the remaining 80%. We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) and the Reporting of Studies Conducted Using Observational Routinely Collected Health Data (RECORD) checklists to ensure completeness of reporting of study background, methodology, and results.

### Ethics approval

The use of data in this project was authorized under section 45 of Ontario's *Personal Health Information Protection Act*, which does not require review by a research ethics board.

## Results

We analyzed 9060 family physicians who enrolled 10 837 909 patients. The physicians with the highest proportion of unvaccinated patients ($n$ = 906) cared for 259 130 unvaccinated patients as of Nov. 1, 2021 (Table 1). The proportion of rostered patients who received 2 or more doses of SARS-CoV-2 vaccine as of Nov. 1, 2021, was 74.2% (interquartile range [IQR] 69.2%–76.7%) in this group, compared with 87.0% (IQR 84.1%–89.8%) among patients of the remaining 90% of physicians. Compared with the remaining physicians, physicians with the largest proportion of unvaccinated patients were more likely to be male (64.6% v. 48.1%), to have trained outside of Canada (46.9% v. 29.3%), to be older (mean age 56 yr v. 49 yr), and to work in an enhanced fee-for-service model (49% v. 28%) (Table 2).

Patients enrolled with physicians in the most unvaccinated group tended to live in places with more ethnic diversity, higher material deprivation, and lower incomes. More patients in this group were recent immigrants. The 2 groups had similar comorbidity indices, rates of in-person and virtual visits in the previous year, and diabetes quality-of-care indicators, but cancer screening indicators such as colorectal cancer screening and Papanicolaou

**Table 1: Physicians practising in a patient enrolment model, ranked by proportion of enrolled patients unvaccinated against SARS-CoV-2**

| Percentile, % | No. of unvaccinated patients | Proportion of unvaccinated patients, %, mean ± standard deviation | No. of physicians |
|---|---|---|---|
| ≤ 10 | 46 681 | 6.0 ± 2.3 | 905 |
| 11–20 | 82 826 | 9.0 ± 0.5 | 906 |
| 21–30 | 99 909 | 10.5 ± 0.4 | 906 |
| 31–40 | 118 941 | 11.8 ± 0.4 | 906 |
| 41–50 | 131 652 | 13.0 ± 0.3 | 906 |
| 51–60 | 147 355 | 14.2 ± 0.4 | 906 |
| 61–70 | 161 231 | 14.6 ± 0.4 | 906 |
| 71–80 | 185 903 | 16.2 ± 0.6 | 909 |
| 81–90 | 208 979 | 18.8 ± 1.0 | 903 |
| 91–100 | 259 130 | 26.2 ± 13.4 | 906 |
| Total | 1 442 607 | 14.0 ± 7.6 | 9059 |

**Table 2: Characteristics of physicians practising in a patient enrolment model with the highest proportion of patients unvaccinated against SARS-CoV-2 (top 10%), compared with the remaining 90% of physicians**

| Characteristic | No. (%) of physicians* | | | Standardized difference |
|---|---|---|---|---|
| | Top 10% *n* = 906 | Remaining 90% *n* = 8153 | Total *n* = 9059 | |
| Sex | | | | 0.34 |
| Male | 585 (64.6) | 3920 (48.1) | 4505 (49.7) | |
| Female | 321 (35.4) | 4233 (51.9) | 4554 (50.3) | |
| Training | | | | 0.37 |
| Outside Canada | 366 (46.9) | 1753 (29.3) | 2119 (31.3) | |
| Canada | 414 (53.1) | 4240 (70.7) | 4654 (68.7) | |
| Physician age, yr, median (IQR) | 56 (46–65) | 49 (39–59) | 50 (40–60) | 0.44 |
| Enrolment model | | | | |
| Enhanced fee for service | 447 (49.3) | 2303 (28.2) | 2750 (30.4) | 0.44 |
| Capitation | 216 (23.8) | 2957 (36.3) | 3173 (35.0) | 0.27 |
| Family health team | 227 (25.1) | 2807 (34.4) | 3034 (33.5) | 0.21 |
| Other primary care model | 16 (1.8) | 86 (1.1) | 102 (1.1) | 0.06 |
| Physician rurality (RIO scores) | | | | |
| Urban (0–9) | 650 (73.5) | 5969 (76.1) | 6619 (75.8) | 0.06 |
| Small town (10–39) | 135 (15.3) | 1363 (17.4) | 1498 (17.2) | 0.06 |
| Rural (≥ 40) | 99 (11.2) | 515 (6.6) | 614 (7.0) | 0.16 |
| Rostered patients, median (IQR) | 1030 (365–1543) | 998 (704–1373) | 1000 (691–1386) | 0.04 |
| Patients with ≥ 2 SARS-CoV-2 vaccine doses, %, median (IQR) | 74.2 (69.2–76.7) | 87.0 (84.1–89.8) | 86.4 (82.9–89.5) | 2.70 |
| Patients with 1 SARS-CoV-2 vaccine dose, %, median (IQR) | 0.9 (0.5–1.2) | 0.6 (0.4–0.8) | 0.6 (0.4–0.9) | 0.84 |

