






Original Article

Coronavirus disease 2019 (COVID-19) vaccine intentions and uptake in a tertiary-care healthcare system: A longitudinal study

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Abstract

Objectives: Healthcare workers (HCWs) are a high-priority group for coronavirus disease 2019 (COVID-19) vaccination and serve as sources for public information. In this analysis, we assessed vaccine intentions, factors associated with intentions, and change in uptake over time in HCWs.

Methods: A prospective cohort study of COVID-19 seroprevalence was conducted with HCWs in a large healthcare system in the Chicago area. Participants completed surveys from November 25, 2020, to January 9, 2021, and from April 24 to July 12, 2021, on COVID-19 exposures, diagnosis and symptoms, demographics, and vaccination status.

Results: Of 4,180 HCWs who responded to a survey, 77.1% indicated that they intended to get the vaccine. In this group, 23.2% had already received at least 1 dose of the vaccine, 17.4% were unsure, and 5.5% reported that they would not get the vaccine. Factors associated with intention or vaccination were being exposed to clinical procedures (vs no procedures: adjusted odds ratio [AOR], 1.39; 95% confidence interval [CI], 1.16–1.65) and having a negative serology test for COVID-19 (vs no test: AOR, 1.46; 95% CI, 1.24–1.73). Nurses (vs physicians: AOR, 0.24; 95% CI, 0.17–0.33), non-Hispanic Black (vs Asians: AOR, 0.35; 95% CI, 0.21–0.59), and women (vs men: AOR, 0.38; 95% CI, 0.30–0.50) had lower odds of intention to get vaccinated. By 6-months follow-up, >90% of those who had previously been unsure were vaccinated, whereas 59.7% of those who previously reported no intention of getting vaccinated, were vaccinated.

Conclusions: COVID-19 vaccination in HCWs was high, but variability in vaccination intention exists. Targeted messaging coupled with vaccine mandates can support uptake.

(Received 20 September 2021; accepted 17 December 2021)

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has had a profound global impact, causing 256,966,237 confirmed cases of coronavirus disease (COVID-19) and 5,151,643 deaths as of November 22, 2021.¹ The availability of COVID-19 vaccines is crucial to the reduction of morbidity and mortality from COVID-19. Early reports on vaccine hesitancy suggested that only 54%–58% of Americans intend to get one of the currently available SARS-CoV-2 vaccines, which decreased from earlier estimates of 67%–71%.^{2–6} This level of hesitancy was particularly alarming considering expert recommendation that as low as 40% but as high as 90% of the population must get vaccinated to see reductions in incidence,

hospitalizations, and deaths.^{7,8} Healthcare workers (HCWs) were given priority status to be one of the first groups vaccinated. This strategy enabled vaccine access to a large portion of the US population (~18,000,000 of America's 330,063,047 people are HCWs).^{9,10} Given HCWs' synergistic occupational and community risks for SARS-CoV-2 infection,^{11,12} their public influence as exemplars of best practice, and their proximity to infected or vulnerable populations, vaccine hesitancy in this group is particularly worrisome. In addition, the landscape continues to rapidly change related to vaccines. The Federal Drug Administration (FDA) recently approved a full authorization of the first COVID-19 vaccine for those aged 16 years and older.¹³ In addition, vaccine mandates are being supported and emerging in healthcare systems across the country.¹⁴ Continuing to understand vaccine intentions will also be important in improving vaccine uptake, particularly now that booster doses have been authorized. Thus, the goal of this analysis was to assess (1) HCW vaccine

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Cite this article: Evans CT, *et al.* (2022). Coronavirus disease 2019 (COVID-19) vaccine intentions and uptake in a tertiary-care healthcare system: A longitudinal study. *Infection Control & Hospital Epidemiology*, <https://doi.org/10.1017/ice.2021.523>

intentions at the beginning of the US vaccine rollout, (2) associations between vaccine hesitancy and level of exposure risk, and (3) change in vaccine uptake over time.

