ABSTRACT Requirements of proof of COVID-19 vaccination were mandated for nonessential businesses and venues by Canada’s ten provinces throughout the fall of 2021. Leveraging variations in the timing of these measures across the provinces, we applied event study regression to estimate the impact the announcement of these measures had nationally on age-specific first-dose uptake in the subsequent seven-week period. Proof-of-vaccination mandate announcements were associated with a rapid, significant increase in first-dose uptake, particularly in people younger than age fifty. However, these behavioral changes were short-lived, with uptake returning to preannouncement levels—or lower—in all age groups within six weeks, despite mandates remaining in place for at least four months; this decline occurred earlier and was more apparent among adolescents ages 12–17. We estimated that nationally, 290,168 additional people received their first dose in the seven weeks after provinces announced proof-of-vaccination policies, for a 17.5 percent increase over the number of vaccinations estimated in the absence of these policies. This study provides novel age-specific evidence showing that proof-of-vaccination mandates led to an immediate, significant increase in national first-dose uptake and were particularly effective for increasing vaccination uptake in younger to middle-aged adults. Proof-of-vaccination mandates may be effective short-term policy measures for increasing population vaccination uptake, but their impact may differ across age groups.

In August 2021, Canada headed into its fourth COVID-19 pandemic wave as its provinces started to lift many of their public health restrictions in recreational venues, workplaces, and schools.1 In response, Canada’s chief public health officer pronounced the need to increase two-dose vaccination uptake, or coverage, above 80 percent in all age groups, but especially in people ages 18–39, who represented a disproportionate number of new cases.2 Over the course of August and September 2021, all ten provinces implemented proof-of-vaccination policies for nonessential services and activities, and the federal government implemented such policies for domestic and international travel on October 30, 2021.3 The first provincial proof-of-vaccination policy was announced in Quebec on August 5, 2021, and came into effect on September 15, 2021.3 Although the specifics varied, all such policies required evidence of a completed primary two-dose vaccine series for people ages twelve and...
COVID-19

older to access specific nonessential services, such as in-restaurant dining. In general, the policies were promoted as a means of reducing the impact of the mounting Delta-driven wave on health systems; more broadly, they were presented as a promising tool for increasing vaccination coverage. In many jurisdictions, elected officials also suggested that proof-of-vaccination policies would facilitate a “return to normal” by enabling the lifting of remaining public health protections (for example, capacity limits, social distancing, and masking).

As in other countries, proof-of-vaccination policies were highly contentious in Canada, culminating in protests across the country throughout early 2022. Vaccination mandates have a long history in Canada in the form of school entry requirements and workplace requirements for health care workers. Debates about these mandates for COVID-19 focused on many of the same issues previously raised regarding earlier proof-of-vaccination policies, such as the need to balance individual rights and freedoms versus collective public health, the legality of conscientious and religious objections, and compensation for rare adverse events after vaccination. Despite Omicron-driven fifth and sixth waves occurring throughout December 2021 and March 2022, provincial COVID-19 proof-of-vaccination requirements were ultimately rescinded between February and April 2022, when most remaining public health measures were revoked.

Although the value of proof-of-vaccination requirements relative to other pandemic mitigation approaches will require significant study, and the entirety of their impact might not be fully understood for decades, some research has begun to explore the direct impact these policies had on COVID-19 vaccine uptake. A recent Canadian study found that the announcement of proof-of-vaccination mandates was associated with a rapid and significant increase in first-dose uptake, resulting in more than a 60 percent increase in first doses nationally as of October 31, 2021; similar effects of varying magnitude have been observed in Europe and Israel.

However, whether the impact of these proof-of-vaccination policies has differed by age has received limited attention to date, despite age-specific differences materializing throughout the pandemic, including in the prioritization and organization of vaccine delivery, risk-reduction behaviors, and epidemiological patterns in disease burden and transmission. In addition, multiple studies from across Canada, the United States, Europe, and other populations have demonstrated that COVID-19 vaccine hesitancy is more common among younger people, even after adjustment for other factors known to influence vaccine acceptance, such as ethnicity and race, gender, and health status. Further, younger people have unique reasons for their hesitancy, such as perceived lower risk of experiencing severe COVID-19 disease; fears related to rare adverse events after immunization; and, particularly, impacts on fertility and pregnancy.

