Using social media surveys and interventions to address vaccine hesitancy in Saudi Arabia

JungKyu Rhys Lim[1], Ellen Moscoe[1], Ada Alqunaibet[2], Daniel Alejandro Pinzon Hernandez[1], Amaal Alruwaily[2], Mohamad Chatila[1], Rasha Alfawaz[2], Laura Zoratto[1], Zeina Afif[1], Renos Vakis[1], Berq J Hadi Al-Yasseri[1], Reem F Alsukait[1], Son Nam Nguyen[1], Christopher H Herbst[1] and Abdullah Algwizani[2]

[1]The World Bank, Washington DC, USA (Correspondence to JungKyu Rhys Lim: rhyslim@worldbank.org). [2]Suadi Arabia Public Health Authority, Riyadh, Saudi Arabia.

Abstract

Background: Countering COVID-19 vaccine hesitancy has been a challenge in Saudi Arabia, one of the countries affected most by the pandemic in the Eastern Mediterranean Region.

Aims: To identify information needs, perceived benefits, concerns, trusted information sources, social norms, and predictors for COVID-19 vaccine uptake in Saudi Arabia and identify effective messaging strategies to increase vaccination intentions among the unvaccinated.

Method: Between March and April 2021, we conducted an online cross-sectional survey (N = 2883), and in part, a randomized experiment for unvaccinated participants (n = 675) in Saudi Arabia using Facebook Ads and Messenger. Unvaccinated participants were randomly assigned to 1 of 5 message conditions and after message exposure, participants were asked if they planned to take the COVID-19 vaccine.

Results: In total, 2883 adults participated in the survey. All message framings worked equally well, with no statistically significant difference between the arms. Approximately 80% of the participants across all message conditions said they intended to vaccinate. However, participants wanted to know more about the vaccines; about 35% wanted to know more about vaccine efficacy, 31.5% about safety, 26.8% about health authority's recommendation, and 3.7% about where to get the vaccines. Health workers (61.4%) and scientists and epidemiologists (25.7%) were the most trusted sources. Others were family members (7.5%), community leaders (2.2%), religious leaders (1.6%), friends (1.4%), and celebrities and social media influencers (0.2%).

Conclusion: Vaccine hesitancy can be overcome by understanding individuals' decision-making processes and using effective risk communication targeted to their needs.

Keywords: vaccine hesitancy, vaccine uptake, immunization, COVID-19, infectious disease, surveys, message experiment, Kingdom of Saudi Arabia

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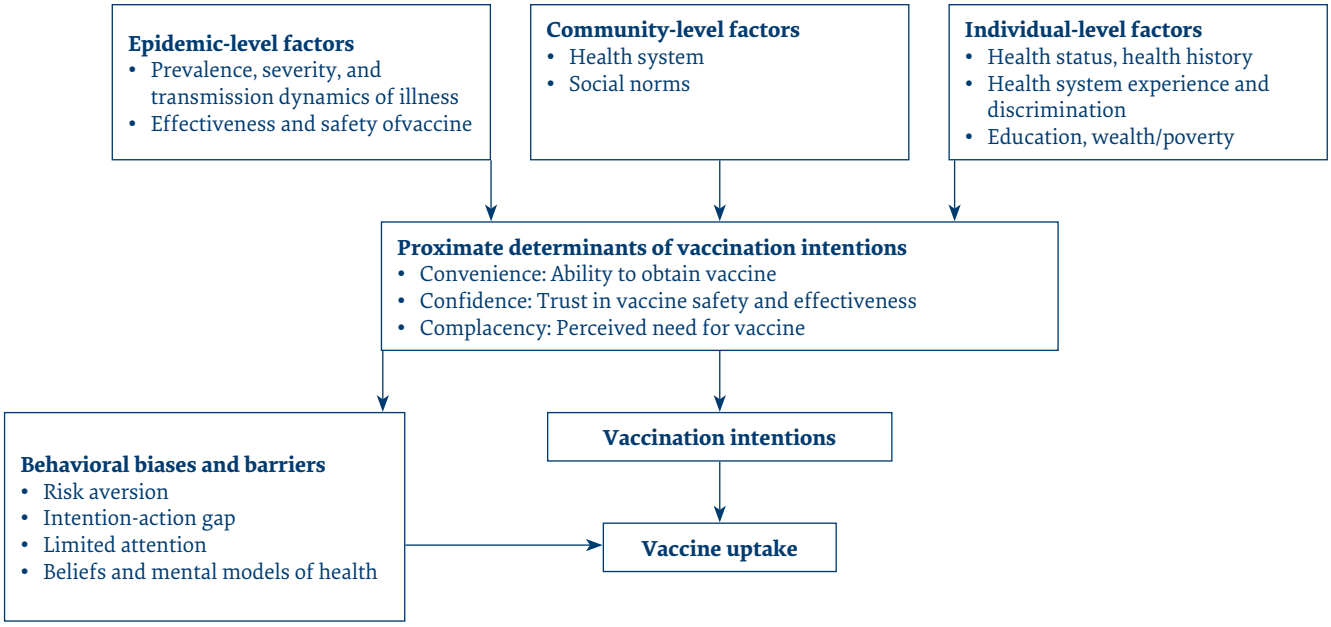
Introduction

Vaccines for the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have been crucial public health preventive measures to lower the risks of COVID-19 infection, spread, illness, and death. However, despite increased availability of vaccine and the potential threat from new variants, vaccination rates have been lagging with many countries far below the coverage rates needed to attain the WHO target of 70% global vaccination coverage by mid-2022 (*1*). Diffusion theory suggests that new innovations follow a trend where a small group of early adopters take up the new technology quickly, followed over time by other population groups with varying degrees of resistance to change (*2*). The SARS-CoV-2 vaccines have followed this pattern (*3,4*). As the pace of new vaccinations slows, interventions that can increase vaccine acceptance, coupled with improvements to vaccine distribution and access, are necessary for countries to meet their vaccination targets.

