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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-050303
Article Type:	Original research
Date Submitted by the Author:	16-Feb-2021
Complete List of Authors:	Ali, Mohammad; Uttara Adhunik Medical College Hossain, Ahmed; North South University, Department of Public Health
Keywords:	COVID-19, Public health < INFECTIOUS DISEASES, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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What is the extent of COVID-19 vaccine hesitancy in Bangladesh? : A cross-sectional rapid national survey

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- Word count: Abstract 262, main text (excluding reference and table) 3125.

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Abstract

objectives: To assess COVID-19 vaccine hesitancy in Bangladesh and identify population subgroups with higher odds of vaccine hesitancy.

design: A nationally representative cross-sectional survey was used. Univariate analysis was employed to compute vaccine hesitancy proportions and compare them across groups and multiple logistic regression analyses were performed to compute the adjusted odds ratio.

setting: Bangladesh

participants: A total of 1134 participants from the general population, aged 18 years and above.

outcome measures: Prevalence and predictors of vaccine hesitancy.

results: 32.5% of participants showed COVID-19 vaccine hesitancy. Hesitancy was high among respondents who were males, over age 60, unemployed, from low-income families, from central Bangladesh including Dhaka, living in rented houses, tobacco users, politically affiliated, participants who did not believe in the vaccine's effectiveness for Bangladeshis and those who did not have any physical illnesses in the last year. In the multilevel logistic regression models, respondents who were transgender (AOR= 3.62), married (AOR=1.49), tobacco users (AOR=1.33), those who did not get any physical illnesses in the last year (AOR=1.49), those with political affiliations with opposition parties (AOR= 1.48), those who believed COVID-19 vaccines will not be effective for Bangladeshis (AOR= 3.20), and those who were slightly

concerned (AOR = 2.87) or not concerned at all (AOR = 7.45) about themselves or a family member getting infected with COVID-19 in the next one year were significantly associated with vaccine hesitancy ($p < 0.05$).

conclusions: Given the high prevalence of COVID-19 vaccine hesitancy, it is important to promote evidence-based communication, mass media campaigns, and policy initiatives across Bangladesh to reduce vaccine hesitancy among the Bangladeshi population.

Keywords COVID-19, Bangladesh, Nationwide assessment, Vaccine hesitancy.

Strengths and Limitations of the study

- This study is the first its kind to measure COVID-19 vaccine hesitancy in Bangladesh.
- In this study, randomly selected participants were interviewed face to face, enabling a nearly true representative sample of the Bangladeshi general population.
- This study identified a wide range of sub-groups of the general population with higher odds of COVID-19 vaccine hesitancy relating to their sociodemographic characteristics in Bangladesh; thus, providing baseline evidence for the low and middle-income and low-resourced countries worldwide.
- Traditional media and social media influence on COVID-19 vaccine hesitancy was not measured which is a major limitation of this study.

INTRODUCTION

The first case of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was detected in December 2019 in Wuhan, China. By the first week of February 2021, COVID-19 had infected over 105 million people across 223 countries or territories and caused more than 2.3 million fatalities worldwide [1]. Subsequently, COVID-19 was declared a pandemic by the WHO in March 2020 and many countries began developing COVID-19 vaccines. Two COVID- 19 vaccines with 90–95% effectiveness developed by two American pharmaceutical companies were declared at the end of November 2020 [2,3]. Subsequently, many other safe and effective vaccines were also developed and announced by other countries [4–7] and by the end of 2020, 10 vaccines were approved for either full or early use in several countries including the USA, UK, and Canada [8]. Immediately after the approval, the vaccines were rolled out in the respective countries.

However, a vaccination program can be promoted or undermined by factors such as vaccine hesitancy. Vaccine hesitancy refers to delay in acceptance or refusal of vaccination despite the availability of the vaccination service [9]. In 2019, WHO declared vaccine hesitancy as one of the top ten global health threats [10]. After the COVID-19 vaccine started to rollout, besides enthusiasm, news regarding adverse effects of the vaccine experienced by a few vaccine recipients along with conspiracy theories and misinformation on social media have drawn the public's attention worldwide [11]. Hence, puzzling news on the effectiveness of some vaccines by the media has had a negative impact on potential vaccine recipients [12,13]. Moreover, the anxiety and hesitancy is further heightened due to the accelerated pace of vaccine development [14]. Along with contemporary consequences, knowledge and awareness-related issues, vaccine hesitancy can also be determined by religious, cultural, gender, or socio-economic factors [9].

A study indicated that the vaccine willingness rate could range from 55-90% worldwide [15]. However, vaccine willingness and/or hesitancy are subject to change over time [9]. Most of the previous studies were conducted in high-income settings and well before the vaccine was made available. Very little is known about COVID-19 vaccine hesitancy in vaccination programs being run in low-income and middle-income countries' (LMICs) population. As Bangladesh did not participate in any COVID-19 vaccine clinical trial, we hypothesized that due to the novelty of COVID-19 vaccine, there is a lack of awareness of its impact on Bangladeshis. Thus, acceptance and/or hesitancy toward the vaccine might be different compared with other available vaccines in Bangladesh.

The health, economic, and community toll of COVID-19 in Bangladesh are one of the highest among LMICs. By Mid February 2021, in Bangladesh, there were about 0.55 million laboratory-confirmed COVID-19 cases and about 10,000 died from this novel disease [16]. While the COVID-19 vaccine rollout in Bangladesh was inaugurated on 27 January 2021 targeting to immunize 138 million people [17], very little is known about COVID-19 vaccine hesitancy and/or willingness among this cohort. The government, public health officials, and advocates must be prepared to address hesitancy to reach their target and build vaccine literacy among potential recipients. Thus, our study aimed (1) to conduct a rapid national assessment of COVID-19 vaccine hesitancy in Bangladesh, and (2) to identify population subgroups with higher odds of vaccine hesitancy.

METHODS

Design and participants

In a cross-sectional study conducted in Bangladesh from 18 to 31 January 2021, male, female, and transgender persons aged 18 years and above were interviewed using a previously used, valid, and reliable vaccine hesitancy questionnaire [18]. To calculate sample size, a margin of error of 5%, a confidence level of 95%, a response distribution of 50% were used to target a 138 million population and secure a minimum sample size of 1067 [19,20]. Therefore, like a similar Asian study, our sample consisted of 1134 respondents [21].

The questionnaire

The questionnaire comprised of two parts. In the first part, participants were asked questions regarding vaccine hesitancy and COVID-19 threat. First, participants were asked about the likelihood of getting a vaccine. The dependent variable and a key outcome of the study (i.e., vaccine hesitancy) were measured through the question: "If a vaccine that would prevent coronavirus infection was available, how likely is it that you would get the vaccine or shot." The response options for this question were "Very likely," "somewhat likely," "not likely," "definitely not." Second, participants were asked two questions regarding the perceived COVID-19 threat: (1) "How likely is it that you or a family member could get infected with coronavirus in the next one year?" with response options: "very likely," "somewhat likely," "not likely," and "definitely not." (2) "How concerned are you that you or a family member could get infected with coronavirus in the next one year?" with response options: "very concerned," "concerned," "slightly concerned," and "not concerned at all."

The second part of the questionnaire comprised of a wide range of sociodemographic questions. A set of structured questions assessed participants' gender, age, religion, marital status, education, employment status, monthly household income in Bangladeshi taka (BDT), permanent address, and region of residence in Bangladesh (north, south, and central zone

including Dhaka), current residence type (Own/rented/hostel or mess), tobacco use and political affiliation. Participants were also asked about the presence of children or older people at home, whether they had any physical illnesses in the last year, whether they had a chronic disease diagnosis (hypertension, diabetes, asthma, etc.), and whether they were regular religious practitioners. These questions had to be answered using the dichotomous option (yes/no). In additions, participants were also asked two more COVID-19 vaccine-related questions: "Do you think the COVID-19 vaccine will be effective among Bangladeshis (no/yes/skeptical), and "Which developers' vaccine would you prefer to take (American, British, Chinese, Russian, Indian, I have no idea regarding this).

Patient and public involvement

Participants or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Data analysis

Descriptive statistics were computed to describe the demographic characteristics of the study participants. Chi-Square tests were used to compute vaccine hesitancy proportions and draw comparisons across groups. Responses were compared for various sociodemographic characteristics by dichotomizing the variable as either a positive (very likely and somewhat likely) or a negative (not likely and definitely not) attitude toward COVID-19 vaccine, indicating the extent of vaccine hesitancy. To compute adjusted odds ratios (AOR) with a 95% confidence interval, multiple logistic regression analyses were performed with vaccine hesitancy as a dependent variable and sociodemographic characteristics and perceived COVID-19 threat as predictor variables for vaccine hesitancy. To ensure the models adequately fit the data, Hosmer-

Lemeshow goodness-of-fit tests were used. The significance level was set at <0.05 and SPSS version 22.0 (IBM Corp.) was used for data analyses.

RESULTS

Descriptive statistics analyses

Table 1 shows sociodemographic characteristics, COVID-19 threat, and vaccine hesitancy of a total of 1134 Bangladeshis who participated in this study. The mean age of the participants was 32.05 (SD ± 11.72). The majority of the study participants were: male (59.2%), aged 26-40 (40.7%), Muslim (93.2%), married (52.7%), held a bachelor's degree (31.4%), full-time employees (28.7%), persons with a monthly household income ≥30,000 BDT (44.9%), from the central zone including Dhaka of Bangladesh (60%), living in their own house (46.3%), tobacco non-users (70.2%), those who did not get physical illnesses (57.3%) and had no political affiliation (56.5%). Regarding the question on the likelihood of getting a COVID-19 vaccine, the responses were: "very likely" (34.2%), "somewhat likely" (53.6%), "not likely" (7.3%), and "definitely not" (5.9%). In addition, **Figure 1** represents day-to-day fluctuation of vaccine hesitancy.

Univariate analysis

Statistically significant differences in vaccine hesitancy were found based on sociodemographic characteristics with the highest prevalence of COVID-19 vaccine hesitancy among males, persons aged over 60, businesspeople and unemployed persons, those with a monthly household income below 15 thousand BDT, living in the central zone, living in a rented house, tobacco users, those who did not face physical illness in the last year, had political affiliations with the

opposition parties, did not believe in COVID-19 vaccine effectiveness among Bangladeshis, and had no knowledge on vaccine developers (**Table 1**).

Furthermore, participants who were not likely to believe that they or a family member could be infected with COVID-19 in the next one year and those who were not concerned at all about themselves or a family member getting COVID-19 infection in the next one year had the highest rates of COVID-19 vaccine hesitancy.

Multiple logistic regression analysis

Table 2. presents predictors of COVID-19 vaccine hesitancy. A multiple regression analysis was conducted to examine predictors of COVID-19 vaccine hesitancy by including factors found to be significantly associated with vaccine hesitancy in the univariate analysis. In this multiple regression model, groups with statistically significantly higher odds of vaccine hesitancy were: transgender persons (AOR= 3.62, 95% CI= 1.177-11.251), married persons (AOR=1.49,CI= 1.047-2.106), tobacco users (AOR=1.33, CI= 1.018-1.745), participants who did not get physical illnesses in the last year (AOR=1.49, CI= 1.134-1.949), those with political affiliations with opposition parties (AOR= 1.48, CI= 1.025-2.134), those who did not believe in COVID-19 vaccines effectiveness for Bangladeshis (AOR= 3.20, CI= 2.079-4.925), and those who were slightly concerned (AOR = 2.87, CI= 1.744-4.721) or not concerned at all (AOR = 7.45, CI= 4.768-11.643) about themselves or a family member getting infected with COVID-19 in the next one year. Likewise, compared with participants who believed it was very likely that they or their family members could get infected with COVID-19 in the next one year, and those who thought such an occurrence would be not likely (AOR = 1.88, CI= 1.109-3.172) had significantly higher odds of vaccine hesitancy. Nonetheless, female participants (AOR= 0.70, CI= 0.537-0.928), students (AOR = 0.60, CI= 0.379-0.966) and those who preferred to take the British (AOR=

0.48, CI= 0.324-0.725), Chinese (AOR=0.44, CI= 0.245-0.807), Russian (AOR= 0.42, CI= 0.222-0.825) or Indian (AOR= 0.33, 0.143-0.774) vaccine had statistically significantly lower odds of vaccine hesitancy.

DISCUSSION

More than one-third of the participants (32.5%) reported vaccine hesitancy in the present comprehensive national study. Analysis of daily data suggested that vaccine hesitancy varied from 18% to 72% in Bangladesh. Moreover, our study identified that predictors of COVID-19 vaccine hesitancy among Bangladeshis are gender, marital status, employment status, tobacco use, physical illness history, political affiliation, faith in vaccine effectiveness among Bangladeshis, vaccine preference, and perceived COVID-19 threat.

This is the first study to measure COVID-19 vaccine hesitancy in Bangladesh; thus, little is known about previous hesitancy rate. However, a June 2020 global survey suggested that more than 80% of participants from China, Korea, and Singapore are very or somewhat likely to receive the COVID-19 vaccine [15]. Another study in September 2020 in Japan found 65% willingness toward the COVID-19 vaccine among participants [21]. However, a January 2021 survey in India suggested that 60% of polled Indians showed hesitancy (40% willingness) towards receiving COVID-19 vaccines [22].

