COVID-19 Vaccine Uptake and Factors Affecting Hesitancy Among US Nurses, March–June 2021

Janet W. Rich-Edwards, ScD, MPH, Carissa M. Rocheleau, PhD, Ming Ding, DSc, MSc, Jennifer A. Hankins, MS, Laura M. Katuska, MPH, Xenia Kumph, Andrea L. Steege, PhD, MPH, James M. Boiano, MS, CIH, and Christina C. Lawson, PhD

See also COVID-19 & Monkeypox, pp. 1564–1620.

Objectives. To characterize COVID-19 vaccine uptake and hesitancy among US nurses.

Methods. We surveyed nurses in 3 national cohorts during spring 2021. Participants who indicated that they did not plan to receive or were unsure whether they planned to receive the vaccine were considered vaccine hesitant.

Results. Among 32 426 female current and former nurses, 93% had been or planned to be vaccinated. After adjustment for age, race/ethnicity, and occupational variables, vaccine hesitancy was associated with lower education, living in the South, and working in a group care or home health setting. Those who experienced COVID-19 deaths and those reporting personal or household vulnerability to COVID-19 were less likely to be hesitant. Having contracted COVID-19 doubled the risk of vaccine hesitancy (95% confidence interval [CI] = 1.85, 2.53). Reasons for hesitancy that were common among nurses who did not plan to receive the vaccine were religion/ethics, belief that the vaccine was ineffective, and lack of concern about COVID-19; those who were unsure often cited concerns regarding side effects or medical reasons or reported that they had had COVID-19.

Conclusions. Vaccine hesitancy was unusual and stemmed from specific concerns.

Public Health Implications. Targeted messaging and outreach might reduce vaccine hesitancy. (*Am J Public Health*. 2022;112(11):1620–1629. https://doi.org/10.2105/AJPH.2022.307050)

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In December 2020, the Advisory Committee on Immunization Practices prioritized health care personnel (HCP) to begin receiving 2 COVID-19 mRNA vaccines (Pfizer-BioNTech and Moderna) authorized under emergency use authorizations[1,2]; a third vaccine (Janssen) was authorized in a February 2021 emergency use authorization. There have been substantial challenges in gathering information on the uptake of vaccinations by HCP. The National Healthcare Safety Network, a Centers for Disease Control and Prevention surveillance system,[3] rapidly deployed modules for reporting HCP vaccinations but faced substantial challenges in data collection.[4] The US Department of Health and Human Services launched the Unified Hospital Data Surveillance System in January 2021 for hospitals to report staff vaccinations; reporting is voluntary, however, and less than half of eligible facilities had reported data by September 2021.[5]

Without comprehensive, accurate data to estimate vaccinations among HCP, media coverage of vaccine controversies might contribute to public perceptions that many HCP are skeptical about the safety and effectiveness of COVID-19 vaccines. Because nursing is consistently ranked among the most trusted professions,[6] this might influence public vaccine hesitancy. Several small surveys of HCP conducted before the emergency use authorizations indicated varying levels of vaccine hesitancy, with studies in the United States reporting percentages ranging from 8% to 18% among HCP surveyed between October 2020 and January 2021.[7] These studies indicated that female HCP were more likely to be vaccine hesitant than male HCP, and nurses were more likely to be hesitant

than physicians.[7] However, after the December 2020 emergency use authorization, opinions could have changed as a result of public health messaging, targeted communications to HCP, and HCP observing their colleagues' experiences receiving the vaccine.

We conducted an evaluation of 32 426 female nurses recruited from 3 large national cohort studies to assess vaccination rates, reasons for vaccine hesitancy, and personal and workplace variables associated with receiving a vaccine by spring 2021. This was a period when most HCP had been offered vaccinations but before vaccinations were widely available to the general population.

METHODS

In April 2020, we launched a yearlong series of COVID-19 surveys within 3 preexisting longitudinal national cohorts: the Nurses' Health Study II (NHSII), the Nurses' Health Study 3 (NHS3), and the Growing Up Today Study (GUTS). General cohort methods[8–10] and specific COVID-19 survey methods[11] are fully detailed elsewhere. In brief, Nurses' Health Study participants are recruited through professional nursing associations and credentialing rosters (in 1989 for the closed NHSII cohort and since 2010 for the open NHS3 cohort). The NHSII cohort was restricted to female nurses, whereas the NHS3 includes both male and female nurses. Members of the GUTS cohort were recruited in 1996 from among 9- to 16-year-old children of NHSII participants. All GUTS participants are now adults working in both health care and non–health care occupations.

At the start of the COVID-19 pandemic, 105 662 cohort members from these 3 longitudinal surveys were invited to participate in a COVID-19 substudy regarding their pandemic experiences (those who responded at baseline in March–April 2020 were surveyed again 1, 2, 3, 6, 9, and 12 months later). In total, 58 606 agreed to participate in the substudy (a 55% response rate) by completing the first survey. Each survey was rolled out over 3 weeks; the final spring 2021 (12 months from baseline) survey was rolled out from March 23 through April 13, 2021; 48 356 surveys were returned by the June 22, 2021, deadline (an 83% completion rate).

