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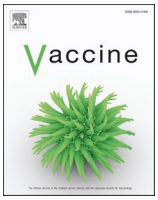

# Canadian health care providers' and education workers' hesitance to receive original and bivalent COVID-19 vaccines

Brenda L. Coleman [a,b,*], Iris Gutmanis [a], Susan J. Bondy [b], Robyn Harrison [c], Joanne Langley [d], Kailey Fischer [a], Curtis Cooper [e], Louis Valiquette [f], Matthew P. Muller [b,g], Jeff Powis [h], Dawn Bowdish [i], Kevin Katz [j], Mark Loeb [i], Marek Smieja [k], Shelly A. McNeil [l], Samira Mubareka [m], Jeya Nadarajah [n], Saranya Arnoldo [o], Allison McGeer [a,b]

[a] Sinai Health System, 600 University Ave, Toronto, ON M5G 1X5, Canada
[b] University of Toronto, 27 King's College Cir, Toronto, ON M5S 1A1, Canada
[c] Division of Infectious Diseases, Department of Medicine, University of Alberta, 8440 112 St, Edmonton, AB T5J 3E4, Canada
[d] Canadian Center for Vaccinology, 5850 University Ave, Halifax, NS B3K 6R8, Canada
[e] University of Ottawa, 501 Smyth Rd, Ottawa, ON K1H 8L6, Canada
[f] hospitalier universitaire de Sherbrooke, 2500 Bd de l'universite, Sherbrooke, QC J1K 2R1, Canada
[g] Unity Health Toronto, 30 Bond Street, Toronto, ON M5B 1W8, Canada
[h] Michael Garron Hospital, 825 Coxwell Avenue, Toronto, ON M4C 3E7, Canada
[i] Hamilton Health Sciences Centre, 237 Barton St East, Hamilton, ON L8L 2X2, Canada
[j] North York General Hospital, 4001 Leslie St, Toronto, ON M2K 1E1, Canada
[k] St. Joseph's Healthcare, 50 Charlton Ave East, Hamilton, ON L8N 4A6, Canada
[l] Dalhousie University, 5820 University Ave, Halifax, NS B3H 2Y9, Canada
[m] Sunnybrook Health Sciences Centre, 2075 Bayview Ave, Toronto, ON M4N 3M5, Canada
[n] Oak Valley Health, 381 Church St, Markham, ON L3P 13P, Canada
[o] William Osler Health System, 2100 Bovaird Dr East, Brampton, ON L6R 3J7, Canada

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## ABSTRACT

**Background**: The demand for COVID-19 vaccines has diminished as the pandemic lingers. Understanding vaccine hesitancy among essential workers is important in reducing the impact of future pandemics by providing effective immunization programs delivered expeditiously. **Method**: Two surveys exploring COVID-19 vaccine acceptance in 2021 and 2022 were conducted in cohorts of health care providers (HCP) and education workers participating in prospective studies of COVID-19 illnesses and vaccine uptake. Demographic factors and opinions about vaccines (monovalent and bivalent) and public health measures were collected in these self-reported surveys. Modified multivariable Poisson regression was used to determine factors associated with hesitancy. **Results**: In 2021, 3 % of 2061 HCP and 6 % of 3417 education workers reported hesitancy ($p < 0.001$). In December 2022, 21 % of 868 HCP and 24 % of 1457 education workers reported being hesitant to receive a bivalent vaccine ($p = 0.09$). Hesitance to be vaccinated with the monovalent vaccines was associated with earlier date of survey completion, later receipt of first COVID-19 vaccine dose, no influenza vaccination, and less worry about becoming ill with COVID-19. Factors associated with hesitance to be vaccinated with a bivalent vaccine that were common to both cohorts were receipt of two or fewer previous COVID-19 doses and lower certainty that the vaccines were safe and effective. **Conclusion**: Education workers were somewhat more likely than HCP to report being hesitant to receive COVID-19 vaccines but reasons for hesitancy were similar. Hesitancy was associated with non-receipt of previous vaccines (i.e., previous behaviour), less concern about being infected with SARS-CoV-2, and concerns about the safety and effectiveness of vaccines for both cohorts. Maintaining

