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Knowledge, attitude and practices towards SARS-CoV-2 genetic mutations and emerging variants among the population in Bangladesh: a cross-sectional study

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ABSTRACT

Objectives The coronavirus is continuously mutating and creating new SARS-CoV-2 variants. Public awareness about SARS-CoV-2 mutation is essential for effective preventive measures. The present study aimed to assess the knowledge, attitude and practices (KAP) towards SARS-CoV-2 variants among the general population in Bangladesh.

Design We conducted this online survey between 9 April 2021 and 10 May 2021 using structured questionnaires to collect the information.

Setting We distributed the survey link among the participants from all 64 districts of Bangladesh using social media platforms.

Participants A total of 1,090 respondents completed this survey. After careful evaluation, we excluded 18 responses due to partial or incomplete information, and 1,072 responses entered into the final analysis.

Primary outcome The KAP of participants towards SARS-CoV-2 variants depends on their demographic backgrounds. Associations between demographic characteristics and the likelihood of having adequate KAP were estimated using adjusted logistic regressions.

Results Among the participants, 42% had a poor knowledge level, 4% had a low attitude level and 14% had a poor practice score. The average knowledge, attitude and practice score were 2.65, 4.194 and 4.464 on a scale of 5, respectively. Only 51.8% of the participants knew about mutant strains, and only 47.6% knew about the effectiveness of vaccines against new variants. The key factors associated with poor knowledge levels were educational levels, area of residence, geographic location, and concern regarding COVID-19. Sociodemographic factors for poor attitude levels were geographic location, vaccination and concern regarding COVID-19. The pivotal factors in determining poor practice scores were the residence area of people and concern regarding COVID-19.

Conclusions The knowledge level and positive attitude are associated with better preventive measures against SARS-CoV-2 variants. Based on these findings, we recommended several awareness programmes on SARS-CoV-2 mutations and variants for the rural population in Bangladesh to increase overall awareness levels.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The theme of this knowledge, attitude and practice study was to get an idea about the perception of the Bangladeshi population about the genetic mutation of coronavirus.
⇒ The present study assessed the three major successive processes of effective pandemic-controlling measures among the general population in Bangladesh.
⇒ This study allows quick data collection during the COVID-19 pandemic and produces results to develop context-specific strategies to prevent new coronavirus variants.
⇒ Online self-reporting surveys may have few biases and are not representative of some underprivileged populations who do not have internet facilities.
⇒ The cross-sectional design of the present study is unsuitable for the impact measurement of these parameters over time.

INTRODUCTION

In late 2019, several pneumonia cases were detected in Wuhan City, China, that spread globally within a few months, and the WHO later renamed it as COVID-19.[1] In January 2020, scientists identified the new beta coronavirus genome by genetic sequencing.[2] The authorities named it SARS-CoV-2 according to the nature of the virus previously known as 2019-nCoV.[3] SARS-CoV-2 continues to spread quickly because of its high transmission rate, and as of 18 October 2023, the WHO reported more than 771 million COVID-19 cases and more than 6.9 million related deaths worldwide.[4] Bangladesh reported the first COVID-19 case on 8 March 2020. Since then, the country has been monitoring and reporting new SARS-CoV-2 variants, COVID-19 cases and related deaths.[5] The development of new SARS-CoV-2 mutant

strains with immune-evading traits and increased infectious capacity raises the possibility that vaccinations against these variants might not be as successful as expected.[6] Bangladesh is a densely populated lower-middle-income country where general people have little or no idea about SARS-CoV-2 mutation. Moreover, genetic mutations of the SARS-CoV-2 are inevitable.[7 8] Scientists had predicted from the beginning of the COVID-19 outbreak that the mutant strains of the virus would lengthen the pandemic.[9] The pathogenicity of a virus can change due to the adaptive mutations in the viral genome.[10] The ability of a virus to elude the immune system can be significantly affected by even a single amino acid exchange.[11] It may also hinder the activity of vaccines against the virus and its transmission.[12] SARS-CoV-2 is similar to other RNA viruses that can adjust within new human hosts through genetic mutations over time. As a result, several variants that may differ from their ancestral strains emerge.[13] Several SARS-CoV-2 variations have been identified.[14 15] Some are considered variants of concern (VOCs) due to their potential impact on public health. The Alpha (B.1.1.7) strain was the first VOC described in the United Kingdom (UK) in late December 2020. Afterwards, South Africa reported the Beta (B.1.351) strain in December 2020, and the Gamma (P.1) strain was reported in Brazil in early January 2021, causing an upsurge in COVID-19-associated death toll in the respective countries.[16 17] However, India detected the first case of the deadliest mutant strain of SARS-CoV-2 Delta (B.1.617.2) in December 2020, causing a nationwide catastrophe. The more recent Omicron (B.1.1.529) variant was first reported in South Africa in November 2021.[18 19] At this moment, Omicron variants named BA.4 and BA.5 are responsible for infecting people specifically BA.5.2.1.7 or BF.7.[20 21] WHO has also classified eight variants of interest (VOIs), named Epsilon (B.1.427 and B.1.429); Zeta (P.2); Eta (B.1.525); Theta (P.3); Iota (B.1.526); Kappa (B.1.617.1); Lambda (C.37) and Mu (B.1.621) which are not a threat to the public health.[13] India was the first nation to report more than 400 000 new COVID-19 cases in a single day on 30 April 2021, due to the delta variant.[22] Findings from a South African investigation indicate that this variant causes higher paediatric hospitalisation rates than previous SARS-CoV-2 variants.[23] Newer variants can have devastating outbreaks with completely newer symptoms. Therefore, people should have proper knowledge, a positive attitude, and a mindset to follow precautions and preventive measures.[24 25]

The level of knowledge, attitude and practices (KAP) is a crucial cognitive factor in public health promotion and prevention. It deals with several viewpoints regarding the origins of the illness and aggravating factors, identification of symptoms, accessibility to therapies and potential outcomes.[26] A cross-sectional web-based study enrolled respondents from six countries using a structured and multi-item questionnaire that showed the relationship between sociodemographic variables and KAP towards SARS-CoV-2 variants. Education level and area of residence played a vital role in determining the KAP score in this study.[27] Another KAP study by Lou *et al* suggested that having proper knowledge about COVID-19 does not ensure more precautionary behaviours and attitude levels play a significant role in preventive measures.[28] Also, Raquib *et al* found that the practices to prevent COVID-19 were higher among the Bangladeshi population, but the subgroup analysis showed poor practices to control infection among men.[29] We conducted this KAP study to assess the awareness level associated with SARS-CoV-2 mutant strains among the general population in Bangladesh. The KAP score of this study would help the government plan the preventive measures against COVID-19 in a structured manner and may help to design an awareness programme to tackle the mutant variants.

