

Factors affecting COVID-19 vaccine hesitancy among healthcare providers in 23 countries

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ABSTRACT

Background: Several early COVID-19 studies aimed to assess the potential acceptance of a vaccine among healthcare providers, but relatively few studies of this population have been published since the vaccines became widely available. Vaccine safety, speed of development, and low perceived disease risk were commonly cited as factors for COVID-19 vaccine hesitancy among this group.

Purpose and methods: In a secondary analysis based on a cross-sectional, structured survey, the authors aimed to assess the associations between self-reported vaccine hesitancy and a number of sociodemographic and COVID-19 vaccine perception factors using data from 3,295 healthcare providers (physicians, nurses, community health workers, other healthcare providers) in 23 countries.

Findings: 494 (15.0%) of the participants reported vaccine hesitancy, of whom 132 (4.0%) would outright refuse to accept a COVID-19 vaccine. Physicians were the least hesitant. Vaccine hesitancy was more likely to occur among those with less than the median income and, to a lesser degree, younger age. Safety and risk concerns and lack of trust that vaccines would be equitably distributed were strongly associated with hesitancy, less so were concerns about the efficacy of COVID-19 vaccines.

Interpretation: Findings suggest a need to address safety and risk concerns through tailored messaging, training, and/or incentive approaches among healthcare providers, as well as the need for international and national vaccination efforts to ensure equitable distribution.

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1. Introduction

The Coronavirus Disease 2019 (COVID-19), caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first recognized in late 2019 and declared a global pandemic in March 2020 [1]. As of January 2022, over 300 million cases resulting in nearly 5.5 million deaths have been reported globally [2]. International collaborations resulted in the rapid development of various COVID-19 vaccines that were approved for distribution in 2020 with emergency use authorizations [3]; in most countries, healthcare providers and staff in long-term care facilities were recognized as priority groups for vaccination due to the initially limited supply [4]. In June 2020, we surveyed 13,426 people in 19 countries to determine potential acceptance rates and factors

influencing acceptance of a COVID-19 vaccine [5] and followed this up with a similar survey in 23 countries in June 2021 [6]. We found that 75.2% of the 23,000 respondents in June 2021 reported vaccine acceptance, a slight increase compared to 71.5% one-year earlier, and in line with similarly reported global acceptance rates [7–10]. Studies evaluating COVID-19 vaccine acceptance among healthcare providers have been conducted in single-country surveys with efficacy and safety concerns being more commonly evaluated than sociodemographic factors, which are associated with hesitancy among the general public [5].

Vaccine hesitancy is defined as the delay in acceptance or refusal to vaccinate despite readily available supply and services and persists as a pervasive public health problem among healthcare providers globally [11–13]. Acceptance of novel COVID-19 vaccines underpins the potential success of current global immunization campaigns. Vaccine hesitancy among healthcare providers may threaten this success via these providers' influential position as trusted sources for vaccination [14]. Unvaccinated, patient-facing

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healthcare workers pose a threat to patients and to other healthcare workers themselves, as well as the healthcare system. Therefore, drivers of vaccine hesitancy in this group should be explored to be better understood and addressed. While the literature regarding COVID-19 vaccination has increased greatly, relatively little has been published specific to healthcare providers. Moreover, most of the existing literature assessed one's intention to vaccinate, which differentiates from explicit acceptance (i.e., behavior) [15]; vaccination intentions do not always correlate with vaccination behaviours [16]. Hesitancy towards vaccination is also contextually dependent, varying across time and by vaccination type, and factors associated with vaccine hesitancy in the general population may not be generalizable to healthcare providers regarding novel COVID-19 vaccines [17].

To help address the paucity of global data regarding COVID-19 vaccine acceptance/hesitancy among various cadres of healthcare providers, we conducted a sub-analysis of the aforementioned global survey fielded in 23 countries in June 2021 to measure their hesitancy towards receiving vaccination themselves, as well as to understand the reasons underlying vaccine hesitancy or refusal.

2. Material and methods

2.1. Study design and recruitment

We used data from 23,000 adult respondents to a global survey in 23 countries (Brazil, Canada, China, Ecuador, France, Germany, Ghana, India, Italy, Kenya, Mexico, Nigeria, Peru, Poland, Russia, Singapore, South Africa, South Korea, Spain, Sweden, Turkey, the United Kingdom (UK), and the United States (US)) during 25–30 June 2021. Among these, 3,295 individuals identified themselves as any type of healthcare provider category (i.e., physician, nurse, community health worker, other healthcare provider). Respondents were recruited from online panels via telephone, direct mail solicitation, and email. Strata were created for demographic variables with each stratum requiring a minimum of 50 participants, and the data weighted using random sampling to ensure representativeness of the country in terms of age, gender, and education level, and is described in detail elsewhere [6,18]. Respondent identities were verified using IP addresses or mobile phone numbers, and informed consent was obtained before progressing to the survey. No personally identifiable information was collected or stored. Respondents were equitably compensated in compliance with ethical standards, varying by country and not exceeding USD 3 per completed survey. Inclusion was limited to participants reporting themselves to be a healthcare provider (see *Survey Instrument*). This study was approved and the survey administered by Emerson College, Boston, USA (institutional review board protocol no. 20–023-F-E-6/12-[R1] updated April 12, 2021).