Vaccine hesitancy is the "delay in acceptance or refusal of vaccines despite availability of vaccination services," on a continuum between full acceptance and refusal (*5*). Such vaccine hesitancy can be influenced by issues of confidence (i.e. not trusting the vaccine or provider), complacency (i.e. not seeing a need for a vaccine) and convenience (i.e. access) (*6*). Guided by and incorporating previous research, we noted that vaccine hesitancy could be influenced by supply and demand, as well as individual, community and system preferences or perceptions (Figure 1).

Specifically, previous research (*7-10*) and major risk communication theories, including the theory of planned behaviour (*11*), the health belief model (*12,13*), the protection motivation theory (*14*), and the extended parallel process model (*15*), have noted that determinants, such as perceived risks, self-efficacy, vaccine safety and efficacy, social norms, vaccine access, and perceived consequences, can impact vaccine hesitancy. For example, people get vaccinated when they think that being infected with COVID-19 could have impacts, or that the vaccine could safely and effectively protect them,

Figure 1 Conceptual framework used for this study



others have been receiving the vaccine, and that they could get the vaccine.

Vaccine supply-related factors, alongside economic, geographic and cultural barriers, can determine vaccination behaviours. For instance, people cannot get vaccinated even though they want to, unless the vaccine is offered and accessible. Policymakers can design more efficient, more accessible and more equitable vaccine distribution programmes by better analysing the factors that determine vaccine acceptance, hesitancy and resistance and tackling the salient factor behind the vaccine hesitancy.

Saudi Arabia began distributing COVID-19 vaccines in December 2020 and had achieved a coverage rate of 40.2% by May 2021, when this study was conducted. Studies conducted before the introduction of the vaccine used hypothetical vaccination intentions (*16,17*). Even after the introduction, researchers primarily examined vaccination intentions, their predictors, information sources, and perceived vaccine benefits and concerns (*18-21*), with a few studies measuring vaccine uptake (*22,23*). The literature on COVID-19 vaccines in Saudi Arabia has largely focused on cross-sectional surveys, with very little experimental evidence on interventions that increase vaccine intentions or uptake (*24*). To fill the gaps, this study examined vaccine uptake, their predictors, and messages to encourage vaccine uptake.

Study objectives

To better understand how public health authorities can effectively address vaccine hesitancy, this paper summarizes 2 studies: a survey contributing to evidence on the drivers of vaccine hesitancy and uptake, and an experiment testing the effects of messaging on increasing vaccine intentions. First, through a survey with participants in the Kingdom of Saudi Arabia (N = 2,883), this study identified demographic and behavioural factors and key drivers of vaccine hesitancy to help develop an effective risk communication strategy. Then, for unvaccinated participants (n = 675), we conducted a randomized experiment that varied framings to develop effective messages based on health communication literature (*11,15,25,26*). By doing so, we provide guidance to public health authorities on how to effectively communicate, generate demand and reduce vaccine hesitancy.

Methods

We conducted an online cross-sectional survey and a randomized experiment for unvaccinated participants nested within the survey, using social media (Facebook Ads and Messenger).

