



## Measuring the impact of influenza vaccination on healthcare worker absenteeism in the context of a province-wide mandatory vaccinate-or-mask policy



Michelle Murti<sup>a,b,c,\*</sup>, Michael Otterstatter<sup>d,b</sup>, Alison Orth<sup>a</sup>, Robert Balshaw<sup>d,e</sup>, Khalif Halani<sup>f</sup>, Paul D. Brown<sup>a</sup>, Samar Hejazi<sup>a</sup>, Darby Thompson<sup>f</sup>, Sandra Allison<sup>g,b</sup>, Aamir Bharmal<sup>a,b</sup>, Meena Dawar<sup>h,b</sup>, Dee Hoyano<sup>i,b</sup>, Victoria Lee<sup>a,b</sup>, Monika Naus<sup>d,b</sup>, Sue Pollock<sup>j,b</sup>, John Bevanda<sup>j</sup>, Sandy Coughlin<sup>k</sup>, John Fitzgerald<sup>i</sup>, Dave Keen<sup>a</sup>, Melanie Maracle<sup>g</sup>, Stacy Sprague<sup>h</sup>, Bonnie Henry<sup>l,b</sup>

<sup>a</sup> Fraser Health Authority, 13450 102nd Ave., Suite 400, Surrey, BC V3T0H1, Canada

<sup>b</sup> University of British Columbia, 2206 East Mall, Vancouver, BC V6T1Z3, Canada

<sup>c</sup> Public Health Ontario, 480 University Ave., Suite 300, Toronto, ON M5G1V2, Canada

<sup>d</sup> BC Centre for Disease Control, 655 W 12th Ave., Vancouver, BC V5Z4R4, Canada

<sup>e</sup> University of Manitoba, 753 McDermot Ave., Third Floor, Winnipeg, MB R3E0T6, Canada

<sup>f</sup> Emmes Canada, 4664 Lougheed Hwy., Suite 200, Burnaby, BC V5C3Y2, Canada

<sup>g</sup> Northern Health Authority, 299 Victoria St., Suite 600, Prince George, BC V2L5B8, Canada

<sup>h</sup> Vancouver Coastal Health Authority, 601 West Broadway, 11th Floor, Vancouver, BC V5Z4C2, Canada

<sup>i</sup> Island Health Authority, 1952 Bay St., Victoria, BC V8R1J8, Canada

<sup>j</sup> Interior Health Authority, 505 Doyle Ave., Kelowna, BC V1Y0C5, Canada

<sup>k</sup> Providence Health Care, 1081 Burrard St., Vancouver, BC V6Z1Y6, Canada

<sup>l</sup> Office of the Provincial Health Officer, PO Box 9648 STN PROV GOVT, Victoria, BC, V8W9P4, Canada

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### ABSTRACT

**Objectives:** In 2012, British Columbia (BC) implemented a province-wide vaccinate-or-mask influenza prevention policy for healthcare workers (HCWs) with the aim of improving HCW coverage, and reducing illness in patients and staff. We assess post-policy impacts of HCW vaccination status on their absenteeism.

**Methods:** We matched individual HCW payroll data from December 1, 2012 to March 31, 2017 with annually self-reported vaccination status for BC health authority employees to assess sick rates (sick time as a proportion of sick time and productive time). We modelled adjusted odds ratios (OR) of taking any sick time, relative rates (RR) of sick time taken, and predicted mean sick rates by vaccination status in influenza (December 1–March 31) and non-influenza seasons (April 1 to November 30). We used two methods to assess changes in influenza season sick rates for HCWs who had a change in their vaccination status over the five years.

**Results:** HCWs who reported 'early' vaccination (before December 1 when the policy is in effect) were less likely to take sick time (OR 0.874, 95%CI: 0.866–0.881) and took less sick time (RR 0.907, 95%CI: 0.901–0.912) in influenza season compared to HCWs who did not report vaccination; whereas HCWs who reported 'late' (between December 1 and March 31, and subject to masking until vaccinated) had similar sick rates to HCWs who did not report vaccination. These trends were also observed in non-influenza season. Influenza season sick rates were similar for HCWs that had at least one year of 'early' vaccination and one year where vaccination was not reported over the five year period.

\* Corresponding author at: Public Health Ontario, 480 University Ave., Suite 300, Toronto, ON M5G1V2, Canada.

