COVID-19 Vaccine Uptake and Intent Among Emergency Healthcare Workers

A Cross-Sectional Survey

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Objective: Vaccine hesitancy limits population protection from SARS-CoV (coronavirus disease [COVID-19]). Vaccine hesitancy among healthcare workers (HCW) could put patients and coworkers at risk. **Methods:** We surveyed 475 emergency department and emergency medical service workers from January to February 2021 to determine vaccine intent/uptake, perceived COVID-19 vulnerability, and factors associated with vaccine intent/uptake. **Results:** Although 79% of HCWs received or had plans to receive the COVID-19 vaccine, 21% had no intent/were unvaccinated; intent/uptake was lower among females (odds ratio [OR] = 0.34) and those with a history of COVID-19 infection (OR = 0.55), and higher among those with advanced degrees (OR = 3.53) and high perceived COVID-19 vulnerability (OR = 1.99). **Conclusions:** This study provides a timely assessment of vaccination status among frontline HCWs and highlights subgroups who may be at high risk of exposure and transmission.

Keywords: COVID-19, COVID-19 vulnerability, Emergency Department Staff, Emergency Medical Service Workers, healthcare workers, vaccine hesitancy, vaccine uptake

Since March 2020, healthcare workers (HCWs) within emergency departments (ED) and emergency medical services (EMS) have served on the frontlines of the coronavirus disease (COVID-19) pandemic. In December, 2020, emergency use authorizations were issued for the Modern and Pfizer COVID-19 Vaccines; HCWs in the United States (U.S.) were immediately eligible for vaccination given their critical role in protecting others and maintaining functional health systems, and their high risk of direct and indirect exposure and transmission.[1] Although initial estimates suggested that 60% to 75% of the population must be vaccinated to halt community spread,[2–4] these numbers were modest and the likelihood of achieving herd immunity in regards to COVID-19 is low and/or tentative given a host of factors relating to the disease itself (eg, new variants) and to vaccine eligibility, efficacy, and uptake.[5,6] The World Health Organization identified vaccine hesitancy (ie, delay or refusal of immunization when it is available) as a top 10 global health threat in 2019.[7] Vaccine hesitancy among trusted medical professionals is particularly problematic; HCW often represent stewards of general public health guidance, and their support of the vaccine may significantly contribute to public uptake of vaccines.[1,8]

Despite their medical training/expertise, HCWs, like all individuals, remain vulnerable to cognitive biases and report vaccine hesitancy[8]; prior to vaccine rollout, over half of U.S. firefighters and EMS workers recently reported uncertainty or low acceptability of the COVID-19 vaccine,[9] and two-thirds of HCWs in Los Angeles reported intentions to delay vaccination in October, 2020.[1] Similarly, recently reported COVID-19 vaccine acceptability ranges from 28% to 78% among HCWs outside of the U.S.[10,11] Based on these reports, many HCWs may have elevated vulnerability and in turn, pose transmission risks to vulnerable patients and coworkers.[12] However, the extent to which these findings translate to vaccination uptake is unclear, particularly given that most research in the U.S. was conducted prior to authorizations[1] and recent efficacy reports that may positively impact behavior.[13] To date, one multicenter study documented a COVID-19 vaccine receipt rate of 86% among ED HCWs approximately 3 weeks after vaccine rollout (January 4, 2021); physicians and APPs had the highest rate of COVID-19 vaccine acceptance and receipt.[14] Concerns about vaccine safety were the primary reason for declining the vaccine.[14] Additional research is needed to determine the generalizability of these findings following vaccine rollout, particularly to additional emergency healthcare workers (eg, EMS workers), and to determine whether additional demographic, infection-related, work-related, and social media variables are associated with intent to receive and/or actual receipt of the COVID-19 vaccine, and with COVID-19 vulnerability.

Study Aims

Following emergency use authorizations for the Moderna and Pfizer COVID-19 vaccines, we surveyed emergency ED and EMS workers to: 1) report rates of vaccine uptake and intent to receive the COVID-19 vaccine; 2) determine whether lower perceived COVID-19 vulnerability is associated with intent/uptake; and 3) to determine whether past COVID-19 infection and presence of an underlying health condition is associated with perceived COVID-19 vulnerability.

