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RESEARCH PAPER

The impact of the COVID-19 pandemic on education in Bangladesh and its mitigation

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Abstract

The global COVID-19 pandemic disrupted various facets of societal functioning, with the education sector facing unprecedented challenges. The sudden closure of schools and universities, coupled with the shift towards remote learning, created a dynamic educational environment. It significantly affected academic performance, psychological health, dropout rates, school closures, and even increased early marriage rates in Bangladesh. In 2021, the dropout rate stood at 14.15 percent. This study delves into the specific repercussions of the pandemic on the education landscape in Bangladesh. The research reveals the disparities in access to online education, shedding light on the socio-economic factors influencing digital learning engagement. Through a comprehensive analysis of quantitative and qualitative data, we explore the multifaceted effects on educational institutions, students, and educators. We present the impact of COVID-19 on education graphically using interpolation polynomials. Mitigating the impact of COVID-19 on the education sector in Bangladesh necessitates a multifaceted approach that addresses various interconnected challenges. Moreover, prioritizing mental health support for students, teachers, and parents is paramount in navigating the emotional toll of the pandemic. Collaboration and partnerships with international organizations, non-government organizations (NGOs), and private sector entities are indispensable for mobilizing resources and expertise. Bangladesh can effectively manage the pandemic's complications and ensure the continued viability of its educational system by implementing such an all-encompassing approach.

Keywords: COVID-19; education; learning loss; interpolation; data analysis

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1 Introduction

Every few hundred years or so, something happens on the planet that permanently alters the way things have been for humanity up until that point. In late December 2019, a novel infectious disease, COVID-19, emerged in the human population. This disease, caused by a previously unidentified coronavirus, was first detected in the city of Wuhan, located in China's Hubei province [1]. By January 2020's end, it was officially designated as a global public health emergency. Subsequently, on March 11, 2020, the World Health Organization classified it as a pandemic [2, 3]. Bangladesh announced its first three confirmed coronavirus cases in the country on 8 March 2020. Institute of Epidemiology, Disease Control, and Research (IEDCR) Director Meerjady Sabrina Flora said at a press conference in Dhaka that two men and a woman tested positive for the coronavirus and that the three were admitted to a hospital [4–6]. As a result of the COVID-19 pandemic, numerous nations and regions worldwide have implemented several non-pharmaceutical precautions known as lockdowns [7]. By April 2020, approximately half of the global population was subjected to different degrees of lockdowns. More than 3.9 billion people were instructed or required to stay at home by governments in more than 90 countries and territories [8–10]. Semlali et al. developed a new delayed SIR epidemic model to examine COVID-19's behavior, considering immigration, vaccination, and general incidence. They found that vaccination reduces confirmed cases, but the disease persists due to the immigration of infected people. They recommended controlling the immigration of infected individuals or eradicating the disease in all regions to eliminate infection [11]. The mathematical model can be used to describe the dynamics of RNA viruses such as SARS-CoV-2 within the human body. This model relies on two key threshold parameters to define its dynamics: the basic reproduction number and the reproduction number for humoral immunity. These parameters are crucial for identifying biologically plausible equilibria within the SARS-CoV-2 infection model [12].

Among many other sectors of day-to-day life, the lockdown took a great toll on our education sector, as educational institutions remained closed for a longer period. The government of Bangladesh announced the first all educational institutions closure from 17 March 2020 to 31st March 2020 and enhanced the closure many times in an attempt to reduce the spread of COVID-19. This closure of educational institutions continued on and off till the first half of 2022. The pandemic has affected all facets of life globally for people, and the education system is experiencing its worst crisis in a century. Such as permanently closed schools, dropouts, staff shortages, unemployment of teachers, etc. Furthermore, students and educators continue to struggle with mental health challenges, high rates of violence and misbehavior, and concerns about lost instructional time. Due to the COVID-19 pandemic, about 38 million students were affected when schools closed on March 17, 2020, and they remained closed for a long time. But the government acted fast to keep learning going. They used TV and the internet to teach students with pre-recorded classes starting in April 2020. The Ministry of Primary and Mass Education set up teams to make learning materials and share them on TV, phones, radio, and the internet [13].

