



COVID-19 vaccine hesitancy among medical students in India

Jyoti Jain¹, Suman Saurabh² , Prashant Kumar³, Mahendra Kumar Verma⁴, Akhil Dhanesh Goel² , Manoj Kumar Gupta², Pankaj Bhardwaj² and Pankaja Ravi Raghav²

Original Paper

Cite this article: Jain J, Saurabh S, Kumar P, Verma MK, Goel AD, Gupta MK, Bhardwaj P, Raghav PR (2021). COVID-19 vaccine hesitancy among medical students in India.

Epidemiology and Infection **149**, e132, 1–10. <https://doi.org/10.1017/S0950268821001205>

Received: 12 March 2021

Revised: 11 May 2021

Accepted: 14 May 2021

Key words:

Covaxin; COVID-19; Covishield; medical students; vaccine hesitancy

Author for correspondence:

Suman Saurabh, E-mail: drsumansaurabh@gmail.com, saurabh@aiimsjodhpur.edu.in

¹All India Institute of Medical Sciences (AIIMS), Basni, Jodhpur, 342005, Rajasthan, India; ²Department of Community Medicine and Family Medicine, All India Institute of Medical Sciences (AIIMS), Basni, Jodhpur, Rajasthan 342005, India; ³Department of Community Medicine, All India Institute of Medical Sciences (AIIMS), Phulwari Sharif, Patna, Bihar 801507, India and ⁴Department of Community Medicine, Institute of Medical Sciences and Research Centre, Jaipur National University, Jagatpura, Jaipur, Rajasthan 302017, India

Abstract

The coronavirus disease 2019 (COVID-19) vaccine was launched in India on 16 January 2021, prioritising health care workers which included medical students. We aimed to assess vaccine hesitancy and factors related to it among medical students in India. An online questionnaire was filled by 1068 medical students across 22 states and union territories of India from 2 February to 7 March 2021. Vaccine hesitancy was found among 10.6%. Concern regarding vaccine safety and efficacy, lack of awareness regarding their eligibility for vaccination and lack of trust in government agencies predicted COVID-19 vaccine hesitancy among medical students. On the other hand, the presence of risk perception regarding themselves being affected with COVID-19 reduced vaccine hesitancy as well as hesitancy in participating in COVID-19 vaccine trials. Vaccine-hesitant students were more likely to derive information from social media and less likely from teachers at their medical colleges. Choosing between the two available vaccines (Covishield and Covaxin) was considered important by medical students both for themselves and for their future patients. Covishield was preferred to Covaxin by students. Majority of those willing to take the COVID-19 vaccine felt that it was important for them to resume their clinical posting, face-to-face classes and get their personal life back on track. Around three-fourths medical students viewed that COVID-19 vaccine should be made mandatory for both health care workers and international travellers. Prior adult vaccination did not have an effect on COVID-19 vaccine hesitancy. Targeted awareness campaigns, regulatory oversight of vaccine trials and public release of safety and efficacy data and trust building activities could further reduce COVID-19 vaccine hesitancy among medical students.

Introduction

The coronavirus disease 2019 (COVID-19) has emerged as a global pandemic with 162 million confirmed cases and 3.4 million deaths worldwide, as on 18 May 2021 [1]. As a part of control measures against COVID-19, vaccines have been launched in India from 16 January 2021, which has been subsequently scaled up in response to the surge of cases starting in April 2021 [2]. The second wave of pandemic in India has triggered a massive humanitarian crisis with unprecedented number of hospitalisations and deaths [3]. Mass vaccination against COVID-19 has emerged as a key preventive strategy [4].

In the first phase, health care workers including medical students were targeted for vaccination with either of the two vaccines approved for restricted emergency use – Covishield or Covaxin. Covishield is manufactured by Serum Institute of India under license from Astra Zeneca (adenovirus vectored ChAdOx1 nCoV-19 vaccine – AZD1222) [4, 5] whereas the inactivated severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) vaccine Covaxin (BBV152) is manufactured in India by Bharat Biotech in collaboration with Indian Council of Medical Research [5, 6]. From 1 March 2021, COVID-19 vaccination has been extended to those aged more than 60 years and those with comorbidities from 45 to 59 years of age [2]. Subsequently, starting 1 April 2021 and 1 May 2021, all individuals in India aged 45–59 years and 18–44 years have become eligible to receive vaccination, respectively. The process of registration for the vaccination is done online through the COVID-19 Vaccine Intelligence Network (CO-WIN) portal which is developed with the support of United Nations Development Programme (UNDP) [7]. It is also configured to track enlisted beneficiaries, issue short messaging service (SMS) reminders and vaccination certificates for users [7].

Vaccine hesitancy has been frequently studied among health care workers and especially medical students [8]. The COVID-19 pandemic spurred the rapid development of vaccines with their prominent coverage in news and social media [9]. Recent studies highlighted the

© The Author(s), 2021. Published by Cambridge University Press. This is an Open Access article, distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives licence (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is unaltered and is properly cited. The written permission of Cambridge University Press must be obtained for commercial re-use or in order to create a derivative work.

concerns regarding adverse events, unduly rapid vaccine development and poor vaccine efficacy as some of the possible reasons for vaccine hesitancy among medical students [10–13]. In the Indian scenario, out of the two vaccines, the safety and phase 3 efficacy data were publicly released for Covishield through a scientific publication of the parent Astra Zeneca vaccine [14, 15]. For Covaxin, the safety and immunogenicity data of phase 1 trial is available [16]. An announcement of 81% efficacy has been made on 3 March 2021 [6], while its peer-reviewed scientific publication is awaited.

Although provided free of charge, there had been no option for the health workers to choose between the two vaccines, since allocation of vaccines to health facilities had been centrally determined owing to limited supply in the initial phase. High vaccination coverage among medical students is needed not only because of their role as future physicians, but also because they are expected to provide COVID-19 care in high burden situations [17]. Therefore, considering the recent surge in COVID-19 cases in India, the study of vaccine hesitancy among medical students is important. The present study aims to assess the awareness and sources of vaccine information, attitudes and possible determinants of COVID-19 vaccine hesitancy among medical students enrolled in MBBS course in India.

Methods

A cross-sectional study was conducted among the cohort of medical students in India for a period of around 5 weeks from 2 February–7 March 2021.