We found higher vaccine hesitancy among male, older, married, and transgender participants. In the final model, women show significantly lower odds of vaccine hesitancy. In agreement with our findings, a global study observed lower odds of vaccine willingness among male participants [15]; however, women in Japan demonstrated very high vaccine hesitancy compared with men

[21]. American women also showed lower willingness toward the COVID-19 vaccine [23]. Nonetheless, an early study suggested that Bangladeshi women's better knowledge, attitude, and practice toward COVID-19 could be the reasons for their lower vaccine hesitancy [24]. An additional regional study is required to determine the gender-based difference in vaccine hesitancy. Unlike other studies, we found higher vaccine hesitancy among older people than younger. This also can be explained by an earlier study that showed lack of sufficient COVID-19-related knowledge among the older population of Bangladesh [24]. Socio-cultural and religious beliefs related to preexisting vaccine hesitancy among the older population could also be another cause of higher vaccine hesitancy. Additionally, results regarding the married population are incorporated with age; therefore, results need to be interpreted by looking at marital status and age together. Furthermore, we found statistically significant higher odds of vaccine hesitancy among the gender minority, that is, the transgender population. Previous research suggested that vaccine hesitancy is universally higher among gender minorities due to limited access and interaction with healthcare professionals, historical biomedical and healthcare-related mistrust, cost-related concerns, lack of belief in the scientific enterprise of medicine and public health, lack of awareness, and education [25].

Unemployment, an education level lower than or equal to high school, and a household monthly income less than 15,000 BDT were associated with a higher likelihood of reporting hesitancy toward COVID-19 vaccine in Bangladesh. In line with our findings, a global study also suggested that participants with lower education and income were less likely to get the COVID-19 vaccine [15]. Moreover, unemployed participants, and participants with a low level of education in the U.S. and Saudi Arabia showed higher vaccine hesitancy [23,26]. In contrast, other studies found that unemployed participants were more likely to accept the COVID-19

vaccine [20, 29]. It could be possible that in some regions, unemployed persons would like to return to work and employment and the vaccine could facilitate this return.

A unique finding of this study was that a high portion of tobacco users showed hesitancy to receive the COVID-19 vaccine. Statistically significantly high odds of vaccine hesitancy (AOR= 1.33) among tobacco users were found in the regression analysis. Universally, tobacco users (including smokers) are known to have unhealthy life practices. Further, a systematic review and meta-analysis concluded that current and previous smoking is clearly associated with severe COVID-19 outcomes [28]. Another systematic review suggested that tobacco use was significantly associated with a higher rate of mortality among COVID-19 patients [29]. So far, there have been discussions on prioritization of vaccination (e.g., for front liners). However, very little vaccination planning has been done for the most vulnerable populations who continue to remain susceptible to COVID-19 outcomes (i.e., a greater number of deaths and severe infections). Our findings would help identify these sub-groups. In contrast, we found high odds (AOR= 1.48) among those who did not have physical illnesses throughout the last year. However, previous evidence suggested that healthier persons can also be infected by COVID-19 and that the outcomes are unpredictable. Policymakers should target these subgroups when planning vaccine literacy for potential vaccine-recipients.

Interestingly, we found statically significantly higher vaccine hesitancy among politically affiliated (either affiliated with ruling parties or oppositions) participants compared with those who described themselves as neutral. However, regression analysis suggested that those who were affiliated with opposition parties had higher odds (AOR= 1.48). A systematic review and meta-analysis found a range of trust relationships with vaccine hesitancy in LMICs; for example,

trust in healthcare professionals, the health system, the government, and friends and family members [30].

It is reported that the effectiveness of vaccines varies from race to race and country to country [31]. However, there was no human clinical trial of any COVID-19 vaccine in Bangladesh. In our study participants were asked whether they believed the vaccines will be effective for Bangladeshi. Those who answered "No" and remained "skeptical" showed a higher rate of vaccine hesitancy. However, this finding is similar to the findings of a study conducted in another country [32]. Finally, our study revealed very high odds of hesitancy (AOR= 7.45) among those who were not concerned about being infected by COVID-19. In support of our findings, a systematic review confirmed that people's perceived risk of infection is one of the strongest predictors of pandemic vaccine acceptance and/or hesitancy [33].

This study result may have influenced by several limitations. Firstly, it is a cross-sectional study, and portrays a depiction of the community response at the climacteric of the study. Nonetheless, vaccine hesitancy is complex in disposition and adherence-specific, varying over time, location, and perceived behavioral nature of the community [33–35]. Secondly, social and traditional media influence are one of the major predictors of pandemic vaccine hesitancy and/or acceptance [36]. In our study, we did not examine the impact of media and this might have confounded the results. Additional research is warranted to address this issue. Despite these limitations, our study provides baseline evidence for the LMICs regarding COVID-19 vaccine hesitancy. Furthermore, our study identifies many sub-groups of the general population that must be considered during vaccine hesitancy discussions. Finally, data collected by interviewing randomly selected participants from the north, south, and central zone including Dhaka would have given a better,

nearly true representative of the population of Bangladesh in the sample which would have made the study results more plausible.

Conclusion

The present rapid community-based study on COVID-19 vaccine hesitancy in Bangladesh found that more than one-third (32.5%) of the respondents were hesitant about getting vaccinated. Differences in vaccine hesitancy were based on sociodemographic characteristics, health, and behavior of participants such as gender, age, marital status, income, employment status, tobacco use, history of illness, place of residence, and political affiliation. Further, faith in vaccine effectiveness in Bangladesh and perceived COVID-19 threat were strong predictors of COVID-19 vaccine hesitancy. Various contributing factors to vaccine hesitancy such as preexisting indecisiveness, cultural and religious views, lack of belief in the scientific enterprise of medicine and public health especially among the older population, and lower levels of awareness were identified. Further research is warranted to comprehend the complicated interplay of a variety of individual and social characteristics that influence vaccine hesitancy to ensure extensive coverage of COVID-19 vaccines. Evidence-based educational and policy-level interventions must be implemented to address these problems and promote COVID-19 immunization programs. The rates of willingness are subject to change with the suitability of the vaccines, but frequent and ambivalent effects of vaccines may reduce those rates. The uptake of COVID-19 vaccines can be increased once the factors identified in this study are properly addressed and the long-term positive effects of the vaccines are clarified.

Acknowledgments

Both the authors acknowledge the participants for providing us the information to conduct the study.

Competing interests

The authors declare that they have no competing interests.

Funding statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data sharing statement

Data will be available from the corresponding author upon reasonable request.

Author contributions

MA participated in study conception, design and coordination of the manuscript. MA also performed the statistical analysis and draft the manuscript. AH reviewed the manuscript and helped to draft the manuscript. Both the authors approved the final manuscript.

Ethical consideration:

Formal ethical approval was taken from the Ethical Review Committee (ERC) of Uttara Adhunik Medical College and Hospital. Prospective observational trial registration has been obtained from the World Health Organization (WHO) endorsed Clinical Trial Registry- India: CTRI/2021/01/030546. Furthermore, we conducted the study strictly following the STROBE guideline [37]. All the invited participants were required to give informed consent for participation and collection and analysis of their data.

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Table 1 Univariate analysis- Sociodemographic characteristics, COVID-19 threat, and vaccine hesitancy

Variables	Total Sample n (%)	Likelihood of getting COVID-19 Vaccine		p-value
		Not likely/definitely not n (%)	Very likely/somewhat-likely n (%)	
All participants	1134 (100%)	369 (32.5)	765 (67.5)	-
Gender				**0.003**
Transgender	14 (1.2)	9 (64.3)	5 (35.7)	
Female	449 (39.6)	127 (28.3)	322 (71.7)	
Male	671 (59.2)	233 (34.7)	438 (65.3)	
Age group				**0.009**
18-25	442 (39.0)	122 (27.6)	320 (72.4)	
26-40	461 (40.7)	174 (37.7)	287 (62.3)	
41-60	200 (17.6)	61 (30.5)	139 (69.5)	
≥ 61	31 (2.7)	12 (38.7)	19 (61.3)	
Religion				0.442
Muslim	1057 (93.2)	349 (33.0)	708 (67.0)	
Hindu	61 (5.4)	16 (26.2)	45 (73.8)	
Cristian and Buddhist	16 (1.4)	4 (25.0)	12 (75.0)	
Marital status				**0.039**
Unmarried	495 (43.6)	141 (28.5)	353 (71.5)	
Married	598 (52.7)	214 (35.8)	384 (64.2)	
Divorce/Widow	42 (3.7)	14 (33.3)	28 (66.7)	
Children at home				0.950
No	481 (42.4)	157 (32.6)	324 (67.4)	
Yes	653 (57.6)	212 (32.5)	441 (67.5)	
Aged people at home				0.224
No	396 (34.9)	138 (34.8)	258 (65.2)	
Yes	738 (65.1)	231 (31.3)	507 (68.7)	
Education				0.268
≤ High school	264 (23.3)	98 (37.1)	166 (62.9)	
College education	309 (27.2)	92 (29.8)	217 (70.2)	
Bachelor's degree	356 (31.4)	111 (31.2)	245 (68.8)	
≥ Master's degree	205 (18.1)	68 (33.2)	137 (66.8)	
Employment status				**0.013**
Full-time employee	326 (28.7)	109 (33.4)	217 (66.6)	
Part-time employee	73 (6.4)	23 (31.5)	50 (68.5)	
Business	169 (14.9)	66 (39.1)	103 (60.9)	
Unemployed	88 (7.8)	35 (39.8)	53 (60.2)	
Home maker	171 (15.1)	60 (35.1)	111 (64.9)	
Student	307 (27.1)	76 (24.8)	231 (75.2)	
Monthly household income				**0.042**
<15,000	239 (21.1)	78 (32.6)	161 (67.4)	
15,000-30,000	386 (34.0)	108 (28.0)	278 (72.0)	
≥ 30,000	509 (44.9)	183 (36.0)	326 (64.0)	
Family type				0.205
Nuclear	715 (63.1)	223 (31.2)	492 (68.8)	
Joint	419 (36.9)	146 (34.8)	273 (65.2)	

Permanent address				0.533
Rural	637 (56.2)	216 (33.9)	421 (66.1)	
Urban	411 (36.2)	126 (30.7)	285 (69.3)	
Sub urban	86 (7.6)	27 (31.4)	59 (68.6)	
Current living location				**0.048**
Central zone	680 (60.0)	237 (34.9)	443 (65.1)	
North zone	237 (20.9)	62 (26.2)	175 (73.8)	
South zone	217 (19.1)	70 (32.3)	147 (67.7)	
Current Residence type				**0.042**
Rented	514 (45.3)	184 (35.8)	330 (64.2)	
Own	525 (46.3)	151 (28.8)	374 (71.2)	
Hostel/Mess	95 (8.4)	34 (35.8)	61 (64.2)	
Regular religious practice				0.064
No	328 (28.9)	120 (36.6)	208 (63.4)	
Yes	806 (71.1)	249 (30.9)	557 (69.1)	
Tobacco user				**0.037**
No	796 (70.2)	244 (30.7)	552 (69.3)	
Yes	338 (29.8)	125 (37.0)	213 (63.0)	
Did you face physical illness in last one year				**0.006**
No	650 (57.3)	233 (35.8)	417 (64.2)	
Yes	484 (42.7)	136 (28.1)	348 (71.9)	
Morbidity				0.943
No	859 (75.7)	280 (32.6)	579 (67.4)	
Yes	275 (24.3)	89 (32.4)	186 (67.6)	
Political affiliation				**0.050**
Ruling party	340 (30.0)	119 (35.0)	221 (65.0)	
Opposition	153 (13.5)	59 (38.6)	94 (61.4)	
Neutral	641 (56.5)	191 (29.8)	450 (70.2)	
Do you think the COVID-19 vaccine will be effective among Bangladeshis				**<0.001**
No	108 (9.5)	72 (66.7)	36 (33.3)	
Yes	367 (32.4)	43 (11.7)	324 (88.3)	
Skeptical	659 (58.1)	254 (38.5)	405 (61.5)	
Which developers' vaccine would you prefer				**0.001**
American	435 (38.4)	160 (36.8)	275 (63.2)	
British	372 (32.8)	102 (27.4)	270 (72.6)	
Chinese	82 (7.2)	21 (25.6)	61 (74.4)	
Russian	64 (5.6)	16 (25.0)	48 (75.0)	
Indian	39 (3.4)	8 (20.5)	31 (79.5)	
Others/no idea	142 (12.5)	62 (43.7)	80 (56.3)	
Perceived likelihood of getting infected in the next 1 year				**<0.001**
Very likely	388 (34.2)	141 (36.3)	247 (63.7)	
Somewhat likely	608 (53.6)	146 (24.0)	462 (76.0)	
Not likely	83 (7.3)	51 (61.4)	32 (38.6)	
Definitely not	55 (4.9)	31 (56.4)	24 (43.6)	
Level of concern about getting infected in the next 1 year				**<0.001**
Very concerned	226 (19.9)	30 (13.3)	196 (86.7)	
Concerned	290 (25.6)	53 (18.3)	237 (81.7)	
Slightly concerned	235 (20.7)	69 (29.4)	166 (70.6)	
Not concerned at all	383 (33.8)	217 (56.7)	166 (43.3)	

