

Impact of COVID-19 Crisis on Healthcare Sector in Bangladesh and Possible Solutions

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Abstract: Like most other countries in the world, the recent COVID-19 outbreak has severely impacted the healthcare sectors in Bangladesh. Despite a very late response to the COVID-19 outbreak, many governments and non-government initiatives have been launched to deal with the crisis in Bangladesh. However, it is evidenced that there is a severe dearth of health personnel, ICU beds, ventilators, PPE, and other required medical equipment for health professionals. The inadequate and ill-timed response from the government has resulted in an increased rate of infection and deaths. Moreover, Non-COVID-19 patients suffer from accessing their regular treatments, primarily due to the lack of safety provided to the health professionals. Therefore, rapid and proactive measurements, digital interventions at a large scale (e.g., use of mHealth and artificial intelligence), decentralization (e.g., equal support and availability of facilities in both rural and urban areas), healthcare budget, multi-party coordination, boosting support for private startups, and increasing testing and treating facilities are highly recommended as possible solutions.

Keywords: COVID-19, Pandemic, Healthcare, Bangladesh.

Introduction

The recent COVID-19 Pandemic has dismally impacted the healthcare sectors in almost every country, including developed, developing, or least-developed countries. Apart from allocating more resources, the healthcare sector's capacity and service scalability in any country is the highest priority to deal with the global outbreak and ensure the occupational safety of health workers (ILO, 2020). In a developing country like Bangladesh, the impact of COVID-19 has exacerbated the overall status of the healthcare sector that has already been out of its capacity due to the preexisting burden of limited resources (Khan & Hossain, 2020; Shammi et al., 2020). In many instances, rehiring retired health professionals and engaging current medical students have scaled up the resources to tackle the spike in day-to-day healthcare demand (The Financial Express, 2020). Besides, a significant surge in adopting technology to manage remote healthcare services is increasingly getting attention in most countries, including

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Bangladesh (LightCastle, 2020c).

Despite a very late response by the government in Bangladesh, several government-led initiatives have been launched in coordination amongst ministries and agencies to reduce the COVID-19 outbreak. For example, awareness building, imposing partial-lockdown, opening free call centers, installing screening machines in the international airports and land-ports, closing education institutions, restricting all non-essential businesses, and setting up testing centers across the country are the primary initiatives, among others. (Islam & Divadkar, 2020). On the other hand, the government has arranged with the help of local garment manufacturers to ensure the provision of personal protective equipment (PPE) availability. As an emergency economic rescue, the government has announced a stimulus package of USD 8.57 billion by April 2020 (Business Line, 2020).

A recent study shows that the common factors causing concerns among the people are: perceived risk of community transmission, incompetency in coordination, inadequate transparency in healthcare reports by the government, fear of losing jobs, lack of access to treatment and biomedical waste disposal facilities (Shammi et al., 2020). While a significant crisis and negative repercussions due to the COVID-19 outbreak in Bangladesh were anticipated earlier in the late March of 2020 (Nooruddin & Shahid, 2020), few studies are available specifically exploring the recent literature to review the impact of the COVID crisis on the healthcare sector. Therefore, this study aims to fill this gap by evaluating the current literature and subsequently recommending several potential solutions based on the existing literature.

The Current COVID-19 Situation in Bangladesh

The current scenario regarding COVID-19 in Bangladesh as of August 2021, shown in Table 1. As per the table, the COVID-19 case tally was 1.433 million (0.871% rate) and the total number of deaths was 0.024 million (0.015% rate). Also, the total number of vaccinations was 19.671 million (12% rate). In total, vaccines from five companies are available in the country currently. To fulfill the high demand, the government has approved the production of Russian Sputnik V and Chinese Sinopharm COVID-19 vaccines in Bangladesh (Daily Star, 2021).

Table 1: Current status of COVID-19 cases in Bangladesh as of August 2021 (WHO, 2021).