Like other countries, Bangladesh has experienced educational challenges as a consequence of the COVID-19 pandemic. Public and private universities have struggled to keep up with teaching and learning because of this. Numerous inquiries have been conducted to address the challenges encountered by universities and to examine their responses. General and engineering university students experienced difficulties including insufficient equipment, stress, and financial difficulties [14]. COVID-19 compelled educational institutions worldwide to switch from in-person to virtual teaching. This change posed a threat to humanity as a whole, requiring everyone in the education sector to modify and adapt their usual practices. Hosen et al. surveyed to explore the impact of COVID-19 on tertiary educational institutions and students in Bangladesh. Their analysis

showed that 60% of respondents didn't have separate reading rooms, and 21% didn't have personal electronic gadgets for online classes. Also, 55% reported spending less time studying during the pandemic. Moreover, 88% of respondents faced mental health-related stress, anxiety, and depression issues. To lessen the impact of COVID-19 on the education sector, authorities must prioritize underprivileged students. This can be achieved by providing interest-free loans, ensuring access to high-speed internet, and organizing online webinars designed to alleviate the mental stress experienced by both students and staff [15].

In addressing the challenges posed by the COVID-19 pandemic in the education sector of an emerging economy like Bangladesh, it is important to adopt flexible strategies. The opening and closure of educational institutions can give rise to various risks, encompassing economic, health, social, mental, and behavioral changes for students. To assist students in overcoming these challenges and attaining Sustainable Development Goals (SDGs), it is imperative to embrace and develop innovative techniques for navigating the evolving and dynamic educational landscape [16]. A qualitative study was conducted using thematic analysis to investigate the impact of COVID-19 on tertiary education in Bangladesh from the student's perspective. The study focused on themes including university closure, disruptions in learning, loss of social interaction, physical health problems, mental health problems, shifting to online education, and financial crisis and parental involvement. Findings underscored that transitioning to online education for tertiary studies induced stress, anxiety, and disappointment due to various challenges associated with virtual learning strategies [17].

With a particular focus on Moroccan high schools, the study investigated how mathematical biology might be incorporated into the teaching of mathematics in high school. Emphasis was placed on the significance of mathematical modeling in recent advancements in epidemiology. The goal was to evaluate the extent to which mathematical applications in biology are incorporated into the high school mathematics curriculum. After examining two bachelor textbooks used in the second year, it was determined that the Moroccan mathematics curriculum is not sufficiently accessible to experimental sciences, especially ignoring biology, as demonstrated by the lesson on differential equations. There is a need to shape students' perspectives on mathematics, mathematical biology and enhance their competencies [18].

Some research highlighted the positive outcomes of the COVID-19 pandemic, contrasting the prevailing focus on its negative impacts. Researchers collected data via online Focus Group Discussions (FGD) conducted from April 2021 to June 2021, involving final-year undergraduate students from the Sylhet division of Bangladesh. During this period, people spent valuable time with their families, pursued personal interests, acquired new skills, and gained a heightened awareness of sanitation, hygiene, and social distancing. Reduced energy use and greenhouse gas emissions improved the environment and helped to preserve ecosystems [19].

We can get more knowledge about education reform in the areas of equity, access, and inclusion; curriculum and assessment; teacher preparation; and higher education. Together, these researches offer a comprehensive view of Bangladesh's educational past, present, and future, including comparisons to other developing nations [20]. With over 100 million cases and 2 million recorded fatalities worldwide, the new coronavirus (COVID-19) pandemic has had a terrible effect on humanity. The educational, economic, medical, and public health infrastructure of China as well as other countries, particularly the neighbors, has been put to the test by this unique virus outbreak. How the virus will affect our life here in Bangladesh will only become clear with time [21, 22].

The coronavirus disease pandemic, as well as the methods taken to stop the virus's spread, have hurt education. These actions included closing schools, which significantly disrupted the lives of children. Long-term school closures will have an impact on the skills that kids can learn during their formative years, as well as on their work prospects and earning potential for many years after

school ends. Due to school closures caused by the epidemic, more than 1.5 billion kids and young people worldwide have been impacted, with major earning and learning losses being widespread in all economies indexed by United Nations Educational, Scientific and Cultural Organization [UNESCO 2021a] [23].

