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## Factors influencing COVID-19 vaccine acceptance and hesitancy among rural community in Bangladesh: A cross-sectional survey based study

Debendra Nath Roy <sup>a,b</sup>, Md. Nazmul Huda<sup>c</sup>, and Md. Shah Azam <sup>d,e</sup>

<sup>a</sup>Department of Pharmacy, Jashore University of Science and Technology, Jashore, Bangladesh; <sup>b</sup>Institute of Education and Research, University of Rajshahi, Rajshahi, Bangladesh; <sup>c</sup>Modina Private Hospital and Clinic, Rajbari, Bangladesh; <sup>d</sup>Department of Marketing, University of Rajshahi, Rajshahi, Bangladesh; <sup>e</sup>Office of the Vice Chancellor, Rabindra University, Bangladesh

### ABSTRACT

Although more than one hundred million beneficiaries were administered COVID-19 vaccine until 20th February, 2022 in Bangladesh; however, proportionally a low turnout has been recorded in rural places and a substantial gap exist among the people living in rural and urban areas concerning the ratio of receiving vaccine. This study aims to investigate COVID-19 vaccine acceptance intention and to identify the potential factors influencing vaccine acceptance and hesitancy among the rural community in Bangladesh. A bilingual, self-administered anonymous questionnaire was developed, and data were collected between 10th June 2021 and 14th August 2021 through face-to-face interview. 655 rural people participated in this cross-sectional study, and sampling was done randomly. Descriptive statistics and binary logistic regressions were used to explore and rationalize study objectives. Out of 655 rural participants, 552 (84.3%, 95% CI 81.2–86.8) responded to accept COVID-19 vaccine; however, minor fractions ( $n = 5$ ,  $n\% = 0.8$ , 95% CI 0.12–1.4) of rural community had willingness to pay (WTP) for a COVID-19 vaccine. The result of binary regression showed that “safety,” “side effects,” “effectiveness,” and “trust” had highly significant ( $p < .01$ ) and positive correlation with vaccine acceptance intention. “Rumor” had moderately significant ( $p < .05$ ) and negative association while “gender” had insignificant correlation with vaccine acceptance intention. Easy and constant access to evidence-based and trustworthy information on vaccination consequences is imperative for resource-less remote people. Health communication regarding safety, side effect, and effectiveness of vaccines were identified as the most important predictor to convert vaccines to vaccinations and for ensuring mass immunization against COVID-19 in Bangladesh.

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### Introduction

The corona virus disease 2019 (COVID-19) affected community people from all walks of life and imposed a heavy disease burden around the world. The treatment protocol is facing challenges because still there is lacking of precise antiviral therapy for COVID-19.<sup>1</sup> Since vaccination is the most effective and fundamental therapeutic tool to eradicate contagious pandemic virus,<sup>2</sup> like many other countries in the world, Bangladesh has moved forward with its vaccination policies and mass inoculation programs. The government of Bangladesh has launched the biggest-ever mass vaccination program to vaccinate 80% (over 130 million) of the country's total population with the vaccines in four different phases.<sup>3</sup> To achieve country-wide massive vaccination programs, the regulatory authority Directorate General of Drug Administration (DGDA) has given approval of seven vaccine candidates to use for Bangladeshi people, and Moderna COVID-19 vaccine was the latest candidate included in this platform for emergency use in the country.<sup>4</sup> Initially, the government published a priority list and decided to provide vaccines to different frontline workers and people at the age of over 55 years in the first phase. Due to the lower population enrollment in vaccination

program, the policymakers decided to drop down the age limit to 40 years and since then, the percentage of people taking vaccination has increased in the country quite sharply. In continuation of its performance in grappling with the worst pandemic situation of the century, the government has shown its credibility in demonstrating the essences of vaccination to protect citizens from further infections and associated complications from the corona virus.

Meanwhile, it has been learned from numerous media outlets that percentage of people receiving vaccines is high in cities and a substantial gap still exists among the people living in rural, semi-urban, and urban areas concerning the ration of receiving vaccines. Bangladesh is a highly dense populated country<sup>5</sup> and in fact most of the peoples living in rural areas and many on the street of cities do not have adequate access to information about COVID-19 vaccinations. On the other hand, ensuring of extensive and nation-wide vaccination coverage could remarkably reduce the severity of symptoms and infection rate through controlling the syndrome,<sup>6</sup> thereby contributing in higher standards of public health, lowering morbidity and mortality rates in community.<sup>7</sup> Taken all together, Bangladesh government set to launch a massive COVID-19

vaccination drive through in-spot registration among the rural community in unions and wards for the people of 30 years of age and above under the mass immunization programs. The government planned to cover 10 million people in a week mainly focused on the community who are living at union and wards levels. Consequently, walk-in vaccination at centers in unions and wards started from 7 August, 2021 to ensure the pooled coverage of the remote people as a pilot project.<sup>8,9</sup> To accomplish successful implementation of a mass vaccination drive in the union and ward levels, it is important to examine the prospective challenges in the process because response to a vaccine can be understood as a continuum ranging from outright refusal to active demand for immediate acceptance.<sup>10</sup> In this aspect, several studies indicated that vaccine hesitancy; low acceptance intention and refusal decision would be the biggest challenges in Low and Middle Income Countries (LMICs)<sup>11</sup> and even also in developed countries.<sup>12</sup>