Sample size was calculated pertaining to the prevalence of COVID-19 vaccine hesitancy or refusal among medical or nursing students from previous reports which ranged from 6% in Egypt, 13.9% in Italy and 23% in USA [12, 18, 19]. This yielded a sample size of 962 individuals corresponding to the lowest prevalence of 6% from Egypt, relative precision of 25% and alpha value of 5%.

An anonymous online structured questionnaire (Supplementary file 1) was prepared using evidence from prior studies on vaccine hesitancy in general [20, 21] and COVID-19 vaccine hesitancy among medical students [12]. The questionnaire was prepared in English language which could be understood by medical students as it is the medium of instruction of medical course throughout India. It was designed to collect information regarding basic demographic details, awareness and sources of information regarding COVID-19 vaccine, attitudes regarding the vaccine and prior vaccination experience. This questionnaire was deployed online using Google forms. Its link was shared by the student investigator within the social media network of medical students – both individually and mainly through the WhatsApp groups, which included students of a particular batch studying in medical colleges. The students further circulated it among their acquaintances within the same medical college. Respondent-driven sampling strategy was used to target all medical students consenting and willing to spare the time to fill the survey. No financial or in-kind reward was offered to students who completed the survey.

Upon completion of the survey, data were downloaded in comma-separated values format and data analysis was conducted using SPSS software v23.0 and EpiInfo™ v7.2.4. Categorical variables related to the survey items were tabulated and odds ratio for vaccine hesitancy was calculated using univariate approach. Subsequently, multivariate logistic regression was conducted to test for plausible determinants of vaccine hesitancy while adjusting for gender, type of medical college, being in pre-clinical or clinical part of course and lack of prior vaccine experience.

Similar analysis was repeated for exploring the determinants of hesitancy of joining COVID-19 vaccine trial. A two-tailed *P*-value of less than 0.05 was taken as significant.

The study has been approved by the Institutional Ethics Committee of All India Institute of Medical Sciences (AIIMS) – Jodhpur, India (Ref: AIIMS/IEC/2021/3438). Data collection was completely anonymous with no individual level identifying information such as name, email or mobile number of student or name of medical colleges being collected (Supplementary file 1).

Results

A total of 1068 students from 22 states and union territories of India participated in the online survey (Fig. 1). Around two-fifths of students were from Rajasthan state (Table 1). Gender of students was almost equally distributed (48.6% females). Nearly one-fourths students were studying in the clinical part of the MBBS course (Table 1). The data collected for the study is included in Supplementary file 2.

In response to the statement 'I am willing to take the COVID-19 vaccine when offered', 43 (4.0%) 'disagreed' and 70 (6.6%) were 'not sure'. Therefore, vaccine hesitancy was found among 113 students (10.6%). Among those who agreed, 689 (64.5%) had already taken the vaccine and 266 (24.9%) were yet to receive the vaccine at the time of responding to the survey. Out of the possible responses of 'yes', 'not sure' and 'no', those responding 'yes' have been cross-tabulated in Table 1 based on whether they accepted the COVID-19 vaccine or hesitated to take it. Cumulative vaccine hesitancy based on the online responses showed a significant declining trend ($P=0.00164$) from 15.5% at the end of the first week of the survey to 10.6% at the end of the fifth week (Fig. 2). Internet, social media and teachers at medical colleges were the most common source of information regarding COVID-19 vaccine for both the vaccine hesitance and acceptance groups (Fig. 3). Further, we found that larger proportion of vaccine-hesitant students obtained vaccine-related information from social media, as compared to those accepting vaccines (Fig. 3). On the other hand, lesser vaccine-hesitant students had teachers at medical college as their source of vaccine-related information (Fig. 3). Concern regarding safety of COVID-19 vaccine followed by concern regarding its efficacy was the most common reason cited by those hesitant to take the vaccine (Fig. 4).

Upon conducting logistic regression, lack of awareness of medical students regarding their COVID-19 vaccine eligibility, concern regarding vaccine safety and efficacy and lack of trust in public health authorities were associated with COVID-19 vaccine hesitancy (Table 2). Hesitation in joining COVID-19 vaccine trial was predicted by lack of trust in government or public health authorities (Table 3). Conversely, the presence of risk perception among students regarding themselves getting affected by COVID-19 was associated with lesser hesitancy in receiving COVID-19 vaccine as well as for participating in COVID-19 vaccine trials (Tables 2 and 3).

Comments by medical students were arranged in four themes – 'confidence in vaccine', 'concern regarding vaccine', 'practical considerations' and 'need for better education' (Table 4).

Discussion

Awareness of COVID-19 vaccine and sources of information

COVID-19 vaccination provides a renewed opportunity to closely study the dynamics of health-related behaviour change in a well-