METHODS

Participants and procedure

This web-based cross-sectional open survey was conducted among the general population of Bangladesh using convenient sampling techniques. The survey was conducted between 9 April 2021 and 10 May 2021, immediately after the International Centre for Diarrheal Disease Research, Bangladesh (icddr,b) confirmed the detection of both United Kingdom's Alpha (B.1.1.7) and South Africa's Beta (B.1.351) variant among COVID-19 patients in Bangladesh.[30] A structured questionnaire was designed using Google Forms and shared with participants using social media platforms such as Facebook, WhatsApp, etc. The online questionnaire was preferred at that time to maintain social distancing because of the countrywide ongoing lockdown imposed by the government authorities. Inclusion criteria for participating in the survey were being a resident of Bangladesh, aged 18 years and above, having web access, and voluntary consent to participation. We calculated the sample size using a single population proportion formula based on the assumption that at a 95% CI and 5% margin of error, the probability of having poor knowledge, attitude and preventive practice towards COVID-19 is 50%. According to the above assumptions, the minimum required sample size was 385. We assumed the response rate might be 30% for this online survey. Therefore, we initially invited 1,500 potential respondents. However, we got responses from 1,090 participants and excluded 18 responses due to partial or incomplete information. Finally, we included 1,072 responses for the final analysis. We presented a detailed algorithm showing sample selection, enrolment, and filtration process by figure 1. We obtained ethical approval for this study from an institutional ethical review board and informed consent was collected from all participants.

Questionnaire design and measures

We developed a questionnaire using Google Forms in English and the native Bengali language to conduct this KAP assessment. The participants had the freedom to choose their language of preference. Questions were adapted from the Centre for Disease Control and

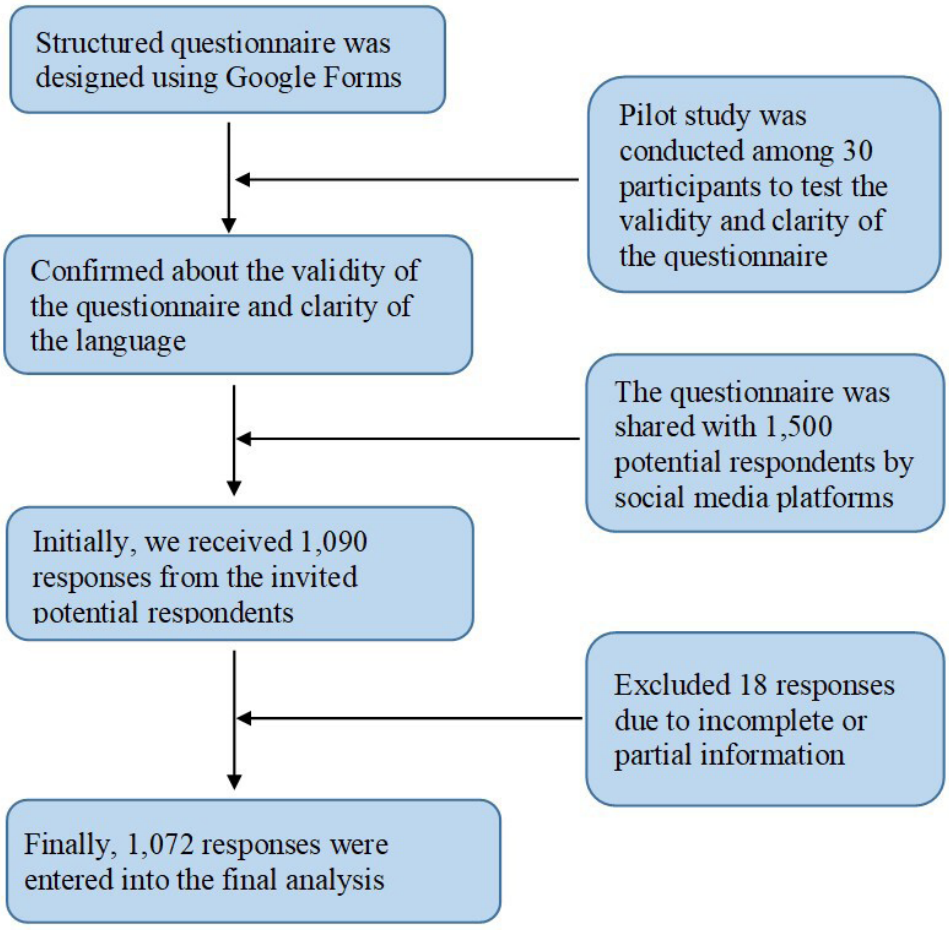

Figure 1 Algorithm showing sample selection, enrolment, exclusion and final analysis.

Prevention (CDC) 'Variants and Genomic Surveillance for SARS-CoV-2' webpage and articulated in a simplified manner.[31] We followed the dual-panel forward-backward translation method to prepare the questionnaire. First, we developed a questionnaire in English and then converted it to Bangla. The first English version of the questionnaire was translated into two Bangla versions separately by a medical graduate and a general person who were native Bengali speakers but fluent in English. A researcher (MRI) compiled both versions to prepare a Bangla forward version and resolved any discrepancies. Similarly, an expert translator and another medical graduate translated the Bangla version into two English versions. Again, another researcher (IA) compiled these two back-translated English versions to prepare an English backward version and resolved any discrepancies. A pilot study was conducted on 30 participants to test the validity of the questionnaire and its clarity of language. The overall Cronbach's alpha of the questionnaire in the pilot study was 0.71, which indicates good internal consistency. For field data, the overall Cronbach's alpha for the questionnaire was 0.76. The questionnaire consisted of four segments of questions. The first segment collected the sociodemographic data and medical history of the respondents. The second segment contained five items that assessed the knowledge regarding the variant strains of SARS-CoV-2. Each question had one correct answer, two incorrect answers, and an option 'I don't know'. Each correct response was assigned 1 point, whereas 0 points for incorrect responses or 'I don't know'. The third segment assessed the attitude of study participants towards the new variants of coronavirus with 5 items. Each question had three options- 'Yes' which indicated a positive attitude and was assigned 1 point, 'Maybe' which indicated a neutral attitude and was assigned 0.5 points, and 'No' which indicated a negative attitude and was assigned 0 points. The fourth and final segment evaluated the practices of participants in dealing with the new variants and had five items. Emphasis was given to the vaccination status of the participants and their approach to dealing with the new strains. Participants who are vaccinated or willing to be vaccinated and practising strong preventive measures were assigned 1 point. Participants who took the vaccine but no longer practised preventive measures or who are still maintaining preventive measures but do not intend to get vaccinated were assigned 0.5 points. Participants who did not care about vaccination or preventive practices were assigned 0 points. Each knowledge, attitude and practice score was categorised according to Bloom's cut-off point.[31] Scores between 80% and 100% were considered good, 60% and 79% were considered moderate, and less than 60% were considered poor. Five questionnaire items

were displayed per page and total six pages were given for this survey.

Statistical analysis

We edited, sorted and coded raw data for analysis using Microsoft Excel 2019. The data file was then analysed using SPSS V.25.0 (Chicago, IL, USA). The present study used descriptive statistics (frequencies, percentages, SD) to report the demographic and health characteristics of the study participants. We observed the correlation of demographic profiles and KAP scores using Pearson's χ^2 test or Fisher's exact test if the expected cell count was less than 5. We applied a multiple logistic regression model to determine the influence of different demographic profiles of respondents on KAP scores using the 'Enter' method. $p<0.05$ was considered statistical significance in all tests.

Patient and public involvement

Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

RESULTS

Sociodemographic characteristics of participants

A total of 1,090 participants took part in the survey. After deleting 18 partial and incomplete responses, the final sample size of the survey came down to 1,072. Among the sample size, 497 (46.4%) were male and 575 (53.6%) were female. We included individuals aged 18 years or more in this survey. The maximum number of respondents was between 18 and 30 years (70.5%). The majority of the sample was students from the undergraduate level or above (71%). Among the participants, 64.8% were students. The participants were married (65.3%) and unmarried (34.7%) (tables 1–3).