Note: IQR = interquartile range, RIO = Rurality Index of Ontario.
*Unless indicated otherwise.

smears for cervical cancer screening were slightly lower among patients enrolled with physicians in the most unvaccinated patient group (Table 3).

Table 4 summarizes the model-adjusted associations of patient and physician characteristics with vaccination. The patient characteristics most strongly associated with being unvaccinated were younger age and less comorbidity, as well as living in rural locations and living in lower-income neighbourhoods. Physician characteristics that were most strongly associated with unvaccinated patients were older age, being male, and working in an enhanced fee-for-service payment model. Unique models for the top 10% and remaining 90% groups can be found in Appendix 2, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.230816/tab-related-content. The output from these 3 models suggests that the characteristics associated with unvaccinated patients were mostly similar. Two patient characteristics were not consistent across the models. Recent immigration was associated with being vaccinated in the top 10% group, but not in the 90% group; male patients were less likely to be vaccinated in the 90% group but not in the top 10% group.

The sensitivity analysis grouping physicians according to the number of unvaccinated patients led to similar results (Appendix 3, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.230816/tab-related-content). The most noteworthy differences between the primary and sensitivity analyses were observed for the variables of practice size and proportion of vaccinated patients, and are a function of differences in how the deciles were defined. Small differences in variables measuring various aspects of structural marginalization likely also represent differences in the approach to analysis (percentage of unvaccinated patients v. number of unvaccinated patients). Our sensitivity analysis of the top 20th percentile produced similar results; however, differences regarding ethnic diversity were not observed (Appendix 3).

## Interpretation

The family physicians in Ontario who had the highest proportion of unvaccinated patients in their practices during the COVID-19 pandemic were more likely to be male, to have trained outside of Canada, to be older, and to be working in an

**Table 3 (part 1 of 2): Characteristics of patients (aged ≥ 12 yr) enrolled with physicians practising in a patient enrolment model by proportion of patients unvaccinated against SARS-CoV-2**