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Clinical significance: Twenty-one percent of emergency healthcare workers were either unvaccinated or did not intend to receive the COVID-19 vaccine; intent/uptake was lower among females and those with prior COVID-19 infection, and higher among those with advanced degrees and high perceived vulnerability. Increasing intent/uptake among healthcare workers is critical for public health.

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METHODS

Participants

Our target population included 1) HCWs affiliated with a large medical center with locations in Pennsylvania and Maryland and 2) EMS staff affiliated with agencies primarily in Western Pennsylvania, and in surrounding regions (eg, eastern Ohio, Maryland, West Virginia, and southwestern New York). Eligible participants were ≥18 years of age and were ED (physician, nurse, other clinical, and nonclinical personnel) or EMS staff (paramedic, emergency medical technician, flight nurse, or related EMS staff or clinician) in the U.S. The survey was available to ED staff between January 8th and 26th, 2021, and to EMS staff between January 12th and February 12th, 2021; 524 participants began the survey during these time frames.

Procedure

The University of Pittsburgh Human Research Protections Office approved the study. A standard recruitment email was sent to listservs of potentially eligible ED and EMS workers. The email included a study summary, a link to a secure anonymous electronic REDCap survey, and a list of available resources. Given that the study was anonymous, it was not feasible to record the number of HCWs that the survey reached. Participants voluntarily entered into a drawing to win one of twenty-five $100 prizes.

Measures

All survey items were self-reported, and assessed demographic factors, clinical roles, provision of direct care to patients with diagnosed or suspected COVID-19 infection, the presence of an underlying health condition, and two items modified from the Epidemic Pandemic Impacts Inventory[15] to determine COVID-19 testing status; a single item was then created to reflect infection history (eg, positive test) or no infection history (eg, negative test or did not receive COVID-19 testing). We assessed social media exposure to news and information about COVID-19 during the previous week with an item modified from Gao and colleagues[16]; responses ranged from 1 = never to 5 = very often. Perceived COVID-19 vulnerability was assessed using a modified 9-item scale (Cronbach's alpha = 0.78) initially designed to capture risk from the SARS outbreak among HCWs.[17,18] Item responses were averaged to reflect a continuous outcome (1 = strongly disagree to 5 = strongly agree; see Table 2).

Our primary outcome variable was vaccination status, measured through two items: Have you received the COVID-19 vaccine? If the response was "no," participants were prompted as follows: "Will you sign up to receive the 1st dose of the COVID-19 vaccine as soon as possible?" Response options were "yes," "no," and "I am already signed up to receive it." To maximize the sample size for analysis, we created a single binary variable to reflect vaccine intent/uptake, and HCWs were categorized into the following two groups: 1) intent/vaccinated group = those who received or intend to receive the vaccine (eg, will sign up/are signed up for it); or the 2) no intent/unvaccinated group = those who did not receive the vaccine and do not intend to receive it (eg, will not sign up as soon as possible).

Data Analysis

We used STATA/SE version 16 for analyses; $P < 0.05$ was considered statistically significant. Distributions were assessed for normality, and bivariate group differences in vaccination status (ie, intent/vaccinated vs no intent/unvaccinated group) were examined either with chi-square or Fisher's exact test for categorical measures, or *t* test, ANOVA, or Wilcoxon test for continuous measures. We performed univariate logistic regression analyses to estimate associations between vaccine status and covariates. We then constructed multivariate logistic and linear regression models including any variable with a *P*-value < 0.20 to examine the outcomes of vaccination status and perceived COVID-19 vulnerability, respectively. To include the maximum number of respondents, we applied pairwise deletion in each analysis.