This study makes a significant contribution to the existing literature by quantifying the impact of proof-of-vaccination policies on the age-specific uptake of first doses of COVID-19 vaccines. We focused on first-dose uptake, as these effects are more proximal and their timing is more clearly defined than that of second doses (as a result of variability in second-dose intervals). We also produced pooled national estimates of the impact on first-dose uptake after the implementation and rescission of proof-of-vaccination policies to provide additional causal insights regarding the impact of proof-of-vaccination mandates, and for comparison, we additionally examined the impact of a federally mandated travel-related proof-of-vaccination policy, which was more limited in scope.

**Study Data And Methods**

**Population** In Canada, public health programs and policies, including vaccination programs and COVID-19 mitigation policies, are primarily a provincial and territorial responsibility. The specifics of each proof-of-vaccination mandate, such as the interval between announcement and implementation, varied by jurisdiction (see online appendix exhibits A1 and A2). As Canada’s three territories introduced proof-of-vaccination policies much later than the provinces and two were more limited in nature (that is, voluntary or limited to specific communities), our primary analysis excluded the territories.

**Data** We used publicly available provincial and territorial data on the weekly number of people vaccinated against COVID-19 (by age group), confirmed COVID-19 cases, and COVID-19-related deaths reported by the Public Health Agency of Canada. Occasional corrections in these values resulted in a negative number of reported new doses; sixty-four such values were treated as missing, representing 1.8 percent of observations. Population sizes were determined on the basis of 2021 census estimates. Finally, proof-of-vaccination policy and age-specific vaccination eligibility dates (appendix exhibit A3) were determined from publicly reported sources.

**Analysis** We conducted an event study regression examining whether the announcement of
Nationally, proof-of-vaccination announcements meaningfully increased first-dose coverage in Canada.

Proof-of-vaccination mandates was associated with changes in weekly first-dose coverage among the following age groups: 12–17, 18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and 80 and older. We focused on the period starting from seven weeks before through seven weeks after each event (for example, the proof-of-vaccination announcement) to provide sufficient time to assess pre-event trends and establish changes in uptake during the post-event window.

Secondary outcomes included changes in population-level first-dose coverage after the implementation and rescinding of proof-of-vaccination policies, as well as the announcement of a federally mandated proof-of-vaccination policy, which applied only to federal employees and services within federal jurisdiction (that is, domestic and international air, rail, and sea travel).

We estimated the impact on first-dose coverage using the event study regression approach described by Wei Lyu and George L. Wehby. Specifically, we estimated percentage changes in first-dose uptake by age group in the less than one, one, two, three, four, five, six, and seven weeks following the event relative to the week before the event (for example, a proof-of-vaccination announcement). See appendix A for further details.

In brief, event study regression is similar to an interrupted time series design, but the period immediately preceding the event is used as the counterfactual comparator group. As vaccine uptake has been shown to be highest immediately after eligibility and increases in response to perceptions of greater transmission risk or disease severity, the following province-specific time-varying confounders were controlled for: time since age-specific eligibility for COVID-19 vaccines and the weekly growth rate of new COVID-19 cases and deaths. Daily variability in vaccine administration and reporting were smoothed as a result of using weekly estimates.

Changes in age-specific first-dose uptake were estimated using ordinary least squares regression; as the objective was to estimate national age-specific changes in vaccination uptake, random effects by province were specified. National effect estimates were pooled using inverse population weights; 95% confidence intervals were estimated using a wild cluster bootstrap approach, clustered by province to account for the geographic level at which proof-of-vaccination mandates were instituted. Using the parameter estimates from these age-specific models, we further estimated the counterfactual first-dose uptake in the seven weeks after a proof-of-vaccination announcement, assuming proof-of-vaccination policies had not been announced.