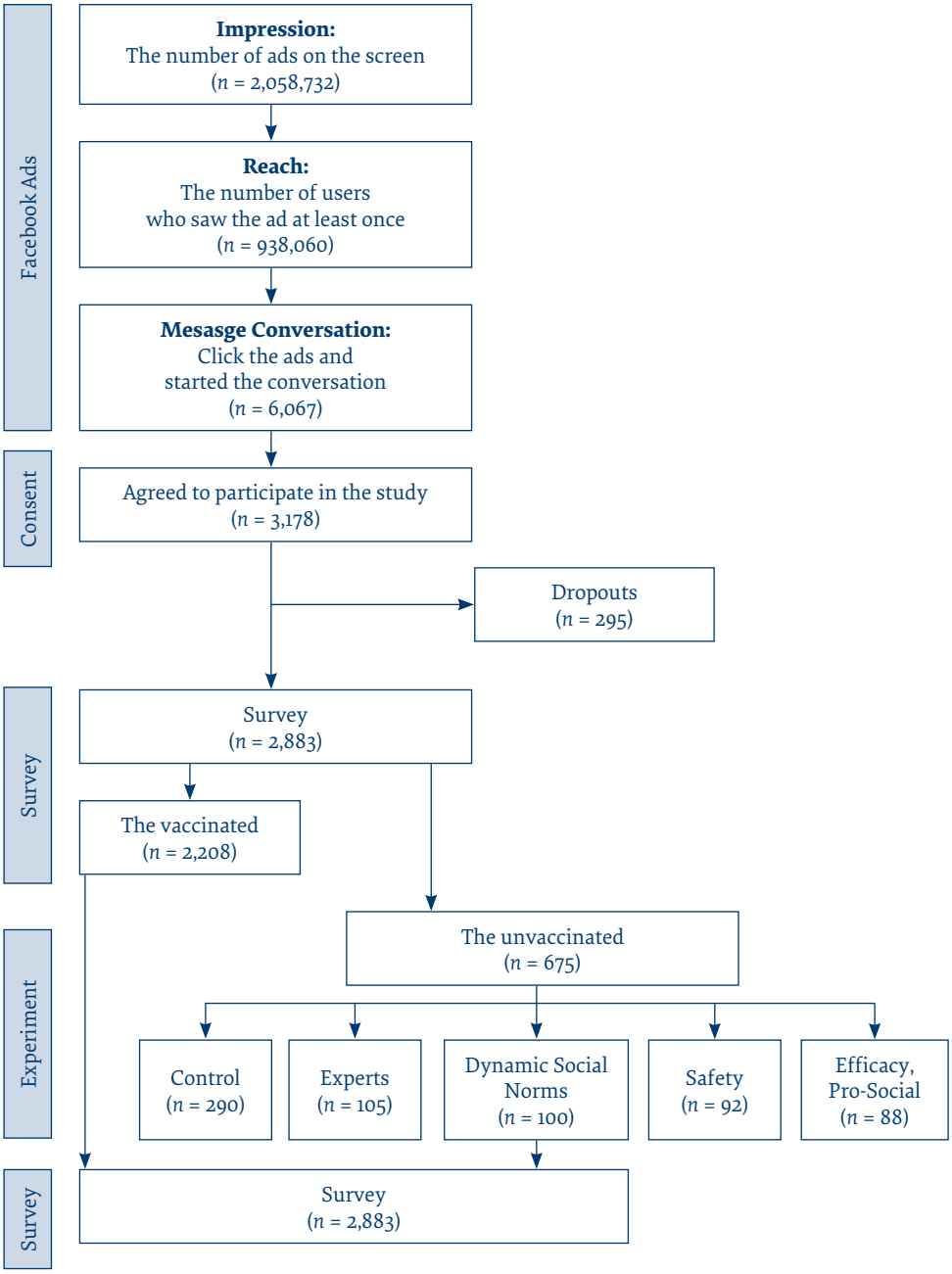
Procedure

Participants in the Kingdom of Saudi Arabia were recruited using Facebook Ads. Facebook users were exposed to the advertisement with the generic recruitment text "Share your opinion" to address potential self-selection bias at the advertisement stage. Those who clicked the ads were redirected to Facebook Messenger, where they consented to participate and completed the survey and experiment via chatbot (Figure 2). Almost 97% of the population in the Kingdom of Saudi Arabia uses the internet (*27*) and Facebook ads can reach approximately 66% of the population. Responses with missing information were removed from the sample during data cleaning. The entire study, including the ads, was conducted in Arabic, the primary language used in Saudi Arabia.

Recruitment

Between May and June 2021, adult participants in the Kingdom of Saudi Arabia were recruited using

Figure 2. **Study flowchart**



Facebook dynamic ads. Instead of using Facebook's ad optimization algorithm, we optimized Facebook ads with 104 clusters based on census demographic information to recruit a sample that reflected, to the extent possible, the country's population distribution by gender, region and age groups. Our optimization helped recruit participants by attempting to keep the ratio between the country's population distribution by age, gender and region, using the number of participants in the clusters, rather than maximizing the reach. Depending on the group's age, gender and region, users may have been exposed to the ad multiple times, until we recruited enough participants in the group. Initially, Facebook ads made 2 058 732 impressions (the number of ads on the screen), reached 938 060 users (i.e. users saw the ad at least once), and 6067 users clicked the Facebook ads and started conversation with the chatbot. Then, those who agreed to participate (n = 3178) continued to respond to the survey, and the unvaccinated (n = 675) participated in a randomized experiment. The final sample was 2883 with a 90.71% completion rate.

Measurement

The survey instrument measured (i) basic demographics to identify views of key groups and correlates of hesitancy for targeting; (ii) previous infection with COVID-19 to identify the relationship between direct experience of illness and participants' opinions and views; (iii) vaccination status and vaccination intentions as the primary outcomes, to assess the roles of demographics (age, gender, education, region), COVID-19-related behaviours (masking, physical distancing), and key

behavioural dimensions of vaccination and vaccination intentions (social norms, trust, locus of control, perceptions, and concerns related to the vaccine).

Experiment framing messages

Participants who reported that they had not been vaccinated against COVID-19 were randomly assigned to 1 of 5 message conditions in advance of being asked about their vaccination intentions: (i) expert endorsement, (ii) dynamic social norms, (iii) safety, (iv) efficacy and pro-sociality, and (v) control group without framing (Table 1). After message exposure, participants were asked "Do you plan to get the COVID-19 vaccine?" with options "No," "Yes," and "Unsure."

Data analysis

Descriptive statistics and correlational analyses, such as chi-square analyses, t-tests, analysis of variance (ANOVA) tests, and binary logistic regression were conducted. Specifically, chi-square analyses were used to examine whether there was significantly different vaccine uptake by demographics, and whether the vaccinated vs. the unvaccinated had differences in their vaccine-related concerns, trusted information sources, social norms, and main benefits of the vaccine. ANOVA tests were used to analyse the difference between message effectiveness and binary logistic regression was used to identify factors predicting vaccine uptake.

Ethical approval

The Kingdom of Saudi Arabia Public Health Authority IRB approved this study (ethics approval #: SCDC-IRB-A035-2021). All participants provided written consent to participate.

Results

Participants

A total of 2883 adults in the Kingdom of Saudi Arabia participated in the survey between 26 May and 8 June 2021. About one-third of the participants lived in the Central Region (Riyadh) and their ages varied, 883 (30.6%) were in their 30s. Some 1719 (59.6%) participants identified as male and 1164 (40.3%) as female. About 15% of them self-reported working in the health sector and almost the same percentage in the education sector. About 5.5% identified as Saudi nationals (n = 158). Overall, the participants' demographics was a representation of the country's demographics (Table 2). However, given that the study was conducted using social media, the participants were younger and more educated.

Vaccine uptake with demographics

About 76.6% of the participants (n = 2208) were vaccinated against COVID-19. Vaccination uptake varied across demographic groups, 81.7% of men (n = 1,404) were vaccinated compared with 69.1% of women (n = 804). Only 58.5% of those aged 18–29 (n = 261) were vaccinated, while 81.4% (n = 438) of participants in their 50s or older were vaccinated ($P < 0.001$). More of the educated participants were more likely to be vaccinated: 67.5% of primary education graduates (n = 85) and 79.5% of tertiary education graduates (n = 1542) ($P < 0.001$). Among the education workers (n = 453), 82.3% were vaccinated (n = 373) and among healthcare workers (n = 410), 88.1% of doctors (n = 133), 74.4% of nurses (n = 58), 81.6% of pharmacists (n = 31), and 86% of other healthcare workers (n = 123) were vaccinated.

COVID-19 vaccine-related information needs

About 35% of the participants wanted to know more about vaccine efficacy (n = 1007), followed by 31.5% about safety (side effects) (n = 908), 26.8% about health authority's recommendation (n = 772), and 3.7% about where to get the vaccines (n = 108).

Vaccinated and unvaccinated participants had different information needs. The vaccinated needed information about efficacy (36.3%, n = 802) the most, followed by vaccine safety (side effects) (29.7%, n = 656), health authority's recommendation (29.4%, n = 650), and where to get the vaccines (2.1%, n = 47). In contrast, the unvaccinated needed information about safety (side effects) (37.3%, n = 252) the most, followed by vaccine efficacy (30.4%, n = 205), health authority's recommendation (18.1%, n = 122), and where to get the vaccines (9%, n = 61).

