

Decreasing transmission and initiation of countrywide vaccination: Key challenges for future management of COVID-19 pandemic in Bangladesh

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Abstract

With a fragile healthcare system, Bangladesh, much like other countries in South East Asia, struggled during the early days of COVID-19 pandemic. In following months several encouraging initiatives were undertaken including nationwide lockdown, maintaining social distancing and setting up COVID-19 dedicated laboratories and hospitals. Despite fear of an escalation in COVID-19 transmission during the winter months like their European counterparts, fortunately infection rates subsided and Bangladesh came out largely unharmed. But the next phase of COVID-19 pandemic management that includes viral transmission suppression and conduction of nationwide immunization program require several urgent steps from government of Bangladesh (GoB) and relevant stakeholders. This qualitative research piece discussed about issues including an urgent need to enhance critical care facilities around the country, especially in peripheral districts; ramping up COVID-19 testing at existing laboratories in view of diagnosing each case, and ensuring vaccines for the vulnerable populations in the country. Furthermore, the researchers shed light on other issues including a need to reinforce a struggling healthcare workforce, encouraging people to take vaccine, proper maintenance of social distancing regulations, routine epidemiological surveillance, management

of environment and biomedical waste and undertaking a holistic approach to combat the pandemic and its environmental and financial consequences.

KEYWORDS

Bangladesh, COVID-19, ICU, PCR, SARS-CoV-2, vaccination

1 | INTRODUCTION

The first case of severe acute respiratory syndrome coronavirus 2 (SARS CoV-2) infection was diagnosed in Wuhan province in China towards the end of 2019.¹ Originally linked to a local fish market, the virus, as of February 8, has spread to 215 countries and territories infecting more than 110 million people and resulting in more than 2.4 million deaths.²

First COVID-19 case was detected in Bangladesh on 8 March 2020, though several experts argue that the virus might have been circulating within the country long before the first diagnosis, in two returning Italian immigrants.³ On March 16 government of Bangladesh (GoB) decided to close all education institution. After the first case of COVID-19 related death on March 18, GoB imposed countrywide travel ban just one day after lockdown was imposed in India on March 26.⁴ During two months of subsequent lockdown in different phases, people were barred from travelling to distant district and social distancing rules were imposed, even though there are arguments whether the social distancing rules had been maintained as expected or advertised in the media. Lots of people lost their livelihood during the lockdown, with around 11 million leaving the capital after failing to secure jobs, further complicating the spread of the disease.⁵ Besides, as cited by previous researchers in Bangladesh, people in general had to go through social and economic crises including exorbitant pricing of commodities, financial uncertainties, food shortages among poor and marginalized sections of the country, social stigma towards the infected people and the front line workers who treated COVID-19 affected individuals, undeniable stress and suicidal tendency among individuals under lockdown etc.⁶⁻⁸ There were even reports that the lockdown would increase the percentage of poor population in Bangladesh to 40%.⁵ Hence, lockdown was ended on May 31, despite numbers of rising cases in the country, citing social and financial concerns as reasons behind such decision.

With more than 535,000 documented cases of COVID-19 infection, Bangladesh is one of the worst affected countries in the world.³ Despite early stutters and inadequate efforts from all the key stakeholders, morbidity and mortality due to COVID-19 complications has remained low compared to other more developed countries.² After a peak in late June and early July, the infection rate and mortality decreased substantially.³ There were fears that infection rate would pick up again during the winter months with daily detection of cases increasing in late October and early November, suggesting a similar scenario to that of France, Italy and UK. But the infection rate remained stable and even decreased towards the end of 2020.⁹ The pandemic curve experienced in Bangladesh is similar to that of India, a neighbouring country with comparable healthcare, social, economic and environmental system and resources.¹⁰

With the dreaded winter season just over, with minimal morbidity and mortality unlike more advanced countries in the west, and with the introduction of nationwide vaccination program on 27 January, the priorities of GoB and healthcare authorities need to be focused on addressing healthcare delivery and management issues that were evident during the early months of the pandemic and reported in previous literature.¹¹ Furthermore, as reported in earlier researches, in addition to recovery and strengthening of health sector, efforts must be put towards revival of economy, agriculture, industry, food security and strengthening of environmental and infectious disease management system considering the dengue season is just around the corner.^{6,7}

This paper will shed light on topics including, but not limited to, major issues that were encountered during the first wave of COVID-19 infection, comparison of key indicator data among neighbouring countries, challenges and priorities for authorities tasked with health service management, and brief intervention strategies based on research findings.