The spring 2021 survey asked whether participants had received at least 1 dose of COVID-19 vaccine and, if not, whether they planned to receive one when it became available to them (yes, no, or unsure). Those who said that they were unsure or said no were considered vaccine hesitant and were asked to indicate which, if any, of 9 reasons applied to their answer. Covariates we evaluated included age, race/ethnicity, geographic region of residence, nursing education, experiencing deaths from COVID-19 (deaths of patients, coworkers, or loved ones), working status, facility type, previous history of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, vulnerability to severe COVID-19 disease (among both participants and household members), and contact with patients with COVID-19.

Age and race/ethnicity were recorded at cohort entry. The questions on race evolved over time and between cohorts; for this analysis of the combined cohorts, we were able to classify race as White, Hispanic, Black, Asian, and other. Geographic region was based on state of residence and classified according to US census region. Nursing education and degree were grouped as LPN/LVN/ADN (licensed practical nurse, licensed vocational nurse, or associate degree in nursing), RN/BSN (registered nurse or bachelor of science in nursing), and advanced practice nurse (nurse practitioner, certified nurse midwife, or other certification typically requiring a master's degree or higher in a nursing specialty).

Nurses were asked to specify the type of health care facility in which they worked. SARS-CoV-2 infection was self-reported on multiple questionnaires, with a further question asking whether the infection had been laboratory confirmed via polymerase chain reaction or antibody screening. We used first-reported infections to classify participants as never infected, having a laboratory-confirmed infection in 2020 (i.e., before vaccine availability), having a laboratory-confirmed infection in 2021 (i.e., infections that might have occurred either before or after vaccination was offered), or having a presumed infection that lacked a date or was not laboratory confirmed. Because it predated the rollout of vaccines to HCP, only laboratory-confirmed infection in 2020 was considered as a predictor of vaccine hesitancy.

Vulnerability to severe COVID-19 disease was assessed according to participants' self-reports that they or someone in their household was vulnerable to severe COVID-19 illness because of age (above 65 years) or an underlying medical condition. Working with patients with COVID-19 was self-reported as an "in-person interaction with a patient with current documented or presumed COVID-19" (response options were yes, documented; yes, presumed; and not that I know of); the history of such exposures by month 9 (approximately January 2021) was calculated. Participants were asked about experiencing the death of a patient, coworker, or loved one as a result of COVID-19 at month 6 (approximately October 2020), and this question was updated in the final spring

2021 survey on which vaccine status was queried; because we did not know whether deaths reported in spring 2021 occurred before or after participants were offered vaccinations, we used deaths reported at month 6 in our main analysis.

We restricted our analysis to credentialed current and former nurses living in the United States (67% of the COVID-19 cohort) who were female (99% of the cohort) and who responded to the spring 2021 survey on which vaccination status was queried. From this group of 32 606 nurses, we further excluded those missing data on vaccination status (n = 106), history of SARS-CoV-2 infection (n = 54), or vulnerability to severe COVID-19 (n = 11) and those whose information on work status and site could not be reconciled (n = 9), leaving a final sample of 32 426 individuals.

We examined odds ratios (ORs) for self-reported vaccine hesitancy using logistic regression models adjusted for age and race/ethnicity (a minimally adjusted model, referred to as model 1) and mutually adjusted for all covariates (a fully adjusted model, referred to as model 2). Missing indicators were used because we hypothesized that the reasons for missing any given survey or item might be related to overwork or illness with COVID-19. In this scenario (i.e., "missing not at random"), either multiple imputation or restricting the analysis to complete data could potentially create greater bias than a missing indicator[12]; as noted subsequently, we also conducted a complete case sensitivity analysis of those without missing data.

Among the subset of participants who were vaccine hesitant, we used logistic regression to examine differences in the distribution of specific reasons or explanations for vaccine hesitancy, comparing reasons cited by participants who were unsure whether they planned to be vaccinated and those who did not plan to be vaccinated. Finally, we conducted a secondary analysis to examine vaccine hesitancy among frontline nurses working directly in patient care and nurses who had not cared for patients in person during the pandemic.

We performed several analyses to test the robustness of our methods. A complete case analysis including 29 991 participants yielded results nearly identical to those of the overall analysis of 32 426 participants that included indicators for missing data (data not shown). Results of an analysis restricted to participants currently employed in nursing (n = 16 908) were also very similar to those of the original analysis (data not shown; any departures are noted in the Results section). Finally, we tested the impact of replacing prospective experiences of COVID-19 deaths of patients, coworkers, or loved ones that had been reported in fall 2020 with the cumulative variable through spring 2021 (when we queried vaccine status); although the number of participants reporting such deaths had doubled by spring 2021, the association between experiencing COVID-19 deaths and vaccine hesitancy was unchanged. SAS version 9.4 (SAS Institute Inc, Cary, NC) was used in conducting our analyses.

RESULTS

In spring 2021, 93.3% of our sample of 32 426 active and retired nurses across the United States reported that they had received at least 1 dose of a COVID-19 vaccine or indicated that they planned to be vaccinated when the opportunity became available; 2.4% reported being unsure regarding whether they planned to get vaccinated, and 4.3% did not plan to get vaccinated. Cohort characteristics are presented in Table 1. Receipt of a vaccine was more common among White (91.1%) and Asian (93.4%) nurses than among those who identified as Black (86.7%) or Hispanic (74.8%); however, a relatively substantial percentage of Black nurses (4.9%) indicated that they planned to be vaccinated when the opportunity became available. There was a trend toward increased vaccination with more nursing education, from 86.1% in the LPN/LVN group to 95.9% among nurses with advanced degrees.