COVID-19 vaccine-related concerns

About 40% of the participants did not have any concerns (n = 1155), about 30% were concerned about the long-term side effects (n = 864) and 13.7% were concerned about the short-term side-effects (n = 396). Some 5.3% had already been infected with COVID-19 (n = 153), 4.8% thought that the vaccine may not work (n = 139), 1.6% were vaccine-

Table 1 Experiment messages

Message type	Tested message
Control group	**N/A**
Experts	Both COVID-19 vaccines from Pfizer and Astra-Zeneca are considered safe and highly effective by national and international experts
Dynamic social norms	Residents of Saudi Arabia are getting vaccinated against COVID-19! More than 5 million have done it so far, with around 1 million just in the past 2 weeks alone. Help us reach herd immunity!
Safety	COVID-19 vaccines are safe, there have been no reported hospitalizations in Saudi Arabia due to vaccinations compared to 7000 deaths due to COVID-19
Efficacy and pro-social	The latest studies from around the world confirm that the COVID-19 vaccines protect you, your friends, and family from COVID-19 by reducing hospitalizations and death to near 0%

Table 2 Participants' demographic characteristics

Characteristic	Study participants frequency (%)	Kingdom of Saudi Arabia population (%)
Total	2883 (100.0)	
COVID-19 vaccination status		
Participants who received the COVID-19 vaccine	2208 (76.6)	
Participants who did not receive the vaccine		
Registered to receive COVID-19 vaccine	138 (4.8)	
Not registered to receive the vaccine	537 (18.6)	
Age group (years)		
18–29	446 (15.5)	28.0
30–39	883 (30.6)	28.8
40–49	745 (25.8)	23.6
≥ 50	809 (28.1)	19.6
Sex		
Female	1164 (40.4)	39.8
Nationality		
Saudi nationality	158 (5.5)	
Educational attainment		
None/primary	144 (5.0)	
Secondary	800 (27.7)	
Tertiary	1939 (67.3)	
Residency/region		
Asir	199 (6.9)	6.6
Al Bahah	54 (1.9)	1.5
Al Jawf	70 (2.4)	1.5
Al Madinah	240 (8.3)	6.4
Al Qassim	157 (5.4)	4.4
Eastern	547 (19)	15.4
Ha'il	75 (2.6)	2.1
Jizan	105 (3.6)	4.6
Makkah	291 (10.1)	26.8
Najran	58 (2)	1.7
Northern Borders	55 (1.9)	1.1
Riyadh	932 (32.3)	25.6
Tabuk	100 (3.5)	2.6
Household size		
1–2	633 (22.0)	
3–4	1195 (41.4)	
5–6	793 (27.5)	
≥ 7	262 (9.1)	
Employment status		
Employed in the health sector	410 (14.9)	
Employed in the education sector	453 (15.6)	
Past vaccination and COVID-19 case		
Past vaccination (self and/or kids)	2,611 (90.6)	
Previous COVID-19 case at home	768 (26.6)	

Source: Saudi Arabia General Authority for Statistics 2018 (47)

hesitant (*n* = 46), 1.3% said their preferred vaccine type was not available (*n* = 38), and 1.2% had low trust in the pharmaceuticals and health institutions (*n* = 35).

Concerns about the vaccine varied between the vaccinated and unvaccinated ($P < 0.001$). More (41%) of the vaccinated participants did not have any concerns (*n* = 910) than the unvaccinated (36%, *n* = 245). The vaccinated were more concerned about the long-term (31.6%, *n* = 698) and short-term (14.3%, *n* = 316) side effect than the unvaccinated (24.6%, *n* = 166; 11.9%, *n* = 80, respectively). In contrast, the unvaccinated felt they did not need the vaccine because they had been previously infected with COVID-19, were generally against vaccines, or had low trust in pharmaceutical and health institutions.

Trusted information sources

About 61.4% of the participants trusted information from healthcare professionals such as doctors, nurses and pharmacists (*n* = 1769). About a quarter (25.7%) trusted scientists and epidemiologists (*n* = 740), followed by 7.5% family (*n* = 217), 2.2% community leaders (*n* = 64), 1.6% religious leaders (*n* = 46), 1.4% friends (*n* = 40), and 0.2% celebrities and social media influencers (*n* = 7). There was no statistically significant difference among trusted information sources between the vaccinated and the unvaccinated.

Perceived main benefits of the vaccine

More than half of the participants (53.4%, *n* = 1539) reported that protecting oneself was the main benefit of receiving the vaccine, about a quarter (26.7%, *n* = 771) mentioned resuming interactions as the main benefit, followed by protecting others 12.5% (*n* = 361) and for other reasons 3.7% (*n* = 107).

Chi-square analysis revealed statistically significant differences in the perceived main benefits between the unvaccinated and vaccinated ($P < 0.001$). Vaccinated participants were more likely to perceive that the vaccine would protect them (55% vs 48.9%) and the unvaccinated were more likely to perceive no benefit from the vaccine (7.7% vs 2.3%).

Social norms

Descriptive social norms

Majority (95%) of the participants believed that their friends (*n* = 2,731) and families (*n* = 2740) would take the vaccine. Chi-square analysis revealed mixed findings on descriptive social norms between family and friends. For the family, statistically significant differences in social norms that family would take the vaccine was found between the unvaccinated and vaccinated ($P < 0.001$). Vaccinated participants were more likely to believe that their family would take the vaccine (95.9%) than the unvaccinated participants (92.1%). In contrast, for friends, there was no statistically significant difference between the unvaccinated (93.6%) and vaccinated (95.1%) ($P < 0.05$).

Injunctive social norms

Majority (94%) believed that everyone should take the vaccine to protect others (*n* = 2715). Chi-square analysis revealed statistically significant differences in injunctive social norms between the unvaccinated and vaccinated ($P < 0.001$). Vaccinated participants (95.7%) were more likely to believe that everyone should take the vaccine to protect others than unvaccinated participants (89.3%).

