



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

COVID-19 Vaccine Acceptance among Health Care Workers in the Kingdom of Saudi Arabia

Jad A. Elharake, MPH^{a,b}, Bayan Galal^c, Saleh A. Alqahtani, MD^{d,e}, Rana F. Kattan, MD, MME^f, Mazin A. Barry, MD^g, Mohamad-Hani Tamsah, MD^h, Aryn A. Malik, MBBS, MPH, PhD^{a,i}, SarahAnn M. McFadden, PhD, RN, CPN^{a,i}, Inci Yildirim, MD, PhD, MSc^{a,i}, Kaveh Khoshnood, PhD^b, Saad B. Omer, MBBS, MPH, PhD, FIDSA^{a,b,i,j}, Ziad A. Memish, MD, FACP, FRCPC, FRCPE, FIDSA^{k,l,m,*}

^a Yale Institute for Global Health, New Haven, Connecticut 06510, USA

^b Yale School of Public Health, New Haven, Connecticut 06510, USA

^c Yale University, New Haven, Connecticut 06520, USA

^d Department of Medicine, The Johns Hopkins University Hospital, Baltimore, Maryland, USA

^e Department of Gastroenterology, King Feisal Specialists Hospital and Research Center, Riyadh, Saudi Arabia

^f General Pediatric Department, King Abdullah Specialist Children's Hospital, College of Medicine, King Saud University for Health Sciences, Ministry of National Guard, Riyadh, Kingdom of Saudi Arabia

^g Infectious Diseases Unit, Department of Internal Medicine, King Saud University Medical City, College of Medicine, King Saud University, Riyadh, Saudi Arabia

^h Pediatric Intensive Care Unit, pediatric department, College of Medicine, King Saud University, Riyadh, Kingdom of Saudi Arabia

ⁱ Department of Internal Medicine, Infectious Disease, Yale School of Medicine, New Haven, Connecticut 06510, USA

^j Yale School of Nursing, Orange, Connecticut 06477, USA

^k Research and Innovation Center, King Saud Medical City, Ministry of Health, the Kingdom of Saudi Arabia

^l College of Medicine, Alfaisal University, Riyadh, the Kingdom of Saudi Arabia

^m Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, GA, USA

ARTICLE INFO

Article history:

Received 26 March 2021

Revised 1 July 2021

Accepted 2 July 2021

Keywords:

Kingdom of Saudi Arabia

COVID-19

vaccine acceptance

refusal

trust

health care workers

ABSTRACT

Objectives: The purpose of our study was to assess COVID-19 vaccine acceptance among health care workers (HCWs) in the Kingdom of Saudi Arabia (KSA) and identify: 1) vaccine acceptance barriers; 2) demographic differences; and 3) the most trusted COVID-19 sources of information.

Methods: Between October and December 2020, all registered HCWs in the KSA were emailed a survey questionnaire, using Qualtrics® and Google Forms®, evaluating their acceptance of a COVID-19 vaccine.

Results: Of the 23,582 participants surveyed, 15,299 (64.9%) said they would accept a COVID-19 vaccine. Vaccine acceptance among HCWs differed by several demographic characteristics, with males (69.7%), Christians (71.9%), and Pakistanis (81.6%) most likely to accept a COVID-19 vaccine. Of the 8,202 (35.1%) who said they would not accept a COVID-19 vaccine, the main reason reported was fear of potential side effects (58.5%). Participants reported health officials (84.6%) as the most reliable source of COVID-19 information. Additionally, participants reported the highest confidence in the KSA Ministry of Health (88.5%).

Conclusions: Overall, these findings provide KSA health care authorities with the information needed to develop public health messaging campaigns for HCWs to best address COVID-19 vaccine concerns—especially as the country prepares to vaccinate its general population.

© 2021 The Author(s). Published by Elsevier Ltd on behalf of International Society for Infectious Diseases.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

* Corresponding author: Ziad A. Memish, MD, FACP, FRCPC, FRCPE, FIDSA, 1 Church St Ste 340, New Haven, Connecticut, 06510. Telephone: +1(9665)5483515.

E-mail addresses: jad.elharake@yale.edu (J.A. Elharake), bayan.galal@yale.edu (B. Galal), salqaht1@jhmi.edu (S.A. Alqahtani), kattanra@ngha.med.sa (R.F. Kattan), mbarry@ksu.edu.sa (M.A. Barry), mtamsah@ksu.edu.sa (M.-H. Tamsah), amyn.malik@yale.edu (A.A. Malik), sarahann.mcfadden@yale.edu (S.M. McFadden), inci.yildirim@yale.edu (I. Yildirim), kaveh.khoshnood@yale.edu (K. Khoshnood), saad.omer@yale.edu (S.B. Omer), zmemish@yahoo.com (Z.A. Memish).

Introduction

Since the beginning of the coronavirus disease-2019 (COVID-19) pandemic, the Kingdom of Saudi Arabia (KSA) has reported approximately 383,000 and 6,600 COVID-19 cases and deaths, respectively (Our World in Data, 2021). In December 2020, the KSA began its COVID-19 vaccine rollout, becoming the first Arab country to distribute the Pfizer-BioNTech vaccine ("GCC News Roundup: Gulf states roll out COVID-19 vaccination campaigns, Saudi Arabia faces financial woes (December 1–31)," 2021). Since then, the first phase of vaccine distribution has included first-responders and health care workers (HCWs) (Reuters, 2020). Given that new virus strains have arisen and vaccines with lower efficacy rates have also been distributed, higher vaccination rates will be needed to achieve herd immunity (Achenbach & Eunjung Cha, 2021). Therefore, there is an even greater need to assess the factors impacting vaccine uptake among HCWs.

However, underlying trust issues and the spread of misinformation about COVID-19 may affect vaccine uptake. Recently, a survey sent to the KSA general population found that most KSA adults reported false information about the COVID-19 pandemic and vaccines (e.g., flu and pneumonia vaccines protect against COVID-19) (Baig et al., 2020). Given that misinformation can have severe implications for worsening the spread of the virus and potentially reducing vaccine acceptance, HCWs play an essential role in being a source of trusted medical information for the KSA general public (Alduraywish et al., 2020).