* Corresponding author at: Sinai Health System, 600 University Ave, Toronto, ON M5G 1X5, Canada.
*E-mail addresses:* b.coleman@utoronto.ca (B.L. Coleman), igutmani@uwo.ca (I. Gutmanis), Sue.Bondy@utoronto.ca (S.J. Bondy), Robyn.Harrison@albertahealthservices.ca (R. Harrison), Joanne.Langley@dal.ca (J. Langley), kaf112@georgetown.edu (K. Fischer), ccooper@toh.ca (C. Cooper), Louis.valiquette@usherbrooke.ca (L. Valiquette), Matthew.Muller@unityhealth.to (M.P. Muller), Jeff.powis@tehn.ca (J. Powis), bowdish@mcmaster.ca (D. Bowdish), Kevin.Katz@nygh.on.ca (K. Katz), loebm@mcmaster.ca (M. Loeb), smiejam@mcmaster.ca (M. Smieja), Shelly.Mcneil@nshealth.ca (S.A. McNeil), Samira.Mubareka@sunnybrook.ca (S. Mubareka), jnadarajah@oakvalleyhealth.ca (J. Nadarajah), Saranya.arnoldo@williamoslerhs.ca (S. Arnoldo), Allison.McGeer@sinaihealth.ca (A. McGeer).

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inter-pandemic trust in vaccines, ensuring rapid data generation during pandemics regarding vaccine safety and effectiveness, and effective and transparent communication about these data are all needed to support pandemic vaccination programs.

## 1. Introduction

Severe acute respiratory disease coronavirus 2 (SARS-CoV-2) causes coronavirus disease 2019 (COVID-19). The SARS-CoV-2 pandemic had claimed the lives of over 7 million people including 53,470 Canadians and 1.14 million Americans as of December 2023 [1]. The first COVID-19 vaccines (Wuhan-1 strain) were available in December 2020 and bivalent vaccines (Wuhan-1 and Omicron BA.1/2 or BA.4/5) were available in the fall of 2022 [2]. In Canada, more than 95 % of administered vaccines have been the mRNA vaccines produced by Pfizer and Moderna [3]. COVID-19 vaccination requirements for essential service workers varied by Canadian province; some required healthcare providers (HCPs) or all civil servants/essential workers to be fully vaccinated [4–7] while Ontario required hospitals to implement vaccination and testing policies, long-term care home staff be fully vaccinated [8], but education workers were not required to be protected by vaccination [9]. Further details on vaccine mandates are available in Supplemental Table 1.

Even before the World Health Organization declared that the COVID-19 pandemic was no longer a public health emergency of international concern [10], the demand for COVID-19 vaccines, and booster doses specifically, had started to decline. This occurred despite on-going viral evolution reducing the effectiveness of the original vaccines [11], relaxation of public health mitigation measures [12], and the persistence of severe COVID-19 in older adults [13]. Recent studies report booster vaccine hesitancy/refusal was associated with perceived immunity from past infection(s) [14], lower risk of infection [15], and reduced effectiveness of vaccines [16,17].

The World Health Organization strategic advisory group of experts (SAGE) working group on vaccine hesitancy describes vaccine hesitancy as lower acceptance of vaccines than expected given that vaccines are readily available [18]. Vaccine hesitancy exists across a continuum and differs from refusal. However, it may result in persistently lower or delayed uptake of vaccines and boosters. Hesitancy varies by vaccine and across time, geographic location, and situation (e.g., pandemic versus endemic) [18]. One systematic review found that women, Black individuals, younger adults, and people with lower education and/or income were less likely to accept COVID-19 vaccines [10]. In another review, people with chronic diseases and higher trust in vaccine effectiveness were more likely to plan to receive a booster dose while those who had experienced a COVID-19 infection were less likely to [19].

Essential workers, including HCPs and education workers, are at increased risk of exposure to communicable diseases due to their frequent close contact with others. If they are not immunized or protected by highly effective non-pharmaceutical measures, they are at high risk of contracting the disease and transmitting it to others including their families, coworkers, and patients or students [20]. Since both HCPs and education workers are at higher risk of exposure and because they can be advocates for public health, understanding their reasons for acceptance/rejection of vaccines is informative for future public health messaging.