Factors predicting vaccine uptake

Binary logistic regression (*n* = 2878) was conducted to identify factors that predict vaccination status (i.e. vaccinated, unvaccinated). Vaccine uptake was predicted by being male ($P < 0.001$); being older ($P < 0.001$); being a health worker, specifically doctors ($P = 0.02$) or other health workers excluding nurses and pharmacists ($P = 0.021$); being a Saudi national ($P = 0.003$); and not having COVID-19 cases at home ($P < 0.001$), adjusting for other factors. Vaccine uptake was predicted by injunctive social norms (i.e. thinking that everyone should take the vaccine to protect others) ($P = 0.004$), the benefits of vaccine, such as resuming interactions ($P < 0.001$), protecting myself ($P < 0.001$), protecting others ($P = 0.002$), or any other vaccine benefits ($P = 0.03$), and preferring AstraZeneca vaccine ($P = 0.001$) to Pfizer vaccines ($P < 0.001$) (Table 3).

We used a more parsimonious model with a reduced set of variables (Table 4). Similarly to the full model, results from the reduced model indicated that vaccine uptake was predicted by being male ($P < 0.001$), being older ($P < 0.001$), being a Saudi national ($P = 0.003$), and being a health worker, specifically doctors ($P < 0.01$) or other health workers excluding nurses and pharmacists ($P = 0.01$), adjusting for other factors. Vaccine uptake was predicted by not having COVID-19 cases at home ($P < 0.001$), the injunctive social norms ($P = 0.003$), seeing any benefits of vaccines such as resuming interactions ($P < 0.001$), protecting myself ($P < 0.001$), protecting others ($P = 0.001$), any other vaccine benefits ($P < 0.05$), and preferring AstraZeneca vaccines ($P = 0.002$) to Pfizer vaccines ($P < 0.001$) (Table 4).

Message framing effectiveness

We conducted a randomized experiment and ANOVA to test message effectiveness on vaccination intentions among the unvaccinated (*n* = 675). We compared a control group to 4 message framings that highlighted different reasons to get vaccinated. Approximately 80% of the participants reported that they intended to get vaccinated across all message conditions; there was no statistically significant difference in intentions across groups ($P < 0.05$). : (i) expert endorsement (M = 1.743, SD = 0.053); (ii) dynamic social norms (M = 1.820, SD = 0.054); (iii) safety (M = 1.783, SD = 0.056); (iv) efficacy and pro-sociality (M = 1.705, SD = 0.057); and (v) control group without framing (M = 1.738, SD = 0.032).

Table 3 Factors predicting vaccine uptake – full model

	Unadjusted (Crude)				Adjusted					
	B	SE *B*	Odds ratio	*P*-value	*B*	SE *B*	Odds ratio	95% CI for odds ratio		*P*-value
								Lower	Upper	
Gender										
Female	-0.691	0.089	0.501	<0.001	-0.71	0.099	0.491	0.405	0.597	<0.001
Age	0.339	0.039	1.403	<0.001	0.317	0.043	1.374	1.263	1.494	<0.001
Education level										
None (Reference)				<0.001						<0.001
Primary	0.277	0.520	1.319	0.594	0.306	0.562	1.359	0.451	4.091	0.586
Secondary	0.456	0.490	1.577	0.352	0.468	0.53	1.597	0.565	4.517	0.377
Tertiary	0.905	0.487	2.472	0.063	1.031	0.529	2.804	0.994	7.909	0.051
Household size	-0.019	0.049	0.981	0.700	0.019	0.053	1.019	0.918	1.131	0.723
Saudi nationals	0.369	0.213	1.446	0.084	0.689	0.231	1.991	1.267	3.129	0.003
Education worker	0.413	0.132	1.512	0.002	-0.199	0.143	0.82	0.619	1.084	0.164
Health worker										
No (Reference)				<0.001						0.029
Doctor	0.883	0.255	2.419	<0.001	0.648	0.28	1.913	1.106	3.308	0.02
Nurse	-0.052	0.263	0.950	0.844	0.19	0.282	1.209	0.696	2.102	0.5
Pharmacist	0.372	0.421	1.450	0.377	0.316	0.451	1.372	0.567	3.32	0.483
Others	0.700	0.246	2.014	0.004	0.597	0.258	1.818	1.096	3.013	0.021
Region										
Riyadh (Reference)				0.090						0.132
Asir	0.032	0.186	1.032	0.864	-0.046	0.199	0.955	0.647	1.409	0.816
Al Bahah	0.054	0.336	1.056	0.872	0.144	0.364	1.155	0.566	2.356	0.692
Al Jawf	0.101	0.301	1.106	0.738	-0.049	0.323	0.952	0.505	1.795	0.879
Al Madinah	-0.077	0.169	0.925	0.646	-0.191	0.181	0.826	0.579	1.179	0.292
Al Qassim	0.05	0.207	1.052	0.808	-0.231	0.22	0.794	0.516	1.222	0.294
Eastern	-0.252	0.123	0.777	0.04	-0.333	0.133	0.717	0.553	0.93	0.012
Tabuk	0.188	0.262	1.207	0.473	-0.007	0.278	0.993	0.577	1.712	0.981
Ha'il	0.273	0.306	1.314	0.372	0.296	0.329	1.345	0.706	2.564	0.368
Jizan	0.188	0.256	1.207	0.463	0.012	0.271	1.012	0.595	1.723	0.963
Makkah	0.304	0.171	1.355	0.075	0.115	0.182	1.122	0.785	1.603	0.528
Najran	-0.632	0.284	0.532	0.026	-0.822	0.306	0.439	0.241	0.8	0.007
Northern Borders	0.188	0.346	1.207	0.587	-0.172	0.381	0.842	0.399	1.777	0.652
Other vaccination status										
No				0.052						0.848
Yes	0.24	0.141	1.271	0.088	0.086	0.155	1.09	0.804	1.476	0.58
I don't know	0.008	0.167	1.008	0.962	0.091	0.181	1.095	0.768	1.562	0.616
COVID-19 at home										
No				0.001						<0.001
Yes	-0.336	0.097	0.715	<0.001	-0.43	0.107	0.651	0.528	0.802	<0.001
I don't know	0.138	0.214	1.148	0.519	0.207	0.231	1.23	0.782	1.935	0.37
Descriptive social norms										
The family will take the vaccine	0.696	0.179	2.005	<0.001	0.295	0.228	1.343	0.858	2.102	0.197
Friends will take the vaccine	0.270	0.186	1.310	0.146	-0.185	0.228	0.831	0.531	1.3	0.417