All analyses were performed using SAS, version 9.4.

Robustness Checks

We conducted several robustness checks to assess the sensitivity of our primary findings to variations in model specification and residual confounding. First, we included all ten provinces and the three territories (which represent less than 0.5 percent of the Canadian population) to provide nationally representative estimates. To assess potential differential impacts between early- and later-adopting provinces, we excluded the two early-adopter provinces (Quebec and British Columbia), the late-adopter provinces (Prince Edward Island, Newfoundland and Labrador, Saskatchewan, New Brunswick, and Alberta), and both early and late adopters (that is, we only included Ontario, Manitoba, and Nova Scotia).

Moreover, we considered a series of alternative model specifications, including crude (unadjusted) models; adjustment only for time since eligibility for vaccination; adjustment for time since the first provincial proof-of-vaccination announcement (in Quebec), as opposed to the timing of these announcements within each individual province; adjustment for calendar time as opposed to the time since age-specific vaccination eligibility, assuming that the novelty of COVID-19 vaccines did not differ by age-specific eligibility; and simultaneous adjustment for both calendar time and age-specific vaccination eligibility. We also considered an alternative model specification assuming fixed effects by province.

Assuming that provinces did not enhance vaccine administration capacity in response to proof-of-vaccination mandates, increased demand for vaccines in specific age groups would have decreased administration capacity for other age groups; thus, we also included a robustness check adjusting for the weekly vaccine uptake in each of the other age groups. Assuming that the impact of proof-of-vaccination policies may have...
been lesser if high coverage had already been achieved, we included additional adjustment for the age-specific baseline first-dose coverage at the time of the proof-of-vaccination announcement; baseline coverage may also serve as a proxy for other difficult-to-measure factors known to influence uptake, such as vaccine confidence and willingness, access barriers, and trust in institutions.

Finally, we examined two secondary outcomes: absolute change in first-dose coverage and percentage change in second-dose coverage.

**Limitations**

*We acknowledge several limitations. This study considered only one outcome associated with a complex policy issue (vaccination uptake), but not other important outcomes such as the potential to reduce transmission and surges in health care system demands. Nor did we consider broader issues related to economics, equity, ethics, public trust, and other considerations beyond the scope of this article, which will require additional research.*

Although a strength of event study regression is the ability to simultaneously control for multiple covariates, the complexity and limited use of these models, particularly for examining health outcomes, makes it more difficult to assess the appropriateness of model specifications and the interpretation of model coefficients. Thus, we conducted a variety of robustness checks to assess the consistency of our findings over varying model specifications, as well as the potential for differential impacts due to the staggered announcement of proof-of-vaccination policies. We observed qualitatively similar results under most checks; that is, an immediate and sizable increase in first-dose uptake occurred among younger to middle-aged Canadians in the weeks after proof-of-vaccination announcements. The magnitude and duration of these effects differed, and differences between age groups were noted. This suggests that our general observation that the announcement of proof-of-vaccination mandates resulted in an increase in first-dose uptake is robust, although point estimates are sensitive to model specifications. Although we included the most relevant covariates for which reliable data were available, the potential for residual confounding remains, particularly given the limited data regarding several important factors, such as province-specific differences in administration capacity, barriers to vaccination, and vaccine confidence. This may be particularly true for the estimates associated with the implementation of provincial proof-of-vaccination policies and the announcement of a federal proof-of-vaccination policy as pre-event trends were apparent, suggesting residual confounding. In contrast, no notable pre-event trends were noted in the weeks preceding the proof-of-vaccination announcement and retraction.

Despite potential limitations regarding the generalizability of these findings within the context of specific provinces, the qualitative finding that proof-of-vaccination mandates were a contributing factor to some people getting vaccinated who might otherwise not have—particularly those most likely to engage in the activities and services for which vaccination was required—is likely generalizable to most populations. In particular, we anticipate that these findings are most likely to generalize to other countries similar to Canada with respect to the accessibility of COVID-19 vaccines, cultural beliefs regarding vaccination, and age-specific vaccination motivators/barriers, such as the United States and the United Kingdom.

