Original Article

Urban-rural divide in COVID-19 infection and vaccination rates in healthcare workers in British Columbia, Canada

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Abstract

Introduction: Healthcare workers (HCWs) play a critical role in responding to the COVID-19 pandemic. Early in the pandemic, urban centres were hit hardest globally; rural areas gradually became more impacted. We compared COVID-19 infection and vaccine uptake in HCWs living in urban versus rural locations within, and between, two health regions in British Columbia (BC), Canada. We also analysed the impact of a vaccine mandate for HCWs.

Methods: We tracked laboratory-confirmed SARS-CoV-2 infections, positivity rates and vaccine uptake in all 29,021 HCWs in Interior Health (IH) and all 24,634 HCWs in Vancouver Coastal Health (VCH), by occupation, age and home location, comparing to the general population in that region. We then evaluated the impact of infection rates as well as the mandate on vaccination uptake.

Results: While we found an association between vaccine uptake by HCWs and HCW COVID-19 rates in the preceding 2-week period, the higher rates of COVID-19 infection in some occupational groups did not lead to increased vaccination in these groups. By 27 October 2021, the date that unvaccinated HCWs were prohibited from providing healthcare, only 1.6% in VCH compared with 6.5% in IH remained unvaccinated. Rural workers in both areas had significantly higher unvaccinated rates compared with urban dwellers. Over 1800 workers, comprising 6.7% of rural HCWs and 3.6% of urban HCWs, remained unvaccinated and set to be terminated from their employment. While the mandate prompted a significant increase in uptake of second doses, the impact on the unvaccinated was less clear.

Conclusions: As rural areas often suffer from under-staffing, loss of HCWs could have serious impacts on healthcare provision as well as on the livelihoods of unvaccinated HCWs. Greater efforts are needed to understand how to better address the drivers of rural-related vaccine hesitancy.

Keywords: COVID-19, rural medicine, vaccination, vaccine mandate

Résumé

Introduction: Les travailleurs de la santé (TS) jouent un rôle essentiel dans la réponse à la pandémie de COVID-19. Au début de la pandémie, les centres

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urbains ont été les plus durement touchés à l'échelle mondiale; les zones rurales ont progressivement été plus touchées. Nous avons comparé l'infection à la COVID-19 et l'adoption du vaccin chez les travailleuses et travailleurs de la santé vivant dans des zones urbaines et rurales au sein de deux régions sanitaires de la Colombie-Britannique (C.-B.), au Canada, et entre ces régions. Nous avons également analysé l'impact d'un mandat de vaccination pour les travailleuses et travailleurs de la santé.

Méthodes: Nous avons suivi les infections au SRAS-CoV-2 confirmées en laboratoire, les taux de positivité et l'adoption du vaccin chez les 29 021 TS d'Interior Health (IH) et les 24 634 TS de Vancouver Coastal Health (VCH), par profession, âge et lieu de résidence, en les comparant à la population générale de cette région. Nous avons ensuite évalué l'impact des taux d'infection ainsi que du mandat sur le recours à la vaccination.

Résultats: Bien que nous ayons trouvé une association entre l'adoption du vaccin par les TS et les taux de COVID-19 des travailleurs de la santé au cours de la période de deux semaines précédentes, les taux plus élevés d'infection par la COVID-19 dans certains groupes professionnels n'ont pas entraîné une augmentation de la vaccination dans ces groupes. En date du 27 octobre 2021, date à laquelle il était interdit aux travailleuses et travailleurs de santé non vaccinés de fournir des soins de santé, seul 1,6% des travailleuses et travailleurs de la VCH, contre 6,5% des travailleuses et travailleurs de l'IH, n'étaient toujours pas vaccinés. Les travailleuses et travailleurs ruraux des deux zones présentaient des taux de non-vaccination significativement plus élevés que les citadins. Plus de 1 800 travailleuses et travailleurs, soit 6,7% des TS ruraux et 3,6% des TS urbains, n'étaient toujours pas vaccinés et devaient être licenciés. Bien que le mandat ait entraîné une augmentation significative de la prise des deuxièmes doses, l'impact sur les personnes non-vaccinées était moins clair.

Conclusions: Comme les zones rurales souffrent souvent d'un manque de personnel, la perte de TS pourrait avoir de graves répercussions sur la prestation des soins de santé ainsi que sur les moyens de subsistance des TS non-vaccinés. Des efforts plus importants sont nécessaires pour comprendre comment mieux aborder les facteurs d'hésitation à SE faire vacciner en milieu rural.