E-mail addresses: [michelle.murti@oahpp.ca](mailto:michelle.murti@oahpp.ca) (M. Murti), [Michael.otterstatter@bccdc.ca](mailto:Michael.otterstatter@bccdc.ca) (M. Otterstatter), [alison.orth@fraserhealth.ca](mailto:alison.orth@fraserhealth.ca) (A. Orth), [Robert.balshaw@umanitoba.ca](mailto:Robert.balshaw@umanitoba.ca) (R. Balshaw), [khalani@emmes.com](mailto:khalani@emmes.com) (K. Halani), [paul.brown@fraserhealth.ca](mailto:paul.brown@fraserhealth.ca) (P.D. Brown), [samar.hejazi@fraserhealth.ca](mailto:samar.hejazi@fraserhealth.ca) (S. Hejazi), [dthompson@emmes.com](mailto:dthompson@emmes.com) (D. Thompson), [Sandra.allison@northernhealth.ca](mailto:Sandra.allison@northernhealth.ca) (S. Allison), [aamir.bharmal@fraserhealth.ca](mailto:aamir.bharmal@fraserhealth.ca) (A. Bharmal), [meena.dawar@vch.ca](mailto:meena.dawar@vch.ca) (M. Dawar), [dee.hoyano@viha.ca](mailto:dee.hoyano@viha.ca) (D. Hoyano), [Victoria.lee@fraserhealth.ca](mailto:Victoria.lee@fraserhealth.ca) (V. Lee), [monika.naus@bccdc.ca](mailto:monika.naus@bccdc.ca) (M. Naus), [sue.pollock@interiorhealth.ca](mailto:sue.pollock@interiorhealth.ca) (S. Pollock), [john.bevanda@interiorhealth.ca](mailto:john.bevanda@interiorhealth.ca) (J. Bevanda), [scoughlin@providence.bc.ca](mailto:scoughlin@providence.bc.ca) (S. Coughlin), [john.fitzgerald@viha.ca](mailto:john.fitzgerald@viha.ca) (J. Fitzgerald), [dave.keen@fraserhealth.ca](mailto:dave.keen@fraserhealth.ca) (D. Keen), [melanie.maracle@northernhealth.ca](mailto:melanie.maracle@northernhealth.ca) (M. Maracle), [stacy.sprague2@vch.ca](mailto:stacy.sprague2@vch.ca) (S. Sprague), [bonnie.henry@gov.bc.ca](mailto:bonnie.henry@gov.bc.ca) (B. Henry).

**Conclusions:** Overall absenteeism is lower among HCWs who report vaccination versus those who do not report. However, absenteeism behaviours appear to be influenced by individual level factors other than vaccination status.

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## 1. Introduction

Annual influenza vaccination is recommended for all Canadian health care providers by the National Advisory Committee on Immunization [1]. However, vaccination in most provinces and territories has remained below the national target of 80% [2,3]. In 2012, British Columbia (BC) was the first province in Canada to implement a province-wide vaccinate-or-mask influenza prevention policy that requires healthcare workers (HCW) and anyone entering a patient care area (including visitors) to mask if they have not received influenza vaccine for that season [4]. There were three goals of the policy: improving HCW vaccination coverage, reducing influenza illness transmission, and reducing influenza-related HCW absenteeism. Previous reports, studies and publications have described the evidence and rationale for the policy, evaluation of the implementation of the policy, changes in HCW coverage rates, and HCW knowledge, attitudes and practices around influenza vaccination [5–10]. The magnitude of the benefit remains uncertain, and attempts to evaluate the impact of the BC policy on hospital-acquired influenza and long-term care facility outbreak outcomes have been limited by the available data sources [11–13].

At the time of initial policy implementation, the goal of reducing HCW influenza-related absenteeism was supported by three randomized controlled trials showing modest reductions in absenteeism among vaccinated HCWs [14–16]. Since then, an ecological study of the United Kingdom National Health Service Trusts found significant decreases in HCW absences due to sickness as influenza vaccination coverage increased [17]. As well, a comparison of HCW absenteeism due to viral respiratory illness in facilities with and without mandatory vaccination policies in the United States (US) has shown lower sick time among vaccinated staff [18].

Despite mounting evidence that increasing HCW influenza vaccination coverage reduces absenteeism, the impacts of influenza vaccination policies on absenteeism have been mixed. Descriptions of mandatory vaccination policy implementations from New York City and Virginia Mason, Seattle, reported reductions in ‘call-off’ hours and a non-significant reduction in absenteeism, respectively [19,20]. An initial evaluation of the impact of the BC policy on HCW absenteeism in one health region of BC after the first season, 2012–13 when the policy was in effect but not enforced, showed that vaccinated HCWs had significantly lower rates of sick time compared to unvaccinated HCWs during influenza season, after accounting for baseline non-influenza season differences in sick rates [21].