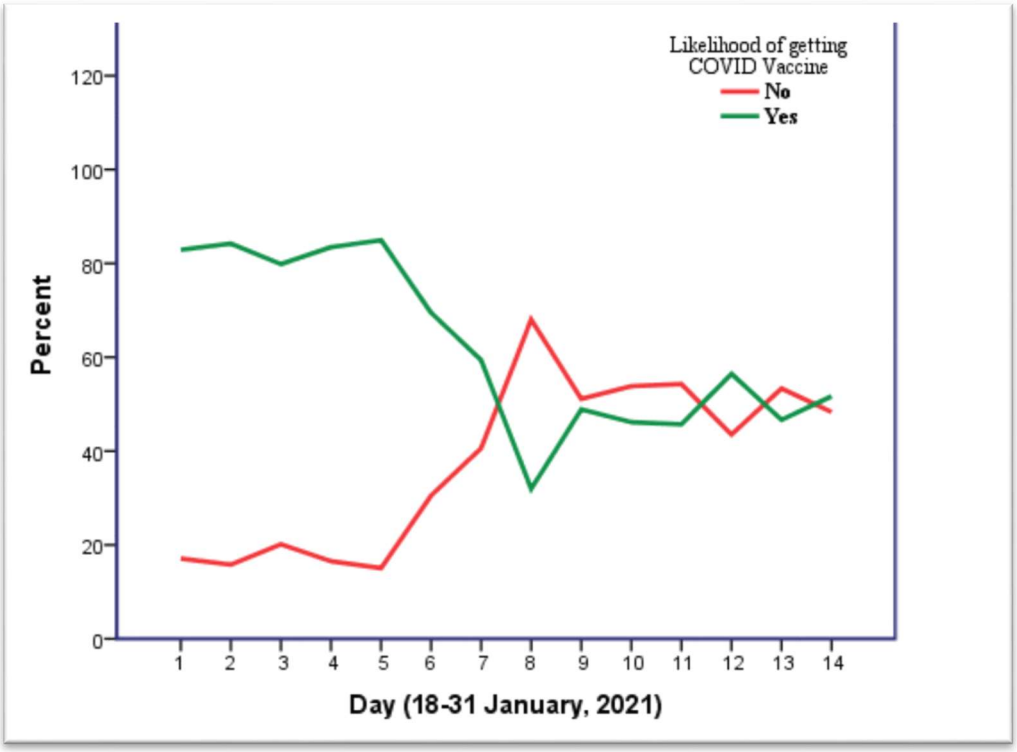
Table 2 Multiple logistic regression- predictors of vaccine hesitancy in study participants

Variables	Adjusted Odds Ratio	Standard Error	Confidence Interval	p-value
Gender				
Transgender	3.639	0.576	1.177-11.251	**0.025**
Female	0.706	0.139	0.537-0.928	**0.013**
Male	Reference			
Age group				
18-25	Reference			
26-40	1.208	0.179	0.851-1.715	0.290
41-60	0.808	0.238	0.508-1.285	0.368
≥ 61	1.053	0.434	0.450-2.465	0.905
Marital status				
Unmarried	Reference			
Married	1.485	0.175	1.047-2.106	**0.027**
Divorce/Widow	1.606	0.394	0.742-3.44	0.229
Employment Status				
Full-time employee	1.006	0.217	0.657-1.539	0.979
Part-time employee	0.914	0.315	0.439-1.693	0.775
Business	1.230	0.227	0.788-1.921	0.362
Unemployed	1.311	0.284	0.751-2.286	0.341
Student	0.606	0.238	0.379-0.966	**0.035**
Home maker	Reference			
Monthly household income				
<15,000	Reference			
15,000-30,000	0.790	0.185	0.550-1.136	0.203
≥ 30,000	1.181	0.185	0.822-1.696	0.368
Current living location				
Central zone	1.105	0.169	0.793-1.540	0.554
North zone	0.762	0.209	0.506-1.147	0.192
South zone	Reference			
Current Residence type				
Rented	0.962	0.235	0.607-1.527	0.871
Own	0.761	0.241	0.475-1.221	0.258
Hostel/Mess	Reference			
Tobacco user				
No	Reference			
Yes	1.333	0.138	1.018-1.745	**0.037**
Did you face physical illness in last one year				
No	1.486	0.138	1.134-1.949	**0.004**
Yes	Reference			
Political affiliation				
Ruling party	1.269	0.143	0.959-1.678	0.096
Opposition	1.479	0.187	1.025-2.134	**0.037**
Neutral	Reference			

Do you think the COVID-19 vaccine will be effective among Bangladeshis				
No	3.199	0.220	2.079-4.925	**<0.001**
Yes	0.212	0.182	0.149-0.303	**<0.001**
Skeptical	Reference			
Which developers' vaccine would you prefer				
American	0.744	0.197	0.506-1.094	0.133
British	0.484	0.205	0.324-0.725	**<0.001**
Chinese	0.444	0.304	0.245-0.807	**0.008**
Russian	0.428	0.335	0.222-0.825	**0.011**
Indian	0.332	0.431	0.143-0.774	**0.011**
No idea	Reference			
Perceived likelihood of getting infected in the next 1 year				
Very likely	Reference			
Somewhat likely	0.645	0.161	0.471-0.884	**0.006**
Not likely	1.875	0.268	1.109-3.172	**0.019**
Definitely not	1.099	0.307	0.602-2.007	0.758
Level of concern about getting infected in the next 1 year				
Very concerned	Reference			
Concerned	1.609	0.255	0.977-2.649	0.062
Slightly concerned	2.869	0.254	1.744-4.721	**<0.001**
Not concerned at all	7.450	0.228	4.768-11.643	**<0.001**

Figure legend:

Day-to-day fluctuation of COVID-19 vaccine wiliness and/or hesitancy among Bangladeshi



STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*N/A*
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N/A
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	N/A
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

What is the extent of COVID-19 vaccine hesitancy in Bangladesh? A cross-sectional rapid national survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-050303.R1
Article Type:	Original research
Date Submitted by the Author:	30-Jun-2021
Complete List of Authors:	Ali, Mohammad; Uttara Adhunik Medical College, Department of Physiotherapy and Rehabilitation ; Bangladesh University of Professionals, Center for Higher Studies and Research Hossain, Ahmed; North South University, Department of Public Health
Primary Subject Heading:	Health policy
Secondary Subject Heading:	Communication, Health informatics, Health policy, Public health
Keywords:	COVID-19, Public health < INFECTIOUS DISEASES, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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What is the extent of COVID-19 vaccine hesitancy in Bangladesh? A cross-sectional rapid national survey

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- Word count: Abstract 257, main text (excluding references and tables) 3666.

What is the extent of COVID-19 vaccine hesitancy in Bangladesh? A cross sectional rapid national survey

Abstract

objectives: To assess COVID-19 vaccine hesitancy in Bangladesh and identify population subgroups with higher odds of vaccine hesitancy.

design: A nationally representative cross-sectional survey was used. Descriptive analyses were employed to compute vaccine hesitancy proportions and compare them across groups. Multiple logistic regression analyses were performed to compute the adjusted odds ratio.

setting: Bangladesh

participants: A total of 1,134 participants from the general population, aged 18 years and above.

outcome measures: Prevalence and predictors of vaccine hesitancy.

results: Of the total participants, 32.5% showed COVID-19 vaccine hesitancy. Hesitancy was high among respondents who were men, over 60, unemployed, from low-income families, from central Bangladesh, including Dhaka, living in rented houses, tobacco users, politically affiliated, those who did not believe in the vaccine's effectiveness for Bangladeshis, and those who did not have any physical illnesses in the past year. In the multiple logistic regression models, transgender respondents (AOR= 3.62), married people (AOR=1.49), tobacco users (AOR=1.33), those who had not experienced any physical illnesses in the past year (AOR=1.49), those with political affiliations with opposition parties (AOR= 1.48), those who believed COVID-19 vaccines would not be effective for Bangladeshis (AOR= 3.20), and those who were slightly

concerned (AOR= 2.87) or not concerned at all (AOR= 7.45) about themselves or a family member getting infected with COVID-19 in the next year were significantly associated with vaccine hesitancy ($p< 0.05$).

conclusions: Given the high prevalence of COVID-19 vaccine hesitancy, evidence-based communication, mass media campaigns, and policy initiatives must be promoted across the country to reduce vaccine hesitancy among the Bangladeshi population.

Keywords COVID-19, Bangladesh, Nationwide assessment, Vaccine hesitancy.

Strengths and Limitations of the study

- This study is the first to measure COVID-19 vaccine hesitancy in Bangladesh using a validated vaccine hesitancy questionnaire.
- Randomly selected participants were interviewed face to face to minimize nonresponse and maximize the quality of the data collected.
- The survey assessed a range of sociodemographic and psychological variables (i.e., perceived COVID-19 risk).
- Including the transgender population made the findings more generalizable.
- Traditional media and social media influence on COVID-19 vaccine hesitancy were not measured, which significantly limited this study.

INTRODUCTION

The first case of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was detected in December 2019 in Wuhan, China. By the first week of February 2021, COVID-19 had infected over 105 million people across 223 countries or territories and had caused more than 2.3 million fatalities worldwide [1]. Subsequently, COVID-19 was declared a pandemic by the World Health Organization (WHO) in March 2020, and many countries began developing COVID-19 vaccines. Two COVID-19 vaccines with 90–95% effectiveness developed by two American pharmaceutical companies were announced at the end of November 2020 [2,3]. Subsequently, many other safe and effective vaccines were also developed and announced by other countries [4–7]. By the end of 2020, 10 vaccines were approved for either full or early use in several countries, including the USA, UK, and Canada [8]. Immediately after they were approved, the vaccines were rolled out in the respective countries.

However, a vaccination program can be promoted or undermined by factors such as vaccine hesitancy. Vaccine hesitancy refers to delay in acceptance or refusal of vaccination despite the availability of the vaccination service [9]. In 2019, the WHO declared vaccine hesitancy as one of the top ten global health threats [10]. Following the COVID-19 vaccine rollout, news regarding adverse effects of the vaccine experienced by a few vaccine recipients, along with conspiracy theories and misinformation on social media, have drawn public attention worldwide [11]. Hence, puzzling news on the effectiveness of some vaccines by the media has negatively impacted potential vaccine recipients [12,13]. Moreover, the anxiety and hesitancy were further heightened due to the accelerated pace of vaccine development [14]. Along with contemporary

consequences, knowledge, and awareness-related issues, vaccine hesitancy can also be determined by religious, cultural, gender, or socio-economic factors [9].

A study indicated that the vaccine willingness rate could range from 55–90% worldwide [15]. However, vaccine willingness or hesitancy changes over time [9]. Most of the previous studies were conducted in high-income settings and well before the vaccine was made available. Little is known about COVID-19 vaccine hesitancy in vaccination programs being run in low-income and middle-income countries' (LMICs) population.

In general, vaccinations are largely accepted in LMICs, such as Bangladesh [16]. A study conducted in 2018 among 140,000 individuals in 140 countries suggested that 94% of participants in South Asia described vaccination as effective, and 95% of them perceived vaccines as safe [17]. However, another study conducted in Bangladesh, China, Ethiopia, Guatemala, and India revealed that over 50% of respondents agreed or were neutral with regards to the question “new vaccines carry more risks than older vaccines” [18]. Nonetheless, Bangladesh did not participate in any COVID-19 vaccine clinical trials. We hypothesized that, due to the novelty of COVID-19 vaccines, Bangladeshis lacked awareness of their impact. Thus, acceptance or hesitancy toward a COVID-19 vaccine might differ from other vaccines available in Bangladesh.

The health, economic, and community toll of COVID-19 in Bangladesh is one of the highest among LMICs. By mid-February 2021, in Bangladesh, about 0.55 million COVID-19 cases had been confirmed, and about 10,000 people had died from the disease [19]. While the COVID-19 vaccine rollout in Bangladesh was inaugurated on January 27, 2021, aiming to immunize 138 million people [20], little was known about COVID-19 vaccine hesitancy or willingness among this cohort. Thus, our study aimed to (1) conduct a rapid national assessment of COVID-19

vaccine hesitancy in Bangladesh and (2) identify population subgroups with higher odds of vaccine hesitancy.

METHODS

Design and participants

In a cross-sectional study conducted in Bangladesh from 18 to 31 January 2021, approximately 1,500 male, female, and transgender persons aged 18 years and above were randomly invited to participate in an interview using a previously employed, valid, and reliable vaccine hesitancy questionnaire [21]. A margin of error of 5%, a confidence level of 95%, and a response distribution of 50% were used to calculate the sample size to target a population of 138 million individuals and secure a minimum sample size of 1,067 [22,23]. Therefore, similar to other studies, our sample consisted of 1,134 respondents [21,24].

Recruitment and training of data collectors

Eighteen health-science students (nine of whom were women) were recruited to collect and clean data for this study. Among the eighteen data collectors, four were assigned to North Bengal and four to South Bengal. Considering the higher population density, eight data collectors were appointed for central Bangladesh, including Dhaka City. Eight teams of two persons (one woman in each team) were created. Interviews were conducted in the Bangla language. One data collector asked the questions first; the answers were then confirmed by the second member of the respective team.

A two-day online training program was arranged for the data collectors. To observe the day-to-day fluctuation of vaccine hesitancy, each team was instructed to collect around 12 pieces of data per day. Furthermore, data collectors were briefed about the study's objectives, methodology, and questionnaire. They were taught the techniques for report building and preserving neutrality and were well-informed on ethical issues, privacy concerns, cultural awareness, and risk management for COVID-19 infection. A pilot study was arranged for all data collectors as a single unit following the training session to observe their capacity to comprehend relevant techniques and troublesome situations that could occur while interviewing. Necessary corrections were made following the piloting. Each trained team visited their designated area to collect data using a semi-structured questionnaire.