| Characteristic | No. (%) of patients* | | | Standardized difference |
|---|---|---|---|---|
| | Top 10% *n* = 962 826 | Remaining 90% *n* = 8 804 494 | Total *n* = 9 767 320 | |
| **Demographic** | | | | |
| Patient age, yr | | | | |
| Mean ± SD | 46.9 ± 19.8 | 48.3 ± 20.2 | 48.1 ± 20.2 | 0.07 |
| Median (IQR) | 47 (31–62) | 49 (32–64) | 48 (32–64) | 0.07 |
| Patient age, yr | | | | |
| 12–19 | 94 898 (9.9) | 805 632 (9.2) | 900 530 (9.2) | 0.02 |
| 20–34 | 202 005 (21.0) | 1 760 580 (20.0) | 1 962 585 (20.1) | 0.02 |
| 35–64 | 464 016 (48.2) | 4 132 346 (46.9) | 4 596 362 (47.1) | 0.03 |
| ≥ 65 | 201 907 (21.0) | 2 105 936 (23.9) | 2 307 843 (23.6) | 0.07 |
| Sex | | | | |
| Male | 478 038 (49.6) | 4 129 671 (46.9) | 4 607 709 (47.2) | 0.05 |
| Female | 484 788 (50.4) | 4 674 823 (53.1) | 5 159 611 (52.8) | 0.05 |
| Immigrated within previous 10 yr | 69 428 (7.2) | 412 526 (4.7) | 481 954 (4.9) | 0.11 |
| **Marginalization index** | | | | |
| Instability quintile | | | | |
| Q1 (lowest) | 199 491 (20.9) | 2 027 338 (23.2) | 2 226 829 (22.9) | 0.06 |
| Q2 | 159 903 (16.7) | 1 760 796 (20.1) | 1 920 699 (19.8) | 0.09 |
| Q3 | 167 141 (17.5) | 1 650 968 (18.9) | 1 818 109 (18.7) | 0.04 |
| Q4 | 177 744 (18.6) | 1 531 088 (17.5) | 1 708 832 (17.6) | 0.03 |
| Q5 (highest) | 250 581 (26.2) | 1 778 839 (20.3) | 2 029 420 (20.9) | 0.14 |
| Material deprivation quintile | | | | |
| Q1 (lowest) | 136 691 (14.3) | 2 204 260 (25.2) | 2 340 951 (24.1) | 0.28 |
| Q2 | 164 754 (17.3) | 1 962 959 (22.4) | 2 127 713 (21.9) | 0.13 |
| Q3 | 178 433 (18.7) | 1 701 938 (19.5) | 1 880 371 (19.4) | 0.02 |
| Q4 | 200 272 (21.0) | 1 522 899 (17.4) | 1 723 171 (17.8) | 0.09 |
| Q5 (highest) | 274 710 (28.8) | 1 356 973 (15.5) | 1 631 683 (16.8) | 0.32 |
| Dependency quintile | | | | |
| Q1 (lowest) | 260 405 (27.3) | 2 357 931 (27.0) | 2 618 336 (27.0) | 0.01 |
| Q2 | 201 215 (21.1) | 1 747 940 (20.0) | 1 949 155 (20.1) | 0.03 |
| Q3 | 170 656 (17.9) | 1 527 286 (17.5) | 1 697 942 (17.5) | 0.01 |
| Q4 | 159 229 (16.7) | 1 489 584 (17.0) | 1 648 813 (17.0) | 0.01 |
| Q5 (highest) | 163 355 (17.1) | 1 626 288 (18.6) | 1 789 643 (18.4) | 0.04 |
| Ethnic diversity quintile | | | | |
| Q1 (lowest) | 122 357 (12.8) | 1 457 758 (16.7) | 1 580 115 (16.3) | 0.11 |
| Q2 | 134 225 (14.1) | 1 532 873 (17.5) | 1 667 098 (17.2) | 0.10 |
| Q3 | 139 860 (14.6) | 1 618 432 (18.5) | 1 758 292 (18.1) | 0.10 |
| Q4 | 201 712 (21.1) | 1 832 769 (20.9) | 2 034 481 (21.0) | 0.00 |
| Q5 (highest) | 356 706 (37.4) | 2 307 197 (26.4) | 2 663 903 (27.5) | 0.24 |
| Income quintile | | | | |
| Q1 (lowest) | 269 848 (28.1) | 1 442 262 (16.4) | 1 712 110 (17.6) | 0.28 |
| Q2 | 212 312 (22.1) | 1 663 125 (18.9) | 1 875 437 (19.2) | 0.08 |
| Q3 | 187 972 (19.6) | 1 810 032 (20.6) | 1 998 004 (20.5) | 0.03 |
| Q4 | 163 411 (17.0) | 1 898 678 (21.6) | 2 062 089 (21.2) | 0.12 |
| Q5 (highest) | 126 506 (13.2) | 1 969 581 (22.4) | 2 096 087 (21.5) | 0.24 |

**Table 3 (part 2 of 2): Characteristics of patients (aged ≥ 12 yr) enrolled with physicians practising in a patient enrolment model by proportion of patients unvaccinated against SARS-CoV-2**