2.2. Survey instrument

A comprehensive literature review of COVID-19 vaccine acceptance studies and earlier studies on pandemic control measures [18] and vaccination intent [5,19,20] informed the development of a 31-question instrument (Supplemental Information 1). These items included: 1) questions representing perceptions of risk (q1) (q3), efficacy (q2), safety (q4), and trust (q5 and q6), identified via the literature review as important determinants of COVID-19 vaccine hesitancy and of routine immunization; 2) two vaccine acceptance-defining questions which included receipt of at least one dose of a COVID-19 vaccine (q7) or strongly agreeing to take it when available (q8) vs hesitancy to take a vaccine when available (q8). Vaccine hesitancy was defined as having reported “no” to the question on whether they have received at least one dose

of a COVID-19 vaccine and also either unsure/no opinion, somewhat disagree, or strongly disagree to the question on whether they will take a COVID-19 vaccine when available to them, in line with the Strategic Advisory Group of Experts (SAGE) on immunization definition of vaccine hesitancy [21]. In addition, the survey collected: 3) experience of anxiety (q21) and depression (q22) (moderate; 3–4 days per week, or most or all of the time; 5–7 days) [22]; 4) COVID-19 experience (self or a family member became ill with COVID-19 (q19), lost a family member to COVID-19 (q20)); 5) demographic variables (age, gender, and earning above or below the country median per capita income); and 6) self-reported role as a healthcare provider (physician, nurse, community health worker, other healthcare provider, or none of the above (excluded from study)).

2.3. Analysis

Descriptive statistics are reported for sample characteristics and acceptance and hesitancy of a COVID-19 vaccine by healthcare provider role across the multi-country sample. Respondents were asked to report whether they earned more or less than the country's median income per capita [23]. Multivariable logistic regressions assess the relationship between vaccine hesitancy and demographic variables in addition to perceptions of risk, efficacy, safety, and trust reported as adjusted odds ratios (aOR) and associated 95% confidence intervals (95% CIs). Due to low sample sizes, experiencing symptoms of anxiety or depression was not evaluated as a risk factor for vaccine hesitancy. All statistical tests were conducted using Stata 16, and statistical significance was set to $\alpha = 0.05$.

3. Results

Of the 3,295 respondents, 27% identified themselves as physicians, 19% as nurses, 24% as community health workers, and 30% as other types of healthcare providers (Table 1). The sample was nearly equally female (50%) and male (49%) with more female nurses (63%) and other healthcare providers (59%). The median age of the sample was 33 years (Q1 25, Q3 44). The countries with the most respondents were India ($n = 661$, 20%), Kenya ($n = 201$, 6.1%), Nigeria ($n = 189$, 5.7%), and Sweden ($n = 169$, 5.2%) (Supplemental Tables 1–23). Most (63%) respondents were from low- or middle-income countries, including among each type of healthcare provider (73.5% of physicians, 54.8% of nurses, 61.3% of community health workers, and 59.6% of other types of healthcare providers). Between 22 and 34% of healthcare providers, community health workers more so than other cadres, reported recently experiencing symptoms of anxiety or depression. 72.4% of the sample reported receiving at least one dose of the COVID-19 vaccine, and this was highest among physicians (85.6%) and lowest among the category of other healthcare providers (61.6%).

Nearly one-sixth (15.0%) of the overall sample reported some degree of vaccine hesitancy, more strongly among other healthcare providers (22.0%) and community health workers (16.8%) than nurses (13.6%) and lowest among physicians (6.5%) (Fig. 1). COVID-19 vaccine hesitancy was marginally higher among respondents from high-income (16.2%), rather than low- or middle-income countries (14.3%) (Fig. 2). Paradoxically only 5.7% of those who were accepting of vaccination in high-income countries had yet to receive at least one dose, while the same was true for 16.6% of those who were accepting of vaccination in low- and middle-income countries, an indication that availability of the vaccine could be a stronger determinant of vaccination than hesitancy. The data show that among the top 20 countries most affected by COVID-19 worldwide [24], the countries with lower observed

Table 1
Sample characteristics by healthcare provider role for global sample.