Here, we further assess the BC situation by examining the first five years of implementation of a province-wide mandatory influenza vaccinate-or-mask policy. We assess the impact of vaccination status at the level of the individual HCW on their influenza and non-influenza season sick rates. In the absence of pre-policy vaccination status information, we also assess whether differences exist in influenza season sick rates for HCWs who had a change in their reported vaccination status in the post-policy period.

## 2. Methods

### 2.1. HCW payroll data and sick time

We used HCW payroll data from employees of the seven regional and provincial health authorities in BC (Fraser Health, Interior

Health, Northern Health, Provincial Health Services, Providence Healthcare, Vancouver Coastal Health, Vancouver Island Health) from December 1, 2012 to March 31, 2017. Available data for each HCW included year of birth and sex, health authority, job type (part-time, full-time status, or casual status), and descriptions of job classification (job descriptions and codes). Job classification descriptions were manually grouped into a summary classification of ‘clinical’ and ‘non-clinical’, with ‘indeterminate’ classification where there was insufficient information on the role. Available data for each day employed include: hours of productive time, hours of sick time, and hours of other absences (e.g., vacation, leaves of absences). Daily hours data were aggregated into calendar months. The monthly “sick rate” for each HCW was defined as the amount of sick time divided by the sum of sick time and productive time in a month (i.e., the amount of sick time relative to the amount of time the HCW was supposed to be working in a month).

We excluded months where a HCW had zero productive time and days in which >12 or <0 hours (h) were recorded in a day. In addition, we excluded individuals with ‘casual’ status because of differences in sick-time policies compared to regular (full-time or part-time) employees. Additional exclusions include HCWs for whom year of birth, sex, or employee identification key was not discernable.

### 2.2. Data on HCW vaccination status

All HCWs self-reported their annual influenza vaccination and date of vaccination via an online reporting tool. These data were recorded in BC’s provincial Workplace Health Indicator Tracking and Evaluation (WHITE) data system. Annual reported HCW vaccination status was categorized as “early” (those who reported receiving vaccine before the policy deadline of December 1), “late” (those who reported receiving vaccine after the policy deadline, between December 1 and March 31, and would have had to mask from December 1 until their vaccination date), and those who were “not reported” and would have been subject to masking for the season. Annual vaccination status from WHITE was matched by employee identifiers to the health authority payroll data and individual HCW aggregated monthly sick rates.

### 2.3. Modelling influenza season sick rates by vaccination status

We compared HCW sick time by their ‘early’, ‘late’ or ‘not reported’ vaccination status using a 2-stage negative binomial hurdle model. The first stage of the two-stage hurdle model is a logistic regression of the factors impacting the risk of taking any sick time in a month. The second stage of the model is a negative binomial regression of the factors impacting the rate of sick time taken in a month [22].

We defined the “influenza season” (IS) each year as the period of time between December 1 and March 31, corresponding to the period when the BC influenza control policy was in effect; with non-influenza season (NIS) as the period from April 1 to November 30. Our model included reported vaccination status and influenza season (IS & NIS) and the interaction between the two terms to isolate the effect of vaccination status on monthly sick rates by season (IS vs NIS). Total time (the sum of sick time plus productive time)

was included as a statistical offset in the model, effectively acting like the denominator of a rate calculation to account for time worked by each employee each month. We adjusted for effects of other important variables by including: year of birth, sex, health authority, job type, job classification, annual influenza vaccine effectiveness (VE) estimate, and calendar year to account for varying seasons and trends over time. VE estimates were based on the all ages and all influenza types estimates from the Canadian Sentinel Practitioner Surveillance Network [23].

As a large proportion of HCWs had no sick time in a month, the hurdle model accounts for the likelihood that there are different underlying mechanisms that influence why HCWs take no sick time versus the amount of sick time off when it is taken. The negative binomial model also addresses the overdispersion in the data, precluding use of standard Poisson or over-dispersed Poisson models. Coefficient estimates and associated 95% confidence intervals (CI) from the logistic and negative binomial models were transformed into odds ratios (ORs) and relative rates (RRs), respectively. The ORs and RRs of predictors in the model are based on coefficients from the hurdle model and conditional on all other things being equal, and therefore, represent the predictors' effect on sick rates on average and in a given month. This approach accounts for HCWs having varying characteristics (e.g., job type, job classification, vaccination status) over time. Predicted marginal means of overall monthly sick rate estimates from the two components of the model were calculated by vaccination status for both IS and NIS.

Sensitivity analyses of the model included removal of the 2012–13 season (when policy was not enforced), removal of the 2016–17 season (unusually high sick rates), and removal of the VE term. As well, the model was re-fit using a 2-stage zero-inflated regression hurdle model.