The questionnaire

The paper-based questionnaire comprised two parts. In the first part, participants were asked questions regarding vaccine hesitancy and perceived COVID-19 threat [21]. First, participants were asked about the likelihood of getting a vaccine. The dependent variable and a key outcome of the study (i.e., vaccine hesitancy) was measured using the question, "If a vaccine that would prevent coronavirus infection was available, how likely is it that you would get the vaccine or shot?" The response options for this question were "very likely," "somewhat likely," "not likely," "definitely not." Second, participants were asked two questions regarding the perceived COVID-19 threat: (1) "How likely is it that you or a family member could get infected with coronavirus in the next one year?" with response options "very likely," "somewhat likely," "not likely," and "definitely not." (2) "How concerned are you that you or a family member could get infected with coronavirus in the next one year?" with response options "very concerned," "concerned," "slightly concerned," and "not concerned at all."

The second part of the questionnaire comprised a wide range of sociodemographic questions. A set of structured questions assessed participants' gender, age, religion, marital status, education, employment status, monthly household income in Bangladeshi taka (BDT), permanent address, and region of residence in Bangladesh (north, south, and central zone, including Dhaka), current residence type (Own/rented/hostel or mess), present tobacco use, and political affiliation. Participants were also asked about the presence of children or older people at home, whether they had any physical illnesses in the last year, whether they had a chronic disease diagnosis (e.g., hypertension, diabetes, asthma), and whether they were regular religious practitioners. These questions were answered by choosing between dichotomous options (yes/no). In addition, participants were also asked two more COVID-19 vaccine-related questions: "Do you think the COVID-19 vaccine will be effective among Bangladeshis (no/yes/skeptical), and "Which developers' vaccine would you prefer to take (American/British/Chinese/Russian/Indian/I have no idea regarding this).

Data collection

Individual face-to-face interviews were conducted to ensure privacy. All participants were informed of the voluntary nature of the participation. We adhered to the adequate COVID-19-related safety measures, including maintaining social distance, wearing a mask, and using hand sanitizers during the interview session. The respondents were given no incentives, such as monetary retribution or food items. The questions were read out to the interviewees one by one during the interview, and the acceptable options were asked. The co-investigators reviewed the data collection sheets for completeness, accuracy, and internal consistency and confirmed them with the principal investigator. The interviews were conducted at homes, marketplaces, shopping malls, and waiting rooms of large hospitals and diagnostic centers. Furthermore, to include

diverse participants, data were collected in the waiting room of bus and rail stations, and a colony of the transgender population was visited. Approximately 1,500 adults were invited to the interview, and 1,250 of them agreed. The rate of invitees who declined the interview was higher among women and transgender people than men.

Participants and public involvement

Participants and the public were not involved in the design, conduct, reporting, and dissemination plans of our research. This study's aim and objective were explained, and assurance of anonymity was given before receiving informed consent from the participants.

Data analysis

Descriptive statistics were computed to describe the demographic characteristics of the study participants. Chi-Square tests were used to compute vaccine hesitancy proportions and draw comparisons between groups. Responses were compared for various sociodemographic characteristics by dichotomizing the variable as either a positive ("very likely" and "somewhat likely") or a negative ("not likely" and "definitely not") attitude toward the COVID-19 vaccine, indicating the extent of vaccine hesitancy. To compute adjusted odds ratios (AOR) with a 95% confidence interval (CI), multiple logistic regression analyses were performed with vaccine hesitancy as a dependent variable and sociodemographic characteristics and perceived COVID-19 threat as predictor variables for vaccine hesitancy. To ensure that the models adequately fit the data, the Hosmer-Lemeshow goodness-of-fit test was used. The significance level was set at $p< 0.05$, and SPSS version 22.0 (IBM Corp.) was used for all data analyses.

RESULTS

Participants' characteristics

Table 1 shows the sociodemographic characteristics, perceived COVID-19 threat, and vaccine hesitancy of the 1,134 Bangladeshis who participated in this study. The mean age of the participants was 32.05 (SD ± 11.72). The majority of the study participants were men (59.2%), aged 26–40 (40.7%), Muslim (93.2%), married (52.7%), with a bachelor's degree (31.4%), full-time employees (28.7%), persons with a monthly household income ≥30,000 BDT (44.9%), from the central zone, including Dhaka, of Bangladesh (60%), living in their own house (46.3%), and those had not experienced physical illnesses (57.3%) and had no political affiliation (56.5%). However, 29.8% of the participants were tobacco users, and only 24.3% had a chronic disease. The question on the likelihood of being infected by COVID-19 in the next year received the following responses: "very likely" (34.2%), "somewhat likely" (53.6%), "not likely" (7.3%), and "definitely not" (5.9%). In addition, **Figure 1** represents the day-to-day fluctuation of vaccine hesitancy.

Descriptive analysis

Statistically significant differences in vaccine hesitancy were found based on sociodemographic characteristics, with the highest prevalence of COVID-19 vaccine hesitancy among transgender persons (64%; p= 0.003), persons aged over 60 (39%; p= 0.009), unemployed persons (40%; p= 0.013), those with a monthly household income <15,000 BDT (33%; p= 0.042), those living in the central zone (35%; p= 0.048), those living in a rented house (36%; p= 0.042), tobacco users (37%; p= 0.037), those who had not faced a physical illness in the past year (36%; p= 0.006), and those affiliated with the opposition parties (39%; p= 0.050), those who did not believe in

COVID-19 vaccine effectiveness for Bangladeshi (67%; p= <0.001), and those who had no knowledge on vaccine developers (43.7%; p= 0.001) (**Table 1**).

Furthermore, participants who were not likely to believe that they or a family member could be infected with COVID-19 in the next year (61%; p= <0.001) and those who were not concerned at all about themselves or a family member getting infected in the next year (57%; p= <0.001) had the highest rates of COVID-19 vaccine hesitancy.

Multiple logistic regression analysis

Table 2 presents the predictors of COVID-19 vaccine hesitancy. A multiple regression analysis was conducted to examine predictors of COVID-19 vaccine hesitancy by including factors significantly associated with vaccine hesitancy in the descriptive analysis. In this multiple regression model, groups with statistically significantly higher odds of vaccine hesitancy were transgender persons (AOR= 3.62, 95% CI= 1.177–11.251), married persons (AOR=1.49, CI= 1.047–2.106), tobacco users (AOR=1.33, CI= 1.018–1.745), participants who had not experienced physical illnesses in the past year (AOR=1.49, CI= 1.134–1.949), those with political affiliations with opposition parties (AOR= 1.48, CI= 1.025–2.134), those who did not believe in COVID-19 vaccines effectiveness for Bangladeshis (AOR= 3.20, CI= 2.079–4.925), and those who were slightly concerned (AOR = 2.87, CI= 1.744–4.721) or not concerned at all (AOR = 7.45, CI= 4.768–11.643) about themselves or a family member getting infected with COVID-19 in the next year. Likewise, compared with participants who believed it was very likely that they or their family members could get infected with COVID-19 in the next one year, those who thought such an occurrence would not be likely (AOR = 1.88, CI= 1.109–3.172) had significantly higher odds of vaccine hesitancy. Nonetheless, women (AOR= 0.70, CI= 0.537–0.928), students (AOR = 0.60, CI= 0.379–0.966), and those who preferred to take the British

(AOR= 0.48, CI= 0.324–0.725), Chinese (AOR=0.44, CI= 0.245-0.807), Russian (AOR= 0.42, CI= 0.222–0.825) or Indian (AOR= 0.33, 0.143–0.774) vaccine had statistically significantly lower odds of vaccine hesitancy.

DISCUSSION

In the current comprehensive national study, more than one-third of the participants (32.5%) reported vaccine hesitancy. Analysis of daily data suggested that vaccine hesitancy varied from 18% to 72% in Bangladesh. To the best of our knowledge, this is the first study to measure COVID-19 vaccine hesitancy in Bangladesh using the previously used COVID-19 vaccine hesitancy questionnaire; thus, little is known about the previous hesitancy rate. However, a global survey from June 2020 suggested that more than 80% of participants from China, Korea, and Singapore were very or somewhat likely to receive the COVID-19 vaccine [15]. Another study in September 2020 in Japan found that 65% of participants were willing to receive the COVID-19 vaccine [24]. However, a January 2021 survey in India suggested that 60% of polled Indians showed hesitancy towards receiving COVID-19 vaccines [25].

We found higher vaccine hesitancy among male, older, married, and transgender participants. In the final model, women showed significantly lower odds of vaccine hesitancy. In agreement with our findings, a global study observed lower odds of vaccine willingness among male participants [15]; however, women in Japan demonstrated very high vaccine hesitancy compared with men [24]. American women also showed lower willingness toward the COVID-19 vaccine [26]. Nonetheless, an early study suggested that Bangladeshi women's better knowledge, attitude, and preventive practice toward COVID-19 could be the reasons for their lower vaccine hesitancy

[27]. Furthermore, we found statistically significant higher odds of vaccine hesitancy among the transgender population. Previous research suggested that vaccine hesitancy is universally higher among gender minorities due to limited access and interaction with healthcare professionals, historical biomedical and healthcare-related mistrust, cost-related concerns, lack of belief in the scientific enterprise of medicine and public health, lack of awareness, and education [28]. An additional regional study is required to determine the gender-based difference in vaccine hesitancy.

Unlike other studies, we found higher vaccine hesitancy among older people than younger people. This difference could also be explained by an earlier study that showed a lack of COVID-19-related knowledge among the older population of Bangladesh [27]. Socio-cultural and religious beliefs related to preexisting vaccine hesitancy among the older population could also cause higher vaccine hesitancy. Additionally, results regarding the married population are incorporated with age; therefore, results need to be interpreted by considering marital status and age together.

Unemployment, an education level lower than or equal to high school, and a monthly household income of less than 15,000 BDT were associated with a higher likelihood of COVID-19 vaccine hesitancy in Bangladesh. In line with our findings, a global study also suggested that participants with lower education and income were less likely to get the COVID-19 vaccine [15]. Moreover, unemployed participants and participants with a low level of education in the USA and Saudi Arabia showed higher vaccine hesitancy [26,29]. In contrast, other studies found that unemployed participants were more likely to accept the COVID-19 vaccine [21,30]. Thus, in some regions, unemployed persons may want to return to work and employment, and the vaccine could facilitate this return.

A unique finding of this study was that a high portion of tobacco users showed hesitancy to receive the COVID-19 vaccine. This high rate may be explained in the sense that, universally, tobacco users (including smokers) tend to have unhealthy life practices. Nonetheless, a systematic review and meta-analysis concluded that current and previous smoking is associated with severe COVID-19 outcomes [31]. Another systematic review suggested that tobacco use was significantly associated with a higher rate of mortality among COVID-19 patients [32]. So far, there have been discussions on vaccine prioritization (e.g., for front liners). However, little vaccination planning has been done for the most vulnerable populations who continue to remain susceptible to COVID-19 outcomes (i.e., a greater number of deaths and severe infections). Our findings would help identify these subgroups. In contrast, we found high odds among those who did not have physical illnesses throughout the last year. However, previous evidence suggested that healthier persons can also be infected by COVID-19 and that the outcomes are unpredictable. Therefore, policymakers should target these subgroups when planning vaccine literacy for potential vaccine recipients.

Interestingly, we found statistically significantly higher vaccine hesitancy among politically affiliated (either affiliated with the ruling parties or oppositions) participants than those who described themselves as neutral. However, regression analysis suggested that those affiliated with opposition parties had higher odds . In addition, a systematic review and meta-analysis found that vaccine hesitancy in LMICs collated with a range of trust relationships, such as trust in healthcare professionals, the health system, the government, and friends and family members [33].

The effectiveness of vaccines varies between races and countries [34]. However, no human clinical trial of any COVID-19 vaccine has been conducted in Bangladesh. In our study,

participants were asked whether they believed the vaccines would be effective for Bangladeshi people. Those who answered "no" and remained "skeptical" showed a higher rate of vaccine hesitancy. However, this finding is similar to the findings of a study conducted in another country [35]. Finally, our study revealed high odds of hesitancy among those who were not concerned about being infected by COVID-19. In support of our findings, a systematic review confirmed that people's perceived risk of infection is one of the strongest predictors of pandemic vaccine acceptance or hesitancy [36].

In our study, participants were asked about their vaccine choice. Evidence suggested that the efficacy of different vaccines from different developers was not matched [37]. For example, vaccines from the American companies Moderna and Pfizer and Russian company Gamaleya have the highest efficacy (i.e., > 90%). A British vaccine, the Oxford-AstraZeneca, has moderate efficacy (76%). A vaccine from the Chinese company Sinovac has shown lower efficacy (51%). Furthermore, some vaccines (e.g., Oxford-AstraZeneca) produce severe adverse effects, such as very rare blood clots and even fatalities [38]. Consequently, some countries, such as Denmark, have stopped using the Oxford-AstraZeneca vaccine. Our study found statistically significant differences in vaccine hesitancy between the vaccine preference subgroups. This finding denoted that the freedom in vaccine choice among recipients could reduce vaccine hesitancy in Bangladesh.