Comorbidities and COVID-19 history of study participants

Among the participants, 27.2% were without any comorbid diseases. Others were suffering from a variety of comorbidities such as hypertension (16.3%), diabetes (8.1%), cardiovascular disorders (5.7%), respiratory disorders (4.7%), renal disorders (2.5%), gastrointestinal tract/ hepatic disorders (1.4%) and others (2.2%). A total of 1000 (93.3%) participants did not have a history of COVID-19, and only 72 (6.7%) participants had a previous history of COVID-19. Vaccinated and non-vaccinated ratios were 17.5% and 77.3%, respectively. Among all participants, 9.1% were unwilling to be immunised for COVID-19. A total of 61.6% of respondents were concerned about COVID-19. However, 32.9% of the participants were moderately concerned, and 5.5% were unconcerned (tables 1–3).

Knowledge about new SARS-CoV-2 variants

We assessed COVID-19-related knowledge using five questions on a scale of 1–5 for each question. The average knowledge score was 2.65. Based on the score, 329 (31%) of the participants had a good knowledge level, 286 (27%) of the participants had a moderate knowledge level and 457 (42%) of the participants had a poor knowledge level (figure 2). Many participants (29.2%) do not have adequate knowledge about SARS-CoV-2 mutations. Furthermore, nearly half the participants (48.2%) failed to give correct answers regarding the characteristics of the new SARS-CoV-2 variant. We found mixed opinions regarding the efficacy of the Oxford-AstraZeneca vaccine in Bangladesh. Almost half (52.4%) of the participants were not well informed regarding the effectiveness of vaccines against the new variants. Only 32.9% were aware of the reduced protection provided by Oxford-AstraZeneca against the new variant. Among all, 61.9% of the participants seem that one can get infected with the new SARS-CoV-2 variants despite vaccination.

Association between knowledge and characteristics of study participants

We presented the distribution of the knowledge level of the participants and their demographic characteristics in table 1. The knowledge level was associated with age, sex, comorbid diseases, previous history of COVID-19 and vaccination status of participants. Also, significant knowledge differences were observed based on the participant's monthly family income, education and marital status. Educated respondents reported higher levels of knowledge. The logistic regression model confirmed the values from the χ^2 test. As compared with participants having an undergraduate or higher level of education, the odds of having poorer knowledge levels were 2.72 times greater in participants with secondary education only (p=0.001; 95% CI, 1.496 to 4.945), and also the odds of having poorer knowledge levels were 1.6 times higher in participants with higher secondary education only (p=0.004; 95% CI, 1.188 to 2.406). Significant knowledge differences were seen in participants of different occupations (p=0.001) from the χ^2 test. Higher levels of knowledge were associated with healthcare professionals. However, non-government employees had poor knowledge. Compared with healthcare professionals, the odds of having low knowledge levels were 4.438 times greater in non-government employees (p=0.008; 95% CI, 1.476 to 13.347). We observed significant knowledge differences based on the residential area of the participants. Urban people have a higher level of knowledge. Compared with urban people, the odds of having poorer knowledge levels were 1.746 times higher in rural people (p=0.001; 95% CI, 1.264 to 2.412). We observed significant knowledge differences among the participants regarding their concerns about COVID-19 (p=0.005). Concerned people had more knowledge about COVID-19. The odds of having poorer knowledge levels were 2.707 times higher among those who have no concern about COVID-19 than those who are concerned (p=0.002; 95% CI, 1.463 to 5.008) (table 1).

Table 1 Distribution of COVID-19 associated knowledge among study participants and factors associated with poor knowledge

Variables	Knowledge levels						
	Good, n (%)	Moderate, n (%)	Poor, n (%)	χ^2 (df) p value	Adjusted OR	95% CI	P value
Sex							
Male	153 (30.8)	135 (27.2)	209 (42.1)	0.157 (2) 0.925	Ref.	Ref.	Ref.
Female	176 (30.6)	151 (26.3)	248 (43.1)		1.238	0.907 to 1.692	0.179
Age in years							
18–30	247 (32.7)	199 (26.3)	310 (41.0)	7.329 (8) 0.502	Ref.	Ref.	Ref.
31–40	24 (26.7)	22 (24.4)	44 (48.9)		0.539	0.246 to 1.18	0.122
41–50	24 (22.9)	34 (32.4)	47 (44.8)		0.541	0.233 to 1.255	0.152
51–60	27 (28.4)	25 (26.3)	43 (45.3)		0.654	0.28 to 1.53	0.328
>60	7 (26.9)	6 (23.1)	13 (50.0)		1.145	0.379 to 3.459	0.81
Educational qualification							
Illiterate/primary	3 (13.6)	2 (9.1)	17 (77.3)	60.18 (6) <0.001	2.7	0.878 to 8.3	0.083
Secondary	14 (15.6)	14 (15.6)	62 (68.9)		2.72	1.496 to 4.945	0.001
Higher secondary	42 (21.1)	54 (27.1)	103 (51.8)		1.69	1.188 to 2.406	0.004
Undergraduate or higher	270 (35.5)	216 (28.4)	275 (36.1)		Ref.	Ref.	Ref.
Occupation							
Students	238 (34.2)	181 (26.0)	276 (39.7)	35.71 (14) 0.001	1.05	0.382 to 2.885	0.925
Teachers	10 (32.3)	11 (35.5)	10 (32.3)		1.639	0.475 to 5.657	0.434
Govt employee	13 (43.3)	6 (20.0)	11 (36.7)		1.613	0.451 to 5.765	0.462
Non. govt employee	10 (15.9)	18 (28.6)	35 (55.6)		4.438	1.476 to 13.347	0.008
Business	18 (23.4)	19 (24.7)	40 (51.9)		2.424	0.798 to 7.362	0.118
Homemaker	17 (24.3)	20 (28.6)	33 (47.1)		2.045	0.646 to 6.48	0.224
Retired/ unemployed	11 (13.4)	26 (31.7)	45 (54.9)		1.812	0.605 to 5.428	0.288
Healthcare/ frontline	12 (50.0)	5 (20.8)	7 (29.2)		Ref.	Ref.	Ref.
Monthly family income (KBDT)							
<10	32 (18.6)	34 (19.8)	106 (61.6)	38.784 (8) <0.001	1.359	0.688 to 2.687	0.377
10–25	58 (29.7)	62 (31.8)	75 (38.5)		0.878	0.46 to 1.677	0.693
25–50	118 (30.3)	109 (28.0)	162 (41.6)		1.214	0.673 to 2.19	0.52
50–100	94 (37.5)	64 (25.5)	93 (37.1)		1.008	0.548 to 1.853	0.979
>100	27 (41.5)	17 (26.2)	21 (32.3)		Ref.	Ref.	Ref.
Marital status							
Unmarried	238 (34.0)	183 (26.1)	279 (39.9)	11.057 (2) 0.004	Ref.	Ref.	Ref.
Married	91 (24.5)	103 (27.7)	178 (47.8)		1.006	0.573 to 1.766	0.983
Residence							
Rural	65 (18.8)	84 (24.3)	197 (56.9)	49.221 (2) <0.001	1.746	1.264 to 2.412	0.001
Urban	264 (36.4)	202 (27.8)	260 (35.8)		Ref.	Ref.	Ref.
Location							