#### 2.4. Measuring differences in influenza season sick rates with a change in reported vaccination status

In addition to the modelling strategy described above, we used two approaches to assess differences in sick rates in the subset of HCWs whose vaccination status changed from 'early' vaccination to 'not reported' (or vice versa) at least once during the five year post-policy period.

*Differences within HCWs:* For the first approach, we used a paired *t*-test to compare the mean sick rates during IS months when 'early' vaccination was reported and sick rates during IS months when no vaccination was reported for individual HCWs who were consistently employed over the five year period.

*Differences among HCWs:* In the second approach we used six pairs of influenza seasons between 2012–13 and 2015–16 and analysed the subset of HCWs that changed their vaccination status from year 1 to year 2 ('early' in year 1 and 'not reported' in year 2 versus 'not reported' in year 1 and 'early' in year 2). HCWs also had a minimum of 160 h of productive time in both year 1 and year 2 influenza seasons. For each pair of years, the change in the mean IS

sick rate from year 1 to year 2 was calculated for each HCW. We used a Wilcoxon-Mann Whitney test to compare the difference between the changes in mean sick rates for those who were 'early' to 'not reported' and those 'not reported' to 'early' in each pair of years. P-values for these six tests were adjusted using a Benjamini-Hochberg correction to control the false discovery rate over six pairs of comparisons.

All analyses were performed using R version 3.4.2 software [24]. This project was assessed by the Fraser Health Authority Research Ethics Board and was determined as evaluation, and therefore exempt from review and approval.

### 3. Results

#### 3.1. HCW demographics and reported vaccination status

Payroll data from 107,258 HCWs employed between December 1, 2012 to March 31, 2017 were included in the analyses; exclusions for daily time >12 or <0 h and indiscernible data removed <4% of daily payroll records. Included HCWs were mostly female 89,625 (84%) and the mean birth year was 1970.7 (range: 1932–1998). As HCWs had multiple job types and classifications over time, the proportion of daily records associated with full-time HCWs was 62.0% (80,256/129,442), and the proportions of daily records by job role were 64.6% (71,781/111,047) for clinical roles, 32.1% (35,645/111,047) for non-clinical roles, and 3.3% (3621/111,047) for indeterminate roles.

The proportion reporting vaccination was lowest in the 2012–13 season when the policy was in place but not enforced, with 64.7% reporting 'early', 2.5% reporting 'late', and 32.8% 'not reported'. Reported vaccination was consistently higher in the 2013–14 to 2016–17 seasons, with 68.0%–70.4% reporting 'early', 5.6% to 8.7% reporting 'late', and 23.3% to 25.2% 'not reported'. Overall crude monthly sick rates were lower in non-influenza season (NIS) compared to influenza season (IS) for all HCWs, and lowest among those who reported receiving influenza vaccine 'early' and highest among those 'not reported' (Table 1).

#### 3.2. Model estimates of HCW factors on sick rates

Table 2A shows the results from stage one (logistic regression of probability of taking any sick time) and stage two (negative binomial regression of sick rate when sick time was taken) of the fully adjusted model for the effects of HCW factors on monthly sick rates (OR and RR and their 95% CI). On average, compared to the 19–29 year old age group, HCWs between 30 and 39 years of age were more likely to have any sick time (OR 1.084, 95%CI: 1.075–1.092), whereas those 40 years and older were less likely to have any sick time (ORs < 1). Monthly sick rates (RR) were higher in all age groups compared to 19–29 year olds. Female HCWs were more likely to have any sick time (OR 1.329, 95%CI: 1.322–1.337), and had higher sick rates (RR 1.070, 95%CI: 1.066–1.075) compared to male HCWs. Full-time HCWs were more likely to have any sick time (OR 1.316, 95%CI: 1.310–1.322), but had lower sick

**Table 1**

Unadjusted overall mean monthly sick rate of HCWs in influenza season and non-influenza season months by annual reported vaccination status (December 1, 2012 to March 31, 2017).

Vaccination Status	Mean Monthly Sick Rate (%)	
	Influenza Season (December 1 – March 31)	Non-influenza Season (April 1 – November 30)
'Early' (received before December 1)	5.14	4.23
'Late' (received between December 1 and March 31)	5.98	5.43
'Not Reported'	6.17	5.85

**Table 2A**

Fully-adjusted\* Odds Ratios (OR), Relative Rates (RR) and associated 95% confidence intervals (CI) of predictors of average monthly sick rates (age group, sex, job type and job classification).