Risk perception is central to many health behavior theories. A systematic review and meta-analysis concluded that vaccination behavior is significantly predicted by risk likelihood, susceptibility, and severity of the disease [39]. In the case of COVID-19, a study suggested that higher risk perception was associated with reduced vaccine hesitancy [40]. Another study also revealed that reduced risk perception was associated with reduced COVID-19 vaccine

willingness [41]. In contrast, one study suggested that the safety of the COVID-19 vaccine outweighs disease risk perception when predicting vaccine hesitancy [42]. In our study, we found that perceived COVID-19 threat was strongly associated with vaccine hesitancy.

Several limitations may have influenced our results. First, this study is a cross-sectional study and portrays the community response at the climacteric of the study. Nonetheless, vaccine hesitancy is complex in disposition and adherence-specific, varying over time, location, and perceived behavioral nature of the community [36,43,44]. Second, social and traditional media influence are major predictors of pandemic vaccine hesitancy or acceptance [45]. In our study, we did not examine the impact of the media, thus potentially confounding the results. Additional research is warranted to address this issue. Third, as the refusal rate to participate in this study was higher among women, we had slightly more male participants in the study sample. Finally, the face-to-face interview format may lead to social desirability bias, so more anonymous methods should be employed in further studies. Despite these limitations, our study provided baseline evidence regarding COVID-19 vaccine hesitancy among LMICs. Furthermore, our study identified many subgroups of the general population that must be considered during vaccine hesitancy discussions. Finally, data collected by interviewing randomly selected participants from the north, south, and central zone of Bangladesh, including Dhaka, would have given a better representation of the population in the sample, thus making the study results more generalizable.

Conclusion

The present rapid community-based study found differences in COVID-19 vaccine hesitancy based on the sociodemographic characteristics, health, and behavior of the Bangladeshi general population. Various contributing factors for vaccine hesitancy, such as preexisting

indecisiveness, cultural and religious views, lack of belief in the scientific enterprise of medicine and public health, especially among the older population, and lower levels of awareness, were identified. Further research is warranted to comprehend the complicated interplay of various individual and social characteristics influencing vaccine hesitancy. To ensure the extensive coverage of COVID-19 vaccines, the government, public health officials, and advocates must be prepared to address vaccine hesitancy to reach their target and build vaccine literacy among potential recipients. Evidence-based educational and policy-level interventions must be implemented to address these problems and promote COVID-19 immunization programs. The rates of willingness are subject to change with the suitability of the vaccines, but the frequent and ambivalent effects of vaccines may reduce those rates. The uptake of COVID-19 vaccines can be increased once the factors identified in this study are properly addressed, and the long-term positive effects of the vaccines are clarified.

Acknowledgments

Both authors acknowledge the participants for providing the information used to conduct the study.

Competing interests

The authors declare that they have no competing interests.

Funding statement

This research received no specific grant from any funding agency in public, commercial or not-for-profit sectors.

Data sharing statement

Data will be available from the corresponding author upon reasonable request.

Author contributions

MA participated in study conception, design, and coordination of the manuscript. MA also performed the statistical analysis and drafted the manuscript. AH reviewed the manuscript and helped to draft the manuscript. Both the authors approved the final manuscript.

Ethical consideration

Formal ethical approval was received from the Ethical Review Committee (ERC) of Uttara Adhunik Medical College and Hospital. Prospective observational trial registration was obtained from the World Health Organization (WHO) endorsed Clinical Trial Registry-India: CTRI/2021/01/030546. Furthermore, we conducted the study strictly following the STROBE guideline. All the invited participants were required to give informed consent for participation, collection, and analysis of their data.

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Table 1 Descriptive analysis: Sociodemographic characteristics, COVID-19 threat, and vaccine hesitancy

Variables	Total Sample n (%)	Likelihood of getting COVID-19 Vaccine		p-value
		Not likely/definitely not n (%)	Very likely/somewhat-likely n (%)	
All participants	1134 (100%)	369 (32.5)	765 (67.5)	-
Gender				**0.003**
Transgender	14 (1.2)	9 (64.3)	5 (35.7)	
Female	449 (39.6)	127 (28.3)	322 (71.7)	
Male	671 (59.2)	233 (34.7)	438 (65.3)	
Age group				**0.009**
18-25	442 (39.0)	122 (27.6)	320 (72.4)	
26-40	461 (40.7)	174 (37.7)	287 (62.3)	
41-60	200 (17.6)	61 (30.5)	139 (69.5)	
≥ 61	31 (2.7)	12 (38.7)	19 (61.3)	
Religion				0.442
Muslim	1057 (93.2)	349 (33.0)	708 (67.0)	
Hindu	61 (5.4)	16 (26.2)	45 (73.8)	
Cristian and Buddhist	16 (1.4)	4 (25.0)	12 (75.0)	
Marital status				**0.039**
Unmarried	495 (43.6)	141 (28.5)	353 (71.5)	
Married	598 (52.7)	214 (35.8)	384 (64.2)	
Divorce/Widow	42 (3.7)	14 (33.3)	28 (66.7)	
Children at home				0.950
No	481 (42.4)	157 (32.6)	324 (67.4)	
Yes	653 (57.6)	212 (32.5)	441 (67.5)	
Aged people at home				0.224
No	396 (34.9)	138 (34.8)	258 (65.2)	
Yes	738 (65.1)	231 (31.3)	507 (68.7)	
Education				0.268
≤ High school	264 (23.3)	98 (37.1)	166 (62.9)	
College education	309 (27.2)	92 (29.8)	217 (70.2)	
Bachelor's degree	356 (31.4)	111 (31.2)	245 (68.8)	
≥ Master's degree	205 (18.1)	68 (33.2)	137 (66.8)	
Employment status				**0.013**
Full-time employee	326 (28.7)	109 (33.4)	217 (66.6)	
Part-time employee	73 (6.4)	23 (31.5)	50 (68.5)	
Business	169 (14.9)	66 (39.1)	103 (60.9)	
Unemployed	88 (7.8)	35 (39.8)	53 (60.2)	
Home maker	171 (15.1)	60 (35.1)	111 (64.9)	
Student	307 (27.1)	76 (24.8)	231 (75.2)	
Monthly household income				**0.042**
<15,000	239 (21.1)	78 (32.6)	161 (67.4)	
15,000-30,000	386 (34.0)	108 (28.0)	278 (72.0)	
≥ 30,000	509 (44.9)	183 (36.0)	326 (64.0)	
Family type				0.205
Nuclear	715 (63.1)	223 (31.2)	492 (68.8)	
Joint	419 (36.9)	146 (34.8)	273 (65.2)	

Permanent address				0.533
Rural	637 (56.2)	216 (33.9)	421 (66.1)	
Urban	411 (36.2)	126 (30.7)	285 (69.3)	
Sub urban	86 (7.6)	27 (31.4)	59 (68.6)	
Current living location				**0.048**
Central zone	680 (60.0)	237 (34.9)	443 (65.1)	
North zone	237 (20.9)	62 (26.2)	175 (73.8)	
South zone	217 (19.1)	70 (32.3)	147 (67.7)	
Current Residence type				**0.042**
Rented	514 (45.3)	184 (35.8)	330 (64.2)	
Own	525 (46.3)	151 (28.8)	374 (71.2)	
Hostel/Mess	95 (8.4)	34 (35.8)	61 (64.2)	
Regular religious practice				0.064
No	328 (28.9)	120 (36.6)	208 (63.4)	
Yes	806 (71.1)	249 (30.9)	557 (69.1)	
Present tobacco user				**0.037**
No	796 (70.2)	244 (30.7)	552 (69.3)	
Yes	338 (29.8)	125 (37.0)	213 (63.0)	
Did you face physical illness in the last year				**0.006**
No	650 (57.3)	233 (35.8)	417 (64.2)	
Yes	484 (42.7)	136 (28.1)	348 (71.9)	
Having a chronic condition				0.943
No	859 (75.7)	280 (32.6)	579 (67.4)	
Yes	275 (24.3)	89 (32.4)	186 (67.6)	
Political affiliation				**0.050**
Ruling party	340 (30.0)	119 (35.0)	221 (65.0)	
Opposition	153 (13.5)	59 (38.6)	94 (61.4)	
Neutral	641 (56.5)	191 (29.8)	450 (70.2)	
Do you think the COVID-19 vaccine will be effective among Bangladeshis				**<0.001**
No	108 (9.5)	72 (66.7)	36 (33.3)	
Yes	367 (32.4)	43 (11.7)	324 (88.3)	
Skeptical	659 (58.1)	254 (38.5)	405 (61.5)	
Which developers' vaccine would you prefer				**0.001**
American	435 (38.4)	160 (36.8)	275 (63.2)	
British	372 (32.8)	102 (27.4)	270 (72.6)	
Chinese	82 (7.2)	21 (25.6)	61 (74.4)	
Russian	64 (5.6)	16 (25.0)	48 (75.0)	
Indian	39 (3.4)	8 (20.5)	31 (79.5)	
Others/no idea	142 (12.5)	62 (43.7)	80 (56.3)	
Perceived likelihood of getting infected in the next 1 year				**<0.001**
Very likely	388 (34.2)	141 (36.3)	247 (63.7)	
Somewhat likely	608 (53.6)	146 (24.0)	462 (76.0)	
Not likely	83 (7.3)	51 (61.4)	32 (38.6)	
Definitely not	55 (4.9)	31 (56.4)	24 (43.6)	
Level of concern about getting infected in the next 1 year				**<0.001**
Very concerned	226 (19.9)	30 (13.3)	196 (86.7)	
Concerned	290 (25.6)	53 (18.3)	237 (81.7)	
Slightly concerned	235 (20.7)	69 (29.4)	166 (70.6)	
Not concerned at all	383 (33.8)	217 (56.7)	166 (43.3)	

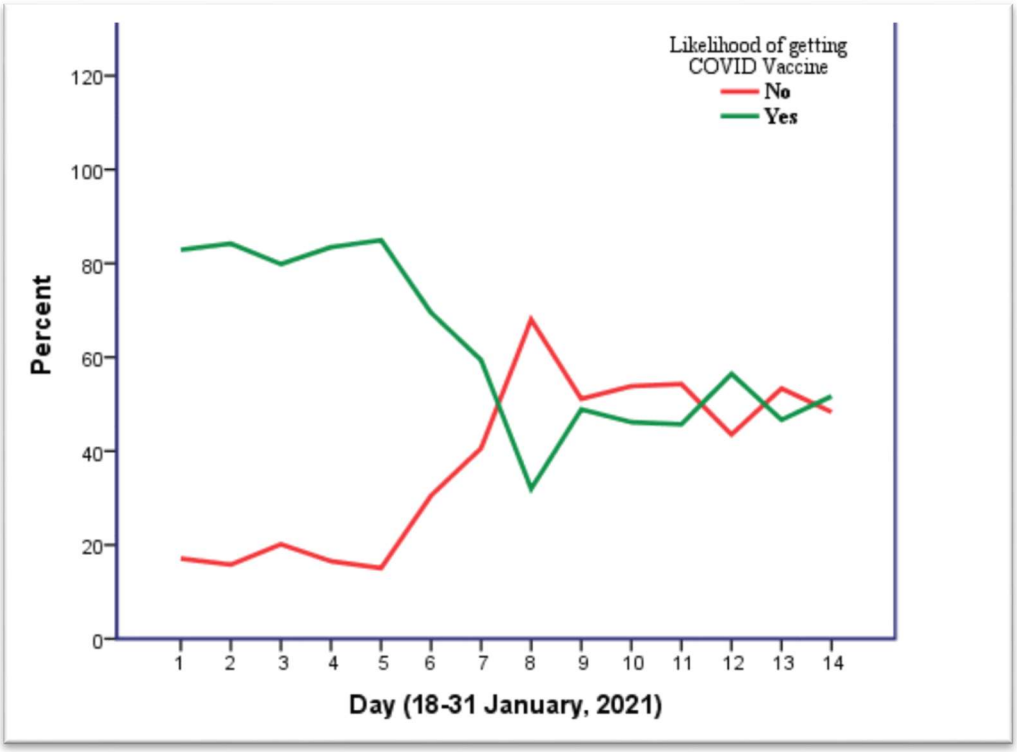
Table 2 Multiple logistic regression: Predictors of vaccine hesitancy in study participants

Variables	Adjusted Odds Ratio	Standard Error	Confidence Interval	p-value
Gender				
Transgender	3.639	0.576	1.177-11.251	**0.025**
Female	0.706	0.139	0.537-0.928	**0.013**
Male	Reference			
Age group				
18-25	Reference			
26-40	1.208	0.179	0.851-1.715	0.290
41-60	0.808	0.238	0.508-1.285	0.368
≥ 61	1.053	0.434	0.450-2.465	0.905
Marital status				
Unmarried	Reference			
Married	1.485	0.175	1.047-2.106	**0.027**
Divorce/Widow	1.606	0.394	0.742-3.44	0.229
Employment Status				
Full-time employee	1.006	0.217	0.657-1.539	0.979
Part-time employee	0.914	0.315	0.439-1.693	0.775
Business	1.230	0.227	0.788-1.921	0.362
Unemployed	1.311	0.284	0.751-2.286	0.341
Student	0.606	0.238	0.379-0.966	**0.035**
Home maker	Reference			
Monthly household income				
<15,000	Reference			
15,000-30,000	0.790	0.185	0.550-1.136	0.203
≥ 30,000	1.181	0.185	0.822-1.696	0.368
Current living location				
Central zone	1.105	0.169	0.793-1.540	0.554
North zone	0.762	0.209	0.506-1.147	0.192
South zone	Reference			
Current Residence type				
Rented	0.962	0.235	0.607-1.527	0.871
Own	0.761	0.241	0.475-1.221	0.258
Hostel/Mess	Reference			
Tobacco user				
No	Reference			
Yes	1.333	0.138	1.018-1.745	**0.037**
Did you face physical illness in the last year				
No	1.486	0.138	1.134-1.949	**0.004**
Yes	Reference			
Political affiliation				
Ruling party	1.269	0.143	0.959-1.678	0.096
Opposition	1.479	0.187	1.025-2.134	**0.037**
Neutral	Reference			