2 | METHODOLOGY

For this qualitative paper the authors did not collect data from primary sources. Rather they relied on already published data from national newspapers, journals, magazines, government websites, international COVID-19 related sites, social-media blogs and televised programs on television starting from the initiation of the pandemic to 15 February 2021. No statistical software was used for this purpose. All data were collected in Microsoft Excel and graphically presented using different diagrams.

3 | RESULTS AND DISCUSSIONS

3.1 | COVID-19 current situation in Bangladesh

As of 15 February 2021, 540,592 people have been diagnosed with COVID-19 and of them 8274 have died as a result of disease complication. Based on total number of diagnosed cases Bangladesh is top 32nd country in the world and accounts for 0.50% of total global cases.¹² According to published WHO country situation report, a total of 2530 people were diagnosed this week (Epidemiological week 6, 2021), down 13.4% from 2923 cases in preceding week. The number of deaths also decreased with 78 (CFR: 1.53) casualties in comparison to 104 the previous week. These numbers are in stark contrast to peak COVID-19 transmission period in the country towards the end of June (epidemiological week 26) when 25,481 cases were diagnosed.¹² In addition, highest number of COVID-19 deaths, 314 in total, were recorded in early July (epidemiological week 27).¹² Since the detection of first case on 8 March 2020, a total of 3,848,116 tests (both polymerase chain reaction [PCR] and antigen-based tests) have been conducted on COVID-19 suspected patients with 2.6% weekly positivity rate on epidemiological week 6 (overall positivity of 14.1% during the course of the pandemic) according to latest published data.¹² Overall, the disease transmission, morbidity and mortality are on downward trend in Bangladesh, much like neighbouring country India who are going through a similar epidemiological pattern in case detection, mortality and morbidity. A graphical illustration of bi-weekly case detection rates in Bangladeshi is provided in Figure 1.

Regarding vaccination, on 7 February 2021 GoB inaugurated a nationwide COVID-19 vaccination program starting with people of 40 years or above, front line workers, and government officials. As of writing this paper, more than 1.3 million people have already received their first dose of the AstraZeneca-Oxford University vaccine.¹³

3.2 | Enhancing critical care facilities is a priority:

According to a recent data, the total number of critical care beds currently available in Bangladesh in 84 critical care facilities around the country is estimated to be 1174, with 0.7 critical care beds per 100,000 population.¹⁴ Regarding COVID-19, according to official government statistics, there are 582 ICU beds and 620 ventilators for critically ill COVID-19 patients in Bangladesh with 297 (49.99%) of those located in hospitals in Dhaka and another 45 (7.73%) in Chittagong.³ In contrast, only 30 million people out of a total population of 165 million reside in Dhaka and Chittagong city.¹⁵ Hence, there are only 240 ICU beds for remaining 135 million people, and that too in select few cities. The numbers are far more encouraging in India with 95,000 ICU and 48,000 ventilators, though

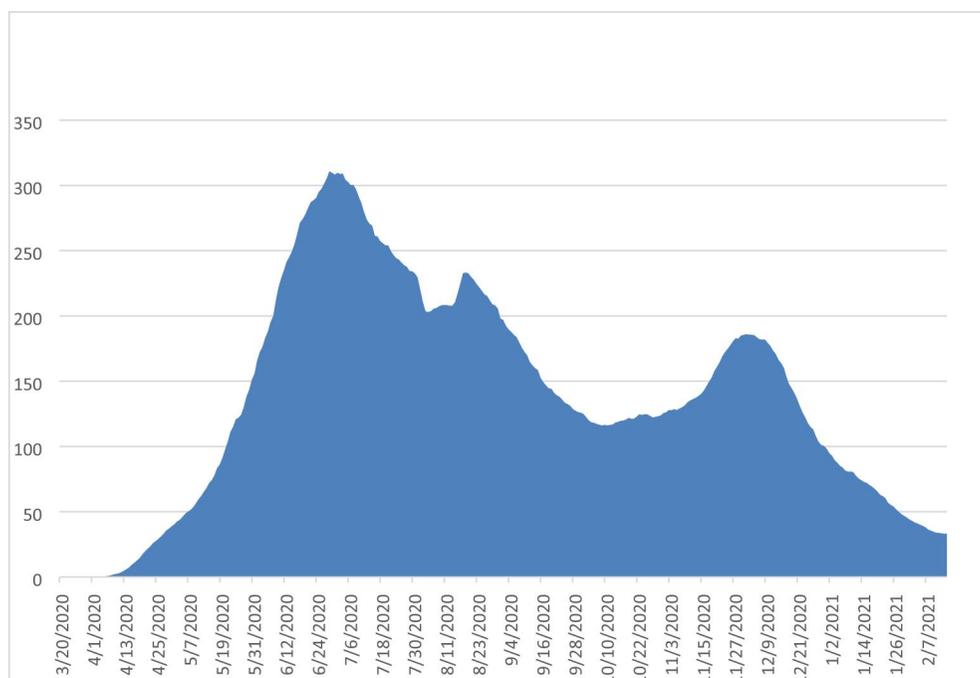


FIGURE 1 Bi-weekly COVID-19 cases per million people in Bangladesh from March 2020 to January 2021 [Colour figure can be viewed at wileyonlinelibrary.com]

most of them are stacked in private healthcare facilities, making it hard for poor population to receive critical care services.¹⁶