Predictors	OR	95% CI	RR	95% CI
Ages 30–39 vs 19–29	1.084	1.075–1.092	1.027	1.021–1.033
Ages 40–49 vs 19–29	0.966	0.959–0.974	1.013	1.008–1.019
Ages 50–59 vs 19–29	0.864	0.858–0.871	1.060	1.054–1.066
Ages 60+ vs 19–29	0.878	0.870–0.887	1.111	1.104–1.119
Females vs Males	1.329	1.322–1.337	1.070	1.066–1.075
Full-time vs Part-time	1.316	1.310–1.322	0.863	0.860–0.865
Clinical vs Non-clinical	1.096	1.091–1.101	1.162	1.158–1.165
Indeterminate vs Non-clinical	0.932	0.918–0.946	0.925	0.915–0.935

\* Adjusted for: age group, sex, health authority, job type, job classification, VE, year).

rates (RR 0.863, 95%CI: 0.860–0.865) compared with part-time HCWs. Compared to HCWs in non-clinical roles, HCWs in clinical roles were more likely to have any sick time (OR 1.096, 95%CI: 1.091–1.101) and higher sick rates (RR 1.162, 95%CI: 1.158–1.165), while HCWs in indeterminate roles were less likely to have any sick time (OR 0.932, 95%CI: 0.918–0.946) and had lower sick rates (RR 0.925, 95%CI: 0.915–0.935).

3.3. Model estimates of vaccination status on sick rates

Table 2B shows the association between vaccination status and sick time during IS and NIS from the fully-adjusted hurdle model. On average and in a given month, HCWs who reported ‘early’ (OR 0.874, 95%CI: 0.866–0.881) and ‘late’ (OR 0.969, 95%CI: 0.954–0.985) were both significantly less likely to have any sick time during IS compared to HCWs who did not report. These effects were more pronounced in NIS months. In IS, HCWs who reported

‘early’ had a significantly lower sick rate (RR 0.907, 95%CI: 0.901–0.912) compared to HCWs who did not report; whereas, there was no significant difference in IS monthly sick rates for those who reported ‘late’ (RR 0.966, 95%CI: 0.986–1.007). In NIS months, HCWs who reported ‘early’ (RR 0.840, 95%CI: 0.836–0.843) and ‘late’ (RR 0.968, 95%CI: 0.960–0.976) had lower sick rates compared to HCWs who did not report. None of the sensitivity analyses performed yielded results contradictory to the primary hurdle model analysis.

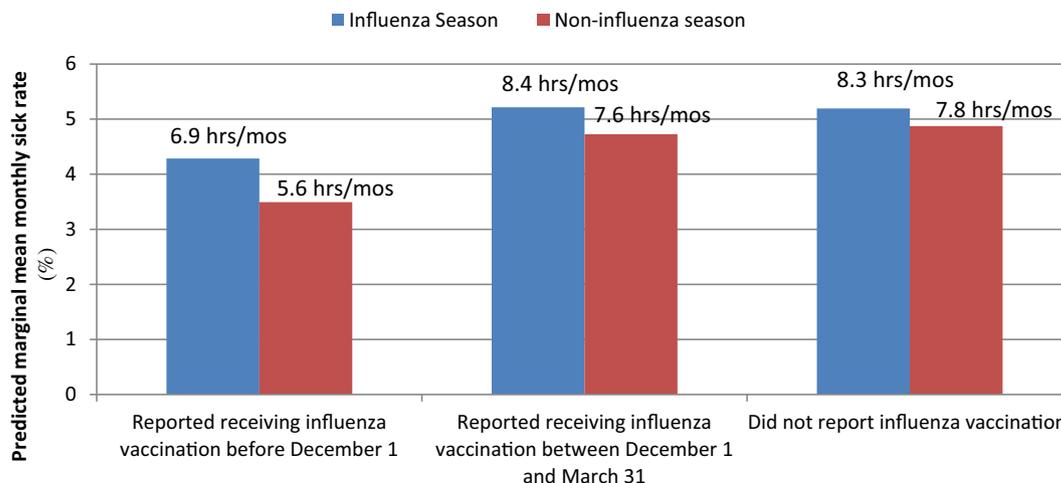
Combining the OR and RR effects from the 2-stage model, the predicted mean monthly sick rates in IS vs NIS were 4.286% vs 3.493% for those HCWs reporting ‘early’, 5.217% vs 4.726% for those reporting ‘late’, and 5.194% vs 4.875% for those ‘not reported’. Based on a theoretical 160 h per month schedule for a full-time employee, these predicted rates equate to sick hours per month of 6.9 and 5.6, 8.4 and 7.6, and 8.3 and 7.8, respectively (Fig. 1).