The study included the following objectives and their alignment:

- The aim is to analyze the educational system in Bangladesh in contrast to global standards and delineate their structural disparities.
- The repercussions of extended school closures and strategies to mitigate their effects in educational institutions.
- The impact of learning loss on student mental health and well-being.
- An examination of early marriage among female students resulting from school dropouts and measures for its prevention.
- Examining how polynomial interpolation techniques interact with the available data.

This article is organized as follows: a general structure of Bangladesh's education system is presented in Section 2. The long-term impacts of COVID-19 on education sectors are discussed in Section 3. Section 4 explores COVID-19's effect on the education system in Bangladesh by using polynomial interpolation. Section 5 of the study covers potential strategies for reducing COVID-19's effects on the education sector. Finally, a fruitful conclusion is included in Section 6.

2 Educational structure of Bangladesh

Education in the twenty-first century is truly a worldwide phenomenon. Getting a good education is seen as both a right and a responsibility in most countries today. The future of a country depends on the products of its current educational systems. Every country in the world has some kind of educational system in place, although these systems differ widely. The primary factors influencing educational systems are the financial and material means available to support them in various countries. Education policies, including a country's cultural attitudes toward education, the amount of time and resources allocated to it, and how it is distributed throughout the country also contribute to these variations.

Education in Bangladesh is heavily subsidized and is overseen by the Ministry of Education (MOE) [24]. The foundation of the educational system in Bangladesh was laid long ago. Over the last decade, Bangladesh has made notable progress in expanding access to education. The government of Bangladesh has made it a priority to ensure that all citizens, regardless of their background or gender, have access to quality education, and as such, they have implemented several programs, and initiatives aimed at doing just that. Apart from having some drawbacks, the educational system has only progressed over time.

General education, madrasah education, English medium education, and technical-vocational education are the four main educational tracks in Bangladesh. Bangladeshi Educational structure has three main levels: primary level, secondary level, and tertiary level. As of 2022, the total literacy rate of Bangladesh is 74.66 percent [25], where the Female and Male students' literacy is presented in Figure 1.

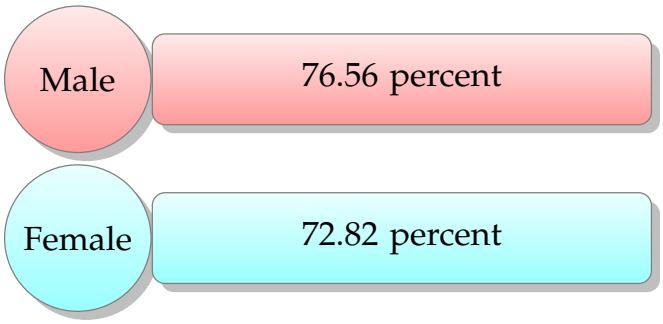

Figure 1. Female and male students distribution

In the national budget of 2017-18, a total amount of Tk 50,432 crore was allocated in the budget for education, which was groomed and boosted up to improve the education and human resources [26]. The budget distribution for three different sectors in 2017-2018 is depicted in the map referenced as Figure 2.

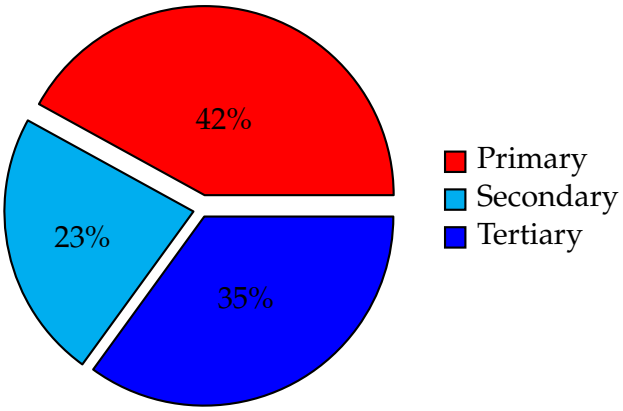

Figure 2. The educational national budget for different education sub-sectors in the fiscal year 2017-18

Primary education

Primary education is the ground floor of formal schooling. It usually marks the beginning of the educational process, coming after preschool or kindergarten and before secondary school. The Ministry of Primary and Mass Education holds the responsibility of implementing primary education programs and government-funded schools at the grassroots level [27]. Primary education is free. Children between the ages of 6 and 11 are served by elementary education, which lasts five years (from grades I through V). Its primary goal is to develop children's literacy and numeracy abilities, which include speaking, listening, reading, and computational abilities. It also aims to build additional competencies and understanding that equip young people for meaningful engagement in society [28].