Methods

Study design and setting

This prospective cohort study of HCWs was conducted in a large, tertiary-care academic health care system.¹² Participants were HCWs from 10 hospitals (the largest in downtown Chicago, with others in the west, northwest, and north suburbs of Chicago), 18 immediate care centers, and 325 outpatient practices in the Chicago area and surrounding Illinois suburbs. The Northwestern University Institutional Review Board approved this study, and all participants gave written informed consent.

Study population and measures

Details of the study and recruitment techniques have been reported previously.^{11,12} Briefly, HCWs were recruited in May and June 2020 to participate in a cohort study assessing prevalence and incidence of SARS-CoV-2 IgG antibodies and COVID-19, with serology testing (via the semiquantitative Abbott Immunoassay System to measure antinucleocapsid IgG) between May 26 and July 10, 2020, and follow-up testing between November 9, 2020, and January 8, 2021. Participants were administered a baseline survey that assessed the following: COVID-19 diagnosis and symptoms, demographic characteristics, occupational group, participation in specific occupational tasks (caring for COVID-19 patients or being involved in procedures such as hemodialysis, nebulizer therapy, colonoscopies, etc), and community exposure to COVID-19. Participants were sent monthly surveys to assess new exposures, diagnoses, symptoms, or testing for COVID-19. The question on vaccine intention, ‘Are you willing to get a vaccine in the next 6 months?’ was asked in the 6-monthly surveys, which occurred between November 25, 2020, and January 9, 2021. This survey was conducted between 3 weeks before and 4 weeks after the first COVID-19 vaccine emergency use authorization (EUA; Pfizer on December 11, 2020, and Moderna on December 18). Vaccination of HCWs in this healthcare system began December 14, 2020. A follow-up survey was conducted from April 24, 2021, to July 12, 2021, with the same question on vaccination to determine change in intention. Participant outcomes in the electronic medical record were also assessed to identify incident COVID-19 (based on PCR testing and physician diagnosis) from March 1, 2020, to January 8, 2021.

Statistical analysis

Demographics, exposure characteristics and serostatus for SARS-CoV-2 IgG, incident COVID-19, and COVID-19 vaccine intentions (yes, no, or unsure) were assessed by participant self-report. Occupations were categorized into 4 groups (ie, physician, registered nurse, administrative, other) based on a priori risk for COVID-19 and for stability of model estimates.¹² Race and ethnicity were included due to known associations with COVID-19, with smaller groups categorized together due to sample size. Respondents to the vaccine intention survey and nonrespondents were also compared to determine whether there were any significant differences in demographics and exposures. We used χ^2 analyses to describe unadjusted associations. Sensitivity analyses were conducted to determine intentions before and after the EUA because the survey was administered over the span of the

determination of the EUAs for both Pfizer and Moderna vaccines. Multivariable logistic regression was used to identify independent associations between demographic and exposure characteristics and vaccine intention (includes both “unsure” and “no” groups). Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) are presented. Notably, multinomial logistic regression using 3 categories of intention (yes, unsure, or no) was also conducted, but the results were similar; thus, logistic regression models are presented. Statistical significance was considered based on the 95% CI (not significant if CI included 1) or $P < .05$.