Characteristic	All (n = 3,295)	Healthcare Provider Role			
		Physician (n = 891)	Nurse (n = 619)	Community (n = 790)	Other (n = 995)
Age, years (median, IQR)	33 (25–44)	36 (28–46)	32 (24–44)	30 (24–41)	32 (24–43)
Age, group (%)					
18–29 years	37.7%	25.5%	42.7%	43.9%	40.6%
30–39 years	31.1%	40.3%	25.9%	27.2%	29.4%
40–49 years	12.3%	10.9%	11.5%	13.8%	12.9%
50–59 years	9.7%	11.1%	10.7%	8.0%	9.1%
60 + years	9.2%	12.2%	9.4%	7.1%	8.1%
Gender (%) ^a					
Male	49.0%	63.9%	36.6%	54.8%	40.6%
Female	50.0%	36.1%	63.4%	45.2%	59.4%
Income (%)					
More than country median	61.2%	85.3%	59.0%	57.0%	44.3%
Less than country median	38.8%	14.7%	41.0%	43.0%	55.7%
Low- or middle-income country (%) ^b					
Yes	62.8%	73.5%	54.8%	61.3%	59.6%
No	37.2%	26.5%	45.2%	38.7%	40.4%
Experience with COVID-19 (%)					
Self/family member sick	57.2%	77.6%	57.7%	56.0%	39.6%
Lost family member	66.5%	84.8%	65.8%	61.3%	40.9%
Mental health (%) ^c					
Anxiety	26.4%	22.2%	22.9%	30.1%	29.4%
Depression	28.3%	24.0%	26.0%	33.7%	29.3%
Vaccinated, one dose or more (%)					
Yes	72.4%	85.6%	74.5%	69.6%	61.6%
No	27.6%	14.4%	25.5%	30.4%	38.4%

^aDue to 37 missing values (12 physicians; 9 nurses; 11 community health workers; 5 other healthcare providers) and rounding, figures do not sum to 100%.

^bAccording to the 2021–2022 classification from the World Bank.

^cExperience of anxiety and depression defined as symptoms lasting a moderate amount of time (3–4 days) or most or all of the time (5–7 days).

case-fatality ratios and deaths per 100,000 population had a lower proportion of healthcare workers who had not received one or more doses of the COVID-19 vaccine at the time of survey response (e.g., South Korea, 43.9% unvaccinated compared to Russia, 55.5% unvaccinated).

Physicians in high-income countries (11%) reported greater vaccine hesitancy than in low- and middle-income countries (4.9%), and a similar pattern was observed for community health workers (Fig. 3), whereas nurses from low- and middle-income countries reported greater vaccine hesitancy (16.8% vs 9.6% in high-income countries). Other healthcare providers reported similar rates of vaccine hesitancy between high (21.6%) and low- and middle-income (22.3%) countries.

3.1. Risk factors for vaccine hesitancy

Earning less than the country median income was the strongest (OR = 2.75 [95% CI 2.25–3.37]) demographic factor for vaccine hesitancy in the sample, and significant among physicians (4.42 [2.49–7.87]), community health workers (3.35 times [2.23–5.03]), and other (1.79 [1.30–2.47]) healthcare providers (Table 2). Each increasing year of age demonstrated 0.02 times greater odds of less hesitancy among other healthcare providers. Gender did not hold significant associations for any type of healthcare provider.

For items related to COVID-19 vaccine risk, efficacy, safety, and trust, after adjusting for demographic variables, concerns that the available vaccines were safe represent the strongest factor for vaccine hesitancy (9.07 [7.30–11.29]) (Table 3). Distrusting the science behind the vaccines was also a strong factor (8.02 [6.47–9.95]). Perceptions of risk of the vaccine and of COVID-19 disease demonstrated greater odds for vaccine hesitancy overall (3.74 [3.00–4.66] and 3.37 [2.49–4.57], respectively), but held weaker associations than did trust of equitable distribution by the government (5.59 [4.52–6.90]) and efficacy (5.00 [4.02–6.24]) concerns. Among physicians and community health workers, the strongest

association with hesitancy was perception of distrust behind the science (18.29 [9.69–34.53] and 6.56 [4.33–9.95], respectively). Vaccine hesitancy among other healthcare providers and nurses was most strongly associated with concerns of vaccine safety (10.09 [7.12–14.30] and 9.10 [5.45–15.20], respectively).

