Research article

COVID-19 risk of infection and vaccination during Ramadan fasting: knowledge and attitudes of Bangladeshi general population

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ABSTRACT

There is some debate whether COVID-19 infection and vaccination will hamper Ramadan among the Muslim population worldwide. Therefore, this study aimed to assess the total proportion of the Bangladeshi population who has adequate knowledge and attitude towards COVID-19 risk of infections and vaccination during Ramadan fasting. A cross-sectional study had conducted among 502 adult participants of Bangladesh. We have used a structured questionnaire which had implemented through a face-to-face interview by trained data collectors. Data were analyzed using statistical package software SPSS version 25.0. Of the 502 participants, 50.2% were male, and most (49.6%) lived in urban areas. About 72.5% and 76.30% reported having adequate knowledge and a positive attitude, respectively, regarding COVID-19 risk of infection and vaccination during Ramadan fasting. Among all variables, no formal education and up to class 8 education had significantly associated with inadequate knowledge (OR = 5.14, 95% CI = 1.63–16.19, and OR = 6.42, 95% CI = 2.55–16.19). Educational status was also associated with attitude (OR = 3.68, 95%CI = 1.17–11.55). Current smokers reported a negative attitude in comparison to non-smokers (OR = 2.48, 95% CI = 1.36–4.50). In conclusion, our study found overall moderate knowledge and attitude among the Bangladeshi population towards COVID-19 infection and vaccination. Government should continue its efforts to increase the knowledge and attitude level to a higher level, and anti-smoking campaigns should strengthen to make people stop smoking to reduce the COVID-19 severity.

1. Introduction

There are five pillars of Islam, and Ramadan is one of them. Usually, it is the ninth month of the Islamic calendar [1]. During this time, all healthy adults refrain from eating foods and drinking liquids from sunrise to sunset, which is sometimes 19 h a day, depending on the latitude [2]. Nevertheless, there are some exemptions to this obligation especially, for travelers, menstruating women, and people with certain diseases. This year is the second consecutive year, while Ramadan month will pass through the pandemic situation. As almost one-third of the world's population is Muslim (1.9 billion in more than 180 countries) and the pandemic is involved the whole world for the last one and half years, the issue is burning and must be well addressed [3].

In Bangladesh, Ramadan, the Islamic month of fasting, began on April 13, 2021. Like Ramadan 2020, the global pandemic ushers in a new age of virtual prayers for what had previously been a month of public prayers and social gatherings. With continuing physical prayers and a mass vaccination campaign, the year 2021 brings even more obstacles. For the world's massive number of Muslims, Ramadan co-incides with vaccination programs, ensuring that their vaccines were available during this period. Ramadan might obstruct effective vaccination roll-out due to significant issues about vaccine refusal among minority ethnic populations [3]. These communities must understand that receiving vaccinations intramuscularly across fasting hours (dawn to dusk) does not invalidate the fast and that vaccination should not be postponed [4].

The coronavirus disease 2019 (COVID-19) outbreak triggered by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) quickly spread into the whole world and claiming the lives of millions of people within a short period [5]. Worries about the COVID-19 vaccine's

adoption during Ramadan are increasing, with questions about whether the injection nullifies the fast, any potential side effects, as well as whether people could break their fast. As a result, a global call to action to eliminate vaccine hesitancy is urgently needed [3]. In Bangladesh, as of May 3, 2021, a total of 8,926,466 vaccine doses have been administered [6].

Immunization programs are the most effective tools to protect individuals with a reduction of morbidity and mortality. As the COVID-19 pandemic continues, getting the vaccine is a decisive step in taking charge of one's health. The reluctance of people to receive safe and recommended available vaccines is delaying the process. Nevertheless, waiting too long to be vaccinated allows the coronavirus to continue spreading in the community, with new variants emerging; thereby, receiving the vaccine sooner will protect the vulnerable [7, 8]. Vaccine hesitancy was a concern for many people, where certain variables such as geographic areas, socioeconomic status, and education level were significant. In a cross-sectional study conducted among Italian parent's attitudes on their children's vaccination, 24.6% reported refusing or delayed taking at least one dose of vaccine for their child [9]. A recent study from New Delhi, India, had found the prevalence of COVID-19 vaccine hesitancy was 28.9% [10].

