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COVID-19 vaccine uptake in individuals with functional difficulty, disability, and comorbid conditions: insights from a national survey in Bangladesh

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Abstract

Background COVID-19 vaccine uptake among individuals with disabilities is crucial for safeguarding their health and well-being. However, the extent of vaccine uptake among this group remains largely unknown in low- and middle-income countries. This study aims to assess the COVID-19 vaccine uptake among persons with functional difficulty, disability and/or comorbidity in Bangladesh and their associated factors.

Methods Data from 9,370 respondents extracted from the 2021 National Household Survey on Persons with Disability were analysed. The outcome variable was the uptake of at least one dose of the COVID-19 vaccine (yes, no). Key explanatory variables included the presence of disability (yes, no), comorbidity (yes, no), and both comorbidity and disability (yes, no) among persons with functional difficulty. The relationship between the outcome and explanatory variables was determined using mixed-effects multilevel logistic regressions adjusted for covariates.

Results The overall uptake of at least one dose of the COVID-19 vaccine among persons with functional difficulty was 57.37%, among persons with functional difficulty and disability was 48.63% and among persons with functional difficulty and single (57.85%) or multi-comorbidity (60.37%). Compared to the respondents with functional difficulty only, the adjusted odds ratio (aOR) of not receiving any dose of the COVID-19 vaccine for individuals with both functional difficulty and disability was 1.37 (95% CI, 1.22–1.53), and for individuals with functional difficulty, disability and one or more comorbid conditions was 1.30 (95% CI, 1.15–1.47). The aOR of receiving at least one dose of the COVID-19 vaccine among individuals with functional difficulty and one or more comorbid conditions was significantly higher than among those with functional difficulty only.

Conclusion In Bangladesh, COVID-19 vaccine uptake was relatively low among individuals with disabilities. The existing COVID-19 vaccine rollout programs and similar future programs should prioritise individuals with disabilities and include targeted strategies to reach them.

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Keywords COVID-19 vaccine, Functional difficulty, Disability, Comorbidity, Bangladesh

Introduction

The coronavirus, scientifically termed SARS-CoV-2, first detected in December 2019 in Wuhan, China, has posed an unprecedented global health challenge and caused the COVID-19 pandemic [1, 2]. This novel virus exhibits a unique capacity for human-to-human transmission, primarily through respiratory droplets [3]. The clinical manifestations of COVID-19 range from mild respiratory symptoms to severe pneumonia, with individuals of advanced age or underlying health conditions being particularly vulnerable [4]. As of August 2024, the COVID-19 outbreak has resulted in more than 7 million deaths worldwide, though there is evidence of significant undercounting, with estimates suggesting 18.2 to 33.5 million deaths during the same period [5]. The economic impact of the COVID-19 pandemic has been profound, leading to a significant increase in poverty rates and job losses, primarily due to restrictive measures such as travel restrictions and public gathering limitations [6, 7]. Healthcare systems across countries have also been severely affected, with patients suffering from conditions other than COVID-19 facing challenges in accessing adequate services, particularly in low- and middle-income countries (LMICs) [8–10].

The majority of these adverse consequences, including deaths, occurred during the first year (December 2019 to December 2020) and before the rollout of the COVID-19 vaccine [11]. However, the widespread distribution of COVID-19 vaccines since December 2020, particularly in the first half of 2021, marked a turning point in the global pandemic, paving the way for a gradual return to normalcy [12, 13]. By providing protection against severe illness, hospitalization, and death, vaccines significantly reduced the burden of COVID-19 on healthcare systems, allowing for the resumption of social and economic activities [6, 13]. As vaccination rates increased, countries began lifting restrictions on travel, businesses, and public gatherings, enabling individuals to reconnect and engage in activities that had been curtailed during the pandemic's peak [14, 15].

The World Health Organization (WHO) recommends the COVID-19 vaccine for everyone, with a high priority for older adults and the adult population with comorbidities [16]. This guidance is consistently reflected in country-level initiatives globally, including Bangladesh [17, 18]. As a result, COVID-19 vaccine acceptance is notably higher among these priority groups [19]. However, this vaccination effort remains voluntary, with government initiatives primarily focused on raising awareness through mass media [14, 20]. Consequently, vulnerable groups, particularly those who have functional difficulties, are living with chronic conditions, or are economically disadvantaged, have limited access to the COVID-19 vaccine [9, 21, 22].

Globally, around 20% of the population experiences functional difficulty, and a substantial portion of this group has a concurrent disability. Notably, 80% of this population resides in LMICs [23]. This group is severely affected by the COVID-19 pandemic due to existing higher burdens of comorbidity and their marginalized socio-economic conditions, resulting in limited access to healthcare services [23, 24]. In addition to healthcare facility-level barriers such as limited coverage, overcrowding and long waiting times, which disproportionately affect persons with disabilities, in many settings this group was not adequately integrated into the COVID-19 vaccine rollout [25]. Consequently, there is evidence of a higher death rate from COVID-19 among persons with disabilities [23, 26]. However, there is a scarcity of data regarding the uptake of the COVID-19 vaccine among this vulnerable group globally, particularly in LMICs [22, 23, 27]. This study was conducted to assess the COVID-19 vaccine uptake among people with functional difficulties, disability and/or morbidity in Bangladesh and factors associated with that uptake.

Methods

Primary sample

Data for this study were obtained from the National Household Survey on Persons with Disability (NSPD) in 2021. This was a cross-sectional survey conducted by the Bangladesh Bureau of Statistics (BBS) as part of governmental efforts to explore the prevalence of disability in Bangladesh and its socio-demographic and health-related conditions. The survey used two-stage stratified random sampling techniques to select nationally representative households from which the samples were included. In the first stage, a total of 800 primary sampling units (PSUs), each with an area of around 300 households, were selected. This selection was made randomly from the list of 293,579 PSUs generated by the BBS as part of the 2011 National Population Survey. In the second stage, a systematic random sampling method was used to select 45 households from each of the PSUs selected in the first stage. This resulted in a total of 36,000 households, of which 35,462 households were found to be accessible with a 98.6% response rate. All individuals who were usual residents of the selected households were included in the survey. This included 155,025 respondents, of whom 54,172 were children aged 0–17 years and 100,853 were adults and older individuals aged 18–95 years. A pre-designed and pre-tested questionnaire was utilized

for data collection. Additional information regarding the sampling methodology and the questionnaire employed for data collection has been previously published elsewhere [28].