Finally, we were limited to examining weekly provincial- and territorial-level changes in vaccination uptake, as daily, age-specific data were not publicly available for all provinces and territories. Although nationally pooled estimates allow for greater statistical power, estimates on the impact of daily differences in vaccination uptake and a more refined understanding of local heterogeneities (that is, by province or subprovincial regions) may offer more informative insights for public health practice. We specified random effects by province partly as a result of these data limitations (that is, we were underpowered to look at changes simultaneously by age and province); however, as our objective was to compare age-specific changes in vaccination uptake at a national level, this was a minor limitation that only affected the provincial-level supplemental analyses.

**Study Results**

**Primary Outcomes** At the time proof-of-vaccination mandates were announced in Canada, 82.3 percent of the eligible population had received at least one dose; however, coverage ranged from 74.5 percent among people ages 18–29 to 92.9 percent among those ages eighty and older. After the announcement of provincial proof-of-vaccination mandates, there was an immediate and substantial increase in the uptake of first doses across all age groups (exhibit 1, with full model results in appendix exhibit A4). In the days after proof-of-vaccination announcements, there was a 0.80, 0.94, 0.71, 0.47, 0.25, 0.13, 0.06, and 0.05 percent increase in first-dose coverage among people ages 12–17, 18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and 80 and older, respectively. The uptick in first-dose uptake after the proof-of-vaccination an-
Estimated age-specific change in first-dose COVID-19 vaccination coverage before and after the announcement of provincial proof-of-vaccination (PoV) policies in Canada, 2021

<table>
<thead>
<tr>
<th>Weeks before or after announcement</th>
<th>Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>12-17</td>
</tr>
<tr>
<td>-5</td>
<td>18-29</td>
</tr>
<tr>
<td>-4</td>
<td>30-39</td>
</tr>
<tr>
<td>-3</td>
<td>40-49</td>
</tr>
<tr>
<td>-2</td>
<td>50-59</td>
</tr>
<tr>
<td>-1</td>
<td>60-69</td>
</tr>
<tr>
<td>1</td>
<td>70-79</td>
</tr>
<tr>
<td>2</td>
<td>80+</td>
</tr>
</tbody>
</table>

This figure presents event study estimates and 95% confidence intervals (indicated by whiskers) of the effects of the announcement of provincially mandated PoV on the age-specific first-dose vaccine coverage in different periods before and after the PoV announcement. The reference period was the week before the PoV announcement. The model controlled for several time-varying effects, including the growth rate in the daily cumulative number of province-level COVID-19 cases and deaths and the time since each age group became eligible for COVID-19 vaccinations in the province's vaccine roll-out timeline. The model was estimated using least squares regression and weighted by the census division 2020 population, and standard errors were heteroskedasticity robust and clustered at the province level. Country-level estimates were weighted using province- and age-specific population.
nouncement persisted among all age groups younger than age fifty up to three weeks post announcement; however, these changes were of varying statistical significance. Although coverage increased most drastically among people ages 12–17, 18–29, and 30–39 after proof-of-vaccination announcements, this uptick was most apparent and longest-lived among those ages 18–29; for example, there remained a 0.98 percent (95% CI: 0.52, 1.38) increase in weekly first-dose coverage in this age group three weeks post announcement (exhibit 1). A similar pattern was observed among those ages 30–39 and 40–49, albeit at a lesser magnitude. Uptake returned to preannouncement levels—or lower—in most groups within six weeks; these changes were shorter-lived among people ages 12–17, declining toward preannouncement levels after only two weeks. Minimal changes were noted among Canadians ages fifty and older.

Nationally, the announcement of provincial proof-of-vaccination mandates was associated with up to a 0.60 percent increase (among those ages 18–29) in first-dose coverage a month following the announcement (exhibit 1). In contrast, although there was a minor increase in first-dose coverage after the implementation of proof-of-vaccination mandates above and beyond that associated with the announcement of these policies, this uptick only occurred during the first week and was not statistically significant (exhibit 2). In addition, coverage remained steady in the seven weeks after the rescission of proof-of-vaccination mandates, despite higher uptake occurring in the weeks prior. Last, announcement of a federal travel-related proof-of-vaccination policy was associated with a significant increase in first-dose coverage, which grew over time.