In the face of such outbreaks, the Bangladeshi public's attitudes and behavior evaluation during Ramadan is critical, particularly given many misunderstandings and false information circulated on social media about disease transmission and acquisition methods [11]. However, a recent study showed that 74.6% of people reported willingness to vaccinate against COVID-19 [12]. As a result, testing the general public's awareness and attitude in various district subpopulations was an urgent call. Furthermore, this study aims to assess the proportion of the Bangladeshi population with adequate knowledge and attitude towards COVID-19 risk of infections and vaccination during Ramadan fasting.

2. Methods & materials

2.1. Study design and participants

This cross-sectional study was conducted from 21 April to 1 May 2021 among the adult Bangladeshi population, both male and female aged 18 years and above, capable of giving informed verbal consent to this study. The individuals who could not respond due to severe physical illness were excluded from this study. We conveniently had collected data from all eight divisions of Bangladesh to represent the whole population. Dhaka and Chattogram divisions were targeted for collecting data from urban areas; the other six divisions Barishal, Khulna, Rajshahi, Rangpur, Mymensingh, and Sylhet, were chosen to collect data from semi-urban and rural areas by approaching individuals in their workplace. Our study sample size was determined by 80% power and 95% CI (0.05–1.96); we targeted 75 people from each division to get the required sample size.

2.2. Recruitment & training

A team of 7 enumerators was recruited for data collection and cleaning. All of them were medical doctors and having postgraduate education and training in public health. The interview was held in Bangla, and all the questions were asked in the Bangla language. A practical training session was arranged for the researchers before data collection about ethical issues, study objectives, methodology, and questionnaires. They were taught about data preservation, reporting, confidentiality, and cultural awareness. A pilot study was conducted among 20 different participants anonymously, and necessary modifications had done afterward, and they had not been included in the final sample. Cronbach's Alpha checked the reliability of the questionnaire had found that 0.93 seemed an excellent internal consistency. The face validity had also done by consulting with experts in the fields.

2.3. Data collection procedure

Data were collected by using a structured questionnaire with a face-to-face interview. At first, we prepared the questionnaires in English, then translated them into the local language Bangla and again back-translated to see the accuracy of Bangla translation. Finally, we have collected data using the Bangla version of the questionnaires. If any participants failed to understand any question during the interview, they were then explained by the interviewer. The interview took approximately 10 min, one person at a time, and the accuracy and completeness were checked each time. We ensured adequate safety measures by maintaining social distance, wearing a mask, and using hand sanitizers during data collection. None of the participants had given money or food-item incentives.

2.4. Questionnaire

The questionnaires consisted of four sections. Section 1 contained socio-demographic variables such as age (18 years and above), gender (female, male), residence (rural, semi-urban, urban), educational status (no formal education, up to class 8, class 9–12, graduation, post-graduation), occupation (no employment, farmer, day laborer, caretaker, business, housewife, student, govt. service, private job, retired). Moreover, section 2 contained Ramadan and COVID-19 related personal variables where we kept seven questions which are as follows-fasting history this Ramadan, has completed 30 days of fasting last Ramadan, currently smoking, recently went for COVID-19 testing, diagnosed with COVID-19 within a couple of months, heard of COVID-19 vaccine, has taken at least one dose of the COVID-19 vaccine. The response was recorded as 'Yes/No.' Section 3 and 4 contained the knowledge and attitude regarding COVID-19 risk of infections and vaccinations during Ramadan. We calculated each participant's response under the 'Yes' and 'No' categories based on their knowledge and attitude. Moreover, the score ranges for both knowledge and attitude were 0–8. Participants with a score of five and above were considered as having adequate knowledge and a positive attitude.

2.5. Ethical approval

Ethical approval of this study was taken from the Institutional Review Board/Ethical Review Committee of North South University (2021/OR-NSU/IRB/0402). All participants had provided informed written consent. Participation in this study was entirely voluntary, no one was forced, and participants were allowed to leave any time while answering any questions. They were assured of keeping their information strictly confidential, and the information would not be used for anything other than research purposes.