The aim of this study was to determine the rate of and reasons for COVID-19 vaccine hesitancy in participants of two Canadian prospective cohort studies: HCPs and education workers. We will also report vaccine uptake, a proxy measure for vaccine acceptance and hesitancy. Our null hypothesis was that there would be no difference in the rate of hesitancy between the monovalent and bivalent vaccines.

## 2. Materials and methods

The COVID-19 Cohort Study of HCPs was open to persons 18–75 years of age working at a participating Canadian acute care hospital for ≥20 h per week or independent providers, e.g. physicians who cared for patients ≥8 h per week. HCPs were eligible whether or not they had patient-facing roles. Participating sites included community and tertiary care hospitals in Ontario ($N = 11$), Alberta ($N = 3$), Nova Scotia ($N = 2$) and Quebec (N = 1). The study was approved by the research ethics boards of all participating hospitals. The second study was open to education workers 18–75 years old who worked for ≥8 h per week for a public or private school or school board in Ontario [21]. Education workers were eligible whether or not they had student-facing roles. The Sinai Health research ethics board approved the education workers' study.

Consenting participants in both studies completed baseline questionnaires and biweekly surveys (see Supplemental Fig. S1) as well as reporting respiratory illnesses and COVID-19 tests and vaccinations, as needed. Demographic information and data on COVID-19 infections and vaccine doses were obtained from these self-report surveys. For this sub-study, participants were also asked to complete two online questionnaires about their intentions to receive COVID-19 vaccines. Because study enrollment continued throughout 2021 and because of low vaccine availability/priority group rollout early in the year [22], the monovalent vaccines questionnaire was available between February 1st and December 31st, 2021 (Fig. S2). The bivalent vaccines questionnaire was available between December 2nd and 31st, 2022 for anyone participating at the time (Fig. S3). All questionnaires for this sub-study were created by the study authors, reviewed by content experts, and pilot tested before use. All surveys were available in English and French with translations conducted by a professional translation service.

The primary outcomes for the analyses were whether the participant planned to receive a monovalent vaccine ("If a COVID-19 vaccine was available to you now, would you be vaccinated today?"), or, for the second questionnaire ("Are you planning to receive a dose of a bivalent COVID-19 vaccine?"). The choices included acceptance (already received; yes, for sure; or very likely) and hesitance (not sure; not likely; or no, definitely not) [18]. HCPs who volunteered that they had already been vaccinated but only because it was mandated were recategorized as hesitant. Secondary outcomes included the reasons for their choices, levels of concern about contracting COVID-19 (monovalent questionnaire) and opinion questions about public health and workplace measures in place in 2022 to protect people from COVID-19 (bivalent questionnaire). Receptive participants were asked for the reasons they planned to be or already were vaccinated while those who were hesitant were asked why they did not plan to be vaccinated; only the respondent's choice of their most important reason was reported.

Covariates assessed for their association with the outcomes are listed in Tables 1 and 2. These data were gleaned from the baseline, illness, and vaccination questionnaires completed closest, but prior, to the completion of the *intent to be vaccinated* questionnaires.

### 2.1. Statistical analyses

Categorical factors were analyzed using Chi square or Fischer's exact tests. Continuous variables were compared using *t*-tests or Wilcoxon rank sum or K-sample equality-of-medians tests, with exact tests being used for sample sizes of ≤200 observations. All tests of statistical significance were two-sided with significance set at $p < 0.05$.

Modified Poisson regression analysis with robust variance estimation

**Table 1**
Factors associated with vaccine hesitancy[1] regarding monovalent COVID-19 vaccination. Results of modified Poisson regression models, specific to cohort, adjusted for other variables in model. Survey data for February–December 2021.