Rates of vaccination were higher among nurses who had an increased risk of severe COVID-19 disease or had a household member at high risk (90.7%–94.6%) than among those who did not (81.6%). Participants with no history of SARS-CoV-2 infection were more likely to have been vaccinated (92.4%) than those with a confirmed case before 2021 (83.6%), even accounting for nurses with confirmed cases who planned to get vaccinated (4.0%).

Table 2 shows the odds ratios for vaccine hesitancy associated with each risk factor adjusted for age and race/ethnicity (model 1) and all covariates (model 2). Results were similar between models. Relative to nurses in the Northeast, those in the West and Midwest had slightly higher odds of being vaccine hesitant (30% and 54% higher odds, respectively); however, those in the South had nearly double the odds of vaccine hesitancy (OR = 1.91; 95% confidence interval [CI] = 1.68, 2.18) in the fully adjusted model. More education predicted lower odds of vaccine hesitancy: those in the LPN/LVN/ADN group were more hesitant (OR = 1.59; 95% CI = 1.18, 2.12) than RNs and those with a bachelor's nursing degree, whereas advanced practice

TABLE 1— Age-Standardized Characteristics of 32 426 US Nurses, by Vaccination Status: Spring 2021

Variable	Already Received Vaccine, No. (%) or Mean ±SD	Plan to Get Vaccinated, No. (%) or Mean ±SD	Unsure About Getting Vaccinated, No. (%) or Mean ±SD	Do Not Plan to Get Vaccinated, No. (%) or Mean ±SD
Participants	29 506 (91.0)	733 (2.3)	791 (2.4)	1 396 (4.3)
Age, y	61.0 ±10.7	55.0 ±13.0	58.2 ±11.6	59.3 ±11.3
Cohort				
Nurses' Health Study II	23 951 (91.9)	448 (1.7)	587 (2.3)	1075 (4.1)
Nurses' Health Study 3	5 381 (87.5)	278 (4.6)	194 (3.0)	309 (4.9)
Growing Up Today Study	174 (86.3)	7 (3.1)	10 (4.9)	12 (5.8)
Race and ethnicity				
White	28 612 (91.1)	695 (2.2)	763 (2.4)	1 346 (4.3)
Hispanic	61 (74.8)	3 (1.4)	6 (10.2)	5 (13.6)
Black	300 (86.7)	22 (4.9)	12 (3.0)	21 (5.4)
Asian	374 (93.4)	8 (1.9)	5 (2.3)	12 (2.5)
Other race[a]	159 (88.3)	5 (2.3)	5 (3.4)	12 (6.0)
Residential census region				
Northeast	8 087 (93.2)	181 (2.1)	161 (1.9)	244 (2.8)
Midwest	8 659 (90.3)	216 (2.2)	277 (2.9)	445 (4.6)
South	6 932 (88.6)	208 (2.7)	240 (3.1)	441 (5.7)
West	5 828 (92.0)	128 (1.9)	113 (1.9)	266 (4.3)
Nursing education				
LPN/LVN/ADN	398 (86.1)	17 (3.4)	17 (3.5)	39 (7.1)
BSN or RN	25 057 (90.2)	652 (2.5)	719 (2.7)	1 276 (4.7)
Advanced practice degree	4 051 (95.9)	64 (1.1)	55 (1.2)	81 (1.8)
Working status				
Front line	9 208 (92.8)	122 (1.2)	240 (2.1)	428 (3.9)
Remote patient care	1 276 (91.1)	59 (2.8)	40 (2.7)	54 (3.5)
Not in direct patient care	2 138 (90.5)	76 (3.0)	55 (2.1)	100 (4.4)
Working outside health care	1 294 (84.5)	71 (7.2)	45 (3.1)	78 (5.2)
Retired, on leave, or at home	13 440 (86.1)	346 (5.4)	333 (3.5)	590 (5.1)
Missing information	2 150 (89.0)	59 (2.0)	78 (3.0)	146 (5.9)
Clinical site				
ER, operating room, or ICU	1 790 (92.4)	24 (1.1)	47 (2.3)	83 (4.2)
Dedicated COVID-19 unit	415 (93.4)	4 (0.6)	10 (2.0)	19 (4.1)
Other hospital inpatient unit	1 850 (91.2)	30 (1.4)	52 (2.6)	98 (4.8)
Outpatient clinic in hospital	1 526 (93.5)	16 (1.1)	39 (2.6)	42 (2.8)
Outpatient clinic outside hospital	1 771 (93.8)	18 (1.0)	38 (2.1)	58 (3.2)
Congregate care facility	382 (85.8)	9 (1.8)	13 (3.2)	35 (9.1)
Home health	419 (89.5)	4 (0.5)	15 (3.4)	31 (6.6)
School clinic	471 (92.0)	4 (1.0)	16 (3.5)	20 (3.5)
Other clinical site	584 (88.9)	13 (2.5)	10 (1.5)	42 (7.1)
COVID-19 patient interactions[b]				
Patients with known infection	5 208 (92.1)	83 (1.2)	153 (2.4)	266 (4.4)
Patients with presumed infection	1 006 (89.5)	21 (1.1)	29 (3.9)	51 (5.6)
No known COVID-19 patient interactions	6 238 (92.0)	110 (1.5)	166 (2.2)	310 (4.3)

