




## Original Article

# Examining drivers of coronavirus disease 2019 (COVID-19) vaccine hesitancy among healthcare workers

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### Abstract

**Objective:** To assess characteristics and perceptions associated with vaccine hesitancy among healthcare workers to increase coronavirus disease 2019 (COVID-19) vaccine uptake in this population.

**Design:** Cross-sectional quantitative survey.

**Setting:** A not-for-profit healthcare system in southwestern Virginia.

**Participants:** A convenience sample of 2,720 employees of a not-for-profit healthcare system.

**Methods:** Between March 15 and 29, 2021, we conducted an Internet-based survey. Our questionnaire assessed sociodemographic and work-related characteristics, vaccine experience and intentions, agreement with vaccine-related perceptions, the most important reasons for getting or not getting vaccinated, and trusted sources of information about COVID-19. We used  $\chi^2$  analyses to assess the relationship between vaccine hesitancy and both HCW characteristics and vaccine-related perceptions.

**Results:** Overall, 18% of respondents were classified as vaccine hesitant. Characteristics significantly associated with hesitancy included Black race, younger age, not having a high-risk household member, and prior personal experience with COVID-19 illness. Vaccine hesitancy was also significantly associated with many vaccine-related perceptions, including concerns about short-term and long-term side effects and a belief that the vaccines are not effective. Among vaccine-acceptant participants, wanting to protect others and wanting to help end the pandemic were the most common reasons for getting vaccinated. Personal physicians were cited most frequently as trusted sources of information about COVID-19 among both vaccine-hesitant and vaccine-acceptant respondents.

**Conclusions:** Educational interventions to decrease vaccine hesitancy among healthcare workers should focus on alleviating safety concerns, emphasizing vaccine efficacy, and appealing to a sense of duty. Such interventions should target younger adult audiences. Personal physicians may also be an effective avenue for reducing hesitancy among their patients through patient-centered discussions.

**Keywords:** Vaccine hesitancy; healthcare workers; COVID-19 vaccines

(Received 2 August 2021; accepted 1 February 2022; electronically published 14 February 2022)

The US Food and Drug Administration (FDA) granted emergency use authorization of coronavirus disease 2019 (COVID-19) vaccines developed by Pfizer and Moderna in December 2020, and the Johnson & Johnson vaccine received the same authorization in February 2021. Given the high risk of exposure<sup>1</sup> and the importance of keeping healthcare workers (HCWs) well, the Centers for Disease Control and Prevention (CDC) guidelines prioritized HCWs to receive these vaccines starting in December 2020.<sup>2</sup> However, continued reports suggest that many HCWs in the United States are reluctant to receive the COVID-19 vaccine.<sup>3</sup>

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**Cite this article:** Swann MC, et al. (2022). Examining drivers of coronavirus disease 2019 (COVID-19) vaccine hesitancy among healthcare workers. *Infection Control & Hospital Epidemiology*, 43: 1813–1821, <https://doi.org/10.1017/ice.2022.34>

Although vaccine hesitancy in other contexts has been studied extensively, reasons for HCW reluctance to receive COVID-19 vaccines are not well understood. Studies performed prior to or in the earliest stages of vaccine roll-out identified common HCW barriers to vaccination including concerns about safety, efficacy, and evolving science, as well as perceptions that COVID-19 is mild.<sup>4–8</sup> In some studies, HCWs who were more likely to accept vaccination included those directly involved in COVID-19 patient care or who consider themselves at risk for severe disease,<sup>5</sup> those who believe in vaccine safety,<sup>8</sup> those who believe vaccination will support herd immunity,<sup>8,9</sup> and those who trust public health experts.<sup>4</sup> Being a physician,<sup>5,6</sup> male sex,<sup>3,5</sup> and younger age<sup>9</sup> were also associated with vaccine acceptance among HCWs.

Although these studies provide useful insights, most focused on frontline HCW characteristics and broad vaccine-related perceptions. Additionally, we are not aware of any studies that have

examined trusted sources of COVID-19 information among HCWs to inform message dissemination channels.

In the present study, we assessed specific barriers to vaccine uptake among different types of HCWs, including characteristics and vaccine-related perceptions, that can be used to improve outreach and educational messaging to reduce COVID-19 vaccine hesitancy among HCWs.

## Methods

Between March 15 and 29, 2021, we conducted a cross-sectional survey targeting all 13,690 employees of a not-for-profit healthcare system in southwestern Virginia comprised of a network of hospitals and ambulatory care facilities. Our survey was developed based on existing vaccine hesitancy literature and consisted of multiple-choice questions about personal experiences with COVID-19, COVID-19 vaccine experience and intentions, COVID-19 vaccine-related perceptions, trusted sources of COVID-19 information, and sociodemographic characteristics. Professional role was captured in broad categories: providers (ie, physicians, physician assistants, or nurse practitioners), nursing staff (ie, nurses, nursing assistants, clinical associates, or nursing management), other responsibilities in patient care areas, other responsibilities in non-patient care areas, and managers without patient care responsibilities. We used 5-point Likert scales were used to assess positive and negative vaccine-related perceptions; response options ranged from “strongly disagree” to “strongly agree.” Those who had already received at least 1 dose of vaccine were asked their most important reason for deciding to be vaccinated; all others were asked their most important reason for not being vaccinated.