| Characteristic | No. (%) of patients* | | | Standardized difference |
|---|---|---|---|---|
| | Top 10% *n* = 962 826 | Remaining 90% *n* = 8 804 494 | Total *n* = 9 767 320 | |
| **Comorbidity (ACG)** | | | | |
| No or low comorbidity (0–4) | 518 681 (53.9) | 4 700 743 (53.4) | 5 219 424 (53.4) | 0.01 |
| Moderate comorbidity (5–9) | 326 225 (33.9) | 3 111 382 (35.3) | 3 437 607 (35.2) | 0.03 |
| High comorbidity (≥ 10) | 117 920 (12.2) | 992 369 (11.3) | 1 110 289 (11.4) | 0.03 |
| **Patient care and quality-of-care measures** | | | | |
| Continuity of care in previous 2 yr, %, median (IQR) | 96.9 (75.0–100) | 93.9 (75.0–100) | 94.1 (75.0–100) | 0.04 |
| Any virtual visits (telephone) in previous 6 mo | 441 955 (45.9) | 4 283 416 (48.7) | 4 725 371 (48.4) | 0.06 |
| Any in-person visits (office) in previous 8 mo | 504 009 (52.3) | 4 699 668 (53.4) | 5 203 677 (53.3) | 0.02 |
| Any colorectal cancer screening for patients aged 50–74 yr, *n* = 3 720 298 | 194 933 (54.2) | 2 140 145 (63.7) | 2 335 078 (62.8) | 0.19 |
| At least 1 Pap smear for females aged 21–69 yr in last 42 mo, *n* = 3 767 327 | 147 495 (41.0) | 1 683 560 (49.4) | 1 831 055 (48.6) | 0.17 |
| At least 1 LDL test for patients with diabetes in previous 2 yr, *n* = 1 160 604 | 98 371 (79.2) | 833 447 (80.4) | 931 818 (80.3) | 0.03 |
| At least 3 $HbA_{1c}$ tests for patients with diabetes in previous 2 yr, *n* = 1 160 604 | 78 223 (63.0) | 677 647 (65.4) | 755 870 (65.1) | 0.05 |
| **SARS-CoV-2 vaccination** | | | | |
| Fully vaccinated (≥ 2 doses) patients as of Nov. 1, 2021 | 694 655 (72.1) | 7 570 735 (86.0) | 8 265 390 (84.6) | 0.35 |

Note: ACG = Adjusted Clinical Group, $HbA_{1c}$ = glycosylated hemoglobin, IQR = interquartile range, LDL = low-density lipoprotein, SD = standard deviation.
*Unless indicated otherwise. Some of the variable-specific totals will not add up to overall total because of inclusion and exclusion criteria or missing data.

enhanced fee-for-service model. These physicians cared for patients living in areas with more ethnic diversity, more material deprivation, and lower incomes, with a higher proportion of immigrants. The family physicians with the most unvaccinated patients were also more likely to practise in enhanced fee-for-service models and less likely to practise in team-based models, meaning they may have had fewer support staff in their clinics. This illustrates the ongoing inverse relationship between the need for care, and its accessibility and utilization.[21] In other words, the practices in highest need receive the fewest resources.[22]

Patient characteristics associated with not being vaccinated included younger age, having less comorbidity, being male, living in low-income neighbourhoods, and living in neighbourhoods with high ethnic diversity. Studies in the United States[23] and the United Kingdom[24] have reported similar findings. In the US, SARS-CoV-2 vaccine coverage was observed to be lower among non-Hispanic Black and Hispanic people.[23] Similarly in the UK and Europe, lower rates of vaccine coverage were found among those who were Black, lived in the most deprived areas, and those with less comorbidity.[24,25]

In August 2020, only 4% of the first and second doses of SARS-CoV-2 vaccines were administered in primary care offices in Ontario.[26] However, family physicians can influence patients' decisions through opportunistic discussions during patient encounters. Studies have found that guidance from health care providers plays a crucial role in influencing both general[27–29] and SARS-CoV-2-specific vaccine-related decision-making.[30,31]

Overall, the median percentage of vaccinated patients was high (86%). However, practices with a high proportion of unvaccinated patients may be a viable target group for efforts to coordinate public health and primary care. This approach would be similar to hotspotting, whereby databases are mined to identify patients who have the highest rates of health care system use and who are then prioritized to receive tailored services.[32] The hotspotting approach typically includes team-based care with a focus on patient engagement and social determinants of health. Adapting the hotspotting model to support quality improvement initiatives in primary care is described in the practice facilitation literature.[33] Practice facilitators use techniques to address gaps in care delivery, such as connecting physicians to outside resources, optimizing the use of electronic health records, implementing evidence-based practices, and addressing barriers to improve processes.[33,34] When designing health system supports, including practice facilitation, the characteristics of the family physicians and the patients they serve should be considered. We found differences in these characteristics, indicating that a tailored approach may be beneficial when developing public health interventions for those in greatest need.