Continued

TABLE 1— Continued

Variable	Already Received Vaccine, No. (%) or Mean ±SD	Plan to Get Vaccinated, No. (%) or Mean ±SD	Unsure About Getting Vaccinated, No. (%) or Mean ±SD	Do Not Plan to Get Vaccinated, No. (%) or Mean ±SD
Experienced COVID-19 death				
No	26 409 (90.6)	668 (2.4)	725 (2.5)	1 284 (4.5)
Yes	3 097 (93.6)	65 (1.7)	66 (1.7)	112 (3.1)
Vulnerability to severe COVID-19				
None	8 421 (81.6)	339 (3.0)	704 (5.0)	396 (10.5)
Self only	8 408 (91.8)	176 (2.6)	297 (2.0)	161 (3.7)
Other household members only	4 527 (90.7)	116 (2.0)	201 (2.8)	121 (4.5)
Self and other household members	8 150 (94.6)	102 (1.6)	194 (1.5)	113 (2.3)
Previous SARS-CoV-2 infection status[c]				
Confirmed infection before 2021	1 474 (83.6)	70 (4.0)	85 (4.8)	134 (7.6)
Never infected	26 903 (92.4)	538 (1.9)	596 (2.1)	1 073 (3.7)

Note. ADN = associate degree in nursing; BSN = bachelor of science in nursing; ER = emergency room; ICU = intensive care unit; LPN = licensed practical nurse; LVN = licensed vocational nurse; RN = registered nurse; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2. With the exception of age, percentages are standardized to the age distribution of the study population. The spring 2021 survey was rolled out from March 23 through April 13, 2021; surveys had to be returned by June 22, 2021, to be accepted.

[a]Depending on the cohort, other race includes American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, self-reported other race/ethnicity, or multiracial with otherwise unspecified race/ethnicity.
[b]Excludes 846 nurses working in clinical settings who were not involved in direct patient care and 1079 nurses working in patient treatment facilities who were missing information on whether they had interacted with patients with COVID-19 infection.
[c]Information is not presented for 1020 presumed COVID-19 cases (which could not be dated) and 533 confirmed cases in 2021 because these cases did not clearly precede the rollout of the vaccine.

TABLE 2— Numbers of Vaccine-Hesitant Participants and Odds Ratios for Vaccine Hesitancy: 32 426 US Nurses, Spring 2021

Variable	Vaccine Hesitant, No./Total No.	Model 1,[a] OR (95% CI)	Model 2,[b] OR (95% CI)
Residential census region			
Northeast	405/8 673	1 (ref)	1 (ref)
Midwest	722/9 597	1.64 (1.45, 1.86)	1.54 (1.36, 1.75)
South	681/7 821	1.93 (1.70, 2.20)	1.91 (1.68, 2.18)
West	379/6 335	1.26 (1.09, 1.46)	1.30 (1.12, 1.51)
Nursing education			
LPN/LVN/ADN	56/471	1.68 (1.26, 2.23)	1.59 (1.18, 2.12)
BSN or RN	1 995/27 704	1 (ref)	1 (ref)
Advanced practice degree	136/4 251	0.38 (0.32, 0.46)	0.42 (0.35, 0.50)
Worksite and status			
ER, operating room, or ICU	130/1 944	1 (ref)	1 (ref)
Dedicated COVID-19 unit	29/448	0.97 (0.64, 1.47)	1.01 (0.66, 1.54)
Other hospital inpatient unit	150/2 030	1.17 (0.92, 1.49)	1.17 (0.91, 1.50)
Outpatient clinic in hospital	81/1 623	0.82 (0.61, 1.09)	0.83 (0.61, 1.11)
Outpatient clinic outside hospital	96/1 885	0.81 (0.62, 1.07)	0.97 (0.72, 1.29)
Congregate care facility	48/439	1.98 (1.39, 2.81)	2.08 (1.44, 2.98)
Home health	46/469	1.84 (1.29, 2.63)	1.80 (1.24, 2.60)