Up until now, most peripheral and even divisional cities are devoid of any sort of ICU facilities for critically ill COVID-19 patients. But previous researchers suggested that standard healthcare facility should contain 5%–12% critical care beds depending on services provided.¹⁷ By that logic, the 2400 bed Dhaka Medical College and Hospital should contain 120–288 ICU beds, while in reality the hospital has only 24 ICU beds.³ In fact, the general bed to ICU ratio in government hospital is 219:1 whereas the standard ratio should be 10:1.¹⁸

The overall situation was even more drastic during the early days of the pandemic in Bangladesh as in early April the authorities had provision for only 112 dedicated ICU beds for critically ill COVID-19 patients.¹⁹ Since then the authorities have converted existing ICU's allocated for critically ill patients suffering from different diseases into COVID-19 specific ICU beds, leaving people suffering from other life-threatening illnesses struggling for critical care services. There were talks of planting central oxygen supply in all district level hospitals before the start of winter season, but up until now, only 18 of them are functioning around the country.²⁰ Moreover, the number of ICU beds remained stagnant for the past few months as the authorities failed to add to their numbers despite repeated assurances.³ A contrasting image could be found while comparing the initiatives taken by Italy during early March, when the infection was picking up in the country the authorities added nearly 6000 ICU beds within a short notice.²¹

Another glaring issue with critical care facilities in Bangladesh is that a lot of ICU beds are owned by private health care service providers, who charge a hefty amount for ICU services. In Dhaka city alone, out of 297 ICU beds 180 beds (60.60%) are owned by private owners.³ In fact, there were several reports of private health care institutions charging exorbitant amount for ICU services, making it nearly impossible for middle class and lower middle-class people to avail ICU services at private institutions.²²

To compare things with other Asian countries, the median number of ICU beds in Asian countries is estimated to be 3.6 per 100,000 population, with low and lower-middle income countries having around 2.3 beds per 100,000

population on average. Neighbouring countries like India, Pakistan and Sri Lanka are far better placed off when it comes to critical care facilities with them reporting 2.3, 2.3 and 1.5 ICU beds per 100,000 population respectively.¹⁴ In fact, Bangladesh is the lowest ranked country among all reporting Asian countries (Figure 2).

Now to put that whole scenario in perspective, according to published data, each year around 600,000 people visit government facilities for cold related problems during November to February, with many of them requiring intensive care services.²³ Besides, disease breakouts like that of dengue in 2018, when the crisis of critical care facilities worsened to a new level, would only complicate the next stage management of COVID-19 pandemic.⁶ Possible interventions may include—increasing number of COVID-19 dedicated ICU beds in peripheral districts, upgrading existing critical care facilities, and strictly monitoring private health care facilities to make sure patients receive affordable health care.

3.3 | Each case detection in crucial:

In order to suppress the viral transmission, it is of paramount importance to detect each case, as evidenced in cases of Vietnam and South Korea.^{24,25} Other countries adopted a similar approach with overwhelming literature evidence in favour of widespread testing as part of combined approach to tackle the pandemic.²⁶ Bangladesh has successfully contained the pandemic with graph of infection going down in recent months. Now, the next stage of management would involve prevention of infection spread from imported cases, specifically in view of more international flights to Bangladesh in recent weeks and more transmissible strains that are being circulated in UK and many other countries, and stopping re-establishment of community transmission.²⁷ It is being argued that the only viable strategies to suppress the viral transmission are mass vaccination and scaling up testing, as evidenced in case of China who successfully contained the pandemic in Wuhan and around the country within two months through widespread screening, isolation and treatment.²⁸

After a high of 19,000 tests in late June, PCR testing decreased sharply once government started to charge money from suspected patients.²⁹ Even though the authorities initially planned on performing 165,000 tests (10 tests per 100,000 population) on average per day citing financial and logistics constraints as reasons,³⁰ currently around 10,000–15,000 PCR tests (0.05–0.09 tests on average per 1000 people per day) are being performed each day in laboratories around the country.³ In comparison, neighbouring India, with a population of 1.3 billion, is

