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Hesitancy towards COVID-19 booster vaccine among healthcare workers in Bangladesh

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Abstract

Background Despite completing the COVID-19 vaccination series, healthcare workers (HCWs) remain at an elevated risk of re-infection. Booster uptake, though essential for this group, remains poorly characterized among Bangladeshi HCWs. This study identified the prevalence and driving factors behind booster hesitancy among Bangladeshi HCWs, providing valuable insights for targeted interventions.

Method From December 2022 to June 2023, we conducted a cross-sectional survey among 1772 HCWs enrolled from 20 healthcare facilities of all tiers purposively selected across four administrative divisions of Bangladesh. We collected information through face-to-face interviews regarding their sociodemographic, pre-existing, and currently existing medical conditions, COVID-19 vaccination status, and their intention, hesitancy, and willingness to receive future booster doses. We used a multivariable logistic regression model to analyze factors associated with booster hesitancy. Odd's ratio with 95% confidence intervals (CIs) was calculated for each factor, with $p < 0.05$ considered statistically significant.

Result Of the 1772 HCWs interviewed in our study, 49% (879) were nurses [median age 36 years (IQR: 30.0-46.0)]; 69% were female. Among the respondents, 94% (1667) were willing to take a booster, and 6% (105) showed hesitancy. Safety concerns, especially regarding potential side effects post-booster administration (86%), emerged as the leading cause of booster hesitancy among healthcare workers. Our multivariable logistic regression analysis revealed that support staff, compared to physicians, were the most hesitant to receive any additional booster dose (aOR 4.68, 95% CI: 1.56-9.03; p=0.006). Compared to rural residency, HCWs with an urban residency type were also more reluctant to receive booster doses (aOR 4.45, 95% CI: 2.03-9.73; $p < 0.001$).

Conclusion Concerns about side effects following booster administration were the primary driver of hesitancy in our study. Targeted interventions focusing on education and addressing these anxieties—supported by evidence-based communication strategies—could play a crucial role in improving booster acceptance and safeguarding this vulnerable workforce.

Keywords COVID-19, Booster dose, Healthcare workers, Booster hesitancy, Vaccine acceptance, Bangladesh

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Background

The emergence of the severe acute respiratory coronavirus (SARS-CoV-2), the virus responsible for COVID-19 has triggered over 776 million confirmed cases and more than seven million deaths worldwide [1]. The pandemic caused by the virus has impacted every aspect of human life, including the environment, economy, and mental health [2, 3]. While interventions like using personal protective equipment (PPE), quarantining, and social distancing played crucial roles in curbing the pandemic's spread [4], achieving herd immunity through mass vaccination has emerged as the cornerstone of long-term control [5]. Several vaccines are currently approved worldwide, using mRNA, adenovirus vector, whole-inactivated coronavirus, or protein subunit vaccine platforms [6]. Available vaccines against SARS-CoV-2 have been shown to produce rapid and effective immune responses after the primary vaccine series of 2 doses [7, 8].

However, due to the virus's rapid evolution, several variants of concern (VOCs) have emerged in recent years, including the Delta and Omicron variants [9]. Growing evidence suggests that these new variants can evade vaccine-induced antibodies due to a high number of mutations in their S proteins. This could lead to easier infection than earlier variants [10–12]. Although the scheduled two vaccine doses can reduce deaths and hospitalization rates in SARS-CoV-2-infected individuals [13], the protective effect of the vaccines wanes over time. It is reported that after the second dose, by week 20, the vaccine effectiveness of Oxford-AstraZeneca ChAdOx1 nCoV-19 reduced to 44% from 92% [14] and to 63% from 89 to 97% in the case of the Pfizer-BioNTech BNT162b2 vaccine [15]. This is attributed to a natural decline in antibody titers after vaccination [16]. Additional risk factors such as age, gender, occupation, vaccine types, and co-morbid conditions also reduce vaccine effectiveness [17–19]. As a result, 'Breakthrough infection' or reinfection with SARS-CoV-2 has been reported in fully vaccinated individuals [20].

Based on the evidence of waning vaccine effectiveness, both the US CDC and WHO recommend getting an extra dose or a booster dose of the COVID-19 vaccine after 4–6 months of completing the primary vaccine series [21, 22]. Studies have shown that a booster dose of the vaccine can increase immunogenicity and peak antibody levels in healthy adults who received the initial two doses [23, 24]. As of 30th September 2023, approximately 5 billion people have taken the primary series of COVID-19 globally, whereas only 2.7 billion people received the booster dose [25]. On the other hand, although 84% of the total population has completed the initial protocol of the scheduled vaccine doses in Bangladesh, only 48% have received the booster [26].

Healthcare Workers (HCWs) face an elevated risk of breakthrough infections due to frequent occupational exposure, with studies indicating that over 25% of HCWs experience reinfection despite full vaccination [27]. Additionally, they may act as vectors for SARS-CoV-2 transmission to vulnerable patient populations [28]. Recognizing this, the US CDC and WHO have prioritized HCWs for booster doses. Beyond physicians, other healthcare professionals also engage directly with patients, playing a critical role in providing assistance and shaping patient perceptions regarding vaccination. Therefore, including a diverse range of healthcare staff in research on COVID-19 vaccine hesitancy is essential to capture insights that could influence broader vaccine acceptance and uptake among patients [29].

While healthcare worker hesitancy toward COVID-19 booster doses has been widely documented in high-income countries [30–32], there is limited information on the attitudes of HCWs in a low- and middle-income country (LMIC) such as Bangladesh, with distinct healthcare challenges and resource constraints. Understanding booster hesitancy in this context is essential, as HCWs in LMICs face unique occupational risks and often serve as primary sources of health information for patients. This study seeks to quantify booster hesitancy among Bangladeshi HCWs and examine sociodemographic and occupational factors influencing their attitudes to inform targeted interventions to enhance booster uptake and protect vulnerable populations.

Method

Study design and participants

Between December 2022 and June 2023, we conducted a cross-sectional study leveraging an ongoing HCW cohort platform in Bangladesh. We recruited all categories of healthcare workers (e.g., physicians, nurses, and support staff) into our study who met the inclusion criteria of (a) being involved in direct or indirect patient care and (b) providing written informed consent to participate. The support staff included cleaning and laundry personnel, radiology physicians and technicians, clerks, phlebotomists, respiratory therapists, nutritionists, social workers, physical therapists, laboratory personnel, cleaners, patient transporters, catering staff, etc. We only excluded recruiting administrative personnel and HCWs employed in basic medical sciences of the facilities (i.e., who were not engaged in clinical care) from our study.