RESULTS

Descriptive Statistics

Although 441 (84.2%) of the initial 524 HCW respondents completed *all* survey items, we included 475 HCWs who completed the items specific to vaccination intent/uptake and infection history. Most participants were EMS workers (66.3%; $n = 315$ paramedics and EMTs: basic, advanced, or emergency medical responder); additional job titles were nurses and patient care technicians (14.7%; $n = 70$), physicians (5.3%; $n = 25$), mid-level providers (2.7%; $n = 13$; eg, nurse practitioner, physician assistant; advance practice provider), and 11% ($n = 52$) other (eg, technicians, health unit coordinators, administrative assistants, etc). Participants were 41 years old on average, and primarily White (94.7%); 29% had an underlying health condition. The sample was split evenly between sex (49.3% female). Most participants (89%) provided direct care to patients with diagnosed or suspected COVID-19.

Seventy-nine percent of participants ($n = 377$) either already received the vaccine or had plans to receive it (intent/vaccinated group); 20.6% ($n = 98$) had not been vaccinated and do not have plans to receive it (no intent/unvaccinated group). Two-hundred forty-seven HCWs were tested for COVID-19, and 80 tested positive (32.4% of those tested and 16.7% of the entire sample). See Table 1 for data corresponding to the following bivariate group differences in vaccination status. Vaccine intent and uptake were significantly associated with male sex, presence of an underlying health condition, higher perceived COVID-19 vulnerability, greater exposure to COVID-19 news and information on social media, no COVID-19 infection history, and an advanced educational degree. Moreover, all physicians or APPs were either vaccinated or intended to receive the vaccine, whereas 21% to 27% of nurses ($n = 19$; 27%), EMS ($n = 65$; 21%), and other clinicians and staff ($n = 14$; 27%) were among the no intent/unvaccinated group ($\chi^2 = 12.95$; $P = 0.01$).

In regards to perceived COVID-19 vulnerability (see Table 2), more than half of participants agreed or strongly agreed that their job puts them at great risk, they feel more stress at work, and that they are afraid that they will pass COVID-19 on to others. In addition, 40% or more "agreed" or "strongly agreed" that family and friends are worried they may get infected through them, and they are afraid of falling ill with COVID-19.

Primary Analyses

All variables included in the model demonstrated a *P*-value < 0.20 in relation to vaccine intent/uptake from Table 1. A multivariate logistic regression model revealed that the odds of vaccine intent/uptake was lower among females and those with a history of COVID-19 infection, and higher among those with an advanced degree education and high perceived COVID-19 vulnerability (Table 3). Further, a multivariate linear regression model revealed that perceived COVID-19 vulnerability was greater among those with an underlying health condition and was negatively associated with age, such that older HCWs perceived less COVID-19 vulnerability than younger HCWs (Table 4).

DISCUSSION

Vaccine hesitancy is an important factor impeding community containment of viral pathogens and increasing the probability of mutations that can imperil public health; it is particularly concerning among HCWs given their role in protecting vulnerable patients and their significant influence in messaging widespread

TABLE 1. Bivariate Differences in Vaccine Intent/Uptake by Demographics and Related Factors