Based on the Primary Education Census of 2018, there were 20.8 million students enrolled in pre-primary through grade five across all types of primary schools [29–31]. Here, a simple list is given in Table 1 which shows the list of primary schools in Bangladesh, the total number of students and female students, the total number of teachers, and female teachers in the primary sector [32].

Table 1. The number of students and teachers in different types of schools in Bangladesh

School type	Students (total)	Students (female)	Teachers (total)	Female
Government School	14671914	7530261	319112	191830
Experimental School	10652	5250	282	246
Ebtadaee Madrasah	372277	181341	11673	2300
Kindergarten	1988365	914016	93799	54813
*NGO School	210170	107898	5454	3764
Community School	16747	8679	405	322
Attached to High Madrasah	871047	427341	19764	2812
Primary Sections of High School	572751	295659	8301	4450
*BRAC	324438	185873	7798	7277
*ROSC School	106884	53751	3591	2867
Sishu Kollyan Primary	15665	8284	410	277
Others School	97519	48808	4875	2967
Grand total	**19,258,429**	**9,767,161**	**475,464**	**274,143**

*NGO School stands for Non-government Organization School; BRAC represents Bangladesh Rehabilitation Assistance Committee; and ROSC stands for Reaching Out of School Children.

Secondary education

Secondary education is managed and administered by the Ministry of Education (MOE) which is charged with policy formation, planning, monitoring, evaluation, and execution of plans and programs. At present, secondary education consists of three sub-stages such as:

- Lower secondary (grade 6 to 8).
- Junior secondary (grade 9 to 10).
- Higher secondary (grade 11 to 12).

The goals of secondary education in Bangladesh were established following the suggestions outlined by the Bangladesh Education Commission of 1974, the National Curriculum and Syllabus Committee of 1975, and the National Curriculum and Coordination Committee of 1993. Its primary purpose was to facilitate learners in acquiring new knowledge and competencies, utilize the possibilities of contemporary science and technology, foster a constructive perspective and scientific mindset, equip them with self-employment abilities, and instill a sense of patriotism alongside religious, ethical, cultural, and societal values [33]. At this level, each student must attain two public examinations named Secondary School Certificate (SSC) and Higher Secondary Certificate (HSC) under the supervision of nine Boards of Intermediate and Secondary Education. They are Dhaka, Chottogram, Barishal, Comilla, Dinajpur, Jashore, Mymensingh, Rajshahi, and Sylhet Education Board. Every high school has a particular education board. The number of high schools for every educational board is listed in Table 2 [34]. In 2021, the total enrolment of students in secondary level was 10.19 million, and the total teachers were 266568. In 2021, the Teacher-Student Ratio (TSR) was 1:38, and the average number of teachers per institution was only 13.

Higher secondary education

The Higher Secondary Education (HSE) serves an essential purpose as a connection point between secondary and tertiary education in Bangladesh. Grades 11 and 12 make up Bangladesh's system of higher secondary education. At this level, most students choose a stream of education (e.g.

Table 2. Education Boards and their corresponding number of High Schools

Education Boards	Number of High Schools
Dhaka	3549
Rajshahi	4607
Comilla	1483
Jeshore	2274
Chottogram	248
Barishal	1396
Sylhet	645

pre-engineering, pre-medicine, business management, or arts/humanities) that will serve as the cornerstone of their career throughout their lives.

The rates of HSE enrollment and completion have significantly increased recently, and there has been some improvement in the gender equity of HSE enrollment. Data reveal there are significant enrollment gaps between urban and rural colleges, which makes it difficult to advance socioeconomic development and equity. Although there has been a notable progression in achieving gender equality in HSE enrollment, there exists a significant task of enhancing and sustaining female participation. Data highlights substantial disparities between urban and rural enrollment. According to research outcomes, enrolment in HSE has significantly increased, necessitating improvements in many areas within this sector [35].