We selected healthcare workers from purposively chosen sites across four administrative divisions—Dhaka, Chittagong, Khulna, and Rangpur of Bangladesh (Fig. 1). The study sites comprised four medical college hospitals (tertiary care), two district hospitals (secondary care), 12 Upazila Health Complexes (primary care), and 120 community health centres (primary care). The sites were

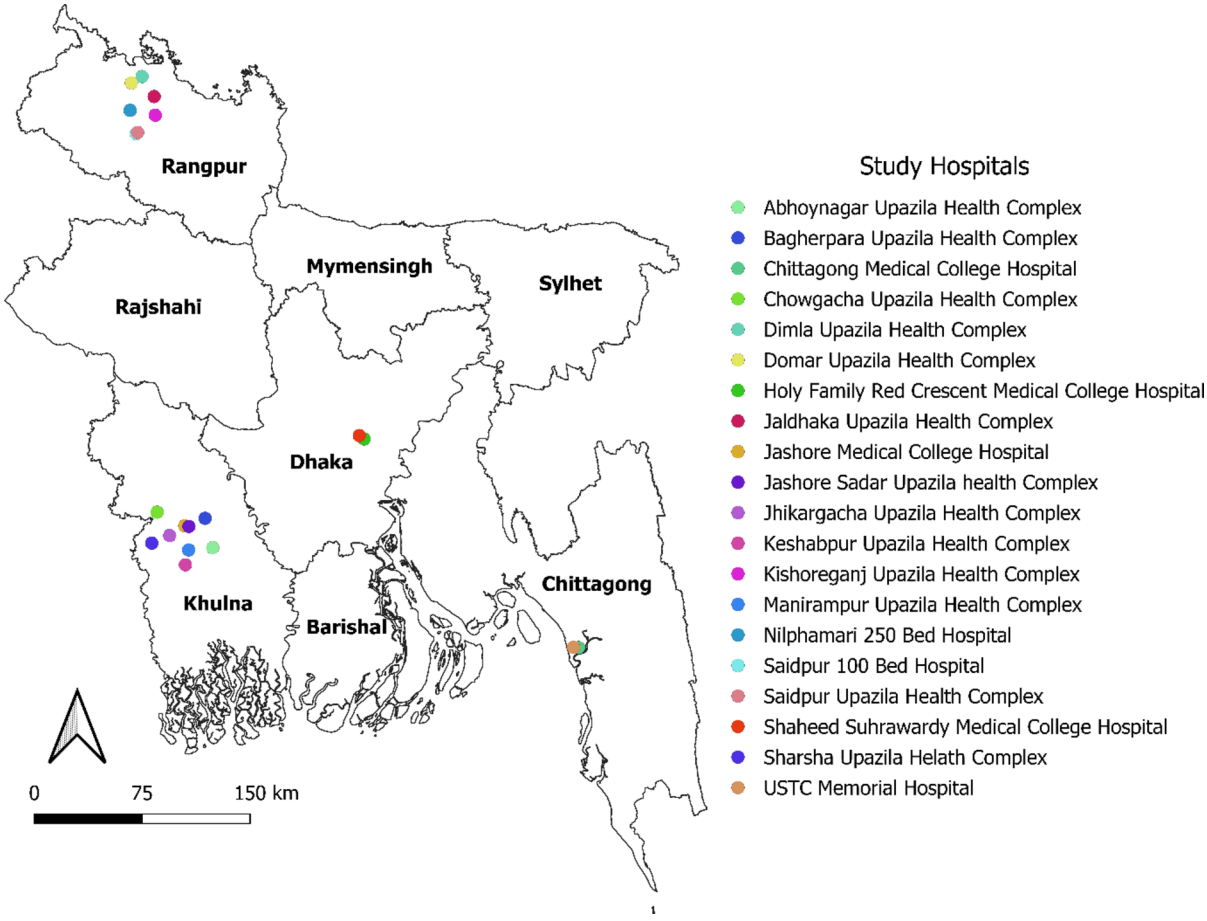

Fig. 1 Administrative divisions depicting the areas from where healthcare facilities and subsequently healthcare workers were chosen. Source: Authors generated the map using QGIS version 3.32.3

chosen to represent four geographically diverse regions of the country and all types of health facilities, including private and public institutions.

Data collection

We collected data through face-to-face interviews using a structured questionnaire. Trained study staff interviewed and collected data on basic demographics (e.g., age, sex, socioeconomic status) and clinical information, including pre-existing and current medical conditions, history of exposure to SARS-CoV-2 (e.g., exposure to COVID-19 patients), and respiratory illness. They also collected data on COVID-19 primary series vaccine uptake (e.g., date of vaccination, doses, brand, and adverse events following immunization), previous history of COVID-19 infection, and whether they required hospitalization due to the disease during the interview using a hand-held tablet computer. Completion of the self-reported primary series of the COVID-19 vaccination status of the participants was verified and confirmed by the vaccination cards available to the HCWs. Before data collection, we pre-tested the questionnaire. The questionnaire was amended based on the responses received during the pre-testing. We then assessed the internal consistency reliability of the final version of the questionnaire, and Cronbach's alpha was found to be 0.74, indicating acceptable internal consistency and reliability for the questionnaire. The questionnaire is added in Supplemental File 1.

Booster vaccination intention

We assessed booster vaccine intentions based on responses to the question, "When a coronavirus booster vaccine becomes available to you, are you going to take one?" Responses were categorized as "Yes," "No," or "Not sure." Participants who answered "Yes" were classified as the "Willing group," while those who answered "No" or "Not sure" were grouped as the "Hesitant group."

To further explore the reasons behind willingness or hesitancy, participants in both groups were asked to select their primary motivation from a predefined list of 10 options. These options were adapted from the existing literature [33–35] and tailored to ensure relevance to the local context. The statements were as follows:

"It is safe to vaccinate with the booster vaccine"
"The booster vaccine is effective"
"The emergence of mutant viruses may reduce the protective effect of previous vaccination"
"Suggestions or recommendations from others"
"I am afraid of the needle"
"I am unsure if the vaccine will be free or not"
"The vaccine might have side effects/safety concerns"
"I don't know how long the vaccine protection will last"
"I have doubts about proper preservation of the vaccine"
"For religious beliefs and reasons"

This approach allowed us to capture specific factors influencing each group's stance on the COVID-19 booster dose.

Major independent variables

Based on existing literature, we identified key explanatory variables that could influence the decision to accept booster vaccines among HCWs [36–41]. These variables included demographic, health-related, and occupational characteristics. Demographic factors encompassed age, sex, monthly family income (defined as the total income from all sources by all family members as reported by the interviewee), residence type, and level of education. Health-related factors included the presence of comorbidities, a previous COVID-19 diagnosis, a positive history of hospitalization due to COVID-19, completion of the COVID-19 vaccine primary series, and any side effects experienced after completing the primary series. Occupational characteristics covered the type of healthcare facility, working hours, and healthcare provider category.