**Table 2B**

Fully-adjusted\* Odds Ratios (OR), Relative Rates (RR) and associated 95% CIs of average monthly sick rates in influenza season and non-influenza season by reported vaccination status.

Vaccination status	Influenza Season (December 1–March 31)				Non-influenza Season (April 1–November 30)			
	OR	95% CI	RR	95% CI	OR	95% CI	RR	95% CI
Early (reported receiving before December 1) vs Not reported	0.874	0.866–0.881	0.907	0.901–0.912	0.788	0.783–0.793	0.840	0.836–0.843
Late (reported receiving between December 1 and March 31) vs Not reported	0.969	0.954–0.985	0.996	0.986–1.007	0.949	0.938–0.960	0.968	0.960–0.976

\* Adjusted for: age group, sex, health authority, job type, job classification, VE, year).



**Fig. 1.** Predicted marginal mean sick rates from 2-stage hurdle model in influenza season and non-influenza season by vaccination status, and equivalent estimated monthly sick hours based on a theoretical 160 h per month full-time schedule.

**Table 3**

Average sick rates (%) during influenza season between 2012–13 and 2015–16 for HCWs with a change in reported vaccination status ('early' or 'not reported') between year 1 and year 2.

	Early (year 1) and Not Reported (year 2)		Not Reported (year1) and Early (year 2)		Adjusted p-value
	Year 1	Year 2	Year 1	Year 2	
12/13 to 13/14	5.5	5.7	4.9	5.2	0.79
12/13 to 14/15	5.1	5.7	5.0	5.1	0.005
12/13 to 15/16	5.5	5.5	5.0	5.0	0.69
13/14 to 14/15	5.1	5.6	5.3	5.4	0.39
13/14 to 15/16	5.2	5.4	5.3	5.1	0.16
14/15 to 15/16	5.3	5.4	5.3	5.4	0.08

### 3.4. Influenza season sick rates within HCWs with a change in vaccination status

There were 6953 HCWs who were consistently employed from December 1, 2012 to March 31, 2017 and who had at least one year each of 'early' vaccination and 'not reported' vaccination over the five year period. The paired *t*-test for the difference in individual HCW sick rates during IS months between years with 'early' vaccination and 'not reported' vaccination was not statistically significant ( $p = 0.744$ ).

### 3.5. Influenza season sick rates among HCWs with a change in vaccination status

Table 3 shows the mean monthly sick rate during IS across six pairs of years from 2012–13 to 2015–16 seasons (with 2016–17 season excluded due to higher overall sick rates that year) amongst HCWs who changed their vaccination status from 'early' to 'not reported' and vice versa. There was a general increase in year 2 sick rates for HCWs who changed from 'early' to 'not reported', with the exception of the 2012–13 and 2015–16 pair where sick rates stayed the same. In contrast, sick rates were more similar between year 1 and year 2 amongst HCWs who changed from 'not reported' to 'early', with the exception of the 2012–13 and 2013–14 pair where there was an increase of 0.3% and the 2013–14 and 2015–16 pair where there was a decrease of 0.2%. Comparing year 1 to year 2 sick rate changes among HCWs who changed their vaccination status, and adjusting for multiple comparisons, five of the six pairs of years showed no significant difference in the differences in sick rates. Only the 2012–13 and 2014–15 pair had a statistically significant difference. Overall, IS sick rates were similar among HCWs regardless of whether they changed from 'early' vaccination in one year to 'not reported' in another year or vice versa.

## 4. Discussion

In the five-year period after implementation of a mandatory province-wide influenza vaccine-or-mask policy, we found that sick rates were the lowest for HCWs who report receiving influenza vaccination before the policy is in effect for the season. HCWs who report receiving their vaccination 'late' (after the policy is in effect, and are required to mask until the date of vaccination), had sick rates that were similar to HCWs who did not report vaccination at all and who would be required to mask for the entire influenza season. Although vaccination is expected to impact sick time only during IS months, the differences in sick rates by vaccination status were present in both IS and NIS months. These results suggest factors associated with reporting 'early' vaccination are also associated with taking less sick time overall. Moreover, among those HCWs who reported 'early' in some years, but then did not report

vaccination in other years, sick rates did not change with their change in vaccination status. Together, these findings suggest that influenza season sick rates of individual HCWs are influenced more by their behaviours and other factors than by their reported vaccination status.