| Factor | Healthcare workers IRR (95 % CI) $N = 2061$ | Teachers & education workers IRR (95 % CI) $N = 3412$ |
|---|---|---|
| First COVID-19 vaccine received, HCW | | |
| Dec 16, 2020 - Jan 31, 2021 | Referent | |
| Feb 1 - Mar 31, 2021 | 6.58 (1.27, 34.2)* | |
| Apr 1 - Nov 29, 2021 | 104 (22.3, 486)*** | |
| After Nov 29, 2021 or not vaccinated | 161 (31.8, 818)*** | |
| First COVID-19 vaccine received | | |
| Dec 16, 2020 - Mar 31, 2021 | – | Referent |
| Apr 1 - May 31, 2021 | | 1.80 (0.58, 5.58) |
| Jun 1 - Nov 29, 2021 | | 5.74 (1.88, 17.6)** |
| After Nov 29, 2021 or not vaccinated | | 10.2 (3.32, 31.4)*** |
| Influenza vaccine 2020/21, received | Referent | Referent |
| Not received | 2.06 (1.22, 3.50)** | 4.87 (3.23, 7.34)*** |
| Occupation | | |
| Nurse/nurse practitioner | Referent | – |
| Physician/physician assistant | 2.22 (0.77, 6.44) | |
| Other regulated professional[2] | 0.86 (0.50, 1.50) | |
| Other hospital staff | 0.45 (0.23, 0.91)* | |
| Occupation | | |
| Teacher | – | Referent |
| Educational assistant | | 1.40 (0.87, 2.25) |
| Early childhood educator | | 2.63 (1.55, 4.45)*** |
| Principal/vice principal | | 0.99 (0.53, 1.85) |
| Administrative | | 1.31 (0.76, 2.26) |
| Other regulated professional[2] | | 0.71 (0.30, 1.69) |
| Other support staff | | 1.61 (0.87, 2.98) |
| Province | | |
| Ontario | Referent | – |
| Alberta | 0.22 (0.11, 0.47)*** | |
| Nova Scotia | 0.86 (0.50, 1.50)** | |
| Quebec | 0.39 (0.18, 0.84)* | |
| Worry about COVID-19 illness | | |
| Very | Referent | Referent |
| Somewhat | 2.21 (0.71, 6.93) | 1.60 (1.06, 2.41)* |
| Not very | 4.00 (1.35, 11.8)** | 3.47 (2.31, 5.23)*** |
| Not at all | 3.51 (1.06, 11.6)* | 4.55 (2.76, 7.49)*** |
| No, was already infected | 5.96 (1.36, 26.1)* | 1.80 (0.47, 6.81) |
| Survey completion, months after vaccines available (December 2020) | 0.92 (0.84, 0.99)* | 0.88 (0.83, 0.94)*** |

CI: confidence interval (95 %); IRR: incidence rate ratio.
*p < 0.05; **$p \leq 0.01$; ***$p \leq 0.001$.
1) Hesitant includes not sure, not likely, and definitely not going to be vaccinated against COVID-19.
2) Regulated professions in study: nurses, physicians, audiologists, chiropodists, dietitians, kinesiologists, medical lab and radiation technologists, occupational, physical, and respiratory therapists, pharmacists and pharmacy technicians, psychologists, psychotherapists, and speech-language pathologists.

to allow for maldispersion and appropriate variance estimation [23] was used to assess factors associated with the primary outcome (receptive/hesitant). All demographic, health-related, and opinion-based factors associated with the outcome in bivariate analyses at a *p*-value of <0.20 were included in the saturated model. Variables were removed sequentially from the model starting with those with the highest p-value until all remaining factors were associated at a p-value of ≤0.10. Factors removed from the saturated model were added back into the reduced model, one at a time, to assess their level of association and their impact on the other estimates. If the removal or addition of any variable changed the estimates of other variables by >10 %, they were retained. Models were assessed for potential effect measure modification for biologically plausible pairings. For highly correlated variables, the variable associated with the highest Wald statistic in the final models was reported. Analyses were conducted in Stata v18 [24]. The power to detect a drop in the rate of hesitancy from 5 % for monovalent to 20 % for bivalent for 3500 vs 2300 participants in the surveys, respectively, was 100 %.