Analytical sample

We analysed the data of 9,370 respondents, extracted from the main survey (Fig. 1). The selection was based on the following inclusion criteria: (i) respondents aged 18–95 years, and (ii) respondents reported functional difficulties who provided responses regarding COVID-19 vaccine-related questions, including registration status for taking the vaccine and whether the vaccine was taken. It is important to mention that the Bangladesh government launched a national immunization scheme for the coronavirus (the virus responsible for COVID-19 disease) on February 7, 2021, initially targeting people aged 40 or more, and later updated it on August 10, 2021, with the decision to include all people aged 18 and above [29, 30]. The survey data we analyzed were collected from November 1 to December 31, 2021, ensuring that all respondents included in our analysis were eligible to take the COVID-19 vaccine at the time of the survey.

Outcome variable

The outcome variable was at least one dose of the COVID-19 vaccine uptake status (yes, no). The relevant data were collected by asking respondents, "*Have you/(name) yet received the Covid-19 vaccine?*". Each respondent was given dichotomous "yes" or "no" options to report.

Explanatory variables

We examined three explanatory variables, with data for two variables directly collected in the survey from the respondents and one generated by us. These variables were the presence of functional difficulty (yes, no), disability with functional difficulty (yes, no), and the co-occurrence of functional difficulty, disability and comorbidity (yes, no). The survey initially posed a set of six questions to the respondents or their actual caregivers to determine functional difficulties (challenges or limitations that individuals may face in performing everyday activities, which can be temporary or permanent and can affect various aspects of a person's life, such as mobility, communication, self-care, and social interactions), following the Washington Group module [31]. These questions were: (i) Do you have difficulty seeing even if wearing glasses?, (ii) Do you have difficulty hearing even if using a hearing aid?, (iii) Do you have difficulty walking or climbing stairs?, (iv) Do you have difficulty remembering or concentrating?, (v) Do you have difficulty with self-care (such as washing all over or dressing)?, (vi) Using your usual (customary) language, do you have difficulty communicating (for example, understanding or being understood by others)?. For each of these questions, respondents could choose from four responses: (a) no difficulty, (b) some difficulty, (c) a lot of difficulty, or (d) cannot do at all. Respondents reporting functional difficulties at any level (some difficulty, a lot of difficulty, or cannot do at all) were then asked to respond to disability-related questions. As per 2013 guidelines on persons with disabilities (condition or state of being that involves impairments, limitations, or restrictions in performing activities and participating fully in society and usually considered long-term and permanent), developed by the government of Bangladesh [32], participants with functional difficulties were asked to report their form of disabilities. This includes autism or autism spectrum disorders, physical disability, mental illness leading to disability, visual disability, speech disability, intellectual disability, hearing disability, deaf-blindness, cerebral palsy, Down syndrome, multiple forms of the aforementioned disabilities and other disabilities. Respondents were allowed to report more than one, if applicable.

The survey subsequently inquired each respondent with functional difficulties about their comorbidity (the state of being diseased or unhealthy, including various health conditions or illnesses) status by asking: "*What other health or physical problem do you (name) have?*" A list of comorbidities, including conditions such as blood pressure, diabetes, asthma, epilepsy, heart problems, physical/movement problems, and other health and physical issues, was provided for respondents to choose from. An open-ended option was also given to indicate if the health condition was not listed. They were also allowed to report more than one option. We later classified these responses to generate a variable indicating whether respondents had functional difficulty only or both functional difficulty and comorbidity.

Covariates

We identified a comprehensive list of covariates based on a literature search covering LMICs and specifically Bangladesh [22, 33–37] and the availability of those covariates in our dataset. Individual-level factors included in the analysis were the age of the respondents (adults aged 18–39 years, late adults aged 40–59 years, and older individuals aged 60 or more), sex (male vs. female), educational qualification (illiterate, primary, secondary, or higher), employment status (agricultural workers, physical workers, business, services, students, housewives, unable to work, and others), and marital status (married, unmarried, and widowed/divorced/separated). At the household level, factors considered were the household wealth index (poorest, poorer, middle, richer, richest) and religion (Muslim vs. others). The survey authority generated the household wealth index using principal