	Total	Total in 100,000
Cases	1.433 million	871
Vaccine doses	19.671 million	12,000
Deaths	0.024 million	15

Based on previous data, a breakdown of the current cases into different divisions is shown in Table 2. Table 2 shows that Dhaka, the capital city of Bangladesh, has the highest percentage of COVID-19 cases (67.3%), and Mymensingh has the lowest percentage of COVID-19 cases (2.0%). Also, Dhaka has the highest cases per million (2,916) and Rangpur has the lowest cases per million (211). However, recently, it is found that out of the eight districts in Bangladesh Rajshahi division belongs to the most high-risk category, whereas the Mymensingh division still has the lowest rate of infection cases (Tribune, 2021). According to WHO, in recent time overall, 64 districts in Bangladesh have been at very high risk in Bangladesh. On the other hand, Table 3 shows that the highest confirmed cases (26.8%) have been reported in the age group of 31 to 40 years, and the highest percentage of death (26.8%) in the age group of 64 to 70 years old.

Table 2: COVID-19 cases in each zonal division in Bangladesh as of 13 July 2020 (WHO, 2020).

Division	Cases percentage	Cases per million
Dhaka	67.3%	2,916
Chittagong	14.9%	827
Sylhet	3.0%	479
Barishal	2.2%	421
Rajshahi	4.6%	395
Khulna	3.8%	386
Mymensingh	2.0%	288
Rangpur	2.2%	211

Table 3: COVID-19 cases and deaths as per age groups in Bangladesh as of 13 July 2020 (WHO, 2020).

Age Group	Cases percentage	Death percentage
21-30	21.3%	2.6%
31-40	26.8%	6.6%
41-50	18.6%	11.4%
51-60	14.7%	24.7%
61-70	7.1%	29.8%
71-80+	3.2%	23.5%

The current resources available in the healthcare sector are shown in Table 4. As per the table, 5.1% of hospitals have emergency transport such as ambulances, 34.5% of healthcare organizations have lab facilities, and only 28% of them have essential medical equipment. On the contrary, the doctor-patient ratio in Bangladesh is about 5.26 per ten thousand (UNDP, 2020). The annual healthcare sector budget is usually 0.9% of the total GDP; however, it has been recommended to be 2% in the 2020-2021 fiscal year budget (Ovi, 2020).

Table 4: Healthcare Facilities in Bangladesh (UNDP, 2020).

Availability	Percentage
Emergency transport	5.1%
Alcohol-based disinfectant	21.5%
Medical masks	27.5%
All basic equipment	28%
Lab facilities	34.5%
Regular electricity	43.1%
Soap and water	55.1%
Improved water source	90.1%

Preventive Measures in Bangladesh

Government Response

The government has taken preventive measures in its limited financial capacity and

substandard healthcare system (Nooruddin & Shahid, 2020)., As a preventive measure, the first initiative has banned all mass gatherings since the beginning of March 2020. The suspension of international flights from Europe, excluding the UK, was followed on 10 March 2020 (Anwar et al., 2020). The government has imposed 14 days of mandatory quarantine on all incoming travelers since 16tg March. The army was called in and deployed on 24 March 2020 to enforce social distancing, followed by a ten-day nationwide lockdown from 26 March to April 4, 2020 (Shammi et al., 2020).

During the lockdown period, the government encouraged the low-earning people, especially the daily labors, to leave cities and go to their villages. Concurrently, the government expedited sourcing medical hand-gloves, masks, testing kits, medical equipment like ventilators, and PPE from both local and international providers. About 2,000 doctors and 5,000 nurses were also recruited in May 2020. The government has also announced hiring an additional 2,000 doctors and 3,000 medical technologists with a target of 1,200 medical technologists to combat the crisis (The Financial Express, 2020). It has been reported that about 4,000 volunteer doctors are also available to offer free health advice to citizens through telemedicine platforms (BAL, 2020).

COVID-19 surveillance and Lab facilities

In Bangladesh, the Institute of Epidemiology, Disease Control and Research (IEDCR), a governmental health organization, has been officially running COVID-19 surveillance programs, including national wide testing and detection. 73 COVID-19 lab testing facilities approved by IEDCR have been set up throughout the entire country. These facilities are largely inadequate for a country with 170 million people (WHO, 2020). Moreover, the country experienced a severe shortage of testing kits and medical equipment until support from other countries like China was available (Anwar et al., 2020). It is reported that only 10-15 sets of PPEs are available for health workers in each Upazila Health Complexes (BAL, 2020). Also, to provide a regular surveillance report, the government launched a dedicated website (corona.gov.bd) for disseminating daily tracking updates and guidelines.