A small pilot test was conducted with infection control staff and frontline HCWs to support comprehensiveness and clarity. The survey was administered through Research Electronic Data Capture (REDCap), a secure, web-based data collection platform for research. An article with a link to the survey was placed prominently on the healthcare system intranet, and a COVID-19 update from the organization’s leadership included a link to the survey. The study team and infection preventionists distributed flyers with a quick response (QR) code to employee break rooms throughout clinical sites. Confidentiality was assured throughout all promotion efforts. Participants who completed the survey could enter a raffle to win one of ten \$20 gift cards. Employees self-administered the survey electronically on a computer, laptop, tablet, or smartphone. Responses were deidentified before being shared with the study team. We received a determination from our organization’s institutional review board that this study was not human-subjects research.

The COVID-19 vaccine was widely available to staff in numerous easily accessed locations throughout the healthcare system beginning in December 2020. Because data collection occurred 3 months into vaccine availability for this population, we classified respondents as hesitant if they had not received at least 1 dose of the vaccine at the time of survey completion.<sup>10</sup> All other respondents were considered acceptant. We condensed the 5-point Likert responses into 3 categories (ie, “disagree,” “neither agree nor disagree,” and “agree”) by combining the 2 disagreement categories and the 2 agreement categories. For analyses involving personal experience with COVID-19, “unsure” responses were excluded. We calculated frequencies and proportions associated with each survey item by vaccine hesitancy status. We used  $\chi^2$  analyses to identify respondent characteristics and vaccine-related perceptions that were associated with vaccine hesitancy. For

questions with multiple-response options, pairwise comparisons for each response option were performed using the Fisher exact test.

Missing responses were excluded from all analyses. We used the Benjamini–Hochberg false discovery rate control procedure to adjust for multiple comparisons.<sup>11</sup> All analyses were conducted using SAS version 9.4 software (SAS Institute, Cary, NC).<sup>12</sup>

## Results

In total, 2,720 HCWs completed the survey, accounting for just fewer than 20% of all targeted participants. The details of respondents’ sociodemographic and professional characteristics and personal experiences with COVID-19 are presented in Table 1. Female sex (83%) and White race (89%) were slightly overrepresented in our sample compared to the overall employee population. Although nursing staff comprised the largest proportion of survey respondents (34%), response rates were highest among those who identified themselves as managers (60% of managers responded to the survey). For all other role categories, response rates ranged between 14% and 20%.

### Participant characteristics and vaccine hesitancy

Overall, 82% of respondents were considered vaccine acceptant and the remaining 18% were considered vaccine hesitant. Among vaccine-hesitant individuals, 20% indicated an intention to get the vaccine in the future. For each characteristic measured in the survey, Table 2 shows the proportions who were vaccine hesitant and vaccine acceptant. Age was significantly associated with vaccine hesitancy ( $P < .0001$ ). Among participants under the age of 25, 37% were vaccine hesitant compared to only 6% among those aged  $\geq 65$  years (Fig. 1). A higher proportion of women (19%) were vaccine hesitant than men (13%) ( $P < .005$ ).

Participants who self-identified as Black race were more likely to be hesitant than non-Black respondents (25% vs 17%;  $P < .05$ ). Professional role was also associated with hesitancy status ( $P < .0001$ ); HCWs with other responsibilities in non-patient-care areas (22%) and nursing staff (20%) were most likely to be hesitant, whereas providers (7%) were least likely to be hesitant.

Not having a household member at high risk for severe disease was associated with vaccine hesitancy (19% vs 13%;  $P < .0001$ ). Vaccine hesitancy was also more common among respondents with a history of COVID-19 (25%) compared to those without (15%;  $P < .0001$ ). Likewise, 21% respondents who had had a family member or loved one get sick from COVID-19 were vaccine hesitant, a significantly higher proportion than the those without that experience (15%) ( $P < .001$ ). Perceptions of risk both at work ( $P < .0001$ ) and outside of work ( $P < .0001$ ) were significantly associated with vaccine hesitancy.

### Perceptions of safety and vaccine hesitancy

Among vaccine-hesitant participants, 43% cited safety concerns as the most important reason they had not gotten vaccinated (Fig. 2). Unease about safety remained the most common primary reason for not getting vaccinated (23%) among the subset of vaccine-hesitant respondents who intended to get the vaccine in the future. Examining vaccine-related perceptions by hesitancy status, safety concerns were strongly associated with vaccine hesitancy. Table 3 presents responses to Likert-type statements about vaccine-related perceptions dichotomized by hesitancy status.

**Table 1.** Respondent Characteristics

Characteristic	No.	%
<b>Age, y (n = 2,712)</b>		
18–24	118	4.4
25–34	600	22.1
35–44	588	21.7
45–54	682	25.1
55–64	629	23.2
65+	95	3.5
<b>Sex (n = 2,708)</b>		
Female	2,223	82.1
Male	473	17.5
Other	12	0.4
<b>Race/Ethnicity (n = 2,720)<sup>a</sup></b>		
African American/Black	151	5.6
American Indian/Alaska Native	26	1.0
Asian/Pacific Islander	70	2.6
Caucasian/White	2,444	89.9
Hispanic/Latino(a)	41	1.5
Other	27	1.0
<b>Role at Carilion (n = 2,715)</b>		
Provider	211	7.8
Nursing staff	924	34.0
Management	310	11.4
Other (patient care)	663	24.4
Other (nonpatient care)	607	22.4
<b>Work setting (n = 2,656)</b>		
Outpatient	865	32.6
Both	512	19.3
Other	521	19.6
<b>Have you had COVID-19 before? (n = 2,716)</b>		
Yes	410	15.1
No	2,124	78.2
Unsure	182	6.7
<b>Have you had a family member or loved one become ill due to COVID-19? (n = 2,701)</b>		
Yes	1,191	44.1
No	1,468	54.4
Unsure	42	1.6
<b>Have you had a family member or loved one die as a result of COVID-19? (n = 2,688)</b>		
Yes	212	7.9
No	2,465	91.7
Unsure	11	0.4
<b>Is there anyone living in your household that may be considered high-risk for a bad outcome? (n = 2,694)</b>		
Yes	859	31.9
No	1,742	64.7
Unsure	93	3.5

<sup>a</sup>Respondents were able to select multiple racial/ethnic categories.