Mots-clés: Travailleuses et travailleurs de la santé, COVID-19, vaccination, mandat de vaccination, milieu rural

INTRODUCTION

Healthcare workers (HCWs) have been on the frontlines of the world's fight against COVID-19, striving to care for COVID-19 patients while also trying to manage regular and ongoing healthcare demands during a pandemic. Significant pressures faced by HCWs during the COVID-19 pandemic have included an increased health system burden, risk of infection, burnout, mental health stresses, risk of healthcare worker shortages and concerns about family transmission.[1] HCWs in rural settings face even greater pressures, as there are often even greater staffing shortages.[2,3]

British Columbia (BC), Canada, instituted mandatory vaccination of healthcare workers; long-term care (LTC) workers were to be vaccinated before 12 October 2021,[4] and those working in acute care and other publicly-funded healthcare facilities were to be vaccinated by 26 October 2021.[5] Vaccine mandates have been discussed for decades for healthcare workers for other communicable diseases such as influenza,[6,7] and while some jurisdictions chose to allow those working in healthcare to remain unvaccinated against COVID-19, the upswing in cases across the world and the Omicron variant[8] led many countries to move towards mandating vaccination for HCWs during this pandemic.[9,10]

In the United States, HCWs from rural areas reported significantly less willingness to take a vaccine in the early phases of the pandemic (26%), compared to their suburban (35%) and urban (37%) peers,[11] with this trend persisting throughout the pandemic.[12] Murthy *et al.* found adult COVID-19 vaccination coverage lower in rural (38.9%) than in urban counties (45.7%) overall, including amongst adults aged 18–64 years (29.1% rural, 37.7% urban), those aged ≥65 years (67.6% rural, 76.1% urban), women (41.7% rural, 48.4% urban) and men (35.3% rural, 41.9% urban).[13] Data on barriers and facilitators to uptake of COVID-19 vaccines within Canada are scarce as Canada has had strong vaccine uptake (81.8% of the Canadian population as of 21 March 2022[14]); however, the range is 70.8% of those in Nunavut to 91.5% in Newfoundland and Labrador.[15] It is well known

that rurality comes with its own set of challenges including recruiting and retaining family physicians and other healthcare professionals,[16-18] making lower vaccine uptake in the face of a mandate requiring vaccination all the more concerning. Access and acceptance disparities in vaccine access have been documented, i.e. people from rural locations having to travel outside their counties to receive a vaccine.[19] This trend has been seen elsewhere as well.[20,21]

Globally, there are disparities noted in the uptake of childhood vaccines with those living in rural locations being less likely to vaccinate their children.[22,23] Rurality itself is defined as an important social determinant of health.[24] As such, there is a particular need to assess the impact not only of COVID-19 infections, but also of how COVID-19 vaccination policies are working in rural compared to urban areas.

As BC brought in a mandate that required vaccination of all HCWs, we sought to compare and contrast rural and urban differences in (1) COVID-19 rates; (2) vaccine uptake, within and between health regions; (3) differences within occupational groups; (4) differences by age-group; (5) impact of higher COVID rates in the previous month on subsequent vaccine uptake and (6) the impact of mandated vaccination (on threat of termination of employment) on vaccine uptake in both settings. Specifically, as vaccine uptake is well established to be an important determinant of COVID-19 morbidity, we sought to understand the extent to which rurality-impacted COVID-19 infection rates, vaccine uptake and drivers of vaccination within two of the five large health regions located in BC, Canada, one mainly rural, located in the interior of the province, namely Interior Health (IH), and one more urban, Vancouver Coastal Health (VCH).

Our study provided an opportunity to examine this question in one of the first jurisdictions to implement a vaccine mandate specifically for healthcare workers.

METHODS

Definition of rural

As discussed by Clark *et al.*,[25] studies vary in how they define 'rural' and 'urban', which can make comparisons difficult.[26] For the purposes of our analyses, we defined a major urban centre as having a regional population >40,000 people and everyone living outside of these areas as rural. As the definition of rurality must always be nuanced to reflect local understandings and realities with relative local comparisons, rather than absolute evaluations across all settings, we deferred to how communities in the Interior of BC define themselves with respect to being rural rather than urban and have explicitly adopted the BC definitions in this study.[27]

Cohort description

The cohort included all healthcare workers employed by IH (n = 29,021) and VCH (n = 24,634) for at least 1 day between 1 March 2020 and 11 November 2021. When analysis considered a specific date within that interval, a subset of the cohort was used, excluding those who did not have an active appointment on that date. In order to be included in this study, HCWs must have been employees of the health authority and thus physicians were not included.

Database

Healthcare worker records were obtained from the provincial Workplace Health Indicator Tracking and Evaluation (WHITE™) database. Following ethics approval (UBC Behavioural Ethics Certificate H21-01380), the data fields extracted included worker demographics (age group, gender, home location), job details (job title, job category, subsector, job location, job start date, and if applicable, job end date), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) polymerase chain reaction (PCR) testing information (date, test result) and COVID-19 vaccination status (date of vaccine and type of vaccine). Data on the background communities were obtained from the B.C. Centre for Disease Control and included vaccinations (daily vaccination dose totals by health region) and infection totals (daily positive and negative test counts by health region, including age group for positive cases), with regional population data obtained from Statistics Canada. Home and work locations were provided by the local health area (LHA), a subdivision of the regional health authorities; these were further classified as either

urban or rural based on population size of the LHA. Jobs were classified into six categories and ages were classified into four categories.