Reportedly, hesitancy or refusal of a vaccine refers to the unwillingness to uptake it, when the service is available to deliver a particular vaccine.<sup>13</sup> It is worth mentioning that hesitation in getting a vaccine lead to a massive outbreak of disease previously,<sup>14</sup> since vaccine always remains a dilemma among a large group of people.<sup>15</sup> Vaccine hesitancy has been identified as one of the top ten threats for global health<sup>16</sup> and vaccine hesitancy is considered as a social phenomenon and it appears as a therapeutic crisis among the hesitant people worldwide. Acceptance rate of a particular vaccine varied among the different countries and vaccine hesitancy intensely relays on the psychological behavior of acceptors, individual's and social characteristics and vaccine-related factors.<sup>17</sup>

Arce JS et al. 2021<sup>18</sup> conducted a cross-sectional study on 45,928 peoples in LMICs of Asia, Africa, and South American countries showed that COVID-19 vaccine hesitancy was 20% and 40%, respectively. The author also indicated that side effects and effectiveness were the potential factors for a people considered to be vaccinated.<sup>18</sup> In India, among 358 participants in first phase of vaccination 30% was hesitant while 8%, 29%, and 44% peoples were concerned on safety, adequate information, and side effect issues, respectively.<sup>19</sup> Similarly, a global survey shown that among the 6639 respondents, 22.5% were hesitant on vaccine of which 50.37% mentioned about side effect, as a major determinant of their vaccination decisions.<sup>20</sup> Whilst to date, several factors have been identified which are potentially associated with COVID-19 vaccine acceptance and hesitancy reported in both of Asian countries and global perspectives included safety and efficacy,<sup>21–23</sup> vaccine effectiveness,<sup>24</sup> fear and anxiety,<sup>21</sup> information sufficiency,<sup>25</sup> anti-vaccine beliefs<sup>26,27</sup> and communication.<sup>28</sup> Hossain et al., 2021<sup>29</sup> conducted a cross-sectional study on Bangladeshi adult peoples, he found that 41.1% was COVID-19 vaccine hesitant. The author reported that vaccine efficacy, side effects, and perceived anti-vaccination beliefs were the major considerations in the COVID-19 vaccine acceptance intention.<sup>29</sup>

Bangladesh, likewise other countries around the world, is undertaking to fight against COVID-19 pandemic. For ensuring country-wide COVID-19 vaccination, the government of Bangladesh made an agreement<sup>30</sup> with a leading pharmaceuticals of the country, Beximco Pharmaceutical Limited requesting to purchase COVID-19 vaccine from the Serum Institute of

India, the world's largest vaccine manufacturer licensed from AstraZeneca to manufacture "COVISHIELD" vaccine for supplying to low- to middle-income countries (LMICs).<sup>31</sup> However, besides Serum Institute Bangladesh government completed additional purchase agreement with some other vaccine manufacturers across the world target to vaccinate at least 80% of the total population.

Mass vaccinations including rural people against COVID-19 have emerged as a key preventive strategy because the second wave of pandemic has triggered a massive humanitarian crisis with unprecedented numbers of hospitalization and deaths in Bangladesh. As the mass inoculation program in ward and union level in Bangladesh was making its way on 7 August, tensions raised among rural people regarding the vaccine. Along with vaccine deployment and distribution policies, adequate research attention should be paid to understand the complex interplay of a variety of individual's psychological and social aspects and the vaccine itself influences acceptance and hesitancy to ensure crude coverage with COVID-19 vaccines.<sup>32</sup> To the best of knowledge till date, there was no exploratory study<sup>33,34</sup> had been investigated on key influential factors of COVID-19 vaccine acceptances intention and hesitancy among the rural community in Bangladesh. Since the COVID-19 vaccine roll out in union and ward level was inaugurated through implementing a pilot project on 7 August, 2021 in Bangladesh, it became very relevant to assess the vaccine acceptance intention and to identify the actual antecedents influencing COVID-19 mass vaccination among the rural community. Therefore, the objectives of the current study were to investigate COVID-19 vaccine acceptance intention and to identify the major factors influencing the COVID-19 vaccine acceptance and hesitancy among the rural community in Bangladesh.