Table 3 Factors predicting vaccine uptake – full model *(concluded)*

	Unadjusted (Crude)				Adjusted					
	B	SE *B*	Odds ratio	*P*-value	*B*	SE *B*	Odds ratio	95% CI for odds ratio		*P*-value
								Lower	Upper	
Injunctive social norms										
Everyone should get the vaccine to protect others	0.966	0.163	2.627	<0.001	0.58	0.204	1.787	1.199	2.662	0.004
Always wear a mask in public	0.908	0.384	2.480	0.018	0.72	0.419	2.055	0.905	4.668	0.085
External locus of control (getting sick)	-0.075	0.093	0.928	0.424	0.066	0.101	1.069	0.876	1.304	0.512
Government response to COVID-19 effective	0.550	0.393	1.732	0.162	0.143	0.454	1.154	0.474	2.807	0.753
Main vaccine benefits										
None				<0.001						<0.001
Resuming interactions	1.274	0.214	3.576	<0.001	1.204	0.267	3.333	1.974	5.627	<0.001
Protecting myself	1.279	0.205	3.595	<0.001	1.052	0.261	2.863	1.715	4.78	<0.001
Protecting others	1.025	0.229	2.787	<0.001	0.863	0.283	2.371	1.363	4.126	0.002
Something else	0.789	0.286	2.2	0.006	0.706	0.325	2.025	1.07	3.831	0.03
Preferred vaccine										
None				<0.001						<0.001
AstraZeneca	0.81	0.249	2.248	0.001	0.837	0.259	2.31	1.391	3.837	0.001
Pfizer	-0.698	0.095	0.498	<0.001	-0.618	0.103	0.539	0.441	0.659	<0.001
Constant					-2.377	0.863	0.093			0.006

n = 2878

Discussion

Predictors of COVID-19 vaccine uptake

In our study, about 76.6% of the participants had taken the COVID-19 vaccine. Vaccine uptake was predicted by being male, being older, being a doctor or other health worker excluding nurses or pharmacists, being a Saudi national, not having COVID-19 cases at home, thinking that everyone should take the vaccine to protect others, seeing the benefits of the vaccine, and preferring AstraZeneca to Pfizer vaccines.

Unlike most previous studies examining vaccination intentions (*7-10*), we also assessed actual vaccine uptake (*17,19,20*). Our results are consistent with previous research that demographic factors such as gender and age predicted vaccination intentions before (*16*) and after vaccine introduction by the government (*18,20,21*). However, unlike previous research finding that non-Saudi residents were more willing to take the vaccine (*16,18*), our findings revealed that Saudi nationals were more likely to get vaccinated than non-Saudi residents. Given that the large non-Saudi population (e.g. foreign workers, migrants) in Saudi Arabia are at increased health risks (*28,29*), more vaccination efforts may be needed for non-Saudi nationals.

Given the low vaccine uptake among the less educated (*16,21*), more efforts are needed to address possible inequalities in communication, which deters access to, processing of, and capacity to act on information among different social classes. Priority should be given to individuals in the low vaccine uptake group in public health communication and by reducing the barriers hindering them from having access to vaccines.

Our findings add to the evidence that behavioural factors, such as injunctive social norms (e.g. people thinking it is important for everyone to get vaccinated or perceived main vaccine benefits), predict vaccine uptake. However, descriptive social norms (e.g. people thinking their friends and family would take the vaccine) did not predict vaccine uptake. These behavioural factors can be incorporated into risk communication plans.

Vaccine concerns, benefits, information needs and trusted messengers

Concerns about vaccine safety and side effects were the most common (43% of participants). Compared to the vaccinated, the unvaccinated were more concerned about not needing the vaccine due to previous COVID-19 infection, being generally against vaccines and having low trust in pharmaceutical and health institutions. The results also showed that majority of unvaccinated participants desired to obtain more information about the safety and efficacy of vaccines, and the recommendations of health authorities and institutions. The main perceived benefits were protecting themselves and others and resuming interactions. The trusted

Table 4 **Factors predicting vaccine uptake – reduced model**

	Unadjusted (Crude)				Adjusted					
	B	SE *B*	Odds ratio	*P*-value	B	SE *B*	Odds ratio	95% CI for odds ratio		*P*-value
								Lower	Upper	
Gender										
Female	-0.691	0.089	0.501	<0.001	-0.609	0.096	0.544	0.451	0.656	<0.001
Age	0.339	0.039	1.403	<0.001	0.328	0.042	1.388	1.279	1.507	<0.001
Saudi nationals	0.369	0.213	1.446	0.084	0.678	0.227	1.969	1.263	3.069	0.003
Health worker										
No (Reference)				<0.001						0.003
Doctor	0.883	0.255	2.419	<0.001	0.782	0.272	2.185	1.281	3.726	0.004
Nurse	-0.052	0.263	0.950	0.844	0.264	0.279	1.302	0.754	2.248	0.344
Pharmacist	0.372	0.421	1.450	0.377	0.514	0.443	1.671	0.702	3.981	0.246
Others	0.700	0.246	2.014	0.004	0.657	0.254	1.929	1.172	3.176	0.01
Region										
Others				<0.001						0.003
Eastern	-0.32	0.108	0.726	0.003	-0.29	0.115	0.748	0.597	0.937	0.012
Najran	-0.7	0.278	0.497	0.012	-0.728	0.294	0.483	0.271	0.86	0.013
COVID-19 at home										
No				0.001						<0.001
Yes	-0.336	0.097	0.715	<0.001	-0.386	0.104	0.68	0.554	0.834	<0.001
I don't know	0.138	0.214	1.148	0.519	0.221	0.227	1.248	0.8	1.947	0.33
Injunctive social norms										
Everyone should take the vaccine to protect others	0.966	0.163	2.627	<.001	0.585	0.197	1.794	1.219	2.642	0.003
Main vaccine benefit										
None				<0.001						<0.001
Resuming interactions	1.274	0.214	3.576	<0.001	1.323	0.257	3.753	2.268	6.211	<0.001
Protecting myself	1.279	0.205	3.595	<0.001	1.079	0.251	2.942	1.8	4.807	<0.001
Protecting others	1.025	0.229	2.787	<0.001	0.889	0.272	2.433	1.427	4.148	0.001
Something else	0.789	0.286	2.2	0.006	0.779	0.318	2.179	1.168	4.063	0.014
Preferred vaccine										
None				<.001						<.001
AstraZeneca	0.81	0.249	2.248	0.001	0.801	0.256	2.227	1.348	3.682	0.002
Pfizer	-0.698	0.095	0.498	<0.001	-0.618	0.101	0.539	0.443	0.657	<0.001
Constant					-0.789	0.27	0.454			0.004