Statistical analysis

For each health authority, we calculated the SARS-CoV-2 infection rate (per 100,000 population) over time as a 7-day moving average, also plotting the cumulative proportion with 2 or more doses of vaccine, for both HCWs and the background community from 1 March 2020 to 11 November 2021. The background community infection rates were both region and age adjusted by weighting positive cases to match the residence and age range distribution of the workforce. Over the same period, we plotted the same variables for HCWs alone, comparing those residing in rural locations with those residing in urban locations.

SARS-CoV-2 infection rates and COVID-19 vaccination status were tabulated by health authority, occupation group, home residence type (urban/rural) and age group. To address our first four research questions (COVID infection and vaccine uptake respectively, and any differences in this regard between occupational or age groups), effect size models using logistic regression were used to calculate odds ratios. The dependent variable was whether the individual had received at least one dose of vaccine prior to a specified date or not or whether the individual had tested positive for SARS-CoV-2 at least once prior to a specified date. The variables of interest included the home residence type (rural or urban), occupation group and age group. These values were calculated on the day before the vaccine mandate announcement, 12 September 2021, and the day the mandate took effect on 27 October 2021.

To ascertain the extent to which COVID-19 rates in the period prior to vaccination drove vaccination rates (question 4), we considered the period when vaccination was available to healthcare workers, from 15 December 2020 to 11 November 2021. For each date in this observation period, we counted one observation per HCW, where the response was 0 if the HCW was unvaccinated on that date and 1 if they received the first dose on that date, excluding all days after the first dose. The variable of interest was the community infection rate for the home region of the HCW on that date; for this, we calculated the daily 14 day moving average background community SARS-CoV-2 infection rate for each region. To account for repeated measures on a single HCW, conditional logistic regression was used, with each individual HCW making up one of the strata. Anyone who had tested positive prior to 15 December 2020 was also excluded from the calculation.

To examine the final question, the extent to which the mandate for compulsory vaccination of all HCWs drove vaccination uptake, we examined the period from 1 July 2021 to 27 October 2021, using segmented regression analysis[28] of the interrupted time series (ITS) to estimate the immediate and sustained effects on the rate of vaccination following the announcement, where the rate is measured as the proportion of workers who received the dose on a given day out of the total number of workers who had not yet received that dose. For workers in the LTC sector, the mandate took affect a few days earlier; therefore, LTC workers were excluded from this analysis.

RESULTS

Figure 1 shows the HCW and background community SARS-CoV-2 infection rates in IH displayed against vaccination status in these respective groups. The initial small peak shown in Figure 1 could be related to a combination of increased case finding activities in HCWs as well as the less clear guidance on personal protective equipment (PPE) use and less availability of PPE than was the case subsequently. In September and October 2020, HCW infections trailed off significantly, even more so than community infections. In the second wave (beginning towards the end of October 2020), again, a peak occurred wherein HCW COVID-19 rates exceeded community rates, again possibly related to increased case results associated with the policy of testing asymptomatic HCWs during outbreaks. In addition, Figure 1 shows that HCW vaccination was steadily higher than that of the general population.

Figure 2 shows that while VCH experienced a larger initial impact, it did not experience the same intensity of infections in the fourth wave as IH [Figure 1], and that, unlike IH, the HCWs in VCH were largely protected in the third wave.

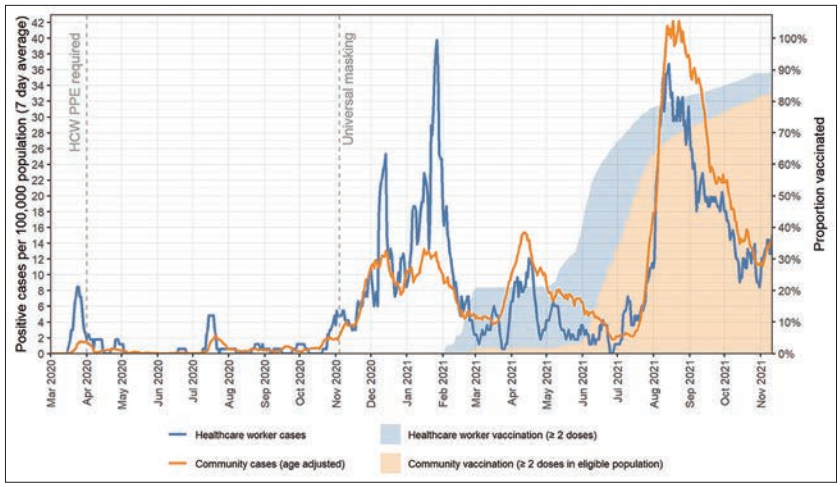


Figure 1: IH COVID-19 case rate in healthcare workers and the age-adjusted community rate, showing the proportion fully vaccinated. IH: Interior Health.