## Methods

### Study and questionnaire design

A validated and anonymous semi-structured multi-items questionnaire was adopted by reviewing evidence from recent studies on COVID-19 vaccination published in LMICs and global perspectives.<sup>18–29</sup> The questionnaire was originally developed in English language and then translated by the expert to native language (Bengali) because translating into native language was considered as a key task in capturing the respondent's perception in a survey-based study. The items in the preliminary questionnaire were validated by a panel of public health experts from reputed universities in Bangladesh to ensure the relevance and clarity of the questionnaires. The first part of questionnaire contains the demographic information where the participants were asked about age, gender, occupation, educational level, religion etc, while the later part of the questionnaire comprised of predictor construct of COVID-19 vaccine acceptance.

### Respondents

We carried out this cross-sectional study by applying self-administered anonymous questionnaire to those who were capable to understand the questionnaires and fill it out. Face-to-face

interview approach was conducted for illiterate and semi-literate respondents. At first, we selected several upazila of Southeast part in Bangladesh for the data collection purpose and the data were collected randomly from selected wards and unions of Southeast areas of the country. The areas were selected based on the convenience of data collection. According to the latest census of 2020, out of a population over 160 million in Bangladesh, approximately 66.88% were residing in rural places, of them, at least 46.72% was women and girls. Although the adult literacy rate in rural areas stood at 65.4%; however, 58% of urban and 40% of rural males above 60 years of age are literate, while the rate is only 24% among urban and 12% among rural females over 60.

The eligibility criteria for the participants were: (i) to sign a consent form agreeing to the study objectives and provide anonymous data on COVID-19 vaccine and vaccination, (ii) residence of union or ward level of those selected areas and (iii) age of 18 years and above.

### Sample and data collection

Due to the prevalence of COVID-19 pandemic, we ensured compliance with community health measures such as wearing face mask and maintaining social distancing strictly. The study conducted among the cohort of rural community people and data were collected from 10 June 2021 to 14 August, 2021 when massive vaccination among rural community was yet to be started. Random sampling technique was used for 655 respondents by interviewing face-to-face approach. Since the binary logistic regression is used, it is evident that, for observational studies with large sample size, taking a minimum sample size of 500 is necessary to derive the binary logistic regression statistics that represent the parameters. The other recommended rules of thumb are event per variable (EPV) of 50 and the formula;  $n = 100 + 50i$ , where  $i$  indicates number of independent variables incorporated to in the final model.<sup>35</sup> To avoid the potential source of non-response bias, the questionnaire was distributed among rural people of the country and encourages them to participate in this study. There was no missing data in final data set used for descriptive statistics and logistic regression analysis.

### Study tools and survey instruments

The questionnaire included sections on socio-demographic characteristics; willingness to accept a COVID-19 vaccine, probable factors associated with vaccine uptake intention, important attributes of rural people toward a COVID-19 vaccine and participant's willingness to pay for a vaccine. The revised questionnaire was subsequently pre-tested on 20 participants from rural community; who, later were excluded from the final analysis. Binary logistic regression tools were used to analyze the correlations and, significance level between predictor variables and outcome variable was examined at 95% CI.

### Study variables

The study had two objectives. The first objective was to assess the COVID-19 vaccine acceptance intention among the rural people and the second objective was to identify the key factors

influencing their vaccine acceptance intention and hesitancy. To address the first objective, the response variable of study we measured as willingness to uptake a new vaccine and the responses were measured as a binary variable (1=Yes, 0=No). The socio-demographic characteristic and other categorical variables such as age, profession, monthly income, educational level, gender, marital status, religion, existence of co-morbidity and COVID-19 experiences of the respondents was also captured. For the second objective, we examined the impact of some psychological, social, and vaccine-related factors on the outcome of variable dichotomized into 1=Yes and 0=No. Additionally, important attributes of rural people toward a COVID-19 vaccine and vaccination were also measured by 1=Yes and 0=No. Willingness to pay (WTP) for a vaccine was measured using one item statement (I am willing to pay for a COVID-19 vaccine) and the responses were measured by 1=Yes and 0=No.

### Equations for regression model

The general form of logistic regression is as follows:

$$y = \text{Constant}(B) + b_1x_1 + b_2x_2 + b_3x_3 + \dots + b_mx_m \quad (1)$$

where  $y$  is the linear combination function while defined as Equation (1) and its value varies from  $-\infty$  to  $+\infty$ ,  $x_1, x_2, \dots, x_m$  are explanatory variables and the parameters  $b_1, b_2, \dots, b_m$  are slope coefficient of the logistic regression model. The dependent variable ( $z$ ) is denoted as a binary response variable, (0 or 1). If  $z$  is value 1 ( $z = 1$ ) means the presence of vaccine uptake intention, and value 0 ( $z = 0$ ) indicates the reservation of vaccination. The computational algorithms are as follows:

$$P = P(z = 1) = Bx/[1 + \exp(Bx)] \quad (2)$$

Here,  $P$  is referred as the probability of vaccine uptake intention,  $x$ =vector of explanatory variables and  $B$  represents the regression coefficient to be estimated. Function of  $y$  is represented as logit ( $p$ ), i.e., the log (to base  $e$ ) of the odds or likelihood ratio that the dependent variable  $z$  is 1.