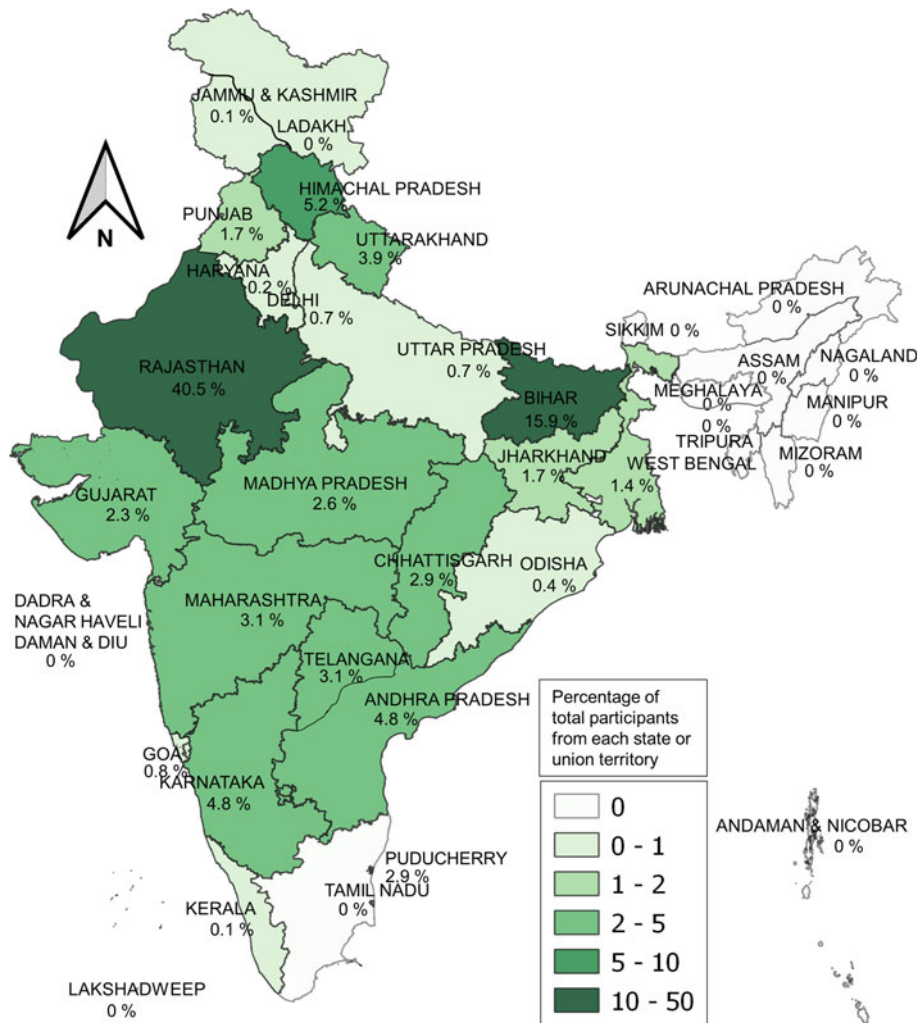


Fig. 1. State/Union territory-wise participation of medical students in the COVID-19 vaccine survey in India ($n = 1068$).

informed young adult population. We found that better awareness regarding the COVID-19 vaccine was associated with reduced hesitancy, similar to study conducted earlier [8]. COVID-19 vaccine hesitancy reduced over time in our study, which has also been observed earlier [22, 23]. COVID-19 vaccine uptake, especially among young college students has been explained through diffusion of innovation theory through openness to experience and adoption of descriptive norm [22]. Innovators and early adopters of COVID-19 vaccination could play a role in facilitating its wider acceptance in the medical student community [24].

The views of students should also be seen in relation to the matrix of multiple sources of information available to them. Our findings support that the role of internet and social media as an information source of health behaviours has been increasingly important for medical students [20]. Any future intervention to reduce vaccine hesitancy among the student population should take into account this realignment of sources of information. Contribution of social media as a source of information was significantly greater among vaccine-hesitant students, which could be explained by unverified and potentially misleading information promoted by anti-vaccination groups [25, 26]. Therefore, we recommend countering this by systematic promotion of more reliable sources of information such as through peers, teachers and official websites.

Determinants of vaccine hesitancy

Adoption of vaccination practices by healthcare workers plays a key role in motivating the general population through setting an example [10, 27]. Concerns regarding COVID-19 vaccine adverse events as a possible reason for hesitancy has been highlighted by most studies concerning university students, health care workers and in the general population [10–13, 18, 28]. Further, concerns regarding vaccine efficacy were also seen to limit the adoption of the COVID-19 vaccine [10, 11, 18, 28]. The real concern regarding adverse events appeared to be from the possible 'long term' effect of the vaccine. This was coupled with the apprehension that the vaccines had not been tested rigorously enough to determine all possible adverse events and efficacy in a proper manner. The short-term adverse events were also inconveniencing the students owing to vaccination sessions held close to their examinations. The concern regarding vaccine adverse events and efficacy were further elaborated by the comments provided by students. Additionally, concern of lack of consent for provision of data for registration of COVID-19 vaccine by medical students was also observed.

Our findings also seemed to match with the health belief model [24] wherein the perceived susceptibility to COVID-19 and perceived benefits of vaccination had a role in reducing the hesitancy for COVID-19 vaccination. We also found that a

Table 1. Responses of medical students belonging to vaccine acceptance and hesitance groups (N = 1068)

Survey items	All students (N = 1068)		Vaccine acceptance group (N = 955)		Vaccine hesitancy group (N = 113)		Odds ratio (95% CI)	P value
	n	%	n	%	n	%		
<i>Demographic details</i>								
Government medical college	938	87.8	843	88.3	95	84.1	0.70 (0.41–1.20)	0.207
Location of medical college in Rajasthan	433	40.5	399	41.8	34	30.1	0.60 (0.39–0.91)	0.016
Students in clinical years (3rd year, 4th year and interns)	255	23.9	227	23.8	28	24.8	1.06 (0.67–1.66)	0.802
Female gender	519	48.6	467	48.9	52	46.0	0.89 (0.60–1.32)	0.565
<i>Awareness and overall attitude regarding vaccine acceptance</i>								
Aware that MBBS students are eligible for COVID-19 vaccination	1011	94.7	922	96.5	89	78.8	0.13 (0.08–0.23)	<0.001
Awareness of the correct number of COVID-19 vaccines (two) available in the country	802	75.1	724	75.8	78	69.0	0.71 (0.46–1.09)	0.122
'I will take the COVID-19 vaccine only if it is made mandatory for me by government authorities or college and not on my own'	396	37.1	308	32.3	88	77.9	7.39 (4.65–11.77)	<0.001
'I will be willing to take part in a COVID-19 vaccine trial in future.'	524	49.1	509	53.3	15	13.3	0.13 (0.08–0.23)	<0.001
'I will be willing to motivate my fellow students to take the COVID-19 vaccine.'	871	81.6	844	88.4	27	23.9	0.04 (0.03–0.07)	<0.001
<i>Perception of vulnerability to COVID-19 and personal attitude regarding usefulness of vaccine</i>								
'I am likely to get COVID-19 in course of my duties as a medical student.'	859	80.4	805	84.3	54	47.8	0.17 (0.11–0.26)	<0.001
'Getting the appropriate vaccines are important for me to stay healthy as a future physician.'	1022	95.7	934	97.8	88	77.9	0.08 (0.04–0.15)	<0.001
'Keeping up to date about the upcoming vaccines is important for my role as a future physician'	1042	97.6	939	98.3	103	91.2	0.18 (0.08–0.40)	<0.001
'COVID-19 vaccination is important to me in order to resume my clinical posting and face-to-face classes'	899	84.2	865	90.6	34	30.1	0.04 (0.03–0.07)	<0.001
'COVID-19 vaccination is important to me to get my personal life back on track.'	776	72.7	746	78.1	30	26.5	0.053 (0.03–0.08)	<0.001
<i>General views regarding usefulness of COVID-19 vaccine for community</i>								
'COVID-19 vaccine can reduce the spread of the disease in the community.'	907	84.9	840	88.0	67	59.3	0.20 (0.13–0.31)	<0.001
'COVID-19 vaccine can help reduce severe COVID-19 disease.'	906	84.8	839	87.9	67	59.3	0.20 (0.13–0.31)	<0.001
'COVID-19 vaccine should be made mandatory for the health care workers.'	800	74.9	764	80.0	36	31.9	0.12 (0.08–0.18)	<0.001
'COVID-19 vaccine should be made mandatory for those travelling abroad.'	853	79.9	804	84.2	49	43.4	0.14 (0.10–0.22)	<0.001
'COVID-19 vaccine should be made mandatory for domestic inter-state travellers'	705	66.0	678	71.0	27	23.9	0.13 (0.08–0.20)	<0.001
<i>Concern regarding COVID-19 vaccines and trust of official information</i>								
'I am concerned that the present COVID-19 vaccines may not be effective enough'	468	43.8	385	40.3	83	73.5	4.10 (2.65–6.34)	<0.001
'I am concerned about the serious adverse events from the currently available COVID-19 vaccines'	621	58.1	523	54.8	98	86.7	5.40 (3.09–9.43)	<0.001
'I am concerned about the present COVID-19 vaccines might not have been tested rigorously prior to launch'	502	47.0	419	43.9	83	73.5	3.54 (2.29–5.48)	<0.001
'I trust the information I am receiving about the COVID-19 vaccine from the government or public health experts.'	799	74.8	765	80.1	34	30.1	0.11 (0.07–0.16)	<0.001