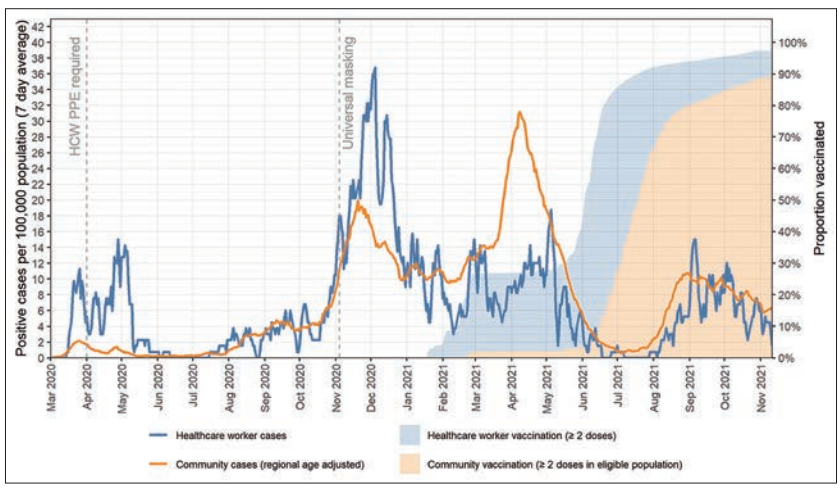


Figure 2: VCH COVID-19 case rate in healthcare workers and the age-adjusted community rate, showing the proportion fully vaccinated. VCH: Vancouver Coastal Health.

Figure 3 shows the urban and rural breakdown of vaccination and cases in healthcare workers in the two jurisdictions (IH and VCH combined). Rural cases have followed a similar trend to their urban counterparts with the exception of spikes in the last 2 months (September–October 2021) where rural cases outpaced those in urban locations.

Table 1 shows that a larger proportion of HCWs living in urban settings were vaccinated compared to their rural counterparts overall. Table 1 further shows a higher rate of unvaccinated rural-dwelling workers (11.3% urban vs. 13.8% rural; odds ratio: 0.79; 95% confidence interval [CI]: 0.73–0.86; $P < 0.001$). Those dwelling rurally and employed by VCH were more than twice as likely to be unvaccinated both on 12 September 2021, the day before the mandate was announced for the entire healthcare workforce (odds ratio: 2.25; 95% CI: 1.85–2.74; $P < 0.001$) and 27 October 2021, when this mandate came into effect (odds ratio: 2.89; 95% CI: 2.20–3.79; $P < 0.001$).

A separate analysis was conducted of only the subset of healthcare workers who worked in LTC facilities, using August 12th, the date of the announcement that all LTC workers would require vaccination. The rate of first doses was shown to significantly increase, but 177 of 5736 (3.1%) LTC workers remained unvaccinated at the time the mandate came into effect, and importantly, 86 (48.6%) of unvaccinated LTC workers were in rural areas.

Before the mandate announcement (12 September 2021), the SARS-CoV-2 infection rate was significantly lower for IH than VCH (3.4% IH vs. 3.9% in VCH; odds ratio: 0.87; 95% CI: 0.79–0.97; $P = 0.009$); rural workers indeed had

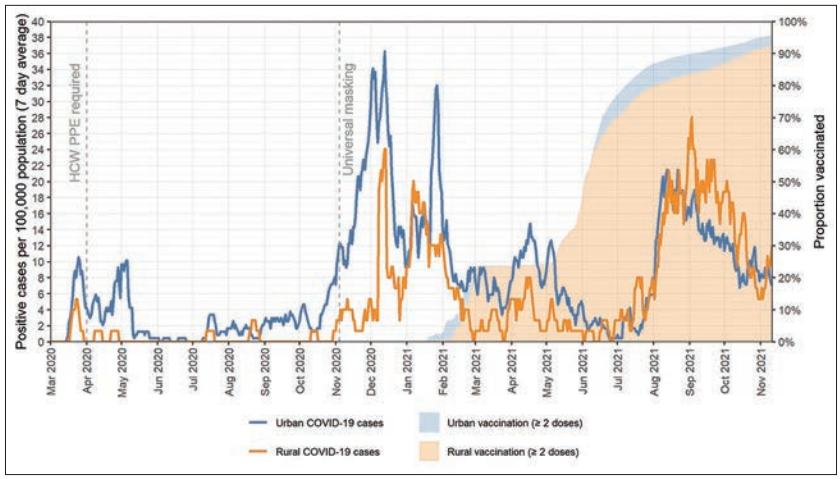


Figure 3: COVID-19 case rate and proportion vaccinated comparing urban and rural populations.

a significantly lower infection rate across both health authorities (2.2% vs. 4.1% amongst urban counterparts; odds ratio: 0.54; 95% CI: 0.47–0.62; $P < 0.001$). Worrisomely, a full 12.2% of HCWs in Interior Health were unvaccinated compared to 3.6% in VCH (odds ratio: 3.76; 95% CI: 3.46, 4.09; $P < 0.001$), despite all being subject to the same provincial policies. The relative difference between health authorities continued to 27 October 2021, when 6.5% of HCWs in Interior Health were still unvaccinated compared to only 1.6% in VCH (odds ratio: 4.17; 95% CI: 3.68–4.72; $P < 0.001$).