Data analysis

We used descriptive statistics to summarize the participants' characteristics and attributes according to their intention to receive booster doses. Continuous variables were summarized using the mean and standard deviation (SD) or the median and interquartile range (IQR) based on their distribution. For categorical variables, frequencies and percentages were calculated. Additionally, we also performed chi-square tests to examine the associations between participants' characteristics and attributes and their intention to receive booster doses.

To identify factors associated with hesitancy toward booster vaccines among HCWs, we first employed univariate logistic regression models to examine the crude associations between the dependent and independent variables. Results from each univariate model were presented as unadjusted Odd's Ratios (OR) with 95% confidence intervals (CIs). Using a backward selection algorithm, we then applied a multivariable logistic regression model to identify factors associated with hesitancy among the HCWs toward receiving COVID-19 booster doses. Variables that exhibited statistical significance in the univariable model with a p-value < 0.2 were subsequently incorporated into the multivariable model. Before including the predictors and finalizing the multivariable model, we assessed multicollinearity as a precautionary step (Supplemental Table 1). The findings of the final multivariable model were presented as adjusted Odd's Ratios (aOR) along with their associated 95% confidence intervals (CI). We utilized a two-tailed alpha level of 0.05 as the threshold for statistical significance. All analysis was conducted with Stata 15.0 software (StataCorp. 2015. Stata Statistical Software: Release 15. College Station, TX: StataCorp LP).

Ethical consideration

The Institutional Review Board of International Centre for Diarrheal Disease Research, Bangladesh (icddr, b) reviewed and approved the study protocol. All participants provided written informed consent before enrollment.

Result

Demographic characteristics of the HCWs

We enrolled 1772 HCWs in our study during the study period, and the median age of the respondents was 36 years (IQR: 30–46). Of them, 69% (1218) were female. Among the participants, 49% (879) were nurses, followed by 30% (528) support staff and 21% (365) physicians (Table 1). Fifty-six percent (993) of our healthcare workers were recruited from tertiary level hospitals, followed by primary 22% (395) and secondary 22% (384) level healthcare facilities. Nearly all (1732, 98%) of HCWs from our study reported completing the primary series of the COVID-19 vaccine. About 33% (590) of healthcare workers reported being infected with the SARS-CoV-2 virus at least once since the beginning of the pandemic in March 2020. Among them, 31% (183) reported requiring hospitalization due to severe illness with COVID-19.

Acceptance of the COVID-19 booster dose

Among the participants, 94% (1667) belonged to the 'willing group' and were willing to receive a booster dose if one becomes available. The main reason behind their willingness to receive it was their perception of the vaccine as safe (80%) and effective (55%). Additionally, 38% (633) believed that the virus's ability to mutate rapidly and generate new variants could decrease the effectiveness of the previous vaccines. On the other hand, only 6% (105) of study participants hesitated to receive a booster in our study, and 86% (91) were concerned about the vaccine side effects. Additionally, almost half of them (46%) were unsure about the duration of the additional dose that could provide them with protection from infection and the severity of SARS-CoV-2 (Table 2).

Table 1 Baseline characteristics of healthcare workers (*N* = 1772) of selected healthcare facilities of Bangladesh from December 2022 to June 2023

Demographic Characteristics (*N* = 1772)	*n* (%)
Age in year	
Median age (IQR)	36 (30–46)
< 30	338(19)
30–44	965(54)
≥ 45	469(26)
Sex	
Female	1218(69)
Educational level	
Up to primary education	194(11)
Secondary education	163(9)
Graduation and above	1415(80)
Place of residence	
Rural	779(44)
Urban	993(56)
Monthly income of the participants	
< 25,000 BDT	209(12)
25,000 to < 50,000 BDT	442(25)
> 50,000 BDT	1121(63)
Type of HCW	
Physician	365(21)
Nurse	879(49)
Support staff	528(30)
Weekly working hours	
≤ 48	465(25)
> 48	1307(75)
Type of healthcare facility	
Primary	395(22)
Secondary	384(22)
Tertiary	993(56)
Having any co-morbid condition	
Yes	929(52)
No	843(48)
Type of co-morbid condition	
Hypertension	334(36)
Diabetes	233(25)
Asthma	178(19)
Heart disease	64(7)
Others*	151(16)
Previously infected with COVID-19	
Yes	590(33)
No	1182(67)
Hospitalization history due to COVID-19	
Yes	183 (31)
COVID-19 vaccine uptake	
Yes	1732 (98)
Side effects after vaccination	
Yes	1041(69)
Type of side effects	
Injection site pain	598(57)
Fever	406(39)
Fatigue	39(4)
Headache	139(13)
Myalgia	260(25)

*Others included cancer, COPD, chronic liver disease, chronic kidney disease, stroke and dyslipidemia, chronic neurological disease

Characteristics of the participants based on their intention to receive the booster vaccine

In our study, 69% (1,144) of participants intending to receive a COVID-19 booster dose were female. Among HCW types within the "Willing" group, 50% (826) were nurses, followed by 29% (484) support staff, and 21% (357) doctors. Over half of those willing to take a booster dose were employed at tertiary-level healthcare facilities. Furthermore, 33% (558) of the "Willing" participants had a previous COVID-19 infection, while 67% (1,109) intended to receive the booster despite no prior infection.

Conversely, 70% (73) of the participants in the "Hesitant" group had no history of SARS-CoV-2 infection. Among the "Willing" group, 98% (1,633) had completed the primary COVID-19 vaccination series, whereas 95% (99) of those in the "Hesitant" group had also received the initial two doses (Table 3).

Factors associated with hesitancy towards receiving the COVID-19 booster dose

Results from our bivariate analysis showed that participants working in tertiary care hospitals were 2.42 times more likely to be hesitant (OR: 2.42, 95% CI: 1.35–4.32; $p = 0.003$) than those working in primary healthcare facilities. HCWs who had finished up to their primary education were also 2.89 times more likely to exhibit hesitancy (OR: 2.89, 95% CI: 1.79–4.65; $p < 0.001$) than those who had completed their graduation. Moreover, HCWs who had completed their primary vaccine series against COVID-19 were 2.66 times (OR: 2.66, 95% CI: 1.01–6.99; $p = 0.040$) more likely to be hesitant than those who did not complete their vaccine series.