Continued

Table 1 Continued

Variables	Knowledge levels			χ^2 (df) p value	Adjusted OR	95% CI	P value
	Good, n (%)	Moderate, n (%)	Poor, n (%)				
Dhaka	236 (35.3)	190 (28.4)	243 (36.3)	82.79 (14) <0.001	Ref.	Ref.	Ref.
Chittagong	28 (24.8)	37 (32.7)	48 (42.5)		1.146	0.735 to 1.786	0.547
Rajshahi	19 (26.8)	19 (26.8)	33 (46.5)		1.374	0.807 to 2.338	0.242
Khulna	17 (12.2)	18 (12.9)	104 (74.8)		3.005	1.823 to 4.956	<0.001
Barisal	7 (58.3)	3 (25.0)	2 (16.7)		0.377	0.079 to 1.794	0.221
Sylhet	0 (0.0)	1 (25.0)	3 (75.0)		5.931	0.597 to 58.963	0.129
Mymensingh	14 (38.9)	10 (27.8)	12 (33.3)		0.906	0.43 to 1.909	0.794
Rangpur	8 (28.6)	8 (28.6)	12 (42.9)		1.249	0.556 to 2.806	0.59
Comorbid chronic diseases							
Yes	95 (32.5)	86 (29.5)	111 (38.0)	3.608 (2) 0.165	Ref.	Ref.	Ref.
No	234 (30.0)	200 (25.6)	346 (44.4)		1.411	0.989 to 2.012	0.057
Previous history of COVID-19							
Yes	21 (29.2)	22 (30.6)	29 (40.3)	0.593 (2) 0.743	Ref.	Ref.	Ref.
No	308 (30.8)	264 (26.4)	428 (42.8)		0.914	0.54 to 1.549	0.738
Vaccination status							
Yes	56 (29.8)	49 (26.1)	83 (44.1)	7.073 (4) 0.132	Ref.	Ref.	Ref.
No, but will take vaccine	254 (32.3)	206 (26.2)	326 (41.5)		0.866	0.531 to 1.413	0.565
No, and will not take vaccine	19 (19.4)	31 (31.6)	48 (49.0)		1.273	0.688 to 2.357	0.442
Concern regarding COVID-19							
Very concerned	201 (30.5)	184 (27.9)	274 (41.7)	15.013 (4) 0.005	Ref.	Ref.	Ref.
Somewhat	120 (34.0)	89 (25.2)	144 (40.8)		1.066	0.796 to 1.428	0.667
Not at all	8 (13.6)	13 (22.0)	38 (64.4)		2.707	1.463 to 5.008	0.002

df, degree of freedom; KBDT, Kilo Bangladeshi taka; N, Number.

Attitude towards new SARS-CoV-2 variants

We evaluated the attitude of people regarding COVID-19 using five questions based on a score ranging from 1 to 5. The average attitude score was 4.194. Based on the score, 850 (79%) of the participants had a good attitude level, 176 (17%) of the participants had a moderate attitude level and 46 (4%) of the participants had a poor attitude level (figure 2). Most participants (89.2%) were very concerned about the emerging variant of COVID-19. But, most of the participants (50.1%) could not predict the upcoming variants correctly. Among the respondents, 90.5% had an idea of a preventive method against the new variants, and 67.3% believed the vaccine would protect against new variants. Furthermore, 61.8% of the participants expressed that they may get infected by coronavirus after recovering from previous COVID-19.

Association between attitude and characteristics of study participants

We observed the attitude distribution among the participants having different demographic characteristics. In both the χ^2 test and logistic regression analysis, age, educational qualification, marital status, residential area, comorbid chronic disease and previous history of COVID-19 had statistically insignificant associations with poor attitudes of study participants. Significant attitude differences were seen based on the sex of the participants (p=0.007), occupation of the participants (p<0.032) and monthly family income (p=0.017) from the χ^2 test. However, the logistic regression model showed no significant differences. We observed attitude differences among the respondents based on their vaccination status (p<0.001). People with poor levels of attitude towards coronavirus variants were not willing to get vaccinated against COVID-19. The odds of having low attitude levels were 11.605 times higher in vaccinated participants than in non-vaccinated individuals or respondents unwilling to take COVID-19 vaccines (p=0.002; 95% CI, 2.396 to 56.207). Attitude difference was significantly observed depending on the concern regarding COVID-19 (p<0.001). Also, the odds of having lower attitude levels were 23.399 times higher in concerned participants than those who were not concerned at all about new

Table 2 Distribution of COVID-19 associated attitudes among study participants and factors associated with poor attitude

Variables	Attitude levels						
	Good, n (%)	Moderate, n (%)	Poor, n (%)	χ^2 (df) p value	Adjusted OR	95% CI	P value
Sex							
Male	379 (76.3)	87 (17.5)	31 (6.2)	9.923 (2) 0.007	1.496	0.673 to 3.321	0.323
Female	471 (81.9)	89 (15.5)	15 (2.6)		Ref.	Ref.	Ref.
Age in years							
18–30	600 (79.4)	123 (16.3)	33 (4.4)	7.831 (8) 0.450	1.83	0.12 to 28.021	0.664
31–40	65 (72.2)	19 (21.1)	6 (6.7)		1.056	0.082 to 13.521	0.967
41–50	84 (80.0)	19 (18.1)	2 (1.9)		0.42	0.026 to 6.687	0.539
51–60	77 (81.1)	14 (14.7)	4 (4.2)		0.5	0.037 to 6.684	0.6
>60	24 (92.3)	1 (3.8)	1 (3.8)		Ref.	Ref.	Ref.
Educational qualification							
Illiterate/primary	18 (81.8)	2 (9.1)	2 (9.1)	9.135 (6) 0.166	0.7	0.065 to 7.602	0.77
Secondary	78 (86.7)	12 (13.3)	0 (0.0)		0	0	0.996
Higher secondary	163 (81.9)	29 (14.6)	7 (3.5)		0.39	0.142 to 1.067	0.067
Undergraduate or higher	591 (77.7)	133 (17.5)	37 (4.9)		Ref.	Ref.	Ref.
Occupation							
Students	554 (79.7)	113 (16.3)	28 (4.0)	25.29 (14) 0.032	0.219	0.023 to 2.062	0.184
Teachers	27 (87.1)	3 (9.7)	1 (3.2)		0.483	0.02 to 11.746	0.655
Govt employee	26 (86.7)	2 (6.7)	2 (6.7)		1.125	0.058 to 21.956	0.938
Non. govt employee	44 (69.8)	18 (28.6)	1 (1.6)		0.228	0.01 to 5.129	0.352
Business	57 (74)	12 (15.6)	8 (10.4)		1.369	0.108 to 17.313	0.808
Homemaker	51 (72.9)	17 (24.3)	2 (2.9)		2.189	0.115 to 41.565	0.602
Retired/ unemployed	69 (84.1)	10 (12.2)	3 (3.7)		1.08	0.074 to 15.729	0.955
Healthcare/ frontline	22 (91.7)	1 (4.2)	1 (4.2)		Ref.	Ref.	Ref.
Monthly family income (KBDT)							
<10	150 (87.2)	17 (9.9)	5 (2.9)	18.637 (8) 0.017	Ref.	Ref.	Ref.
10–25	141 (72.3)	44 (22.6)	10 (5.1)		1.301	0.365 to 4.629	0.685
25–50	297 (76.3)	74 (19.0)	18 (4.6)		1.672	0.494 to 5.661	0.409
50–100	210 (83.7)	30 (12.0)	11 (4.4)		1.4	0.373 to 5.247	0.618
>100	52 (80.0)	11 (16.9)	2 (3.1)		1.105	0.163 to 7.464	0.919
Marital status							
Unmarried	554 (79.1)	115 (16.4)	31 (4.4)	0.095 (2) 0.954	1.186	0.292 to 4.814	0.812
Married	296 (79.6)	61 (16.4)	15 (4.0)		Ref.	Ref.	Ref.
Residence							
Rural	267 (77.7)	56 (16.2)	21 (6.1)	3.936 (2) 0.140	1.864	0.87 to 3.995	0.109
Urban	581 (80.0)	120 (16.5)	25 (3.4)		Ref.	Ref.	Ref.
Location							