Results

The initial survey (conducted November 25, 2020, through January 9, 2021) with the vaccine intention question was completed by 4,180 HCWs (64.2%) of the 6,510 enrolled in the study. Respondents significantly differed from nonrespondents in occupation, race or ethnicity, age, and seropositivity for SARS-CoV-2 at baseline. A higher proportion of respondents were in administrative roles (15.8% vs 10.4%) and a lower proportion were in nursing roles (26.1% vs 30.2%) compared to nonrespondents ($P < .001$). Also, there was a higher proportion of non-Hispanic White participants (78.4% vs 68.6%; $P < .001$) and participants aged ≥ 50 years (28.6% vs 18.6%; $P < .001$) in the respondent group versus nonrespondents. Respondents also had a lower prevalence of IgG seropositivity at baseline than nonrespondents (4.3% vs 5.8%; $P = .006$). Of those who responded, 77.1% indicated that they intended to get the vaccine or had already received the vaccine (23.2%); 17.4% were not sure if they would get the vaccine; and 5.5% reported that they would not get the vaccine. There were significant differences in intention to get vaccinated by occupation, sex, race or ethnicity, age, hospital and community COVID-19 exposures, and participant serology results (Table 1). Table 2 shows the vaccine intentions for the ‘other’ HCW group further categorized by occupation group. Physicians had the highest vaccine intentions (92.1%) whereas nurses (71.2%) and ‘other’ occupation groups (72.6%) had the lowest ($P < .001$). Women reported lower vaccine intentions than men (73.7% vs 90.9%; $P < .001$) (Table 1). Asian HCWs had the highest vaccine intentions (82.9%) whereas non-Hispanic Blacks had the lowest (57.3%) ($P < .001$). Respondents aged 30–39 years had the highest hesitancy, with higher proportions of this age group reporting being unsure or no to intending to get the vaccine ($P < .008$). Participants reporting being involved in patient care procedures (ie, hemodialysis) reported higher intention to get vaccinated than those who were not involved in these procedures (80.0% vs 74.2%; $P < .001$).

Vaccine intention was higher in HCW participants who completed the survey after the Pfizer and Moderna EUAs than before these EUAs (85.8% vs 70.4%). Before the EUAs, 23.4% of HCWs were unsure about getting the vaccine and 6.2% reported that they would not get the vaccine; after the EUAs, only 9.6% were unsure and 4.6% reported that they would not get the vaccine (Fig. 1).

Multivariable logistic regression results are shown in Figure 2. Compared to physicians, several occupations were associated with a lower odds of intending to get the vaccine: nurse (OR, 0.24; 95% CI, 0.17–0.33), administrator (OR, 0.41; 95% CI, 0.28–0.58), or other occupational group (OR, 0.27; 95% CI, 0.20–0.36). Non-Hispanic Black HCWs had lower odds of intending to get the vaccine (vs Asians: OR, 0.35; 95% CI, 0.21–0.59), and women had lower odds of intending to get the vaccine (vs men: OR, 0.38, 95% CI, 0.30–0.50). Participants aged 30–39 years also had lower odds of getting vaccinated (vs < 30 years: OR, 0.67; 95% CI,

Table 1. Healthcare Worker Demographics and Characteristics by Intention to get the COVID-19 Vaccine