Responses to the statement “I believe the COVID-19 vaccine is safe” were significantly associated with hesitancy status ( $P < .0001$ ). Only 17% of vaccine-hesitant individuals agreed with this statement compared with 77% of vaccine-acceptant individuals. Perceptions about fast-tracked vaccine development were also associated with hesitancy status ( $P < .0001$ ). Among those who were vaccine hesitant, 79% felt that vaccine development was rushed without sufficient quality control, whereas only 11% of vaccine acceptant participants shared this view. Similarly, views about the sufficiency of information to make an informed decision about getting vaccinated were associated with hesitancy status ( $P < .0001$ ). Even though only 20% of vaccine-hesitant participants felt that adequate data were available, 66% of vaccine-acceptant individuals did. On specific safety concerns, worry over unknown, long-term side effects of the vaccine and concerns about the vaccine affecting a current pregnancy or future ability to have children were both significantly ( $P < .0001$ ) associated with hesitancy status.

### Perceptions of efficacy and vaccine hesitancy

Responses to the statement “I believe the COVID-19 vaccine is effective in preventing COVID-19” were significantly associated with hesitancy status ( $P < .0001$ ), and only 23% of vaccine-hesitant individuals agreed with this statement. However, agreement jumped to 75% among vaccine-acceptant individuals. Also, 30% of hesitant participants agreed that the vaccine would help end the pandemic compared to 80% of vaccine-acceptant participants ( $P < .0001$ ). In addition, 35% of vaccine-hesitant participants believed that natural immunity would be more protective than a vaccine, whereas only 7% of acceptant individuals agreed with this statement ( $P < .001$ ).

### Drivers of vaccine acceptance

For vaccine-acceptant individuals, wanting to do their part to end the pandemic (27%) and wanting to protect family members (26%) were the most important reasons for getting vaccinated (Fig. 3). When asked about trusted sources of COVID-19 information, personal physicians were cited more frequently than other sources by both vaccine-hesitant (48%) and vaccine-acceptant (38%) participants (Fig. 4).

### Discussion

Our findings align with previous studies reports that providers were more vaccine acceptant than other HCWs like nursing staff.<sup>5,6</sup> Our survey also included nonclinical staff and thus provides a more nuanced picture revealing high levels of vaccine hesitancy among workers in both clinical and nonclinical settings. This finding indicates that perception of work-related risk is not the sole driver of this association, suggesting that vaccine-related outreach may be needed in both contexts with a focus on nursing and nonmanagement staff.

Even though HCWs in our system had similar and easy access to the vaccine, Black respondents to our survey demonstrated higher levels of hesitancy than non-Blacks. This finding mirrored hesitancy rates for the general population early in the vaccine rollout.<sup>13</sup> Although the proportion of Blacks in the United States who are vaccinated is still lower than other races and ethnicities, more recent data indicate that racial disparities in vaccine uptake have diminished over time.<sup>14</sup> This difference may be in part due to more equitable vaccine access. Strategies that address structural barriers

**Table 2.** Vaccine Hesitancy by Respondent Characteristics

Characteristic	Vaccine Hesitancy Status				$\chi^2$ P Value
	Hesitant		Acceptant		
	No.	%	No.	%	
Total	482	17.7%	2,238	82.3%	
<b>Age, y</b>					<.0001
18–24	44	37.3	74	62.7	
25–34	148	24.7	452	75.3	
35–44	110	18.7	478	81.3	
45–54	111	16.3	571	83.7	
55–64	61	9.7	568	90.3	
65+	6	6.3	89	93.7	
<b>Sex<sup>a</sup></b>					.0037
Female	411	18.5	1,812	81.5	
Male	61	12.9	412	87.1	
<b>Race/Ethnicity<sup>b</sup></b>					
African American/Black	38	25.2	113	74.8	.0206
American Indian/Alaska native	7	26.9	19	73.1	.2035
Asian/Pacific Islander	8	13.3	52	86.7	.5106
Caucasian/White	415	17.0	2,029	83.0	.0035
Hispanic/Latino(a)	11	26.8	30	73.2	.1461
Other	13	48.1	14	51.9	.0003
<b>Role at Carilion</b>					<.0001
Provider	15	7.1	196	92.9	
Nursing staff	182	19.7	742	80.3	
Management	34	11.0	276	89.0	
Other (patient care)	116	17.5	547	82.5	
Other (nonpatient care)	134	22.1	473	77.9	
<b>Work setting</b>					.0775
Inpatient	121	16.0	637	84.0	
Outpatient	162	18.7	703	81.3	
Both	77	15.0	435	85.0	
Other	105	20.2	416	79.8	
<b>I believe I am at risk of getting COVID-19 while at work</b>					.0001
Agree	145	13.8	902	86.2	
Unsure	140	20.9	530	79.1	
Disagree	195	19.5	804	80.5	
<b>I believe I am at risk of getting COVID-19 outside of work</b>					<.0001
Agree	109	12.3	778	87.7	
Unsure	178	20.5	692	79.5	
Disagree	194	20.3	760	79.7	
<b>Have you had COVID-19 before?</b>					<.0001
Yes	101	24.6	309	75.4	
No	321	15.1	1,803	84.9	
<b>Have you had a family member or loved one become ill due to COVID-19?</b>					.0004
Yes	244	20.5	947	79.5	
No	223	15.2	1,245	84.8	