While there are data on COVID-19 vaccine sentiments expressed by the general population (Al-Mohaithef & Padhi, 2020), assessing the attitudes of HCWs and their potential to impact the general public's opinion is also essential. It was recently reported that 30% of the KSA HCW population were unwilling to receive a COVID-19 vaccine (Barry et al., 2020). However, little is known about the factors associated with COVID-19 vaccine refusal. The high vaccination rates needed to contain the virus can potentially be better achieved by understanding HCWs' perceptions of the COVID-19 vaccine. Thus, the purpose of our study was to describe the current COVID-19 vaccine acceptance landscape among HCWs in the KSA with aims to identify: 1) COVID-19 vaccine acceptance barriers; 2) demographic differences in COVID-19 vaccine refusal, and 3) the most trusted COVID-19 sources of information and organizations. Our findings will provide KSA health care authorities with an understanding of the COVID-19 vaccine acceptance among the HCW population, especially as the country plans to vaccinate its general population, which may help frame messaging and improve overall acceptance and uptake.

Methods

Data were collected between October and December 2020, using an electronic questionnaire via Qualtrics® (Qualtrics, Provo, UT) and Google Form® (Google, Mountainview, CA). Using purposive sampling, the survey (Supplementary Material) was emailed by the Saudi Commission for Health Specialties (SCHS), with the option to choose English or Arabic, to HCWs who were registered with the SCHS. The SCHS is a group of approximately 700,000 HCWs (including physicians, nurses, and physician assistants) who supervise and evaluate training programs and set standards for health care practice at all levels in the KSA (Saudi Commission for Health Specialties, 2021). Participants were eligible if they were 18 years of age or older, a HCW, could read English and/or Arabic, and had access to the internet via computer and/or smartphone.

The survey was adapted from a previous study (Malik, McFadden, Elharake, & Omer, 2020) and contained 22 questions that required a response and one optional question that did not require a response from the participants. Basic demographic information

was collected, as well as the country of origin and religious affiliation. Additionally, we asked participants the following question: "If a vaccine for COVID-19 becomes available in your country and is recommended for you, will you take it?"; this variable was dichotomized to COVID-19 vaccine acceptance (0 = No/Don't know; 1 = Yes). Participants who responded "No" or "Don't know" were then asked for the main reason for not accepting a COVID-19 vaccine with the following choices: 1) religion; 2) fear of potential side effects; 3) lack of trust for those creating and distributing the vaccine, and 4) do not believe vaccines work. This was the one optional question that did not require a response. Finally, participants were asked about their confidence in media sources and the reliability of these sources regarding the COVID-19 pandemic; these variables were dichotomized (0 = Very Little/Little/Some/Don't Know; 1 = Much/Very Much).

The Yale University Institutional Review Board (IRB protocol number: 2000029237) and the KSA Ministry of Health (MOH; H-01-R-053) approved this study. Participants provided e-consent before data collection.

Statistical Analysis

Survey results were summarized, graphed, analyzed, and reported using Microsoft Excel® (Microsoft, Redmond, WA) and STATA® (STATA, Version 16.1, College Station, TX). Descriptive statistics were used to determine the sample demographic characteristics. Additionally, the frequency and percentage of responses to questions pertaining to COVID-19 vaccine acceptance, reasons for not accepting a COVID-19 vaccine, and confidence in organizations, and reliability of media sources regarding COVID-19 were calculated.

Lastly, univariable and multivariable logistic regressions were used to assess the associations between demographic factors with COVID-19 vaccine acceptance. The multivariable model was adjusted for potential confounders, including age, gender, country of origin, religion, and education. The results were reported as the odds ratios (ORs) with 95 confidence intervals (95% CI). Two-sided p -values <0.05 were considered statistically significant.

Results

A total of 23,582 participants completed the survey with 12,365 (52.4%) males, 10,917 (46.3%) were 25–34 years old, and 12,208 (51.7%) had a graduate/professional degree. Most of the participants reported their country of origin as KSA ($n = 12,630$; 53.6%) and identified as Muslim ($n = 18,787$; 79.7%). Table 1 shows the characteristics of the survey participants and the KSA HCW population.

COVID-19 Vaccine Acceptance

Of the 23,582 participants surveyed, 15,299 (64.9%) said they would accept a COVID-19 vaccine (Table 1). Vaccine acceptance among the health care population differed by several demographic characteristics. Males (8,619/12,365; 69.7%), Christians (3,025/4,208; 71.9%), and Pakistanis (427/523; 81.6%) comprised the largest groups of respondents who were most likely to accept a COVID-19 vaccine (Table 1).

A multivariable logistic regression analysis (Table 2) showed that after adjusting for gender, age, country of origin, religion, education, chronic illness, have been sick with COVID-19, and known someone who has been sick with COVID-19, HCWs in the KSA who were female (OR: 0.5; 95% CI: 0.5 – 0.6; $p < 0.001$) were less likely to accept a COVID-19 vaccine compared to males. Those who were 35–44 years old (OR: 0.8; 95% CI: 0.7 – 0.8; $p < 0.001$), 45–54 years old (OR: 0.8; 95% CI: 0.7 – 0.8; $p < 0.001$), and 55 years and older