Table 1 shows occupational roles and it can be seen that a total of 5.8% of LPN/care aides in IH had contracted PCR-confirmed SARS-COV-2 infections, compared to 4.1% of the IH healthcare workforce overall; in VCH, the corresponding figures were 5.7% and 4.2%. Within IH across both time points, LPN/care aides, administrative and support workers had significantly lower vaccination rates, and nurses and allied health workers had higher vaccination rates. Within VCH, only support workers had a significantly lower vaccination rate, and nurses had a higher vaccination rate.

When considering the differences between age groups, within IH, the vaccinated rate in HCWs was significantly lower in the age group 30–39 years across both time points; simultaneously, the SARS-CoV-2 infection rate was significantly higher in that age group at both time points. In VCH, differences in vaccination by age group did not appear consistent between time points; however, when we considered SARS-CoV-2 infection rates, we found that the infection rate was higher for those aged 39 and under. We analysed the entire workforce of both regions combined to determine differences between urban and rural-dwelling workers, taking age and occupational mix into consideration. We found that rural workers were vaccinated at a significantly lower rate than their age-adjusted and occupation-adjusted counterparts in urban areas, both by September 12th before the mandate was announced (odds ratio: 0.57; 95% CI: 0.53–0.62; $P < 0.001$), and by October 27th when the mandate came into force (odds ratio: 0.55; 95% CI: 0.50–0.61; $P < 0.001$).

In exploring whether infection rates drove vaccine uptake in HCWs, we found that an average increase of 1 case per 100,000 in the community SARS-CoV-2 infection rate was associated with a 3.5% (95% CI: 3.2%–3.8%) increased likelihood of vaccination 2 weeks later.

Our analysis showed the extent to which the announcement of the provincial vaccine mandate requiring all BC healthcare workers to be vaccinated before 27 October 2021 drove up vaccination rates. Interrupted time series (ITS) segmented regression analysis of the period from 1 July 2021 to October 27 showed significant effects over the vaccine mandate period, with similar effects in both urban and rural settings [Table 2]. However, while the daily proportion of unvaccinated workers who received first doses showed an immediate rate increase of 0.78%, (from 1.01% vaccinating per day to 1.79%), the sustained effect was a daily reduction of 0.028% HCWs being

Table 1: Healthcare worker's unvaccinated rate by region on the date of the announcement of the mandate and when it took effect, by residence type, occupation and age group