**Table 2**
Factors associated with hesitance[1] to receive a bivalent COVID-19 vaccine. Results of modified Poisson regression models, specific to cohort, adjusted for other variables in model. Survey date: December 2022.

| Factor | Healthcare workers IRR (95 % CI) $N = 868$ | Teachers & education workers IRR (95 % CI) $N = 1333$ |
|---|---|---|
| COVID-19 vaccines before survey | | |
| ≤2 | Referent | Referent |
| 3 | 0.79 (0.65, 0.96)* | 0.94 (0.81, 1.09) |
| ≥4 | 0.12 (0.07, 0.20)*** | 0.23 (0.16, 0.33)*** |
| Influenza vaccine 2020/21 | | |
| Received | Referent | Referent |
| Not received | 1.16 (0.96, 1.42) | 1.46 (1.21, 1.76)*** |
| Age group (years) | | |
| 18–29 | – | Referent |
| 30–39 | | 0.65 (0.44, 0.95)** |
| 40–49 | | 0.62 (0.44, 0.88)** |
| ≥50 | | 0.56 (0.39, 0.80)** |
| Province | | |
| Ontario | Referent | |
| Alberta | 1.31 (1.02, 1.69)* | |
| Nova Scotia | 0.80 (0.53, 1.20) | |
| Québec | 1.51 (1.18, 1.94)*** | – |
| Bivalent COVID vaccines are safe | | |
| Strongly agree | Referent | Referent |
| Agree | 2.52 (1.62, 3.94)*** | 1.81 (1.20, 2.73)** |
| Not sure | 4.06 (2.46, 6.72)*** | 2.71 (1.75, 4.21)*** |
| Disagree/strongly disagree | 3.32 (1.88, 5.87)*** | 2.68 (1.72, 4.16)*** |
| Bivalent COVID vaccines are effective | | |
| Strongly agree | Referent | Referent |
| Agree | 1.33 (0.89, 2.00) | 1.73 (1.11, 2.70)* |
| Not sure/disagree/ strongly disagree[2] | 1.68 (1.06, 2.66)* | 2.73 (1.71, 4.37)*** |

CI: confidence interval (95 %); IRR: incidence rate ratio.
*p < 0.05; **$p \leq 0.01$; ***$p \leq 0.001$
1) Hesitant includes not sure, not likely, and definitely not going to receive a bivalent vaccine
2) Disagree/strongly disagree/not sure responses were combined due to small numbers

## 3. Results

### 3.1. Monovalent vaccines

#### 3.1.1. Health care providers

Of the 2414 HCPs enrolled before December 31, 2021, 2061 (85 %) completed the monovalent vaccine questionnaire of whom 86 % were female, the median age was 40 years, and 32 % were nurses (see Table S1). Of the 2061 respondents, 63 (3.1 %) were hesitant about receiving a monovalent COVID-19 vaccine at the time they completed their questionnaire (see Table S2).

In multivariable analysis, HCPs vaccinated later in 2021 were more likely to report being hesitant, as were participants who had not received their influenza vaccine in 2020/21, HCPs working in Ontario hospitals, and those less worried about contracting COVID-19 (Table 1). Compared with nurses, hospital staff who were not regulated professionals were less likely to report being hesitant. Date of survey completion was also a significant predictor, with the rate ratio of

hesitancy about 8 % lower per month during 2021.

#### 3.1.2. Teachers and other education workers

Of the 3601 education workers, 3417 (95 %) completed the questionnaire about the monovalent vaccines of whom 85 % were female, the median age was 45 years, and 80 % were teachers (see Table S3). As shown in Table S2, only 39.9 % of education workers (compared with 90.2 % of HCPs) had received a COVID-19 vaccine prior to completing the survey. This was likely due to government strategies that prioritized HCPs and older adults due to limited vaccine availability during the first 6 months of 2021 [22]. Of the 3417 respondents to the questionnaire, 210 (5.9 %) were hesitant about receiving a monovalent COVID-19 vaccine.

In multivariable analysis, vaccine hesitant education workers received their first COVID-19 vaccine later in 2021, were less worried about contracting COVID-19, and were less likely to have received an influenza vaccine in 2020/21. Early childhood educators were more likely to be hesitant than teachers. Participants who completed the survey later in 2021 were less likely to be hesitant than those who completed it earlier.

### 3.2. Bivalent vaccines

#### 3.2.1. Health care providers

Of the 1392 HCPs participating in the cohort study in November 2022, 868 (62 %) completed the bivalent vaccine questionnaire and of those, 99.5 % had already received two or more doses of COVID-19 vaccine. Of the 868 respondents, 180 (20.7 %) were hesitant about receiving a bivalent COVID-19 vaccine (see Table S4).