Nationwide, we estimated a 17.5 percent increase in first-dose vaccination coverage and 290,168 additional people receiving first doses above what would have been expected in the absence of the proof-of-vaccination announcement in the seven weeks after provinces announced their proof-of-vaccination policies (1,950,596 versus 1,660,428 doses) (appendix exhibit A5). This reflects an absolute 0.9 percentage-point increase in coverage (88.1 percent versus 87.2 percent) (appendix exhibit 3). However, these estimates differed substantially by age, yielding absolute percentage-point increases in coverage of −1.9 (95% CI: −14.5, 9.3), 3.5 (95% CI: −15.0, 9.8), 1.4 (95% CI: −15.9, 7.9), 0.9 (95% CI: −12.0, 5.9), 0.0 (95% CI: −8.0, 3.9), 0.1 (95% CI: −4.7, 2.8), 0.2 (95% CI: −3.4, 1.7), and 0.1 (95% CI: −2.4, 2.0) in coverage, respectively, for those ages 12–17, 18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and 80 and older (exhibit 3, with 95% confidence intervals in appendix exhibit A6). Effect sizes also varied substantially by province, ranging from an increase of 0.2 percentage points in coverage in Manitoba (88.2 percent versus 88.0 percent) to an increase of 3.2 percentage points in Newfoundland and

**EXHIBIT 2**

 Estimated impact of the announcement, implementation, and rescinding of provincial proof-of-vaccination (PoV) policies and announcement of a national travel policy on percent change in national first-dose COVID-19 vaccination coverage in Canada, 2021–22

<table>
<thead>
<tr>
<th>Weeks before or after announcement</th>
<th>PoV policy announced</th>
<th>PoV policy implemented</th>
<th>PoV policy rescinded</th>
<th>Federal travel PoV policy announced</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>−1.2%</td>
<td>−1.0%</td>
<td>−0.8%</td>
<td>−0.6%</td>
</tr>
<tr>
<td></td>
<td>−0.4%</td>
<td>0.0%</td>
<td>0.2%</td>
<td>0.4%</td>
</tr>
<tr>
<td></td>
<td>0.6%</td>
<td>0.8%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Change in weekly first-dose coverage**

**SOURCE** Authors' analysis of age-specific province-level first-dose COVID-19 vaccination uptake data from June 12, 2021, to April 24, 2022, from the Public Health Agency of Canada (see note 16 in text). **NOTES** This figure presents event study estimates and 95% confidence intervals (indicated by whiskers) of the effects of the announcement of provincially mandated PoV, implementation date for provincial PoV policies, date provincial PoV policies were dropped, and announcement date for the federal travel-related PoV policy on the age-specific percent change in first-dose coverage during different periods before and after PoV announcement. The reference period was the week before the PoV announcement. The model controlled for several time-varying effects, including the growth rate in the daily cumulative number of province-level COVID-19 cases and deaths, the time since each age group became eligible for COVID-19 vaccinations in the province’s vaccine roll-out timeline, and the time since PoV mandates were announced (in the case of the latter three policy events). Each model was estimated separately, using least squares regression and weighted by the census division 2020 population, and standard errors were heteroscedasticity robust and clustered at the province level. Country-level estimates were weighted using province- and age-specific population.
Labrador (97.3 percent versus 94.1 percent) (appendix exhibit A5). Appendix exhibits A7–A14 provide further data showing that the pattern of first-dose uptake post announcement differed by both age and province.15

SECONDARY OUTCOMES Qualitatively similar results were obtained when we assessed changes in absolute first-dose coverage (appendix exhibit A15). Namely, increases after the proof-of-vaccination announcement were immediate and mostly affected younger people, particularly those ages 12–17, who had the lowest baseline vaccination coverage of all age groups. In contrast, proof-of-vaccination mandates had a non-significant and lesser, more delayed impact on second-dose uptake, presumably as a result of differences in the timing of the second dose between people receiving their first dose after the proof-of-vaccination announcement and those who had previously received their first dose but not their second. No statistically significant increases in second-dose uptake were noted.