Do you think the COVID-19 vaccine will be effective among Bangladeshis				
No	3.199	0.220	2.079-4.925	**<0.001**
Yes	0.212	0.182	0.149-0.303	**<0.001**
Skeptical	Reference			
Which developers' vaccine would you prefer				
American	0.744	0.197	0.506-1.094	0.133
British	0.484	0.205	0.324-0.725	**<0.001**
Chinese	0.444	0.304	0.245-0.807	**0.008**
Russian	0.428	0.335	0.222-0.825	**0.011**
Indian	0.332	0.431	0.143-0.774	**0.011**
No idea	Reference			
Perceived likelihood of getting infected in the next 1 year				
Very likely	Reference			
Somewhat likely	0.645	0.161	0.471-0.884	**0.006**
Not likely	1.875	0.268	1.109-3.172	**0.019**
Definitely not	1.099	0.307	0.602-2.007	0.758
Level of concern about getting infected in the next 1 year				
Very concerned	Reference			
Concerned	1.609	0.255	0.977-2.649	0.062
Slightly concerned	2.869	0.254	1.744-4.721	**<0.001**
Not concerned at all	7.450	0.228	4.768-11.643	**<0.001**

Figure legend:

Figure 1 Day-to-day fluctuation of COVID-19 vaccine wiliness or hesitancy among participants



STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*N/A*
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N/A
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	N/A
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

What is the extent of COVID-19 vaccine hesitancy in Bangladesh? A cross-sectional rapid national survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-050303.R2
Article Type:	Original research
Date Submitted by the Author:	27-Jul-2021
Complete List of Authors:	Ali, Mohammad; Uttara Adhunik Medical College, Department of Physiotherapy and Rehabilitation ; Bangladesh University of Professionals, Center for Higher Studies and Research Hossain, Ahmed; North South University, Department of Public Health
Primary Subject Heading:	Health policy
Secondary Subject Heading:	Communication, Health informatics, Health policy, Public health, Pharmacology and therapeutics
Keywords:	COVID-19, Public health < INFECTIOUS DISEASES, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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What is the extent of COVID-19 vaccine hesitancy in Bangladesh? A cross-sectional rapid national survey

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- Word count: Abstract 293, main text (excluding references and tables) 3918.

What is the extent of COVID-19 vaccine hesitancy in Bangladesh? A cross sectional rapid national survey

Abstract

objectives: To assess COVID-19 vaccine hesitancy in Bangladesh and identify population subgroups with higher odds of vaccine hesitancy.

design: A nationally representative cross-sectional survey was used for this study. Descriptive analyses helped to compute vaccine hesitancy proportions and compare them across groups. Multiple logistic regression analyses were performed to compute the adjusted odds ratio.

setting: Bangladesh

participants: A total of 1,134 participants from the general population, aged 18 years and above participated in this study.

outcome measures: Prevalence and predictors of vaccine hesitancy.

results: Of the total participants, 32.5% showed COVID-19 vaccine hesitancy. Hesitancy was high among respondents who were men, over 60, unemployed, from low-income families, from central Bangladesh, including Dhaka, living in rented houses, tobacco users, politically affiliated, doubtful of the vaccine's efficacy for Bangladeshis, and those who did not have any physical illnesses in the past year. In the multiple logistic regression models, transgender respondents (AOR= 3.62), married individuals (AOR=1.49), tobacco users (AOR=1.33), those who had not experienced any physical illnesses in the past year (AOR=1.49), those with political affiliations with opposition parties (AOR= 1.48), those who believed COVID-19 vaccines would not be

effective for Bangladeshis (AOR= 3.20), and those who were slightly concerned (AOR= 2.87) or not concerned at all (AOR= 7.45) about themselves or a family member getting infected with COVID-19 in the next year were significantly associated with vaccine hesitancy ($p< 0.05$).

conclusions: Given the high prevalence of COVID-19 vaccine hesitancy, in order to guarantee that COVID-19 vaccinations are widely distributed, the government and public health experts must be prepared to handle vaccine hesitancy and increase vaccine awareness among potential recipients. To address these issues and support COVID-19 immunization programs, evidence-based educational and policy-level initiatives must be undertaken especially for the poor, older and chronically diseased individuals.

Keywords COVID-19, Bangladesh, Nationwide assessment, Vaccine hesitancy.

Strengths and Limitations of the study

- This study is the first to measure COVID-19 vaccine hesitancy in Bangladesh using a validated vaccine hesitancy questionnaire.
- Participants were interviewed face to face to minimize non-response and maximize the quality of the data collected.
- The survey assessed a range of sociodemographic and psychological variables (i.e., perceived COVID-19 risk).
- Including the transgender population increased the generalizability of the findings.
- The influence of traditional media and social media on COVID-19 vaccine hesitancy were not measured, which significantly limited this study.

INTRODUCTION

The first case of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was detected in December 2019 in Wuhan, China. By the first week of February 2021, COVID-19 had infected over 105 million people across 223 countries or territories and had caused more than 2.3 million fatalities worldwide [1]. Consequently, COVID-19 was declared a pandemic by the World Health Organization (WHO) in March 2020, and many countries began developing COVID-19 vaccines. Two COVID-19 vaccines with 90–95% effectiveness developed by two American pharmaceutical companies were announced at the end of November, 2020 [2,3]. Subsequently, many other safe and effective vaccines were also developed and announced by other countries [4–7]. By the end of 2020, 10 vaccines were approved for either full or early use in several countries, including the USA, UK, and Canada [8]. Immediately after they were approved, the vaccines were rolled out in the respective countries.

However, a vaccination program can be promoted or undermined by factors such as vaccine hesitancy. Vaccine hesitancy refers to delay in acceptance or refusal of vaccination despite the availability of the vaccination service [9]. In 2019, the WHO declared vaccine hesitancy as one of the top 10 global health threats [10]. Following the COVID-19 vaccine rollout, news regarding adverse effects of the vaccine experienced by a few vaccine recipients, along with conspiracy theories and misinformation on social media, have drawn public attention across the world [11]. Hence, confusing news about the effectiveness of some vaccines by the media has negatively impacted the opinions of potential vaccine recipients [12,13]. Moreover, the anxiety and hesitancy were further heightened due to the accelerated pace of vaccine development [14].

Along with contemporary consequences, knowledge, and awareness-related issues, vaccine hesitancy can also be determined by religious, cultural, gender, or socio-economic factors [9].

A study indicated that the rate of willingness to vaccinate could range from 55–90% worldwide [15]. However, vaccine willingness or hesitancy changes over time [9]. Most of the previous studies were conducted in high-income settings and well before the vaccine was made available. However, little is known about COVID-19 vaccine hesitancy in vaccination programs being run in low-income and middle-income countries' (LMICs) population.

Generally, vaccinations are largely accepted in LMICs, such as Bangladesh [16]. A study conducted in 2018 with 140,000 individuals in 140 countries suggested that 94% of participants in South Asia described vaccination as effective, and 95% of them perceived vaccines as safe [17]. However, another study conducted in Bangladesh, China, Ethiopia, Guatemala, and India revealed that over 50% of respondents agreed or were neutral with regards to the notion, “new vaccines carry more risks than older vaccines” [18]. Nonetheless, Bangladesh did not participate in any COVID-19 vaccine clinical trials. We hypothesized that, due to the novelty of COVID-19 vaccines, Bangladeshis lacked awareness of their impact. Thus, acceptance or hesitancy toward a COVID-19 vaccine among Bangladeshis might differ from other vaccines available in in the country.

The impact of COVID-19 on the overall health, economy, and community of Bangladesh is one of the highest among the LMICs. By mid-February 2021, in Bangladesh, about 0.55 million COVID-19 cases had been confirmed, and about 10,000 people had died from the disease [19]. While the COVID-19 vaccine rollout in Bangladesh was inaugurated on January 27, 2021, aiming to immunize 138 million people [20], little was known about COVID-19 vaccine hesitancy or willingness among this cohort. Thus, our study aimed to (1) conduct a rapid national

assessment of COVID-19 vaccine hesitancy in Bangladesh and (2) identify population subgroups with higher odds of vaccine hesitancy.

METHODS

Design and participants

In a cross-sectional study conducted in Bangladesh from 18 to 31 January 2021, approximately 1,500 male, female, and transgender participants aged 18 years and above were invited to participate in an interview using a previously employed, valid, and reliable vaccine hesitancy questionnaire [21]. A margin of 5% error, a confidence level of 95%, and a response distribution of 50% were used to calculate the sample size to target a population of 138 million individuals and secure a minimum sample size of 1,067 participants [22,23]. Therefore, similar to other previous studies, our sample consisted of 1,134 respondents [21,24].

Recruitment and training of data collectors

Eighteen health-science students (nine of whom were women) were recruited to collect and sort data for this study. A two-day online training program was arranged for the data collectors. However, 16 successful trainees were appointed for further procedures. Among the sixteen data collectors, four were assigned to North Bengal and four to South Bengal. Considering the higher population density, eight data collectors were appointed for central Bangladesh, including Dhaka City. Eight teams of two persons (one woman in each team) were created. Interviews were conducted in the Bangla language. A data collector asked the questions first, and the answers were then confirmed by the second member of the respective team.

To observe the day-to-day fluctuation of vaccine hesitancy, each team was instructed to collect around 12 pieces of data per day. Furthermore, the data collectors were briefed about the study's objectives, methodology, and questionnaire. They were taught the techniques for report building and preserving neutrality and were well-informed on ethical issues, privacy concerns, cultural awareness, and risk management for COVID-19 infection. A pilot study was arranged for all data collectors as a single unit following the training session to observe their capacity to comprehend relevant techniques and troublesome situations that could occur while interviewing. Necessary corrections were made following the pilot study. Each trained team visited their designated area to collect data using a semi-structured questionnaire.

The questionnaire

The paper-based questionnaire comprised two parts. In the first part, participants were asked questions regarding vaccine hesitancy and perceived COVID-19 threat [21]. First, participants were asked about the likelihood of getting a vaccine. The dependent variable and a key outcome of the study (i.e., vaccine hesitancy) was measured using the question, "If a vaccine that would prevent coronavirus infection was available, how likely is it that you would get the vaccine or shot?" The response options for this question were "very likely," "somewhat likely," "not likely," and "definitely not." Second, participants were asked two questions regarding the perceived COVID-19 threat: (1) "How likely is it that you or a family member could get infected with coronavirus in the next one year?" with response options "very likely," "somewhat likely," "not likely," and "definitely not." (2) "How concerned are you that you or a family member could get infected with coronavirus in the next one year?" with response options "very concerned," "concerned," "slightly concerned," and "not concerned at all."

The second part of the questionnaire comprised a wide range of sociodemographic questions. A set of structured questions assessed participants' gender, age, religion, marital status, education, employment status, monthly household income in Bangladeshi taka (BDT), permanent address, and region of residence in Bangladesh (north, south, and central zone, including Dhaka), current residence type (Own/rented/hostel or mess), present tobacco use status, and political affiliation. Participants were also asked about the presence of children or older people at home, whether they had any physical illnesses in the last year, whether they had a chronic disease diagnosis (e.g., hypertension, diabetes, asthma), and whether they practiced religion regularly. These questions were answered by choosing between dichotomous options (yes/no). Additionally, participants were also asked two more COVID-19 vaccine-related questions: "Do you think the COVID-19 vaccine will be effective among Bangladeshis" (no/yes/skeptical), and "Which developers' vaccine would you prefer to take" (American/British/Chinese/Russian/Indian/I have no idea regarding this).

Data collection

Individual face-to-face interviews were conducted to ensure privacy of the participants. All participants were informed of the voluntary nature of the participation. We adhered to the adequate COVID-19-related safety measures, including maintaining social distance, wearing a mask, and using hand sanitizers during the interview session. The respondents were given no incentives, such as monetary retribution or food items. The questions were read out to the interviewees individually during the interview, and the acceptable options were asked. The co-investigator reviewed the data collection sheets for completeness, accuracy, and internal consistency and confirmed them with the principal investigator. The interviews were conducted at homes, marketplaces, shopping malls, and waiting rooms of large hospitals and diagnostic

centers. Furthermore, to include diverse participants, data were collected in the waiting room of bus and rail stations, and from a colony of the transgender population . Approximately 1,500 adults were invited to the interview, and 1,250 of them agreed to participate. The rate of invitees who declined the interview was higher among women and transgender people than men.

Sampling technique:

We employed a two-stage cluster sampling technique to include potential participants for the study. The residential areas, marketplaces, shopping malls, and waiting rooms of large hospitals, diagnostic centers, and bus and rail stations were randomly chosen and processed as a cluster in the first stage. The list of given data collection sites were collected from the districts' websites. In the second stage, we chose the participants in a methodical and convenient manner by selecting alternate individuals from diverse groups.