<i>Choice of vaccines</i>								
'I consider it important to choose between the different available COVID-19 vaccines for myself'	800	74.9	724	75.8	76	67.3	0.66 (0.43–1.00)	0.053
'I consider it important to choose between the different available COVID-19 vaccines for my patients in future'	907	84.9	819	85.8	88	77.9	0.58 (0.36–0.94)	0.034
<i>If provided an option, which vaccine would you choose for yourself?</i>								
Covaxin	213	19.9	205	21.5	8	7.1	0.17 (0.08–0.37)	<0.001
Covishield	483	45.2	446	46.7	37	32.7	0.36 (0.23–0.57)	<0.001
No preference for either of them	86	8.1	71	7.4	15	13.3	0.93 (0.49–1.75)	0.834
Don't have enough information to choose	286	26.8	233	24.4	53	46.9	1 (reference)	–
<i>Prior vaccination experience</i>								
'Have you received any other vaccine(s) after joining as a medical student (apart from COVID-19 vaccine) ?'	414	38.8	376	39.4	38	33.6	0.78 (0.52–1.18)	0.237
Type of vaccine	<i>N</i> = 414		<i>N</i> = 376		<i>N</i> = 38			
Hepatitis B	325	78.5	293	77.9	32	84.2	0.68 (0.30–1.52)	0.352
Tetanus	116	28.0	108	28.7	8	21.1	1 (reference)	–
Hepatitis A	23	5.6	19	5.1	4	10.5	0.352 (0.10–1.29)	0.142
Hepatitis C	17	4.1	16	4.3	1	2.6	1.19 (0.14–10.11)	0.957
Varicella	15	3.6	14	3.7	1	2.6	1.04 (0.12–8.92)	0.952
Human Papilloma Virus	10	2.4	9	2.4	1	2.6	0.67 (0.07–5.94)	0.688
Herpes	2	0.5	1	0.3	1	2.6	0.07 (0.004–1.30)	0.153
Other vaccines	91	22.0	91	24.2	0	0	–	–

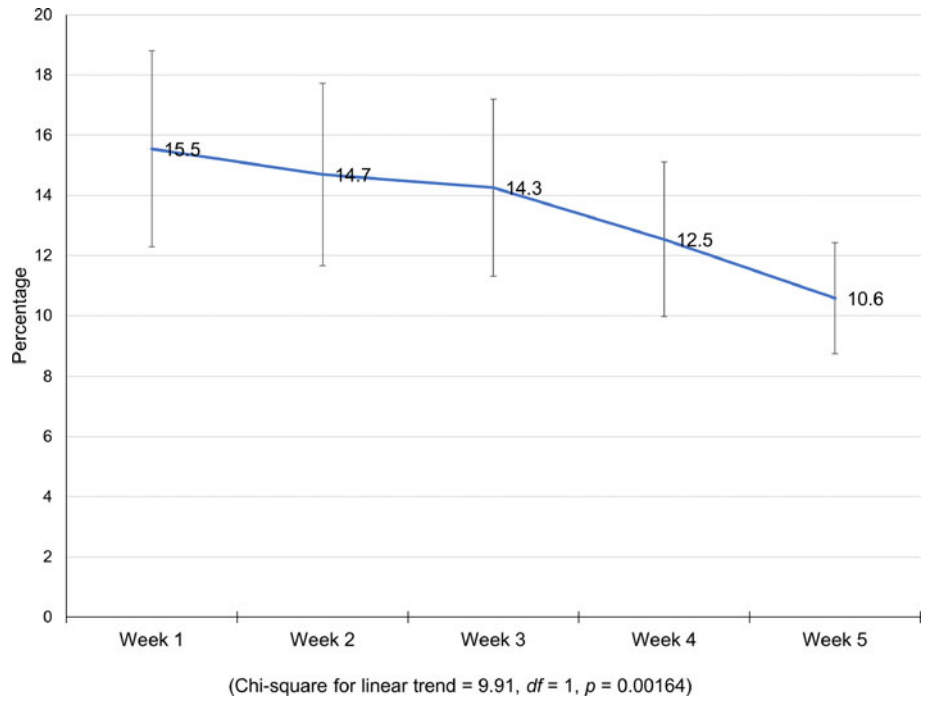


Fig. 2. Week-wise trend of cumulative COVID-19 vaccine hesitancy among surveyed medical students.