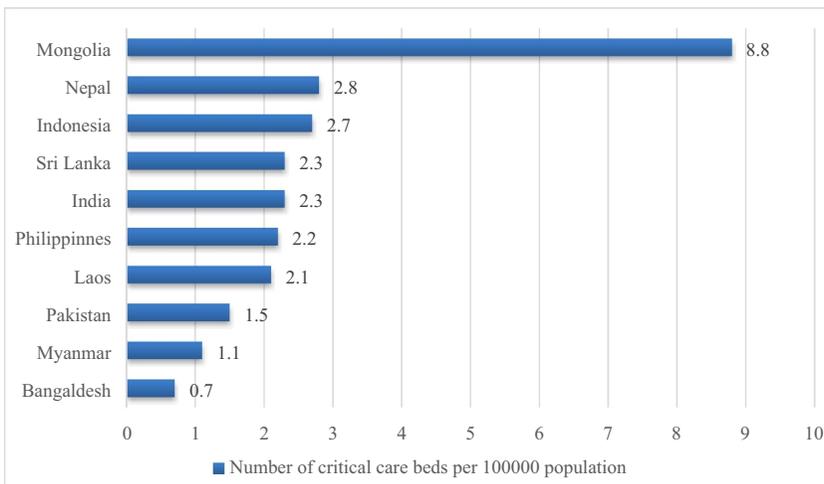


FIGURE 2 Number of critical care beds per 100,000 population in 10 low and low-middle income countries [Colour figure can be viewed at wileyonlinelibrary.com]

performing 0.50 tests per 1000 people per day.³¹ Other Asian countries with comparable financial means; such as Pakistan, Bhutan, Myanmar and Sri Lanka are performing more tests per 1000 people compared to Bangladesh (Figure 3).

Another issue is that these daily figures include around 5000–8000 tests that are being performed each day as a pre-requirement for people willing to travel abroad. So, the actual number of tests performed on suspected COVID-19 patient samples are even lower than announced in the media. Hence, while the infection curve is seemingly going downwards, it might be misleading to conclude that the pandemic is almost over in Bangladesh by performing so few tests. From the very beginning of COVID-19 pandemic, considering the huge population, experts have been urging the authorities to perform a minimum of 30,000 tests each day to ensure maximum coverage.³² But after initial increase in testing the system reached a plateau towards the end of June and since then the numbers have been hovering in the range of 10,000–15,000 (0.05–0.09 test per 1000 population).

3.4 | Reinforcing a stressed healthcare workforce

According to published data from 2018 there are 0.6 doctors, and 0.4 nurses and midwives per 1000 population in Bangladesh while World Health Organization (WHO) recommends a minimum of 2.3 physicians, nurses and midwives per 1000 population, illustrating a dire need to reinforce the healthcare system.³³ Bangladesh is lagging far behind in that aspect among South-Asian countries as only Bhutan has a lower doctor to patient ratio at 0.4 doctors for 1000 population.³³ Neighbouring country India has a much higher doctor to population ratio as reports suggest there is 0.9 doctor per 1000 population in the country, much higher than that of Bangladesh, though other reports suggest the numbers to be a less encouraging than portrayed in media.³⁴ A comparative analysis of physicians, nurses and midwives per 1000 people among neighbouring countries is provided in (Figure 4).

Besides, there is a long-standing disparity between number of doctors in urban cities and rural areas. While 63.4% of total population in Bangladesh reside in rural areas, most of the doctors are located in Dhaka and major cities around the country.³⁰ In addition, there are shortages of qualified medical technologists and nurses. WHO recommends allocating three nurses and five technologists for each doctor.³⁵ According to official data, there are currently 25,615 doctors working in government services. By that calculation, Bangladesh should have 128,075