Table 1
Demographic Characteristics & COVID-19 Vaccine Acceptance among HCWs in KSA (N = 23,582)

	n (%)*	COVID-19 Vaccine Acceptance (Total = 15,299/23,582; 64.9%) n (%)**
Gender		
Male	12,365 (52.4)	8,619 (69.7)
Female	11,217 (47.6)	6,680 (59.6)
Age (years)		
18-24	669 (2.9)	442 (66.1)
25-34	10,917 (46.3)	7,156 (65.6)
35-44	7,693 (32.6)	4,866 (63.3)
45-54	3,164 (13.4)	2,065 (65.3)
55+	1,139 (4.8)	770 (67.6)
Country of Origin		
Egypt	2,256 (9.6)	1,730 (76.7)
India	1,500 (6.4)	1,219 (81.3)
Jordan	307 (1.3)	173 (56.4)
Lebanon	81 (0.3)	41 (50.6)
Malaysia	200 (0.8)	158 (79.0)
Pakistan	523 (2.2)	427 (81.6)
Philippines	3,762 (15.9)	2,692 (71.6)
Saudi Arabia	12,630 (53.6)	7,373 (58.4)
Sudan	819 (3.5)	556 (67.9)
Syria	401 (1.7)	274 (68.3)
Other	1,103 (4.7)	656 (59.5)
Religion		
Christianity	4,208 (17.8)	3,025 (71.9)
Islam	18,787 (79.7)	11,838 (63.0)
None	125 (0.5)	69 (55.2)
Other	462 (2)	367 (79.4)
Education		
No High School	41 (0.2)	30 (73.2)
High School	509 (2.1)	323 (63.5)
Some College	1,343 (5.7)	840 (62.6)
College	9,481 (40.2)	5,883 (62.1)
Graduate/Professional	12,208 (51.8)	8,223 (67.4)
Chronic Illness		
Yes	3,432 (14.6)	2,203 (64.2)
No	20,150 (85.4)	13,096 (65.0)
Have been sick with COVID-19		
Yes	3,481 (14.8)	2,266 (65.1)
No	20,101 (85.2)	13,033 (64.8)
Know someone who has been sick with COVID-19		
Yes	16,219 (68.8)	10,370 (63.9)
No	7,363 (31.2)	4,929 (66.9)

* Denominator is the total sample size = 23,582.

** Denominator is the number of participants per demographic characteristic.

(OR: 0.8; 95% CI: 0.7 – 0.9; p < 0.01) were also less likely to accept a COVID-19 vaccine compared to those 25-34 years old. Additionally, most non-Saudi participants were more likely to accept a COVID-19 vaccine than those from the KSA (see Table 2 for more details). Those who reported their level of education as high school (OR: 1.3; 95% CI: 1.0 – 1.5; p = 0.02), some college (OR: 1.3; 95% CI: 1.1 – 1.4; p < 0.001), or college (OR: 1.2; 95% CI: 1.1 – 1.2; p < 0.001) were more likely to accept a COVID-19 vaccine compared with those with a graduate/professional degree. Lastly, those who did not know someone who contracted COVID-19 were more likely to accept a COVID-19 vaccine than those who did (OR: 1.1; 95% CI: 1.0 – 1.2; p = 0.01).

Reasons for Refusal to Accept COVID-19 Vaccines

Of the 8,202 (35.1%) who said they would not accept a COVID-19 vaccine, 4,801 (58.5%) reported fear of potential side effects, 2,827 (34.5%) reported lack of trust for those creating and distributing the vaccine, 541 (6.6%) reported they do not believe vaccines work, and 33 (0.4%) reported religion (Figure 1).

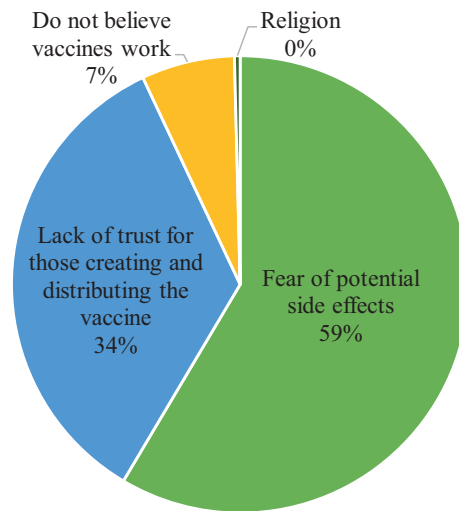


Figure 1. Reasons for COVID-19 Vaccine Refusal among HCWs in the KSA (N = 8,202*)

*Legend: missing data (n = 81)

Across demographic groups, the two most common reasons participants reported for not accepting a COVID-19 vaccine were fear of potential side effects and lack of trust for those creating and distributing the vaccine. See Table 3 for more details.

COVID-19 Reliability of Media Sources and Confidence in Organizations

Participants reported health officials (n = 19,949; 84.6%), health care providers (n = 19,159; 81.2%), and the World Health Organization (WHO) (n = 14,793; 62.7%) as the most reliable media sources of COVID-19 information (Figure 2). Additionally, participants reported the highest confidence in the KSA MoH (n = 20,872; 88.5%), the KSA Government (n = 20,568; 87.2%), health care providers (n = 19,956; 84.6%), and the WHO (n = 14,588; 61.9%) (Figure 3).

COVID-19 Reliability of Media Sources and Confidence in Organizations across the COVID-19 Vaccine Landscape

Participants who would take the COVID-19 vaccine (n = 15,299; 64.9%) reported health officials (n = 13,580; 88.8%), health care providers (n = 13,042; 85.3%), the WHO (n = 10,687; 69.9%), and websites (n = 9,037; 59.1%) as the most reliable media sources of COVID-19 information (Figure 2). Participants who would not take the COVID-19 vaccine (n = 8,202; 35.1%) reported health officials (n = 6,369; 76.9%) and health care providers (n = 6,117; 73.9%) as the most media reliable sources of COVID-19 information (Figure 2).

Additionally, participants who would take the COVID-19 vaccine (n = 15,299; 64.9%) reported the highest confidence in the KSA MoH (n = 14,169; 92.6%), the KSA Government (n = 13,858; 90.6%), health care providers (n = 13,591; 88.8%), and the WHO (n = 10,626; 69.5%) (Figure 3). Participants who would not take the COVID-19 vaccine (n = 8,202; 35.1%) reported the highest confidence in the KSA MoH (n = 6,703; 80.9%), the KSA Government (n = 6,710; 81.0%), and health care providers (n = 6,365; 76.8%) (Figure 3).