Participants and public involvement

The participants and the public were not involved in the design, conduct, reporting, and dissemination plans of our research. This study's aim and objective were explained, and assurance of anonymity was given before receiving informed consent from the participants.

Data analysis

Descriptive statistics were computed to describe the demographic characteristics of the study participants. Chi-Square tests were used to compute vaccine hesitancy proportions and draw comparisons between groups. Responses were compared for various sociodemographic characteristics by dichotomizing the variable as either a positive ("very likely" and "somewhat likely") or a negative ("not likely" and "definitely not") attitude toward the COVID-19 vaccine, indicating the extent of vaccine hesitancy. To compute adjusted odds ratios (AOR) with a 95%

confidence interval (CI), multiple logistic regression analyses were performed with vaccine hesitancy as a dependent variable and sociodemographic characteristics and perceived COVID-19 threat as predictor variables for vaccine hesitancy. To ensure that the models adequately fit the data, the Hosmer-Lemeshow goodness-of-fit test was used. The significance level was set at $p< 0.05$, and SPSS version 22.0 (IBM Corp.) was used for all data analyses.

RESULTS

Participants' characteristics

Table 1 shows the sociodemographic characteristics, perceived COVID-19 threat, and vaccine hesitancy of the 1,134 Bangladeshis who participated in this study. The mean age of the participants was 32.05 years (SD ± 11.72). The majority of the study participants were men who were (59.2%), aged 26–40 years (40.7%), Muslim (93.2%), married (52.7%), with a bachelor's degree (31.4%), full-time employees (28.7%), having a monthly household income ≥30,000 BDT (44.9%), from the central zone, including Dhaka, of Bangladesh (60%), living in their own house (46.3%), and had no experience of physical illnesses (57.3%) and were not politically affiliated (56.5%). However, 29.8% of the participants were tobacco users, and only 24.3% had a chronic disease. The question on the likelihood of being infected by COVID-19 in the next year received the following responses: "very likely" (34.2%), "somewhat likely" (53.6%), "not likely" (7.3%), and "definitely not" (5.9%). Furthermore, **Figure 1** represents the day-to-day fluctuation of vaccine hesitancy.

Descriptive analysis

Statistically significant differences in vaccine hesitancy were found based on sociodemographic characteristics, with the highest prevalence of COVID-19 vaccine hesitancy among the transgender population (64%; p= 0.003), persons aged over 60 (39%; p= 0.009), unemployed persons (40%; p= 0.013), those with a monthly household income <15,000 BDT (33%; p= 0.042), those living in the central zone (35%; p= 0.048), those living in a rented house (36%; p= 0.042), tobacco users (37%; p= 0.037), those who had not faced a physical illness in the past year (36%; p= 0.006), and those affiliated with the opposition parties (39%; p= 0.050), those who did not believe in COVID-19 vaccine effectiveness for Bangladeshi (67%; p= <0.001), and those who had no knowledge on vaccine developers (43.7%; p= 0.001) (**Table 1**).

Furthermore, participants who were not likely to believe that they or a family member could be infected with COVID-19 in the next year (61%; p= <0.001) and those who were not concerned at all about themselves or a family member getting infected in the next year (57%; p= <0.001) had the highest rates of COVID-19 vaccine hesitancy.

Multiple logistic regression analysis

Table 2 presents the predictors of COVID-19 vaccine hesitancy. A multiple regression analysis was conducted to examine predictors of COVID-19 vaccine hesitancy by including factors significantly associated with vaccine hesitancy in the descriptive analysis. In this multiple regression model, groups with significantly higher odds of vaccine hesitancy were found to be transgender individuals (AOR= 3.62, 95% CI= 1.177–11.251), married persons (AOR=1.49, CI= 1.047–2.106), tobacco users (AOR=1.33, CI= 1.018–1.745), participants who had not experienced physical illnesses in the past year (AOR=1.49, CI= 1.134–1.949), those with political affiliations with opposition parties (AOR= 1.48, CI= 1.025–2.134), those who doubted the efficacy of COVID-19 vaccines for Bangladeshis (AOR= 3.20, CI= 2.079–4.925), and those

who were slightly concerned (AOR = 2.87, CI= 1.744–4.721) or not concerned at all (AOR = 7.45, CI= 4.768–11.643) about themselves or a family member getting infected with COVID-19 in the next year. Compared with participants who believed it was very likely that they or their family members could get infected with COVID-19 in the next one year, those who thought such an occurrence would not be likely (AOR = 1.88, CI= 1.109–3.172) had significantly higher odds of vaccine hesitancy. Nonetheless, women (AOR= 0.70, CI= 0.537–0.928), students (AOR = 0.60, CI= 0.379–0.966), and those who preferred to take the British (AOR= 0.48, CI= 0.324–0.725), Chinese (AOR=0.44, CI= 0.245-0.807), Russian (AOR= 0.42, CI= 0.222–0.825) or Indian (AOR= 0.33, 0.143–0.774) vaccine had statistically significantly lower odds of vaccine hesitancy.

DISCUSSION

In the current comprehensive national study, more than one-third of the participants (32.5%) reported vaccine hesitancy. Analysis of daily data suggested that vaccine hesitancy varied from 18% to 72% in Bangladesh. To the best of our knowledge, this is the first study to measure COVID-19 vaccine hesitancy in Bangladesh using the previously used COVID-19 vaccine hesitancy questionnaire; thus, little is known about the previous hesitancy rate. However, a global survey from June 2020 suggested that more than 80% of participants from China, Korea, and Singapore were very or somewhat likely to receive the COVID-19 vaccine [15]. Another study conducted in September 2020 in Japan found that 65% of participants were willing to receive the COVID-19 vaccine [24]. However, a January 2021 survey in India suggested that 60% of polled Indians showed hesitancy toward receiving COVID-19 vaccines [25].

In the current study, we found a higher vaccine hesitancy among male, older, married, and transgender participants. In the final model, women showed significantly lower odds of vaccine hesitancy. In agreement with our findings, a global study observed lower odds of vaccine willingness among male participants [15]; however, women in Japan demonstrated very high vaccine hesitancy compared with men [24]. American women also showed lower willingness toward the COVID-19 vaccine [26]. Nonetheless, an early study suggested that Bangladeshi women's better knowledge, attitude, and preventive practice toward COVID-19 could be the reasons for a lower rate of vaccine hesitancy among them [27]. Furthermore, we found statistically significant higher odds of vaccine hesitancy among the transgender population. Previous research suggested that vaccine hesitancy is universally higher among gender minorities due to limited access and interaction with healthcare professionals, historical, biomedical, and healthcare-related mistrust, cost-related concerns, lack of belief in the scientific enterprise of medicine and public health, lack of awareness, and education [28]. An additional regional study is required to determine the gender-based difference in vaccine hesitancy.

Unlike other studies, we found higher vaccine hesitancy among older people than younger individuals. This difference could also be explained by an earlier study that showed a lack of COVID-19-related knowledge among the older population of Bangladesh [27]. Socio-cultural and religious beliefs related to preexisting vaccine hesitancy among the older population could also cause higher vaccine hesitancy among the Bangladeshis. Additionally, results regarding the married population are incorporated with age; therefore, results need to be interpreted by considering marital status and age together.

Unemployment, an education level lower than or equal to high school, and a monthly household income of less than 15,000 BDT were associated with a higher likelihood of COVID-19 vaccine

hesitancy in Bangladesh. In line with our findings, a global study also suggested that participants with lower education and income were less likely to get the COVID-19 vaccine [15]. Moreover, participants who were unemployed and those with a low level of education in the USA and Saudi Arabia showed higher vaccine hesitancy [26,29]. Contrastingly, other studies found that unemployed participants were more likely to accept the COVID-19 vaccine as in some regions, unemployed individuals may want to return to work, which could only be facilitated after vaccination [21,30].

A unique finding of this study was that a high portion of tobacco users showed hesitancy to receive the COVID-19 vaccine. This high rate may be explained with the reason that, universally, tobacco users (including smokers) tend to have unhealthy life practices. Nonetheless, a systematic review and meta-analysis concluded that current and previous smoking habit is associated with severe COVID-19 outcomes [31]. Another systematic review suggested that tobacco use was significantly associated with a higher rate of mortality among COVID-19 patients [32]. So far, there have been discussions on vaccine prioritization (e.g., for front liners). However, little vaccination planning has been done for the most vulnerable populations who continue to remain susceptible to COVID-19 outcomes (i.e., a greater number of deaths and severe infections). Our findings would help identify these subgroups. In contrast, we found high odds among those who did not have physical illnesses throughout the last year. However, existing evidence suggests that healthier individuals can also be infected by COVID-19 and that the outcomes are unpredictable. Therefore, policymakers should target these subgroups when planning vaccine literacy for potential vaccine recipients.

Interestingly, we found statistically significantly higher vaccine hesitancy among politically affiliated (either affiliated with the ruling parties or oppositions) participants than those who

described themselves as neutral. However, regression analysis suggested that those affiliated with opposition parties had higher odds. Additionally, a systematic review and meta-analysis found that vaccine hesitancy in LMICs collated with a range of trust-based relationships, such as trust in healthcare professionals, the health system, the government, and friends and family members [33].

The effectiveness of vaccines in general, varies between races and countries [34]. However, no human clinical trial of any COVID-19 vaccine has been conducted in Bangladesh. In our study, participants were asked whether they believed in the efficacy of the vaccines for Bangladeshis. Those who answered "no" and remained "skeptical" showed a higher rate of vaccine hesitancy. However, this finding is similar to the findings of a study conducted in another country [35]. Finally, our study revealed high odds of hesitancy among those who were not concerned about being infected by COVID-19. In support of our findings, a systematic review confirmed that people's perceived risk of infection is one of the strongest predictors of pandemic vaccine acceptance or hesitancy [36].

In our study, participants were asked about their vaccine choice. Evidence suggested that the efficacy of different vaccines from various developers was not matched [37]. For example, vaccines from the American companies, Moderna and Pfizer, and Russian company Gamaleya have the highest efficacy (i.e., > 90%). A British vaccine, Oxford-AstraZeneca, has moderate efficacy (76%). A vaccine from the Chinese company Sinovac has shown lower efficacy (51%). Furthermore, a study has shown that some vaccines (e.g., Oxford-AstraZeneca) produce severe adverse effects, such as very rare blood clots and even fatalities [38]. Consequently, some countries, such as Denmark, have stopped using the Oxford-AstraZeneca vaccine. Our study found statistically significant differences in vaccine hesitancy between the vaccine preference

subgroups. This finding highlights the need to further study whether freedom in vaccine choice among the population could reduce vaccine hesitancy in Bangladesh.

Risk perception is central to many health behavior theories. A systematic review and meta-analysis concluded that vaccination behavior is significantly predicted by likelihood of risk, susceptibility, and severity of the disease [39]. In the case of COVID-19, a study suggested that higher risk perception was associated with reduced vaccine hesitancy [40]. Furthermore, another study revealed that reduced risk perception was associated with reduced COVID-19 vaccine willingness [41]. Contrastingly, a particular study suggested that the safety of the COVID-19 vaccine outweighs disease risk perception when predicting vaccine hesitancy [42]. In our study, we found that perceived COVID-19 threat was strongly associated with vaccine hesitancy. However, our study found significantly high fluctuation rate in day-to-day vaccine hesitancy among Bangladeshi general population. Negative news on social and traditional media regarding adverse effects of vaccination during vaccine roll out in Bangladesh or neighboring countries like India and changes in the local pandemic situation might be the potential causes of this fluctuation. Further study is required to find the details to implicate the results.

Several limitations may have influenced our results. First, this study is a cross-sectional study that portrays the community response at the climacteric of the study. Nonetheless, studies have found that vaccine hesitancy is complex in disposition and is adherence-specific, varying over time, location, and perceived behavioral nature of the community [36,43,44]. Second, the influence of social and traditional media influence is major predictor of pandemic vaccine hesitancy or acceptance [45]. In our study, we did not examine the impact of the media, thus potentially confounding the results. Additional research is warranted to address this issue. Third, as the refusal rate to participate in this study was higher among women, we had slightly higher

number of male participants in the study sample. Finally, the face-to-face interview format may have led to social desirability bias, so more anonymous methods should be employed in further studies. Additionally, participants were asked about their willingness to get a vaccine that prevents infection, however, for many vaccines, the shot actually lessened the severity of the disease. This might have slightly influenced the study results. Despite these limitations, our study provided baseline evidence regarding COVID-19 vaccine hesitancy among LMICs. Furthermore, our study identified many subgroups of the general population that must be considered during vaccine hesitancy discussions. Finally, data collected by interviewing randomly selected participants from the north, south, and central zone of Bangladesh, including Dhaka, would have given a better representation of the population in the sample, thus increasing the generalizability of the study.

Conclusion

The current study found differences in COVID-19 vaccine hesitancy based on the sociodemographic characteristics, health, and behavior of the Bangladeshi general population. Various contributing factors for vaccine hesitancy, such as preexisting indecisiveness, cultural and religious views, lack of belief in the scientific enterprise of medicine and public health, especially among the older population, and lower levels of awareness, were identified. Further research is warranted to comprehend the complicated interplay of various individual and social characteristics influencing vaccine hesitancy. To ensure the extensive coverage of COVID-19 vaccines, the government, public health officials, and advocates must be prepared to address vaccine hesitancy to reach their target and build vaccine literacy among potential recipients. Evidence-based educational and policy-level interventions must be implemented to address these problems and promote COVID-19 immunization programs. The rates of willingness are subject

to change with the suitability of vaccines, but the frequent and ambivalent effects of vaccines may further reduce those rates. The uptake of COVID-19 vaccines can be increased once the factors identified in this study are properly addressed, and the long-term positive effects of the vaccines are clarified to the general population.