Improvising and upgrading quarantine facilities

To tackle the increased COVID-19 cases s, many business centers have started to operate as makeshift hospitals and temporary quarantine facilities (Xinhua, 2020). For instance, the COVID-19 Isolation Hospital, built by Bashundhara Groups of company and Dhaka's upmarket Banani that can accommodate up to 5000 and 1,390 patients at a time, respectively. Additionally,

to manage the issues with the Rohingya refugees from Myanmar, limited testing and isolation facilities are arranged for those who live in exceptionally dense facilities (Nath et al., 2020).

Support for health professionals

The government has extended its financial support, emotional and mental health services for health professionals. Special health insurance, ranging from Taka 5 lakh to 10 lakhs, and increment in the salary have been announced for the doctors and allied health professionals (UNDP, 2020). In the case of the death of any health professionals, a compensation package, up to Taka 50 lakh, is also announced (BAL, 2020).

Support from Private Sector and Healthcare Startups

To enhance the effort to fight against COVID-19, the government has been offered support from the local private manufacturing companies (Reza & Kawsar, 2020). For instance, a large electric company called Walton has prototyped and started manufacturing medical equipment such as ventilators, powered air-purifying respirators, UV-disinfectants, and safety respirators and eye goggles to meet immediate local demand (TBS, 2020). Another large company, Akij Group, has started building a temporary 301-bed hospital (Observerbd, 2020). To increase the isolation and treatment facility, Bashundhara Group, US-Bangla Group, and Navana Group have offered isolation and building spaces (Reza & Kawsar, 2020). Incepta Pharmaceuticals provided 3 lakh hydroxychloroquine tablets for free of cost and started manufacturing Remdesivir, a potential antiviral medication with high demand worldwide. The non-government organizations (NGOs) also offered considerable financial support to the government to deal with the COVID-19 crisis. In addition to the support from the established companies, the startup companies have also come forward in response to the call for nation initiative, called "ACT COVID," by the government (Dowla, 2020).

Impact on the Healthcare Sector

Bangladesh is one of the top 30 countries, considering the confirmed COVID-19 cases (Shammi et al., 2020). With minimal resources and a weak healthcare system, the country experiences many significant challenges and losses to manage the necessary healthcare needs. One of the biggest challenges in the healthcare sector is ensuring the resources needed for safety and all-out support (e.g., mental, financial, etc.) for the doctors and allied health professionals. They have been infected through hospital transmissions (Tithila, 2020). Besides, ensuring the provision of medical equipment across the country is found to be a mammoth challenge.

Inconvenience in getting treatment and test

The fear of being infected has led to demonstrate reluctant behavior by health professionals. The situation worsens with the evidence of frontline workers being infected (UNDP, 2020). Almost 1,200 doctors have already been affected by COVID-19 (Nath et al., 2020). Due to this concern, it is reported that many private hospitals are reluctant to offer medical services to many new patients (Shammi et al., 2020). As a consequence, many patients are being neglected and forsaken without any health treatment. Therefore, coping with non-COVID-19 patients has become more difficult (Mohiuddin, 2020; UNDP, 2020). Moreover, critical non-COVID-19 patients often have to go through additional COVID-19 tests before allowing them to be admitted to many hospitals. Elderly patients experience further difficulties accessing geriatric healthcare (Hossain et al., 2020).

There are only 399 ICU beds and 500 ventilators available, reported on 6 June, throughout the entire country to deal with critical coronavirus patients (Kabir, 2020, Mohiuddin, 2020). There are only 112 dialysis beds available for kidney patients in the country. Besides, the shortage of oxygen cylinders is also reported, especially for panic buying, linked with the perceived feeling of insecurity and instability connected with the corona pandemic (GlobalVoices, 2020). The situation has also worsened due to centralized service facilities (primarily in major cities) and the lack of PPE in the local hospitals and clinics (Anwar et al., 2020).