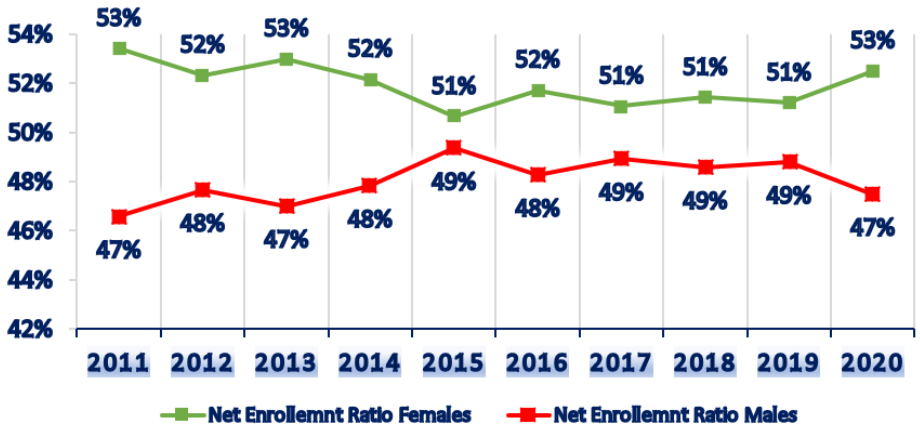

Figure 3. Enrollment ratio comparison between boys and girls [36]

According to BANBEIS 2021 data [36], the net enrollment ratio (NER) for male students at the HSE level could never beat the NER of female students in the last decade from Figure 3. This pattern can be linked to heightened parental awareness of the significance of enrolling girls in higher education and attaining an HSE diploma. Moreover, over the past five years, the Bangladesh government has amplified the stipend/scholarship initiative to expand greater participation of girls in higher education. The Bangladesh government has implemented specific policies to address the challenges of the 21st century in various sectors, including education. Some of these policies include:

National Education Policy: The government has formulated and implemented a National Education Policy aimed at modernizing and improving the quality of education in Bangladesh. This policy focuses on enhancing access to education, improving the quality of teaching and learning,

and promoting lifelong learning opportunities for all citizens.
Digital Bangladesh Initiative: The government has launched the Digital Bangladesh initiative to promote the use of information and communication technology (ICT) in education. This initiative includes programs to provide digital literacy training to students and teachers, promote e-learning platforms, and integrate ICT into the curriculum.
Science, Technology, Engineering, and Mathematics (STEM) Education: Recognizing the importance of STEM education in the 21st century, the government has prioritized initiatives to promote STEM education in schools and colleges. This includes the establishment of STEM-focused schools and the introduction of STEM-related curriculum and extracurricular activities.

3 Cumulative impact of COVID-19 on education

Learning loss

The phrase "learning loss" is frequently used in the literature to characterize declines in student knowledge and skills. Learning loss describes the deterioration or regression of students' academic knowledge and skills over extended periods of interrupted or inadequate learning opportunities. Historical data, which is frequently obtained through regular testing, gives academics insight into where student learning should be on an annual basis. When educational advancement is not made at the same rate that it has historically compared to previous years, learning loss occurs.
COVID-19 has disrupted the education of an entire generation of children. The pandemic has caused one of the lengthiest school closures worldwide, affecting the education of 37 million children in Bangladesh [37]. At the height of school closures, globally 168 million children were out of school. Furthermore, around 214 million children, or 1 in 7 have missed more than three-quarters of their in-person learning [38].
The impact of school closures was particularly challenging for all children, with girls and children from underprivileged homes suffering the greatest difficulties. They experienced noticeable learning setbacks and confronted intensified risk of dropping out of their education. Before the pandemic, as early as 2017, more than half of Bangladeshi children who completed primary school struggled to read and comprehend basic texts. Current simulations indicate that due to the extended school closures, a staggering seventy-six percent of children will likely not achieve the essential reading proficiency level by the end of primary school. While some countries managed to limit the losses, the actual impact of COVID-19 on learning progress shows that school closures frequently have a large, persistent, and unequal effect on learning. Online education is not a good enough substitute for in-person learning, particularly for children from low-income families. An examination of 35 rigorous studies from 20 countries reveals three key issues:

i. The majority of studies (32) discover evidence of learning loss. 27 of the 35 studies that reported learning loss findings did so in a format with a similar effect size. In most research, learning losses were reported to range between 0.25 and 0.12 standard deviations (SDs). Losses in learning were even higher in five studies. The average amount of learning lost across all studies is 0.17 standard deviations or more than half a school year.
ii. The studies consistently find different levels of learning loss by student socioeconomic status, past academic learning, and the subject of knowledge. By socioeconomic position, learning loss was studied in 20 research. 15 of them demonstrate a statistically significant difference between children or schools with lower socioeconomic levels and greater learning loss, whereas 5 do not. Numerous studies have also revealed that pupils who had academic difficulties before the epidemic suffer more from learning loss. In the studies that used this measure, 11 showed that students with lower levels of academic achievement experienced larger learning losses, while 3 showed that students with higher levels of prior academic achievement experienced greater

learning losses.

iii. Learning losses increased in proportion to the length of school closures. The average length of school closures for the 19 nations for which we have reliable learning loss data was 15 weeks, resulting in an average learning loss of 0.18 standard deviations. In other words, learning decreased on average by 1.2 points, or 0.01 standard deviations, for each week that schools were closed. These nations show compelling evidence that the pandemic-induced school closures were responsible for learning deficits. Average learning losses in these European nations were 0.16 standard deviations, and average school closures lasted 11 weeks on average. As a result, learning losses were roughly 1.5 points, or 0.015 standard deviations, per month, for each week that schools were closed.

Here, results presented in months of loss are converted to standard deviations, with 1 school year of learning equal to 0.33 standard deviations [39].

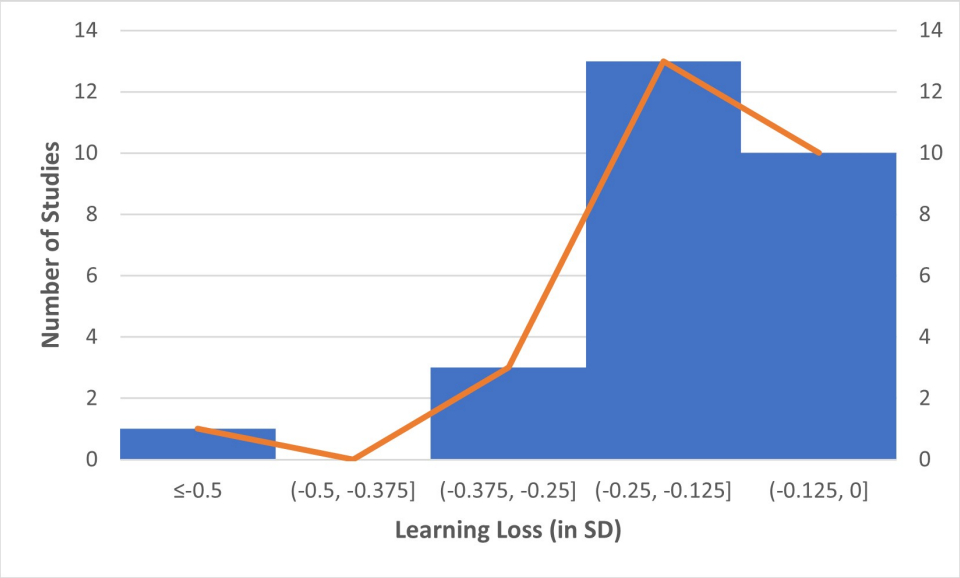

Figure 4. Range of learning loss (in SDs) in the 27 studies reporting comparable effect sizes

In Figure 4, learning equal to 0.33 standard deviations. Negative SDs represent learning loss. According to Figure 4, most studies indicate a loss of approximately one academic year in learning. However, one study showed 1.5 school years of learning loss. In 2020, the Bangladeshi government decided to cancel one of the nation's significant public examinations due to concerns related to the COVID-19 pandemic. The Ministry of Education declared that approximately 1.4 million candidates who were supposed to appear for the HSC and equivalent examinations that year would instead be assessed based on their performance in two of their preceding public exams, namely the JSC (Junior School Certificate) and SSC. As a result, all candidates were granted an 'Auto-pass' [40]. Furthermore, various countries postponed their major public exams due to rising cases of COVID-19.