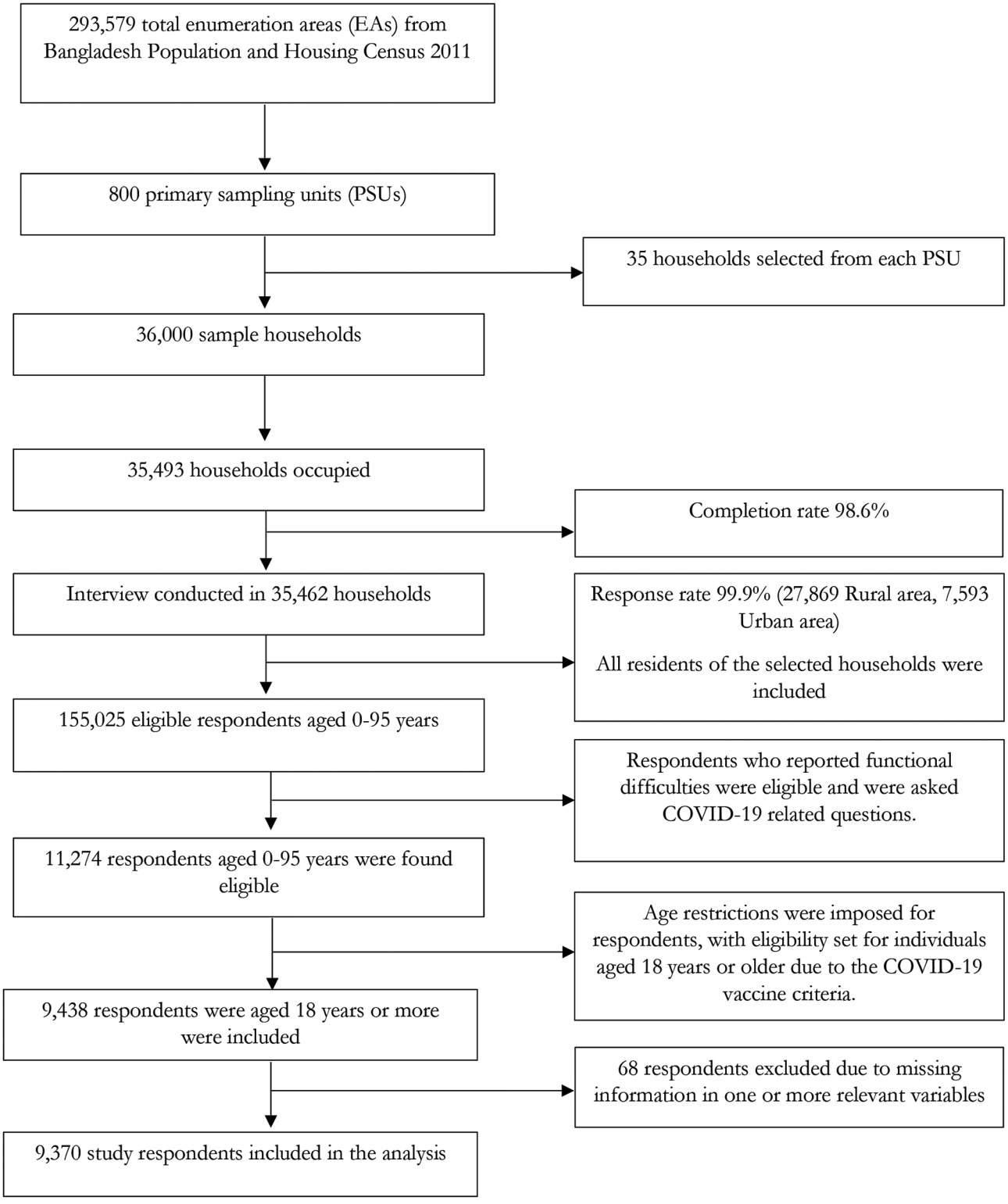


Fig. 1 Sample selection procedure to study COVID-19 vaccine uptake among persons with functional difficulties

component analysis of multiple variables related to household assets, such as ownership of a radio or television and the type of household roof. For community-level factors, we included the place of residence (urban and rural) and the division of residence (Barishal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur and Sylhet).

Statistical analysis

Descriptive statistics were conducted to characterize the respondents. The Pearson chi-square test was used to ascertain factors associated with the uptake of at least one dose of the COVID-19 vaccine and comorbidities. To explore the association between not receiving at least one dose of COVID-19 vaccine and participants' functional difficulty, functional difficulty with disability, and the co-occurrence of functional difficulty, disability and comorbidity, adjusted for possible confounders, three distinct mixed-effect multilevel logistic regression models were employed. We used mixed-effect multilevel regressions because of the nested structure of the NSPD data, where individuals are nested within households, and households are nested within a cluster. This hierarchical structure implies dependency among participants' responses, and previous studies have demonstrated that multilevel modelling yields more accurate results in such scenarios [38]. Before running each model, multicollinearity was checked, and if evidence of multicollinearity was identified, the relevant variable was omitted, and the model was rerun. Results were recorded as adjusted odds ratios (aOR) along with 95% confidence intervals (95% CI). Sampling weight was considered in all analyses. Stata software version 14.0 (StataCorp.org, College Station, Texas, USA) was employed for all statistical analyses.

Results

Background characteristics of the respondents

Table 1 shows the background characteristics of the respondents. Approximately half of the respondents were female and aged 60 years or higher. More than half (56.39%) of the respondents were illiterate. About 28% of the respondents reported being unable to work, 24.01% were housewives and 12.59% were employed in the service sector. Two-thirds of the respondents were married at the time of the survey. Around 24% were in the poorest quintile and 20% in the poorer quintiles. The majority of the respondents resided in rural areas (79.85%), and the largest portion of individuals were located in the Dhaka division (22.32%).

Prevalence of disability and morbidity among people with functional difficulties

Among the respondents having functional difficulties, 36.26% reported having a disability and 66.37% reported having comorbidity (Fig. 2). Nearly 20% of the respondents reported having both comorbidity and disability.

Distribution of disability and comorbidity among people with functional difficulty

Table 2 presents the prevalence of disability and comorbidity among persons with functional difficulty in Bangladesh. The most prevalent types of disability among persons with functional difficulty were physical impairments (46%), followed by visual impairment (16%), and multidimensional disability (10%). Other common forms of disabilities were mental illness (9%), hearing impairment (8%), and intellectual disability (4%). Around two-thirds (66.37%) of the respondents with functional difficulties reported having comorbidity; of them, 36.97% reported single morbidity and 29.40% reported multimorbidity. The most prevalent forms of single morbidity were hypertension (42%), followed by physical/movement problems (19%), heart problems (11%), asthma (11%), and diabetes (9%).

Distribution of the at least one dose of the COVID-19 vaccine uptake across individual-, household-, and community-level factors

Table 3 presents the distribution of at least one dose of the COVID-19 vaccine uptake across disability, comorbidity, and respondents' socio-economic characteristics. The overall proportion of individuals who received at least one dose of the COVID-19 vaccine was 57.37%. This proportion was 48.63% among people with a disability, 57.85% among those with single morbidity and 60.37% among those with multi-morbidity. Respondents aged 45–59 years, females, individuals with higher educational attainment, or those engaged in business were more likely to report receiving at least one dose of the COVID-19 vaccine. A higher proportion (60.58%) of people from the richest wealth quintile received at least one dose of the COVID-19 vaccine. Geographically, respondents residing in the Khulna and Rangpur divisions had an elevated prevalence of at least one dose of COVID-19 vaccine uptake. This variation was even higher at the district level, with only three districts having 80% or more uptake of the COVID-19 vaccines in line with the WHO recommendation (Fig. 3).

At least one dose of the COVID-19 vaccine uptake across different types of comorbidity and disability among people with functional difficulty

We further segregated vaccine uptake status across types of comorbidities and presented the findings in Fig. 4. The uptake of at least one dose of vaccine acceptance was relatively high among respondents living with diabetes (68.3%), hypertension (62.9%), heart problem (60.6%) and asthma (55.1%).