n = 2878

messengers mentioned include healthcare professionals, scientists and epidemiologists.

Our findings are aligned with previous research on the vaccine safety and efficacy concerns among the public (*17,22*) and the main benefits to protect themselves and others (*21*). The findings add new evidence on trusted messengers (i.e. healthcare professionals) to previous literature that identified information sources (e.g.

Ministry of Health) and channels (e.g. social media) in Saudi Arabia (*19,23*). Since healthcare professionals are trusted messengers that interact directly with patients (*30,31*) and previous research found that sharing expert opinions on the COVID-19 vaccine increased vaccine uptakes in the Czech Republic (*32*), future research can test messages using healthcare professionals, while public health authorities can collaborate with healthcare professionals and communicate their perceptions about vaccination. Messages that individuals who had already been infected with COVID-19 need to get vaccinated can be tested and communicated. By incorporating these insights, public health authorities can increase vaccination uptake.

Messaging to address vaccine hesitancy

Our experiment revealed that all message framings (i.e. expert, dynamic social norms, safety, efficacy and pro-social messages) were equally effective and that unvaccinated participants overwhelmingly intended to get vaccinated. Regarding vaccination intentions, researchers have commonly used behavioural intentions to predict behaviours in experiments (*33*), and one meta-analysis examining 47 experiments found that a medium-to-large change in behavioural intention (d = 0.66) led to a small-to-medium change in behaviours (d = 0.36) (*33*).

Our experiment leveraged an online survey and employed cutting-edge risk communication techniques (*25,26,34-38*) to examine which messages could increase vaccination intention relatively early for vaccination roll-out in the Kingdom of Saudi Arabia. Most of the previous research in Saudi Arabia focused on identifying factors predicting vaccination intentions using cross-sectional surveys (*18-21*). In contrast, previous experimental research conducted in other regions had mixed findings (*34,37*). For example, vaccine safety messages encouraged vaccination intentions (*34*) in Latin America (*39*), the United Kingdom (*40*), and USA (*41*), but not among unvaccinated adults in California (*42*) and adults in Poland (*43*). Social norms messages increased vaccination intentions among healthcare workers (*44*) and adults (*41*) in the USA but not in Poland (*43*) and the United Kingdom (*45*). Sharing expert opinions about the COVID-19 vaccine increased vaccine uptakes in the Czech Republic (*32*). Our framing experiment provides causal evidence to support communication campaign designs and adds evidence from non-Western societies (*34-38,46*).

The already high baseline intention rate and relatively small sample sizes of the unvaccinated in the framing arms may be the reason for not detecting statistically significant differences. However, descriptively, dynamic social norms and safety messages increased the vaccination intentions of unvaccinated participants, while messages using national and international experts and efficacy, and pro-social messages, reduced the vaccination intentions. Given previous research (*34-41,44*) and with a caution that only unvaccinated adults participated in our experiment, and we only found descriptive differences, public health authorities could attempt to use social norms and safety messages in their immunization communication efforts. Future research can test messages with physicians or doctors to guide risk communication by public health authorities, given previous research findings in the Czech Republic (*32*) and our insignificant findings about expert messages. Also, there may be other impactful message types that can be applied in the Middle East and North Africa, such as value-based messages or messages using different sources, narratives, visuals, and emotional appeals, which future research can examine (*26*).

Limitations

This study has limitations which may affect interpretation of the results. First, the study represents one cross-section in May and June 2021, a time when the COVID-19 pandemic and vaccine distribution were changing quickly, and this study did not capture how the relationships between key indicators presented here changed over time. Findings from the cross-sectional surveys cannot be generalized to other risks, diseases, countries, and/or larger populations, which future research can examine.

Second, although our participants' demographics represented the country's demographics (*47*), study participants were recruited via Facebook ads and chose to participate in the survey (e.g. self-selection bias). Thus, our participants may differ from the overall population in important and unobservable ways. Caution needs to be applied in interpreting the results. The use of the Facebook platform disproportionately excluded the poorest and the elderly, who are most vulnerable to COVID-19. We found that COVID-19 vaccine uptake was predicted by being a doctor or other health workers excluding nurses or pharmacists. Future research could explore vaccine uptake among different categories of health workers.

Third, the study used self-reported measures, which could be affected by biases (*48,49*). The anonymous nature of the web-based survey may have reduced social desirability bias and may also suffer from other issues relating to attention and comprehension. However, this study is the first of its kind conducted after wide availability of the COVID-19 vaccine in Saudi Arabia, measuring various participant characteristics and testing messages to encourage vaccination.

Conclusion

Although the COVID-19 pandemic showed a decline in 2023, while countries strived to vaccinate their populations, information about the drivers of vaccine acceptance and effective risk communication have been powerful tools for policymakers around the world, including Saudi Arabia (*25*). To guide risk communication, this study identified demographic and behavioural predictors for vaccine uptake, trusted information sources, perceived vaccine benefits and concerns, and effective messaging. Social media particularly can be

very useful to public health authorities not only to collect timely data and gain insights for shaping their risk communication, but also to communicate risks with at-risk populations. Our study demonstrates how public health authorities can collect timely data using social media to guide their risk communication efforts, and a similar approach could be used for targeting risk communication efforts. More evidence is needed on the impact of risk communication on vaccine uptake, as opposed to intentions.