ROBUSTNESS CHECKS Including the three territories had a negligible impact on estimates (appendix exhibit A16). Negligible differences were also observed when we excluded the late-adopter provinces; however, there were notable differences when we excluded the two early-adopter provinces and both early and late adopters. Specifically, the effects among younger age groups were more pronounced and longer-lived in these two analyses. When early adopters were excluded, a nonsignificant increase in first-dose uptake was sustained during the entire seven-week period post announcement among people ages 12–17; when both early and late adopters were excluded, an increasing, statistically significant uptick in coverage was observed in this age group.

In our crude unadjusted model, a pattern similar to the primary analysis was observed in which the effect of proof-of-vaccination announcements was no longer apparent four weeks post announcement; however, age-specific differences were more apparent in the six-to-seven-week period after announcements (appendix exhibit A17). Adjusting only for time since eligibility for vaccination resulted in results nearly identical to those of the primary analysis; however, the 95% confidence intervals were noticeably narrower. Adjusting for baseline age-specific vaccination coverage led to results that were both qualitatively and quantitatively very similar to those of the primary analysis. Adjustment for the weekly first-dose uptake in other age groups muted the postannouncement effects in all age groups except those ages 12–17, for whom a relative decrease in uptake was noted starting two weeks post announcement. Adjusting for different specifications of time resulted in point estimates nearly identical to those of the primary analysis (appendix exhibit A18), except for differences in the width of 95% confidence intervals. Specifically, 95% confidence intervals were substantially larger when specifying provincial fixed effects, and statistically nonsignificant differences in effect direction were also noted for the group ages 18–29 six or more weeks after the proof-of-vaccination announcement.

When considering the time since the an-

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**EXHIBIT 3**

<table>
<thead>
<tr>
<th>Age group, years</th>
<th>Coverage when PoV announced (%)</th>
<th>Coverage 7 weeks post announcement (%)</th>
<th>Absolute difference in coverage attributed to PoV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed</td>
<td>Counterfactual</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>82.3</td>
<td>88.1</td>
<td>0.9</td>
</tr>
<tr>
<td>12–17 years</td>
<td>76.0</td>
<td>85.0</td>
<td>9.0</td>
</tr>
<tr>
<td>18–29 years</td>
<td>74.5</td>
<td>84.1</td>
<td>9.6</td>
</tr>
<tr>
<td>30–39 years</td>
<td>75.7</td>
<td>83.3</td>
<td>2.4</td>
</tr>
<tr>
<td>40–49 years</td>
<td>81.4</td>
<td>87.0</td>
<td>5.6</td>
</tr>
<tr>
<td>50–59 years</td>
<td>85.6</td>
<td>89.2</td>
<td>3.6</td>
</tr>
<tr>
<td>60–69 years</td>
<td>89.5</td>
<td>91.7</td>
<td>2.2</td>
</tr>
<tr>
<td>70–79 years</td>
<td>92.0</td>
<td>93.5</td>
<td>1.5</td>
</tr>
<tr>
<td>80+</td>
<td>92.9</td>
<td>94.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

**SOURCE** Authors’ analysis of age-specific province-level first-dose COVID-19 vaccination uptake data from June 12, 2021, to November 13, 2021, from the Public Health Agency of Canada (see note 16 in text). **NOTES** Country-level estimates were weighted using province-and age-specific population. Appendix exhibit A6 contains 95% confidence intervals (see note 15 in text). aCoverage predicted in the absence of PoV announcement. bDifference between the observed and counterfactual number of people receiving their first vaccine dose.
nouncement of the first provincial proof-of-vaccination mandate (in Quebec), we did not find any immediate increases in uptake (appendix exhibit A19). However, an increase was observed in people ages 18–29, 30–39, and to a lesser extent 40–49 starting two weeks after Quebec’s announcement.