Factors associated with no uptake of the COVID-19 vaccine

The factors influencing not receiving even one dose of the COVID-19 vaccine, as elucidated by multilevel mixed-effect logistic regression models, are presented in Table 4. There was a 1.37 times higher likelihood of not receiving even one dose of the COVID-19 vaccine among

Table 1 Background characteristics of the respondents ($n = 9370$)

Characteristics	Frequency	Percentage	95% Confidence interval	
	(*n*)	(%)	Lower	Upper
Individual-level factor				
Respondents' age				
Adult aged 18–39	1,849	19.73	18.85	20.64
Late adult aged 40–59	2,917	31.13	30.12	32.16
Older aged 60+	4,604	49.14	47.93	50.35
Sex of respondents				
Male	4,659	49.73	48.69	50.76
Female	4,711	50.27	49.24	51.31
Educational qualification				
Illiterate	5,284	56.39	54.95	57.82
Primary	2,078	22.17	21.2	23.17
Secondary	778	8.31	7.685	8.977
Higher	1,230	13.13	12.18	14.13
Respondents' occupation				
Agricultural workers	1,126	12.03	11.2	12.91
Lobourers[+]	630	6.719	6.108	7.387
Business	429	4.574	4.131	5.062
Services	1,180	12.59	11.67	13.57
Students	133	1.42	1.18	1.698
Housewives	2,249	24.01	22.97	25.08
Unable to work	2,644	28.21	27.05	29.41
Others[++]	979	10.45	9.627	11.34
Marital status				
Married	6,094	65.04	63.93	66.13
Unmarried	747	7.97	7.38	8.61
Widowed/Divorced/Separated	2,529	26.99	26	28
Household-level factor				
Religion				
Muslim	8,378	89.41	87.35	91.18
Others	992	10.59	8.82	12.65
Wealth quintile				
Poorest	2,260	24.12	22.53	25.79
Poorer	1,886	20.13	19.04	21.27
Middle	1,880	20.06	18.93	21.25
Richer	1,764	18.82	17.62	20.08
Richest	1,580	16.87	15.30	18.56
Community-level factor				
Place of residence				
Urban	1,888	20.15	18.57	21.83
Rural	7,482	79.85	78.17	81.43
Division of residence				
Barishal	506	5.40	4.77	6.11
Chattogram	1,537	16.40	15.06	17.84
Dhaka	2,091	22.32	20.70	24.02
Khulna	1,264	13.49	12.36	14.71
Mymensingh	706	7.54	6.784	8.372
Rajshahi	1,586	16.93	15.29	18.7
Rangpur	1,137	12.14	11.14	13.21
Sylhet	543	5.79	5.00	6.703

Note[+]Lobourers means industry or factory labour, transportation worker, day labour, rickshaw/van driver, and fisherman. [++]Other occupation defines looking for work, beggar, else occupation, and missing who had no specific work

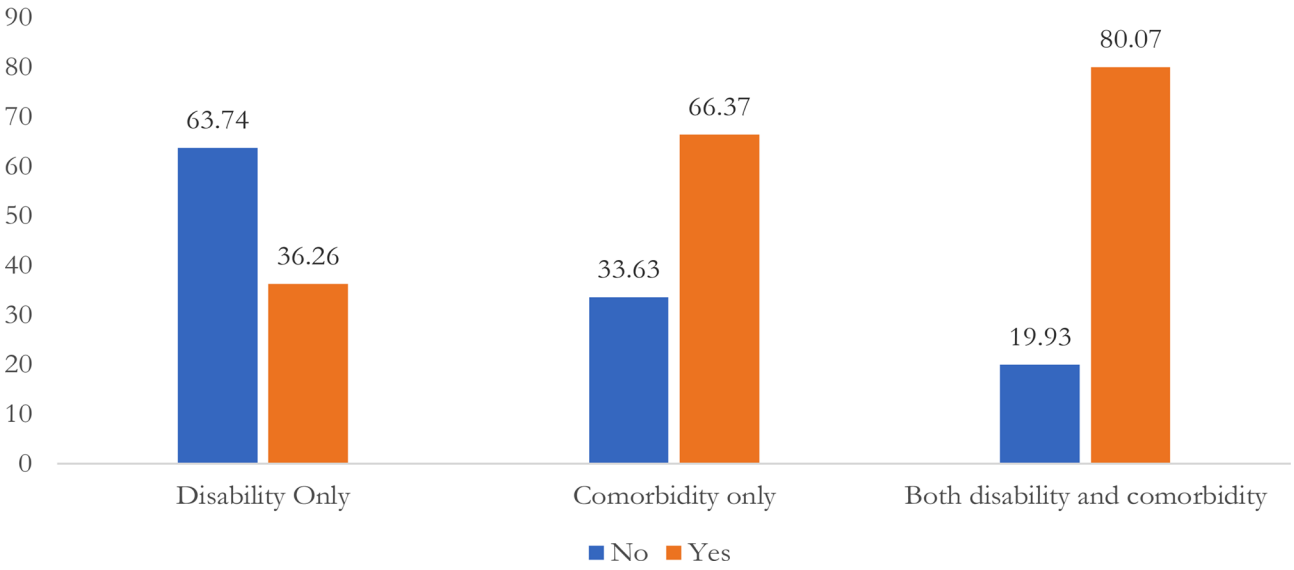


Fig. 2 Distribution of disability and comorbidity among the people with functional difficulty, Bangladesh

Table 2 Prevalence of disability and comorbidity across their types among people with functional difficulty in Bangladesh

Type of disability among people with functional difficulty (n = 3,398)	Percentage (95% CI)	Type of comorbidity among people with functional difficulty (n = 6,219)	Percentage (95% CI)
Autism or autism spectrum disorder	0.67 (0.43–1.06)	**Single morbidity**	**36.97 (35.89–38.07)**
Physical impairment	45.74 (43.87–47.62)	-Hypertension	41.51 (39.20-43.86)
Mental illness	9.45 (8.46–10.54)	-Diabetes	9.30 (8.13–10.61)
Visual impairment	16.23 (14.97–17.58)	-Asthma	10.50 (9.37–11.76)
Speech impairment	2.35 (1.88–2.94)	-Epilepsy	1.55 (1.18–2.02)
Intellectual disability	3.89 (3.27–4.62)	-Heart problem	10.66 (9.52–11.92)
Hearing impairment	8.26 (7.28–9.37)	-Physical/movement problem	19.16 (17.38–21.07)
Hearing-visual impairment	0.57 (0.36–0.86)	-Others	7.32 (6.31–8.49)
Cerebral palsy	0.78 (0.52–1.16)	**Multi-morbidities**	**29.40 (28.00-30.84)**
Down syndrome	0.58 (0.38–0.91)	**No morbidity**	**33.63 (32.33–34.95)**
Multidimensional disability	10.4 (9.32–11.58)		
Others	1.08 (0.77–1.52)		

respondents with functional difficulties and disabilities compared to those experiencing functional difficulties only (adjusted odds ratio [aOR], 1.37; 95% confidence interval [95% CI], 1.22–1.53). Furthermore, in comparison to respondents with functional difficulty only, those with functional difficulty and single or multi-morbidity showed a 12% (aOR 0.88, 95% CI, 0.78–0.99) and 18% (aOR 0.82, 95% CI, 0.71–0.94) decreased odds of not receiving of the COVID-19 vaccine, respectively. In other words, among respondents with functional difficulty, those with single or multi-morbidity had 1.14 times (95% CI, 1.01–1.28) and 1.23 times (95% CI, 1.07–1.41) higher odds of receiving at least one dose of the COVID-19 vaccine, respectively. Participants with both comorbidity and disability had a 1.30 times increased likelihood of not receiving even a single dose of the COVID-19 vaccine compared to those living with functional difficulty only.