Demographics	Full Sample ($N = 475$) N (%); M (SD)	No Intent/ Unvaccinated ($N = 98$)	Intent/ Vaccinated ($N = 377$)	P Value	OR (95% Confidence Interval)
Age	41.01 (13.29) Range 18–75	38.9 (12.4)	41.6 (13.4)	0.08	1.02 (0.99, 1.03)
Missing	15 (3.2%)				
Sex				0.01	
Male	241 (50.7%)	39 (39.8%)	202 (53.9%)		REF
Female	229 (48.2%)	59 (60.2%)	170 (45.3%)		0.56 (0.35, 0.87)
Other (prefer not to answer; third gender)	3 (0.6%)				
Missing	2 (0.4%)				
Race				0.24	
White	450 (94.7%)	91 (92.9%)	359 (95.7%)		REF
Nonwhite (Black, Hispanic, Asian, multiracial, other)	23 (4.8%)	7 (7.1%)	16 (4.3%)		0.58 (0.23, 1.45)
Missing	2 (0.4%)				
Marital status				0.85	
Single (including divorced, widowed, separated)	151 (31.8%)	32 (32.7%)	114 (31.6%)		REF
Married/living with significant other	323 (68%)	66 (67.3%)	257 (68.4%)		0.96 (0.59, 1.53)
Missing	1 (0.2%)				
Job role				*0.01	*12.95
Doctor and Mid-Level Provider	38 (8.0%)	0 (0%)	38 (10.1%)		
Nurse and Patient Care Technicians	70 (14.7%)	19 (19.4%)	51 (13.5%)		
Emergency Medical Services	315 (66.3%)	65 (66.4%)	250 (66.3%)		
Other	52 (10.9%)	14 (14.3%)	38 (10.1%)		
Education				0.01	
No degree	150 (31.6%)	34 (34.5%)	116 (31.3%)		REF
Degree	255 (53.7%)	59 (60.2%)	196 (53.0%)		0.97 (0.60, 1.57)
Advanced/professional degree	63 (13.3%)	5 (5.1%)	58 (15.7%)		3.40 (1.26, 9.15)
Other	7 (1.5%)		7 (1.9%)		
Direct care to patients with COVID-19 or suspected COVID-19				0.96	
Yes	425 (89.5%)	88 (89.8%)	337 (89.6%)		REF
No	49 (10.3%)	10 (10.2%)	39 (10.4%)		0.98 (0.47, 2.04)
Missing	1 (0.2%)				
COVID-19 testing status†				0.02	
Received a positive test	80 (16.8%)	24 (24.5%)	56 (14.8%)		0.54 (0.31, 0.92)
Negative test or not tested for COVID-19	395 (83.2%)	74 (75.5%)	321 (85.2%)		REF
Underlying health condition				0.03	
Yes	139 (29.3%)	20 (20.6%)	119 (31.8%)		1.80 (1.05, 3.08)
No	332 (69.9%)	77 (79.4%)	255 (68.2%)		REF
Prefer not to answer	4 (0.8%)				
Social Media (eg, Twitter, Facebook, Instagram, Reddit, Tumblr, etc)	3.54 (1.24)	3.29 (1.31)	3.61 (1.22)	0.02	1.23 (1.03, 1.47)

*Due to small numbers and a 0 in the no intent/unvaccinated category for Doctors, a logistic regression could not be conducted. These numbers represent the Pearson's Chi-Square and corresponding P value, suggesting differences in vaccine uptake/intent between job roles.

†COVID-19 testing status numbers are greater than 475 because HCWs could have received both a negative and positive test since the beginning of the pandemic; those who endorsed both test results were included in the positive category for final analysis. The outcome was coded as 0 = no intent/unvaccinated and 1 = intent/vaccinated. OR = odds ratio. The "other" and "missing" categories were excluded from all logistic regression analyses given small numbers, and therefore do not have an associated OR. Education was defined as follows: no degree program (eg, high school or some college); degree program (eg, trade, vocational or technical school; associates degree; college degree); advanced degree (eg, postgraduate degree—PhD, DSc, etc or professional degree—MD, DO, DNP, etc). Underlying health condition was specified as high blood pressure, heart disease, lung disease, kidney disease, etc.

COVID-19 vaccine uptake. Most HCWs had either received or intended to receive the COVID-19 vaccine (79%). Although this rate is somewhat lower than vaccine receipt among ED HCWs in a multicenter study in the U.S. (87%),[14] it is consistent with influenza vaccination rates among HCWs during 2017 to 2018 (78.4%),[19] and exceeds vaccine acceptance rates reported by HCWs in the U.S. (<50%)[1,9] and worldwide.[10,11] However, a significant proportion of HCWs was unvaccinated and/or did not intend to receive the vaccine (21%). Given that the majority of extant research was conducted prior to rollout (for exception, see Ref.[14]), the high efficacy of the Moderna and Pfizer vaccines may have contributed to our findings. To this end, prior research suggests that despite high COVID-19 vulnerability, trust in vaccine safety was the strongest predictor of high intentions to receive the vaccine,[20] and safety concerns were the primary reason for declining the vaccine.[14]