Discussion

We found a majority of KSA HCWs (64.9%) would accept a COVID-19 vaccine. Among those who would not accept a COVID-19 vaccine, the main reason reported for vaccine refusal was fear of

Table 2
Multivariable Ordinal Logistic Regression of COVID-19 Vaccine Acceptance across Demographic Characteristics

Variable	Unadjusted			Adjusted		
	OR	p-value	95% CI	OR	p-value	95% CI
<i>Outcome: COVID-19 Vaccine Acceptance</i>						
Gender						
Male	Ref					
Female	0.6	<0.001	0.6 - 0.7	0.5	<0.001	0.5 - 0.6
Age (years)						
25-34	Ref					
18-24	1	0.8	0.9 - 1.2	1.4	<0.001	1.2 - 1.7
35-44	0.9	<0.01	0.9 - 1.0	0.8	<0.001	0.7 - 0.8
45-54	1	0.8	0.9 - 1.1	0.8	<0.001	0.7 - 0.8
55+	1.1	0.2	1.0 - 1.2	0.8	<0.01	0.7 - 0.9
Country of Origin						
Saudi Arabia	Ref					
Egypt	2.3	<0.001	2.1 - 2.6	2.4	<0.001	2.2 - 2.7
India	3.1	<0.001	2.7 - 3.5	3.9	<0.001	3.3 - 4.6
Jordan	0.9	0.5	0.7 - 1.2	1	0.7	0.8 - 1.2
Lebanon	0.7	0.2	0.5 - 1.1	0.9	0.5	0.6 - 1.3
Malaysia	2.7	<0.001	1.9 - 3.8	4.3	<0.001	3.0 - 6.0
Pakistan	3.2	<0.001	2.5 - 4.0	3.6	<0.001	2.9 - 4.6
Philippines	1.8	<0.001	1.7 - 1.9	2.5	<0.001	2.2 - 2.9
Sudan	1.5	<0.001	1.3 - 1.8	1.7	<0.001	1.4 - 2.0
Syria	1.5	<0.001	1.2 - 1.9	1.6	<0.001	1.3 - 1.9
Other	1	0.5	0.9 - 1.2	1.2	<0.01	1.1 - 1.4
Religion						
Islam	Ref					
Christianity	1.5	<0.001	1.4 - 1.6	1.1	0.4	0.9 - 1.2
None	0.7	0.1	0.5 - 1.0	0.8	0.1	0.5 - 1.1
Other	2.3	<0.001	1.8 - 2.8	1.3	0.1	1.0 - 1.6
Education						
Graduate/Professional	Ref					
No High School	1.3	0.4	0.7 - 2.6	1.8	0.1	0.9 - 3.7
High School	0.8	0.1	0.7 - 1.0	1.3	0.02	1.0 - 1.5
Some College	0.8	<0.001	0.7 - 0.9	1.3	<0.001	1.1 - 1.4
College	0.8	<0.001	0.7 - 0.8	1.2	<0.001	1.1 - 1.2
Chronic Illness						
No	Ref					
Yes	1.0	0.4	0.9 - 1.0	1.1	0.2	1.0 - 1.1
Have been sick with COVID-19						
No	Ref					
Yes	1.0	0.8	0.9 - 1.1	1.0	0.9	0.9 - 1.1
Know someone who has been sick with COVID-19						
Yes	Ref					
No	1.1	<0.001	1.1 - 1.2	1.1	0.01	1.0 - 1.2

potential side effects. Additionally, participants reported health officials and health care providers as the most reliable media sources of COVID-19 information. Across KSA organizations, HCWs reported the highest confidence in the KSA MoH, the KSA Government, and health care providers. Overall, these findings provide KSA health care authorities with the information needed to develop COVID-19 messaging campaigns to best address COVID-19 vaccine concerns—especially as the country prepares to vaccinate its general population.

The KSA MoH has now approved three COVID-19 vaccines (Pfizer/BioNTech, AstraZeneca, and Moderna) to be distributed from over 100 vaccination facilities across the country (Ministry of Health, 2021). However, immunization programs are only successful when there are high rates of acceptance and coverage. While most of the KSA HCWs in our study would accept a COVID-19 vaccine, this level of acceptance (64.9%) may not be sufficient to reach the herd immunity threshold, which is estimated to be between 55% and 82% (Sanche et al., 2020). Additionally, COVID-19 vaccine acceptance rates among HCWs in other countries are significantly higher, such as Canada (70.4%), France (75.4%), Belgium (76.0%), China (76.4%), United States (92.0%), and Indonesia (95.5%) (Fu et al., 2020; Harapan et al., 2020; Shekhar et al., 2021; Verger et al., 2021). However, we acknowledge that reported acceptance may not always translate into actual behavior. For exam-

ple, only one-third of the KSA HCW population has enrolled to receive or has already received a COVID-19 vaccine (Barry et al., 2021). Given the alarming gap between our study's 64.9% vaccine acceptance and the current reported vaccine coverage of 33.3% (Barry et al., 2021), KSA health care authorities should swiftly launch vaccine messaging and educational campaigns catered to HCWs to improve uptake in a COVID-19 vaccine.

Given that our study found demographic differences in COVID-19 vaccine acceptance, message-framing to encourage trust in a COVID-19 vaccine must also be catered to specific demographic groups across the HCW population. Female HCWs were less likely to accept a COVID-19 vaccine compared to males, which was consistent with a previous influenza vaccine acceptance study (Alshammari, Yusuff, Aziz, & Subaie, 2019) and other KSA COVID-19 vaccine acceptance studies (Barry et al., 2020; Barry et al., 2021; Magadmi & Kamel, 2020). The gender difference in COVID-19 vaccine acceptance may be due to the WHO and KSA MoH recommending pregnant women not to take the COVID-19 vaccine due to the lack of data on the effects of a COVID-19 vaccine on the risks of pregnancy (Gulf Insider Report, 2021; World Health Organization, 2021b). Additionally, males may be more likely to accept a COVID-19 vaccine due to the several studies that have reported higher risks for COVID-19 hospitalization, infection, and death among males (Chen et al., 2020; Galbadage et al., 2020;