Continued

TABLE 2— Continued

Variable	Vaccine Hesitant, No./Total No.	Model 1,[a] OR (95% CI)	Model 2,[b] OR (95% CI)
School clinic	36/511	1.24 (0.84, 1.82)	1.16 (0.78, 1.73)
Other clinical site	52/649	1.48 (1.05, 2.07)	1.63 (1.14, 2.32)
Remote patient care	94/1 429	1.13 (0.86, 1.49)	1.33 (0.97, 1.83)
Patient treatment facility but not direct patient care	155/2 369	1.21 (0.94, 1.54)	1.32 (1.00, 1.75)
Outside health care	123/1 488	1.65 (1.27, 2.15)	1.91 (1.39, 2.63)
Retired, on leave, or at home	923/14 709	1.31 (1.06, 1.61)	1.75 (1.34, 2.28)
Missing worksite	224/2 433	1.62 (1.29, 2.03)	1.50 (1.15, 1.97)
COVID-19 patient interactions			
Patients with known infection	419/5 710	1 (ref)	1 (ref)
Patients with presumed infection	80/1 107	1.03 (0.80, 1.32)	0.95 (0.73, 1.23)
No known COVID-19 patient interactions	476/6 824	1.06 (0.92, 1.21)	0.95 (0.81, 1.11)
Experienced COVID-19 death			
No	2 009/29 086	1 (ref)	1 (ref)
Yes	178/3 340	0.68 (0.58, 0.79)	0.69 (0.58, 0.82)
Vulnerability to severe COVID-19			
None	1 100/9 860	1 (ref)	1 (ref)
Self only	458/9 042	0.38 (0.33, 0.43)	0.37 (0.32, 0.42)
Other household members only	322/4 965	0.52 (0.45, 0.59)	0.51 (0.45, 0.59)
Self and household members	307/8 559	0.26 (0.22, 0.30)	0.25 (0.22, 0.29)
Previous SARS-CoV-2 infection status[c]			
Never infected	1 669/29 110	1 (ref)	1 (ref)
Confirmed infection before 2021	219/1 763	2.23 (1.92, 2.60)	2.17 (1.85, 2.53)

Note. ADN = associate degree in nursing; BSN = bachelor of science in nursing; CI = confidence interval; ER = emergency room; ICU = intensive care unit; LPN = licensed practical nurse; LVN = licensed vocational nurse; OR = odds ratio; RN = registered nurse; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2. The spring 2021 survey was rolled out from March 23 through April 13, 2021; surveys had to be returned by June 22, 2021, to be accepted. Data include unvaccinated nurses who answered "no" or "unsure" to the question, "Do you plan to receive a COVID-19 vaccine when it becomes available to you?"

[a]Model 1 (minimally adjusted model) included covariates for age in years (continuous) and dichotomized race/ethnicity (White, other).
[b]Model 2 (fully adjusted model) included all covariates: age in years (continuous), dichotomized race/ethnicity (White, other), residential census region, nursing education, worksite and status, COVID-19 patient interactions, experiences of COVID-19 deaths, vulnerability to severe COVID-19, and COVID-19 history.
[c]This variable also included categories for the 533 individuals who had laboratory-confirmed cases in 2021 (model 2 OR = 4.12; 95% CI = 3.30, 5.14) and the 1020 individuals who had presumed cases that were undated (model 2 OR = 3.46; 95% CI = 2.92, 4.12). These COVID-19 cases could have occurred after the nurse was offered vaccination and therefore could have been the result of vaccine hesitancy.

nurses were less hesitant (OR = 0.42; 95% CI = 0.35, 0.50). Relative to nurses working in emergency rooms, operating rooms, or intensive care units, nurses working in home health (OR = 1.80; 95% CI = 1.24–2.60) or congregate care facilities (OR = 2.08, 95% CI = 1.44, 2.98) had higher odds of vaccine hesitancy after adjustment for other covariates.

Working with COVID-19 patients did not affect nurses' vaccine hesitancy. However, nurses who reported that a patient, coworker, loved one, or someone important to them had died from COVID-19 had lower odds of vaccine hesitancy (OR = 0.69; 95% CI = 0.58–0.82) than others who had not experienced COVID-19 deaths. Similarly, vaccine hesitancy odds were lower among those who considered themselves (OR = 0.37; 95% CI = 0.32, 0.42), other household members (OR = 0.51; 95% CI = 0.45, 0.59), or both (OR = 0.25; 95% CI = 0.22, 0.29) to fall into a high-risk category for severe COVID-19. In an analysis restricted to currently employed nurses, we saw a similar inverse association of perceived COVID-19 vulnerability with vaccine hesitancy, although the odds ratios were modestly closer to the null: 0.52 (95% CI = 0.43, 0.63) for participants' own vulnerability, 0.63 (95% CI = 0.53, 0.75) for vulnerability of household

members, and 0.36 (95% CI = 0.28, 0.46) for both.

Finally, having had COVID-19 was strongly associated with vaccine hesitancy. Nurses reporting a laboratory-confirmed SARS-CoV-2 infection occurring before 2021 were twice as likely to be vaccine hesitant (OR = 2.17; 95% CI = 1.85, 2.53) as those who had never been infected; this was also true among currently employed nurses with a history of infection (OR = 2.08; 95% CI = 1.71, 2.53).

Table 3 documents the reasons cited by the 6.7% (n = 2187) of nurses who were vaccine hesitant. The most common concerns were safety and side effects. A third of those who were vaccine hesitant were skeptical that the vaccine was effective, and 25% reported that they were not worried about COVID-19. Eighteen percent self-reported having already had COVID-19 as a reason for not getting vaccinated. Medical reasons, religious or ethical reasons, and "other" reasons were each indicated by roughly 12% of those who were vaccine hesitant. Five percent of vaccine-hesitant nurses cited pregnancy or breastfeeding.