Continued

Table 2 Continued

Variables	Attitude levels			χ^2 (df) p value	Adjusted OR	95% CI	P value
	Good, n (%)	Moderate, n (%)	Poor, n (%)				
Dhaka	537 (80.3)	111 (16.6)	21 (3.1)	27.65 (14) 0.016	Ref.	Ref.	Ref.
Chittagong	84 (74.3)	22 (19.5)	7 (6.2)		2.53	0.863 to 7.419	0.091
Rajshahi	55 (77.5)	12 (16.9)	4 (5.6)		1.507	0.387 to 5.868	0.554
Khulna	118 (84.9)	16 (11.5)	5 (3.6)		1.566	0.462 to 5.307	0.471
Barisal	11 (91.7)	0 (0.0)	1 (8.3)		6.338	0.665 to 60.384	0.108
Sylhet	1 (25.0)	2 (50.0)	1 (25.0)		11.816	0.862 to 162.03	0.065
Mymensingh	25 (69.4)	8 (22.2)	3 (8.3)		5.559	1.32 to 23.419	0.019
Rangpur	19 (67.9)	5 (17.9)	4 (14.3)		15.791	4.096 to 60.881	<0.001
Comorbid chronic diseases							
Yes	231 (79.1)	48 (16.4)	13 (4.5)	0.026 (2) 0.987	1.451	0.635 to 3.313	0.377
No	619 (79.4)	128 (16.4)	33 (4.2)		Ref.	Ref.	Ref.
Previous history of COVID-19							
Yes	57 (79.2)	11 (15.3)	4 (5.6)	0.349 (2) 0.840	1.659	0.487 to 5.646	0.418
No	793 (79.3)	165 (16.5)	42 (4.2)		Ref.	Ref.	Ref.
Vaccination status							
Yes	158 (84.0)	26 (13.8)	4 (2.1)	42.008 (4) <0.001	Ref.	Ref.	Ref.
No, but will take vaccine	637 (81.0)	120 (15.3)	29 (3.7)		3.285	0.786 to 13.733	0.103
No, and will not take vaccine	55 (56.1)	30 (30.6)	13 (13.3)		11.605	2.396 to 56.207	0.002
Concern regarding COVID-19							
Very concerned	559 (84.7)	86 (13.0)	15 (2.3)	90.594 (4) <0.001	Ref.	Ref.	Ref.
Somewhat	262 (74.2)	75 (21.2)	16 (4.5)		2.043	0.923 to 4.526	0.078
Not at all	29 (49.2)	15 (25.4)	15 (25.4)		23.399	8.617 to 63.533	<0.001

df, degree of freedom; KBDT, Kilo Bangladeshi taka; N, Number.

coronavirus variants (p<0.001; 95% CI, 8.617 to 63.533) (table 2).

Practices toward new SARS-CoV-2 variants

We evaluated the practices of participants regarding COVID-19 preventive measures using five questions. The score of each question ranges from 1 to 5. The average practice score was 4.464. Based on the score, 858 (80%) participants had a good practice level, 60 (6%) of the participants had a moderate practice level and 154 (14%) of the participants had a poor practice level (figure 2). Most participants (77.9%) who were vaccinated or keen to be vaccinated were maintaining social distancing. We observed that 79.9% of vaccinated participants were using face masks. Also, 82% of the participants were willing to follow self-isolation for COVID-19 symptoms that appeared even after vaccination. Among the respondents, 80.6% of the participants were interested in using soap and sanitiser despite getting vaccinated. Most participants (78.7%) wanted to avoid social gatherings after immunisation.

Association between practices and characteristics of study participants

We analysed the distribution of preventive practices against SARS-CoV-2 variants among the participants for different demographic characteristics. The χ^2 test and logistic regression model revealed that sex, educational qualification, monthly income, location, comorbid disease and previous history of COVID-19 were associated with poor health safety practices towards COVID-19. We observed significant differences among the respondents in following preventive measures according to their age (p=0.002), marital status (p<0.001) and occupation (p=0.001). The rural people had a low level of health safety practices. Compared with urban people, the odds of having poorer practice levels were 2.707 times greater in rural people (p<0.001; 95% CI, 1.677 to 4.369). We noticed the difference in practices between the vaccinated and non-immunised participants. Also, we observed significant practice differences among participants based on concerns about COVID-19 (p<0.001) because the

Table 3 Distribution of COVID-19 associated practices among study participants and factors associated with poor practice

Variables	Knowledge levels						
	Good, n (%)	Moderate, n (%)	Poor, n (%)	χ^2 (df) p value	Adjusted OR	95% CI	P value
Sex							
Male	385 (77.5)	31 (6.2)	81 (16.5)	3.853 (2) 0.146	0.987	0.62 to 1.569	0.954
Female	473 (82.3)	29 (5.0)	73 (12.7)		Ref.	Ref.	Ref.
Age in years							
18–30	578 (76.5)	52 (6.9)	126 (16.7)	23.995 (8) 0.002	0.376	0.024 to 5.83	0.484
31–40	79 (87.8)	2 (2.2)	9 (10.0)		0.985	0.077 to 12.608	0.991
41–50	96 (91.4)	2 (1.9)	7 (6.7)		0.612	0.046 to 8.216	0.711
51–60	82 (86.3)	2 (2.1)	11 (11.6)		2.154	0.162 to 28.571	0.561
>60	23 (88.5)	2 (7.7)	1 (3.8)		Ref.	Ref.	Ref.
Educational qualification							
Illiterate/primary	19 (86.4)	0 (0.0)	3 (13.6)	8.678 (6) 0.193	0.404	0.066 to 2.467	0.327
Secondary	81 (90.0)	4 (4.4)	5 (5.6)		0.283	0.082 to 0.978	0.046
Higher secondary	157 (78.9)	10 (5.0)	32 (16.1)		1.009	0.576 to 1.767	0.976
Undergraduate or higher	601 (79.0)	46 (6.0)	114 (15.0)		Ref.	Ref.	Ref.
Occupation							
Students	530 (76.3)	42 (6.0)	123 (17.7)	35.69 (14) 0.001	2.893	0.272 to 30.728	0.378
Teachers	30 (96.8)	0 (0.0)	1 (3.2)		0.596	0.02 to 17.699	0.765
Govt employee	28 (93.3)	0 (0.0)	2 (6.7)		3.958	0.128 to 121.97	0.432
Non. govt employee	59 (93.7)	3 (4.8)	1 (1.6)		0.577	0.019 to 17.868	0.753
Business	63 (81.8)	4 (5.2)	10 (13.0)		0.886	0.067 to 11.704	0.927
Homemaker	62 (88.6)	1 (1.4)	7 (10.0)		1.4	0.099 to 19.884	0.804
Retired/ unemployed	64 (78.0)	9 (11.0)	9 (11.0)		2.866	0.215 to 38.136	0.425
Healthcare/frontline	22 (91.7)	1 (4.2)	1 (4.2)		Ref.	Ref.	Ref.
Monthly family income (KBDT)							
<10	141 (82.0)	13 (7.6)	18 (10.5)	8.808 (8) 0.359	0.688	0.211 to 2.251	0.537
10–25	146 (74.9)	13 (6.7)	36 (18.5)		1.352	0.457 to 3.998	0.586
25–50	311 (79.9)	19 (4.9)	59 (15.2)		1.376	0.486 to 3.897	0.547
50–100	204 (81.3)	13 (5.2)	34 (13.5)		1.133	0.384 to 3.344	0.821
>100	56 (86.2)	2 (3.1)	7 (10.8)		Ref.	Ref.	Ref.
Marital status							
Unmarried	531 (75.9)	46 (6.6)	123 (17.6)	22.257 (2) <0.001	1.856	0.68 to 5.068	0.227
Married	327 (87.9)	14 (3.8)	31 (8.3)		Ref.	Ref.	Ref.
Residence							
Rural	252 (72.8)	25 (7.2)	69 (19.9)	16.794 (2) <0.001	2.707	1.677 to 4.369	<0.001
Urban	606 (83.5)	35 (4.8)	85 (11.7)		Ref.	Ref.	Ref.
Location							