Characteristics	Yes (N = 3,222), No. (%)	Unsure (N = 728), No. (%)	No (N = 230), No. (%)	Total (N = 4,180), No. (%)	P Value
Occupation					<.001
Physician	739 (92.1)	53 (6.6)	10 (1.2)	802 (100.0)	
Registered Nurses	776 (71.2)	231 (21.2)	83 (7.6)	1,090 (100.0)	
Administrative	526 (79.6)	107 (16.2)	28 (4.2)	661 (100.0)	
Other occupations	1,181 (72.6)	337 (20.7)	109 (6.7)	1,627 (100.0)	
Sex					<.001
Female	2,466 (73.7)	668 (20.0)	214 (6.4)	3,348 (100.0)	
Male	756 (90.9)	60 (7.2)	16 (1.9)	832 (100.0)	
Race/Ethnicity					<.001
Asian	316 (82.9)	51 (13.4)	14 (3.7)	381 (100.0)	
Hispanic/Latino	175 (68.4)	58 (22.7)	23 (9.0)	256 (100.0)	
Multiracial	57 (71.2)	21 (26.2)	2 (2.5)	80 (100.0)	
Non-Hispanic Black	55 (57.3)	26 (27.1)	15 (15.6)	96 (100.0)	
Non-Hispanic White	2,551 (77.8)	559 (17.0)	170 (5.2)	3,280 (100.0)	
AI/AN/NH/PI/Other/NA	68 (78.2)	13 (14.9)	6 (6.9)	87 (100.0)	
Age group					.008
18–29 y	512 (77.8)	108 (16.4)	38 (5.8)	658 (100.0)	
30–39 y	1,013 (73.7)	271 (19.7)	91 (6.6)	1,375 (100.0)	
40–49 y	747 (78.4)	154 (16.2)	52 (5.5)	953 (100.0)	
50–59 y	599 (78.2)	129 (16.8)	38 (5.0)	766 (100.0)	
60+ y	351 (82.0)	66 (15.4)	11 (2.6)	428 (100.0)	
COVID-19 patient exposure in the past month					.39
No	1,556 (77.6)	351 (17.5)	98 (4.9)	2,005 (100.0)	
Unsure	411 (74.9)	104 (18.9)	34 (6.2)	549 (100.0)	
Yes, I think so	237 (76.2)	59 (19.0)	15 (4.8)	311 (100.0)	
Yes, definitely	1,018 (77.4)	214 (16.3)	83 (6.3)	1,315 (100.0)	
Procedure exposure in the past month					<.001
No	1,557 (74.2)	409 (19.5)	132 (6.3)	2,098 (100.0)	
Yes	1,665 (80.0)	319 (15.3)	98 (4.7)	2,082 (100.0)	
COVID-19 exposure out of hospital in the past month					.15
No	2,034 (77.7)	441 (16.9)	142 (5.4)	2,617 (100.0)	
Unsure	658 (75.5)	174 (20.0)	40 (4.6)	872 (100.0)	
Yes, I think so	177 (77.3)	34 (14.8)	18 (7.9)	229 (100.0)	
Yes, definitely	353 (76.4)	79 (17.1)	30 (6.5)	462 (100.0)	
Household COVID-19 exposure					.37
No	3,085 (77.3)	689 (17.3)	218 (5.5)	3,992 (100.0)	
Yes	137 (72.9)	39 (20.7)	12 (6.4)	188 (100.0)	
Household member COVID-19 test result					.47
No	247	66	18	331	
Negative	124 (77.5)	29 (18.1)	7 (4.4)	160 (100.0)	
Positive	123 (71.9)	37 (21.6)	11 (6.4)	171 (100.0)	
Baseline serology result					.46
Negative	3,087 (77.2)	691 (17.3)	222 (5.5)	4,000 (100.0)	
Positive	135 (75.0)	37 (20.6)	8 (4.4)	180 (100.0)	

(Continued)

Table 1. (Continued)

Characteristics	Yes (N = 3,222), No. (%)	Unsure (N = 728), No. (%)	No (N = 230), No. (%)	Total (N = 4,180), No. (%)	P Value
6-mo follow-up serology result					<.001
Did not return	836 (71.0)	259 (22.0)	82 (7.0)	1,177 (100.0)	
Negative	2,239 (80.3)	418 (15.0)	130 (4.7)	2,787 (100.0)	
Positive	147 (68.1)	51 (23.6)	18 (8.3)	216 (100.0)	

Note. AI/AN/NH/PI/Other/NA represents American Indian/Alaska Native/Native Hawaiian/Other Pacific Islander/Other/Did not answer.