Worksite region	Exposure group	Remaining unvaccinated							
		12 September 2021				27 October 2021			
		Percentage	#/*n*	OR (95% CI)	COVID + (%)	Percentage	#/*n*	OR (95% CI)	COVID + (%)
IH	Urban	11.3	1703/15,077	0.79 (0.73-0.86)*	4.1	6.0	906/15,145	0.81 (0.73-0.90)*	4.6
	Rural	13.8	1246/9002	1.26 (1.17-1.36)*	2.3	7.3	651/8973	1.23 (1.11-1.36)*	3.1
	LPN/care aides	15.1	1136/7507	1.45 (1.34-1.57)*	4.9	7.6	567/7470	1.30 (1.17-1.45)*	5.8
	Nurses	7.6	493/6479	0.51 (0.46-0.56)*	2.9	4.5	288/6470	0.60 (0.53-0.69)*	3.6
	Administration	13.9	492/3543	1.19 (1.07-1.32)*	2.4	7.9	282/3574	1.29 (1.13-1.48)*	2.6
	Allied health	6.9	214/3117	0.49 (0.43-0.57)*	2.2	3.9	122/3121	0.55 (0.46-0.67)*	2.8
	Support	17.8	566/3176	1.69 (1.52-1.86)*	3.3	8.2	262/3203	1.35 (1.18-1.55)*	4.0
	39 and under	13.5	1413/10,450	1.23 (1.14-1.33)*	4.2	6.8	721/10,563	1.11 (1.01-1.24)*	5.0
	40-49	11.7	643/5476	0.94 (0.86-1.03)	2.9	6.5	360/5508	1.02 (0.90-1.15)	3.7
	50-59	10.8	580/5385	0.83 (0.76-0.92)*	3.1	6.0	320/5353	0.90 (0.79-1.02)	3.7
	60 and over	11.3	313/2768	0.90 (0.80-1.02)	1.8	5.8	156/2694	0.88 (0.74-1.04)	2.0
	Overall	12.2	2949/24,079	-	3.4	6.5	1557/24,118	-	4.1
VCH	Urban	3.2	569/17,696	0.44 (0.37-0.54)*	4.1	1.4	232/16,736	0.35 (0.26-0.45)*	4.4
	Rural	7.0	132/1898	2.25 (1.85-2.74)*	1.8	3.9	70/1795	2.89 (2.20-3.79)*	2.2
	LPN/care aides	4.1	189/4559	1.23 (1.03-1.45)*	5.3	1.9	84/4383	1.25 (0.97-1.61)	5.7
	Nurses	2.8	187/6733	0.69 (0.58-0.81)*	3.6	1.3	83/6318	0.73 (0.57-0.94)*	4.0
	Administration	4.2	157/3703	1.25 (1.04-1.50)*	3.5	1.8	66/3605	1.16 (0.88-1.53)	3.9
	Allied health	3.0	97/3283	0.79 (0.64-0.98)*	2.8	1.3	40/3168	0.74 (0.53-1.03)	2.9
	Support	8.0	55/690	2.45 (1.84-3.26)*	4.0	3.4	23/670	2.24 (1.45-3.45)*	4.3
	39 and under	3.4	281/8312	0.90 (0.78-1.06)	4.7	1.4	109/7672	0.80 (0.63-1.01)	5.0
	40-49	3.1	141/4478	0.85 (0.70-1.02)	3.9	1.3	58/4346	0.77 (0.58-1.03)	4.5
	50-59	4.2	186/4402	1.26 (1.06-1.49)*	3.0	1.9	80/4.280	1.20 (0.93-1.56)	3.2
	60 and over	3.9	93/2402	1.10 (0.88-1.37)	2.7	2.5	55/2233	1.64 (1.22-2.21)*	2.8
	Overall	3.6	701/19,594	-	3.9	1.6	302/18,531	-	4.2
Overall (both VCH and IH combined)	Urban	6.9	2272/32,773	0.51 (0.48-0.55)*	4.1	3.6	1138/31,881	0.52 (0.47-0.57)*	4.5
	Rural	12.6	1378/10,900	1.94 (1.81-2.08)*	2.2	6.7	721/10,768	1.94 (1.76-2.13)*	3.0
	LPN/care aides	11.0	1325/12,066	1.55 (1.45-1.67)*	5.0	5.5	651/11,853	1.42 (1.29-1.57)*	5.8
	Nurses	5.1	680/13,212	0.50 (0.46-0.55)*	3.2	2.9	371/12,788	0.57 (0.51-0.64)*	3.8
	Administration	9.0	649/7246	1.10 (1.00-1.20)*	3.0	4.8	348/7179	1.14 (1.02-1.29)*	3.2

Contd...

Table 1: Contd...

Worksite region	Exposure group	Remaining unvaccinated							
		12 September 2021				27 October 2021			
		Percentage	#/n	OR (95% CI)	COVID + (%)	Percentage	#/n	OR (95% CI)	COVID + (%)
	Allied health	4.9	311/6400	0.52 (0.46-0.58)*	2.5	2.6	162/6289	0.54 (0.46-0.64)*	2.8
	Support	16.1	621/3866	2.32 (2.12-2.55)*	3.5	7.4	285/3873	1.88 (1.65-2.14)*	4.1
	39 and under	9.0	1694/18,762	1.16 (1.09-1.25)*	4.4	4.6	830/18,235	1.08 (0.99-1.19)	5.0
	40-49	7.9	784/9954	0.92 (0.85-1.00)*	3.3	4.2	418/9854	0.96 (0.86-1.08)	4.0
	50-59	7.8	766/9787	0.91 (0.84-0.99)*	3.1	4.2	400/9633	0.94 (0.84-1.05)	3.5
	60 and over	7.9	406/5170	0.93 (0.83-1.03)	2.2	4.3	211/4927	0.98 (0.85-1.13)	2.4
	Overall	8.4	3650/43,673	-	3.6	4.4	1859/42,649	-	4.1

*Unadjusted OR is significant at 95% confidence. LPN: Licensed practical nurse, OR: Odds ratio, CI: Confidence interval, IH: Interior Health, VCH: Vancouver Coastal Health

vaccinated each day after the announcement. This showed a sustained cumulative effect of -1.29% over the 45-day period between the mandate announcement and implementation, such that the overall impact of the mandate on first dose uptake was unclear [Figure 4]. When second doses were considered, the immediate effect was not significant, but the sustained effect showed a significant increase, as would be expected [Figure 5]. The sustained effect rate increase, of 0.063% second doses daily, after the mandate announcement, showed a sustained cumulative effect of 2.77% over the period.

DISCUSSION

Globally, HCWs have faced a heavy emotional and physical toll during the pandemic, including shouldering care for children and elderly relatives along with their essential health system role.[29] Notwithstanding reports[30,31] of peaks in HCW infections in the early stages possibly being attributed to increased testing, these studies, as well as results here, show that some occupational groups of HCWs were at particularly higher risk of COVID-19 infection.[30] The combined burden of psychological, social and physical work-related stressors has caused those working on the frontlines of healthcare to quit in unprecedented numbers.[32]

The rural–urban divide in vaccine uptake by HCWs is concerning. While we found an association between vaccine uptake by HCWs and HCW COVID-19 rates in the preceding 2-week period as would be expected, the higher rates of COVID-19 infection in some occupational groups did not lead to increased vaccination in these groups.