4. Discussion

Vaccine hesitancy impedes our ability to control the COVID-19 pandemic. The literature since COVID-19 vaccines were first approved for emergency use in December 2020 reports only minimally on vaccine hesitancy and uptake among healthcare providers, a factor that could represent a risk to their own health as well as that of their patients [25]. We found that although most healthcare providers had accepted a novel COVID-19 vaccine, approximately one-sixth of the respondents (15.0%) reported hesitancy, including a small proportion (4.0%) that strongly or somewhat disagreed to get vaccinated against COVID-19. Compared to physicians, community health workers and other healthcare providers reported higher degrees of vaccine hesitancy. Hesitancy and acceptance rates are comparable between high- and low- and middle-income countries, and may thus not reflect vaccine availability and enforcement of mandates in these countries. Mandatory COVID-19 vaccination may increase vaccine uptake, but interpretation and transferability of findings must be considered within the context of the pandemic trajectory, pre-existing levels of vaccine uptake and hesitancy, and eligibility changes for vaccination [26]. Mandatory vaccination is only one mechanism to increase uptake to reach population-level immunity and protect the broader population [27]. Perceptions regarding vaccine risk, efficacy, safety, and trust were significant barriers to vaccination among all types of healthcare providers. Healthcare workers reported vaccine hesitancy (15%) less often compared to our earlier survey of the general population in which 24.8% of respondents reported vaccine hesitancy [6]. Across both studies, safety and risk concerns and lack

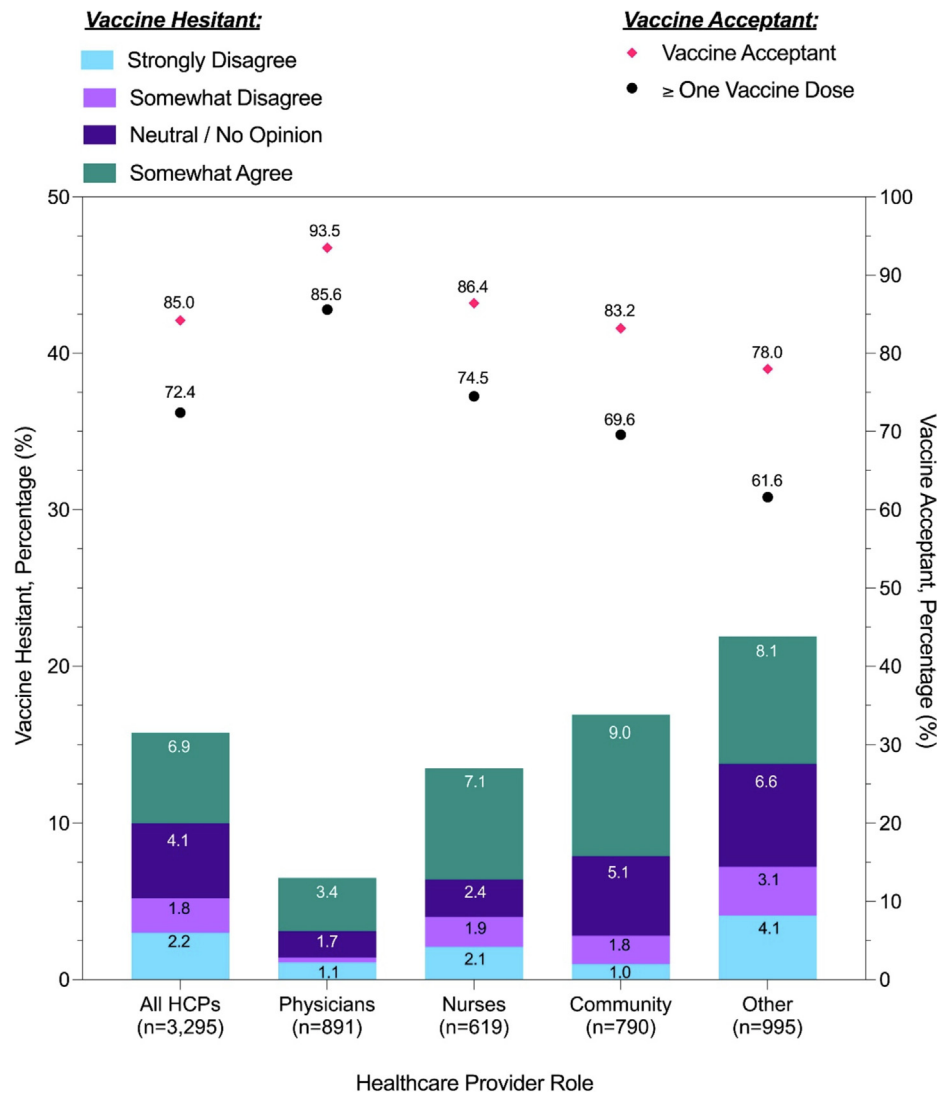


Fig. 1. Reported vaccine hesitancy and acceptance by healthcare provider role. **Note:** ‘Vaccine hesitant’ is coded as ‘somewhat agree,’ ‘no opinion,’ ‘somewhat disagree,’ and ‘strongly disagree’ to the item ‘I will take the COVID-19 vaccine when it is available to me,’ and ‘vaccine acceptant’ is coded as ‘strongly agree’ or having reported receiving at least one dose of a COVID-19 vaccine. HCP, healthcare provider.

of trust that vaccines would be equitably distributed were strongly associated with hesitancy. Our data show that COVID-19 vaccine acceptance among healthcare providers is on average higher compared to other adult-administered vaccines (for example, the proportion of healthcare providers who accept vaccination for seasonal influenza remains below 50%) [28], which suggests that vaccine hesitancy in this population is context and disease specific. Likelihood of exposure and severity of illness could be influencing factors [29].