Most (64%) vaccine-hesitant nurses indicated no plan to be vaccinated; 36% were unsure whether they planned to be vaccinated. The middle 2 columns of Table 3 show the percentages of nurses reporting each reason for hesitancy among those who were unsure and those who did not plan to be vaccinated. When we restricted the analysis to participants currently employed as nurses, slightly higher percentages cited pregnancy (7.1%) and having already had COVID-19 (20.9%) as reasons for hesitancy. After adjustment for age, vaccine safety concerns ($P = .03$), belief that the vaccine was not effective ($P = .001$), lack of worry about COVID-19 ($P < .001$), and religious or ethical reasons for not being vaccinated ($P < .001$) distinguished those who did not plan to be vaccinated from those who were unsure. In contrast, similar proportions of those who did not plan to be vaccinated and those who were unsure cited concerns about side effects, having had COVID-19, medical reasons, pregnancy or breastfeeding, or other reasons for not being vaccinated.

In a secondary analysis, we compared vaccine hesitancy among nurses who worked on the front line (i.e., directly with patients) and those who did not. Nurses working remotely (OR = 1.04; 95% CI = 0.83, 1.31) and those employed in health care facilities but not in direct patient care (OR = 1.11; 95% CI = 0.92, 1.33) had odds of vaccine hesitancy similar to those of frontline nurses; however, women trained as nurses who were working outside health care (OR = 1.51; 95% CI = 1.23, 1.85) or who were retired, on leave, or at home (OR = 1.19; 95% CI = 1.06, 1.34) were more likely to be vaccine hesitant after adjustment for age and race/ethnicity.

Except as noted, results from multivariable models were very similar in sensitivity analyses (1) restricted to participants with complete data for all covariates, (2) restricted to currently employed nurses, or (3) adjusted for experiences of close COVID-19 deaths through spring 2021 (the odds ratio in the latter analysis was 0.68; 95% CI = 0.58, 0.80).

TABLE 3— Reasons Cited by 2187 US Nurses Who Said That They Were Unsure or That They Did Not Plan to Be Vaccinated: Spring 2021

Reason Cited by Those Who Were Vaccine Hesitant[a]	All Vaccine-Hesitant Nurses (n = 2 187), No. (%)	Unsure (n = 791), No. (%)	Do Not Plan to Be Vaccinated (n = 1 396), No. (%)	P[b]
Safety concerns	1 466 (67.0)	507 (64.1)	959 (68.7)	.03
Side effects	1 260 (57.6)	458 (57.9)	802 (57.4)	.86
Vaccine is not effective	699 (32.0)	220 (27.8)	479 (34.3)	.001
Not worried about COVID-19	537 (24.6)	121 (15.3)	416 (29.8)	< .001
Already had COVID-19	394 (18.0)	155 (19.6)	239 (17.1)	.18
Medical reasons	273 (12.5)	97 (12.3)	176 (12.6)	.9
Religious or ethical reasons	253 (11.6)	55 (7.0)	198 (14.2)	< .001
Pregnant or breastfeeding	98 (4.5)	40 (5.1)	58 (4.2)	.77
Other	270 (12.3)	85 (10.7)	185 (13.3)	.11

Note. The spring 2021 survey was rolled out from March 23 through April 13, 2021; surveys had to be returned by June 22, 2021, to be accepted.

[a]Reasons are not mutually exclusive; a participant could choose all that applied.
[b]Derived from a logistic regression model (adjusted for age) comparing the likelihood of citing the reason for vaccine hesitancy among those who were unsure whether they planned to be vaccinated and those who did not plan to be vaccinated.

DISCUSSION

We found that 93% of participating nurses had received at least 1 dose of COVID-19 vaccine or intended to receive the vaccine during March through June 2021. It is important to note that, at the time of the survey, vaccines were available only under an emergency use authorization. No mandates had yet been passed for HCP vaccination, although there were discussions that mandates might be required after full Food and Drug Administration approval.

Our results are consistent with those of a survey conducted by the American Nurses Foundation in February 2021 showing that 80% of respondents had received at least 1 vaccine dose and another 10% intended to get vaccinated, for an overall vaccine acceptance rate of 90%.[13] Surveys of HCP have reported varying rates of vaccine hesitancy; in general, however, hesitancy has declined over time.[4,14–19]

Our estimates are higher than those reported in the Unified Hospital Data Surveillance System, in which only 70% of staff members in reporting hospitals were fully vaccinated as of September 2021.[5] However, the authors of that report noted that they likely underestimated vaccine coverage because they accounted only for staff members receiving vaccinations directly from their employers, and only 41% of eligible hospitals reported.[5,7] The Unified Hospital Data Surveillance System estimate also includes nonclinical staff (e.g., administrative or clerical, dietary, and cleaning staff) and clinical staff with an associate degree or less (e.g., nursing assistants or orderlies and allied health staff)[5]; our study and others have shown that vaccine acceptance tends to be lower both among staff members who do not have patient contact and among those with less education.[7]

This report is subject to several limitations. People who participate in research studies (particularly longitudinal studies) might have a higher degree of trust in the scientific research process than those who decline to participate, which might also result in higher vaccine acceptance relative to the general population of nurses. Those who agreed to participate in the COVID-19 substudy might have also been more concerned about the newly declared COVID-19 pandemic than those who declined to participate and thus might not represent all nurses. Participants in these cohorts underrepresent licensed practical nurses and licensed vocational nurses in comparison with the working population of nurses in the United States. The fact that vaccination rates were lower in the LPN/LVN/AND group suggests that our results might slightly overestimate vaccine acceptance among the general population of nurses, although even among this group vaccine acceptance was still very high at 89.5%.