The crisis-induced learning deficits will exploit a substantial economic cost. According to the World Bank's estimations, today's generation of school children could face a lifetime earnings reduction of USD 17 trillion in current value. This amount equates to approximately 14 percent of the existing global Gross Domestic Product (GDP) [41].

Effect on student's mental health

Since the start of the COVID-19 pandemic in early 2020, school closures have affected the education of around 37 million children in Bangladesh and approximately 800 million children worldwide including Asia, encompassing South Asia, Southeast Asia, and East Asia [42]. In Bangladesh, schools were closed throughout the entire pandemic until 12 September 2021, when they reopened again after an 18-month closure. A whole generation's future is on the line. The pandemic has provided parents, teachers, and kids with several difficulties. We are just now beginning to understand the far-reaching effects of school closures, isolation policies, and other abrupt changes on students. The COVID-19 pandemic has had a significant impact on student mental health, and several quotes shed light on the situation. From a student: "I miss going to school every day and seeing my friends. Learning from home is challenging because I don't have access to a computer or internet connection. Sometimes, I feel like I'm falling behind in my studies" and from another educator: "It's heartbreaking to see how the pandemic has disrupted the education of so many students. We're doing our best to provide support and resources to help them continue learning, but it's challenging without the structure of regular school days."

COVID-19 has significantly affected primary school students and children. The effects on children of the disruption of educational services cannot be disregarded. Children lose the largest chance to learn and grow to their full potential when schools are closed. Children who already deal with mental health issues have been particularly susceptible to the changes. When school restarts, some depressed children may have a difficult time returning to their regular routines. Approximately 29% of parents report that their children are presently grappling with emotional or mental health challenges due to the effects of social distancing and closures. An additional 14% of parents suggest that their children can endure a few more weeks of social distancing before their mental health begins to deteriorate [43].

The consequences on high school students or teenagers as a result of the COVID-19 pandemic are notable. The year 2020 proved challenging for everyone, but it had an especially significant effect on the mental well-being of teenagers and young adults. A recent study involving 5,400 participants reported that 25% of individuals aged 18 to 24 had thoughts of doing suicide in the preceding 30 days. Moreover, a recent survey revealed that 80% of students faced adverse effects on their mental health as a result of the pandemic, with 20% indicating a substantial deterioration in their mental well-being [44].

The impact on college students is evident due to COVID-19. 20% of college students say their mental health has significantly worsened under COVID-19. 48% have experienced financial setbacks due to COVID-19. Among all students, 38% said having trouble focusing on their studies. 74% are challenged in maintaining a routine [45]. A data table of the impact on mental health due to COVID-19 is listed in Table 3 according to types of mental problems [45].

Table 3. Impacts of COVID-19 on students' mental health [45]

Type	All students	College students	High school students
Stress or anxiety	87%	91%	74%
Disappointment or sadness	78%	80%	74%
Loneliness or isolation	42%	48%	26%
Financial setback	42%	48%	26%
Relocation	39%	56%	2%
Illness (myself or loved one)	7%	5%	9%
Loss of a loved one	4%	3%	5%
None of the above	4%	2%	8%

COVID-19's influence on university students is discernible. There has been an upswing in concern about the mental health of undergrads in recent years. Since COVID-19, the educational landscape in Bangladesh has undergone significant change. All university campuses were closed during the pandemic. There was a problem with the student's mental health. University students are now more likely to have mental health problems due to the pandemic's stressors and constraints, which could seriously harm their academic performance, social connections, and future careers. University students indicated normal levels of depression 30.41%, anxiety 43.29%, and stress 47.40% during COVID-19 [46]. Many of them committed suicide due to mental issues. Male students reported lower levels of anxiety and stress compared to female students. Furthermore, students living in the urban area of Dhaka displayed higher levels of depression and anxiety in comparison to students residing outside the city [46]. Table 4 displays the frequencies and percentages of depression, anxiety, and stress labels among university students in Bangladesh [46].