Resources constraints and financial loss

COVID-19 has brought an additional burden of safety measurement and compliances. Additional workforce and equipment are essential to ensure the mandatory preparedness and safety precautions in the hospitals. Lack of human resources, hospital beds, ventilator machines, PPE, a sophisticated laboratory, and other health service facilities are starkly noticed across the country. The previous report shows that there are only eight beds for every ten thousand people in Bangladesh (Islam et al., 2020).

Moreover, most hospitals have been forced to cancel elective surgery to meet the surge in COVID-19 demand, which has a substantial financial implication. Pharmaceutical companies experience severer challenges in managing their production due to a disruption in the supply chain of the raw material (e.g., Active Pharmaceutical Ingredients) (LightCastle, 2020a).

Possible Solutions

Studies show that the critical strategies for the prevention and management of COVID-19

Pandemic successfully were to ensure strict lockdown, ample quarantine facilities, fast testing facilities and required medical equipment availability, and stimulus package as financial aid (Anderson et al., 2020). Some other specific solutions to deal with such a pandemic crisis are discussed below in light of the existing literature.

Increase awareness, testing and treatment facilities

A recent study on the knowledge and preventive behaviors towards COVID-19 by Bangladesh citizens shows that the knowledge of COVID-19 prevention is higher among the citizens who dwell in urban areas than those who dwell in rural areas (Hosen et al., 2021). Therefore, the government should work at a community level in rural areas with having a far-reaching program to enhance the knowledge of preventive of COVID-19. Another study also supports the necessity of improving the healthcare system, awareness building, and imposing social distance to prevent the spread of infection (Rahman et al., 2021).

Also, the initiative by the government should foremost include the provision of rapid isolation facilities for the mass population across the country as recommended by WHO (Salathé et al., 2020). Besides, the government should also scale up facilities to ensure treatments for the COVID-19 and non-COVID-19 patients in due time (Mohiuddin, 2020), especially for patients with comorbidities. The government should also consider increasing the healthcare budget to GDP ratio to facilitate better healthcare access for low-income citizens. To ensure equal access to healthcare facilities, especially in remote and regional areas, digital infrastructure needs to scale up throughout the country (Hossain et al., 2020).

A study by Mohiuddin (2020) indicates that people rely primarily on unauthentic information because of overburdened loads on the doctors in Bangladesh (Mohiuddin, 2020). To scale up healthcare facilities, the government should encourage pharmacists to be more active in the healthcare system to facilitate the distribution of authentic information about medicines. The government should also take the initiative to offer awareness programs among general citizens about boosting their immunity systems by nutrients. A subsidy to healthy foods and supplements could be very encouraging for most citizens suffering from financial burdens. Overall, the supply of protective and medical equipment, required technology, and skilled workforce are recommended with a proper holistic approach.

Digital interventions

The Information and Communication Technology (ICT) based solutions are increasingly being used in Bangladesh to avoid the spread and inconvenience caused by the COVID-19 crisis.

Digital intervention plays a critical role in the delivery of physical health services (e.g., advice on chronic physical conditions) and the delivery of services to decrease the mental health burden of the COVID-19 crisis, including isolation (Rauschenberg et al., 2020). For example, digital interventions like eHealth, mHealth, information portal, chatbots, social media pages, interactive voice services, reminder and awareness tools, Artificial intelligence (AI) based self-assessment and diagnosis tools are some of the widely used platforms worldwide which could help to minimize the health service burden caused by COVID-19. Currently, most of these digital intervention platforms are available but to a minimal extent (Islam & Islam, 2020).

To maximize the benefits of digital interventions in delivering health services for the entire population, including vulnerable people, a multidisciplinary approach integrating digital, psychological, financial, social, and neuroscientific aspects is crucial (Holmes et al., 2020). Therefore, the government should encourage collaboration among various stakeholders by offering incentives and developing and implementing appropriate policies and procedures. While developing strategies, it is also important to consider the contextual dimensions such as clinical requirements, local health systems, and stakeholders (Maeder et al., 2020).

Decentralization

Currently, the healthcare system in Bangladesh is highly centralized. A decentralized health system is critically important to improving the COVID-19 test and treatment facilities across the country (Shammi et al., 2020). A decentralized system can be materialized through building dedicated infectious disease units, providing PPE, an epidemiological knowledge center, training facilities for the health workforce, and recruiting more doctors in every government hospital, including at every union level in the country.