Discussion
Requiring people to provide proof of vaccination to engage in certain activities and receive certain services is contentious because such mandates present social, psychological, legal, economic, and political risks to individuals and society at large. However, many experts, including those on the COVID-19 expert panel convened by Canada’s chief science advisor,4 have concluded that the benefits of temporary proof-of-vaccination policies that are carefully crafted to take into account the greater epidemiological, policy, and economic contexts exceed any potential harms during a deadly pandemic causing significant economic and health impacts. Early studies of COVID-19 proof-of-vaccination policies in Canada, Europe, and Israel found immediate positive effects on both first- and to a lesser extent second-dose uptake. Canadian media similarly documented increased demand for vaccination in response to proof-of-vaccination policies.

To inform the specific design and implementation of future vaccination initiatives, we built on earlier studies by focusing on the age-specific effects of proof-of-vaccination mandates. We found that announcement of provincial mandates increased uptake of COVID-19 vaccination, particularly first doses, and that this impact was greatest among young to middle-aged Canadians in the first few weeks after the announcement. The effects of proof-of-vaccination policies on second-dose uptake were less noticeable and mostly limited to people ages 18–39—notably, the same age group for which the chief public health officer pronounced the need to achieve greater vaccination coverage. In addition, the delayed timing observed for the increase in second doses is consistent with the average period between announcement and implementation (3.5 weeks) and requirements that recipients wait a minimum of three to four weeks between doses. Although we found that implementation of proof-of-vaccination mandates was not associated with a large increase in first-dose uptake (beyond the effect associated with their announcement), the weeks after rescission of provincial mandates were marked by a stagnation in first-dose coverage, providing further support for a causal relation between proof-of-vaccination mandates and increased vaccination uptake.

We also found that the announcement of a federally mandated travel proof-of-vaccination policy was followed by a sustained and sizable increase in first-dose uptake beyond that associated with the recently announced provincial proof-of-vaccination mandates, suggesting that more targeted proof-of-vaccination mandates may also be valuable policy options for increasing vaccination uptake.

A recent study found no statistically significant differences in the age-specific impact of proof-of-vaccination policies on first-dose uptake in Canada; however, the authors noted that their study design may have been underpowered to detect any true age-specific differences. In contrast, our findings align with a growing body of research demonstrating that younger people experience different motivators and beliefs regarding vaccination. In addition to differences in hesitancy, emerging evidence suggests that these differential attitudes toward COVID-19 vaccination might extend toward mandatory COVID-19 vaccination policies. For example, a recent representative survey of French adults found that those younger than age thirty-five were significantly more likely to oppose vaccine mandates compared with older adults, particularly those ages seventy-five and older.

We found that first-dose coverage increased more in people ages 18–29, 30–39, and 40–49 than older age groups, and it steadily increased for weeks after the proof-of-vaccination announcement. Interestingly, sharp increases in uptake by those ages 12–17 ceased after only two weeks. Given that our adjustment for first-dose uptake in all other age groups muted post-announcement effects in all age groups except adolescents (ages 12–17), and the downward trend occurred earlier and was more pronounced among adolescents, this may point to issues with their ability to access vaccines. During the school year, adolescents would have received their doses at different locations or times than adults. Unless doses could be received at school-based clinics, adolescents would have needed to find evening or weekend vaccination clinics or appointments, which may have preferentially been given to older adults (for example, given their greater potential for severe disease) or may have been more difficult to access because of the concurrent demand from adults, arising from both the proof-of-vaccination mandates and the concurrent roll-out of third or booster doses to older adults starting in the fall of 2021.

Nationally, proof-of-vaccination announcements meaningfully increased first-dose coverage in Canada; however, the degree to which these policies affected coverage varied sub-
Proof-of-vaccination mandates may have limited utility in influencing vaccination among hesitant or hard-to-reach populations.