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Utilisation d'enquêtes et d'interventions sur les médias sociaux pour lutter contre la réticence face à la vaccination en Arabie saoudite

Résumé

Contexte : La réticence face à la vaccination contre la COVID-19 a constitué un défi en Arabie saoudite, l'un des pays les plus touchés par la pandémie dans la Région de la Méditerranée orientale.

Objectifs : Identifier les besoins d'informations, les avantages perçus, les inquiétudes, les sources d'informations fiables, les normes sociales et les facteurs prédictifs concernant l'adoption des vaccins contre la COVID-19 en Arabie saoudite et déterminer les stratégies de communication efficaces permettant d'augmenter les intentions de vaccination chez les personnes non vaccinées.

Méthode : Entre mars et avril 2021, nous avons mené une enquête transversale en ligne (n = 2883), ainsi qu'une expérience randomisée à l'aide de Facebook Messenger et de publicités Facebook auprès de participants non vaccinés, parmi ceux ayant participé à l'enquête susmentionnée en Arabie saoudite (*n* = 675). Ces derniers ont consulté aléatoirement un des cinq messages à tonalités différentes, puis il leur a été demandé s'ils envisageaient de se faire vacciner contre la COVID-19.

Résultats : Au total, 2883 adultes ont participé à l'enquête. Les cadrages de messages se sont tous avérés efficaces, sans différence statistiquement significative entre les groupes. Près de 80 % des participants, indépendamment de la tonalité du message auquel ils ont été exposés, ont déclaré avoir l'intention de se faire vacciner. Cependant, ils souhaitaient obtenir plus d'informations sur les vaccins. Près de 35 % d'entre eux voulaient en savoir plus sur leur efficacité, 31,5 % sur leur innocuité, 26,8 % s'interrogeaient sur les recommandations des autorités sanitaires et 3,7 % sur les endroits où se procurer les vaccins. Les agents de santé (61,4 %) et les scientifiques ainsi que les épidémiologistes (25,7 %) étaient les sources d'informations les plus fiables. Les autres sources incluaient les membres de la famille (7,5 %), les responsables de communauté (2,2 %), les chefs religieux (1,6 %), le cercle amical (1,4 %) et les célébrités et influenceurs de médias sociaux (0,2 %).

Conclusion : La réticence face à la vaccination peut être surmontée grâce à la compréhension des processus de décisions des individus et à l'utilisation d'une stratégie de communication efficace concernant les risques, adaptée aux besoins de la population.

استخدام مسوحات وتدخلات وسائل التواصل الاجتماعي للتصدي للتردد في أخذ اللقاح في المملكة العربية السعودية

جونجكيو ريز ليم، إلين موسكو، عذا القنيبط، دانييل أليخاندرو بينزون هيرناندیز، آمال الرويلي، محمد شاتيلا، رشا الفواز، لاورا زوراتو، زينة عفيف، رينوس فاكيس، برق جعفر هادي الياسري، ريم فهد السكيت، سون نام نجويين، كريستوفر هـ. هيربست، عبد الله القويزاني

الخلاصة

الخلفية: لا يزال التصدي للتردد في أخذ لقاح كوفيد-19 يمثل تحديًا في المملكة العربية السعودية التي تُعد من البلدان الأكثر تضررًا من الجائحة في إقليم شرق المتوسط.

الأهداف: هدفت هذه الدراسة الى تحديد الاحتياجات من المعلومات، والفوائد المتصورة، والمخاوف، ومصادر المعلومات الموثوق بها، والأعراف الاجتماعية، وعوامل التنبؤ المتعلقة بالإقبال على لقاح كوفيد-19 في المملكة العربية السعودية، وتحديد الاستراتيجيات الفعالة لتوجيه الرسائل لزيادة اعتزام الحصول على اللقاح لدى غير الملقحين.

طرق البحث: في المدة بين مارس/ آذار وأبريل/ نيسان 2021، أجرينا مسحًا مقطعيا عبر الإنترنت (العدد = 2883)، وتجربة عشوائية جزئيًّا للمشاركين غير الملقَّحين (العدد = 675) في المملكة العربية السعودية باستخدام برنامج المراسلة فيسبوك ماسنجر. ووُزِّع المشاركون غير الملقحين عشوائيًّا على نسق واحد من 5 أنساق للرسائل، وبعد تلقِّي الرسائل، سُئل المشاركون عما إذا كانوا يعتزمون أخذ لقاح كوفيد-19.

النتائج: شارك في المسح 2883 بالغًا. وقد حققت جميع أطر الرسائل نتيجة جيدة على قدم المساواة، مع عدم وجود فارق ذي دلالة إحصائية بين المجموعات. وقال نحو 80٪ من المشاركين في جميع أنساق الرسائل إنهم يعتزمون أخذ اللقاح. ومع ذلك، أعرب المشاركون عن رغبتهم في معرفة المزيد عن اللقاح؛ حيث أعرب نحو 35٪ عن رغبتهم في معرفة المزيد عن فعالية اللقاح، و31.5٪ عن المأمونية، و26.8٪ عن توصية الهيئة الصحية، و3.7٪ عن مكان أخذ اللقاح. وكان العاملون الصحيون (61.4٪) والعلماء واختصاصيو الوبائيات (25.7٪) المصادر الأكثر موثوقية. وكانت المصادر الموثوق بها الأخرى هي أفراد الأسرة (7.5٪)، وقادة المجتمع (2.2٪)، والزعماء الدينيون (1.6٪)، والأصدقاء (1.4٪)، والمشاهير والشخصيات المؤثرة على وسائل التواصل الاجتماعي (0.2٪).

الاستنتاجات: يمكن التغلب على التردد في أخذ اللقاح من خلال فهم عمليات اتخاذ القرارات لدى الأفراد واستخدام الطرق الفعالة للإبلاغ عن المخاطر التي تستهدف تلبية احتياجاتهم.

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