The likelihood of not receiving any dose of the COVID-19 vaccine was 32–34% higher among female than male participants. An increase in education level corresponded to significantly decreased likelihoods of not receiving (i.e., higher likelihood of receiving) at least one dose of the COVID-19 vaccine among respondents. Increased likelihoods of not receiving any dose of the COVID-19 vaccine were found among labourers, those unable to work, and others, while decreased likelihoods were observed among housewives, and service/business compared to those engaged in agricultural work. Individuals who were unmarried [3.65–3.85 times] or widowed/divorced/separated [1.43–1.45 times] showed higher likelihoods of not receiving the COVID-19 vaccine compared to married respondents. Reduced likelihoods of not receiving (i.e., higher likelihood of receiving) the COVID-19 vaccine were observed among individuals practicing religions other than Islam (Table 4). However,

Table 3 Distribution of at least one dose of COVID-19 vaccine uptake across individual-, household-, and community-level factors among respondents with functional difficulty, Bangladesh ($n = 9,370$)

Characteristics	At least one dose of the COVID-19 vaccine uptake		p-value
	No	Yes	
Total	**42.63**	**57.37**	
Individual-level factors			
Disability only			< 0.001
No	37.66	62.34	
Yes	51.37	48.63	
Comorbidity status			< 0.001
No morbidity	45.79	54.21	
Single morbidity	42.15	57.85	
Multi-morbidity	39.63	60.37	
Both comorbidity and disability with functional difficulty			< 0.001
No	40.51	59.49	
Yes	51.17	48.83	
Respondents' age			< 0.001
Adult aged 18–39	54.22	45.78	
Late adult aged 40–59	35.16	64.84	
Older aged 60+	42.71	57.29	
Sex of respondents			< 0.001
Male	40.75	59.25	
Female	44.49	55.51	
Educational qualification			< 0.001
Illiterate	46.76	53.24	
Primary	41.02	58.98	
Secondary	38.56	61.44	
Higher	30.18	69.82	
Respondents' occupation			< 0.001
Agricultural workers	33.16	66.84	
Labourers	46.01	53.99	
Business	28.97	71.03	
Services	37.29	62.71	
Students	54.25	45.75	
Housewives	33.92	66.08	
Unable to work	56.6	43.4	
Others^{+}	44.52	55.48	
Marital status			< 0.001
Married	36.08	63.92	
Unmarried	71.67	28.33	
Widow/Divorce/Separate	49.84	50.16	
Household-level factors			
Religion			< 0.05
Muslim	43.49	56.51	
Hindu	35.73	64.27	
Other religion	31.52	68.48	
Wealth quintile			< 0.05
Poorest	46.06	53.94	
Poorer	41.65	58.35	
Middle	42.46	57.54	
Richer	42.36	57.64	
Richest	39.42	60.58	
Community-level factors			
Place of residence			0.973
Urban	42.62	57.38	
Rural	42.69	57.31	
Division of residence			< 0.001
Barishal	45.67	54.33	
Chattogram	45.81	54.19	
Dhaka	41.18	58.82	
Khulna	33.91	66.09	
Mymensingh	48.6	51.4	
Rajshahi	43.25	56.75	
Rangpur	40.77	59.23	

Note All values are weighted, and row percentages are presented. p-values are obtained from the Pearson chi-square test. The "+Other occupation" category encompasses individuals engaged in looking for work, beggars, self-employed individuals, or those who did not disclose their occupation

the odds of receiving at least one dose of the COVID-19 vaccine among participants from the richest households were significantly higher than those from the poorest households. Furthermore, there was a decreased likelihood of not receiving (i.e., higher likelihood of receiving) the COVID-19 vaccine among respondents residing in the Khulna, Rangpur, and Dhaka divisions, while there were increased likelihoods for participants in the Chattogram, Mymensingh, and Sylhet divisions compared to those residing in the Barishal division.

Discussion

The aims of this study were to assess the uptake of at least one dose of the COVID-19 vaccine among people experiencing functional difficulty with disability and/or comorbidity. The overall prevalence of uptake of at least one dose of the COVID-19 vaccine was 57.37% among persons with functional difficulty, lower among respondents with functional difficulty and disability (48.63%), higher among those with functional difficulty and single (57.85%) and multi-comorbidity (60.35%). The findings also underscore the inadequate healthcare received by respondents with disability and both disability and comorbidity during uncertain events such as the COVID-19 pandemic. The results emphasize the imperative for tailored policies and programs specifically designed for individuals with disabilities in anticipation of future uncertain events.

We found a higher likelihood of not receiving at least one dose of the COVID-19 vaccine among respondents with functional difficulty and disability alone or both disability and comorbidity compared to those with