Table 2. Other Occupations by Intention to Get the COVID-19 Vaccine

Occupation Category	Yes (N = 1,181), No. (%)	Unsure (N = 337), No. (%)	No (N = 109), No. (%)	Total (N = 1,627), No. (%)
Clinical/Education coordinator	27 (65.9)	13 (31.7)	1 (2.4)	41 (100.0)
High-risk respiratory therapy providers	22 (71.0)	7 (22.6)	2 (6.5)	31 (100.0)
Laboratory personnel	80 (73.4)	20 (18.3)	9 (8.3)	109 (100.0)
Medical assistant	51 (63.0)	15 (18.5)	15 (18.5)	81 (100.0)
Mental health/Counsellor	67 (78.8)	16 (18.8)	2 (2.4)	85 (100.0)
Nurse practitioner	143 (80.8)	29 (16.4)	5 (2.8)	177 (100.0)
Other miscellaneous	150 (77.7)	35 (18.1)	8 (4.1)	193 (100.0)
Patient access/Registration worker	78 (62.9)	36 (29.0)	10 (8.1)	124 (100.0)
Patient care technician or equivalent	74 (67.3)	27 (24.5)	9 (8.2)	110 (100.0)
Pharmacy worker	76 (78.4)	18 (18.6)	3 (3.1)	97 (100.0)
Phlebotomist	18 (64.3)	4 (14.3)	6 (21.4)	28 (100.0)
Physician assistant	84 (84.8)	12 (12.1)	3 (3.0)	99 (100.0)
Physical or occupational therapy/Speech pathologist	138 (72.3)	41 (21.5)	12 (6.3)	191 (100.0)
Radiology/X-ray technician	74 (63.2)	31 (26.5)	12 (10.3)	117 (100.0)
Security/Floor admin	23 (60.5)	11 (28.9)	4 (10.5)	38 (100.0)
Sonographer	28 (59.6)	13 (27.7)	6 (12.8)	47 (100.0)
Support services	21 (67.7)	9 (29.0)	1 (3.2)	31 (100.0)

0.53–0.85). Being exposed to patient procedures (OR, 1.39; 95% CI, 1.16–1.65) or having a negative serology test for SARS-CoV-2 at follow-up (vs no follow-up test: OR, 1.46; 95% CI, 1.24–1.73) increased the odds of vaccination intention. Those participants who completed the survey before the EUAs for vaccines had lower intentions to get vaccinated (OR, 0.34; 95% CI, 0.29–0.41).

At the follow-up survey 4–6 months after vaccination began, of those who completed the survey (n = 3,162), 95.6% had received the vaccine, and there were no significant differences in their characteristics. Most HCWs (90.6%) who had previously been unsure were vaccinated, and 59.7% of those who previously reported no intention of getting vaccinated, also were vaccinated at a later time. Of those who were initially unsure or reported no intention to get vaccinated, there were no significant differences in characteristics between those who eventually were vaccinated by the follow-up survey and those who were not.

Discussion

In this cohort, after COVID-19 vaccines were made available, vaccine intentions were higher among HCWs (77.1%) than estimates

from the general US population, which had reached 49% by February 2021 according to the Centers for Disease Control and Prevention (CDC).¹⁵ More recently by June 2021, 96% of practicing physicians¹⁶ had been fully vaccinated for COVID-19.¹⁷ However, there were considerable differences in intentions across HCW occupational and demographic groups, even after adjustment in multivariable models. Higher vaccine hesitancy rates were observed in groups at higher risk for COVID-19. Most notably, nurses had the lowest intentions of receiving the vaccine even after controlling for demographic and exposure characteristics. These findings are consistent with previous research showing that nurses have lower influenza vaccination rates than physicians,^{18–20} as well as recent research showing similarly lower COVID-19 vaccine acceptance among nurses.²¹ This finding is particularly troublesome because nurses have the highest rates of SARS-CoV-2 infection among HCW groups.¹² Not only could low vaccine uptake put front line nurses at risk for severe COVID-19 or postinfectious sequelae, but prolonged occupational contact with patients and other HCWs also increases the possibility of spread within health-care settings.²² Further research into the perceptions and beliefs that determine vaccine decision making in nurses is urgently