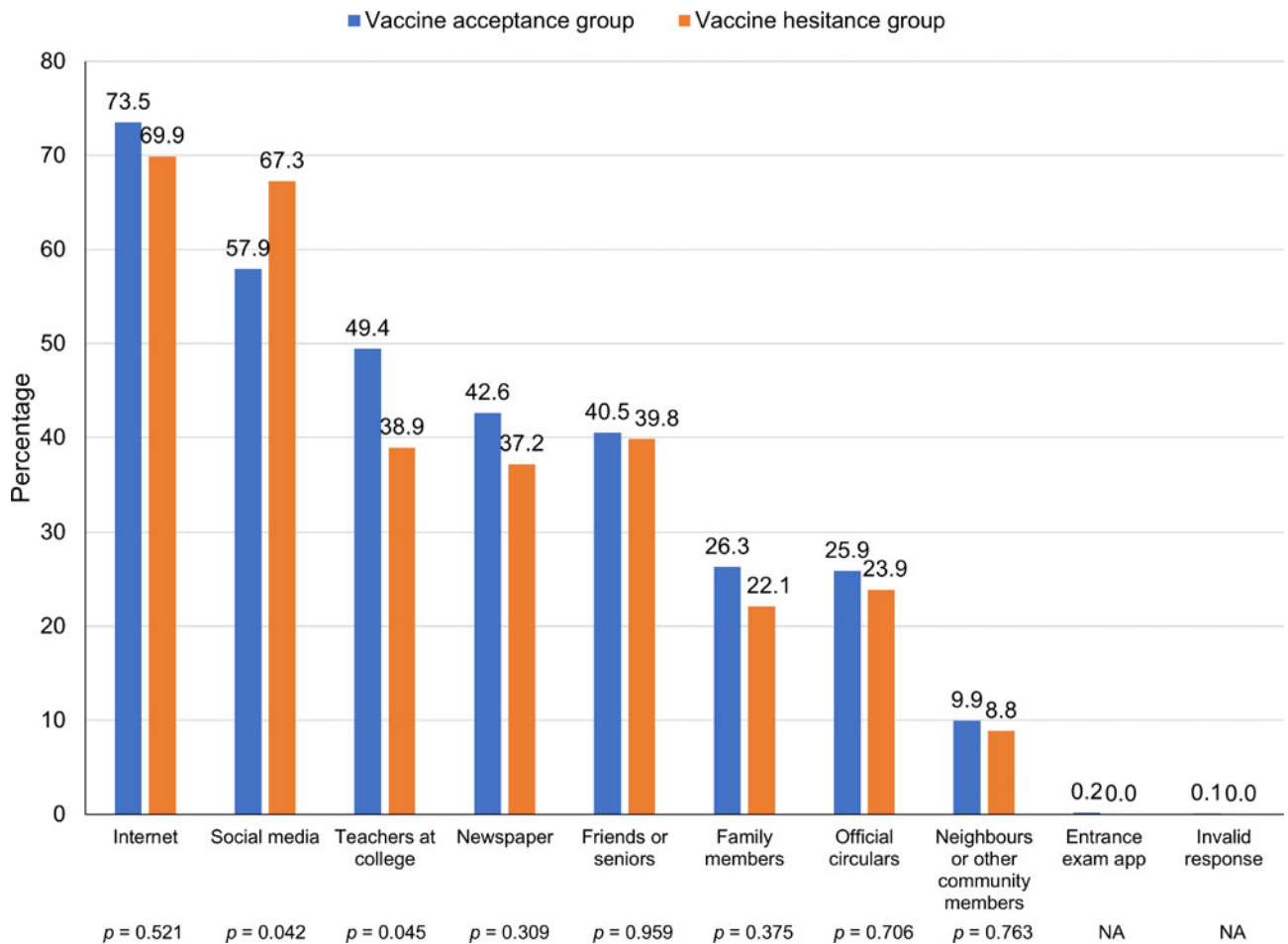


Fig. 3. Sources of information regarding COVID-19 vaccine for the medical students belonging to vaccine hesitance and vaccine acceptance groups (*n* = 1068).