The observed lower sick rates for HCWs with 'early' vaccination compared to those with 'late' vaccination or who were 'not reported' suggest there is a real difference in how HCWs who report 'early' take sick time. Similar observed differences in sick rates among these groups of HCWs in NIS months further supports this hypothesis. These differences in approaches to sick time may be related to attitudes towards receiving and reporting the influenza vaccine on time. Sick rates among HCWs who reported 'late' vaccination were more similar to sick rates for HCWs who were 'not reported', albeit somewhat lower, compared to sick rates for HCWs who reported 'early'. From the 2012–13 season when the policy was in effect but not enforced, to the 2013–14 season when it was enforced, there was an increase in the proportion of HCWs who reported receiving the vaccine after December 1st ('late') from 2.5% to 8.7%. It is plausible that these HCWs, who eventually reported being vaccinated 'late', may be HCWs who otherwise would not have been vaccinated at all pre-policy implementation, and therefore, would be expected to have similar absenteeism behaviours as HCWs who do not report.

The observed lower sick rates among HCWs who report 'early' may also be related to differences in attitudes towards taking sick time and known "presenteeism" behaviours associated with HCWs, where individuals continue to work despite illness [25–27]. One survey of HCWs in Washington State found evidence of "presenteeism" among respondents where the minority (31%) said they always take sick leave when having flu-like symptoms and do not feel their workplace expected or encouraged sick leave when symptomatic [25]. In a 2017 report of a nosocomial influenza outbreak on an oncology ward related to HCW presenteeism, the two most common reasons for presenteeism included "sense of duty as a health care worker" (56%) and "viewed illness as too minor to pose a risk to other" (44%) [26]. With respect to presenteeism out of 'duty to care', part of the BC influenza prevention policy included annual communication campaigns targeted to HCWs in health authorities with messages to stay home when sick. Therefore, increased HCW awareness of positive employer attitudes towards taking sick time when ill may have reduced the likelihood of 'duty to care' presenteeism affecting HCW absenteeism in our evaluation. With respect to 'illness perception' presenteeism, it has been postulated that vaccinated HCWs may feel protected against influenza, and therefore disregard symptoms and work when ill. In a survey of HCWs in the US in the 2014–15 season, HCWs who were vaccinated were significantly more likely to report presenteeism than those who were not vaccinated, although the timing of vaccination to illness was not known [27]. Therefore, absenteeism among vaccinated HCWs in our study may be an

underestimate of actual illness due to presenteeism behaviours from 'duty to care' or a disregard of symptoms. Presenteeism may also be related to the ability of certain jobs to be conducted at home versus at a work site. Studies have shown individuals in management and executive roles are generally more likely to continue working despite ILL symptoms versus those in administrative and direct patient care roles who are more likely to take sick time [25,28]. Our findings of lower sick rates associated with those in non-clinical roles may be related to differences in exposures to illness as well as the ability/expectation to continue working when sick. Finally, there may be increased absenteeism among HCWs who report 'late' or who do not report related to avoidance of mask wearing or other impacts of not reporting.

The initial evaluation of the 2012–13 season of the policy in one HA found unvaccinated HCWs had a greater increase in sick time compared to vaccinated HCWs in influenza season compared to baseline [21]. Therefore, we would have expected to see a larger difference between IS and NIS sick rates among HCWs who do not report vaccination compared to those who report 'early' in our analysis. However, our results show an opposite trend where the difference between IS and NIS sick rates associated with HCWs who reported 'early' was greater than the difference between IS and NIS sick rates for HCWs who reported 'late' or did not report. In our analysis, the IS sick rates for HCWs who reported 'late' or did not report may have been truncated by the HAs' administrative policies around accrual and maximum allowed sick time. Full-time employees in BC HAs can earn 1.5 days/month of sick time up to a maximum of 135 h/year (approximately 6.8% sick rate), and attendance management measures come into effect for individuals who exceed certain levels of absenteeism. With mean unadjusted IS sick rates of 6.17% and NIS sick rates of 5.85% for HCWs who do not report vaccination, there is a limited ability to take additional sick time. Whereas, on average, HCWs who report 'early' have more remaining sick time available based on their lower sick rates in NIS (4.23%) and IS (5.14%).