$$y = \log_e [P/1 - P] = \text{logit}(P) \quad (3)$$

$$P = e^y/(1 + e^{-y}) \quad (4)$$

Usually Equations (2) and (3) are written as logit ( $P$ ) or the log odd ratio as follows:

$$\text{logit}(P) = \log_e [P/1 - P] = Bx \quad (5)$$

$B$  reflects the degree of influence of predictor variables on the vaccine uptake intention.

### Data analysis

Descriptive statistics expressed as weighted frequencies and percentages was performed on the categorical and socio-demographic characteristics of the respondents. We had no missing data in the extracted data set that we performed analysis for descriptive statistics and logistic regression. A non-parametric data analysis tool (binary logistic regression) was applied to find out the key predictive factors of COVID-19

vaccine acceptance and hesitancy. Model summary was evaluated by Nagelkerke  $R^2$  value and goodness-of-fit for binary model was assessed by using Omnibus Tests of Model Coefficients and Hosmer and Lemeshow tests.<sup>36</sup> Microsoft excel (version 10) was used for accounting the sample from technical data sheet and imported the data set to the SPSS accordingly. The entire analysis was conducted by using the IBM SPSS statistical package (version 25). The minimum significance level ( $p$  value) was set at the value of 0.05.

## Results

### Respondents' characteristics

Table 1 displays the socio-demographic characteristics of the study populations. A total of 655 eligible respondents participated in this study. We examined for eligibility and confirmed the eligible participants by using the previously set standard. 369 (56.3%) male and 286 (43.7%) female participated in the study. The minimum age was 18 years and maximum was 75 years while mean age was 35.13 years. As a result, majority of

the participants 233 (35.5%) were youth age ranges of 30–39 years. The minimum monthly income of the participants was 500 Bangladeshi Taka (BDT) and the maximum was 35,000 BDT. Although the mean income was calculated as 5802 BDT; however, the highest 418 (63.8%) participants had monthly income level of 0–5000 BDT. According to the latest data published from the Bangladesh Bureau of Statistics (BBS), out of population over 160 million in Bangladesh about 24% of population in Bangladesh is still illiterate and this study captured 13.6% of total respondents were illiterate. The highest count 162 (33.9%) of the rural community had elementary or primary education. In professional diversification, the majority 155 (23.7%) was reported as house keeper. Among the total participants, 537 (82.0%) was Muslim by religion and 523 (79.8%) was married. 578 (88.2%) respondents had no severe illness or co-morbidity and 82 (12.5%) reported COVID-19 infected previously. Most importantly, 552 (84.3%, 95% CI 81.2–86.8) of rural people responded to accept a COVID-19 vaccine any time.

### Descriptive statistics findings

The descriptive statistic of independent variables and the outcome variable is shown in Table 2.

Figure 1 presents the result of some important attributes toward COVID-19 vaccine and vaccination among rural people. Interestingly, the WTP for a COVID-19 vaccine is scored very low ( $n=5$ ,  $n\%=0.8$ , 95% CI 0.12–1.4) among the rural community in Bangladesh.

### Model summary

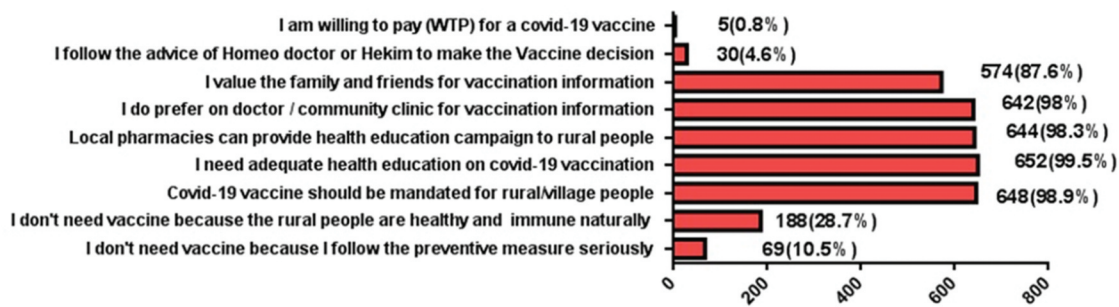
Table 3 discusses the model summary; in order to identify the key predictors associated with vaccine uptake intention, a binary logistic regression model was applied. The most common assessment of overall model fit in the logistic regression is the likelihood ratio test. The joint impact of independent variables on the dependent variable was determined by using Nagelkerke R Square test that explained the model summary.