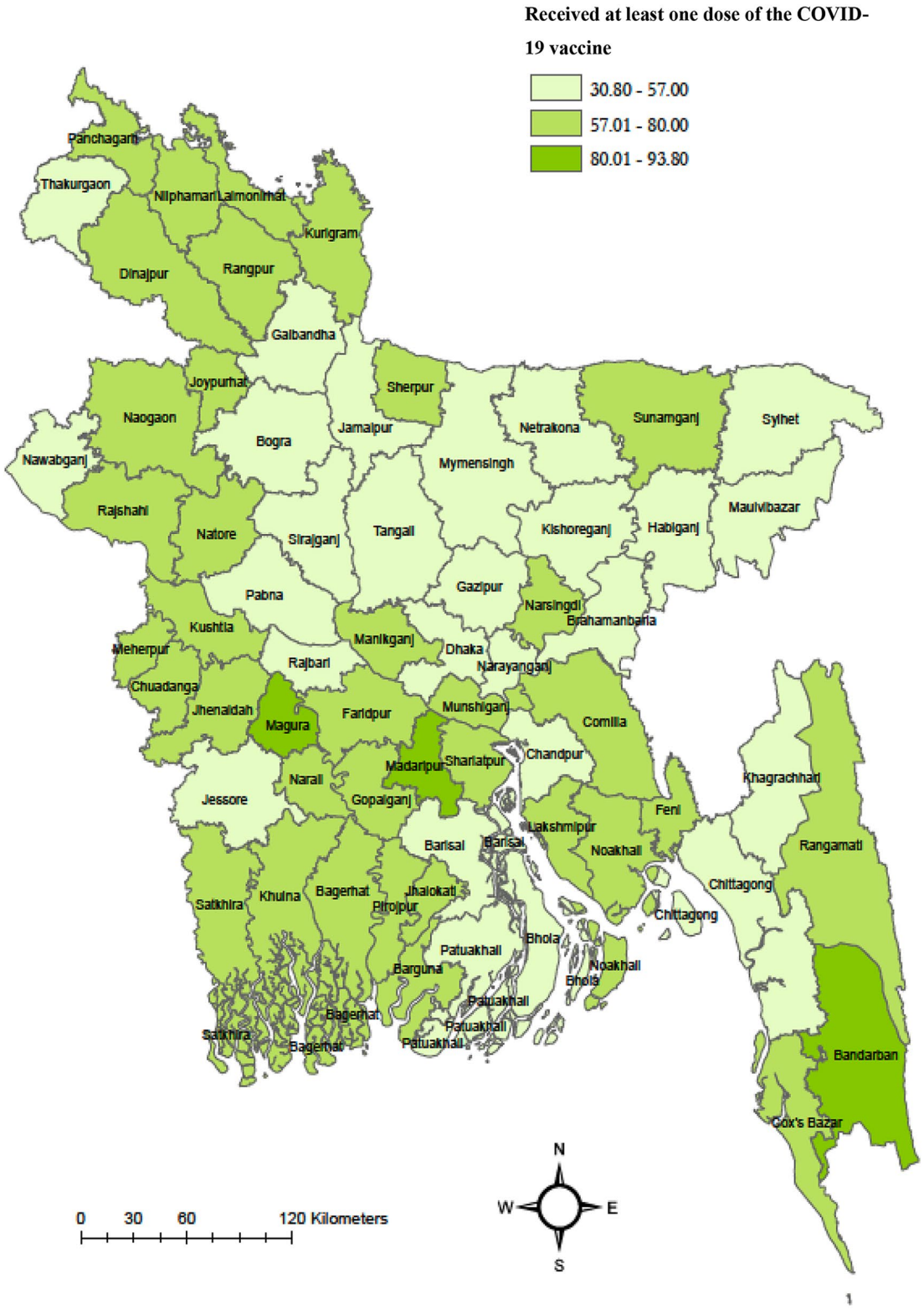


Fig. 3 District-level distribution of at least one dose of the COVID-19 vaccine uptake among persons with functional difficulties in Bangladesh

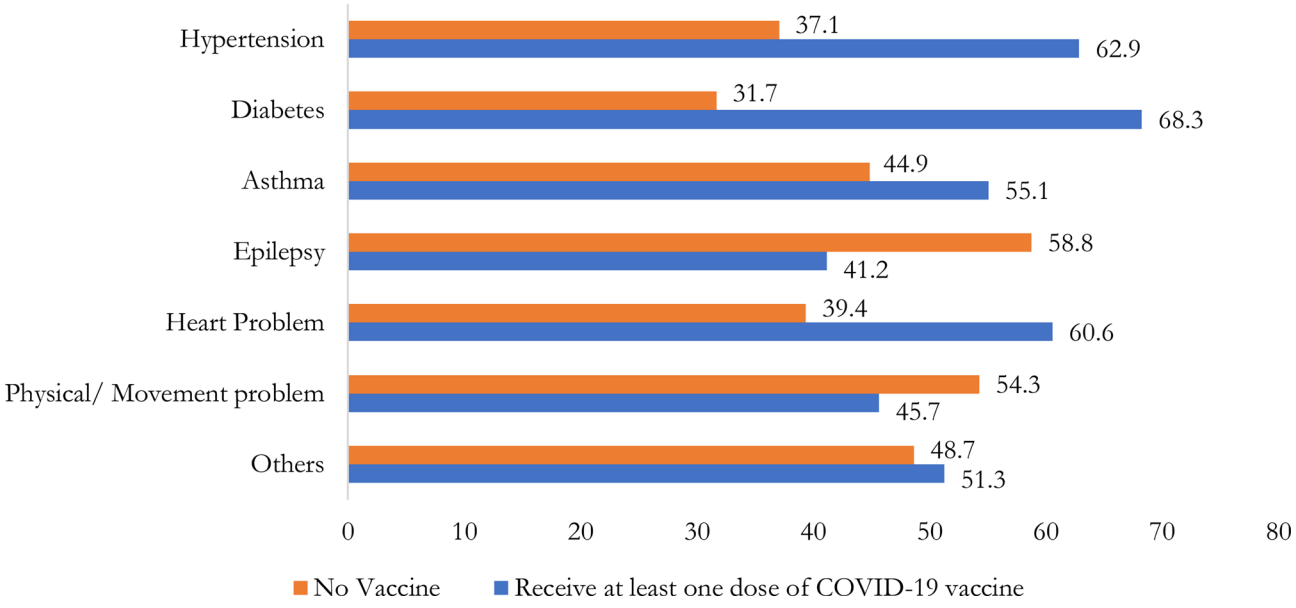


Fig. 4 Prevalence of COVID-19 vaccine uptake among people with functional difficulties across their disability and comorbidity status

functional difficulty only. However, those with functional difficulty and one or more comorbidities exhibited a higher likelihood of receiving at least one dose of the COVID-19 vaccine. While an exact comparison to our findings for LMICs was not possible due to a lack of relevant data, studies in developed countries consistently highlight higher vulnerability among persons with disabilities to COVID-19 [23, 24, 27]. This dearth of evidence may introduce additional barriers to achieving predictable and successful vaccination among vulnerable groups, who already exhibit a reduced tendency to utilize immunization services in general [4, 22]. The reasons for the higher likelihood of not receiving the COVID-19 vaccines by individuals with functional difficulty having a disability or both disability and comorbidity are complex; however, major contributing factors include challenges at both societal and health facility levels [23, 35]. These stem from ingrained societal stigmas and discriminatory practices perpetuate marginalization and exclusion [39].