**Table 4 (part 1 of 2): Random-effect logistics model of characteristics of patients and physicians associated with unvaccinated status***

| Variable | OR (95% CI) |
|---|---|
| Patient age group, yr | |
| 12–17 | 2.341 (2.322–2.360) |
| 18–36 | 2.440 (2.425–2.455) |
| 37–65 | 1.542 (1.533–1.551) |
| ≥ 66 | Ref. |
| Patient sex | |
| Female | 0.962 (0.958–0.966) |
| Male | Ref. |
| Patient income quintile | |
| Q1 (lowest) | 1.721 (1.710–1.732) |
| Q2 | 1.418 (1.409–1.427) |
| Q3 | 1.262 (1.254–1.270) |
| Q4 | 1.140 (1.133–1.147) |
| Q5 (highest) | Ref. |
| Patient ethnic diversity quintile | |
| Q1 (lowest) | Ref. |
| Q2 | 1.014 (1.007–1.021) |
| Q3 | 1.005 (0.998–1.013) |
| Q4 | 1.037 (1.029–1.045) |
| Q5 (highest) | 1.020 (1.012–1.029) |
| Patient comorbidity (ACG) | |
| No or low comorbidity (0–4) | 1.844 (1.831–1.858) |
| Moderate comorbidity (5–9) | 1.063 (1.055–1.071) |
| High comorbidity (≥ 10) | Ref. |
| Immigrated in previous 10 yr | |
| Yes | 0.988 (0.980–0.997) |
| No | Ref. |

**Table 4 (part 2 of 2): Random-effect logistics model of characteristics of patients and physicians associated with unvaccinated status***

| Variable | OR (95% CI) |
|---|---|
| Physician age group, yr | |
| < 45 | Ref. |
| 45–64 | 1.100 (1.079–1.120) |
| 65–74 | 1.144 (1.112–1.176) |
| ≥ 75 | 1.387 (1.315-1.464) |
| Physician sex | |
| Female | 0.913 (0.898–0.928) |
| Male | Ref. |
| RIO score group, physician | |
| Urban | Ref. |
| Small town | 1.258 (1.249–1.267) |
| Rural | 1.485 (1.468–1.502) |
| Enrolment model | |
| Capitation | Ref. |
| Family health team | 0.966 (0.948–0.985) |
| Other primary care model | 0.927 (0.856–1.005) |
| Enhanced fee for service | 1.177 (1.153–1.201) |
| Physician percentile of proportion of unvaccinated patients | |
| Top 10% | 1.433 (1.396–1.472) |
| Remaining 90% | Ref. |

Note: ACG = adjusted clinical group, CI = confidence interval, OR = odds ratio, Ref. = reference category, RIO = Rurality Index of Ontario.
*This model assessed all variables associated with unvaccinated status included in the table.

Many of the physicians who cared for the largest proportion of unvaccinated patients served patients living in marginalized neighbourhoods. When considering supports for primary care, cultural differences in perceptions toward vaccines and heath interventions should be considered.[35] Many marginalized communities have a history of neglect from government (municipal, provincial, federal) and health care, and this may lead to mistrust in public health initiatives.[2] Interventions to support these communities should include meaningful community engagement and consideration for age-, language- and culturally appropriate communication tools to assist primary care in boosting vaccine uptake.[36–41]

We did not see large differences between groups with respect to other quality metrics related to chronic disease management or cancer screening. We postulate that the high continuity of care seen across groups is protective for these metrics, while potentially unmeasurable influences known to be related to vaccine uptake (such as news sources or political affiliations) may have been different.[24,42,43]

Overall, our findings suggest that primary care practices serving communities with greater need may benefit from additional supports. During the COVID-19 pandemic, Ontario implemented a hotspot strategy whereby public health efforts targeted communities that were disproportionately affected.[6] The practices identified in our analysis had opportunities for improvement in SARS-CoV-2 vaccine coverage, but the hotspot strategy was not implemented at the practice level. Further research is needed to understand local best practices for integration between primary care and public health when addressing public health issues.

## Limitations

Our analysis of patient and physician characteristics was limited to administrative databases. Aside from the inability to measure many social determinants of health, psychological factors, and beliefs, which are all known to be associated with vaccine uptake, the most notable limitation of this study is that our analyses were limited to patients that were attached to a family physician. Patients with no attachment to primary care likely represented the greatest public health priority, during the pandemic and beyond.[26,44–46] Likewise, the generalizability of our findings to jurisdictions — where the availability of primary care

may differ or the links between primary care and public health are more (or less) formalized — is limited. Further, our analysis was cross-sectional in nature and did not account for temporal trends.

## Conclusion

We found that family physicians in Ontario who cared for the largest proportion of unvaccinated patients had distinct patterns that may represent opportunities for targeted interventions. Overall, these physicians tended to serve patients living in marginalized neighbourhoods and were less likely to work in team-based models of care. More equitable resource allocation, specifically expanding primary care teams in equity-seeking neighbourhoods, should be considered when supporting primary care practices with public health efforts.

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