**Table 1.** Respondents demography.

Variable	<i>f</i>	%
<b>Age</b>		
18–29 Years	193	29.5
30–39 Years	233	35.5
40–49 Years	129	19.7
50–59 Years	83	12.7
60+	17	2.6
<b>Monthly Income BDT</b>		
0-5000	418	63.8
5001– 10,000	150	22.9
10,001– 15,000	40	6.1
15,001– 20,000	36	5.5
20,001– 25,000	3	0.5
25,001– 30,000	4	0.6
30,001+	4	0.6
<b>Education</b>		
Illiterate	89	13.6
Primary education	162	24.6
Below SSC	82	12.5
SSC/Equivalent	91	13.9
HSC/Equivalent	79	12.1
Degree(Hon's)/Equivalent	65	9.9
<b>Profession</b>		
Vendors and small business	133	20.3
Service holder	110	16.8
House keeper	155	23.7
Day labor	99	15.1
Farmer	73	11.1
Student	49	7.5
<b>Religion</b>		
Muslim	537	82.0
Hindu	118	18.0
<b>Gender</b>		
Male	369	56.3
Female	286	43.7
<b>Marital status</b>		
Single	132	20.2
Married	523	79.8
<b>Experience of COVID positive</b>		
Not Infected	573	87.5
Having experience of Corona Infection	82	12.5
<b>Presence of co-morbidity</b>		
No	578	88.2
Yes	77	11.8
<b>Intention to receive vaccine</b>		
Reservation to accept vaccination	103	15.7
Accept Vaccination anytime	552	84.3

**Table 2.** Descriptive statistics of variables.

Variables	Mean	SD
I intend to accept vaccination anytime (Yes = 1, otherwise = 0)	0.84	0.364
I am confirm that the vaccination is safe (Yes = 1, otherwise = 0)	0.81	0.394
I think the Vaccination has no significant side effect (Yes = 1, otherwise = 0)	0.68	0.468
I believe the Vaccination has effectiveness to protect (Yes = 1, otherwise = 0)	0.85	0.358
I am well communicated about the vaccination (Yes = 1, otherwise = 0)	0.71	0.455
I felt constraints religiously to accept vaccination (Yes = 1, otherwise = 0)	0.09	0.282
I believe there remain a conspiracy against the vaccination (Yes = 1, otherwise = 0)	0.01	0.095
Have a trust on the vaccination (Yes = 1, otherwise = 0)	0.86	0.348
I received many negative communication about the vaccination (Yes = 1, otherwise = 0)	0.13	0.331
I am afraid of needles and pain from injections (Yes = 1, otherwise = 0)	0.06	0.24
I am satisfied by receiving any vaccine approved in Bangladesh (Yes = 1, otherwise = 0)	0.25	0.431
GENDER (Female = 1, otherwise = 0)	1.44	0.496



**Figure 1.** Important observations on COVID-19 vaccination were given by participants in percent (N = 655).

**Table 3.** Model summary.

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
163.047 <sup>a</sup>	.463	.796

**Table 4.** Omnibus tests of model coefficients.

	Chi-square	df	Sig.
Step	406.914	11	.000
Block	406.914	11	.000
Model	406.914	11	.000

**Table 5.** Hosmer and Lemeshow test.

Chi-square	df	Sig.
4.806	5	.440

The result of Cox and Snell  $R^2$  indicates that outcome variable was explained as 46%–80% by the independent variables in the predictive model which is assumed to be very good level.

### Goodness of model fit

In **Table 4**, the  $p$ -value of Omnibus Tests of Model Coefficients is significant, less than 0.05 which indicates a very good model fit.

According to the analysis of “**Table 5**”, the  $p$ -value is .440 which is insignificant in Hosmer and Lemeshow Test indicates a good model fit. Hence, our fitted logistic model is a good fit for testing of both assumptions.

### Binary logistic regression model

**Table 6** displays the result of correlation analysis of explanatory variables with the dependent variables in the binary regression analysis model. According to the result of regression analysis, the predictor variables “safety”, “side effects”, “effectiveness”, and “trust” had highly significant ( $p < .01$ ) and positive correlation with vaccine acceptance intention among the rural community. The result also revealed that “rumor” has moderately significant ( $p < .05$ ) and negative association with outcome variable while categorical variable “gender” had no significant correlation with the vaccine uptake intention.