Policy and proactive measurement

A Prompt making of required policy and proactive measurements are essential to increase readiness (Sultana et al., 2020). A strategic plan like implementing herd immunity can be very suitable for the Bangladesh context and gradual easing of general restrictions (Mahmood, 2020). As well as having proactive policies such as allocating budget, building IT and health infrastructure, and training the health workforce for testing, isolating, tracing, and treating infected people very aggressively in case of a future surge of COVID-19 infection are essential.

Other proactive measures should include contingency plans, sufficient stock and supply of PPE, oxygen, ventilators, etc. Contact tracing should also be considered as another useful

proactive measurement. However, it is essential to ensure that the technology and/or procedure used to preserve the patient's information privacy as per the privacy policy in the country (Salathé et al., 2020). Unfortunately, privacy policy related to the contact tracing app is available in developed countries, but Bangladesh is yet to address this issue by conducting proper research (Hasan, 2020). Screening and Standard Operating Procedure (SOP), be specific to every workplace, should also be implemented in every industry (Sultana et al., 2020). Research indicates that screening, SOP, and contact tracing are practical, proactive measurement tools against asymptomatic carrier transmission (Bai et al., 2020).

Forecasting models and artificial intelligence

Several data-driven models are available for forecasting the spread of infectious diseases, healthcare resource use and depletion, and the number of deaths. Existing forecasting models, such as the SEIR epidemic model (Efimov & Ushirobira, 2020) and Infection Trajectory-Pathway Strategy (ITPS) (Khan & Hossain, 2020), have not been tested at the Government level yet. However, the government has the most extensive dataset repository in general; therefore, it could undertake the necessary steps of testing these models if effective in forecasting and managing healthcare resources and workforce in the country.

Besides, Artificial Intelligence (AI) tools leveraged in specific contexts should be developed to fight against the COVID-19 crisis (Wynants et al., 2020). It has been used to detect infected people by analyzing data obtained from various sources, such as mobile data, x-ray images, body temperature from multiple wearable sensors, etc. AI has been adopted successfully in various application areas, such as early warnings, prediction, diagnosis, treatments, contact tracing, and social control to tackle the COVID-19 crisis (Naudé, 2020). It is reported that currently, Bangladesh has been using AI to tracking COVID-19 but to a limited extent, like for track coronavirus growth (Kabir, 2020). In the future, the government needs to use AI to help with COVID-19 diagnosis (Talukder, 2020).

Conclusions

Since the first case of the novel COVID-19 was detected in Wuhan city, China, the necessary preventive response to deal with any foreseeable critical crisis has significantly been under-resourced in Bangladesh. The overall response by the government has been observed as reactive rather than proactive. Since the first COVID-19 case on 08 March 2020, the rapid spread of the disease and the subsequent failure to test and treat the patients have utterly and undisputedly exposed the incompetence of the overall healthcare sector in the country. In the

public and private healthcare sectors, the urgency of the essential resources, supports, and policies to deal with emerging fatal health crises has been dealt with inadequately and with uncertainty. This study identifies that lack of resources, workforce, coordinated management, and decentralization of the medical facilities are significant concerns in effectively dealing with the current crisis.

Although the overall healthcare expenditure of individuals had not increased largely because of COVID-19 (LightCastle, 2020); however, the health care sector has exhibited inadequate healthcare capacity because of the dearth of health personnel, ICU beds, ventilators, PPE for the doctors and health workers, and standard operation procedure for occupational safety. Besides, weak governance has caused mental stress and anxiety to the general population, who are deprived of fundamental needs (Shammi et al., 2020). Apart from low capacity, the healthcare sector also has to encounter safety, supply chain logistics, and financial loss. Therefore, timely, proper, and empirical understating regarding the coordination among the stakeholders and responsible bodies are needed to improve the current policies, infrastructural, and resource in the healthcare system to successfully manage the pandemic crisis.