A multivariate model revealed varied demographic, work-related, infection-related, and media variables were associated with vaccination intent/uptake: specifically, female HCWs, those without an advanced degree, and those with a positive history of COVID-19 infection and lower perceived COVID vulnerability were more likely to belong to the no intent/unvaccinated group. These results confirm that risk perception is critical to vaccination intention and behavior.[12] In general, when the risk of contracting a disease is low, preventive behaviors and vaccination rates are low.[20] Indeed, those with an underlying condition perceived greater COVID-19 vulnerability in multivariate analyses, and were more likely to be in the intent/vaccinated group in bivariate analyses; contrary to hypotheses, individuals with a history of COVID-19 infection were more likely to be in the no intent/unvaccinated group, potentially due to a low perceived risk of contracting the virus again and/or of severe

TABLE 2. Percentage of Participants Rating Agreement With 9-item Perceived COVID-19 Vulnerability Instrument

Perceived COVID-19 Vulnerability ($n = 460$)	Agree or Strongly Agree
My job puts me at great risk	384 (83.5%)
I feel more stress at work	320 (69.6%)
I am afraid of falling ill with COVID-19	185 (40.2%)
I have little control over whether I get infected or not	146 (31.7%)
I have little chance of survival if I were to get COVID-19	17 (3.7%)
I think of resigning because of COVID-19	39 (8.5%)
I am afraid I will pass COVID-19 to others	301 (65.4%)
My family and friends are worried they might get infected through me	204 (44.4%)
People avoid my family because of my work	125 (27.2%)

TABLE 3. Summary of Logistic Regression Analysis Demonstrating Odds of Vaccine Intent/Uptake

	β	SE *B*	*z*	OR	95% CI	*P* Value
Outcome: Vaccine intent/uptake ($n = 446$)						
Variables						0.000
Age	0.01	0.01	1.32	1.01	0.99, 1.03	0.187
Female sex	−0.59	0.25	−2.33	0.34	0.34, 0.91	0.020
Education: degree	−0.01	0.26	−0.03	0.99	0.59, 1.65	0.977
Advanced degree	1.26	0.57	2.22	3.53	1.16, 10.77	0.026
Health condition	0.32	0.30	1.07	1.38	0.76, 2.50	0.286
Positive Infection History	−0.60	0.29	−2.04	0.55	0.31, 0.98	0.041
Social media exposure	0.20	0.10	1.92	1.22	1.00, 2.90	0.054
COVID-19 vulnerability	0.69	0.19	3.61	1.99	1.37, 2.90	0.000

The outcome was coded as 0 = no intent/unvaccinated and 1 = intent/vaccinated. OR = odds ratio. Sex was coded dichotomously such that 0 = male and 1 = female; three HCWs who preferred not to answer or selected third gender were not included in this model due to small numbers. Education was coded such that 0 = no degree program; 1 = degree program and 2 = advanced degree program; 7 HCWs with "other" responses were not included in this model due to small numbers. Positive Infection History was coded such that 0 = no infection history and/or did not get tested for COVID-19 and 1 = tested positive for COVID-19. Age was analyzed as a continuous variable; subjects provided their age in response to the question "How old are you?" HCWs = healthcare workers.

consequences. Relatedly, females are generally more likely to report vaccine hesitancy[11,21,22] and have a lower risk of severe COVID-related outcomes[23]; this sex difference warrants focused future research on family structure, pre-existing vaccine beliefs and comorbidities, and safety and efficacy concerns.[22]

Despite that the COVID-19 infection disproportionately affects older adults,[24] our results indicate that older HCWs perceive less COVID-19 vulnerability than younger HCWs. These findings are consistent with studies in the general population documenting that, with the exception of perceived risk of mortality,[25] older adults were less concerned about getting COVID-19 and less concerned with the threat of COVID-19 impacting multiple life domains including mental health, finances, and work.[25,26] To this end, our assessment of COVID-19 vulnerability only included one item reflecting perceived mortality (eg, little chance of survival if I were to get COVID-19), whereas the 8 additional items reflected general risk and vulnerability/stress due to COVID-19. Consistent with prior literature, physicians had greater vaccine intent/uptake than other HCWs[1,11,14]; in fact, no physicians or advanced practice providers were in the no intent/unvaccinated group. Additionally, education level was strongly associated with vaccine acceptance. Educational programs similar to the Center for Disease Control and Prevention