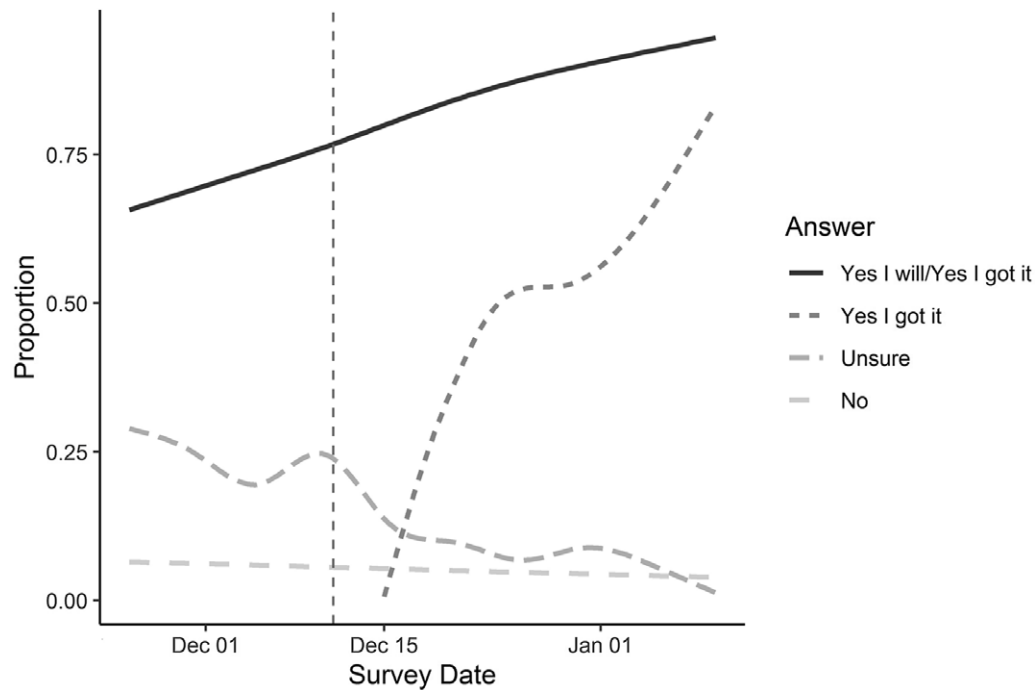


Fig. 1 Participants response to willingness to get vaccinated over time and by timing of first COVID-19 vaccine Emergency Use Authorization (dotted line).¹

needed. Specific concerns of women and those aged 30–39 years may need to be studied further, as their relative higher hesitancy may be related to age or sex-specific reasons such as reproductive concerns. However, the CDC has recommended COVID-19 vaccination for pregnant women and those planning to get pregnant in 2021.^{19,23}

Black participants reported 65% lower odds of intention to get vaccinated than Asian participants. This is consistent with other studies examining COVID-19 vaccine intentions and perceptions in Black non-HCW populations early in the vaccine rollout.^{4,6,24} Higher reporting of being unsure or not being willing to be vaccinated by Black participants, even after controlling for other factors, is concerning due to the disproportionate burden of COVID-19 and severe COVID-19 complications observed in Black people. This study did not assess reasons for vaccine hesitancy or deliberation. Others have found that the fundamental issue of mistrust between the Black community and the broader health system likely undermines vaccine uptake even among HCWs.^{23,25} Approaches that address barriers to COVID-19 vaccination in Black and other marginalized communities should be applied.^{26,27}

Women also had a lower intention to get vaccinated than men. Other studies have found a similar trend.^{4-6,24,28} Concerns with safety of the vaccine may be of key importance for women, especially for those in their reproductive years.²⁹ The CDC now recommends COVID-19 vaccine for pregnant women,^{19,30} and although the COVID-19 vaccination trials did not specifically enroll pregnant women, the risk of severe illness and death is elevated for pregnant versus age- and morbidity-matched controls.

Older age was associated with higher intentions to get vaccinated. This trend has been found in some other studies.^{4-6,24,28} People aged ≥ 65 years are at significant risk for COVID-19 hospitalization and death, and this increased interest in vaccination may reflect recognition by HCWs in this age group of their elevated risk.