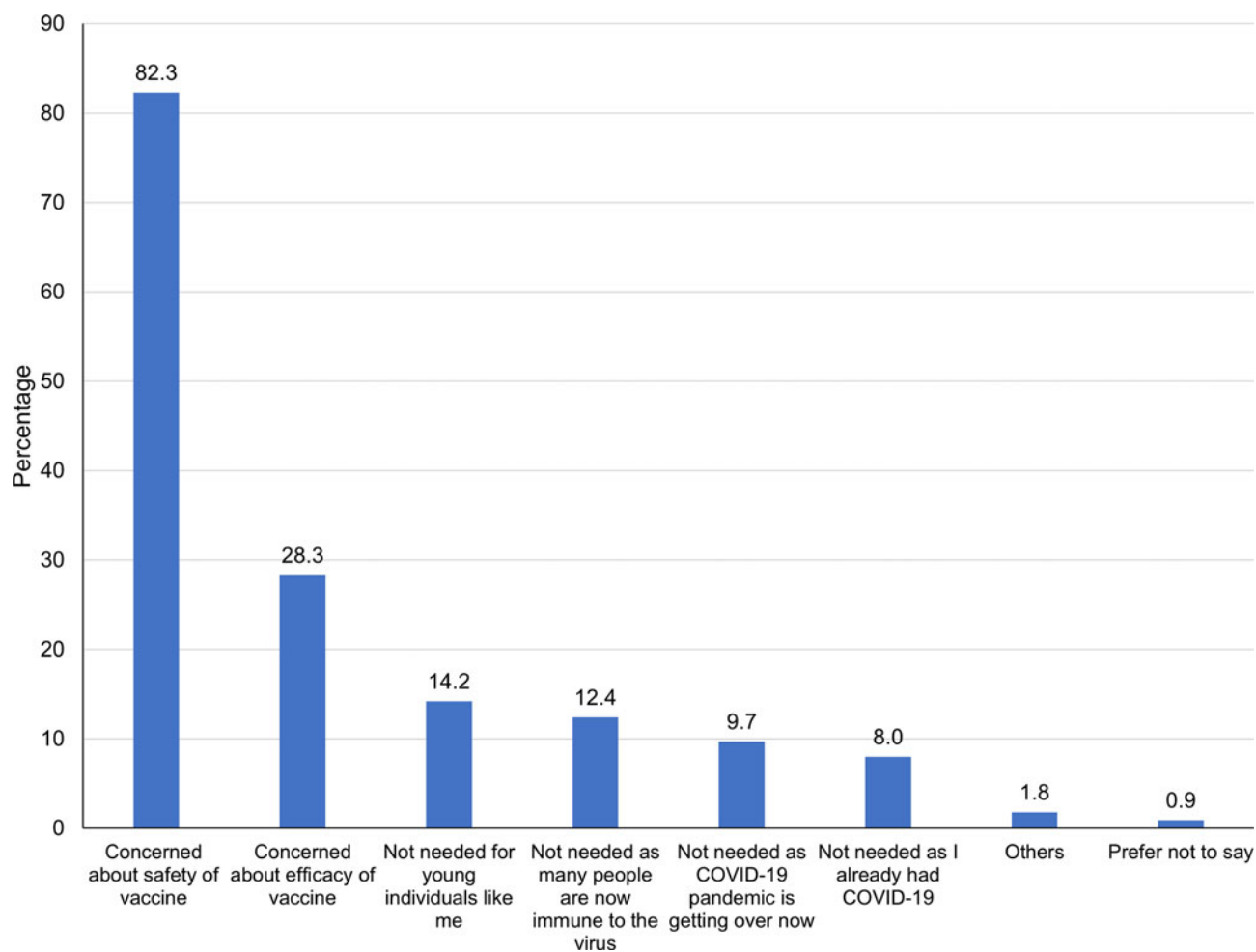


Fig. 4. Reasons for COVID-19 vaccine hesitancy among the medical students ($n = 113$).

Table 2. Multivariable logistic regression for plausible determinants of COVID-19 vaccine hesitancy ($N = 1068$)

Variables	Odds ratio (95% CI)	<i>P</i> value
Studying in government medical college	1.32 (0.82–2.13)	0.243
Studying in clinical year	0.99 (0.57–1.72)	0.966
Male gender	1.33 (0.82–2.13)	0.244
Lack of awareness regarding eligibility of medical students for COVID-19 vaccination	4.08 (1.97–8.45)	<0.001
Presence of risk perception regarding COVID-19	0.18 (0.11–0.30)	<0.001
Prior vaccination experience present	0.97 (0.59–1.60)	0.908
Concern regarding adverse effect of vaccine	3.63 (1.86–7.07)	<0.001
Concern regarding efficacy of vaccine	2.23 (1.30–3.84)	0.004
Lack of trust in govt. or public health authorities	5.93 (3.68–9.56)	<0.001

Model parameters: Log likelihood = -247.59, minus 2 log likelihood difference vs. intercept = 226.05, $df = 9$, $P < 0.0001$. Pseudo $R^2 = 0.3134$.

sizeable proportion of students had indeed received the vaccination despite having concerns which indicated that acceptance of vaccination was not purely voluntary. It appears unlikely that this coercion could be entirely driven by pressure from college authorities. Within this framework, COVID-19 vaccine acceptance could have been a subjective norm and pressure of social conformity could have influenced some hesitant students to

finally get vaccinated. Further, majority of those choosing to be vaccinated were motivated by desire for resumption of clinical and face-to-face classes and by the prospect of getting their personal lives back on track. Therefore, COVID-19 vaccination was also seen a confidence building measure which could help the students ease their restricted life during COVID-19 pandemic. Confidence regarding the vaccine was also expressed by the

Table 3. Multivariable logistic regression for plausible determinants of hesitancy regarding participation in COVID-19 vaccine trials (N = 1068)

Variables	Odds ratio (95% CI)	P value
Studying in government medical college	1.14 (0.77–1.70)	0.513
Studying in clinical year	1.43 (1.05–1.95)	0.024
Male gender	0.91 (0.71–1.17)	0.478
Lack of awareness regarding eligibility of medical students for COVID-19 vaccination	1.45 (0.79–2.66)	0.234
Presence of risk perception regarding COVID-19	0.34 (0.24–0.49)	<0.001
Prior vaccination experience present	1.14 (0.88–1.49)	0.320
Concern regarding adverse effect of vaccine	0.95 (0.71–1.27)	0.713
Concern regarding efficacy of vaccine	1.18 (0.88–1.58)	0.264
Lack of trust in govt. or public health authorities	2.33 (1.71–3.17)	<0.001

Model parameters: Log likelihood = -691.08, minus 2 log likelihood difference vs. intercept = 98.03, df = 9, $P < 0.0001$. Pseudo $R^2 = 0.0662$.

students through free comments. On the other hand, those hesitating were much less likely to believe in this enabling effect of COVID-19 vaccination.

Hesitancy for participation in COVID-19 vaccine trials

Concern for adverse events did not deter medical students to participate in vaccine trials unlike their counterparts in the United States of America [12]. Risk perception of self-regarding COVID-19 increased the students' willingness to participate in COVID-19 vaccine trial. On the other hand, lack of trust in government or public health authorities deterred them from participating in vaccine trials, similar to what was observed in previous studies [12, 29, 30].

Attitudes regarding COVID-19 vaccine mandates

Overall, more than three-fourths medical students viewed that COVID-19 vaccine should be made mandatory for both health care workers and international travellers. However, those hesitating to take COVID-19 vaccination were also less convinced about the various aspects of usefulness of the vaccine for the community such as its potential in reducing the spread of infection or severe COVID-19 disease. They were also much less likely to have it mandated for health care workers and domestic and international travellers. Majority of even those hesitating displayed a sense of responsibility in their role as future physicians to keep up to date regarding the upcoming vaccines and their importance in keeping themselves healthy. This suggests that hesitation regarding COVID-19 vaccination could be related to issues specific to it rather than due to apathy towards vaccines in general. Therefore, targeted education and trust building by regulatory agencies and medical colleges could considerably reduce COVID-19 vaccine hesitancy among medical students.

Choice of vaccines and previous vaccination

Students considered it important to choose between the available COVID-19 vaccines both for themselves and for their future patients. Between the two available vaccines, Covishield was preferred whereas a considerable proportion also felt that they did not have enough information to choose. Acceptance of Covaxin was found to be less in general and was even lesser among

those hesitating to take the vaccine. This situation might change in future with more information on safety and efficacy of vaccines being available.

Experience of prior vaccination has been found to have a role in increasing the acceptance of COVID-19 vaccine [29, 31]. However, this was not replicated in the present study. This could be mainly because in the present setting, Hepatitis-B was the vaccine taken by majority of the students unlike the studies from outside India in which annual Influenza vaccination had been considered [29, 31]. Since the importance of Hepatitis B vaccine is well-accepted for healthcare professionals, its uptake might be more related to medical colleges' policy of offering vaccination to medical students during their course rather than vaccine hesitancy *per se*.