In multivariable analysis, the support staff were 4.68 times more hesitant to take an additional booster vaccine than physicians (aOR: 4.68, 95% CI 1.56–9.03; $p = 0.006$). HCWs who reported working less than 48 h a week also showed higher hesitancy than those who worked more than 48 h a week (aOR: 2.38, 95% CI: 1.50–3.77; $p < 0.001$). Moreover, HCWs residing in an urban residence had 4.45-fold increased hesitancy towards COVID-19 booster doses than those with rural residence (95% CI 2.03–9.73, $p < 0.001$) (Table 4). Additionally, participants with a monthly family income between 25,000 and 50,000 BDT were 1.82 times more hesitant than those whose family income was more than 50,000 BDT (aOR: 1.82, 95% CI: 1.03–3.20; $p = 0.039$).

Table 2 Reasons for taking or not taking the COVID-19 booster dose of selected healthcare facilities in Bangladesh from December 2022 to June 2023 (*N* = 1772)

	n **(%)**
Reason to TAKE the booster,*n* = 1667	
Getting vaccinated with the booster vaccine is safe	1339(80)
The booster vaccine is effective	918(55)
The mutant virus's emergence will reduce the protective effect of the previous vaccination	633(38)
Suggestions or recommendations from others	250(15)
Reason to NOT to take the booster, *n* = 105	
The vaccine might have side effects/safety concerns	91(86)
Not sure of the duration of the protection by getting vaccinated by a booster	49(46)
Afraid of the needle	39(37)
Doubtful about the proper preservation of the vaccine	37(35)
Not sure whether the vaccine will be free or not	15(14)
For religious beliefs and reasons	2(2)

Discussion

This study highlights key findings on the willingness and hesitancy of healthcare workers (HCWs) in Bangladesh to receive COVID-19 booster doses. The vast majority (94%) of Bangladeshi HCWs expressed willingness to receive a booster vaccine, underscoring the potential of booster doses in controlling future SARS-CoV-2 outbreaks and emphasizing the importance of HCWs' positive influence on public vaccine perceptions. HCWs have long been trusted providers of vaccine information, and studies have shown that patients are more likely to accept vaccines when recommended by healthcare providers [42, 43]. This positive disposition towards boosters among Bangladeshi HCWs parallels the high acceptance rates observed in other Southeast Asian countries, such as Pakistan (92%), though it is considerably higher than rates reported in other countries, including Jordan (49.3%), Italy (52.6%), Saudi Arabia (55.3%), Czechia (71.3%), and Nepal (78.6%) [44–47]. In Bangladesh, this high acceptance rate could be attributed to strong advocacy and awareness campaigns by the Ministry of Health and Family Welfare (MoH&FW) emphasizing the importance of booster shots, especially given the ongoing pandemic. Additionally, the MoH&FW followed WHO's recommendation and prioritized HCWs for vaccination [48, 49]. The high intent to receive boosters among Bangladeshi HCWs reflects multifaceted implications. It not only strengthens the HCWs' role in public health but also indicates that they are likely to support subsequent booster campaigns against emerging variants. This is particularly critical, as evidence suggests that vaccinated HCWs can positively influence their patients' vaccine intentions, promoting higher vaccine uptake within communities [50, 51].

Despite the high willingness observed, vaccine hesitancy remains a complex, multifactorial issue. Defined by the WHO as a delay or refusal to vaccinate despite vaccine availability, hesitancy can arise from factors like lack of confidence, complacency, or risk aversion [52]. Although only 6% of HCWs in this study exhibited hesitancy, the primary reason cited by 86% of this group was fear of side effects. This aligns with findings from similar studies in India and Saudi Arabia, where side-effect concerns were a major barrier to booster acceptance [53]. Given that most side effects associated with COVID-19 boosters are mild and short-term [54], it is essential that the Bangladesh government and public health authorities prioritize educating HCWs about the minimal risks associated with booster doses. Addressing these concerns may help alleviate fears and build a more confident approach toward booster vaccinations.

Our findings also show that hesitancy was particularly pronounced among support staff, with 42% expressing reluctance to receive a booster—a rate higher than that observed among other HCW categories. Multivariable analysis revealed that support staff were 4.68 times more likely to be hesitant than nurses and physicians, a trend similarly observed among ancillary staff in Singapore (36%) [55]. Targeted interventions for support staff, who often have less access to formal medical education, are essential. Strategies could include informational sessions highlighting booster benefits, the importance of protecting vulnerable patients, and even policies mandating boosters in healthcare settings to ensure compliance and safety in high-risk environments. However, it is important to note that while such mandates may improve vaccine uptake, they may not fully address vaccine hesitancy [56]. Overcoming hesitancy requires additional efforts, including addressing concerns, fostering trust, and providing tailored evidence-based information.

Interestingly, nurses comprised half of the "willing" group in this study, contrasting with findings from other studies where physicians were more likely to seek boosters [45]. The higher proportion of nurses in our study sample could explain this difference, yet the overall positive response across all HCW groups (physicians, nurses,

Table 3 Characteristics of the HCWs based on their booster vaccine intention in selected healthcare facilities in Bangladesh from December 2022 to June 2023 ($N = 1772$)

Characteristics	Willing, *n*(%)	Hesitant, *n*(%)	*p*-value
Age			
< 30	317(19)	21(20)	0.962
30–44	909(55)	56(53)	
≥ 45	441(26)	28(27)	
Sex			
Female	1144(69)	75(71)	0.548
Male	523(31)	30(29)	
Educational level			
Up to primary education	168(10)	26(25)	< 0.001
Secondary education	156(9)	7(7)	
Graduation and above	1343(81)	72(69)	
Residence type			
Rural	755(45)	24(23)	< 0.001
Urban	912(55)	81(77)	
Monthly income of the participants			
< 25,000 BDT	190(11)	19(18)	0.108
25,000 to < 50,000 BDT	414(25)	28(27)	
> 50,000 BDT	1063(64)	58(55)	
Type of HCW			
Doctor	357(21)	8(8)	0.001
Nurse	826(50)	53(50)	
Support staff	484(29)	44(42)	
Weekly working hours			
≤ 48	425(25)	40(38)	0.004
> 48	1242(75)	65(62)	
Type of healthcare facility			
Primary	381(23)	14(13)	< 0.001
Secondary	374(22)	10(10)	
Tertiary	912(55)	81(77)	
Having any co-morbid condition			
Yes	872(52)	57(54)	0.694
No	795 (48)	48(46)	
Previously infected with COVID-19			
Yes	558(33)	32(30)	0.527
No	1109(67)	73(70)	
Hospitalization due to COVID-19			
Yes	174(31)	9(28)	0.721
No	384(69)	23(72)	
COVID-19 vaccine uptake			
Yes	1633(98)	99(95)	0.039
No	34(2)	6(5)	
Side effects after vaccination			
Yes	970 (58)	71(68)	0.497
No	697 (42)	34(32)	

and support staff) reinforces Bangladeshi HCWs' general readiness to accept booster doses. Future studies should aim for a balanced representation of HCWs across categories to accurately capture any variations in booster acceptance.