(Continued)

Table 2. (Continued)

Characteristic	Vaccine Hesitancy Status				$\chi^2$ P Value
	Hesitant		Acceptant		
	No.	%	No.	%	
Have you had a family member or loved one die as a result of COVID-19?					.9623
Yes	37	17.5	175	82.5	
No	203	21.3	752	78.7	
Is there anyone living in your household who might be considered high-risk for a bad outcome?					<.0001
Yes	111	12.9	748	87.1	
No	336	19.3	1,406	80.7	

<sup>a</sup>Due to small sample size, respondents who selected “Other” were excluded from the present analysis.

<sup>b</sup>Respondents were able to select more than one racial/ethnic category which precluded the use of  $\chi^2$  testing. As a result, the Fisher exact tests was used to perform pairwise comparisons for each racial/ethnic category.

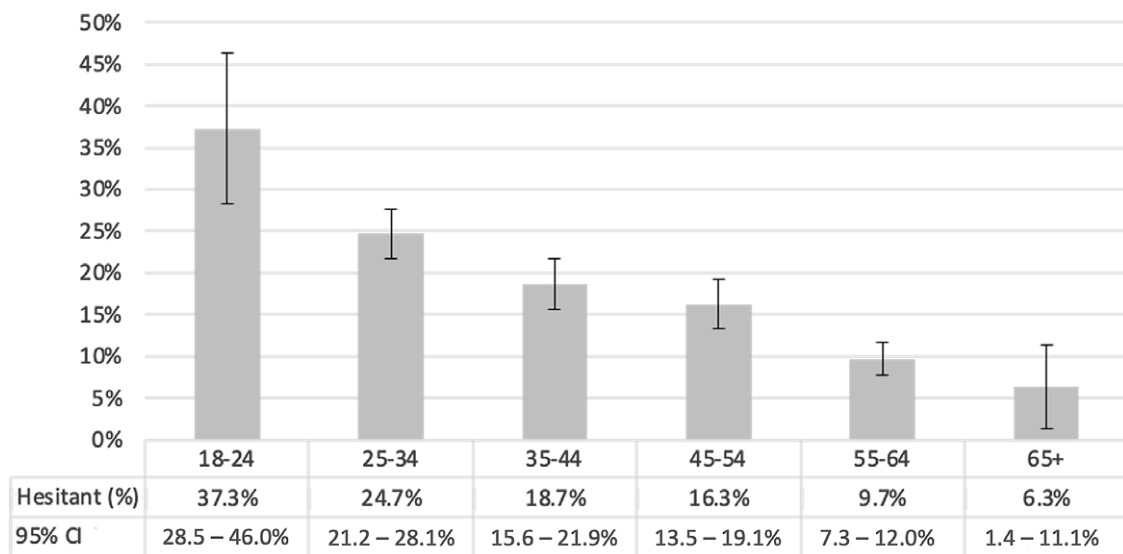


Fig. 1. Vaccine hesitancy by age (proportion hesitant and 95% confidence interval).

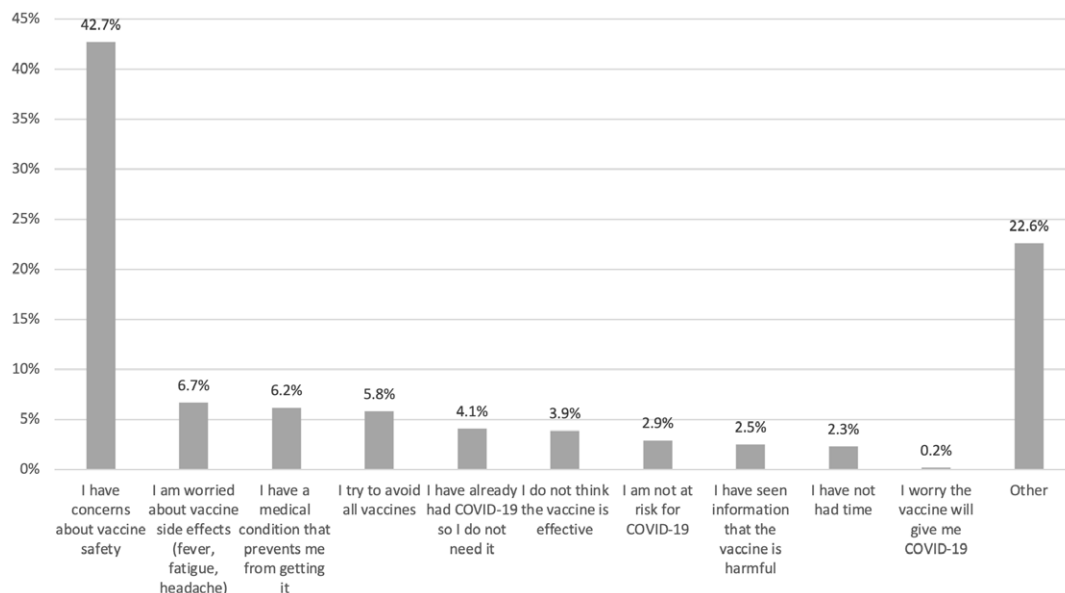


Fig. 2. Most important reasons for not getting vaccinated.