2.6. Statistical analysis

Data were analyzed by using Statistical Package for Social Sciences (SPSS) software version 25.00. Descriptive statistics calculated the frequencies, percentages, mean and standard deviation of all independent variables. We categorized the age into four age groups using visual binning, where the cut point was three to get an equal percentage. Pearson's Chi-square test had used to see the associations of knowledge and attitudes towards COVID-19 risk of infection and vaccination. A Binary logistic regression model was fitted to examine the associations between continuous data (knowledge, attitude) and categorical or nominal data (demographic variables). Therefore, we entered the dichotomous socio-demographic variables and COVID-19 related personal variables as dependent variables and knowledge and attitude scores as covariates into the model to measure the association. Logistic regression coefficients from the model were exponentiated and presented as adjusted odds ratios (AOR) with a corresponding 95% confidence interval. All tests were two-tailed, where p-value < 0.05 has considered

statistically significant. We also obtained logistic regression models' tolerance and variance inflation factors (VIF) to evaluate potential multicollinearity.

3. Results

3.1. Participant characteristics

Around 600 participants were approached from all eight divisions in their workplace. Among them, 537 gave consent to participate and completed the questionnaire. After analyzing and checking for consistency verification and reduction, 502 data has analyzed in Statistical Package for the Social Sciences (SPSS) software version 25.0 with a response rate of 83.67%. Most of our participants were male (50.2%), and the mean age of the study participants was 36.98 years. Participants' minimum age was 18, and the maximum age was 73. The majority of them belong to the age group of between 26 and 35 (32.1%). Nearly half of the respondents resided in the urban area (49.6%). 36.9% of participants were graduates, and 21.5% were doing private jobs, followed by students (19.7%), housewives (17.1%), and businesses (11.8%) (Table 1). Ramadan and COVID-19 related personal information had shown in (Table 2) where most of the participants (91.4%) were fasting in this current Ramadan during the pandemic. In the last year, 69.5% have completed 30 days of Ramadan fasting. Only 13.5% of participants were currently smoking during Ramadan. 20.9% have gone for COVID-19 testing recently, and only 8.2% have been diagnosed with COVID-19 within a couple of months. The majority of the participants (90.4%) heard about the COVID-19 vaccine, and good percentages (32.1%) have taken at least one dose of the COVID-19 vaccine.

Table 1. Socio-demographic characteristics of the respondents (N = 502).

Variables	Frequency (n)	Percentage (%)
Age Groups		
≤ 25	120	23.9
26–35	161	32.1
36–50	117	23.3
51+	104	20.7
Gender		
Female	250	49.8
Male	252	50.2
Residence		
Rural	164	32.7
Semi-urban	89	17.7
Urban	249	49.6
Educational Status		
No formal education	36	7.2
Up to class 8	61	12.2
Class 9-12	111	22.1
Graduation	185	36.9
Postgraduation	109	21.7
Occupation		
No employment	34	6.8
Farmer	3	0.6
Day laborer	20	4.0
Caretaker	21	4.2
Business	59	11.8
Housewife	86	17.1
Student	99	19.7
Govt. service	45	9.0
Private job	108	21.5
Retired	27	5.4

Table 2. Ramadan and COVID-19 related personal information (N = 502).

Variables	Yes (n%)	No (n%)
Fasting history this Ramadan	459 (91.4%)	43 (8.6%)
Has completed 30 days of fasting last Ramadan	349 (69.5%)	153 (30.5%)
Currently Smoking	68 (13.5%)	434 (86.5%)
Recently went for COVID-19 testing	105 (20.9%)	397 (79.1%)
Diagnosed with COVID-19 within a couple of months	41 (8.2%)	461 (91.8%)
Heard that Covid 19 vaccine has been started	454 (90.4%)	48 (9.6%)
Has taken at least one dose of the COVID-19 vaccine	161 (32.1%)	341 (67.9%)

3.2. Knowledge

Knowledge regarding COVID-19 risk of infection and vaccination during Ramadan has shown in (Table 3), where almost 89% answered correctly to the question related to the chance of COVID-19 spreading due to religious gatherings. Half of the participants (50.6%) did not know that COVID-19 infection can cause dehydration while fasting, whereas 76.3% were correct that fasting will not increase the symptoms of COVID-19. In response to, whether fasting would break or not due to testing for COVID-19 and taking the vaccine, 80.1% and 62.7% answered correctly. About 69.1% of the participants correctly replied in the affirmative regarding vaccination safety during Ramadan, and 71.3% were aware of the vaccine's benefits. However, 62.7% were correct that they would not break their fast if they developed side effects during Ramadan.