For some HCWs who may be vaccine hesitant, mandates exacerbated an already stressful situation.[33] In some jurisdictions, vaccine mandates have been highly effective in driving up vaccinations; in France, the law on mandatory vaccination for HCWs led to a massive boost in vaccination rates, from 60% in July (when the new requirement was announced) to over 99% in October,[34] with COVID-19 cases declining.[35] However, it is important to note the downside to vaccine mandates for HCWs[36] – while vaccination increased, those who chose not to be vaccinated lost their jobs and were lost to the healthcare system[37] - at least temporarily - with

Table 2: Effect of the vaccine mandate on the vaccination rate for both first and second doses, using segmented regression interrupted time series analysis

Subgroup	First doses (95% CI)		Second doses (95% CI)	
	Immediate effect	Sustained effect	Immediate effect	Sustained effect
IH	0.67 (0.22-1.11)*	−0.028 (−0.044-−0.013)*	0.15 (−0.23-0.53)	0.055 (0.042-0.068)*
VCH	1.25 (0.48-2.01)*	−0.023 (−0.050-0.003)	−0.19 (−0.71-0.33)	0.094 (0.076-0.112)*
Urban	0.69 (0.19-1.19)*	−0.020 (−0.037-−0.003)*	0.03 (−0.36-0.41)	0.067 (0.053-0.080)*
Rural	0.88 (0.33-1.42)*	−0.040 (−0.059-−0.022)*	0.22 (−0.28-0.72)	0.055 (0.038-0.072)*
LPN/care aides	0.82 (0.22-1.42)*	−0.027 (−0.047-−0.006)*	−0.14 (−0.53-0.24)	0.052 (0.039-0.065)*
Nurses	0.64 (0.15-1.13)*	−0.030 (−0.047-−0.013)*	0.24 (−0.18-0.65)	0.045 (0.031-0.060)*
Administration	0.65 (0.12-1.18)*	−0.013 (−0.031-0.006)	0.33 (−0.24-0.91)	0.087 (0.067-0.107)*
Allied health	1.05 (0.48-1.61)*	−0.040 (−0.059-−0.021)*	−0.10 (−0.68-0.48)	0.065 (0.045-0.085)*
Support	1.18 (0.45-1.92)*	−0.046 (−0.072-−0.021)*	−0.06 (−0.62-0.50)	0.065 (0.046-0.084)*
39 and under	0.68 (0.16-1.20)*	−0.033 (−0.051-−0.015)*	0.05 (−0.33-0.44)	0.060 (0.046-0.073)*
40-49	0.73 (0.14-1.31)*	−0.022 (−0.043-−0.002)*	0.11 (−0.39-0.60)	0.065 (0.048-0.082)*
50-59	1.02 (0.39-1.64)*	−0.028 (−0.050-−0.007)*	0.16 (−0.34-0.67)	0.072 (0.055-0.089)*
60 and over	1.01 (0.49-1.52)*	−0.016 (−0.034-0.001)	0.19 (−0.34-0.73)	0.057 (0.039-0.075)*
Overall	0.78 (0.31-1.25)*	−0.028 (−0.044-−0.012)*	0.09 (−0.29-0.47)	0.063 (0.050-0.076)*

*Effect of the mandate compared is significantly different from 0 at 95% confidence. No subgroup is significantly different from the other subgroups.
CI: Confidence interval, LPN: Licensed practical nurse, IH: Interior Health, VCH: Vancouver Coastal Health

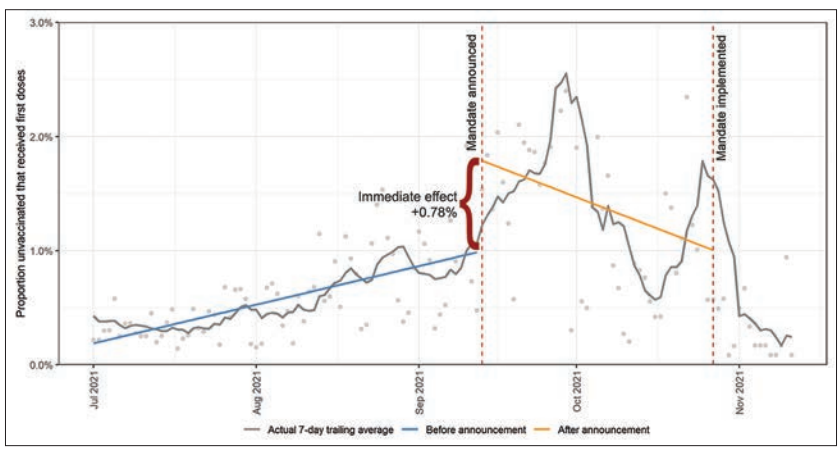


Figure 4: Overall daily proportion of unvaccinated who received first doses from 1 July 2021 to 11 November 2021, with the segmented regression ITS predicted values (blue and orange lines). ITS: Interrupted time series.

the long-term effects not yet known. The impacts have been felt more in small towns and rural locations,[37,38] which were already suffering from staff-shortages. In our study, over 1800 workers, comprising 6.4% of rural HCWs and 3.5% of urban HCWs, remained unvaccinated when the mandate was enforced, despite consequent employment termination.