Limitations

Our survey had the limitation that it was conducted after COVID-19 vaccination had started in some of the medical colleges. Therefore, it could have underestimated the initial vaccine hesitancy of those who subsequently converted to the vaccine acceptance group and were ultimately vaccinated. Since participation in this survey was based on peer-to-peer communication through social media networks, the denominator for calculation of response rate could not be determined. Due to the non-probability sampling approach in the study, the generalisability of vaccine hesitancy among medical students across India would need to be further informed by the local context. We also did not specifically ask about scientific journals as a source of vaccine information. Although we captured students' responses through open comments, the online mode of data collection often fails to capture the depth of information which could otherwise have been possible through qualitative methods applied in face-to-face settings.

Conclusions

COVID-19 vaccine hesitancy was found in one out of every 10 medical students. Lack of awareness regarding vaccination eligibility, concern regarding adverse events and efficacy of the vaccine and lack of trust in government were independently predictive of vaccine hesitancy. Heightened risk perception regarding COVID-19 seemed to reduce vaccine hesitancy. Concerns

Table 4. Comments provided by medical students regarding COVID-19 vaccine

Theme (total number of comments)	Representative quotes
Concerns regarding vaccine	<p>'Adverse effects of vaccine are too much.'</p> <p>'We still don't know the long-term effect of this vaccine so the people who are in low covid prone area can avoid taking the vaccine until clinical trial ends & rest who are at high risk of exposure to COVID-19 should take the vaccine. In this way it won't affect the entire population'</p> <p>'Vaccine is being administered without consent especially to the medical students, which is not ethically correct, given the unavailability of adequate data regarding its safety. My registration was done by the college authorities without my prior knowledge and without asking about my medical background e.g., if I have any coexisting diseases which could probably be related to increased risk of any adverse effects of the vaccine. Nor were we warned about the expected side effects like fever and injection site pain.'</p> <p>'I just wanted that Govt. of India makes sure that these vaccines have gone through complete and proper testing/trial before they start being used widely.'</p> <p>'It's efficacy and side effects should be mentioned properly, updated information.'</p> <p>'Heard, Covishield is fully tested vaccine till last phase and is a formula from Oxford, but I'm concerned about Covaxin, which they didn't complete the last phase of trial (rumour) and is manufactured in India and is being given.'</p> <p>'It should not be mandatory for any one'</p> <p>'I am worried about the side effects of the vaccine'</p> <p>'I doubt Its potential'</p> <p>'There are some questions which can be answered rather than this or that. I mean to express our own thoughts and.. I am bit concerned of the vaccines as they are not properly tested under the trials but I don't mind if it causes minute problems. And I am ready for the trials if wanted.'</p> <p>'The socioethical condition, family condition of student must be considered and Side effects must be taken into account.'</p> <p>'It would be very good if this vaccination trail is transparent and the data and efficacy should be approved by WHO and then given trials on people...hoping for a better tomorrow with COVID-19 free world'</p> <p>'Govt. and medical officials failed to provide proper info to common folks about mechanism of action of vaccines.'</p> <p>'I hope it works.'</p>
Confidence in vaccine	<p>'I think to control the spread of this disease, vaccination is must and everyone should participate in it'</p> <p>'Vaccine should be made available for the general public as soon as possible.'</p> <p>'Vaccination is must. Only believe the experts and not the fake media or social influencers. Side effects are just as same as other vaccination like fever, body pain, etc which is quite normal. Be mentally strong before vaccination as being mentally strong is very important for your health. And being a medical student, it is your duty to get vaccinated.'</p> <p>'Just go for it'</p> <p>'We as health care professionals should avoid rumours about COVID-19 vaccine as they don't have any proper base and should believe in our researchers, doctors and government'</p> <p>'It's awesome, thanks for the adventure'</p> <p>'Do it as fast as possible'</p> <p>'We medical students should encourage everyone to being vaccinated'</p> <p>'Vaccination is important to all the country.'</p> <p>'Proud to say that it's our own.'</p>
Practical considerations regarding vaccination	<p>'Those below 20 should not be given vaccine according to me!!'</p> <p>'Don't be vaccinated during exam because it may cause variable side effect'</p> <p>'There should be certain blood parameters to determine if the vaccine has generated certain immune response or not'</p> <p>'I think it would be better to have a test done for each one regarding the vaccine. Because the vaccine can act differently in different persons. And if he has already immunised himself by his body defence system. I think no need to take vaccine then...'</p> <p>'Our vaccination is yet pending'</p> <p>'Colleges should take better part in organising vaccines, and assigning authority for management and information on where to receive vaccines as many days vaccination site is not created in college itself, so management should take into consideration students' comfort as classes are already without significant social distancing'</p> <p>'Because of Covid Vaccine our exams are being started in hurry. So much less preparation'</p>
Need for better education regarding vaccine	<p>'The medical institutions should inform about the dos and don'ts after putting vaccine.'</p> <p>'All the effects after virus should be informed. So that people don't consider them as side effects and advise against it'</p> <p>'I think data analysis should be made clearer. Or it might be possible that I am not going to the right articles?'</p> <p>'Which vaccine is best right now?'</p> <p>'Because of less awareness about vaccination, number of vaccinated people are less so we should create awareness about COVID-19 vaccination, its benefits and its effect on our country.'</p> <p>'Please make this type of forms for spreading awareness of different types of vaccines, basic differences, plus points, minus points.'</p>

regarding lack of vaccine-related information and launch of vaccine prior to release of safety and efficacy data were noted. Although vaccine hesitancy showed a diminishing trend over time, health education programmes tailored to boost awareness regarding vaccine and improve trust in government agencies would be helpful. Focus should be on promoting official sources of information to counter apprehension generated through social media use. Taking due informed consent for registration of personal information in vaccine portal and ensuring that vaccination sessions are not held just before examinations could further improve acceptance of newly launched vaccines. As future health care providers, concerns of medical students should be addressed on priority.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S0950268821001205>

Acknowledgement. We acknowledge the help of medical students who participated in the study.

Author contributions. JJ conceived the idea of the study. JJ and SS designed the data collection format with inputs from MKG, PB, JJ, PK, MKV and SS conducted data collection. SS wrote the manuscript with inputs from JJ, MKG, PB, AG, MKV, PK and PRR. All authors approved the final manuscript.

Financial support. The authors declare that no funding was received from any source for the study and preparation of this article.

Conflict of interest. The authors declare that there are no conflicts of interest for publication of this article. The views expressed in this article are those of the authors alone and do not necessarily represent the views of their organisations.

Ethical standards. The study has been approved by the Institutional Ethics Committee of All India Institute of Medical Sciences (AIIMS) – Jodhpur, India (Ref: AIIMS/IEC/2021/3438).