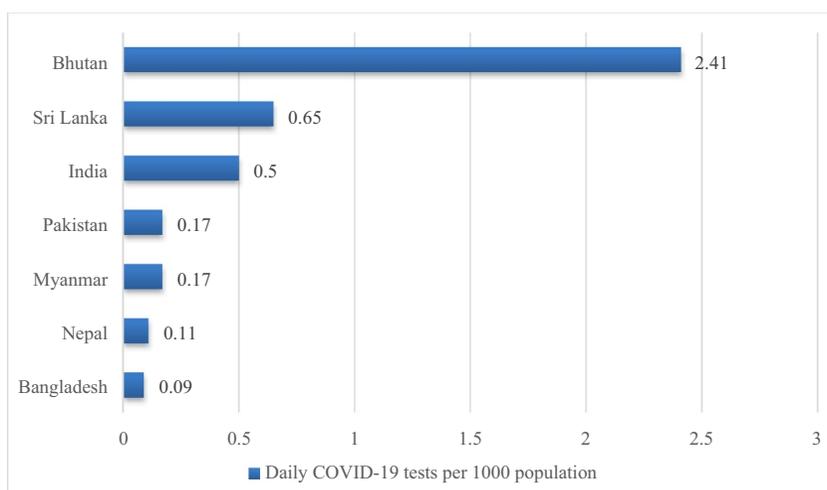


FIGURE 3 Daily COVID-19 tests performed per 1000 population in countries with comparable financial means. The figures illustrated here are given as a rolling 7-day average [Colour figure can be viewed at wileyonlinelibrary.com]

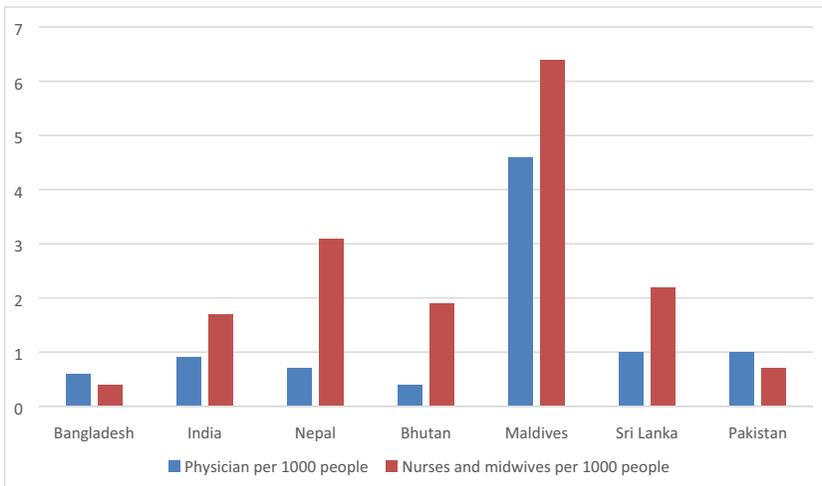


FIGURE 4 A comparative analysis of physicians, nurses and midwives per 1000 people among neighbouring countries [Colour figure can be viewed at wileyonlinelibrary.com]

medical technologists but in reality, only 7920 posts are sanctioned by authorities and among them only 1417 medical technologists are working in laboratories around the country.³⁵

The government have acknowledged the issue and sanctioned recruitment of 2000 doctors and more than 5000 nurses in May 2020 amid the COVID-19 outbreak, and vowed to recruit another 1200 medical technologists and 2000 doctors.³⁶ Despite the early initiatives, recruitment of medical technologists has not been completed with only 183 out of 1200 of them being recruited till date. This has hampered the collection and PCR testing of COVID-19 samples around the country, evidenced by the dwindling numbers of tests performed in recent months.

While no official data could be found regarding the morbidity and mortality among COVID-19 infected doctors, nurses and medical technologists, Bangladesh Doctor's Foundation (BDF), an organization dedicated to protect doctor's rights, stated that more than 5000 doctors have been infected till date by SARS-COV-2 and 200 of them died as a result of complications. A report published in June reported doctors' mortality rate in Bangladesh to be highest in the world.³⁷ Organizations of doctors, nurses and medical technologists cited lack of proper protective equipment, extensive duty hours, revoking quarantine facilities by the government, and lack of training regarding COVID-19 management as key reasons behind such alarming statistics.³⁷

So, venturing into unknown territory regarding the direction of pandemic in 2021, the authorities have to address to two urgent issues—protecting already stressed workforce by providing them with quality protective equipment, ensuring proper quarantine facility and reinforcing them by recruiting new health care workers, and that too within a short period of time.

3.5 | Ensuring social distancing

On 1 November 2020 Bangladeshi authorities announced a new measure—'no mask, no service' to curb the infection rate among people seeking services at government offices.³⁸ This laudable decision was taken once it was evident that people were not following social distancing measures, with many of them visiting places like markets, mosques and other busy areas without mask or any sort of safety measures. But early report suggests people are already ignoring the newly imposed rules and restrictions.³⁸

Hence, more drastic steps are needed in order to make sure of proper social distancing or another lock-down, with a huge financial consequence, might be necessary in the coming months. For example, few months back

government allowed resumption of public transport in Dhaka city on condition of maintaining social distancing and hygiene protocol.³⁹ After an initial few day of strict adherence, people started to ignore COVID-19 protocol and now there is widespread disregard of social distancing and hygiene rules.³⁸ Without a herd immunity, social distancing, up until now, is the only effective strategy to fight off COVID-19. Hence, an awareness campaign, especially in rural areas where social distancing protocols and the deadly impact of COVID-19 is mocked about, and more severe punishment for violating protocols should be at the forefront of COVID-19 prevention strategy by the health authorities in Bangladesh.