Individuals who had negative serology results at follow-up also had higher likelihood of intending to get vaccinated compared to those who had not been tested at follow-up or who were

seropositive at follow-up. Those who had positive serology at follow-up did not differ significantly in intention to those who had not been tested at follow-up. These findings suggest differences in perceptions and misperceptions of immunity following natural infection with SARS-CoV-2. Although previous infection provides some short-term and modest immunity, reinfection is a significant risk³¹ and CDC recommends vaccination, regardless of previous SARS-CoV-2 infection.

Previous studies have shown that people were concerned with EUAs for COVID-19 vaccines and in fact, intentions to get vaccinated were lower with an EUA being associated with the vaccine versus a full approval from the FDA.^{24,32} In this study, completing the survey after the EUA was provided for both the Pfizer and Moderna vaccines was associated with higher intentions to be vaccinated. Several factors may explain the findings of this study that, in many places, COVID-19 rates were increasing during this period due to a 'Thanksgiving surge.' In addition, the widely reported high vaccine effectiveness associated with the Pfizer and Moderna vaccines introduced a level of excitement reflecting the published study results and the growing recognition that this measure was more effective than behavioral prevention measures (mask, social distancing) for reducing risk at work and home and ending the pandemic. Finally, while not as persuasive as full approval, the EUA may have encouraged some HCWs who had previously been hesitant.

Efforts to get HCWs vaccinated in this healthcare system included a tiered system of getting those deemed at most risk (ie, occupational groups working in COVID-19 units) vaccinated first, using e-mail outreach and education fliers across the system, and vaccine availability at all work sites. These findings may have supported the increased vaccine uptake over time, with 90% of HCWs eventually getting vaccinated, including most of those who were initially unsure about getting vaccinated. Thus, minds can be moved to increase uptake. This change over time is particularly important to inform ongoing work, considering that the uptake of vaccine has slowed in the United States and certain communities have shown decreased uptake.