3.3. Attitude

Participant's attitude towards COVID-19 risk of infection and vaccination has shown in (Table 4), where the majority (73.7%) thought it was not safe to pray in the mosque during the COVID-19 situation. Most of the respondents (89.9%) had shown interest in wearing masks whenever they went for prayer in the mosque during this pandemic. 74.7% favored agreeing with the obligatory lockdown/measures of coronavirus during Ramadan. Most of the participants (77.5%) did not want to have Iftar outside the house in the traditional way in this COVID-19 situation during Ramadan. 58.6% of the participants did not want to take the COVID-19 vaccine during fasting hours. Moreover, 62.7% were willing to go for Taraweeh prayer at the mosque during Ramadan if fully vaccinated. However, 78.3% showed willingness to take the COVID-19 vaccine in the evening if the vaccination site is transferred to a mosque during Ramadan.

Table 3. Knowledge regarding COVID-19 infection and vaccination during Ramadan (N = 502).

Questions	Yes (n%)	No (n%)
1. If a crowd happens due to religious purpose, is there any chance of COVID-19 spreading?	445 (88.6%)	57 (11.4%)
2. Can one get dehydrated during Ramadan because of COVID-19 infection?	248 (49.4%)	254 (50.6%)
3. Do you think fasting will increase the incidence of COVID-19 symptoms?	119 (23.7%)	383 (76.3%)
4. Will it break your fast, if you go for COVID-19 testing during Ramadan?	100 (19.9%)	402 (80.1%)
5. Will it break your fast, if you take the COVID-19 vaccine during Ramadan?	187 (37.3%)	315 (62.7%)
6. Do you think the newly discovered COVID-19 vaccine is safe to take during Ramadan?	347 (69.1%)	155 (30.9%)
7. Are you aware of the benefits of COVID-19 vaccine?	358 (71.3%)	144 (28.7%)
8. If you develop mild side effects after taking the COVID-19 vaccine during Ramadan, will it break your fast?	187 (37.3%)	315 (62.7%)

Table 4. Attitudes regarding COVID-19 infection and vaccination during Ramadan (N = 502).

Questions	Yes (n%)	No (n%)
1. Will you feel safe to go outside for prayers in this Covid-19 situation?	132 (26.3%)	370 (73.7%)
2. Will you wear a mask every time going for prayer in the mosque in this pandemic?	451 (89.8%)	51 (10.2%)
3. Do you agree with the obligatory lockdown/measures of coronavirus during Ramadan?	375 (74.7%)	127 (25.3%)
4. Will you go outside to have an iftar with everyone in the traditional way during the Covid-19 situation?	113 (22.5%)	389 (77.5%)
5. Do you maintain a nutritional balance by eating lots of vitamins and fruits during Ramadan to reduce the risk of Covid-19 infection?	375 (74.7%)	127 (25.3%)
6. Do you wish to get vaccinated during fasting hour?	208 (41.4%)	294 (58.6%)
7. If you are fully vaccinated, will you continue to go for Taraweeh prayer at mosque during Ramadan?	315 (62.7%)	187 (37.3%)
8. If the vaccination site is transferred to a mosque, will you take COVID-19 vaccine at evening during Ramadan?	393 (78.3%)	109 (21.7%)

3.4. Dichotomous variables

Binary logistic regression found that among all variables, educational status was significantly associated with knowledge regarding COVID-19 infection and vaccination during Ramadan fasting among all the socio-demographic characteristics (Table 5). The participants with an educational level of up to class 8 and no formal education were associated with 6.42 times and 5.14 times higher odds with inadequate knowledge of

COVID-19 risk of infection and vaccination than the graduates. The educational status was also significant with attitude towards COVID-19 infection and vaccination during Ramadan fasting. The participants who had no formal education were 3.68 times more likely with negative attitudes towards COVID-19 risk of infection and vaccination than the graduates. All other variables were not statistically significant. Current smokers during Ramadan had shown a significant association (OR = 2.48, 95% CI = 1.36–4.50) with a negative attitude towards COVID-19 risk of infection and vaccination during Ramadan Fasting compared to non-smokers (Table 6). All other variables were not statistically significant.