Consistent with the literature on vaccine hesitancy, distrust in vaccine safety and efficacy was often a predictor of reluctance [57–59]. Yet, in our study, 80% of the "willing" group held a positive view of booster efficacy, and over half trusted the safety of recommended future vaccines. This optimism could be influenced by Bangladesh's notable immunization success through the Expanded Program on Immunization (EPI) since 1974, which has enhanced vaccine trust within the healthcare sector [60]. Additionally, the firsthand experience of HCWs with the primary series may have positively shaped their perception of boosters.

We have found that 70% of hesitant participants reported no prior COVID-19 infection. Similar findings have been observed in other South Asian studies, where HCWs without a history of COVID-19 infection were more likely to be hesitant [61]. In our study, such participants may also represent a population with asymptomatic infections, which could influence their perceptions of both the virus and the vaccine. Moreover, the absence of symptomatic disease could have potentially led to a diminished sense of urgency or perceived need for vaccination. However, studies of primary vaccination intentions show mixed results, with some suggesting higher booster uptake among previously uninfected HCWs and others showing increased reluctance [62, 63].

HCWs in this study with an urban residence type were 4.45 times more hesitant to receive the booster than their rural counterparts. This significant disparity highlights critical contextual differences that warrant further exploration. Contrary to global trends where rural populations often exhibit greater vaccine hesitancy [64–66], our finding aligns with a study from China, where urban residents demonstrated higher reluctance toward vaccination [67]. Several factors may contribute to this pattern, including greater exposure to diverse information sources, including misinformation, on social media platforms and varying levels of trust in healthcare systems and vaccine producers [68]. Urban HCWs may also experience a lower perceived risk of COVID-19 due to greater access to healthcare, potentially reducing their motivation for booster doses.

We observed from our results that HCWs who worked less than or equal to 48 h per week were found to be 2.38 times more likely to have hesitancy toward receiving the COVID-19 booster vaccine than those working more than 48 h per week. Our finding implies that fewer working hours could be linked to higher vaccine hesitancy among HCWs, possibly driven by several reasons. HCWs with fewer working hours may have less frequent exposure to patients, leading to a lower perceived risk of COVID-19 infection, which could further reduce their motivation to get vaccinated [63]. Moreover, HCWs working fewer hours might have less engagement with

Table 4 Factors associated with hesitancy towards receiving the booster dose among HCWs of selected healthcare facilities in Bangladesh from December 2022 to June 2023

Characteristics	Unadjusted model	*p*-value	Adjusted model	*p*-value
	uOR (95% CI)		aOR (95% CI)	
Age				
< 30	Reference		-	
30–44	0.93(0.55–1.56)	0.783	-	
≥ 45	0.96(0.53–1.72)	0.887	-	
Sex				
Male	0.87(0.56–1.46)	0.540	-	
Female	Reference		-	
Educational level				
Up to primary education	2.89 (1.79–4.65)	< 0.001	1.23 (0.48–3.14)	0.661
Secondary education	0.84 (0.38–1.85)	0.660	0.58 (0.21–1.62)	0.301
Graduation and above	Reference		Reference	
Residence type				
Rural	Reference		Reference	
Urban	2.80(1.75–4.45)	< 0.001	4.45 (2.03–9.73)	< 0.001
Monthly income of the participants				
<25,000 BDT	1.31 (0.81–2.11)	0.270	1.52 (0.73–3.14)	0.262
25,000 to < 50,000 BDT	1.77 (1.02–3.09)	0.044	1.82 (1.03–3.20)	0.039
>50,000 BDT	Reference		Reference	
Type of HCW				
Doctor	Reference		Reference	
Nurse	2.86(1.35–6.08)	0.006	3.10 (1.43–6.72)	0.004
Support staff	4.06(1.88–8.72)	< 0.001	4.68 (1.56–9.03)	0.006
Weekly working hours				
≤ 48	1.83 (1.21–2.76)	0.004	2.38 (1.50–3.77)	< 0.001
> 48	Reference		Reference	
Type of healthcare facility				
Primary	Reference		Reference	
Secondary	0.73 (0.32–1.66)	0.449	0.82 (0.30–2.20)	0.692
Tertiary	2.42 (1.35–4.32)	0.003	0.89 (0.67–1.35)	0.534
Having any co-morbid condition				
Yes	1.08 (0.73–1.61)	0.694	-	
No	Reference		-	
Previously infected with COVID-19				
Yes	1.19(0.70–2.03)	0.511	-	
No	Reference		-	
Hospitalization due to COVID-19				
Yes	0.86(0.39–1.91)	0.721	-	
No	Reference		-	
COVID-19 vaccine uptake				
Yes	Reference		Reference	
No	2.66(1.01–6.99)	0.040	1.04 (0.36–2.98)	0.632
Side effects after vaccination				
Yes	0.94(0.59–1.51)	0.819	-	
No	Reference		-	

institutional communication or peer discussions surrounding the vaccine, increasing their vulnerability to misinformation [69].

Our findings also indicate that HCWs with a monthly family income between 25,000 and 50,000 BDT were 1.82 times more hesitant to receive the COVID-19 booster vaccine than those earning above 50,000 BDT. This aligns with studies showing that financial constraints can influence vaccine decisions, particularly in LMICs. In Bangladesh, lower-income HCWs may worry about missing work due to side effects, especially if they lack paid sick leave or job security [70]. Additionally, they may have

limited access to institutional vaccine campaigns and rely more on informal sources of information, increasing susceptibility to misinformation [71].

This study has several limitations. First, the purposive sampling of healthcare facilities may limit generalizability. The facilities included in this study, selected across primary, secondary, and tertiary levels in four administrative divisions, may not fully capture the diversity of perspectives across other regions or facility types. This could affect the broader applicability of our findings, especially in settings with different healthcare structures or resources. However, the range of facility types provides a meaningful overview of hesitancy trends that may be relevant across similar LMIC contexts. Second, by focusing on HCWs, our study captured perspectives from a group with higher-than-average knowledge of vaccine benefits and risks, potentially resulting in a more favourable view of boosters than might be found in the general population. Thirdly, the use of closed-ended questions may not have captured all possible reasons behind HCW's motivation or hesitancy. Despite this, the specific concerns identified, such as side effects, remain relevant for understanding vaccine hesitancy factors within healthcare settings and could inform interventions aimed at HCWs and broader groups. Lastly, the evolving nature of the COVID-19 pandemic presents a dynamic challenge to assess long-term attitudes. Our cross-sectional study reflects HCW attitudes at a specific point in time, which may shift with new variants, booster recommendations, or updated safety data. Future studies with longitudinal designs could further elucidate changes in hesitancy and booster acceptance over time, strengthening the foundation for targeted public health strategies.