Policy Implications

Although the precision of the age-specific estimates presented in this study was likely influenced by our modeling assumptions and methodological assumptions, our overall finding that the announcement of proof-of-vaccination mandates had the greatest impact on influencing the vaccination behaviors of younger to middle-aged Canadians in the weeks immediately after proof-of-vaccination announcements was qualitatively robust under a range of robustness checks. This suggests that when designing, communicating, and implementing proof-of-vaccination mandates, policy makers and public health officials need to carefully consider age-specific beliefs, motivators, behaviors, facilitators and barriers to accessing vaccines, and concerns regarding vaccination. These findings may also suggest that proof-of-vaccination mandates may have limited utility in influencing vaccination among hesitant or hard-to-reach populations, as suggested by our finding that the mandates had limited impact in older populations for whom high coverage had already been achieved. Presumably, the remaining unvaccinated people in older age groups may be unvaccinated by choice or as a result of particular challenges beyond the influence of mandates; in contrast, the relatively low baseline coverage in younger populations offered a greater opportunity for improvement and was less likely the result of ardent opposition to vaccines. Policy makers must also anticipate that certain age groups may respond more immediately than others and allocate resources, including communications tools and immunizers, accordingly. On the basis of our analysis of Canadians’ responses to proof-of-vaccination policies enacted in the months after primary doses of COVID-19 vaccine became available, we recommend that health officials maximize immunization capacity and minimize barriers to access immediately after the announcement of proof-of-vaccination requirements or eligibility for new doses of vaccine, including by making plans to shift immunization resources (such as doses of vaccine or immunizers) in a targeted fashion.

Conclusion

We estimated that the announcement of provincial proof-of-vaccination policies led to an immediate, short-lived uptick in first-dose COVID-19 vaccination coverage in Canada, particularly among younger to middle-aged adults. These observations align with other research showing age-specific differences in health behaviors, risk perception, and vaccination attitudes throughout the COVID-19 pandemic and more broadly.
Although additional research exploring the specific mechanisms driving these age-specific differences will be invaluable, these findings offer important insights given the ongoing need to reduce severe disease through vaccination, including with booster and multivalent vaccines. Further research is required to understand the broader impacts of proof-of-vaccination mandates, determine the optimal policy design and implementation strategies (for example, time limiting or restricted to high-risk settings), overcome technical challenges (for example, improved interoperability of digital vaccine certificate platforms), and evaluate other aspects beyond the scope of this study. Our work suggests that proof-of-vaccination mandates may be effective short-term policy options for substantially increasing vaccination coverage, particularly among younger populations; however, additional approaches are likely necessary to reach remaining unvaccinated people and support long-term improvements in public vaccine confidence and access.

At the time of writing, Tiffany Fitzpatrick was a research associate with the North American Observatory on Health Systems and Policies (NAO). Cheryl Camillo was a deputy pillar lead with the Coronavirus Variants Rapid Response Network (CoVaRR-Net) and also an associate with the NAO. Marin Habick was also a research assistant with the Department of Community Health and Epidemiology and Saskatchewan Population Health and Evaluation Research Unit, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Nazeem Muhajarine was also a pillar lead with CoVaRR-Net. Sara Allin was also an associate with CoVaRR-Net and an associate professor at the Institute of Health Policy, Management, and Evaluation, University of Toronto, Toronto, Ontario, Canada. This project was supported by funding from a CoVaRR-Net Rapid Response Research Grant. The authors acknowledge the CoVaRR-Net Pillar 8 Public Health, Health Systems, and Social Policy Impact investigative team, led by Muhajarine, Cory Neudorf, Camillo, Doug Manuel, and Andrew Morris. CoVaRR-Net is funded by an operating grant from the Canadian Institutes of Health Research (FRN 225711). An open access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY-NC-ND 4.0) license, which permits others to distribute this work provided the original work is properly cited, not altered or used for commercial purposes. See https://creativecommons.org/licenses/by-nc-nd/4.0/.

**NOTES**


15 To access the appendix, click on the Details tab of the article online.