**Tables 7** and **8** represent the value of chi-square test and odds ratio for categorical variable “gender”. According to the **Table 8**, male group was 1.2 times more responsive in receiving vaccine

**Table 6.** Logistic regression analysis.

Variables	B	S.E.	Wald	Sig.	Exp(B)	95% C.I. for EXP(B)	
						Lower	Upper
Safety	<b>2.616***</b>	.484	29.218	<b>.000</b>	13.684	5.299	35.335
Side effects	<b>2.833***</b>	.603	22.093	<b>.000</b>	17.004	5.217	55.421
Effectiveness	<b>1.546***</b>	.494	9.801	<b>.002</b>	4.690	1.782	12.344
Communication	-.241	.584	.170	.680	.786	.250	2.468
Religious beliefs	.313	.635	.243	.622	1.368	.394	4.747
Conspiracy beliefs	-1.164	1.369	.723	.395	.312	.021	4.572
Trust	<b>3.048***</b>	.560	29.647	<b>.000</b>	21.063	7.032	63.087
Rumor	<b>-1.306**</b>	.563	5.389	<b>.020</b>	.271	.090	.816
Vaccine choice	-.397	.489	.658	.417	.672	.258	1.754
Anxiety	-.965	.597	2.612	.106	.381	.118	1.228
Gender	.123	.454	.073	.786	1.131	.464	2.756
Constant	-3.530	.903	15.284	.000	.029		

\*\*\*= significant at  $<.01$ , \*\*= significant at  $<.05$ , \*.

which was found insignificant at Pearson chi-Square test result in **Table 7**. Hence, statistically no group was identified as a vaccine hesitant risky group in implementing mass vaccination.

### Discussion

The government of Bangladesh formally launched the COVID-19 vaccination programs since 7 February 2021 by administering Oxford/AstraZeneca vaccine and attempted to extend the immunization coverage country-wide. The average number of persons that have already been vaccinated is substantially different between urban and rural areas. As a result, to reinforce the country-wide mass vaccination programs, this cross-sectional survey aimed to examine the willingness to uptake the COVID-19 vaccine among the rural community and to investigate the factors that predict their willingness to be vaccinated with an approved vaccine in Bangladesh. According to the findings of our study, approximately 85% of the rural peoples had the COVID-19 vaccine uptake intention anytime while the remaining had the reservation. A cross-sectional online survey conducted across 9 LMICs included Bangladesh showed the prevalence of COVID-19 vaccine acceptance varied from 76.4% to 88.8%.<sup>11</sup> A similar study carried out among 10 LMICs showed that, more than 80% people in Asia, Africa, and South African regions had the willingness to accept a COVID-19 vaccine.<sup>37</sup> These findings are consistent with our study result.

Several factors modify vaccination decisions and determine whether an individual will refuse, delay, or accept a vaccine. Personal decision-making regarding vaccination is complex

**Table 7.** Chi-square tests result.

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.740 <sup>a</sup>	1	.390		
Continuity Correction <sup>b</sup>	.565	1	.452		
Likelihood Ratio	.744	1	.388		
Fisher's Exact Test				.449	.227
Linear-by-Linear Association	.739	1	.390		
N of Valid Cases	655				

**Table 8.** Risk group estimation.

	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for GENDER (Male/Female)	1.207	.786	1.853
For cohort INTENT = 0	1.172	.815	1.685
For cohort INTENT = 1	.971	.909	1.037
N of Valid Cases	655		

and influenced by psychological, emotional, societal, cultural, spiritual, and vaccine-related factors.<sup>38</sup> The binary regression model of this study demonstrated that “safety”, “side effect”, “effectiveness”, and “trust” has highly significant and positive correlation with the vaccine uptake intention among the rural people in Bangladesh. Perceived vaccine safety is highly determined by the magnitude of side effects and safety margin. Acceptance of a newly launched vaccine depends upon the level of individual’s trust regarding the vaccine safety, effectiveness, and adverse effect prevalence.<sup>39,40</sup> Safety issue regarding the COVID-19 vaccination was primary concern among 45% in Indian population,<sup>24</sup> 39.1% in Saudi Arabia,<sup>41</sup> 47.8% in China,<sup>42</sup> 46%<sup>43</sup> in Qatar and 25.5% in Bangladesh<sup>23</sup> reported from Asian countries while 60.4% found in Africa and Middle East.<sup>44</sup> In the same line, side effect was primary consideration to receive a COVID-19 vaccine identified 44.1% in India,<sup>19</sup> 79.45% in China,<sup>45</sup> 26.3% in Jordan<sup>46</sup> and 31.4% in Turkey<sup>47</sup> of Asian continents while 40% in LMICs of Asia, Africa, and South American countries.<sup>18</sup> Vaccine effectiveness was one of the key determinants that emphasized effectiveness of COVID-19 vaccine that might increase public intention to get vaccinated. Consequently, vaccine effectiveness has been recognized as an important factor to accept a COVID-19 vaccine among 53.8% people in India,<sup>24</sup> 49.9% in Saudi Arabia,<sup>41</sup> 16% in Qatar,<sup>43</sup> and 14.7% in Jordan<sup>46</sup> reported from in Asia while 14.1% in United States<sup>48</sup> and 15.1% in LMICs.<sup>11</sup> Trust in vaccine discovery, public health experts and domestic health systems as well as government actions are important drivers of vaccine acceptance globally. Arguably, trust is an intrinsic and potentially modifiable component of successful uptake of a COVID-19 vaccine. Our findings shown that trust in health actors was strongly associated with vaccine uptake intention and can contribute to public compliance in vaccination process. Therefore, trust has already been identified as one of the most critical antecedents for making a vaccination decision among 18.1% people in