4. Discussion

For the last two consecutive years, holy Ramadan is passing through the COVID-19 pandemic situation. Muslims worldwide do intermittent fasting from dawn to dusk during Ramadan, which is a recent concern for increasing the risk of COVID-19 infection [12]. Findings from this study specified us to get the scenario of knowledge and attitude level about the risk of infection and vaccination during Ramadan among the Bangladeshi population. A cross-sectional study has conducted over 502 participants from all eight districts of Bangladesh. We had a nearly equal response from the male (50.2%) and female (49.8%) participants, and the majority of our study participants belong to the age group between 26 to 35 years (32.1%). Education has an immense effect on gaining proper knowledge and developing a good attitude, reflected in our study [13]. Most of our participants were graduates (36.9%) and postgraduates (21.7%). Age, educational level, and occupation seemed to influence people's perception of the COVID-19 situation in previous studies [14]. In our study

Table 5. Association of socio-demographic variables with knowledge & attitude category regarding COVID-19 risk of infection and vaccination during Ramadan.

Variables	Knowledge Category		OR (95% CI)	Attitude Category		OR (95% CI)
	Good (≥5)	Poor (≤4)		Good (≥5)	Poor (≤4)	
Age Groups						
≤25	81 (75.7%)	26 (24.3%)	Reference	80 (74.8%)	27 (25.2%)	Reference
26–35	129 (74.1%)	45 (25.9%)	1.82 (0.63–5.25)	140 (80.5%)	34 (19.5%)	1.01 (0.37–2.76)
36–50	80 (68.4%)	37 (31.6%)	1.27 (0.39–4.09)	87 (74.4%)	30 (25.6%)	1.12 (0.37–3.38)
51+	74 (71.2%)	30 (28.8%)	0.96 (0.29–3.26)	76 (73.1%)	28 (26.9%)	0.88 (0.28–2.79)
Gender						
Female	167 (66.8%)	83 (33.2%)	Reference	191 (76.4%)	59 (23.6%)	Reference
Male	197 (78.2%)	55 (21.8%)	0.66 (0.37–1.15)	192 (76.2%)	60 (23.8%)	1.16 (0.65–2.06)
Residence						
Rural	91 (55.5%)	73 (44.5%)	Reference	109 (66.5%)	55 (33.5%)	Reference
Semi-urban	65 (73.0%)	24 (27.0%)	0.82 (0.42–1.59)	68 (76.4%)	21 (23.6%)	0.77 (0.39–1.54)
Urban	208 (83.5%)	41 (16.5%)	0.60 (0.33–1.09)	206 (82.7%)	43 (17.3%)	0.62 (0.34–1.14)
Educational Status						
No formal education	17 (47.2%)	19 (52.8%)	5.14 (1.63–16.19)	13 (36.1%)	23 (63.9%)	3.68 (1.17–11.55)
Up to class 8	23 (37.7%)	38 (62.3%)	6.42 (2.55–16.19)	41 (67.2%)	20 (32.8%)	1.13 (0.45–2.85)
Class 9-12	71 (64.0%)	40 (36.0%)	2.40 (1.24–4.65)	78 (70.3%)	33 (29.7%)	1.29 (0.66–2.52)
Graduation	157 (84.9%)	28 (15.1%)	Reference	157 (84.9%)	28 (15.1%)	Reference
Postgraduation	96 (88.1%)	13 (11.9%)	0.93 (0.44–1.99)	94 (86.2%)	15 (13.8%)	1.08 (0.49–2.33)
Occupation						
No employment	22 (64.7%)	12 (35.3%)	0.75 (0.25–2.31)	14 (41.2%)	20 (58.8%)	2.34 (0.86–6.38)
Farmer	1 (33.3%)	2 (66.7%)	1.98 (0.15–25.65)	2 (66.7%)	1 (33.3%)	0.56 (0.04–7.66)
Day laborer	7 (35.0%)	13 (65.0%)	1.75 (0.52–5.92)	13 (65.0%)	7 (35.0%)	0.58 (0.17–1.94)
Caretaker	14 (66.7%)	7 (33.3%)	0.65 (0.19–2.19)	10 (47.6%)	11 (52.4%)	1.66 (0.52–5.31)
Business	43 (72.9%)	16 (27.1%)	Reference	41 (69.5%)	18 (30.5%)	Reference
Housewife	45 (52.3%)	41 (47.7%)	1.23 (0.49–3.03)	62 (72.1%)	44 (51.2%)	0.76 (0.31–1.87)
Student	74 (74.7%)	25 (25.3%)	1.47 (0.45–4.80)	76 (76.8%)	23 (23.2%)	0.69 (0.23–2.07)
Govt. service	37 (82.2%)	8 (17.8%)	0.91 (0.30–2.72)	43 (95.6%)	2 (4.4%)	0.11 (0.02–0.54)
Private job	100 (92.6%)	8 (7.4%)	0.37 (0.13–1.08)	99 (91.7%)	9 (8.3%)	0.24 (0.09–0.65)
Retired	21 (77.8%)	6 (22.2%)	2.38 (0.67–8.47)	23 (85.2%)	4 (14.8%)	0.52 (0.14–1.96)

Table 6. Association of Ramadan and Covid-19 related personal variables with knowledge & attitude category regarding COVID-19 risk of infection and vaccination during Ramadan.