In multivariable analysis, factors significantly associated with being hesitant were receipt of two or fewer doses of COVID-19 vaccines prior to the survey, working in Quebec or Alberta, and not strongly agreeing that the bivalent vaccines were safe and effective (Table 2).

#### 3.2.2. Teachers and other education workers

Of the 1900 education workers still participating in the cohort study and thus, eligible to respond to the survey, 1457 (76.7 %) completed the survey and 98.6 % had received their primary series of COVID-19 vaccines. As shown in Table S4, 347 (23.8 %) were hesitant about receiving a bivalent vaccine against COVID-19.

In multivariable analysis, factors significantly associated with hesitancy were having received fewer doses of COVID-19 vaccines prior to the survey, not receiving the 2020/21 influenza vaccine, being younger, and thinking that COVID-19 bivalent vaccines were not very safe and not very effective (Table 2).

#### 3.2.3. Reasons for vaccine acceptance and hesitancy

In both surveys and for both cohorts, the most common reasons for vaccine acceptance were similar: protecting oneself against COVID-19 ranked first followed by stopping the spread of the virus and protecting other household members (Table S5 and S6). HCPs were more likely than education workers to report stopping the spread of the virus as one of the most important reasons for vaccination. Self-protection was reported more commonly as the reason for vaccination for bivalent versus original monovalent vaccines in both cohorts.

Among vaccine hesitant individuals, 83 % of both HCPs and education workers reported uncertainty about vaccine safety as the most important reasons for hesitancy in the first survey (Table S5). At the time of the second survey, concern about adverse effects remained the most common reason for vaccine hesitancy but was the most important reason for hesitancy in <35 % of workers. Lack of concern about the risk of serious infection, presumed immunity from prior infection, and concern about vaccine effectiveness were each reported by more than 10 % of hesitant participants (Table S6). Opinions about public health and workplace measures are reported in Tables S7a and S7b.

#### 3.2.4. Stated intention compared to vaccine uptake

Not everyone follows through with their stated intentions. A lower percentage of HCPs (63/2061 or 3.0 %) than education workers (201/3417 or 5.9 %; $p < 0.001$) reported being vaccine hesitant in 2021. Only 20.6 % of hesitant HCPs (13/63) compared with 63.2 % of hesitant education workers (127/201) received their primary series of vaccines ($p < 0.001$). Meanwhile, 99.6 % of receptive HCPs (1990/1998) compared with 84.8 % of receptive education workers (2728/3216) received at least two doses of vaccine ($p < 0.001$).

HCPs (180/868 or 20.7 %) and education workers (347/1457 or 23.8 %; $p = 0.09$) were equally likely to be hesitant to receive a bivalent vaccine. Hesitant HCPs (9/179; 5.0 %) and education workers (20/344; 5.8 %) were equally likely to receive a bivalent vaccine ($p = 0.76$). Receptive HCPs (519/688; 75.4 %) were more likely to receive a bivalent vaccine than education workers (756/1104; 68.5 %; $p = 0.002$). In both surveys and both cohorts, receptive respondents were more likely to be vaccinated if they said, “yes, for sure” versus “very likely”. Correspondingly, hesitant respondents were more likely to be vaccinated if their survey response was “not sure” rather than “not likely” or “definitely not” indicating that their responses were correlated with their future actions.

## 4. Discussion

It is vital that public health do its utmost to protect our essential service workers including HCPs and education workers, the participants in these studies. This includes maximizing their protection against SARS-CoV-2 and other pathogens through vaccination and, as a consequence, also protecting the people they work with from exposure. HCPs and education workers are also trusted resources. The general public turns to them when unsure of the best course of action for themselves and their loved ones. As such, vaccine hesitant HCPs and education workers may influence parents, coworkers, and students/patients [25]. It is necessary, for all of these reasons, to understand vaccine hesitancy in these cohorts to design effective interventions to combat vaccine hesitancy. Given the similarity in vaccine hesitance between these two female-dominated professions, it may be possible to design interventions that are effective for both.