Pervasive stigma surrounding disabilities often lead to limited access to information and healthcare services, leaving individuals with disabilities uninformed about the importance and safety of COVID-19 vaccines [24]. This lack of awareness, coupled with misconceptions and fearmongering, fuels vaccine hesitancy and reluctance to seek vaccination [33]. Secondly, physical and communication barriers pose significant challenges to getting to the vaccination sites [25]. Transportation limitations, inadequate infrastructure, and inaccessible facilities hinder mobility for individuals with disabilities, while communication barriers, such as the lack of sign language interpreters or accessible information formats, impede effective communication and informed decision-making [23, 40]. Crowded vaccination centre, along with long waiting times, may also deter persons with disabilities from receiving the COVID-19 vaccination [27]. The online-based registration system for COVID-19 vaccines presented another challenge, as many persons with disabilities lack access to such platforms [41]. Additionally, the country, like other LMICs and developed countries, has not made any separate arrangements to ensure vaccination for people with functional difficulties with disability, comorbidity, or both, which further hinders their vaccine acceptance.

Moreover, entrenched social norms and cultural beliefs can dissuade individuals with disabilities from seeking vaccines [39]. In Bangladesh, as in other LMICs, individuals with disabilities are often perceived as vulnerable and dependent, leading to decisions being made on their behalf without their full participation or consent [23, 25]. This lack of autonomy and informed consent create further barriers to vaccination [33]. Additionally, as persons with disabilities typically stay at home more than the general population, they may be considered less vulnerable to contracting the coronavirus, fostering the perception that COVID-19 vaccination is not essential [34].

Individuals with comorbidities like diabetes, hypertension, and heart disease exhibit higher uptake of the COVID-19 vaccines than those with functional difficulty only. These findings are comparable with the available studies in LMICs and developed countries [18, 34, 42, 43]. This paradox stems from several factors: Firstly, individuals with comorbidities often have established relationships with healthcare providers due to their ongoing medical needs. These regular interactions with healthcare professionals provide opportunities for education,

Table 4 Mixed-effects multilevel logistic regression models exploring factors associated with not receiving the COVID-19 vaccine by people with functional difficulty in Bangladesh, NSPD 2021

Characteristics	Model 1 aOR (95% CI)	Model 2 aOR (95% CI)	Model 3 aOR (95% CI)
Individual-level factor			
Disability (Ref: No §)			
Yes	1.37 (1.22–1.53) ***	-	-
Comorbidity status (Ref: No morbidity)			
Single morbidity	-	0.88 (0.78–0.99) **	-
Muti-morbidity	-	0.82 (0.71–0.94) **	-
Both disability and comorbidity (Ref: No §)			
Yes	-	-	1.30 (1.15–1.47) ***
Respondent's age	0.99 (0.99-1.00) ***	0.99 (0.99–0.99) ***	0.99 (0.99–0.99) ***
Sex of respondent's (Ref: Male)			
Female	1.34 (1.16–1.59) ***	1.32 (1.14–1.54) ***	1.32 (1.14–1.53) ***
Educational qualification (Ref: Illiterate)			
Primary	0.86 (0.76–0.98) **	0.86 (0.76–0.98) **	0.85 (0.75–0.97) **
Secondary	0.81 (0.67–0.98) **	0.81 (0.67–0.98) **	0.80 (0.66–0.97) **
Higher	0.50 (0.42–0.60) ***	0.50 (0.42–0.60) ***	0.50 (0.41–0.59) ***
Respondent's occupation (Ref: Agriculture workers)			
Labourers	1.36 (1.08–1.73) **	1.34 (1.06–1.70) **	1.36 (1.08–1.73) **
Business	0.79 (0.60–1.05))	0.80 (0.61–1.07)	0.79 (0.59–1.04)
Services	0.90 (0.72–1.11)	0.90 (0.73 – 0.12)	0.89 (0.72–1.10)
Students	1.24 (0.79–1.99)	1.24 (0.77–1.98)	1.25 (0.78–1.99)
Housewives	0.74 (0.60–0.93) ***	0.74 (0.59–0.92) **	0.73 (0.58–0.90) **
Unable to work	2.24 (1.86–2.69) ***	2.47 (2.05–2.97) ***	2.25 (1.87–2.72) ***
Others	1.32 (1.06–1.65) **	1.37 (1.10–1.70) **	1.34 (1.07–1.66) **
Marital status (Ref: Married)			
Unmarried	3.64 (2.88–4.59) ***	3.76 (2.98–4.74) ***	3.85 (3.06–4.86) ***
Widow/Divorce/Separate	1.43 (1.25–1.64) ***	1.44 (1.25–1.65) ***	1.45 (1.26–1.66) ***
Household-level factor			
Religion (Ref: Muslim)			
Others	0.63 (0.52–0.80) ***	0.63 (0.51–0.78) ***	0.64 (0.52–0.78) ***
Wealth quintile (Ref: Poorest)			
Poorer	0.83 (0.72–0.96) **	0.83 (0.71–0.96) **	0.83 (0.72–0.96) **
Middle	0.97 (0.83–1.13)	0.96 (0.83–1.12)	0.97 (0.83–1.12)
Richer	0.94 (0.79–1.10)	0.92 (0.78–1.09)	0.93 (0.79–1.09)
Richest	0.77 (0.63–0.94) **	0.77 (0.63–0.94) **	0.76 (0.62–0.93) **
Community-level factor			
Place of residence (Ref: Urban)			
Rural	0.90 (0.72–1.13)	0.90 (0.71–1.13)	0.91 (0.72–1.14)
Division of residence (Ref: Barishal)			
Chattogram	1.08 (0.75–1.54)	1.09 (0.76–1.55)	1.08 (0.75–1.54)
Dhaka	0.89 (0.63–1.27)	0.90 (0.63–1.27)	0.90 (0.63–1.28)
Khulna	0.58 (0.40–0.84) ***	0.59 (0.41–0.86) **	0.58 (0.40–0.84) **
Mymensingh	1.16 (0.78–1.73)	1.13 (0.76–1.70)	1.18 (0.79–1.75)
Rajshahi	1.03 (0.72–1.48)	1.03 (0.72–1.48)	1.03 (0.72–1.48)
Rangpur	0.81 (0.56–1.18)	0.82 (0.57–1.20)	0.83 (0.57–1.21)
Sylhet	1.24 (0.83–1.86)	1.24 (0.83–1.86)	1.24 (0.83–1.86)
Model summary			
Variance of random intercept model	0.95 (0.87–1.03) ***	0.95 (0.86–1.04) ***	0.95 (0.87–1.04) ***
Intra-class correlation (ICC)	21% (± 0.02)	22% (± 0.02)	22% (± 0.02)
Akaike's Information Criterion (AIC)	11369.24	11392.38	11382.58
Bayesian Information Criteria (BIC)	11583.81	11614.10	11597.15