Conclusion

Our study showed that the majority of HCWs expressed a positive intention toward receiving COVID-19 booster doses, highlighting a strong base of support within this critical group. However, concerns about potential adverse events following booster administration emerged as a key barrier among those hesitant to receive the booster. Addressing these concerns by promoting booster vaccination—especially among support staff, who demonstrated higher levels of hesitancy—remains essential for reinforcing the effectiveness of vaccination efforts and ensuring the safety of both HCWs and the broader community in future pandemics.

Targeted communication and education strategies that transparently address the minimal risks associated with booster doses could help mitigate apprehension and build a more informed and confident approach to booster uptake among HCWs. Such efforts are vital to not only maintaining HCW protection but also enhancing public trust in vaccination, as HCWs play a pivotal role in influencing community health behaviours and vaccine acceptance.

Abbreviations

HCW	Health Care Worker
LMIC	Low- and middle-income countries
SARS-CoV-2	Severe Acute Respiratory Syndrome Corona Virus 2
COPD	Chronic Obstructive Pulmonary Disease
HIV	Human Immunodeficiency Virus
COVID-19	Corona Virus Disease 2019

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions

MZH conceptualized and acquired funding for the study. HRS, AKB, ASP, and MKH performed formal data analysis. HRS and AKB did the investigation while HRS, AKB, and ASP conducted all necessary visualization contents. HRS and AKB prepared the primary draft of the manuscript. MZH supervised the study. FC, ASP, MZH, and MKH reviewed the paper and provided critical feedback. All the authors read and approved the final manuscript.

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Data availability

All relevant data are provided within the manuscript. As per institutional policy, the datasets used in this work can be obtained from the icddrb's research administration by making a reasonable request to the corresponding author.