Variables	Knowledge Category		OR (95% CI)	Attitude Category		OR (95% CI)
	Good (≥5)	Poor (≤4)		Good (≥5)	Poor (≤4)	
Fasting history this Ramadan						
Yes	336 (73.2%)	123 (26.8%)	1.25 (0.58–2.69)	355 (77.3%)	104 (22.7%)	0.85 (0.39–1.85)
No	28 (65.1%)	15 (34.9%)	Reference	28 (65.1%)	15 (34.9%)	Reference
Has completed 30 days of fasting last Ramadan						
Yes	271 (77.7%)	78 (22.3%)	0.42 (0.27–0.68)	275 (78.8%)	74 (21.2%)	0.68 (0.41–1.11)
No	93 (60.8%)	60 (39.2%)	Reference	108 (70.6%)	45 (29.4%)	Reference
Currently Smoking						
Yes	47 (69.1%)	21 (30.9%)	1.45 (0.78–2.67)	43 (63.2%)	25 (36.8%)	2.48 (1.36–4.50)
No	317 (73.0%)	117 (27.0%)	Reference	340 (78.3%)	94 (21.7%)	Reference
Recently went for Covid-19 testing						
Yes	92 (87.6%)	13 (12.4%)	0.53 (0.27–1.03)	93 (88.6%)	12 (11.4%)	0.56 (0.28–1.11)
No	272 (68.5%)	125 (31.5%)	Reference	290 (73.0%)	107 (27.0%)	Reference
Diagnosed with Covid-19 within a couple of months						
Yes	38 (92.7%)	3 (7.3%)	0.28 (0.08–0.99)	38 (92.7%)	3 (7.3%)	0.36 (0.10–1.29)
No	326 (70.7%)	135 (29.3%)	Reference	345 (74.8%)	116 (25.2%)	Reference
Heard that Covid 19 vaccine has been started						
Yes	343 (75.6%)	111 (24.4%)	0.31 (0.16–0.59)	361 (79.5%)	93 (20.5%)	0.27 (0.14–0.51)
No	21 (43.8%)	27 (56.3%)	Reference	22 (45.8%)	26 (54.2%)	Reference
Has taken at least one dose of the Covid-19 vaccine						
Yes	142 (88.2%)	19 (11.8%)	0.35 (0.20–0.61)	144 (89.4%)	17 (10.6%)	0.38 (0.21–0.68)
No	222 (65.1%)	119 (34.9%)	Reference	239 (70.1%)	102 (29.9%)	Reference

participants mainly were from the private sector (21.5%), followed by students (19.7%).

In the Ramadan and COVID-19 related personal history section, we had asked seven questions, among which most of the participants (91.4%) were fasting this Ramadan; the rate was higher than the previous year (69.5%) during the COVID-19 pandemic. We interviewed the participants during the middle of Ramadan month; therefore, it was not sure whether all 91.4% of them would keep fasting for 30 days or not. In our study, 13.5% of people were currently smoking in this Ramadan. Smoking has a strong correlation with COVID-19, even though no direct evidence had been found about smoking and attitudes. However, active smokers had shown worse progression towards severe COVID-19 infection than non-smokers [15]. We had found that 20.9% of participants had gone for COVID-19 testing recently. COVID-19 is still a mystery to us, and it has long-term effects on our bodies. Therefore, recently recovered patients were advised not to fast for the next six weeks at this recovery time [12]. Among all our participants, only 8.2% had been diagnosed with COVID-19 within a couple of months. The majority (90.4%) heard about the COVID-19 vaccine, and a good percentage (32.1%) had taken at least one dose of the COVID-19 vaccine.