Note § the reference group is individuals with functional difficulty only, ***=P-value less than 0.01, **=P-value less than 0.05, Ref=Reference category

counselling, and vaccine administration, increasing the likelihood of vaccination acceptance. Secondly, individuals with comorbidities are more aware of their vulnerability to severe COVID-19 outcomes, prompting them to seek vaccination as a protective measure. The heightened risk perception stems from increased exposure to health information and personal experiences with health complications. Thirdly, individuals with comorbidities are often more proactive in managing their health, making them more inclined to adopt preventive measures like vaccination. This proactive approach to health management likely extends to COVID-19 vaccination.

Socio-demographic conditions of respondents may significantly influence the likelihood of individuals receiving the COVID-19 vaccine from various perspectives. Notably, increased age and education have been associated with a higher likelihood of receiving at least one dose of the COVID-19 vaccine [18, 28, 44]. This connection is likely to be attributed to increased healthcare use and, therefore, awareness of their health conditions by people of relatively high age and socio-economic status. We also found a lower likelihood of receiving at least one dose of the COVID-19 vaccine among unmarried or widowed/divorced/separated people than married people. This phenomenon could be attributed to a combination of factors. Firstly, unmarried individuals may encounter constraints in accessing healthcare services and comprehensive information about vaccination, impeding informed decision-making. Secondly, divorced/separated individuals may face social isolation and limited social support networks, hindering their motivation to seek vaccination. Moreover, ingrained gender norms and cultural beliefs may discourage women from making independent choices regarding their health, including vaccination [45]. Additionally, financial constraints may pose challenges in affording transportation to vaccination centre or covering associated costs like childcare [7, 40]. However, the lower likelihood of uptake of at least one dose of the COVID-19 vaccine among individuals with both disability and comorbidity is attributed to the combined effect of pervasive individual- social- and healthcare facility-level challenges related to disability and slightly higher likelihood of uptake among those with comorbidity.

The findings of this paper underscore critical needs for policies and programs to ensure vaccination for individuals with disabilities during future events similar to the COVID-19 pandemic. It is likely that a subset of participants did not receive any doses due to hesitancy towards the COVID-19 vaccine. Previous studies found a small but substantial proportion of people with disabilities had reluctance towards COVID-19 vaccines [46–48]. Thus, addressing the misconceptions and social barriers of people with disabilities is crucial in this regard. Implementing targeted outreach programs, culturally sensitive communication strategies, and creating accessible infrastructure are essential for equitable access to vaccination. These measures aim to empower individuals with disabilities, enabling them to make informed decisions about their health and fostering inclusivity in vaccination initiatives.

This study possesses several strengths and a few limitations. The data analysed were derived from a nationally representative survey, employing globally recognized criteria such as the Washington Group on Disability to logically categorize disability and comorbidity status. The association between not accepting at least one dose of the COVID-19 vaccine and disability and comorbidity status was determined through advanced statistical modelling, encompassing a wide range of confounders, and accounting for survey weights. These methodological strengths enhance the validity of our study findings, marking it as the first of its kind in Bangladesh and other LMICs, to our knowledge. However, the primary limitations lie in its cross-sectional design, indicating that the findings reported are correlational rather than causal. It is also possible that, in addition to the reported comorbidity, various other morbidities and pregnancy could hinder COVID-19 vaccine uptake. The survey relied on self-reported data, including information on persons with disability and morbidity, introducing the possibility of recall bias. Moreover, the three outcomes we considered—disability with functional difficulties, comorbidity status with functional difficulties, and both disability and comorbidity with functional difficulties—may be related to each other, with one potentially causing the other, such as comorbidity leading to functional difficulties. However, we could not account for this in our analyses due to a lack of data. Additionally, crucial healthcare facility-level factors, such as access to healthcare services and the distance to the nearest healthcare facility, were not considered in the analyses due to the unavailability of this data. Despite these challenges, the findings of this study are likely to serve as the basis for shaping policies and programs to ensure vaccination among persons with disabilities during future events akin to the COVID-19 pandemic.

Conclusion

The overall uptake of at least one dose of the COVID-19 vaccine was 57.37% among persons with functional difficulties and 48.63% among persons with functional difficulties and disabilities. Respondents' disability, with or without comorbidity, was associated with a relatively low likelihood of receiving at least one dose of the COVID-19 vaccine. However, comorbidity/multimorbidity among people with functional difficulties was associated with a higher likelihood of receiving at least one dose of the

COVID-19 vaccine. Existing policies and programs to roll out the COVID-19 vaccine need to prioritize persons with functional difficulties and disabilities with comorbid conditions.

Abbreviations

COVID-19	Corona Virus Disease 2019
LMICs	Low- and middle-income countries
WHO	World Health Organization
NSPD	National Survey on Persons with Disability
BBS	Bangladesh Bureau of Statistics
PSU	Primary Sampling Unit
aOR	Adjusted Odds Ratio
CI	Confidence Interval

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Author contributions
Khanam SJ and Rana MS developed the study concept. Rana MS conducted data analysis. Khanam SJ drafted the initial manuscript. Islam MM, Khanam SJ, Rana MS and Khan MN critically reviewed the manuscript. All authors approved the final version of the manuscript.

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Data availability
The authors have included all relevant data associated with this study in the manuscript. For additional data relevant to the manuscript, interested parties should contact the corresponding author. However, access to the complete dataset requires researchers to contact the Bangladesh Bureau of Statistics (https://bbs.gov.bd) and submit a formal research proposal, following a similar process as the one we adhered to.

Declarations

Ethics approval and consent to participate
The survey underwent review and approval by the Ethical Review Committee of the Bangladesh Bureau of Statistics. Informed written consent was obtained from all respondents before their participation in the survey. In instances where respondents were unable to provide written consent due to factors such as illiteracy or cognitive disabilities, informed written consent was obtained from their legal guardians. We explored de-identified data from the BBS by submitting a research proposal for this study. Therefore, additional ethical approval to conduct this study was not required.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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