Jordan<sup>46</sup> and 31.4% in Turkey<sup>47</sup> in Asian region, 65% in Portugal,<sup>39</sup> 33.5% in Slovenia<sup>49</sup> and 20.2% in Germany<sup>50</sup> while 28.5% reported in multi-ethnic areas.<sup>51</sup> For developing a sustainable vaccine confidence to public, rebuilding and restoring the public trust would act as a clarified response to accept a COVID-19 vaccine.<sup>52,53</sup> All these recent scientific evidences are supportive to our study findings.

Anti-vaccination rumors and propaganda potentially lead to mistrust contributing in vaccine hesitancy that could be reduced by providing adequate scientific information to remote people. Our study result demonstrated that rumor had moderately significant and negative association with COVID-19 vaccine uptake intention. Fake news and misinformation is important predictor that influenced the acceptance intention of COVID-19 vaccine in South Asia<sup>54</sup> and in Bangladeshi adult populations reported recently.<sup>23,29</sup> Since rumors negatively impacted COVID-19 vaccine uptake intention; therefore, our findings suggested that reducing the associated rumors and propaganda would increase the mass vaccination coverage to rural community.

In this study, religious beliefs and conspiracy beliefs had insignificant effect on receiving COVID-19 vaccination by the rural community in Bangladesh. Although Hossain et al., 2021<sup>29</sup> collected data in first week of February, 2021 and evident that the Muslim dwellers in city corporation areas were more hesitant toward vaccination however, we collected the data from rural areas at the period when country-wide mass vaccination has rolled-out and community people were connected with vaccine awareness programs. Public were conscious about COVID-19 vaccine origin data which largely contributed them to avoid rumors and anti-vaccine beliefs including religious and conspiracy beliefs.

Since a significant portion (28.7%) of them believed that they do not need the vaccine because rural people are healthy and acquire herd immune naturally, so the authority should declare mandate the vaccine for rural people, otherwise large portions of population may avoid vaccination uptake due to their self-beliefs regarding acquired immunity in rural people naturally. Therefore, in [Figure 1](#), almost all respondents (98.9%) opined that COVID-19 vaccine should be mandated for rural population.

Although the government offered COVID-19 vaccine with free of cost to their citizens in Bangladesh, however, the study result shows that only 0.5% of the rural people had WTP for a COVID-19 vaccine. The current study did not fix the price ranges and values for a single dose of vaccine rather the study aimed to assess their future willingness to pay for a vaccine. The WTP for a newly promoted vaccine was found very low among rural community in Bangladesh. Actually the monthly income of the rural community was insufficient and the inside decision to pay for a vaccine is typically correlated with household income. The acceptance and hesitancy toward a new vaccine depends on cost-related concerns<sup>32</sup> and significantly associated with different household income.<sup>55</sup> We collected data from large sample size to ensure external validity or representativeness of the study findings. More clearly, 655 respondents living in rural areas were participated in this study. The variation in the respondents demography and sample size provide much strength to anticipate the generalizability

of the study results in addressing the population and deliver health messaging to increase public interest on COVID-19 vaccination.

In Bangladesh, COVID-19 vaccination roll-out in union and ward level was inaugurated through implementing a pilot project on 7 August 2021. Hence, in advance, it became very relevant to assess the vaccine uptake intention and exploring the key factors of COVID-19 vaccine acceptance intention among rural community. This is the first study that used a new analytical approach to identify potential factors that influences COVID-19 vaccine acceptance and hesitancy in rural places of Bangladesh. The application of new model in explaining the key factors of COVID-19 vaccination would add new value in the body of existing knowledge in the field. Few studies conducted on COVID-19 vaccine hesitancy in Bangladeshi adults and general people reported 40–55%<sup>29,56,57</sup> vaccine hesitancy rate and one study mentioned hesitancy rate approximately 25%.<sup>23</sup> As we discussed earlier, Bangladesh formally launched COVID-19 vaccination programs on the 7 of February, 2021 and these studies<sup>23,29,56,57</sup> were performed at the period when COVID-19 vaccination started in urban areas and nation-wide mass vaccination was not to be started yet. Therefore, relatively high vaccine hesitancy rate was observed among the respondents of those studies conducted in Bangladesh. On the other hand, current study was performed at June to August, 2021 when mass COVID-19 vaccination in union and ward level has been started successfully alongside urban areas. Afterward, mass people received vaccination information through educational campaigns and media communication, thereby generated adequate vaccine confidence throughout the country. Consequently, relatively low vaccine hesitancy rate (15.7%) among rural people was reported in this study.