Knowledge-related eight specific questions regarding COVID-19 risk of infection and vaccination were asked to our participants in which based on the total Knowledge score, 72.5% had found adequate knowledge, and 27.5% with inadequate knowledge among the overall population. COVID-19 infections do not produce any severe symptoms in most cases, but slight flu-like clinical features can lead to dehydration [16, 17]. Also, during these long fasting days of Ramadan, this situation can worsen and lead to reduced fluid intake and thereby severe dehydration. We had asked our participants regarding this, where 50.6% did not know that COVID-19 infection can cause dehydration while fasting. As far, there is no solid evidence that Ramadan fasting had an adverse impact during the COVID-19 pandemic in healthy adults [18]. 76.3% of our participants answered correctly regarding this question. There had found disinterest in COVID-19 testing during the Ramadan period among many people as they assumed inserting a swab stick at nostrils might break their fast, as nasopharynx or oropharynx swab is taken as coronavirus sample [19, 20]. In response to the questions, whether fasting would break or not due to testing for COVID-19, 80.1% give the exact answer that it will not break their fast.

Ramadan and vaccine hesitancy were a global concern since the beginning [21]. Not only the COVID-19 vaccine, previously this situation had seen during the West African Ebola epidemic, a study conducted in Guinea had also found a significantly lower vaccine acceptance among the general Muslim population [3]. Few studies showed signs of re-infection frequency and increased resistance in vaccinated individuals where the variants spread dominantly [22]. Also, with the concern of vaccine safety, a large sample from an Israeli field study had shown vaccinated people with sixteen adverse reactions [23]. These concerns diverted people from taking COVID-19 vaccination during the Ramadan period. The development of the COVID-19 vaccines did not cut corners on testing for safety and efficacy, and clinical trials for the vaccines were diverse. In many countries, Muslims were concerned about the COVID-19 vaccine efficacy at the fasting hour, but evidence showed that the vaccine works even better while fasting [24]. The vaccine does not pass through our intestine; therefore, it does not break the fast. Based on that, we had asked our participants whether taking the COVID-19 vaccine at Ramadan will break the fast or not, where 62.7% answered it would not. However, many of our study population (37.3%) still thought that taking the COVID-19 vaccine is unsuitable at fasting hours. About 69.1% of the participants replied affirmatively regarding vaccination safety during Ramadan. While asked about the benefits of vaccines, most participants (71.3%) answered that they were aware of the COVID-19 vaccine's benefits. Side effects of the COVID-19 vaccine are temporary, lasting only a day or two, and the symptoms signal a natural response to the immune system. In a question related to this, 62.7% answered correctly not to break their fast if anyone had developed side effects of COVID-19 during Ramadan.

Based on these findings, our results found a significant association of knowledge category with educational status by using binary logistic regression. Participants who had an educational level of up to class 8 and no formal education were associated with 6.42 times and 5.14 times, respectively, higher odds with inadequate knowledge than the graduates. These same results were found in other studies where the knowledge gap had an exciting way with education. The study from Universitas Ahmad

Dahlan, Yogyakarta, Indonesia, found that their participants who graduated from higher education were associated with 1.98-fold higher odds of having good knowledge about COVID-19 than people who hold senior high school education [14]. An online population-based survey from Bangladesh found a significant education gap towards COVID-19 knowledge and attitudes among rural and older adults [25]. The study conducted among university students in Mizan Tepi University, Ethiopia, showed that about 47.0% of their students had adequate knowledge, and health sciences college students had almost three times good odds of knowing about COVID-19 those from non-health sciences students [26]. A cross-sectional study conducted in the United Arab Emirates shown medical and health sciences students high knowledgeable about the COVID-19 pandemic compared with allied health students [27].

Attitude-related eight specific questions regarding COVID-19 risk of infection and vaccination were asked to our participants in which based on the total attitude score, positive and negative attitudes had shown 76.3% and 23.7%, respectively, among the overall population. Most of our participants (73.7%) thought it is not safe for them to pray in the mosque during the COVID-19 situation. Moreover, almost 90% had said to wear a mask every time they pray in the mosque during the pandemic. To tackle the current worsening COVID-19 situation, the government had imposed lockdown throughout the whole country. We asked a question considering this issue where 74.7% favored agreeing with the obligatory lockdown/measures of coronavirus during Ramadan. During Ramadan fasting, Muslims follow a ritual where religious and social gatherings are essential parts of the evening [21]. Most of our participants (77.5%) did not want to have Iftar outside the house in the traditional way in this COVID-19 situation during Ramadan. From recent studies, poor and unhealthy diets are becoming the primary cause of deaths globally besides non-communicable diseases [28]. With COVID-19 risk of infection and Ramadan, Muslims seemed to have a chance of having a nutritional deficiency. Regarding this, 74.7% of our participants did maintain a balanced and healthy diet by eating lots of vitamins and fruits during Ramadan to reduce the chance of COVID-19 infection.