Few published studies report on actual COVID-19 vaccine acceptance and uptake among healthcare providers, reporting only on likelihood of acceptance of a potential vaccine among this group [11,12]. Verger and colleagues investigated attitudes among healthcare providers towards COVID-19 vaccination in France and French-speaking regions in Belgium and Canada, finding that nearly half of respondents reported high acceptance in contrast to 23.0% reporting moderate acceptance and 28.4% reporting hesitancy [30]. Comparable to the findings from our study, safety of the vaccine developed under emergency conditions was identified as a significant barrier to vaccine uptake [31,32]. Factors significantly associated with increased intention to vaccinate included male

gender, increased age, being a physician, and direct contact with patients diagnosed with COVID-19 [9,10,29,33]. Our results differ from previous studies in respect to the association between female gender and hesitancy among healthcare providers [11,33–37]. In the early months after initial vaccine rollout, vaccine uptake in Saudi Arabia was reported to be 33%, considerably lower than 64% in the UK and 70% in Pakistan. Among 1,398 healthcare providers in a study of 20 emergency departments in the US, 85% reported receiving it [38]. Similar to our findings, the primary barriers to vaccine uptake were concerns surrounding vaccine safety, possibly due to the speed of the development process and/or trust in manufacturers [11,39]. It is plausible that this group’s vaccine acceptance may improve over time as information on vaccine safety and risks are continuously disseminated in the academic literature and mainstream media [33,40].

Healthcare providers who hesitate or refuse vaccination initially may accept vaccination in the future, provided that the barriers to vaccine acceptance are assuaged [39,41]. Just as misinformation and anti-vaccination views propagate rapidly through social networks, so too may positive vaccine information through perceptions of equitable administration and accurate,