**Table 3.** Vaccine Perceptions by Hesitancy Status

Survey Item	Agree		Unsure		Disagree		$\chi^2$ P Value
	No.	%	No.	%	No.	%	
I believe the COVID-19 vaccine is safe							<.0001
Hesitant	81	16.9	155	32.4	242	50.6	
Acceptant	1,703	76.7	396	17.8	122	5.5	
I feel there is enough information/data about the COVID-19 vaccine to make an informed decision							<.0001
Hesitant	96	19.9	109	22.6	277	57.5	
Acceptant	1,468	65.7	511	22.9	255	11.4	
I believe the COVID-19 vaccine is effective in preventing COVID-19							<.0001
Hesitant		22.8	215	45.0	154	32.2	
Acceptant		74.8	457	20.6	101	4.6	
I believe the COVID-19 vaccine will help stop the pandemic							<.0001
Hesitant		29.7	176	36.5	163	33.8	
Acceptant		79.5	332	15.0	122	5.5	
I feel that COVID-19 vaccine development was rushed without sufficient quality control							<.0001
Hesitant		78.5	11	2.9	71	18.6	
Acceptant		11.4	592	26.5	1,388	62.1	
I am worried about the known/reported short-term side effects from the COVID-19 vaccine (eg, fever, fatigue, headache)							<.0001
Hesitant		46.0	127	26.5	132	27.5	
Acceptant		11.7	380	17.1	1,582	71.2	
I am worried about potential (unknown) long-term side effects of the COVID-19 vaccine							<.0001
Hesitant		83.1	59	12.3	22	4.6	
Acceptant		32.0	589	26.5	920	41.4	
I am concerned about information I have seen that the vaccine is very harmful							<.0001
Hesitant		24.3	185	38.5	179	37.2	
Acceptant		6.9	369	16.6	1,699	76.5	
I am worried the vaccine will negatively affect a current pregnancy or my future ability to have children							<.0001
Hesitant		31.7	134	28.1	192	40.3	
Acceptant		5.1	542	24.7	1,543	70.2	
I am worried that the vaccine will give me COVID-19							<.0001
Hesitant		5.5	74	15.5	376	79.0	
Acceptant		1.9	75	3.4	2,097	94.8	
I believe natural immunity from getting COVID-19 is more protective than a vaccine							<.0001
Hesitant		35.4	200	41.7	110	22.9	
Acceptant		7.3	635	28.6	1,426	64.1	
COVID-19 is not that dangerous so I do not need a vaccine							<.0001
Hesitant		11.0	143	29.7	285	59.3	
Acceptant		2.2	109	4.9	2,071	93.0	
In general, I try to avoid vaccinations							<.0001
Hesitant		22.9	96	20.0	274	57.1	
Acceptant		5.7	140	6.3	1,945	88.0	

and mistrust of the scientific community may further reduce vaccine hesitancy among Blacks.<sup>15–17,18</sup> Like Dror *et al*,<sup>18</sup> we found that vaccine hesitancy was more common among female HCWs, running counter to the higher COVID-19 vaccination rates among women in the general population.<sup>18</sup> In our study, concerns about the vaccine affecting fertility or future child-bearing ability were

cited by a substantial proportion of both vaccine-hesitant men (22%) and vaccine-hesitant women (34%). This concern in HCWs can be alleviated by highlighting more recent research that addresses the safety of the vaccine in the context of both pregnancy and fertility,<sup>19,20</sup> but this perception may continue to drive vaccine hesitancy for some.<sup>21</sup>



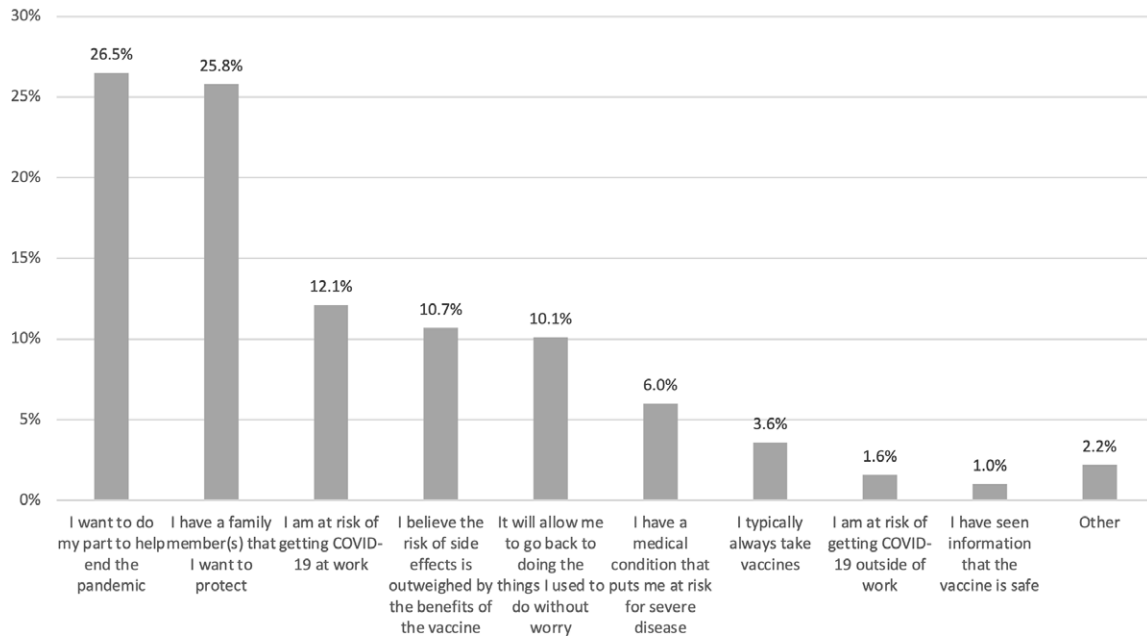


Fig. 3. Most important reasons for getting vaccinated.