Overall, the late response has resulted in an increased rate of infection and deaths. Inconvenience for the non-COVID-19 patients while trying to get regular treatment is widely reported, mainly due to the lack of safety provided to the health professionals. In the future, the government should support scaling up all private initiatives, especially digital health initiatives. Also, financial support to the private healthcare sector is essential to reducing resource constraints and financial loss. The government support should be equally distributed in both rural and urban areas to ensure the decentralization of the COVID-19 test, treatment, and services. It is also necessary to adopt technologies like Artificial Intelligence (AI), the Internet of Things (IoT) and Big Data to achieve a significant edge in improving pandemic crisis management and patient care. Finally, dealing with any foreseeable future crisis, ensuring enough medical resources and equipment stock, rapid taskforce development, timely multi-sectoral coordination, use of technology such as artificial intelligence of COVID-19 patient tracking, and decentralizing medical facilities across the country are highly recommended.

Declarations

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Competing Interests

None.

References

- Anderson, R. M., Heesterbeek, H., Klinkenberg, D., & Hollingsworth, T. D. (2020). How will country-based mitigation measures influence the course of the COVID-19 epidemic? *The Lancet*, 395(10228), 931–934. [https://doi.org/https://doi.org/10.1016/S0140-6736\(20\)30567-5](https://doi.org/https://doi.org/10.1016/S0140-6736(20)30567-5)
- Anwar, S., Nasrullah, M., & Hosen, M. J. (2020). COVID-19 and Bangladesh: Challenges and how to address them. *Frontiers in Public Health*, 8.
- Bai, Y., Yao, L., Wei, T., Tian, F., Jin, D.-Y., Chen, L., & Wang, M. (2020). Presumed asymptomatic carrier transmission of COVID-19. *Jama*, 323(14), 1406–1407.
- BAL. (2020). *COVID-19: Bangladesh Situation Report*. <http://albd.org/articles/news/33190/Covid-19:-Bangladesh-Situation-Report>
- Business Line. (2020). *Bangladesh PM unveils massive stimulus package to counter adverse effects of coronavirus*. <https://www.thehindubusinessline.com/news/world/bangladesh-pm-unveils-massive-stimulus-package-to-counter-adverse-effects-of-coronavirus/article31261915.ece>
- Daily Star. (2021). Covid-19: 40 districts in Bangladesh now at very high risk, says WHO. Available from: <https://www.thedailystar.net/coronavirus-deadly-new-threat/news/govt-approves-proposal-producing-russian-chinese-covid-19-vaccines-bangladesh-2085225>
- Dhaka Tribune. (2021). Govt approves proposal of producing Russian, Chinese Covid-19 vaccines in Bangladesh. Available from: <https://www.dhakatribune.com/bangladesh/2021/06/24/covid-19-40-districts-on-bangladesh-now-at-very-high-risk-says-who>
- Dowla, R. (2020). *Extending support to local startups*. <https://thefinancialexpress.com.bd/views/extending-support-to-local-startups-1594402509>
- Efimov, D., & Ushirobira, R. (2020). *On an interval prediction of COVID-19 development based on an SEIR epidemic model*.
- GlobalVoices. (2020). *COVID-19 is rapidly exhausting the Bangladesh healthcare system amidst an alarming rise of infected people*. <https://globalvoices.org/2020/06/14/covid-19-is-rapidly-exhausting-bangladesh-healthcare-system-amidst-alarming-rise-of-infected-people/>