Continued

Table 3 Continued

Variables	Knowledge levels			χ^2 (df) p value	Adjusted OR	95% CI	P value
	Good, n (%)	Moderate, n (%)	Poor, n (%)				
Dhaka	535 (80.0)	36 (5.4)	98 (14.6)	14.74 (14) 0.396	Ref.	Ref.	Ref.
Chittagong	87 (77.0)	6 (5.3)	20 (17.7)		1.02	0.522 to 1.992	0.954
Rajshahi	54 (76.1)	4 (5.6)	13 (18.3)		0.712	0.321 to 1.575	0.401
Khulna	118 (84.9)	9 (6.5)	12 (8.6)		0.603	0.272 to 1.34	0.215
Barisal	12 (100.0)	0 (0.0)	0 (0.0)		0	0	0.998
Sylhet	2 (50.0)	0 (0.0)	2 (50.0)		1.889	0.127 to 28.133	0.644
Mymensingh	28 (77.8)	2 (5.6)	6 (16.7)		1.57	0.585 to 4.216	0.37
Rangpur	22 (78.6)	3 (10.7)	3 (10.7)		0.948	0.251 to 3.581	0.937
Comorbid chronic diseases							
Yes	239 (81.8)	18 (6.2)	35 (12)	1.977 (2) 0.372	Ref.	Ref.	Ref.
No	619 (79.4)	42 (5.4)	119 (15.3)		1.037	0.592 to 1.815	0.899
Previous history of COVID-19							
Yes	57 (79.2)	4 (5.6)	11 (15.3)	0.052 (2) 0.974	1.044	0.441 to 2.471	0.922
No	801 (80.1)	56 (5.6)	143 (14.3)		Ref.	Ref.	Ref.
Vaccination status							
Yes	182 (96.8)	6 (3.2)	0 (0.0)	265.70 (4) <0.001	0	0	0.994
No, but will take vaccine	652 (83.0)	45 (5.7)	89 (11.3)		0.055	0.032 to 0.095	<0.001
No, and will not take vaccine	24 (24.5)	9 (9.5)	65 (66.3)		Ref.	Ref.	Ref.
Concern regarding COVID-19							
Very concerned	555 (84.1)	27 (4.1)	78 (11.8)	43.912 (4) <0.001	Ref.	Ref.	Ref.
Somewhat	274 (77.6)	24 (6.8)	55 (15.6)		1.229	0.778 to 1.942	0.376
Not at all	29 (49.2)	9 (15.3)	21 (35.6)		7.708	3.328 to 17.852	<0.001

df, degree of freedom; KBDT, Kilo Bangladeshi taka; N, Number.

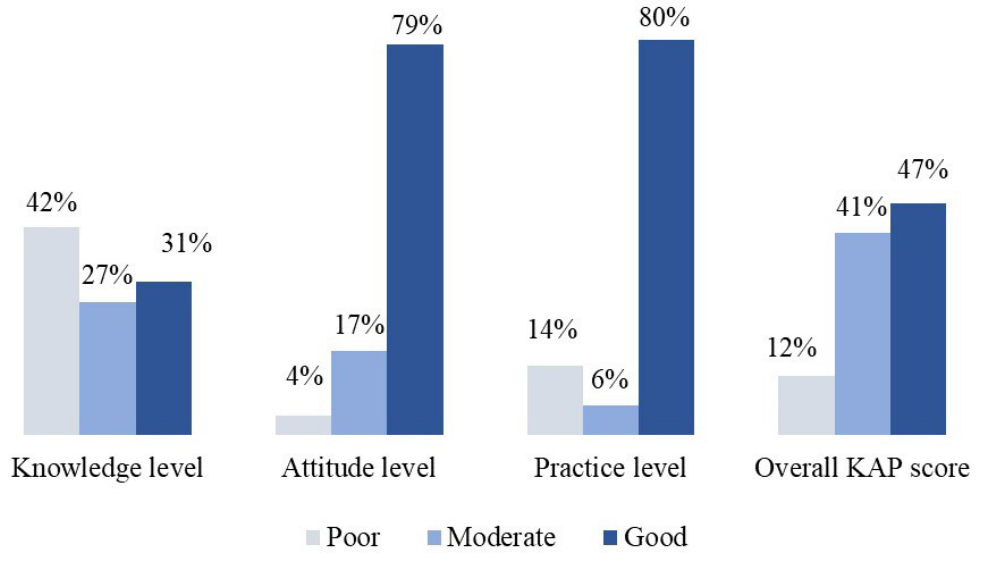

Figure 2 Level of knowledge, attitude and practices against SARS-CoV-2 variants among study participants.

concerned people were more likely to have higher practice levels. The odds of having poorer practice levels were 7.708 times greater in concerned participants than those who were not concerned at all about new coronavirus variants (p<0.001; 95% CI, 3.328 to 17.852) (table 3). We conducted this KAP study to get an idea of the level of knowledge, attitude and practice regarding COVID-19, especially about the mutant strains among the population of Bangladesh. The KAP score depends on responses by participants. We classified the participants into three groups according to their KAP scores such as good (47%), moderate (41%) and poor (12%) (figure 2).

DISCUSSION

According to the present findings, we observed that the Bangladeshi people do not have adequate knowledge about the mutation, characteristics and efficacy of vaccines against the coronavirus. The attitude of the respondents towards the mutant strains was not up to the mark. The practice level of the respondents was on the higher side despite having mixed opinions about the mutant strains. The contributing factors behind these facts might be the lack of health programmes to raise knowledge among people about the mutant strains.[32 33] Mutation of a virus is not a graspable term for the general population in any country. Hence, the authorities should increase the knowledge about viral mutation and its health impact among the general population. This KAP study indicated that the people with a higher level of education were more knowledgeable about COVID-19 and practiced healthcare measures better. A study found that higher levels of education were associated with more dedicated practitioners against COVID-19.[26] This study also revealed that non-government employees had low knowledge levels about COVID-19 and emerging SARS-CoV-2 variants. As a developing country, many people in Bangladesh with lower education levels have inadequate knowledge about COVID-19. So, a lack of education is associated with levels of knowledge about infectious diseases. Therefore, education proved to be a vital factor for knowledge associated with COVID-19. This result is consistent with other KAP studies conducted in Pakistan and South Korea.[34 35] Therefore, quality education and awareness are recommended to prevent infectious diseases.