Data availability statement. Data file upon which the study findings are based is included as Supplementary file 2.

References

1. WHO (2021) Weekly epidemiological update for COVID-19 – 18 May 2021. World Health Organization, Geneva; 2021. Available at https://www.who.int/docs/default-source/coronaviruse/situation-reports/20210518-weekly-epi-update_40.pdf?sfvrsn=ba1c16cd_10 (Accessed May 2021).
2. MoHFW (2021) Frequently asked questions: COVID-19 vaccination. New Delhi: Ministry of Health and Family Welfare, Government of India. Available at https://www.mohfw.gov.in/covid_vaccination/vaccination/index.html (Accessed May 2021).
3. Mallapaty S (2021) India's massive COVID surge puzzles scientists. *Nature* **592**, 667–668.
4. Kumar VM et al. (2021) Strategy for COVID-19 vaccination in India: the country with the second highest population and number of cases. *NPJ Vaccines* **6**, 60.
5. Padma TV (2021) India's COVID-vaccine woes – by the numbers. *Nature* **592**, 500–501.
6. Bharat Biotech (2021) Announces Phase 3 Results of COVAXIN®: India's First COVID-19 Vaccine Demonstrates Interim Clinical Efficacy of 81%. Hyderabad: Bharat Biotech International Ltd. Available at <https://www.bharatbiotech.com/images/press/covaxin-phase3-efficacy-results.pdf> (accessed May 2021).
7. MoHFW (2021) COVID-19 vaccination – operational guidelines (updated 20 December 2020). New Delhi: Ministry of Health and Family Welfare, Government of India. Available at <https://www.mohfw.gov.in/pdf/COVID19VaccineOG111Chapter16.pdf> (Accessed May 2021).
8. Paterson P et al. (2016) Vaccine hesitancy and healthcare providers. *Vaccine* **34**, 6700–6706.
9. Kashte S et al. (2021) COVID-19 vaccines: rapid development, implications, challenges and future prospects. *Human Cell* **34**, 711–733.
10. Manning ML et al. (2021) COVID-19 vaccination readiness among nurse faculty and student nurses. *Nursing Outlook*, S0029-6554(21)00023-3. doi:10.1016/j.outlook.2021.01.019.
11. Taylor S et al. (2020) A proactive approach for managing COVID-19: the importance of understanding the motivational roots of vaccination hesitancy for SARS-CoV2. *Frontiers in Psychology* **11**, 575950.
12. Lucia VC, Kelekar A and Afonso NM (2020) COVID-19 vaccine hesitancy among medical students. *Journal of Public Health (Oxf)*. fdaa230. doi:10.1093/pubmed/fdaa230.
13. Qiao S et al. (2020) Vaccine acceptance among college students in south Carolina: do information sources and trust in information make a difference? *medRxiv* [Preprint]. 2020 Dec 4: 2020.12.02.20242982. doi:10.1101/2020.12.02.20242982.
14. Voysey M et al. (2021) Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. *Lancet (London, England)* **397**, 99–111.
15. Bhuyan A (2021) India begins COVID-19 vaccination amid trial allegations. *Lancet (London, England)* **397**, 264.
16. Ella R et al. (2021) Safety and immunogenicity of an inactivated SARS-CoV-2 vaccine, BBV152: a double-blind, randomised, phase 1 trial. *Lancet Infectious Diseases* **21**, 637–646.
17. Wallen J (2021) Medical students to be sent to Covid frontlines as India's hospitals face collapse. *The Telegraph* [newspaper on the Internet]. 2021 May 4 [cited 2021 May 18]; Available at <https://www.telegraph.co.uk/global-health/science-and-disease/medical-students-sent-covid-frontlines-indias-hospitals-face/>.
18. Saied SM et al. (2021) Vaccine hesitancy: beliefs and barriers associated with COVID-19 vaccination among Egyptian medical students. *Journal of Medical Virology*. 10.1002/jmv.26910. doi:10.1002/jmv.26910.
19. Barelo S et al. (2020) "Vaccine hesitancy" among university students in Italy during the COVID-19 pandemic. *European Journal of Epidemiology* **35**, 781–783.
20. Afonso NM et al. (2017) Will they lead by example? Assessment of vaccination rates and attitudes to human papilloma virus in millennial medical students. *BMC Public Health* **17**, 35.
21. Kernéis S et al. (2017) Vaccine education of medical students: a nationwide cross-sectional survey. *American Journal of Preventive Medicine* **53**, e97–e104.
22. Mo PK et al. (2021) Intention to receive the COVID-19 vaccination in China: application of the diffusion of innovations theory and the moderating role of openness to experience. *Vaccines (Basel)* **9**, 129.
23. Nguyen KH et al. (2021) COVID-19 vaccination intent, perceptions, and reasons for not vaccinating among groups prioritized for early vaccination – United States, September and December 2020. *Morbidity Mortality Weekly Report (MMWR)* **70**, 217–222.
24. WHO (2012) *Health Education: Theoretical Concepts, Effective Strategies and Core Competencies: A Foundation Document to Guide Capacity Development of Health Educators*. Cairo: World Health Organization – EMRO. Available at <https://apps.who.int/iris/handle/10665/119953> (Accessed May 2021).
25. Wilson SL and Wiysonge C (2020) Social media and vaccine hesitancy. *BMJ Global Health* **5**, e004206.
26. Hotez P (2021) COVID vaccines: time to confront anti-vax aggression. *Nature* **592**, 661.
27. Szmyd B et al. (2021) Medical students and SARS-CoV-2 vaccination: attitude and behaviors. *Vaccines (Basel)* **9**, 128.
28. Shekhar R et al. (2021) COVID-19 vaccine acceptance among health care workers in the United States. *Vaccines (Basel)* **9**, 119.
29. Fisher KA et al. (2020) Attitudes toward a potential SARS-CoV-2 vaccine: a survey of U.S. adults. *Annals of Internal Medicine* **173**, 964–973.
30. Sun S, Lin D and Operario D (2021) Interest in COVID-19 vaccine trials participation among young adults in China: willingness, reasons for hesitancy, and demographic and psychosocial determinants. *Preventive Medicine Reports* **22**, 101350.
31. Pastorino R, et al. (2021) Impact of COVID-19 pandemic on flu and COVID-19 vaccination intentions among university students. *Vaccines (Basel)* **9**, 70.