Table 3
Reasons for COVID-19 Vaccine Refusal across Demographic Characteristics

	Total N = 23,582; n (%) [*]	Would not accept a COVID-19 Vaccine if it is recommended to them; Total N = 8,202; n (%) ^{**}	Religion n (%) ^{***}	Fear of potential side effects n (%) ^{***}	Lack of trust for those creating and distributing the vaccine n (%) ^{***}	Do not believe vaccines work n (%) ^{***}
Gender						
Male	12,365 (52.4)	3706 (30.0)	20 (0.5)	1,963 (53.0)	1,490 (40.2)	233 (6.3)
Female	11,217 (47.6)	4496 (40.1)	13 (0.3)	2,838 (63.1)	1,337 (29.7)	308 (6.9)
Age (years)						
18–24	669 (2.9)	223 (33.3)	1 (0.5)	129 (57.9)	74 (33.2)	19 (8.5)
25–34	10,917 (46.3)	3714 (34.0)	12 (0.3)	2,276 (61.3)	1,191 (32.1)	235 (6.3)
35–44	7,693 (32.6)	2808 (36.5)	15 (0.5)	1,598 (56.9)	997 (35.5)	198 (7.1)
45–54	3,164 (13.4)	1090 (34.5)	5 (0.5)	615 (56.4)	401 (36.8)	69 (6.3)
55+	1,139 (4.8)	367 (32.2)	0 (0)	183 (49.9)	164 (44.7)	20 (5.5)
Country of Origin						
Egypt	2,256 (9.6)	520 (23.0)	0 (0)	314 (60.4)	188 (36.2)	18 (3.5)
India	1,500 (6.4)	263 (17.5)	2 (0.8)	162 (61.6)	61 (23.2)	38 (14.5)
Jordan	307 (1.3)	131 (42.7)	1 (0.8)	63 (48.1)	60 (45.8)	7 (5.3)
Lebanon	81 (0.3)	40 (49.4)	0 (0)	18 (45)	19 (47.5)	3 (7.5)
Malaysia	200 (0.8)	42 (21)	0 (0)	23 (54.8)	16 (38.1)	3 (7.1)
Pakistan	523 (2.2)	95 (18.2)	0 (0)	51 (53.7)	36 (37.9)	8 (8.4)
Philippines	3,762 (15.9)	1066 (28.3)	5 (0.5)	910 (85.4)	124 (11.6)	27 (2.5)
Saudi Arabia	12,630 (53.6)	5214 (41.3)	22 (0.4)	2,835 (54.4)	1,962 (37.6)	395 (7.6)
Sudan	819 (3.5)	259 (31.6)	0 (0)	128 (49.4)	120 (46.3)	11 (4.3)
Syria	401 (1.7)	127 (31.7)	0 (0)	74 (58.3)	52 (40.9)	1 (0.8)
Other	1,103 (4.7)	445 (40.3)	3 (0.7)	223 (50.1)	189 (42.5)	30 (6.7)
Religion						
Christianity	4,208 (17.8)	1168 (27.8)	7 (0.6)	899 (77.0)	214 (18.3)	48 (4.1)
Islam	18,787 (79.7)	6886 (36.7)	25 (0.4)	3,824 (55.5)	2,563 (37.2)	474 (6.9)
None	125 (0.5)	56 (44.8)	0 (0)	18 (32.1)	29 (51.8)	9 (16.1)
Other	462 (2)	92 (19.9)	1 (1.1)	60 (65.2)	21 (22.8)	10 (10.9)
Education						
No High School	41 (0.2)	11 (26.8)	0 (0)	8 (72.7)	2 (18.2)	1 (9.1)
High School	509 (2.1)	185 (36.3)	5 (2.7)	118 (63.8)	48 (26.0)	14 (7.6)
Some College	1,343 (5.7)	497 (37)	4 (0.8)	273 (54.9)	170 (34.2)	50 (10.1)
College	9,481 (40.2)	3559 (37.5)	12 (0.3)	2,037 (57.2)	1,243 (34.9)	267 (7.5)
Graduate/Professional	12,208 (51.8)	3950 (32.4)	12 (0.3)	2,365 (59.9)	1,364 (34.5)	209 (5.3)
Chronic Illness						
Yes	3,432 (14.6)	1222 (35.6)	4 (0.3)	698 (57.1)	454 (37.2)	66 (5.4)
No	20,150 (85.4)	6980 (34.6)	29 (0.4)	4,103 (58.8)	2,373 (34.0)	475 (6.8)
Have been sick with COVID-19						
Yes	3,481 (14.8)	1198 (34.4)	2 (0.2)	684 (57.1)	425 (35.5)	87 (7.3)
No	20,101 (85.2)	7004 (34.8)	31 (0.4)	4,117 (58.8)	2,402 (34.3)	454 (6.5)
Know someone who has been sick with COVID-19						
Yes	16,219 (68.8)	5788 (35.7)	17 (0.3)	3,357 (58.0)	2,047 (35.4)	367 (6.3)
No	7,363 (31.2)	2414 (32.8)	16 (0.7)	1,444 (59.8)	780 (32.3)	174 (7.2)

* Denominator is the total sample size = 23,582.

** Denominator is the number of participants per demographic characteristic.

*** Denominator is the number of participants per demographic characteristic for those who would not accept a COVID-19 vaccination.

Peckham et al., 2020). Health care authorities must clarify any confusion regarding COVID-19 vaccine information among female HCWs to increase vaccine uptake.

Our study also found that health care workers between 25–34 years of age were more likely to accept a COVID-19 vaccine than those who were 35–44, 45–54, and 55 years and older. While this finding was consistent with a previous study evaluating the general KSA population (Magadmi & Kamel, 2020), it is contrary to other KSA studies (Al-Mohaithef & Padhi, 2020; Barry et al., 2021). One possible explanation for why younger HCWs were more likely to accept a COVID-19 vaccine than older HCWs may be due to the social restrictions and curfews that were enforced by KSA authorities. Although these mitigations were enacted to reduce the spread of the virus, it may have impacted the younger population more, which is why they may have been more willing to receive the vaccine. Additionally, HCWs who reported their level of education as high school, some college, or college were more likely to accept a COVID-19 vaccine than those with a graduate/professional degree. While our finding differs from that of previous COVID-19 vaccine acceptance studies (Al-Mohaithef & Padhi, 2020; Magadmi & Kamel, 2020), HCWs with lower educational degrees may be more

likely to accept a COVID-19 vaccine because they are less likely to provide telecommuting health care services compared to HCWs who are physicians. Given that their jobs require more frequent in-person contact with patients, which will increase their risk of contracting COVID-19, these HCWs may be more likely to accept a COVID-19 vaccine than physicians who have the option to work from home.