Both of our study populations had high rates of uptake of their primary series of COVID-19 vaccines (99.5 % of HCPs and 98.6 % of education workers) but it should be noted that HCPs were required to be vaccinated against SARS-CoV-2 as a requirement to work in three of the four provinces in which the study was conducted while education workers in Ontario were not [4–6,9]. While 3 % of HCPs and 6 % of education workers in our study reported hesitancy related to receiving the monovalent (Wuhan-1) vaccines, a significantly higher percent (21 % and 24 %, respectively) reported hesitancy regarding bivalent booster doses. Uptake of the bivalent vaccines was higher in HCPs (60.9 %) than for education workers (53.6 %) but lower than expected given the rates of hesitancy reported in the surveys. Concern about vaccine safety was the number one reason for hesitance about being vaccinated for both the monovalent and bivalent vaccines. However, a much higher percent of hesitant respondents reported being less worried about becoming seriously ill with COVID-19 at the time of the bivalent vaccine questionnaire (December 2022).

Similar to our results, Lee et al. [26] reported that HCPs in the USA who worked for an employer that required vaccination were more likely to be vaccinated than those without this obligation (90 % vs 73 %). Similar to our results, Lu et al. [27] reported that 90 % of American essential health care and 88 % of school/child care worker respondents to the National Immunization Survey in November/December 2022 had completed a primary series of COVID-19 vaccines. Of those who had completed a primary series, 25–27 % had received a bivalent booster by December 31, 2022 while 28–37 % were hesitant to do so. By May 2023, the Public Health Agency of Canada and the US Centers for Disease Control and Prevention reported that 19–20 % of Canadian and

American adults had received a dose of bivalent COVID-19 vaccine [28,29].

Vaccine hesitance (reluctance to obtain primary vaccinations) has been distinguished from both vaccine fatigue (reluctance to receive booster doses) and vaccine hostility (vaccine non-adoption) [30,31]. Our study clearly demonstrates increased hesitancy to receive a bivalent COVID-19 vaccine, which may be related, in part, to vaccine fatigue. Failure to address factors associated with vaccine hesitance and fatigue may negatively impact public health measures taken during future pandemics. Stamm et al. [30] note that campaigns promoting vaccine uptake among the unvaccinated should target community spirit. In comparison, among those with one or two vaccinations, positive incentives may prove beneficial. Among the triple vaccinated, any costs, including medical/scientific dissensus, were detrimental to vaccine uptake in their scenario-based study.

In our studies, hesitance was associated with receipt of the first dose of COVID-19 vaccine later in 2021. This finding is not unexpected since the top reasons for hesitancy were concerns about vaccine safety. Lazarus et al. also reported a reduction in vaccine hesitancy in Canadian respondents from 36 % in 2020 to 22 % in 2021 and to 13 % in 2022 [32] likely indicating reduced concern about safety with the ongoing and ever-expanding administration of the vaccines. Although hesitancy decreased over time in these studies, the percentage of COVID-19 related tweets expressing vaccine hesitancy in six high income countries, including Canada, increased substantially, from 1 % to 6 % between March 2020 and June 2022 [33]. These findings indicate that social media may be a misleading source of information on which to base public health decisions.

Having been vaccinated against influenza in the 2020/21 season was associated with not being COVID-19 vaccine hesitant with either the monovalent or bivalent vaccines for our respondents. Receipt of influenza and/or other adult vaccines has been reported as predictive of COVID-19 vaccination in several other studies [27,34–36]. These data, along with those of other studies, [32,37] suggest that vaccine uptake for a particular vaccine is closely tied with the belief that vaccines, in general, are safe and effective.

Our data also suggest that attitudes regarding vaccines and public health measures are correlated: study participants who were hesitant to receive a COVID-19 bivalent vaccine were more likely to rate public health and workplace recommendations as too restrictive and to report not following recommendations. Similar to these results, Moro et al. reported that vaccine-hesitant Ontario university students and staff rated the need for public health precautions lower than vaccine accepting participants [38]. Similarly, American dental health care workers who reported higher compliance with physical distancing, the use of personal protective equipment, and environmental disinfection were also more likely to intend to be vaccinated against COVID-19 [39]. Also, Italian adults who associated personal protective equipment and vaccines with *safety,* rather than *danger,* were more likely to intend to be vaccinated. These findings suggest that people are consistent in their efforts to use many or all available means to reduce their risk of infection: non-pharmaceutical and pharmaceutical. It suggests that future research into combatting hesitancy be more broad by investigating both vaccine and non-pharmaceutical interventions.