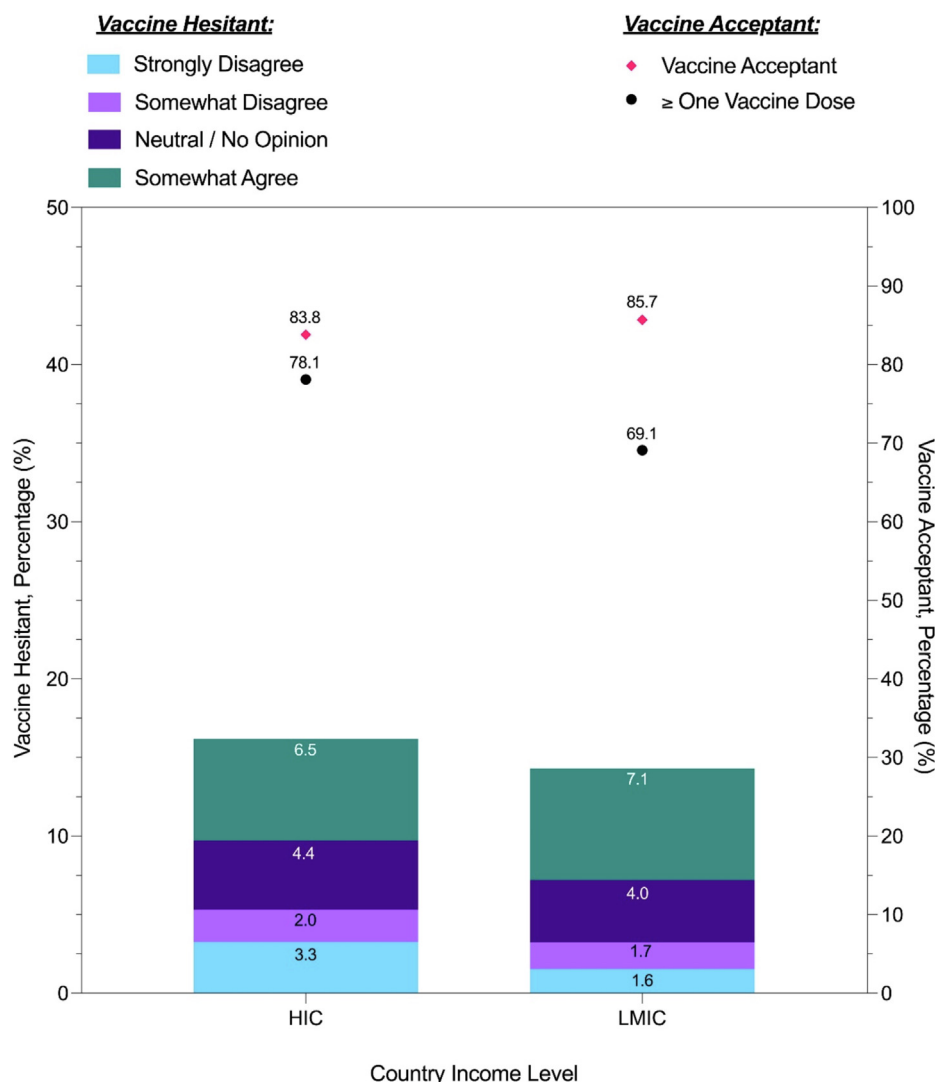


Fig. 2. Reported vaccine hesitancy and acceptance by country income. **Note:** 'Vaccine hesitant' is coded as 'somewhat agree,' 'no opinion,' 'somewhat disagree,' and 'strongly disagree' to the item 'I will take the COVID-19 vaccine when it is available to me', and 'vaccine acceptant' is coded as 'strongly agree' or having reported receiving at least one dose of a COVID-19 vaccine. HIC, high-income country; LMIC, low- or middle-income country.

compassion-driven messaging [42,43]. Our study identified a lack of confidence in the safety of the vaccine as the strongest factor associated with hesitancy to vaccinate. We also identified two subgroups among healthcare providers reporting hesitancy: those who were somewhat agreeable to vaccination and those who were committed refusers, the former being more common than the latter. Our data and extant literature indicate that promotional campaigns with messaging that emphasizes vaccine safety, and that provides clear, consistent, and comprehensive information describing the science and rigorous review process underpinning vaccine development, could improve vaccine acceptance [44]. These efforts are enhanced with multi-pronged approaches that, for example, may include equitable distribution of vaccines by governments, incentives, and advocacy campaigns [44]. Others have also identified that non-physician healthcare workers in low-income countries reported vaccine hesitancy for reasons like those reported during the H1N1 pandemic (e.g., concerns about side-effects, newness of the vaccine, and not knowing enough about the vaccine) [45]. Even in high-income countries, non-immigrant healthcare workers including physicians are up to five times more likely to be vaccine hesitant than healthcare workers who immigrated from low- or middle-income countries [46]. Vaccine hesitancy is com-

plex, multifactorial, and may be driven by ethnic and cultural differences including differential experiences with systematic racism within the healthcare system that we did not capture in order to fully explain these findings.

An attractive area for future inquiry on this topic is to assess additional factors affecting vaccine acceptance or hesitancy among healthcare providers, such as societal risk, self-protection, and personal acknowledgement of vaccination via social media platforms over time. Healthcare providers posting about their own vaccinations may be particularly persuasive. Physicians are consistently reported to be one of the most effective and trusted messengers of health information, which applies to COVID-19 and across diverse racial and ethnic communities that have been disproportionately impacted by the pandemic [16,47]. In contrast, unaddressed vaccine hesitancy among healthcare providers can have a downstream impact on the vaccination belief structures of those they interact with in person and online. Physicians who oppose vaccination and promote alternative therapies have a substantial social media presence and mainstream media coverage. It is thus crucial to identify the more persuadable segment of this priority audience and address pervasive barriers to vaccine acceptance among them.