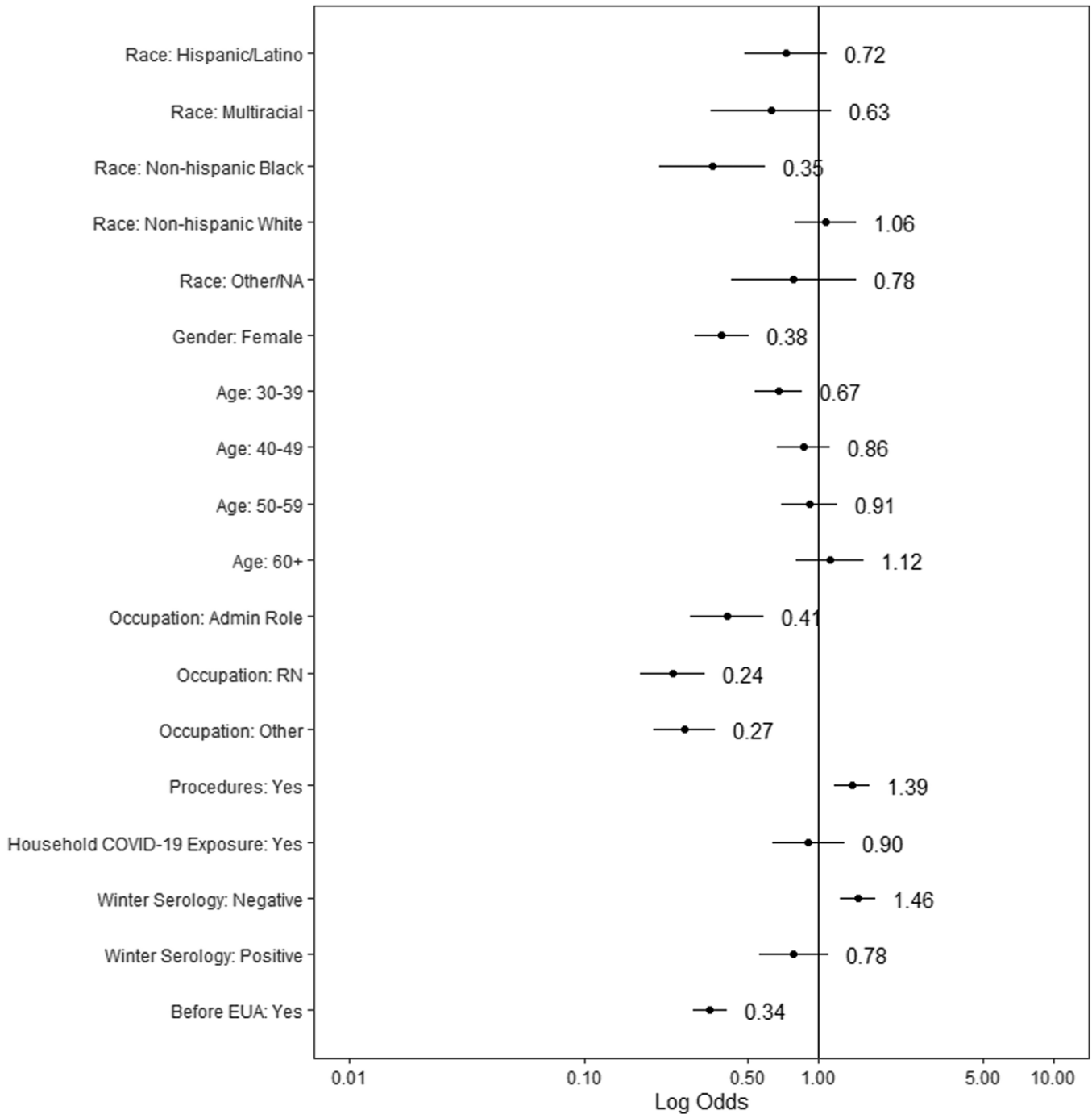


Fig. 2 Multivariable logistic regression model of the association between willingness to get a COVID-19 vaccine and healthcare worker characteristics, adjusted odds ratios and 95% confidence intervals. Reference groups are race (Asian), sex (male), age (<30 years), occupation (physician), procedures (no exposure), household COVID-19 exposure (no exposure), winter serology (no test), before EUA (no).

Our study had some limitations. We did not assess reasons for vaccine hesitancy, and despite the HCW sample's diversity, those who participated differed from our larger enrolled cohort. However, our cohort was comparable to the overall US healthcare workforce in age and sex but had a smaller proportion of Black and Hispanic HCWs.³³ Also, the sample was large and represented HCWs located across a large metropolitan and suburban area whom we followed longitudinally as the vaccines were introduced and evidence in effectiveness and safety continued to emerge.

Despite the risk of exposure and the significant health impact of COVID-19, some hesitancy remained at the start of vaccination availability after the EUA. However, with access and time, vaccination increased. These findings strongly support the public health importance of consistent, accurate messaging about the efficacy and safety of the vaccine, which are tailored to the targeted populations. Although women, those aged 30–39 years, and Black participants had lower intentions of getting vaccinated early in the vaccine rollout, progress (increasing vaccination intention

prevalence) was seen in these groups over time. Understanding how messaging and other factors including mistrust of the healthcare system and inclusion in research can affect perception and uptake in these groups is important to develop effective interventions now and in the future. To achieve this goal, participatory research is needed with HCWs to understand how more effective messaging can be developed and how to address underlying mistrust of the healthcare system generally and vaccines specifically.

Acknowledgments. The opinions, results and conclusions reported are those of the authors. No endorsement by Northwestern Medicine or any of its funders or partners is intended or should be inferred.

Financial support. This work was supported by the Northwestern University Clinical and Translational Sciences Institute and the Northwestern Memorial Foundation.

Conflicts of interest. All authors report no conflicts of interest relevant to this article. Research funding support was received from Novo Nordisk, Eli Lilly, United Healthcare Group (A.W.); consulting fees were received from BioK+ (C.T.E.).

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