Rural people showed low knowledge levels and healthcare practices because they are more reluctant to follow proper measures against infectious diseases.[36 37] This finding is similar to a study done in Bangladesh on cholera, where the authors observed that rural children were more likely to get infectious diseases than urban children.[38] Another KAP study in Bangladesh reported that rural people had lower KAP scores.[39] Geographical location was a determining factor for the knowledge and attitude levels. According to an earlier study in Palestine, geographical location was vital in implementing preventive measures against COVID-19. Researchers observed that people of a particular area in Palestine followed better healthcare practices than others.[40] Hence, the awareness programmes should be well directed towards specific locations. Our study reflected that people with poor attitudes were reluctant to get vaccinated. Also, we observed that people who follow poor practices were not vaccinated but were willing to get vaccinated. It indicates that the vaccinated people were practicing better healthcare measures and showing better attitudes.[41] Vaccinated people were already very concerned about COVID-19. They follow better hygiene and show a positive attitude.[42] Initially, the authorities of Bangladesh administered the Covishield vaccine manufactured by the Serum Institute of India for mass immunisation. This vaccine was well tolerable and showed few reported mild transitory side effects among the population in Bangladesh.[43] Thus, the authorities can take initiatives to improve awareness among unvaccinated people regarding the safety and importance of vaccines. Another Saudi Arabian study reported that the lower awareness regarding COVID-19 and vaccines can be a reason for people having low levels of knowledge.[44] Our KAP study also mirrored the fact that the people who are careless about COVID-19 had poor knowledge, poor attitudes towards the variant strains, and did not follow the proper practices like a survey result in Ethiopia. In that survey, the authors observed that the people who did not have access to the TV were associated with poor practice. They were not concerned about COVID-19 as people were not accustomed to technology and could not predict the devastating outcome of COVID-19.[31] It is sometimes not possible for authorities to understand the COVID-19-associated knowledge of the general population in any country. In this sense, the present study findings would help healthcare authorities and policymakers to design better healthcare services for the people in Bangladesh. A prior study conducted in Bangladesh confirmed that only 17.2% of undergraduate pharmacy students possessed high levels of COVID-19-associated knowledge.[45]

Strengths and limitations of this study

There are a few limitations of this study. We performed this survey by convenience sampling methods due to COVID-19 imposed restrictions. Students/young population participated more in this online survey due to the easy internet accessibility. This might not guide the public opinion, but the specific group of the society. Furthermore, the self-selection bias by participants can be another drawback. Also, the nature of the study was cross-sectional. Therefore, the causal relationship is not possible to explore. We could have increased the number of questions in the questionnaire to get a detailed description of the mindset of people. The entire KAP study was themed to get an idea about the perception of Bangladeshi people about the mutant strains of coronavirus. We observed some sociodemographic factors such as education, residential area, geographical location and awareness regarding COVID-19 and vaccines were determinants of the perception of coronavirus. Therefore, we recommend healthcare programmes, seminars and

workshops to create awareness and a positive mindset about coronavirus and preventive measures.

Future research

The present KAP study identified contributing factors for inadequate knowledge, poor attitude and improper practices towards COVID-19 and emerging SARS-CoV-2 variants among the Bangladeshi population. This study highlights the need for more awareness campaigns about the preventive measures of new SARS-CoV-2 variants among the general population of Bangladesh. We recommend future studies assessing the impact of knowledge, attitude and practices towards communicable diseases to explore the actual effects of emerging SARS-CoV-2 variants on human health.

Conclusion

Our findings indicate that the people of Bangladesh do not have adequate knowledge about the mutation of the SARS-CoV-2 variants. As coronavirus is continuously mutating to create new variants, it has the potential to cause a massive outbreak. Therefore, government authorities need to arrange an awareness programme to let people know about the devastating impact of COVID-19 that mutated variants may cause. Besides, they can organise effective and customised healthcare programmes to spread knowledge about COVID-19 and SARS-CoV-2 variants. Also, we recommend campaigns and social awareness to build up proper knowledge, a positive attitude and preventive practices.

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Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Informed consent was collected from all participants through the front page of Google Forms where the nature of the study, procedure, and outcomes was documented. The anonymity of study participants and the confidentiality of their information has been strictly maintained. Participants gave informed consent to participate in the study before taking part.

Ethics approval The study was conducted following the International Research Ethics guidelines and adheres to the declarations of Helsinki. Formal ethical approval was granted from the Ethical Review Committee of the Faculty of Allied Health Sciences, Daffodil International University, Bangladesh (Ref: FAHSREC/DIU/2021/1003-22).

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REFERENCES

1 Zhu N, Zhang D, Wang W, *et al*. A novel Coronavirus from patients with pneumonia in China, 2019. *N Engl J Med* 2020;382:727–33.
2 Tan W, Zhao X, Ma X, *et al*. A novel Coronavirus genome identified in a cluster of pneumonia cases — Wuhan, China 2019–2020. *China CDC Wkly* 2020;2:61–2.
3 Merad M, Blish CA, Sallusto F, *et al*. The Immunology and Immunopathology of COVID-19. *Science* 2022;375:1122–7.
4 World Health Organization. WHO Coronavirus (COVID-19) dashboard. 2022. Available: https://covid19.who.int
5 Islam MT, Talukder AK, Siddiqui MN, *et al*. Tackling the COVID-19 pandemic: the Bangladesh perspective. *J Public Health Res* 2020;9:1794.
6 Forchette L, Sebastian W, Liu T. A comprehensive review of COVID-19 Virology, vaccines, variants, and Therapeutics. *Curr Med Sci* 2021;41:1037–51.
7 Akif A, Bhuiyan MA, Islam MR. SARS-COV-2 Omicron Subvariant BF.7 is again triggering the Covid fear: what we need to know and what we should do? *J Med Virol* 2023;95:e28551.
8 Dhama K, Nainu F, Frediansyah A, *et al*. Global emerging Omicron variant of SARS-Cov-2: impacts, challenges and strategies. *J Infect Public Health* 2023;16:4–14.
9 Rahman S, Hossain MJ, Nahar Z, *et al*. Emerging SARS-Cov-2 variants and Subvariants: challenges and opportunities in the context of COVID-19 pandemic. *Environ Health Insights* 2022;16:11786302221129396.
10 Islam MR, Hossain MJ. Detection of SARS-Cov-2 Omicron (B.1.1.529) variant has created panic among the people across the world: what should we do right now. *J Med Virol* 2022;94:1768–9. 10.1002/jmv.27546 Available: https://onlinelibrary.wiley.com/toc/10969071/94/5
11 Rabiul Islam M, Nasreen W, Anjum R, *et al*. Characteristics of the SARS-Cov-2 Omicron (B.1.1.529) variant and emerging impact on global public health. *Clin Pathol* 2022;15:2632010X221124908.
12 Dewan SMR, Islam MR. Increasing Reinfections and decreasing effectiveness of COVID-19 vaccines urge the need for vaccine Customization. *Ann Med Surg (Lond)* 2022;84:104961.
13 Aleem A, Akbar Samad AB, Slenker AK. *Emerging Variants of SARS-CoV-2 And Novel Therapeutics Against Coronavirus (COVID-19)*. Treasure Island, FL: StatPearls Publishing, 2022. Available: https://pubmed.ncbi.nlm.nih.gov/34033342
14 Islam MR. The SARS-Cov-2 Omicron (B.1.1.529) variant and the re-emergence of COVID-19 in Europe: an alarm for Bangladesh. *Health Sci Rep* 2022;5:e545.
15 Islam S, Islam T, Islam MR. New Coronavirus variants are creating more challenges to global Healthcare system: A brief report on the current knowledge. *Clin Pathol* 2022;15:2632010X221075584.
16 Mohapatra RK, Tiwari R, Sarangi AK, *et al*. Omicron (B.1.1.529) variant of SARS-Cov-2: concerns, challenges, and recent updates. *J Med Virol* 2022;94:2336–42.
17 Daria S, Islam MR. The SARS-Cov-2 Omicron wave is indicating the end of the pandemic phase but the COVID-19 will continue. *J Med Virol* 2022;94:2343–5.
18 Sohan M, Hossain MJ, Islam MR. The SARS-Cov-2 Omicron (B.1.1.529) variant and effectiveness of existing vaccines: what we know so far. *J Med Virol* 2022;94:1796–8.
19 Rahman FI, Ether SA, Islam MR. "The "Delta plus" COVID-19 variant has evolved to become the next potential variant of concern: Mutation history and measures of prevention". *J Basic Clin Physiol Pharmacol* 2022;33:109–12.
20 Islam MR, Shahriar M, Bhuiyan MA. The latest Omicron BA.4 and BA.5 lineages are frowning toward COVID-19 preventive measures: A threat to global public health. *Health Science Reports* 2022;5. 10.1002/hsr2.884 Available: https://onlinelibrary.wiley.com/toc/23988835/5/6
21 Shrestha LB, Foster C, Rawlinson W, *et al*. Evolution of the SARS-Cov-2 Omicron variants BA.1 to BA.5: implications for immune escape and transmission. *Rev Med Virol* 2022;32:e2381.