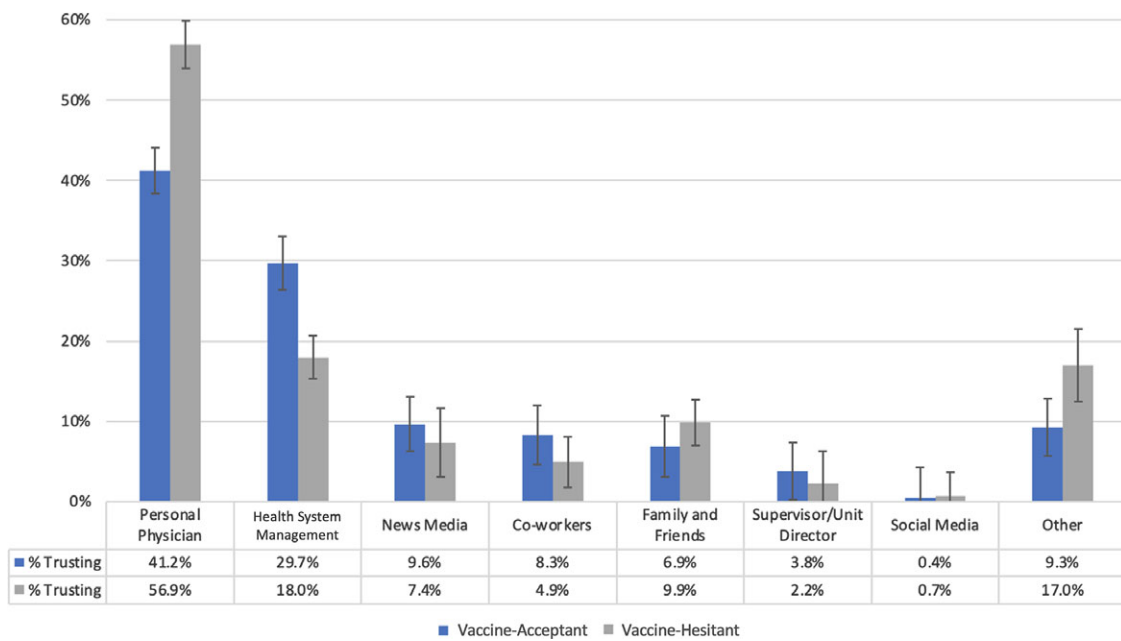


Fig. 4. Trusted sources of information by vaccine hesitancy status (percent and 95% confidence interval).

Our data suggest that vaccine outreach should target younger HCWs. Older individuals have been more susceptible to severe disease throughout the COVID-19 pandemic; thus, it is unsurprising that they are more accepting of the vaccine even in a healthcare context in which vaccines were not prioritized by age. With virus variants taking hold throughout the United States and with many older adults already vaccinated, younger adults are now experiencing a more substantial burden of disease and comprise most recent COVID-19 hospitalizations.<sup>18</sup> In addition, one study found that adults aged 20–49 years are currently driving transmission in the United States, making this age group an important population for epidemic control.<sup>22</sup>

The observed association between low risk perception and vaccine hesitancy is consistent with existing research.<sup>5</sup> Unexpectedly, in our study, experience with COVID-19—either a personal history of infection or a loved one having the disease—was associated with greater vaccine hesitancy. This difference may be because individuals with a personal history feel they already have sufficient natural immunity, or perhaps because those with a personal and/or family history of COVID-19 may have a lower perception of risk, having survived the disease. Alternatively, it is possible that the association is attributable to broader attitudes about the pandemic. One study reported that participants who did not engage in protective behaviors such as social distancing and masking were less

likely to report an intention to vaccinate.<sup>23</sup> Because these behaviors are known to reduce the incidence of COVID-19, these findings might help explain the observed relationship.

Consistent with prior studies, we found that overcoming vaccine hesitancy among HCWs will require addressing common safety concerns, especially fears around possible long-term side effects. Alleviating vaccine safety fears in a context of fast-tracked development and evolving science will be paramount, and public health messaging should focus on the decades-long development of mRNA vaccine technology.<sup>24</sup> Addressing other common fears, such as concerns about effects on fertility and serious side effects such as blood clots, while debunking pervasive myths like the vaccine having a tracking microchip or altering DNA,<sup>25</sup> will likely be needed to encourage vaccination among some vaccine-hesitant HCWs. Studies of vaccine hesitancy in other contexts suggest that approachable scientific messaging may be beneficial.<sup>26</sup>

At this stage of vaccine roll-out, it may be a challenge to overcome the sentiment that there is insufficient information available to make an informed vaccination decision. Interestingly, 34% acceptant individuals did not feel that there was enough information, and a similar proportion of acceptant individuals (32%) had concerns about potential long-term side effects. Future research should examine how such individuals overcame these barriers, which could have implications for encouraging hesitant individuals to get vaccinated.

The finding that vaccine hesitancy was associated with perceptions of low efficacy indicate a need for clearer, more approachable public health messaging about the well-documented protective benefits of the vaccine for the individual and the community. Wanting to protect others was the most important reason for getting vaccinated for most acceptant participants in our study. This finding indicates that messaging emphasizing protecting loved ones and contributing to a collective effort may be effective at increasing uptake, particularly among those less concerned about their personal risk.