3.6 | Procuring and conducting a mass vaccination campaign

In November, the government of Bangladesh announced a memorandum of understanding with Serum Institute, India to purchase 30 million doses of COVID-19 vaccine initially, 5 million doses each month for a duration of 6 months, developed by AstraZeneca, a UK based drug manufacturer.⁴⁰ So far, the government has received scheduled 5 million doses from serum institute, India and another 2 million doses as gift.⁴¹ According to detailed government plan 138,247,000 people will be vaccinated in five stages throughout 2021 and 2022.⁴² While the GoB have done a commendable job thus far, making sure Bangladesh receive vaccines ahead of many other more advanced and wealthy countries, it remains to be seen whether GoB becomes successful in purchasing remaining 280 million doses within the stipulated timeframe.

According to published report, GoB are planning to purchase vaccine developed by Pfizer-BioNTech through COVAX program.⁴³ While this would enhance the chances of more Bangladeshi people receiving COVID-19 vaccines, there are several challenges to overcome. The vaccines must be stored in ultra-low temperature environment (-70°C) and must be administered within 5 days of leaving ultra-low temperature storage due to relatively short shelf-lives.⁴⁴ Currently, Bangladesh do not have such cold chain facilities required for mRNA vaccines around the country with only few ultra-low temperature freezers available in Dhaka and few other major cities. Potential ways to circumvent such scenarios would be to purchase vaccines that do not require such resource hungry storage facility or to purchase vaccines with low required jabs for immune protection. On a positive note, latest interim trial results for vaccine developed by Johnson and Johnson showed a single jab of its candidate vaccine can produce robust immune response, comparable to AstraZeneca and Pfizer-BioNTech vaccine, in individuals and can be stored in normal freezer (2° – 8°C) too.⁴⁵ If approved and made available to people around the world, Bangladesh would benefit by striking deals with the developer early. This would increase the rate of inoculation and ease the burden on supply chain.

3.7 | Overcoming vaccine ignorance among rural population

Online surveys were carried out in UK to find out the attitude of general population towards a potential vaccine and more than one third of participating adults showed their mistrust in a potential vaccine.⁴⁶ Similar findings were obtained from a study conducted in France.⁴⁷ Overall, vaccine hesitancy is a burning issue in higher income countries.⁴⁸ Luckily, Bangladesh, South East Asia in general, is a country with low vaccine hesitancy, with 94% of participants in survey conducted in 2018 voicing their opinion in favour of a suitable vaccine.⁴⁸ This might be attributed to Bangladesh's incredible success with the EPI program over the past 30 years.

During first days of the campaign there were uncertainties regarding the vaccine including possible life-threatening complication. But people receiving the vaccine in Bangladesh during first few days experienced little to no complications and, hence after a period of uncertainty, people are turning up for their vaccine doses, but mostly in city areas.⁴⁹ But one glaring issue is that rural population are less aware of the vaccine and its importance. As a result, there are reports of less people registering from the rural areas largely due to lack of knowledge and

limited access to internet that is required for online registration purpose.⁵⁰ The GoB needs to devise a plan to include rural people into the program possibly with the help of local politicians and religious authorities, and make sure each vulnerable individual receives the vaccine, if needed with the help of mobile vaccine sites as proposed by other researchers.⁵¹

Besides, there should be clear protocol on how to make sure of two vaccine doses for the people as people receiving the first dose might not turn up for the next dose due to adverse events experienced during first dose or miss their appointment altogether.⁵² Since the government has already deferred the date of second dose for people already receiving the first dose by one month after consultation with nation bodies, this may create further confusion among those already vaccinated leading to missed doses for some people.⁵³ A specific team should deal with the issue, notify vaccine candidates through SMS or other forms of communication, track down, and possibly escort the candidates to nearest vaccine centre on scheduled dates through a team of volunteers and healthcare workers, as happened during the EPI schedule.