TABLE 4. Summary of Linear Regression Analysis Demonstrating Perceived COVID-19 Vulnerability Adjusted for Confounding

	β	SE *B*	*t*	95% CI	*P* Value
Outcome: COVID-19 vulnerability ($n = 446$)					
Model					0.002
Age	−0.01	0.00	−2.06	−0.01, −0.00	0.040
Female sex	0.07	0.06	1.12	−0.06, 0.20	0.263
Education: degree	−0.10	0.07	−1.35	−0.24, 0.04	0.178
Advanced degree	−0.13	0.11	−1.25	−0.35, 0.08	0.211
Health condition	0.26	0.07	3.39	0.11, 0.40	0.001
Positive Infection History	0.08	0.08	0.91	−0.09, 0.25	0.361
Social media exposure	0.05	0.03	1.69	−0.01, 0.10	0.091

Sex was coded dichotomously such that 0 = male and 1 = female; three HCWs who preferred not to answer or selected third gender were not included in this model due to small numbers. Education was coded such that 0 = no degree program; 1 = degree program and 2 = advanced degree program; 7 HCWs with "other" responses were not included in this model due to small numbers. Positive Infection History was coded such that 0 = no infection history and/or did not get tested for COVID-19 and 1 = tested positive for COVID-19. Age was analyzed as a continuous variable; subjects provided their age in response to the question "How old are you?" HCWs = healthcare workers.

web-based toolkit to increase influenza vaccination rates among HCWs may also serve to increase COVID-19 vaccination uptake.[19] Further, research is needed to determine whether and how leveraging social media platforms contribute to vaccination uptake; although our bivariate results suggest that social media served a positive role in vaccination uptake (the association was marginal in multivariate analyses), this finding is contrary to prior work,[11] and the sources of information viewed by HCWs in this study is unknown.

These findings must be interpreted in the context of limitations; given the non-purposive sampling (primarily in Pennsylvania), the cross-sectional design, and our lack of knowledge regarding the number of HCWs reached by the survey, bias may be present in our sample and the extent to which these findings can be generalized to other HCWs is unknown. Additionally, we lack data on the specific reasons that HCWs were not vaccinated and did not intend to sign up for the vaccine; further, vaccine intent/uptake was self-reported, potentially allowing for social desirability to bias responses (eg, some HCWs may have falsely reported that they received or planned to receive the COVID-19 vaccine). However, the anonymous nature of the web-based survey may have reduced that bias. Moving forward, given that vaccine hesitancy is best measured on a continuum from acceptance to refusal of all vaccines,[27] future work may consider including the matrix of determinants of vaccine hesitancy (eg, contextual, individual and group, and vaccine-specific factors that influence the decision to accept, delay, or reject vaccines, etc) to better help address COVID-19 vaccine hesitancy and improve uptake.[28] Finally, our sample was predominantly White, further limiting generalizability; representative samples are critically needed to unpack established racial and ethnic differences in vaccination uptake.[9,14]

CONCLUSION

This study provides a timely assessment of vaccination status among HCWs in the U.S. following emergency use authorizations for the Moderna and Pfizer vaccines. Despite their eligibility, over 20% of ED and EMS staff did not receive or plan to receive the vaccine. We identified specific factors associated with lack of intent/non-vaccinated status and perceived COVID-19 vulnerability, and highlighted subgroups of high-risk HCWs. Future research is warranted to understand the complex relationship between sex, prior infection history and vaccination uptake, the reasons for vaccine delay and refusal, and to develop novel strategies to improve vaccine intent/uptake among critical groups. Given their vital role in the general public health messaging of vaccine efficacy and safety, a unified message from HCWs supporting COVID-19 vaccination is a critical step in facilitating widespread vaccine uptake.[8]

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