In our study, personal physicians were a trusted source of information on COVID-19, particularly for hesitant individuals (Fig. 4). Recent publications describe different categories of COVID-19 vaccine hesitancy based on influences, fears, barriers, and motivations, each requiring different strategies to address.<sup>27–29</sup> This situation implies that transitioning vaccine delivery to more personalized channels such as doctors' offices could reduce hesitancy. Through patient-centered conversations, trusted medical professionals can address these individual influences on hesitancy through active listening and tailored messaging. Our findings suggest that these conversations will be most effective if they address safety concerns while reinforcing efficacy and community benefits.

This study has several important limitations. We relied on a convenience sample of participants, so our findings may not be generalizable to the entire population of HCWs in this healthcare system or to healthcare systems in different settings given the narrow geographic scope of the study. Additionally, our reliance on e-mail and computers or smartphones for survey administration likely reduced participation among individuals and departments that do not use these technologies in their day-to-day work. However, the similar response rates we observed across nonmanagement positions suggests that our sample likely represents the diverse roles in this healthcare system.

Because our survey was administered through work channels, responses may have been subject to social desirability bias. However, self-administration has been shown to reduce this

bias.<sup>30</sup> In addition, participants were assured that their data would be private and deidentified in survey-related communications and within the questionnaire. Administrative data indicated that ~63% of staff were vaccinated at the time of the survey; therefore, vaccine-acceptant staff are overrepresented in our study. However, the high number of responses even among those who were unvaccinated indicates that some employees were comfortable responding openly about vaccine hesitancy.

All data were collected during a 2-week span, prior to the emergence of key variants including the  $\delta$  (delta) variant. In the context of a pandemic, in which information about COVID-19, data on vaccine safety and efficacy against different variants, and reports of adverse events are continually evolving, our survey may not reflect newer perceptions about the vaccine. This study was also conducted prior to vaccine mandate discussions or requirements in healthcare settings. However, an understanding of the drivers of hesitancy can inform complementary strategies that support the implementation of mandates while maintaining HCW job satisfaction and patient care standards.

Future plans for these data include analyses that will deepen our understanding of the drivers of vaccine hesitancy by controlling for potential confounders. An analysis of the subset of hesitant individuals who indicated receptivity to receiving the COVID-19 vaccine in the future is also forthcoming. Additionally, many respondents provided free-text responses when asked about their most important reasons for not getting vaccinated. A qualitative analysis of these responses may provide a more nuanced understanding of vaccine hesitancy. Nevertheless, this study fills a gap in the literature, providing empirical evidence about characteristics and perceptions associated with COVID-19 vaccine hesitancy among HCWs. As vaccine demand continues to wane, additional strategies are needed to achieve herd immunity. The characteristics and perceptions associated with vaccine hesitancy, along with the trusted sources of information identified in this study, provide a roadmap to encourage greater vaccine acceptance among HCWs, including improved educational messaging. Personalized efforts by physicians and approachable public health messaging that center on alleviating safety concerns, emphasizing vaccine effectiveness, and promoting a culture of “doing your part” to protect others may be most effective.

**Acknowledgments.** We thank Mattie Tenzer and Hunter Sharp from Carilion Clinic Health Analytics and Ruth Ndolo, Research Nurse for this study. Finally, we thank all the respondents who shared their information with us.

**Financial support.** The REDCap platform is supported by the National Center for Advancing Translational Sciences of the National Institutes of Health (grant nos. UL1TR003015 and KL2TR003016). The content is solely the responsibility of the authors and does not represent the views of the National Institutes of Health. We received no other financial support.

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

## References

1. Abelson R. COVID overload: US hospitals are running out of beds for patients. *New York Times* website. <https://www.nytimes.com/2020/11/27/health/covid-hospitals-overload.html>. Published November 28, 2020. Accessed February 10, 2022.
2. Dooling K, McClung N, Chamberland M, *et al*. The Advisory Committee on Immunization Practices' interim recommendation for allocating initial supplies of COVID-19 vaccine—United States. *Morb Mortal Wkly Rep* 2020;69:1857–1859.