Since the beginning, negative attitudes towards the COVID-19 vaccine and people's constant unwillingness were barriers to controlling the pandemic [29]. Vaccine hesitancy had been reported among urban, rural, to ethnic minorities of all classes of people. Antivaccine attitudes or beliefs and a lack of trust were significantly higher in the younger age group and Black race [30]. In contrast, people who had adequate knowledge regarding COVID-19 were willing to receive a vaccine and had no concern for its safety [31]. A comparison study from the national survey from two countries China and the United States had shown that the discrete choice towards vaccination varies with the efficacy followed by the cost of vaccination [32]. Healthcare workers are still convincing about why this vaccine is necessary to take and its safety, efficacy during Ramadan [33, 34]. A study from India conducted among health care workers and medical students reported a high vaccine acceptability rate in Females (73%) than males [35]. In contrast, our study found that 58.6% were unwilling to take the COVID-19 vaccine during fasting hours. Attitudes about vaccines vary widely among Muslim populations; therefore, about 62.7% were willing to go for Taraweeh prayer at the mosque during Ramadan if fully vaccinated. However, 78.3% showed their willingness to take the COVID-19 vaccine in the evening if the vaccination site is transferred to a mosque during Ramadan. Therefore, we urge the government to address this situation regarding COVID-19 vaccination concerns.

The association between attitude with COVID-19 risk of infection and vaccination was also significant with educational status. The participants who had no formal education were 3.68 times more likely with a negative attitude towards COVID-19 risk of infection and vaccination than the graduates. All other variables were not statistically significant. Northwestern University, Chicago had conducted a self-reported knowledge, attitudes, and behaviors related to COVID-19, where they found in both cases older participants, not employed, retired, and had low literacy had more deficient knowledge of COVID-19 [36]. A study conducted among

the South Korean population showed an indirect effect of knowledge on people's attitudes. They found that females with higher education levels significantly connected with COVID-19 knowledge and attitude [37]. The same result had shown in a national survey conducted among frontline healthcare workers in Nepal found that among all factors, participants with the educational level of master's degree or above were significantly associated with appropriate attitude and practice towards COVID-19 [38]. Another knowledge, attitude, and practice-related online survey conducted within the Muslim community in the United Kingdom showed that women and those aged less than 30 years had achieved lower scores across all [39]. Furthermore, these findings suggested that education played an essential role in participants' knowledge and attitude towards COVID-19 risk of infection and vaccination.

4.1. Strength and limitation

The findings of this study have given us a glimpse of the whole scenario of the knowledge and attitude level among the Bangladeshi adult population regarding COVID-19 risk of infection and vaccination during Ramadan fasting. We collected the data during Ramadan, so there was no recall bias. Data was collected by face-face interview while in the whole country, more than 60% of the population had taken at least one dose of COVID-19 vaccine. However, our sampling technique may represent the social desirability bias and underreport the result. Also, the representativeness of the sample size of our study was small; therefore, we recommend further study to cover each area with a larger sample size. However, this was the first-ever study conducted regarding the COVID-19 risk of infection and vaccination concerns during Ramadan.

5. Conclusion

This study found moderate knowledge and attitude among the Bangladeshi population towards COVID-19 risk of infection and vaccination. Level of education played a significant association with both knowledge and attitude, and smokers during Ramadan were found to had a negative attitude towards COVID-19 infection and vaccination. Hence, efforts should continue to increase the knowledge and attitude level to a higher level, and anti-smoking campaigns should strengthen people to refrain from smoking.

Declarations

Author contribution statement

Nusrat-E-Mozid: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Mohammad Ashraful Amin: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Shirin Shahadat Jhumur and Wharesha Sarker: Conceived and designed the experiments; Performed the experiments.

Imran Hossain Monju and Shakila Sharmin: Performed the experiments; Analyzed and interpreted the data.

Sanjana Binte Ahmed: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Mohammad Delwer Hossain Hawlader: Conceived and designed the experiments; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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