3.8 | Notifying and managing adverse events following immunization

Adverse effects, in most cases mild in nature, are not uncommon among vaccinated individuals. Patients receiving COVID-19 vaccine in different countries complained of pain in the injection site, fever, muscle pain, nausea, fatigue and other symptoms.⁵⁴ Moreover, majority of incidences reported after vaccination are usually coincidences with no causal relationship with vaccination events.⁵⁴ There were reports of several elderly people dying after receiving the Pfizer-BioNTech vaccine in Norway, creating mass hysteric reactions in social media sites, though any causal relationship is yet to be established.⁵⁵ COVISHILED vaccine, one developed by AstraZeneca, is currently being administered in Bangladesh and India. Last month on first day of vaccine administration there were reports of adverse events among Indian recipients, leading to negative press coverage in Bangladeshi media.⁵⁶ This impacted the early registration procedure in Bangladesh so much so that the authorities had to scale back their initial projection of five million doses administered in first month to 3.5 million doses.⁴⁹

Recently WHO came up with a detailed protocol for post-vaccination surveillance citing possible adverse events in adult populations with co-morbidities, the main recipient group of COVID-19 vaccine, as reasons behind routine surveillance.⁵⁷ Following suit, Directorate General of Drug Administration (DGDA) in Bangladesh recently published their Advanced Events Following Immunization (AEFI) report form, vowing to locate and investigate all cases of potential adverse effects of vaccination.⁵⁸ The reasons behind such cautious approach could be the much-publicized rumours linking measles, Mumps and rubella vaccine (MMR) to Autism in UK in 1998, which decreased the uptake of MMR vaccine from 91% to 80% and giving rise to localized measles outbreak in 2008.^{59,60} Similar reports could be found in Nigeria where in 2003 several groups boycotted the Oral Polio Vaccine (OPV) citing western media's plot to decrease Muslim population in Nigeria by introducing anti-fertility agents in vaccines.⁶¹ Even before the vaccination schedule began, there were negative reports in news media and social media sites regarding the AstraZeneca-Oxford Vaccine manufactured by serum institute in India including reports of decreased efficacy, conspiracy plot to harm Bangladesh vaccine recipients, doubt regarding rapid development of an effective vaccine etc.⁶² Now the main challenge for the authorities would be to scour social media and new sites for information regarding serious adverse effects on COVID-19 vaccines, as news medias and social media sites are often the first sources for such information.⁶¹ Rather than dismissing the allegations out of hand or trying to suppress the information source, as advised by other researchers, the authorities need to approach the issue on a transparent manner and investigate whether the morbidity is associated with the vaccine. Often people receiving vaccines die of other serious medical conditions completely unrelated to the vaccine, hence the authorities need to dispel mounting fear among general population, otherwise the success of whole program could be in jeopardy.⁵⁴

3.9 | Conducting routine molecular and serological surveillance

Another possible issue with vaccination is that, the UK and South African strain specifically one with E484K mutation, thought to be more transmissible than the one currently circulating in Bangladesh, have not yet been detected among Bangladeshi people.⁶³ Hence, there are valid fears that the strain might be found in population without any or less vaccine coverage during the next few months and might cause new breakouts of the disease.

There are even reports of decreased efficacy of AstraZeneca vaccine against the South African strain with E484K mutation even though personnel associated with the vaccine development are adamant that the vaccine is still 100% effective in preventing severe COVID-19 disease.⁶⁴ Hence, it is of importance that authorities conduct routine serological surveillance to find out antibody response in vaccinated individuals. To date, very few studies have been conducted to find out antibody response in COVID-19 infected individuals in Bangladesh whereas in India two largescale national surveys have already been conducted to find out COVID-19 antibody prevalence among slum dwellers and city people in select cities.^{65,66} Bangladesh needs to formulate a nationwide surveillance plan and these data could later be used to implement the next stage vaccination strategy as lower immunity or vaccine efficacy would necessitate an introduction of booster dose on a certain interval within the COVID-19 vaccination program.

Besides, Bangladesh have done a commendable job on sequencing COVID-19 samples from affected individuals with more than 800 sequences already being deposited in GISAID, a global sequence sharing platform.⁶⁷ But that effort was limited to several institutions and was conducted in a rather incoherent manner with samples from Dhaka making up the bulk of sequenced samples, with little to no representative sequences from several other divisions. In order to detect vaccine escape mutants of COVID-19, the government will need a concentrated effort on sequencing COVID-19 samples, including each representative geographical region and population, from suspected individuals or their close acquaintances to find out the genetic variants circulating in the country at that moment. Special attention needs to be paid towards people getting infected even after vaccination as that might be caused by mutant strains.⁶⁸

3.10 | Environmental health protection and biomedical waste management:

Even before the COVID-19 pandemic Bangladesh was struggling to manage biomedical waste and the pandemic worsened the situation to the point where without a proper management plan the country could slide into another health care disaster. It is estimated that 1–63–1.99 kg of medical wastes are generated per bed and in April 2020 alone 14,500 tons of medical wastes were generated across the country.⁶⁹ Despite passing a biomedical waste management rule in 2008, 40,000 untrained and ill-protected workers currently working in this sector are putting themselves in risks of COVID-19 as well as other infections.⁷⁰ A transformation is necessary to convert existing rudimentary waste management system into a state-of-the-art system modelled around countries like USA, Japan and European nations, and for that a policy level participation is necessary for environmental health and disaster management experts into the current COVID-19 management, as well as overall infectious disease management programs, in Bangladesh.