As a result, we were not able to apply a similar methodology of using "baseline" NIS sick rates by vaccination status to adjust for IS differences, given that they may be capped by administrative policy limits and not reflect the amount of sick time a HCW would have taken. Instead, we attempted to understand individual-level absenteeism behaviours in relation to changes in vaccination status over time using two methods. Both methods compared sick time for individual HCWs who had at least one season with 'early' reported vaccination and at least one season with no vaccination reported. We looked across all five years in the first approach and across six pairs of years in the second approach to account for annual changes in the severity of the influenza season and the effectiveness of the influenza vaccine that may influence yearly IS sick rates. Interestingly, in the second approach, the only pair of years with a significant difference was the 2012–13 and 2014–15 seasons, where there was a 0.6% increase in sick rate for HCWs who went from 'early' to 'not reported', and a 0.1% increase for HCWs who went from 'not reported' to 'early' report. However, the Canadian VE estimate for the 2014–15 season was 9% (95%CI: –14% to 27%) and there were high levels of influenza activity likely contributing to higher overall sick rates that year for both vaccinated and unvaccinated HCWs [23,29]. The overall findings from the two approaches suggest that there are factors, other than vaccination status, that influence the amount of annual IS sick time taken by an individual HCW. Further information to distinguish influenza-related sick-time from all-cause sick time would be necessary to isolate influenza-specific absenteeism effects due to changes in vaccination status.

While our analysis includes five years of policy implementation, several seasons had unique features that may have impacted IS absenteeism. The 2012–13 season was a transitional year when

the policy was not enforced. The 2016–17 season had unusually high IS sick rates occurring at the same time as a major prolonged snowstorm in Vancouver and surrounding regions of BC [30]. The 2012–13, 2014–15, and 2016–17 seasons were all influenza A (H3N2) dominant seasons in BC with higher levels of influenza activity, while 2013–14 and 2015–16 were both A(H1N1) dominant [23]. As mentioned above, the 2014–15 season VE estimate was exceptionally low compared to other Canadian VE estimates which ranged from a low of 45% (95%CI: 31%–56%) in 2016–17 to a high of 68% (95%CI: 58%–76%) in 2013–14 [23]. The impact of the low 2014–15 season VE on HCW absenteeism was also noted in a US study of out-patient facilities with and without mandatory vaccination policies, where they found different patterns of ILL-related sick time in the 2014–15 season compared to the 2012–13 and 2013–14 seasons [18]. Sites with a mandatory policy in that study required employees to be vaccinated unless there was a valid exemption, and >92% of staff were vaccinated. Therefore, it would be expected that ILL-related sick time in a highly vaccinated population would be more sensitive to variations in influenza activity and vaccine effectiveness. In contrast, the BC vaccinate-or-mask policy requires masking of HCWs who choose to not report vaccination. As well, the BC policy applies to everyone (e.g., employees, visitors, students) and includes mass communications campaigns each year to raise awareness of the policy and general infection prevention and control messages. In this context, it is difficult to predict the impact of variations in influenza activity and vaccine effectiveness on the all-cause sick time of BC HCWs.

The limitations of our study include the use of available administrative all-cause sick time data when the policy goal is to reduce influenza-related HCW absenteeism. Some health authorities had started collecting information on reason for sick time, but at different time points after the policy was implemented. All BC health authorities are subject to similar human resources requirements with provincial unions and there were no significant changes in sick time policies over the study period. However, differences at the hospital site/department level in implementation and enforcement of the policy may affect local absenteeism rates and vaccination reporting. As well, our findings reflect a unionized and Canadian health care system context and may not be generalizable to jurisdictions in other countries. Misclassification of vaccination status is possible if HCWs falsely reported receiving the vaccine (as there is no confirmation of vaccination) or if vaccinated HCWs failed to report their vaccination. Information on individual-level reported vaccination status was not collected pre-policy implementation, and we were not able to assess the change in absenteeism among individuals pre to post-2012. Clinical vs non-clinical roles were assigned manually based on the combination of job description factors, and may not represent the actual level of patient-interaction of the role. As well, measures of total available sick and other leave time (often related to duration of employment) was not available for analysis, but may impact how sick time was used among individual HCWs. Despite these limitations, the use of province-wide payroll data and reported HCW vaccination status is the most robust source of information available for assessing HCW absenteeism by vaccination status.

## 5. Conclusions

In the context of the first five years of a mandatory province-wide vaccinate-or-mask influenza prevention policy, HCWs who reported vaccination had lower overall rates of absenteeism than HCWs who did not report vaccination. This was particularly true for HCWs who reported vaccination prior to the deadline when the policy came into effect for the influenza season. However, the continuation of these differences outside of influenza season, and

similar influenza season sick rates across years regardless of a change in vaccination status, suggest that individual level factors influence absenteeism behaviours more than vaccination status. Further research is needed to explore these factors, as well as factors influencing presenteeism/absenteeism behaviours and their association to influenza vaccination. Other jurisdictions considering implementation of HCW influenza vaccination policies should aim to collect pre and post-policy data on individual vaccination status and influenza-related illness absenteeism to fully assess the impacts of their policy on absenteeism.

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### Declaration of Competing Interest

All authors report no conflicts of interest relevant to this article.

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