3. Lazer D, Perlis RH, Ognyanova K *et al.* The COVID states project #40: COVID-19 vaccine attitudes among healthcare workers. *OSFPreprints* 2021. doi: [10.31219/osf.io/p4q9h](https://doi.org/10.31219/osf.io/p4q9h).
4. Lucia VC, Kelekar A, Afonso NM. COVID-19 vaccine hesitancy among medical students. *J Public Health* 2021;43:445–449.
5. Dror AA, Eisenbach N, Taiber S, *et al.* Vaccine hesitancy: the next challenge in the fight against COVID-19. *Eur J Epidemiol* 2020;35:775–779.
6. Gadoth A, Halbrook M, Martin-Blais R, *et al.* Assessment of COVID-19 vaccine acceptance among healthcare workers in Los Angeles. *medRxiv* 2020. doi: [10.1101/2020.11.18.20234468](https://doi.org/10.1101/2020.11.18.20234468).
7. Grech V, Gauci C, Agius S. Vaccine hesitancy among Maltese healthcare workers toward influenza and novel COVID-19 vaccination. *Early Hum Dev* 2020. doi: [10.1016/j.earlhumdev.2020.105213](https://doi.org/10.1016/j.earlhumdev.2020.105213).
8. Barry M, Temsah MH, Alhuzaimi A, *et al.* COVID-19 vaccine confidence and hesitancy among healthcare workers: a cross-sectional survey from a MERS-CoV experienced nation. *medRxiv* 2020. doi: [10.1101/2020.12.09.20246447](https://doi.org/10.1101/2020.12.09.20246447).
9. Kwok KO, Li KK, WEI WI, Tang A, Wong SYS, Lee SS. Influenza vaccine uptake, COVID-19 vaccination intention and vaccine hesitancy among nurses: a survey. *Int J Nurs Stud* 2021;114:103854.
10. MacDonald NE. Vaccine hesitancy: definition, scope and determinants. *Vaccine* 2015;33:4161–4164.
11. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J R Stat Soc Ser B* 1995;57:289–300.
12. The SAS system for Windows. SAS Institute website. <http://www.sas.com>. Published 2013. Accessed February 10, 2022.
13. Intent to get a COVID-19 vaccine rises to 60% as confidence in research and development process increases. Pew Research Center website. <https://www.pewresearch.org/science/2020/12/03/intent-to-get-a-covid-19-vaccine-rises-to-60-as-confidence-in-research-and-development-process-increases/>. Published 2020. Accessed February 10, 2022.
14. Ndugga N, Hill L, Artiga S, Haldar S. Latest data on COVID-19 vaccinations by race/ethnicity. Kaiser Family Foundation website. <https://www.kff.org/coronavirus-covid-19/issue-brief/latest-data-on-covid-19-vaccinations-by-race-ethnicity/>. Published 2022. Accessed February 10, 2022.
15. Dada D, Djiometio JN, McFadden SM, *et al.* Strategies that promote equity in COVID-19 vaccine uptake for black communities: a review. *J Urban Health* 2022. doi: [10.1007/s11524-021-00594-3](https://doi.org/10.1007/s11524-021-00594-3).
16. Boulware LE, Cooper LA, Ratner LE, LaVeist TA, Powe NR. Race and trust in the healthcare system. *Public Health Rep* 2003;118:358–365.
17. Njoku A, Joseph M, Felix R. Changing the narrative: structural barriers and racial and ethnic inequities in COVID-19 vaccination. *Int J Environ Res Public Health* 2021;18:9904.
18. COVID data tracker. Centers for Disease Control and Prevention website. <https://covid.cdc.gov/covid-data-tracker/#vaccination-demographics-trends>. Published 2021. Accessed May 14, 2021.
19. Wesselink AK, Hatch EE, Rothman KJ, *et al.* A prospective cohort study of COVID-19 vaccination, SARS-CoV-2 infection, and fertility. *Am J Epidemiol* 2022. doi: [10.1093/aje/kwac011](https://doi.org/10.1093/aje/kwac011).
20. Hillson K, Clemens SC, Madhi SA, Voysey M, Pollard AJ, Minassian AM. Fertility rates and birth outcomes after ChAdOx1 nCoV-19 (AZD1222) vaccination. *Lancet* 2021;398:1683–1684.
21. Hamel L, Lopes L, Sparks G, *et al.* KFF COVID-19 vaccine monitor: October 2021. Kaiser Family Foundation website. <https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-october-2021/>. Published October 2021. Accessed February 10, 2022.
22. Monod M, Blenkinsop A, Xi X, *et al.* Age groups that sustain resurging COVID-19 epidemics in the United States. *Science* 2021;371(6536):eabe8372.
23. Latkin CA, Dayton L, Yi G, Colon B, Kong X. Mask usage, social distancing, racial, and gender correlates of COVID-19 vaccine intentions among adults in the US. *PLoS One* 2021;16(2):e0246970.
24. Thompson D. How mRNA technology could change the world. *The Atlantic* website. <https://www.theatlantic.com/ideas/archive/2021/03/how-mrna-technology-could-change-world/618431/>. Published 2021. Accessed February 10, 2022.
25. Frequently asked questions about COVID-19 vaccination. Centers for Disease Control and Prevention website. [https://www.cdc.gov/coronavirus/2019-ncov/vaccines/faq.html?CDC\\_AA\\_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fvaccines%2Fkeythingstoknow.html](https://www.cdc.gov/coronavirus/2019-ncov/vaccines/faq.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fvaccines%2Fkeythingstoknow.html). Updated February 2, 2022. Accessed February 10, 2022.
26. Kuru O, Stecula D, Lu H, *et al.* The effects of scientific messages and narratives about vaccination. *PLoS One* 2021;16(3):e0248328.
27. Elwy AR, Clayman ML, LoBrutto L, *et al.* Vaccine hesitancy as an opportunity for engagement: a rapid qualitative study of patients and employees in the US Veterans' Affairs healthcare system. *Vaccine X* 2021. doi: [10.1016/j.jvaxc.2021.100116](https://doi.org/10.1016/j.jvaxc.2021.100116).
28. Wiysonge CS, Ndwandwe D, Ryan J, *et al.* Vaccine hesitancy in the era of COVID-19: could lessons from the past help in divining the future? *Hum Vaccin Immunother* 2021. doi: [10.1080/21645515.2021.1893062](https://doi.org/10.1080/21645515.2021.1893062).
29. Thompson D. The surprising key to combatting vaccine refusal. *The Atlantic* website. <https://www.theatlantic.com/ideas/archive/2021/02/vaccine-hesitancy-isnt-just-one-thing/618164/>. Published online February 2021. Accessed February 10, 2022.
30. Krumpal I. Determinants of social desirability bias in sensitive surveys: a literature review. *Qual Quant* 2013;47:2025–2047.