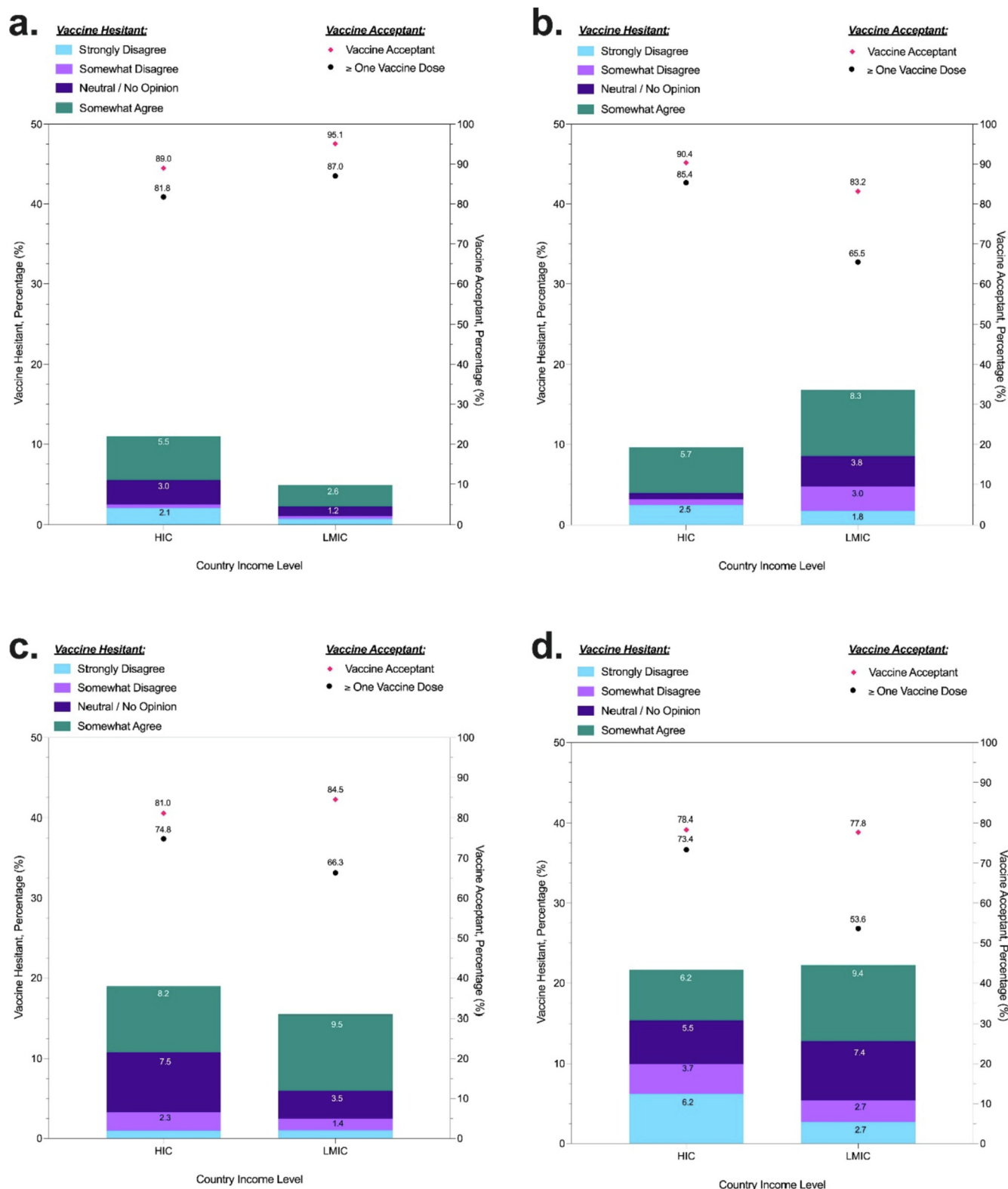


Fig. 3. Vaccine hesitancy among a) physicians (n = 891); b) nurses (n = 619); c) community healthcare workers (n = 790); and d) other healthcare providers (n = 995) in June 2021 by country income. **Note:** 'Vaccine hesitant' is coded as 'somewhat agree,' 'no opinion,' 'somewhat disagree,' and 'strongly disagree' to the item 'I will take the COVID-19 vaccine when it is available to me,' and 'vaccine acceptant' is coded as 'strongly agree' or having reported receiving at least one dose of a COVID-19 vaccine. HIC, high-income country; LMIC, low- or middle-income country.

There are limitations to consider when interpreting the findings of our study. First, our cross-sectional survey was conducted prior to full regulatory authorization and the availability of booster

doses of some COVID-19 vaccines, and does not take vaccine availability into consideration in the countries surveyed at that moment in time. Thus, responses reported in June 2021 may not reflect cur-

Table 2

Odds of vaccine hesitancy given demographic characteristics.

Demographics	All (n = 3,258)	Healthcare Provider Role			
		Physician (n = 879)	Nurse (n = 610)	Community (n = 779)	Other (n = 990)
Age (continuous years)					
Odds ratio	0.98** (0.98 – 0.99)	0.99 (0.97 – 1.01)	0.98 (0.97 – 1.00)	0.99 (0.98 – 1.01)	0.98* (0.97 – 0.99)
Gender (female)					
Odds ratio	1.12 (0.93 – 1.37)	1.33 (0.76 – 2.32)	0.99 (0.66 – 1.62)	0.74 (0.50 – 1.10)	1.26 (0.92 – 1.50)
Income (below country median)					
Odds ratio	2.75** (2.25 – 3.37)	4.42** (2.49 – 7.87)	1.41 (0.87 – 2.27)	3.35** (2.23 – 5.03)	1.79* (1.30 – 2.47)

Estimates represent odds ratios with 95% confidence intervals for vaccine hesitancy, which is coded as 'somewhat agree,' 'no opinion,' 'somewhat disagree,' and 'strongly disagree' to the item 'I will take the COVID-19 vaccine when it is available to me', and 'vaccine acceptant' is coded as 'strongly agree' or having reported receiving at least one dose of a COVID-19 vaccine. *, p-value ≤ 0.05 ; **, p-value ≤ 0.001 .

Table 3

Odds of vaccine hesitancy given disagreement with perceptions of trust, efficacy, safety, and risk regarding the COVID-19 vaccine, by healthcare provider role.