Like all research, our study has limitations. Participants were self-selected, withdrew over time, and not everyone completed both surveys. All of these influences may reduce the generalizability of the results. However, our HCP study included staff from 19 hospitals across four Canadian provinces with good representation across occupations and age groups. Nonetheless, results should be interpreted with caution since our sample is not necessarily representative of all HCP or education workers in Canada. Education workers were from the Canadian province with the largest population and also had a good representation of occupations and age groups. Bias may also be present because younger participants were less likely to continue with the main studies or to participate in the surveys. These limitations may be somewhat mitigated by the fact that our studies had large numbers of participants from across various geographic regions. All results are self-reported, meaning they may suffer from social desirability bias. Since we used different questions for the two surveys, we could not make direct comparisons about changes in opinions over time.

## 5. Conclusions

Despite differences in workplaces and workplace regulations, there was no statistically significant difference in the rate of uptake of monovalent vaccines between HCPs and education workers in our studies. Factors predicting COVID-19 vaccine hesitancy were largely similar for both cohorts and for both the primary vaccine series and bivalent boosters. Hesitancy was associated with non-receipt of influenza vaccine, less concern about being ill with COVID-19, and lower opinions of the safety and the effectiveness of vaccines. Providing clear messaging regarding the safety and effectiveness of vaccines, including those manufactured to combat illnesses caused by SARS-CoV-2, is necessary to build and maintain confidence in vaccines.

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## Research ethics board statements

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Research Ethics Boards of Sinai Health System (20–0080-E, 2020-04-17), Sunnybrook Health Sciences Centre (1644, 2020-04-13), Michael Garron Hospital (807–2004-Inf-055, 2020-04-29), North York General Hospital (20–0017, 2020-05-06), University Health Network (20–5368, 2020-05-21), Unity Health Toronto (20–109, 2020-06-01), Oak Valley Health (121–2010, 2020-11-04), William Osler Health System (2020-12-18), Hamilton Health Sciences Centre (12809, 2020-12-31), St. Joseph's Healthcare Hamilton (13044, 2020-12-31), University of Alberta (Pro00106776, 2021-01-13), Nova Scotia Health (1026317, 2021-02-02), The Ottawa Hospital (20210024-01H, 2021-02-05), and Centre hospitalier universitaire de Sherbrooke (MP-31-2021-4104, 2021-06-09) for the HCP study and Sinai Health System (20–0343-A, 2021-01-26) for the education workers study.

## Informed consent statement

Informed consent was obtained from all subjects involved in the study.

## CRediT authorship contribution statement

**Brenda L. Coleman:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Iris Gutmanis:** Writing – review & editing. **Susan J. Bondy:** Writing – review & editing. **Robyn Harrison:** Writing – review & editing. **Joanne Langley:** Writing – review & editing. **Kailey Fischer:** Writing – review & editing, Project administration. **Curtis Cooper:** Writing – review & editing. **Louis Valiquette:** Writing – review & editing, Funding acquisition. **Matthew P. Muller:** Writing – review & editing. **Jeff Powis:** Writing – review & editing. **Dawn Bowdish:** Funding acquisition. **Kevin Katz:** Writing – review & editing. **Mark Loeb:** Writing – review & editing. **Marek Smieja:** Writing – review & editing. **Shelly A. McNeil:**

Writing – review & editing. **Samira Mubareka:** Writing – review & editing. **Jeya Nadarajah:** Writing – review & editing. **Saranya Arnoldo:** Writing – review & editing. **Allison McGeer:** Writing – review & editing, Resources, Methodology, Funding acquisition.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Brenda L Coleman reports financial support was provided by Canadian Institutes of Health Research. Allison McGeer reports financial support was provided by Canadian Institutes of Health Research. Allison McGeer reports financial support was provided by Physicians' Services Inc. Foundation. Dawn Bowdish reports financial support was provided by Weston Family Foundation. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2024.126271.

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