The study had some limitations; the foremost of which was the sample size of the participants in comparison with number of rural population in Bangladesh. The study thus did not involve the largest numbers sample size to ascertain the generalizability of the current findings. As a result, non-response bias is a possibility as those who did not respond might have been more intention or hesitancy regarding the COVID-19 vaccination than the study respondents. This non-response would undermine the true prevalence of COVID-19 vaccine acceptance and hesitancy among rural community resulted in larger differences between those who were willing to receive a vaccine and those who were not. Secondly, this study assessed uptake intention of a COVID-19 vaccine and identified the associated influential factors of receiving a vaccine; this may differ from behavioral context. Still, with frequent changes in the perceived risk of disease, new approval and deployment of existing vaccines and the development of new COVID-19 vaccine themselves, individual's behavioral context may be changed. Therefore, it is difficult to predict in-spot vaccine acceptance and hesitancy level, and there are some other relevant factors that could influence the COVID-19 vaccine acceptance intention to the rural people were truly unidentified in this study.

Even few months ago, the rural community of Bangladesh had to passionately wait to hear when they would get COVID-19 vaccine that would enable them to move freely as most of the country men had to stay at home to protect them from

COVID-19 contamination for a long time. Since a substantial gap existed among the people living in rural and urban areas to be registered for receiving vaccines, so the rural community should be well communicated with vaccination information.

The authors would like to recommend that the government's foremost step should have to be initiated for robust campaign in favor of vaccination. Of course, the government is carrying out different campaigns, but the intensity needs to be increased to encounter the fake news already conceptualized in rural places of Bangladesh. Government could consider using the potential of Union Digital Center (UDC), which is working at the Union Parishad (UP). They could also consider issuing a directive through the local government division to all the UDCs of the UPs to provide effective communication services to the rural people at a minimal price. This would facilitate the process of mass involvement in vaccination services. The government could also leverage UP's potential to undertake comprehensive health educational campaigns to motivate people to receive COVID-19 vaccine. According to our study, it has been found that some people suffering from long-term co-morbidities such as hypertension, diabetes, chronic kidney disease, cancer, and asthmatic problem may have reservations in receiving vaccine. These people are confused about whether the vaccine will have any adverse side-effects, safe, and effective enough. To address the perception, the local government division should disseminate evidence-based scientific information to motivate these groups of people to be included under mass vaccination programs. In this aspect, further examination of key factors influencing COVID-19 vaccine hesitancy is urgent for getting more people under the vaccination program and to accomplish the ultimate goal of making a COVID-19 free Bangladesh.

## Conclusions

Implementation of mass vaccination has already been shown to be a great success in reducing COVID-19 disease and its associated mortality and morbidity; however, achieving high acceptance and uptake rates is a fundamental aspect of successful COVID-19 vaccination effort. This study investigated the underlying factors of vaccine acceptance intention among rural community in Bangladesh because mass vaccinations against COVID-19 have been started in already. According to our study result, safety, side effect, and effectiveness of the vaccine and trust in the process significantly and positively correlated with the vaccine uptake while rumor impacted negatively. Hence, crude vaccination coverage throughout the country is empowered by ensuring sustainable public trust on vaccination and disseminating safety, side effect, and effectiveness data of a newly promoted vaccine toward rural community. The government, healthcare stakeholder, and vaccine policymaker should consider the practical strategies to minimize the existing vaccination gap between the urban and rural people. Evidence-based communication, mass media strategies, and effective policy on providing health educational campaigns in rural places could reduce anti-vaccination rumors thus improving COVID-19 vaccine acceptance among the marginalized people in Bangladesh. This paper highlighted a tentative roadmap and practical recommendation to properly achieve the mass vaccination drive by subduing its potential public

health challenges in remote areas. With this study, we hoped to establish practical guidelines for ensuring mass public immunization programs and reinforce the vaccination among rural people in Bangladesh.

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## Author contributions

DNR conceptualized and designed the study and performed data acquisition statistical analysis, data interpretation, the original draft writing, and revised the manuscript. MNH performed data collection, assisted data curation, conducted preliminary analysis, and revised manuscript. MSA assisted with study design and execution, performed data interpretation, manuscript edition, revision and supervision. All authors have approved the final article version submitted.

## Consent to participate

All participants provided objectives of the study and informed consent prior to study participations.

## Data availability statement

All data used for analysis in this manuscript are available from corresponding author or first author upon request.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Ethical approval

The study did not require ethical approval as no clinical experimental procedure was conducted, and data were anonymously collected from participants who previously signed an informed consent.

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## ORCID

Debendra Nath Roy  <http://orcid.org/0000-0001-8622-0108>  
Md. Shah Azam  <http://orcid.org/0000-0001-5674-6424>

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