While the negative impacts of lockdown cannot be ignored, in instances, lockdown and restriction in movement served as catalyst for environmental regeneration and pollution reduction.⁷¹ There were several researches indicating a strong relationship between COVID-19 disease severity and air pollution. Association was found between PM_{2.5}, PM₁₀, NO₂, CO₂ and SO₂ level in air and disease severity in a prospective Chinese study, possibly through overexpression of ACE2 on respiratory epithelial cells.⁷² These findings were later reconfirmed when death of COVID-19 patients in France, Germany, Italy and Spain were linked to increased NO₂ level in the air.⁷² In Bangladesh more deaths and infections were registered in Dhaka, Chittagong and Narayanganj—traditionally three most polluted cities in the country, indicating of a possible causal relationship between pollution and COVID-19.

This was further confirmed as polluted cities in India such as Mumbai and Delhi, according to air quality index, went through severe situation compared to other Indian cities.⁷³ Hence, steps must be taken to decrease pollution in Dhaka city and surrounding areas. Possible solution includes – modernizing the transport system within the metro area discarding the age-old vehicles currently in operation, relocating factories and industries to a specific designated area with excellent sewage system far away from city, making the rivers around the cities free of pollution by redirecting the sewage system to another area, reduction of greenhouse gas emission, undertaking tree plantation initiatives etc.

4 | CONCLUSION: STUDY LIMITATIONS AND FUTURE PROSPECTS OF COVID-19 IN BANGLADESH

There are several limitations to this study. First of all, authors relied on published data from government websites, press reports, previously published articles and social media reactions. The authors did not conduct any primary research to find out the validity of the datasets. Several datasets are prone to reporting bias and is a major limitation of this paper. In addition, there are myriad of challenges that need to be paid attention to by the respective authorities including financial restructuring, improvement in disaster management planning, ensuring food security, reformation of healthcare system, strengthening of governance etc. in order to successfully manage the aftermaths of this deadly pandemic. For this short research, the authors decided to concentrate on aspects that require urgent attention and more related to health care management. But comprehensive research is required in future integrating all aspects of pandemic management.

In addition, the authors would like to include a model of COVID-19 pandemic, adopted from Paital et al. (2020), illustrating the current scenario of COVID-19 in Bangladesh and neighbouring countries including its inception, management strategies and priorities, and future intervention strategies including social isolation, vaccine implementation and repurposing drugs.^{34,74} (Figure 5). Based on the graphical model and the author's own review work, the authors would like to provide several recommendations for future COVID-19 pandemic management in tabulated form:

- Test each arriving individual from other countries by air or road, possibly using a point of care rapid detection kit. Increase existing detection capacity by concentrating of rapid antigen and antibody tests rather than costly and time-consuming PCR
- Social distancing should still be part of pandemic management programs until herd immunity is achieved. Specific task force should be implemented, possibly with the help of artificial intelligence, to ensure people abide by social distancing measures.
- New recruitment of healthcare workers including doctors, nurses and medical technologists should be completed and reach minimum threshold level as suggested by WHO
- Vaccine uptake by rural and small city people should be revisited. If needed special team should be deployed in areas identified as less interested in a vaccine and make sure people register and appear for vaccine doses
- Financial aids should be provided to poor population most affected by the pandemic. Job opportunities should be created for vulnerable population including migrants and lesbian, gay, bisexual and transgender community people
- Counselling should be provided to people suffering from mental health disorders as a result of pandemic and subsequent lockdown. Creation of temporary clinics for their rehabilitation should be a priority.

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CONFLICT OF INTEREST

The authors have nothing to disclose.

ETHICS STATEMENT

For this research, the authors mostly relied on secondary data from reputable sources. No patient was involved and no one was interviewed during the whole study duration. Hence, ethical permission from appropriate bodies was not required.

AUTHOR CONTRIBUTION

Md. Maruf Ahmed Molla conceived and copy-edited the manuscript. All the listed authors made equal contribution in reviewing literature and writing the paper. All authors agreed on the final manuscript before submission.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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