Most participants were White and female, further limiting generalizability to all nurses. Our descriptive results in Table 1 indicate differences in vaccine hesitancy by race and ethnicity, but we were unable to perform stratum-specific analyses to explore these differences fully. Because of small sample sizes, we had to dichotomize race and ethnicity (non-Hispanic White vs other) in our multivariable models, which may have obscured important differences within specific groups. Because race was solicited at the time of entry into the NHSII, NHS3, and GUTS cohorts, the race/ethnicity variables varied between questionnaires and over time; this may have led to misclassification of people who identified as multiracial or multiethnic. Additional research in more racially/ethnically diverse populations is needed to understand reasons for vaccine hesitancy that might be unique to a specific group.

Finally, our findings represent one point in time in a changing landscape. We assessed only initiation of vaccination in the spring of 2021. We do not know whether the individuals in our sample went on to become fully vaccinated or receive recommended booster shots; similarly, we do not know whether those who were vaccine hesitant in spring 2021 may have later become vaccinated. Further research is needed to understand the impact of later events (including full Food and Drug Administration authorization of vaccines, emerging SARS-CoV-2 variants, travel restrictions for unvaccinated individuals, and emerging employer and school vaccine mandates) on nurses' COVID-19 vaccination.

Our study also benefited from several significant strengths. Because participants were recruited to the parent cohorts before the pandemic and recruited to the COVID-19 substudy during its earliest days, their original involvement in the COVID-19 questionnaire series was unlikely to have been influenced by later public debate or polarization about COVID-19 vaccines or public health mandates. This study had a very large sample size and national reach. Data on characteristics that could influence vaccine hesitancy were collected prospectively and included information on participants' experiences of the COVID-19 pandemic in their personal lives, communities, and workplaces.

Because the relationships between individual factors affecting COVID-19 experiences are complex, we constructed both a minimally adjusted model for each predictor of COVID-19

vaccine hesitancy (i.e., model 1, which examined each predictor while adjusting for race and ethnicity) and a fully adjusted model (i.e., model 2, which examined each predictor while adjusting for all other covariates) to provide greater insight into the factors that may have contributed to participants' attitudes toward COVID-19 vaccines. Most odds ratios showed little change between the minimally adjusted and fully adjusted models, indicating that these variables were robust and independent predictors of vaccine hesitancy. Likewise, sensitivity analyses yielded very similar results when analyses were restricted to participants with complete data for all covariates, restricted to those currently employed as nurses, or updated to include experiences of close COVID-19 deaths through spring 2021.

Our data on reasons for vaccine hesitancy might inform future educational campaigns in several ways. First, emphasizing the very high uptake of vaccines among nurses could be used to help balance news coverage; reporting that heavily covers protests or resignations might lead the public to believe that HCP resistance to vaccines is more pervasive than it really is, contributing to vaccine hesitancy in the public. Research has shown that media coverage can bias public perceptions of how common a phenomenon is; that is, the more coverage a topic receives, the more common the public tends to perceive it.[20]

Second, our research identified groups of nurses and facility types with substantially lower vaccination acceptance that could be targeted for interventions (e.g., those working in home health or group care facilities and those with less education might benefit from targeted messaging about vaccine safety and benefits).

Finally, comparing the reasons cited by those who were unsure about vaccination and those who did not intend to get vaccinated can help identify information that might be particularly effective in swaying those whose minds are not made up. The 3% of participants who were unsure might have been persuaded by more or earlier information about safety (including while women are pregnant or breastfeeding), side effects, and the utility of the vaccine for those previously infected with COVID-19. Further work assessing participants' unstructured write-in comments regarding vaccinations and reasons for vaccine hesitancy (frontline nurses provided 2724 write-in comments on vaccines) might also lead to additional insights to inform educational campaigns for COVID-19 boosters or other immunizations in the future. AJPH

ABOUT THE AUTHORS

Janet W. Rich-Edwards is with the Division of Women's Health, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, and the Department of Epidemiology, Harvard T. H. Chan School of Public Health, Boston, MA. Carissa M. Rocheleau, Andrea L. Steege, James M. Boiano, and Christina C. Lawson are with the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, OH. Ming Ding and Laura M. Katuska are with the Department of Nutrition, Harvard T. H. Chan School of Public Health. Jennifer A. Hankins and Xenia Kumph are with the Channing Division of Network Medicine, Harvard Medical School and Brigham and Women's Hospital.

CORRESPONDENCE

Correspondence should be sent to Janet Rich-Edwards, ScD, MPH, Division of Women's Health, Department of Medicine, Brigham and Women's Hospital, 75 Francis St, OBC 3-34Q, Boston, MA 02115 (e-mail: jr33@partners.org). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

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CONTRIBUTORS

J. W. Rich-Edwards, C. M. Rocheleau, A. L. Steege, and C. C. Lawson conceptualized the study. J. W. Rich-Edwards, J. A. Hankins, L. M. Katuska, and X. Kumph led the procurement of data. M. Ding performed the data analysis. J. W. Rich-Edwards and C. M. Rocheleau wrote the initial draft. All of the authors provided critical input and edits to the article and its revisions.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

HUMAN PARTICIPANT PROTECTION

This study was approved by the institutional review board of Brigham and Women's Hospital, which allowed voluntary survey completion to represent participant consent. This activity was reviewed by the Centers for Disease Control and Prevention (CDC) and was conducted in a manner consistent with applicable federal law and CDC policy.