Declarations

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Ethical Review Committee (ERC) of the institutional review board (IRB) of icddr, b (protocol number PR-22113). The Institutional Review Board at the Centers for Disease Control and Prevention (Atlanta, GA, USA) relied on icddr, b's approval. All procedures performed in this study involving human participants were in accordance with the 1964 Helsinki Declaration and its later amendments. Written informed consent was obtained from the participants before they were enrolled in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. WHO. WHO Coronavirus (COVID-19). Dashboard. 2023 [Available from: https://covid19.who.int/]. Accessed on 27 Oct 2024.
2. Onyeaka H, Anumudu CK, Al-Sharify ZT, Egele-Godswill E, Mbaegbu P. COVID-19 pandemic: A review of the global lockdown and its far-reaching effects. Sci Prog. 2021;104(2):368504211019854.
3. Clemente-Suárez VJ, Navarro-Jiménez E, Moreno-Luna L, Saavedra-Serrano MC, Jimenez M, Simón JA, et al. The impact of the COVID-19 pandemic on social, health, and economy. Sustainability. 2021;13(11):6314.
4. Coccia M. Preparedness of countries to face COVID-19 pandemic crisis: strategic positioning and factors supporting effective strategies of prevention of pandemic threats. Environ Res. 2022;203:111678.
5. Song F, Bachmann MO. Vaccination against COVID-19 and society's return to normality in England: a modelling study of impacts of different types of naturally acquired and vaccine-induced immunity. BMJ Open. 2021;11(11):e053507.
6. (WHO) WHO. COVID 19 Vaccine Tracker. 2022 [Available from: https://covid19.trackvaccines.org/agency/who/]. Accessed on 27 Oct 2024.
7. Baden LR, El Sahly HM, Essink B, Kotloff K, Frey S, Novak R, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. N Engl J Med. 2021;384(5):403–16.
8. Voysey M, Clemens SAC, Madhi SA, Weckx LY, Folegatti PM, Aley PK, et al. Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. Lancet. 2021;397(10269):99–111.
9. Abdullah F, Myers J, Basu D, Tintinger G, Ueckermann V, Mathebula M, et al. Decreased severity of disease during the first global Omicron variant covid-19 outbreak in a large hospital in Tshwane, South Africa. Int J Infect Dis. 2022;116:38–42.
10. Planas D, Bruel T, Grzelak L, Guivel-Benhassine F, Staropoli I, Porrot F, et al. Sensitivity of infectious SARS-CoV-2 B.1.1.7 and B.1.351 variants to neutralizing antibodies. Nat Med. 2021;27(5):917–24.
11. Carreño JM, Alshammary H, Tcheou J, Singh G, Raskin AJ, Kawabata H, et al. Activity of convalescent and vaccine serum against SARS-CoV-2 Omicron. Nature. 2022;602(7898):682–8.
12. Hoffmann M, Krüger N, Schulz S, Cossmann A, Rocha C, Kempf A, et al. The Omicron variant is highly resistant against antibody-mediated neutralization: implications for control of the COVID-19 pandemic. Cell. 2022;185(3):447–e5611.
13. Haas EJ, McLaughlin JM, Khan F, Angulo FJ, Anis E, Lipsitch M, et al. Infections, hospitalisations, and deaths averted via a nationwide vaccination campaign using the Pfizer-BioNTech BNT162b2 mRNA COVID-19 vaccine in Israel: a retrospective surveillance study. Lancet Infect Dis. 2022;22(3):357–66.
14. Andrews N, Stowe J, Kirsebom F, Toffa S, Sachdeva R, Gower C, et al. Effectiveness of COVID-19 booster vaccines against COVID-19-related symptoms, hospitalization and death in England. Nat Med. 2022;28(4):831–7.
15. Menni C, May A, Polidori L, Louca P, Wolf J, Capdevila J, et al. COVID-19 vaccine waning and effectiveness and side-effects of boosters: a prospective community study from the ZOE COVID study. Lancet Infect Dis. 2022;22(7):1002–10.
16. Feikin DR, Higdon MM, Abu-Raddad LJ, Andrews N, Araos R, Goldberg Y, et al. Duration of effectiveness of vaccines against SARS-CoV-2 infection and COVID-19 disease: results of a systematic review and meta-regression. Lancet. 2022;399(10328):924–44.
17. Ben Fredj S, Ghammem R, Zammit N, Maatouk A, Haddad N, Haddad N, et al. Risk factors for severe Covid-19 breakthrough infections: an observational longitudinal study. BMC Infect Dis. 2022;22(1):894.
18. Hacisuleyman E, Hale C, Saito Y, Blachere NE, Bergh M, Conlon EG, et al. Vaccine breakthrough infections with SARS-CoV-2 variants. N Engl J Med. 2021;384(23):2212–8.
19. Alishaq M, Nafady-Hego H, Jeremijenko A, Al Ajmi JA, Elgendy M, Vinoy S, et al. Risk factors for breakthrough SARS-CoV-2 infection in vaccinated healthcare workers. PLoS ONE. 2021;16(10):e0258820.
20. Lipsitch M, Krammer F, Regev-Yochay G, Lustig Y, Balicer RD. SARS-CoV-2 breakthrough infections in vaccinated individuals: measurement, causes and impact. Nat Rev Immunol. 2022;22(1):57–65.
21. (CDC) CfDCaP. CDC Recommends the First Updated COVID-19 Booster. 2022 [Available from: https://www.cdc.gov/media/releases/2022/s0901-covid-19-booster.html]. Accessed on 27 Oct 2024.
22. (WHO); WHO. Interim statement on the use of additional booster doses of Emergency Use Listed mRNA vaccines against COVID-19. 2022 [Available from: https://www.who.int/news/item/17-05-2022-interim-statement-on-the-use-of-additional-booster-doses-of-emergency-use-listed-mrna-vaccines-against-covid-19]. Accessed on 27 Oct 2024.
23. Munro APS, Janani L, Cornelius V, Aley PK, Babbage G, Baxter D, et al. Safety and immunogenicity of seven COVID-19 vaccines as a third dose (booster) following two doses of ChAdOx1 nCov-19 or BNT162b2 in the UK (COV-BOOST): a blinded, multicentre, randomised, controlled, phase 2 trial. Lancet. 2021;398(10318):2258–76.
24. Choi A, Koch M, Wu K, Chu L, Ma L, Hill A, et al. Safety and immunogenicity of SARS-CoV-2 variant mRNA vaccine boosters in healthy adults: an interim analysis. Nat Med. 2021;27(11):2025–31.
25. Data OWi. Coronavirus (COVID-19) Vaccinations. 2023 [Available from: https://ourworldindata.org/covid-vaccinations]. Accessed on 27 Oct 2024.
26. (DGHS) DGoHS. COVID-19 vaccination dashboard for Bangladesh. 2023 [Available from: COVID-19 Vaccination Dashboard for Bangladesh].
27. Almufty HB, Mamani MMA, Ali AH, Merza MA. COVID-19 vaccine breakthrough infection among fully vaccinated healthcare workers in Duhok Governorate, Iraqi Kurdistan: A retrospective cohort study. J Med Virol. 2022;94(11):5244–50.
28. Ferrari C, Somma G, Ippoliti L, Magrini A, Di Giampaolo L, Coppeta L. Global policy to reduce the incidence of infection spreading in Non-Vaccinated healthcare workers: A literature review. Vaccines (Basel). 2022;10(12):2058.
29. Petereit DG, Molloy K, Reiner ML, Helbig P, Cina K, Miner R, et al. Establishing a patient navigator program to reduce cancer disparities in the American Indian communities of Western South Dakota: initial observations and results. Cancer Control. 2008;15(3):254–9.
30. Klugar M, Riad A, Mohanan L, Pokorná A. COVID-19 vaccine booster hesitancy (VBH) of healthcare workers in Czechia: National Cross-Sectional study. Vaccines (Basel). 2021;9(12):1437.
31. Pal S, Shekhar R, Kottewar S, Upadhyay S, Singh M, Pathak D et al. COVID-19 vaccine hesitancy and attitude toward booster doses among US healthcare workers. Vaccines (Basel). 2021;9(11):1358.
32. Della Polla G, Del Miraglia G, Folcarelli L, Napoli A, Angelillo IF. Willingness to accept a second COVID-19 vaccination booster dose among healthcare workers in Italy. Front Public Health. 2022;10:1051035.
33. Larson HJ, Jarrett C, Schulz WS, Chaudhuri M, Zhou Y, Dube E, et al. Measuring vaccine hesitancy: the development of a survey tool. Vaccine. 2015;33(34):4165–75.
34. Decouttere C, Banzimana S, Davidsen P, Van Riet C, Vandermeulen C, Mason E, et al. Insights into vaccine hesitancy from systems thinking, Rwanda. Bull World Health Organ. 2021;99(11):783–d94.
35. Wu F, Yuan Y, Deng Z, Yin D, Shen Q, Zeng J, et al. Acceptance of COVID-19 booster vaccination based on the protection motivation theory: A cross-sectional study in China. J Med Virol. 2022;94(9):4115–24.
36. Noh Y, Kim JH, Yoon D, Choe YJ, Choe SA, Jung J, et al. Predictors of COVID-19 booster vaccine hesitancy among fully vaccinated adults in Korea: a nationwide cross-sectional survey. Epidemiol Health. 2022;44:e2022061.
37. Nery N Jr., Ticona JPA, Cardoso CW, Prates A, Vieira HCA, Salvador de Almeida A, et al. COVID-19 vaccine hesitancy and associated factors according to sex: A population-based survey in Salvador, Brazil. PLoS ONE. 2022;17(1):e0262649.
38. Chew NWS, Cheong C, Kong G, Phua K, Ngiam JN, Tan BYQ, et al. An Asia-Pacific study on healthcare workers' perceptions of, and willingness to receive, the COVID-19 vaccination. Int J Infect Dis. 2021;106:52–60.
39. Silver D, Kim Y, McNeill E, Piltch-Loeb R, Wang V, Abramson D. Association between COVID-19 vaccine hesitancy and trust in the medical profession and public health officials. Prev Med. 2022;164:107311.
40. Geers AL, Clemens KS, Colagiuri B, Jason E, Colloca L, Webster R, et al. Do side effects to the primary COVID-19 vaccine reduce intentions for a COVID-19 vaccine booster?? Ann Behav Med. 2022;56(8):761–8.
41. Klugar M, Riad A, Mohanan L, Pokorná A. COVID-19 vaccine booster hesitancy (VBH) of healthcare workers in Czechia: National Cross-Sectional study. Vaccines. 2021;9(12):1437.
42. Smith PJ, Kennedy AM, Wooten K, Gust DA, Pickering LK. Association between health care providers' influence on parents who have concerns about vaccine safety and vaccination coverage. Pediatrics. 2006;118(5):e1287–92.
43. Finney Rutten LJ, Zhu X, Leppin AL, Ridgeway JL, Swift MD, Griffin JM, et al. Evidence-Based Strategies for Clinical Organizations to Address COVID-19 Vaccine Hesitancy. Mayo Clin Proc. 2021;96(3):699–707.
44. Rehman S, Rehman E, Jianglin Z. Uptake of COVID-19 booster shot among healthcare workers: A mediation analysis approach. Front Public Health. 2022;10:1033473.