Across the respondents who would not accept a COVID-19 vaccine, the most common reported reason for their refusal was fear of potential side effects. COVID-19 vaccine hesitancy studies worldwide have identified similar concerns among HCWs and the general population (Chou & Budenz, 2020; Dror et al., 2020; Khan et al., 2020; Murphy et al., 2021). COVID-19 vaccines were rapidly developed in less than a year, so HCWs may be hesitant to accept the vaccine, given that previous vaccines have taken 10–15 years to produce (History of Vaccines, 2021). However, researchers were already familiar with coronaviruses, including SARS and MERS, and this existing data helped speed up the vaccine development process. Additionally, given that the spread of COVID-19 led to a pandemic that detrimentally impacted the social, economic, and employment realms, international organizations (e.g.,

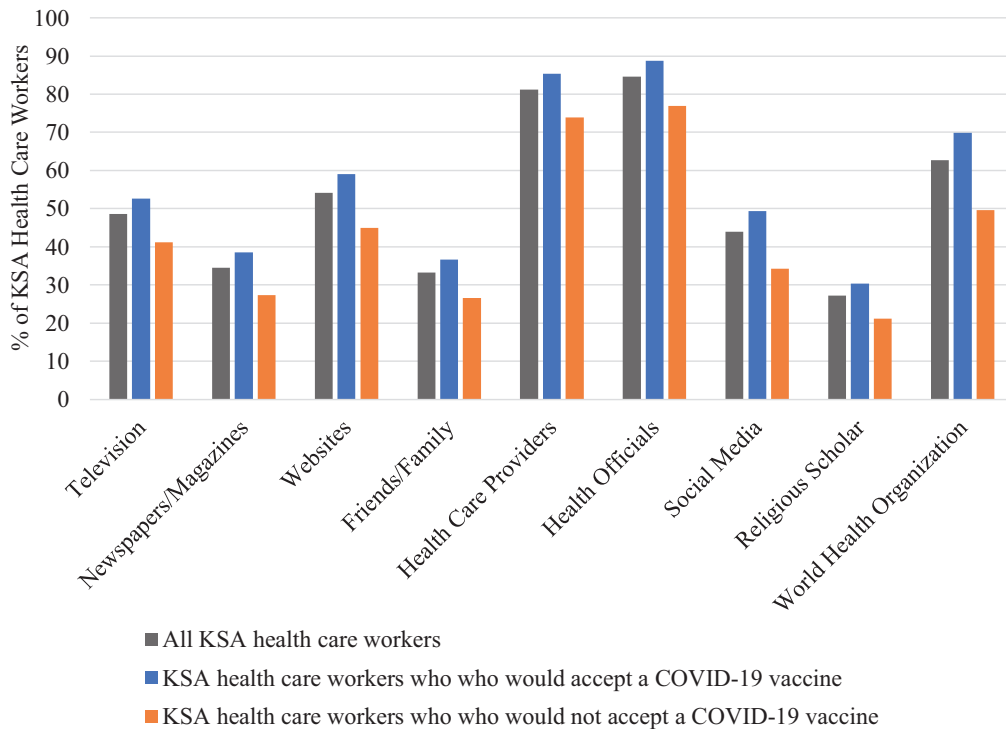


Figure 2. Reliability of COVID-19 Sources of Information across COVID-19 Vaccine Landscape

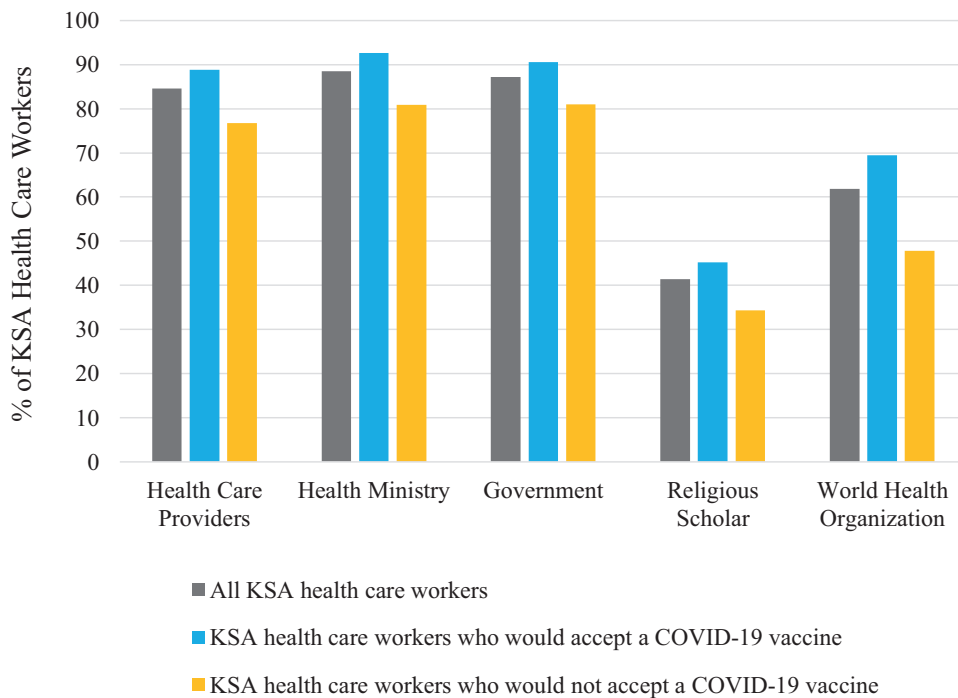


Figure 3. Confidence in KSA Organizations across COVID-19 Vaccine Landscape

the US Operation Warp Speed, the European Commission, and the UK Government Vaccine Taskforce.) invested millions of dollars for vaccine researchers to mobilize quickly (World Health Organization, 2021a). Therefore, health care authorities in the KSA must address any misinformation about COVID-19 side effects to improve uptake among HCWs.