- Hasan F. Contact tracing app: What it does, how it works [Internet]. 2020. Available from: <https://thefinancialexpress.com.bd/views/contact-tracing-app-what-it-does-how-it-works-1593878224>
- Holmes, E. A., O'Connor, R. C., Perry, V. H., Tracey, I., Wessely, S., Arseneault, L., Ballard, C., Christensen, H., Cohen Silver, R., Everall, I., Ford, T., John, A., Kabir, T., King, K., Madan, I., Michie, S., Przybylski, A. K., Shafran, R., Sweeney, A., ... Bullmore, E. (2020). Multidisciplinary research priorities for the COVID-19 Pandemic: a call for action for mental health science. *The Lancet Psychiatry*, 7(6), 547–560. [https://doi.org/https://doi.org/10.1016/S2215-0366\(20\)30168-1](https://doi.org/https://doi.org/10.1016/S2215-0366(20)30168-1)
- Hossain, I., Mullick, A. R., Khan, M. H., Ahmad, S. A., Rahman, M. S., & Aktaruzzaman, M. M. (2020). Epidemiology of Coronavirus Disease: Past, Present, Future Prospects and Its Journey Towards Bangladesh. *Epidemiology*, 25(06).
- Hossain, M. M., Mazumder, H., Tasnim, S., Nuzhath, T., & Sultana, A. (2020). Geriatric health in Bangladesh during COVID-19: challenges and recommendations. *Journal of Gerontological Social Work*, 1–4.
- Hosen, I., Pakpour, A. H., Sakib, N., Hussain, N., Al Mamun, F., & Mamun, M. A. (2021). Knowledge and preventive behaviors regarding COVID-19 in Bangladesh: A nationwide distribution. *PLoS One*, 16(5), e0251151.
- ILO. (2020). *COVID-19 and the health sector*. https://www.ilo.org/wcmsp5/groups/public/--ed_dialogue/---sector/documents/briefingnote/wcms_741655.pdf
- Islam, M. N., & Islam, A. K. M. N. (2020). A systematic review of the digital interventions for fighting COVID-19: the Bangladesh perspective. *IEEE Access*, 8, 114078–114087.
- Islam, M. T., Talukder, A. K., Siddiqui, M. N., & Islam, T. (2020). *Tackling the Pandemic COVID-19: The Bangladesh Perspective*.
- Islam, S. T., & Divadkar, Y. N. (2020). *How Bangladesh's leaders should respond to the economic threats of COVID-19*. <https://www.weforum.org/agenda/2020/04/covid-19-coronavirus-bangladesh/>
- Kabir, H. (2020). *Only 399 ICU beds amid virus spike*. <https://thefinancialexpress.com.bd/health/only-399-icu-beds-amid-virus-spike-1591415722>
- Kabir SA. Artificial Intelligence, a weapon to fight coronavirus [Internet]. 2020. Available from: <https://tbsnews.net/feature/panorama/artificial-intelligence-weapon-fight-coronavirus-98632>

- Khan, M. H. R., & Hossain, A. (2020). COVID-19 Outbreak Situations in Bangladesh: An Empirical Analysis. *MedRxiv*.
- LightCastle. (2020a). *Bangladesh Pharmaceutical Sector Wading through the Pandemic*. <https://www.lightcastlebd.com/insights/2020/03/30/bangladesh-pharmaceutical-sector-wading-through-the-pandemic>
- LightCastle. (2020b). *Impact of Coronavirus on Livelihoods: Low- and Lower Middle-Income Population of Urban Dhaka*. <https://www.lightcastlebd.com/insights/2020/04/30/impact-of-coronavirus-on-livelihoods-low-and-lower-middle-income-population-of-urban-dhaka>
- LightCastle. (2020c). *Telemedicine for Bangladesh: Bridging the Doctor-Patient Gap*. <https://databd.co/stories/telemedicine-for-bangladesh-bridging-the-doctor-patient-gap-12385>
- Maeder, A., Bidargaddi, N., & Williams, P. (2020). Contextualising digital health contributions to fighting the COVID-19 Pandemic. *Journal of the International Society for Telemedicine and EHealth*, 8, e3-1.
- Mahmood M. Covid-19: Strategic policy options for Bangladesh [Internet]. 2020. Available from: <https://thefinancialexpress.com.bd/views/opinions/covid-19-strategic-policy-options-for-bangladesh-1591459682>
- Mohiuddin, A. K. (2020). Covid-19 Situation in Bangladesh. *Preprints*.
- Nath, J., Chowdhury, A. F., & Nath, A. K. (2020). *Analyzing COVID-19 Challenges in Bangladesh*.
- Naudé, W. (2020). *Artificial Intelligence against COVID-19: An early review*.
- Nooruddin, I., & Shahid, R. (2020). *Defusing Bangladesh's COVID-19 time bomb*. <https://www.atlanticcouncil.org/blogs/new-atlanticist/defusing-bangladeshs-covid-19-timebomb/>
- Observerbd. Akij Group begins construction of 301-bed hospital in city [Internet]. 2020. Available from: <https://www.observerbd.com/details.php?id=251683>
- Ovi, I. H. (2020). *CPD: Allocate 2% of GDP for healthcare sector*. <https://www.dhakatribune.com/business/2020/05/09/cpd-allocate-2-of-gdp-for-health-sector-in-the-next-budget-to-tackle-covid-19-fallout>
- Rahman, M. R., Sajib, E. H., Chowdhury, I. M., Banik, A., Bhattacharya, R., & Ahmed, H.