Acknowledgments

Both authors are thankful to the participants for providing the information used to conduct the study.

Competing interests

The authors declare that they have no competing interests.

Funding statement

This research received no specific grant from any funding agency in public, commercial or not-for-profit sectors.

Data sharing statement

Data will be available from the corresponding author upon reasonable request.

Author contributions

MA participated in study conception, design, and coordination of the manuscript. MA also performed the statistical analysis and drafted the manuscript. AH reviewed the manuscript and helped to draft it. Both the authors approved the final manuscript.

Ethical consideration

Formal ethical approval was received from the Ethical Review Committee (ERC) of Uttara Adhunik Medical College and Hospital. Prospective observational trial registration was obtained from the World Health Organization (WHO) endorsed Clinical Trial Registry-India: CTRI/2021/01/030546. Furthermore, we conducted the study strictly following the STROBE guideline. All the invited participants were required to provide informed consent for participation, collection, and analysis of their data.

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Table 1 Descriptive analysis: Sociodemographic characteristics, COVID-19 threat, and vaccine hesitancy

Variables	Total Sample n (%)	Likelihood of getting COVID-19 Vaccine		p-value
		Not likely/definitely not n (%)	Very likely/somewhat-likely n (%)	
All participants	1134 (100%)	369 (32.5)	765 (67.5)	-
Gender				**0.003**
Transgender	14 (1.2)	9 (64.3)	5 (35.7)	
Female	449 (39.6)	127 (28.3)	322 (71.7)	
Male	671 (59.2)	233 (34.7)	438 (65.3)	
Age group				**0.009**
18-25	442 (39.0)	122 (27.6)	320 (72.4)	
26-40	461 (40.7)	174 (37.7)	287 (62.3)	
41-60	200 (17.6)	61 (30.5)	139 (69.5)	
≥ 61	31 (2.7)	12 (38.7)	19 (61.3)	
Religion				0.442
Muslim	1057 (93.2)	349 (33.0)	708 (67.0)	
Hindu	61 (5.4)	16 (26.2)	45 (73.8)	
Cristian and Buddhist	16 (1.4)	4 (25.0)	12 (75.0)	
Marital status				**0.039**
Unmarried	495 (43.6)	141 (28.5)	353 (71.5)	
Married	598 (52.7)	214 (35.8)	384 (64.2)	
Divorce/Widow	42 (3.7)	14 (33.3)	28 (66.7)	
Children at home				0.950
No	481 (42.4)	157 (32.6)	324 (67.4)	
Yes	653 (57.6)	212 (32.5)	441 (67.5)	
Aged people at home				0.224
No	396 (34.9)	138 (34.8)	258 (65.2)	
Yes	738 (65.1)	231 (31.3)	507 (68.7)	
Education				0.268
≤ High school	264 (23.3)	98 (37.1)	166 (62.9)	
College education	309 (27.2)	92 (29.8)	217 (70.2)	
Bachelor's degree	356 (31.4)	111 (31.2)	245 (68.8)	
≥ Master's degree	205 (18.1)	68 (33.2)	137 (66.8)	
Employment status				**0.013**
Full-time employee	326 (28.7)	109 (33.4)	217 (66.6)	
Part-time employee	73 (6.4)	23 (31.5)	50 (68.5)	
Business	169 (14.9)	66 (39.1)	103 (60.9)	
Unemployed	88 (7.8)	35 (39.8)	53 (60.2)	
Home maker	171 (15.1)	60 (35.1)	111 (64.9)	
Student	307 (27.1)	76 (24.8)	231 (75.2)	
Monthly household income				**0.042**
<15,000	239 (21.1)	78 (32.6)	161 (67.4)	
15,000-30,000	386 (34.0)	108 (28.0)	278 (72.0)	
≥ 30,000	509 (44.9)	183 (36.0)	326 (64.0)	
Family type				0.205
Nuclear	715 (63.1)	223 (31.2)	492 (68.8)	
Joint	419 (36.9)	146 (34.8)	273 (65.2)	

Permanent address				0.533
Rural	637 (56.2)	216 (33.9)	421 (66.1)	
Urban	411 (36.2)	126 (30.7)	285 (69.3)	
Sub urban	86 (7.6)	27 (31.4)	59 (68.6)	
Current living location				**0.048**
Central zone	680 (60.0)	237 (34.9)	443 (65.1)	
North zone	237 (20.9)	62 (26.2)	175 (73.8)	
South zone	217 (19.1)	70 (32.3)	147 (67.7)	
Current Residence type				**0.042**
Rented	514 (45.3)	184 (35.8)	330 (64.2)	
Own	525 (46.3)	151 (28.8)	374 (71.2)	
Hostel/Mess	95 (8.4)	34 (35.8)	61 (64.2)	
Regular religious practice				0.064
No	328 (28.9)	120 (36.6)	208 (63.4)	
Yes	806 (71.1)	249 (30.9)	557 (69.1)	
Present tobacco user				**0.037**
No	796 (70.2)	244 (30.7)	552 (69.3)	
Yes	338 (29.8)	125 (37.0)	213 (63.0)	
Did you face physical illness in the last year				**0.006**
No	650 (57.3)	233 (35.8)	417 (64.2)	
Yes	484 (42.7)	136 (28.1)	348 (71.9)	
Having a chronic condition				0.943
No	859 (75.7)	280 (32.6)	579 (67.4)	
Yes	275 (24.3)	89 (32.4)	186 (67.6)	
Political affiliation				**0.050**
Ruling party	340 (30.0)	119 (35.0)	221 (65.0)	
Opposition	153 (13.5)	59 (38.6)	94 (61.4)	
Neutral	641 (56.5)	191 (29.8)	450 (70.2)	
Do you think the COVID-19 vaccine will be effective among Bangladeshis				**<0.001**
No	108 (9.5)	72 (66.7)	36 (33.3)	
Yes	367 (32.4)	43 (11.7)	324 (88.3)	
Skeptical	659 (58.1)	254 (38.5)	405 (61.5)	
Which developers' vaccine would you prefer				**0.001**
American	435 (38.4)	160 (36.8)	275 (63.2)	
British	372 (32.8)	102 (27.4)	270 (72.6)	
Chinese	82 (7.2)	21 (25.6)	61 (74.4)	
Russian	64 (5.6)	16 (25.0)	48 (75.0)	
Indian	39 (3.4)	8 (20.5)	31 (79.5)	
Others/no idea	142 (12.5)	62 (43.7)	80 (56.3)	
Perceived likelihood of getting infected in the next 1 year				**<0.001**
Very likely	388 (34.2)	141 (36.3)	247 (63.7)	
Somewhat likely	608 (53.6)	146 (24.0)	462 (76.0)	
Not likely	83 (7.3)	51 (61.4)	32 (38.6)	
Definitely not	55 (4.9)	31 (56.4)	24 (43.6)	
Level of concern about getting infected in the next 1 year				**<0.001**
Very concerned	226 (19.9)	30 (13.3)	196 (86.7)	
Concerned	290 (25.6)	53 (18.3)	237 (81.7)	
Slightly concerned	235 (20.7)	69 (29.4)	166 (70.6)	
Not concerned at all	383 (33.8)	217 (56.7)	166 (43.3)	

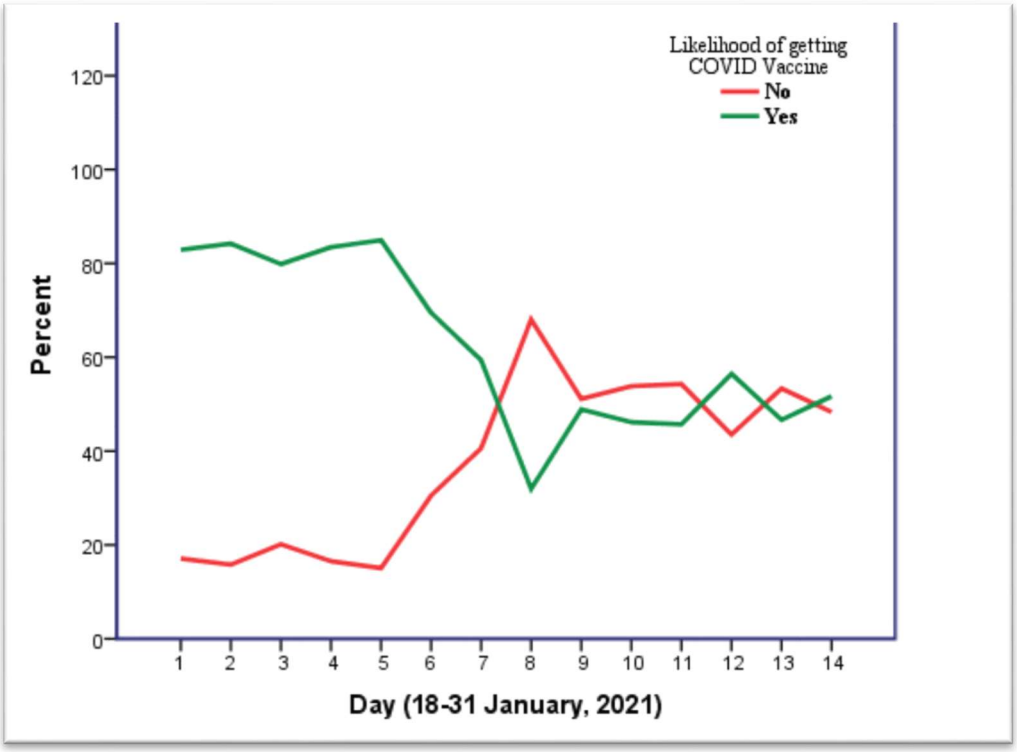
Table 2 Multiple logistic regression: Predictors of vaccine hesitancy in study participants

Variables	Adjusted Odds Ratio	Standard Error	Confidence Interval	p-value
Gender				
Transgender	3.639	0.576	1.177-11.251	**0.025**
Female	0.706	0.139	0.537-0.928	**0.013**
Male	Reference			
Age group				
18-25	Reference			
26-40	1.208	0.179	0.851-1.715	0.290
41-60	0.808	0.238	0.508-1.285	0.368
≥ 61	1.053	0.434	0.450-2.465	0.905
Marital status				
Unmarried	Reference			
Married	1.485	0.175	1.047-2.106	**0.027**
Divorce/Widow	1.606	0.394	0.742-3.44	0.229
Employment Status				
Full-time employee	1.006	0.217	0.657-1.539	0.979
Part-time employee	0.914	0.315	0.439-1.693	0.775
Business	1.230	0.227	0.788-1.921	0.362
Unemployed	1.311	0.284	0.751-2.286	0.341
Student	0.606	0.238	0.379-0.966	**0.035**
Home maker	Reference			
Monthly household income				
<15,000	Reference			
15,000-30,000	0.790	0.185	0.550-1.136	0.203
≥ 30,000	1.181	0.185	0.822-1.696	0.368
Current living location				
Central zone	1.105	0.169	0.793-1.540	0.554
North zone	0.762	0.209	0.506-1.147	0.192
South zone	Reference			
Current Residence type				
Rented	0.962	0.235	0.607-1.527	0.871
Own	0.761	0.241	0.475-1.221	0.258
Hostel/Mess	Reference			
Tobacco user				
No	Reference			
Yes	1.333	0.138	1.018-1.745	**0.037**
Did you face physical illness in the last year				
No	1.486	0.138	1.134-1.949	**0.004**
Yes	Reference			
Political affiliation				
Ruling party	1.269	0.143	0.959-1.678	0.096
Opposition	1.479	0.187	1.025-2.134	**0.037**
Neutral	Reference			
Do you think the COVID-19 vaccine will be effective among Bangladeshis				

No	3.199	0.220	2.079-4.925	**<0.001**
Yes	0.212	0.182	0.149-0.303	**<0.001**
Skeptical	Reference			
Which developers' vaccine would you prefer				
American	0.744	0.197	0.506-1.094	0.133
British	0.484	0.205	0.324-0.725	**<0.001**
Chinese	0.444	0.304	0.245-0.807	**0.008**
Russian	0.428	0.335	0.222-0.825	**0.011**
Indian	0.332	0.431	0.143-0.774	**0.011**
No idea	Reference			
Perceived likelihood of getting infected in the next 1 year				
Very likely	Reference			
Somewhat likely	0.645	0.161	0.471-0.884	**0.006**
Not likely	1.875	0.268	1.109-3.172	**0.019**
Definitely not	1.099	0.307	0.602-2.007	0.758
Level of concern about getting infected in the next 1 year				
Very concerned	Reference			
Concerned	1.609	0.255	0.977-2.649	0.062
Slightly concerned	2.869	0.254	1.744-4.721	**<0.001**
Not concerned at all	7.450	0.228	4.768-11.643	**<0.001**

Figure legend:

Figure 1 Day-to-day fluctuation of COVID-19 vaccine wiliness or hesitancy among participants



STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*N/A*
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N/A
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	N/A
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.