45. Lubad MA, Abu-Helalah MA, Alahmad IF, Al-Tamimi MM, QawaQzeh MS, Al-Kharabsheh AM, et al. Willingness of healthcare workers to recommend or receive a third COVID-19 vaccine dose: A Cross-Sectional study from Jordan. Infect Dis Rep. 2023;15(2):210–21.
46. Alhasan K, Aljamaan F, Temsah MH, Alshahrani F, Bassrawi R, Alhaboob A et al. COVID-19 Delta variant: perceptions, worries, and Vaccine-Booster acceptability among healthcare workers. Healthc (Basel). 2021;9(11):1566.
47. Paudel K, Shah S, Bhusal S, Dahal K, Bhatta N, Pokhrel S, et al. Knowledge and attitude toward COVID-19 booster dose among health care professionals in Nepal: a cross-sectional study. Ann Med Surg (Lond). 2023;85(4):772–7.
48. Dhali B. Covid-19 vaccine registration site now open. Dhaka: Dhaka Tribune; 2021.
49. Abedin M, Islam MA, Rahman FN, Reza HM, Hossain MZ, Hossain MA, et al. Willingness to vaccinate against COVID-19 among Bangladeshi adults: Understanding the strategies to optimize vaccination coverage. PLoS ONE. 2021;16(4):e0250495.
50. Wiysonge CS, Alobwede SM, de Marie CKP, Kidzeru EB, Lumngwena EN, Cooper S, et al. COVID-19 vaccine acceptance and hesitancy among healthcare workers in South Africa. Expert Rev Vaccines. 2022;21(4):549–59.
51. Herzog R, Álvarez-Pasquin MJ, Díaz C, Del Barrio JL, Estrada JM, Gil Á. Are healthcare workers' intentions to vaccinate related to their knowledge, beliefs and attitudes? A systematic review. BMC Public Health. 2013;13(1):154.
52. World Health Organization (WHO). Report of the SAGE Working Group on Vaccine Hesitancy. Geneva: WHO; 2014. Available from https://www.who.int/publications/i/item/report-of-the-sage-working-group-on-vaccine-hesitancy. Accessed 27 Oct 2024.
53. Vellappally S, Naik S, Alsadon O, Al-Kheraif AA, Alayadi H, Alsiwat AJ et al. Perception of COVID-19 booster dose vaccine among healthcare workers in India and Saudi Arabia. Int J Environ Res Public Health. 2022;19(15):8942.
54. Nguyen DC, Dao TL, Truong TMD, Nguyen TH, Phan TN, Nguyen HM et al. Short-Term adverse effects immediately after the start of COVID-19 booster vaccination in Vietnam. Vaccines (Basel). 2022;10(8):1325.
55. Koh SWC, Tan HM, Lee WH, Mathews J, Young D. COVID-19 vaccine booster hesitancy among healthcare workers: A retrospective observational study in Singapore. Vaccines (Basel). 2022;10(3):464.
56. Kainth MK, Sembajwe GN, Ahn H, Qian M, Carrington M, Armellino D, et al. Despite mandated primary series, health care personnel still hesitant about COVID-19 vaccine and immunizing children. Vaccine. 2024;42(12):3122–33.
57. Galanis P, Vraka I, Katsiroumpa A, Siskou O, Konstantakopoulou O, Katsoulas T, et al. Predictors of second COVID-19 booster dose or new COVID-19 vaccine hesitancy among nurses: A cross-sectional study. J Clin Nurs. 2023;32(13–14):3943–53.
58. Lai X, Zhu H, Wang J, Huang Y, Jing R, Lyu Y et al. Public perceptions and acceptance of COVID-19 booster vaccination in China: A Cross-Sectional study. Vaccines (Basel). 2021;9(12):1461.
59. Lounis M, Bencherit D, Rais MA, Riad A. COVID-19 vaccine booster hesitancy (VBH) and its drivers in Algeria: National Cross-Sectional Survey-Based study. Vaccines (Basel). 2022;10(4):621.
60. Nazmunnahar AB, Haque MA, Tanbir M, Roknuzzaman ASM, Sarker R, et al. COVID-19 vaccination success in Bangladesh: key strategies were prompt response, early drives for vaccines, and effective awareness campaigns. Health Sci Rep. 2023;6(5):e1281.
61. Arshad MS, Masood I, Imran I, Saeed H, Ahmad I, Ishaq I et al. COVID-19 vaccine booster hesitancy (VBH) among healthcare professionals of Pakistan, a nationwide survey. Vaccines (Basel). 2022;10(10):1736.
62. Kaplan AK, Sahin MK, Parildar H, Adadan Guvenc I. The willingness to accept the COVID-19 vaccine and affecting factors among healthcare professionals: A cross-sectional study in Turkey. Int J Clin Pract. 2021;75(7):e14226.
63. Peterson CJ, Lee B, Nugent K. COVID-19 vaccination hesitancy among healthcare Workers-A review. Vaccines (Basel). 2022;10(6):948.
64. Dong W, Miao Y, Shen Z, Zhang W, Bai J, Zhu D, et al. Quantifying disparities in COVID-19 vaccination rates by rural and urban areas: Cross-Sectional observational study. JMIR Public Health Surveill. 2024;10:e50595.
65. Reichelt M, Cullen JP, Mayer-Fried S, Russell HA, Bennett NM, Yousefi-Nooraie R, Addressing. COVID-19 vaccine hesitancy in rural communities: A case study in engaging trusted messengers to Pivot and plan. Front Public Health. 2023;11:1059067.
66. Khanam M, Sanin KI, Rita RS, Akand F, Rabbi MF, Hasan MK, et al. COVID-19 vaccine barriers and perception among rural adults: a qualitative study in Bangladesh. BMJ Open. 2023;13(10):e074357.
67. Miao Y, Bai J, Shen Z, Li Y, Zhang W, Zhu D, et al. How urban versus rural population relates to COVID-19 booster vaccine hesitancy: A propensity score matching design study. Hum Vaccin Immunother. 2024;20(1):2297490.
68. Hong L, Jin Z, Xu K, Shen G, Zou Y, Li R, et al. COVID-19 vaccine uptake and vaccine hesitancy in rural-to-urban migrant workers at the first round of COVID-19 vaccination in China. BMC Public Health. 2023;23(1):139.
69. Gu M, Taylor B, Pollack HA, Schneider JA, Zaller N. A pilot study on COVID-19 vaccine hesitancy among healthcare workers in the US. PLoS ONE. 2022;17(6):e0269320.
70. Khubchandani J, Sharma S, Price JH, Wiblishauser MJ, Sharma M, Webb FJ. COVID-19 vaccination hesitancy in the united States: A rapid National assessment. J Community Health. 2021;46(2):270–7.
71. Md. Monirul Islam AZ. Md. Imran Nur Manik, Md. Mahmodul Islam. Perception and attitudes towards COVID–19 vaccination in Bangladesh: A Cross-sectional analysis. Bangladesh J Infect Dis. 2023;10:65–70.

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