22 Moona AA, Daria S, Asaduzzaman M, *et al*. Bangladesh reported Delta variant of Coronavirus among its citizen: actionable items to tackle the potential massive third wave. *Infect Prev Pract* 2021;3:100159.
23 Gao SJ, Guo H, Luo G. Omicron variant (B.1.1.529) of SARS-Cov-2, a global urgent public health alert *J Med Virol* 2022;94:1255–6.
24 Daria S, Bhuiyan MA, Islam MR. Detection of highly muted Coronavirus variant Omicron (B.1.1.529) is triggering the alarm for South Asian countries: associated risk factors and preventive actions. *J Med Virol* 2022;94:1267–8.
25 Daria S, Asaduzzaman M, Shahriar M, *et al*. The massive attack of COVID-19 in India is a big concern for Bangladesh: the key focus should be given on the interconnection between the countries. *Int J Health Plann Manage* 2021;36:1947–9.
26 Ferdous MZ, Islam MS, Sikder MT, *et al*. Knowledge, attitude, and practice regarding COVID-19 outbreak in Bangladesh: an online-based cross-sectional study. *PLoS One* 2020;15:e0239254.
27 Mangla S, Zohra Makkia FT, Pathak AK, *et al*. COVID-19 vaccine hesitancy and emerging variants: evidence from six countries. *Behav Sci (Basel)* 2021;11:148.
28 Luo Y-F, Chen L-C, Yang S-C, *et al*. Knowledge, attitude, and practice (KAP) toward COVID-19 pandemic among the public in Taiwan: A cross-sectional study. *Int J Environ Res Public Health* 2022;19:2784.
29 Raquib A, Raquib R, Jamil S, *et al*. Knowledge, attitudes, and practices toward the prevention of COVID-19 in Bangladesh: A systematic review and meta-analysis. *Front Med* 2022;9:856156.
30 Emergence of South African variant of SARS-Cov-2 in Bangladesh. 2021. Available: https://www.icddrb.org/news-and-events/news?id=874
31 Feleke BT, Wale MZ, Yirsaw MT. Knowledge, attitude and preventive practice towards COVID-19 and associated factors among outpatient service visitors at Debre Markos compressive specialized hospital, North-West Ethiopia, 2020. *PLoS ONE* 2021;16:e0251708.
32 Islam MR, Hasan M, Nasreen W, *et al*. The COVID-19 vaccination experience in Bangladesh: findings from a cross-sectional study. *Int J Immunopathol Pharmacol* 2021;35:20587384211065628.
33 Bari MdS, Hossain MdJ, Ahmmed F, *et al*. n.d. Knowledge, perception, and willingness towards immunization among Bangladeshi population during COVID-19 vaccine rolling period. *Vaccines*;9:1449.
34 Faisal S, Khotib J, Zairina E. Knowledge, attitudes, and practices (KAP) towards COVID-19 among university students in Pakistan: a cross-sectional study. *J Basic Clin Physiol Pharmacol* 2021;32:681–6.
35 Lee M, Kang BA, You M. Knowledge, attitudes, and practices (KAP) toward COVID-19: a cross-sectional study in South Korea. *BMC Public Health* 2021;21:295.
36 Daria S, Islam MR. The use of cow dung and urine to cure COVID-19 in India: A public health concern. *Int J Health Plann Manage* 2021;36:1950–2.
37 Daria S, Islam MR. Indiscriminate use of antibiotics for COVID-19 treatment in South Asian countries is a threat for future Pandemics due to antibiotic resistance. *Clin Pathol* 2022;15:2632010X221099889.
38 Colombara DV, Cowgill KD, Faruque ASG. Risk factors for severe cholera among children under five in rural and urban Bangladesh, 2000–2008: A hospital-based surveillance study. *PLoS ONE* 2013;8:e54395.
39 Rahman MS, Karamehic-Muratovic A, Amrin M, *et al*. COVID-19 epidemic in Bangladesh among rural and urban residents: an online cross-sectional survey of knowledge, attitudes, and practices. *Epidemiologia (Basel)* 2020;2:1–13.
40 Qutob N, Awartani F. Knowledge, attitudes and practices (KAP) towards COVID-19 among Palestinians during the COVID-19 outbreak: A cross-sectional survey. *PLOS ONE* 2021;16:e0244925.
41 Islam MR. Urgent call for mass immunization against Coronavirus in Bangladesh. *Sci Prog* 2021;104:00368504211058562.
42 Islam T, Hasan M, Rahman MS, *et al*. Comparative evaluation of authorized drugs for treating COVID-19 patients. *Health Sci Rep* 2022;5:e671.
43 Jahan N, Rahman FI, Saha P, *et al*. Side effects following administration of the first dose of Oxford-Astrazeneca's Covishield vaccine in Bangladesh: A cross-sectional study. *Infect Dis Rep* 2021;13:888–901. 10.3390/idr13040080 Available: https://doi.org/10.3390/idr13040080
44 Jan M, Alqahtani M, Amer KA, *et al*. COVID-19 and vaccine hesitancy: individual determinants among Saudis in Asir region. *Cureus* 2022;14:e22331.
45 Ether SA, Emon FA, Roknuzzaman A, *et al*. A cross-sectional study of COVID-19-related knowledge, risk perceptions, and preventive practices among Pharmacy students in Bangladesh. *SAGE Open Med* 2022;10:20503121211073014.