In our study, HCWs reported health officials and health care providers as the most reliable COVID-19 media sources of information. Among KSA organizations, participants reported the high-

est confidence in the KSA MoH, the KSA Government, and health care providers. These findings highlight the need for COVID-19 vaccine messaging to be mainly communicated by health officials and health care providers through the KSA MoH and Government. HCWs also play a crucial role in being one of the most trusted sources of medical information for the general public in the KSA (Alduraywish et al., 2020). As the KSA MoH begins to vaccinate its general population (Ministry of Health, 2021), it must immediately address any COVID-19 vaccine misinformation among the

HCW population to achieve a high vaccination rate among the public. Health care authorities can then empower HCWs to have strong relationships with their patients and prominently feature HCWs in communications campaigns to reduce COVID-19 vaccine misinformation across the KSA.

Strengths & Limitations

The timeliness of this study is crucial as this is the largest study, to our knowledge, evaluating COVID-19 vaccine acceptance and trusted sources of COVID-19 information and organizations in the KSA. However, there are a few limitations that should be considered as well. While our study included a large sample size, and we knew there were approximately 700,000 HCWs registered with the SCHS, we were unable to track the number of emails received, bounced back, and sent to spam. Therefore, we were unable to calculate the response rate. Also, we used a purposive sampling method and not a stratified random sample; thus, our findings may not be generalizable to the whole KSA HCW population. Although almost all HCWs in the KSA have access to a smartphone and/or computer (Altamimi, Khan, & Alex, 2021), the survey was distributed through an online platform, which may limit those who may not have easy access to a smartphone and/or computer.

Additionally, our findings were based on HCWs, which may not reflect the general KSA population. Another limitation is that merging the "don't know" and "no" groups may have resulted in some loss of statistical variability when dichotomizing the outcome variable, COVID-19 vaccine acceptance. Lastly, our findings may be influenced by a social desirability bias, as HCWs may respond to the survey questions in a manner that is viewed favorably by others.

Conclusions

Only 64.9% of HCWs would accept a COVID-19 vaccine—with some variability across demographic groups. The main reason reported for COVID-19 vaccine refusal was fear of potential side effects. Our findings highlight the need for KSA health care authorities to frame public health messaging to best address COVID-19 vaccine concerns among the HCW population. After that, HCWs must be empowered to lead communication campaigns to improve COVID-19 vaccine uptake among the general population.

Author Contributions

JAE, BG, KK, SBO, and ZAM conceptualized the study. SMM and AAM designed the initial survey questionnaire. JAE, BG, and ZAM finalized and translated the questionnaire. JAE cleaned the data and performed the analyses. JAE, BG, SA, RFK, MB, M.H.T., AAM, SMM, and IY interpreted the data. JAE and BG wrote the initial draft of the manuscript with support from SA, RFK, MB, M.H.T., and all other authors, and under the supervision of KK, SBO, and ZAM. All authors read, edited, and approved the final version of the manuscript.

Declaration of Competing Interest

All authors declare no conflicts of interest.

Funding

This work was supported by the Yale Institute for Global Health. Funders played no role in 1) study design; 2) the collection, analysis, and interpretation of data; 3) the writing of the manuscript; or 4) the decision to submit the manuscript for publication. The authors had full access to the data and are responsible for the findings presented in this manuscript.

Acknowledgments

We would like to thank the King Saud Medical City - MoH for assisting us with this project by distributing the survey questionnaires to the participants.