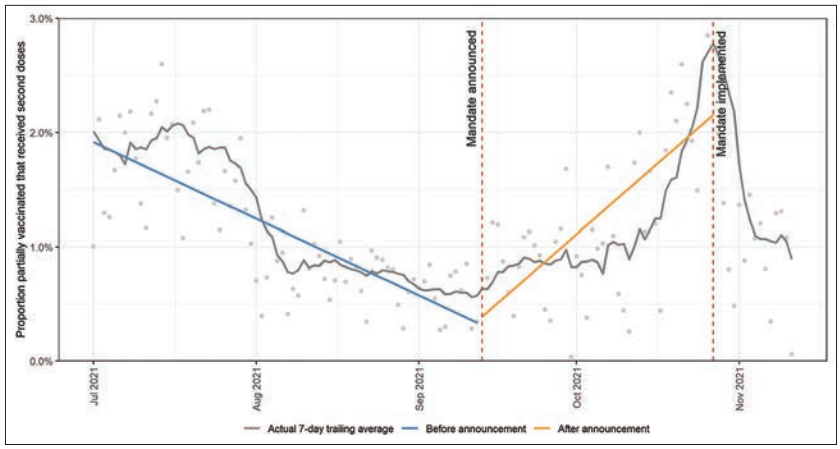


Figure 5: Overall daily proportion of partially vaccinated workers who received second doses from 1 July 2021 to 11 November 2021, with the segmented regression ITS predicted values. ITS: Interrupted time series.

Similar to other studies,[39] we expected mandates to drive up vaccination rates. In a study of 6 countries, it was noted that countries with pre-intervention vaccine uptake below average had a more pronounced increase in daily vaccinations following mandatory COVID-19 certificates compared with those where uptake was already average or higher.[36] As such, we expected that the BC mandate for HCWs would have significantly narrowed the gap in vaccine uptake between rural and urban HCWs. We found, however, that while the vaccination mandate increased vaccine rates in HCWs in BC, the policy fell short of achieving very high levels of uptake. The vaccine mandate had a significant, albeit small, effect on uptake of second doses, suggesting some impact amongst those hesitant to be vaccinated. It did not significantly impact first dose uptake, indicating a lack of significant change amongst those who decisively rejected vaccination.

Limitations

The data used on vaccination in this study were taken directly from provincial immunisation figures and we have confidence in their validity. Nonetheless, possible limitations of this study include differences in testing strategies in various parts of the province of BC at different points in the pandemic and between HCWs and the general population; VCH began vaccinating HCWs in December of 2020 and IH began in January of 2021 which may have slightly impacted uptake, although is unlikely to have had a major impact on the results. Furthermore, we used local definitions of 'rural' and 'urban' based on the configuration of the population in our two health authorities.

Future research

With ongoing concern and uncertainly regarding emerging Omicron variants,[40] further research is needed to better understand the reasons behind vaccine hesitancy and what can be done to address these factors. The analysis presented here was conducted based on data ending just before Omicron spread rapidly in this jurisdiction; further analysis is needed to assess the long-term impact on vaccine uptake given the lower effectiveness of the vaccine against Omicron[41] and possible requirements for more than a third dose (or booster) in future. Specifically, it is crucial that we acquire a deep understanding of how rurality impacts the 7Cs of vaccine hesitancy[42] (complacency: not perceiving diseases as high risk enough to bother taking action; constraints: structural and psychological barriers; confidence: trust in the effectiveness and safety of vaccines, the system that delivers these and/or motivations of policymakers; calculation: calculating one's own risk; and aspects pertaining to collective responsibility, i.e. willingness to protect others; as well as conspiracy: the tendency to endorse conspiratorial beliefs about vaccination and compliance: the tendency to adhere to regulations). Moreover, with ongoing boosters possibly essential to protect the health of the public, it is necessary that attention be paid to how to increase uptake of vaccinations in rural healthcare workers without aggravating staff shortages in these areas. Given that rural HCWs'

beliefs, behaviours and actions are reflective of their communities,[43,44] there may be value in examining the impacts of rural community-based strategies at the local level[45] with the view to improving the effectiveness of vaccination uptake and other public health/health literacy initiatives/campaigns. Intervention studies exploring the use of trusted local leaders and the impact on vaccine uptake are needed.

CONCLUSION

Since conducting this study, there has been Canadian media coverage of exorbitant wait times for healthcare reported to be driven by staffing issues; the underlying factors impacting staffing shortages must be further explored. In this context, greater efforts are needed to understand the urban–rural divide and the role of vaccine policy.

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