- (2021). Present scenario of COVID-19 in Bangladesh and government preparedness for facing challenges. *Journal of Advanced Biotechnology and Experimental Therapeutics.* ; 4(2): 187-199.
- Rauschenberg, C., Schick, A., Hirjak, D., Seidler, A., Apfelbacher, C., Riedel-Heller, S. G., & Reininghaus, U. (2020). *Digital interventions to mitigate the negative impact of the COVID-19 pandemic on public mental health: a rapid meta-review.*
- Reza, F., & Kawsar, E. (2020). *COVID-19 impact and responses: Bangladesh.* https://gsgii.org/wp-content/uploads/2020/05/Bangladesh-NAB_COVID-19-Impact-and-Responses_April-2020.pdf
- Salathé, M., Althaus, C. L., Neher, R., Stringhini, S., Hodcroft, E., Fellay, J., Zwahlen, M., Senti, G., Battegay, M., & Wilder-Smith, A. (2020). COVID-19 epidemic in Switzerland: on the importance of testing, contact tracing and isolation. *Swiss Medical Weekly*, 150(11–12), w20225.
- Shammi, M., Bodrud-Doza, M., Islam, A. R. M. T., & Rahman, M. M. (2020). COVID-19 Pandemic, socioeconomic crisis and human stress in resource-limited settings: A case from Bangladesh. *Heliyon*, e04063.
- Sultana, R., Fuad, N., & Ferdous, J. (2020). Containment Strategy during COVID-19 Outbreak- Analysis of Hospitals Hotspots in Dhaka to prevent Community Transmission. *Available at SSRN 3581666.*
- Talukder MSR. A 'responsible AI' can help Bangladesh fight Covid-19 effectively [Internet]. 2020. Available from: <https://tbsnews.net/thoughts/responsible-ai-can-help-bangladesh-fight-covid-19-effectively-87307>
- TBS. Walton to make life-saving medical equipment [Internet]. 2020. Available from: <https://tbsnews.net/companies/walton-make-life-saving-medical-equipment-ventilators-63421>
- The Financial Express. (2020). *Govt to recruit another 2,000 doctors, 3,000 health workers to fight COVID-19.* <https://thefinancialexpress.com.bd/national/govt-to-recruit-another-2000-doctors-3000-health-workers-to-fight-covid-19-1590730587>
- Tithila, K. K. (2020). *Coronavirus: Inadequate protective gear leaves Bangladesh health workers at high risk.* <https://www.dhakatribune.com/bangladesh/2020/03/20/covid-19-inadequate-protective-gears-leave-health-workers-at-high-risk>
- UNDP. (2020). *Covid-19: A reality check for Bangladesh's healthcare system.* <https://www.>

bd.undp.org/content/bangladesh/en/home/stories/a-reality-check-for-bangladesh-s-healthcare-system.html

WHO. (2020). *WHO Bangladesh COVID-19 Morbidity and Mortality Weekly Update*. https://www.who.int/docs/default-source/searo/bangladesh/covid-19-who-bangladesh-situation-reports/who-covid-19-update-20-20200713.pdf?sfvrsn=931a9b9d_2

WHO. (2021). *Bangladesh Situation*. <https://covid19.who.int/region/searo/country/bd>

Wynants, L., Van Calster, B., Bonten, M. M. J., Collins, G. S., Debray, T. P. A., De Vos, M., Haller, M. C., Heinze, G., Moons, K. G. M., & Riley, R. D. (2020). Prediction models for diagnosis and prognosis of covid-19 infection: systematic review and critical appraisal. *Bmj*, 369.

Xinhua. (2020). *Business centers converted into hospitals, quarantine facilities in Bangladesh amid COVID-19 outbreak*. http://www.xinhuanet.com/english/2020-05/17/c_139064555.htm

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