COVID-19 Perceptions	All (n = 3,258)	Healthcare Provider Role			
		Physician (n = 879)	Nurse (n = 610)	Community (n = 779)	Other (n = 990)
The COVID-19 vaccines available to me are safe.					
Odds ratio	9.07** (7.30 – 11.29)	15.46** (8.22 – 29.09)	9.10** (5.45 – 15.20)	5.11** (3.37 – 7.77)	10.09** (7.12 – 14.30)
I trust the science behind the COVID-19 vaccines.					
Odds ratio	8.02** (6.47 – 9.95)	18.29** (9.69 – 34.53)	4.72** (2.87 – 7.78)	6.56** (4.33 – 9.95)	8.10** (5.77 – 11.37)
I trust that my government is able to deliver the COVID-19 vaccine to everyone, everywhere in my country, equally.					
Odds ratio	5.59** (4.52 – 6.90)	7.31** (3.96 – 13.48)	4.95** (3.01 – 8.13)	4.80** (3.16 – 7.30)	5.06** (3.66 – 7.00)
COVID-19 can be prevented by vaccination.					
Odds ratio	5.00** (4.02 – 6.24)	6.68** (3.50 – 12.76)	3.45** (2.06 – 5.76)	5.08** (3.27 – 7.89)	4.81 (3.44 – 6.72)
The risks of COVID-19 disease are greater than the risks of the vaccine.					
Odds ratio	3.74** (3.00 – 4.66)	6.92** (3.72 – 12.86)	2.65** (1.54 – 4.56)	2.53** (1.65 – 3.87)	4.11** (2.92 – 5.81)
COVID-19 is a dangerous health threat.					
Odds ratio	3.37** (2.49 – 4.57)	5.35** (2.43 – 11.80)	3.29** (1.62 – 6.67)	2.57** (1.46 – 4.53)	3.50** (2.12 – 5.80)

Perceptions were self-reported on a five-point Likert scale, dichotomized as 'strongly agree' and 'somewhat agree' vs 'no opinion,' 'somewhat disagree,' and 'strongly disagree'. Estimates represent odds ratios with 95% confidence intervals for vaccine hesitancy, which is coded as 'somewhat agree,' 'no opinion,' 'somewhat disagree,' and 'strongly disagree' to the item 'I will take the COVID-19 vaccine when it is available to me', and 'vaccine acceptant' is coded as 'strongly agree' or having reported receiving at least one dose of a COVID-19 vaccine. Multivariate logistic regression models were adjusted for age (continuous, years), gender (male/female), and income (above country median, or below). *, p-value ≤ 0.05 ; **, p-value ≤ 0.001 .

rent beliefs. Second, some variables were not available for all respondents, which prevented inclusion of all respondents in multivariable analyses. Third, respondents from India are overrepresented in our sample, which might impact sociodemographic and health-related information such as race, education, and income. Our sample is not representative of healthcare workers in each country. Fourth, existing mandates for healthcare providers to vaccinate, which vary across and within countries, were not included in the analysis. Fifth, due to survey design limitations, we were unable to learn more detailed information about professions included in the category of "other healthcare providers". The proportion of respondents who stated that they had accepted vaccination in our study is similar to that found in studies in Canada [39], France [33], and the US [34] on this topic, suggesting consistency among the findings. Sixth, we adopted the definition for vaccine hesitancy from the SAGE Working Group on Vaccine Hesitancy, which categorizes individuals with strong intentions to vaccinate as vaccine acceptant; this may have underestimated the proportion of healthcare workers in our sample who were vaccine hesitant. Seventh, we asked if respondents identified as a healthcare worker to describe a relatively heterogeneous group of

patient-facing professionals. Perhaps any healthcare worker who comes into contact with patients—not only physicians and nurses—should be vaccinated, including physiotherapists, dietitians, and speech language pathologists, for example. It is also possible that, in responding to this survey, healthcare workers who strongly oppose COVID-19 vaccination may have not disclosed their profession due to social desirability bias, which would have caused underestimation of the prevalence of vaccine hesitancy in this population. The results reported here suggest a need for tailored vaccine messaging and health promotion campaigns to increase uptake of the COVID-19 vaccine among healthcare providers.

5. Conclusion

This global study suggests that while most healthcare providers have received one or more doses of a COVID-19 vaccine or are willing to be vaccinated in the future, underlying vaccine hesitancy among this group is not trivial. Barriers to vaccine acceptance included concerns regarding vaccine risk, efficacy, and safety, and

low trust in expecting its equitable distribution. The findings indicate that providing accurate information and training on these topics, for example through positive peer influence, could be useful to future vaccination campaigns to address the leading concerns of healthcare providers who hesitate to be vaccinated against COVID-19.

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Conflict of interest statement

Authors have no competing interests to report.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2022.04.097>.

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