REFERENCES

1. Dooling K, Marin M, Wallace M, et al. The Advisory Committee on Immunization Practices' updated interim recommendation for allocation of COVID-19 vaccine—United States, December 2020. *MMWR Morb Mortal Wkly Rep*. 2021; 69(5152):1657–1660. https://doi.org/10.15585/mmwr.mm695152e2
2. Food and Drug Administration. COVID-19 vaccines. Available at: https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/covid-19-vaccines. Accessed September 17, 2021.
3. Centers for Disease Control and Prevention. National Healthcare Safety Network: COVID-19 information. Available at: https://www.cdc.gov/nhsn/covid19/index.html. Accessed September 17, 2021.
4. Goodman B, Miller A. We made a map. It's probably wrong. Available at: https://www.webmd.com/vaccines/covid-19-vaccine/news/20210628/we-made-a-map-its-probably-wrong. Accessed September 17, 2021.
5. Reses HE, Jones ES, Richardson DB, Cate KM, Walker DW, Shapiro CN. COVID-19 vaccination coverage among hospital-based healthcare personnel reported through the Department of Health and Human Services Unified Hospital Data Surveillance System, United States, January 20, 2021–September 15, 2021. *Am J Infect*

Control. 2021;49(12):1554–1557. https://doi.org/10.1016/j.ajic.2021.10.008

6. Saad L. US ethics ratings rise for medical workers and teachers. Available at: https://news.gallup.com/poll/328136/ethics-ratings-rise-medical-workers-teachers.aspx. Accessed January 19, 2022.
7. Biswas N, Mustapha T, Khubchandani J, Price JH. The nature and extent of COVID-19 vaccination hesitancy in healthcare workers. *J Community Health.* 2021;46(6):1244–1251. https://doi.org/10.1007/s10900-021-00984-3
8. Bao Y, Bertoia ML, Lenart EB, et al. Origin, methods, and evolution of the three Nurses' Health Studies. *Am J Public Health.* 2016;106(9):1573–1581. https://doi.org/10.2105/AJPH.2016.303338
9. Nurses' Health Study. Available at: https://nurseshealthstudy.org. Accessed January 19, 2022.
10. GUTS Growing Up Today Study. American frontline healthcare personnel's access to and use of personal protective equipment early in the COVID-19 pandemic http://www.gutsweb.org. Accessed January 19, 2022.
11. Rich-Edwards JW, Ding M, Rocheleau CM, et al. American frontline healthcare personnel's access to and use of personal protective equipment early in the COVID-19 pandemic, *J Occup Environ Med.* 2021;63(11):913–920. https://doi.org/10.1097/JOM.0000000000002308
12. Donders A, Rogier T, van der Heijden GJ, et al. A gentle introduction to imputation of missing values. *J Clin Epidemiol.* 2006;59(10):1087–1091. https://doi.org/10.1016/j.jclinepi.2006.01.014
13. American Nurses Foundation. COVID-19 Impact Assessment Survey: first year. Available at: https://www.nursingworld.org/practice-policy/work-environment/health-safety/disaster-preparedness/coronavirus/what-you-need-to-know/year-one-covid-19-impact-assessment-survey. Accessed January 19, 2022.
14. Meyer MN, Gjorgjieva T, Rosica D. Trends in health care worker intentions to receive a COVID-19 vaccine and reasons for hesitancy. *JAMA Netw Open.* 2021;4(3):e215344. https://doi.org/10.1001/jamanetworkopen.2021.5344
15. Roy B, Kumar V, Venkatesh A. Health care workers' reluctance to take the Covid-19 vaccine: a consumer-marketing approach to identifying and overcoming hesitancy. Available at: https://catalyst.nejm.org/doi/full/10.1056/CAT.20.0676. Accessed January 19, 2022.
16. Amin DP, Palter JS. COVID-19 vaccination hesitancy among healthcare personnel in the emergency department deserves continued attention. *Am J Emerg Med.* 2021;48:372–373. https://doi.org/10.1016/j.ajem.2021.01.089
17. Schrading WA, Trent SA, Paxton JH, et al. Vaccination rates and acceptance of SARS-CoV-2 vaccination among US emergency department health care personnel. *Acad Emerg Med.* 2021;28(4):455–458. https://doi.org/10.1111/acem.14236
18. Shaw J, Hanley S, Stewart T, et al. Healthcare personnel (HCP) attitudes about coronavirus disease 2019 (COVID-19) vaccination after emergency use authorization. *Clin Infect Dis.* 2022;75(1):e814–e821. https://doi.org/10.1093/cid/ciab731.
19. Baniak LM, Luyster FS, Raible CA, McCray EE, Strollo PJ. COVID-19 vaccine hesitancy and uptake among nursing staff during an active vaccine rollout. *Vaccines (Basel).* 2021;9(8):858. https://doi.org/10.3390/vaccines9080858
20. Jensen JD, Scherr CL, Brown N, Jones C, Christy K, Hurley RJ. Public estimates of cancer frequency: cancer incidence perceptions mirror distorted media depictions. *J Health Commun.* 2014;19(5):609–624. https://doi.org/10.1080/10810730.2013.837551