References

- Achenbach, J., & Eunjung Cha, A. (2021). Coronavirus mutations add urgency to vaccination effort as experts warn of long battle ahead. Retrieved from https://www.washingtonpost.com/health/covid-mutations-herd-immunity/2021/01/30/0741722e-627c-11eb-9430-e7c77b5b0297_story.html
- Al-Mohaithef M, Padhi BK. Determinants of COVID-19 Vaccine Acceptance in Saudi Arabia: A Web-Based National Survey. *J Multidiscip Healthc* 2020;13:1657–63. doi:10.2147/jmdh.S276771.
- Alduraywish SA, Altamimi LA, Aldhwayhi RA, AlZamil LR, Alzagher LY, Alsaleh FS, ..., Tharkar S. Sources of Health Information and Their Impacts on Medical Knowledge Perception Among the Saudi Arabian Population: Cross-Sectional Study. *J Med Internet Res* 2020;22(3):e14414. doi:10.2196/14414.
- Alshammari TM, Yusuff KB, Aziz MM, Subaie GM. Healthcare professionals' knowledge, attitude and acceptance of influenza vaccination in Saudi Arabia: a multi-center cross-sectional study. *BMC health services research* 2019;19(1):1–10.
- Altamimi T, Khan M, Alex J. Impact of Smartphone Usage on Healthcare Professionals in Saudi Arabia: A Cross-Sectional Multicenter Study. *International Journal of Medical Research & Health Sciences* 2021.
- Baig M, Jameel T, Alzahrani SH, Mirza AA, Gazzaz ZJ, Ahmad T, ..., Almurashi SH. Predictors of misconceptions, knowledge, attitudes, and practices of COVID-19 pandemic among a sample of Saudi population. *PLoS One* 2020;15(12). doi:10.1371/journal.pone.0243526.
- Barry M, Temsah M-H, Alhuzaimi A, Alamro N, Al-Eyadhy A, Aljamaan F, Al-Tawfiq JA. COVID-19 vaccine confidence and hesitancy among healthcare workers: a cross-sectional survey from a MERS-CoV experienced nation. *MedRxiv* 2020.2020.12.2009.20246447. doi:10.1101/2020.12.09.20246447.
- Barry M, Temsah M-H, Aljamaan F, Saddik B, Al-Eyadhy A, Alanazi S, ..., Alshome F. COVID-19 vaccine uptake among healthcare workers in the fourth country to authorize BNT162b2 during the first month of rollout. *medRxiv* 2021.
- Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, ..., Zhang L. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* 2020;395(10223):507–13. doi:10.1016/s0140-6736(20)30211-7.
- Chou WS, Budenz A. Considering Emotion in COVID-19 Vaccine Communication: Addressing Vaccine Hesitancy and Fostering Vaccine Confidence. *Health Commun* 2020;35(14):1718–22. doi:10.1080/10410236.2020.1838096.
- Dror AA, Eisenbach N, Taiber S, Morozov NG, Mizrahi M, Zigran A, ..., Sela E. Vaccine hesitancy: the next challenge in the fight against COVID-19. *Eur J Epidemiol* 2020;35(8):775–9. doi:10.1007/s10654-020-00671-y.
- Fu C, Wei Z, Pei S, Li S, Sun X, Liu P. Acceptance and preference for COVID-19 vaccination in health-care workers (HCWs). *MedRxiv* 2020.
- Galbadage T, Peterson BM, Awada J, Buck AS, Ramirez DA, Wilson J, Gunasekera RS. Systematic Review and Meta-Analysis of Sex-Specific COVID-19 Clinical Outcomes. *MedRxiv* 2020.
- GCC News Roundup: Gulf states roll out COVID-19 vaccination campaigns, Saudi Arabia faces financial woes (December 1-31). (2021). Retrieved from <https://www.brookings.edu/blog/up-front/2021/01/06/gcc-news-roundup-gulf-states-roll-out-covid-19-vaccination-campaigns-saudi-arabia-faces-financial-woes-december-1-31/>
- Gulf Insider Report. (2021). Women should allow 90 days after Covid-19 vaccine before getting pregnant. Retrieved from <https://www.gulf-insider.com/women-should-allow-90-days-after-covid-19-vaccine-before-getting-pregnant/>
- Harapan H, Wagner AL, Yufika A, Winardi W, Anwar S, Gan AK, ..., Mudatsir M. Acceptance of a COVID-19 Vaccine in Southeast Asia: A Cross-Sectional Study in Indonesia. *Front Public Health* 2020;8:381. doi:10.3389/fpubh.2020.00381.
- History of Vaccines. (2021). Vaccine Development, Testing, and Regulation. Retrieved from <https://www.historyofvaccines.org/content/articles/vaccine-development-testing-and-regulation>
- Khan YH, Mallhi TH, Alotaibi NH, Alzarea AI, Alanazi AS, Tanveer N, Hashmi FK. Threat of COVID-19 Vaccine Hesitancy in Pakistan: The Need for Measures to Neutralize Misleading Narratives. *Am J Trop Med Hyg* 2020;103(2):603–4. doi:10.4269/ajtmh.20-0654.
- Magadmi, R. M., & Kamel, F. O. (2020). Beliefs and Barriers Associated with COVID-19 Vaccination Among the General Population in Saudi Arabia.
- Malik AA, McFadden SM, Elharake J, Omer SB. Determinants of COVID-19 vaccine acceptance in the US. *Eclinicalmedicine* 2020;26.
- Ministry of Health. (2021). Media Center. Retrieved from <https://www.moh.gov.sa/en/Ministry/MediaCenter/Pages/default.aspx>
- Murphy J, Vallières F, Bentall RP, Shevlin M, McBride O, Hartman TK, ..., Hyland P. Psychological characteristics associated with COVID-19 vaccine hesitancy and resistance in Ireland and the United Kingdom. *Nat Commun* 2021;12(1):29. doi:10.1038/s41467-020-20226-9.
- Our World in Data. (2021). Saudi Arabia: Coronavirus Pandemic Country Profile. Retrieved from <https://ourworldindata.org/coronavirus/country/saudi-arabia?country=SAU>
- Peckham H, de Groot NM, Raine C, Radziszewska A, Ciurtin C, Wedderburn LR, ..., Deakin CT. Male sex identified by global COVID-19 meta-analysis

- as a risk factor for death and ITU admission. *Nat Commun* 2020;11(1):6317. doi:[10.1038/s41467-020-19741-6](https://doi.org/10.1038/s41467-020-19741-6).
- Reuters. (2020). Saudi Arabia begins inoculating people with Pfizer COVID-19 vaccines. Retrieved from <https://www.reuters.com/article/us-health-coronavirus-saudi-idUSKBN28Q347>
- Sanche S, Lin YT, Xu C, Romero-Severson E, Hengartner N, Ke R. High Contagiousness and Rapid Spread of Severe Acute Respiratory Syndrome Coronavirus 2. *Emerg Infect Dis* 2020;26(7):1470–7. doi:[10.3201/eid2607.200282](https://doi.org/10.3201/eid2607.200282).
- Saudi Commission for Health Specialties. (2021). About SCFHS. Retrieved from <https://www.scfhs.org.sa/en/about/pages/organization.aspx>
- Shekhar R, Sheikh AB, Upadhyay S, Singh M, Kottewar S, Mir H, Pal S. COVID-19 Vaccine Acceptance among Health Care Workers in the United States. *Vaccines (Basel)* 2021;9(2). doi:[10.3390/vaccines9020119](https://doi.org/10.3390/vaccines9020119).
- Verger P, Scronias D, Dauby N, Adedzi KA, Gobert C, Bergeat M, Dubé E. Attitudes of healthcare workers towards COVID-19 vaccination: a survey in France and French-speaking parts of Belgium and Canada. *Euro Surveill* 2021;26(3). doi:[10.2807/1560-7917.Es.2021.26.3.2002047](https://doi.org/10.2807/1560-7917.Es.2021.26.3.2002047).
- World Health Organization. (2021a). G7 leaders commit US\$ 4.3 billion to finance global equitable access to tests, treatments and vaccines in 2021. Retrieved from <https://www.who.int/news/item/19-02-2021-g7-leaders-commit-us-4.3-billion-to-finance-global-equitable-access-to-tests-treatments-and-vaccines-in-2021>
- World Health Organization. (2021b). Interim recommendations for use of the Moderna mRNA-1273 vaccine against COVID-19. Retrieved from <https://www.who.int/publications/i/item/interim-recommendations-for-use-of-the-moderna-mrna-1273-vaccine-against-covid-19>