Table 4. Labels indicating depression, anxiety, and stress levels among university students in Bangladesh [46]

Rating	Depression (n%)	Anxiety (n%)	Stress (n%)
Normal	111 (30.41)	158 (43.29)	173 (47.40)
Mild	53 (14.52)	25 (6.85)	43 (11.78)
Moderate	84 (23.01)	82 (22.47)	54 (14.79)
Severe	33 (9.04)	25 (6.85)	49 (13.42)
Extremely Severe	84 (23.01)	75 (20.55)	46 (12.60)

Consequently, there was a discernible escalation in mental health distress when students indicated the experience of COVID-19-related symptoms. For instance, in cases where individuals reported experiencing one or more symptoms, the risk of stress elevated by a factor of 1.60, while the presence of at least one symptom amplified this risk to 3.06 times. Similarly, anxiety's risk factor increased to 3.02 times with the presence of one or more symptoms and further to 4.96 times with at least one symptom [47]. Moreover, a different research investigation revealed that undergoing symptoms such as fever, dry cough, fatigue, sore throat, and difficulty breathing played a pivotal role in the emergence of mental diseases.

The concern about contracting COVID-19 emerged as a noteworthy indicator of depression, anxiety, and stress in multiple studies. Likewise, incidents, where family members or friends had been affected by COVID-19, were also associated with heightened levels of anxiety. According to a study, students who expressed high levels of anxiety about coming into contact with individuals infected with COVID-19 faced 3.5 and 2.75 times greater risks of experiencing anxiety and depression compared to those who had no or minimal contact. Likewise, students who had been in contact with confirmed COVID-19 cases were found to be at 4 and 3.17 times higher risk of experiencing stress and anxiety, respectively [47].

The duration of internet browsing has been considered a predictive element for psychological disorders in one study. According to this study, students who spent 5 to 6 hours or more than 6 hours browsing the internet were at a high risk of experiencing psychological problems, in contrast to those who spent less than 2 hours. Furthermore, experiencing sleep difficulties was also associated with an elevated risk of mental health issues. Another study asserted that students who reported dissatisfaction with their sleep patterns experienced higher levels of psychological distress compared to those who were satisfied with their sleep quality. The habit of smoking was reported as a significant factor in evaluating mental health problems. The students who were

engaged in smoking were more prone to psychological suffering [47].

Economical impact of COVID-19 related school closures

The economic impact of school closures in Bangladesh can be significant and multifaceted, affecting individuals, teachers, and students in various ways: loss of income, increased household expenses, reduced productivity, professional challenges, disrupted education and emotional impact. All these issues somehow connected with the individuals, teachers, and students.

Education helps people to be more effective at their jobs, especially in today's knowledge-based industries. Education also gives people the information and abilities they need to create and use novel ideas and breakthroughs that advance technology and boost the nation's economy completely. The coronavirus disease (COVID-19) and related school closures substantially disrupted children's education. Long-term school closures will affect the students' learning and potential professional productivity. The COVID-19 pandemic has seriously disrupted educational systems around the world. According to UNESCO (2021b), a total of 210 economies have experienced either full or partial school closures, with 84 of them enduring closures lasting over 40 weeks, equivalent to a full school year. Due to prolonged school closures during COVID-19, Bangladesh has endured substantial declines in gross domestic product (GDP) and employment [23].

Especially in developing economies, where students frequently suffer from reliable access to high-speed internet connectivity, online education might not yield the same effectiveness as traditional in-person teaching and learning. While online learning can lessen the effects of an interrupted school year, its success depends on the accessibility of learning resources and their effectiveness in promoting learning. To address the learning deficit, one frequently proposed solution is online education. However, the transition to online learning is not currently a feasible solution for Bangladesh. Approximately 5 percent of households lack access to a mobile phone, and when it comes to computers/tablets, only 5.60 percent of households possess one. However, merely owning a computer/tablet is insufficient. With only 37.60 percent of households having internet connectivity at home (with urban areas at 53.10 percent and rural areas at 33.20 percent), the feasibility of this option appears dimmer. Additionally, clear regional and income disparities are evident: rural and economically disadvantaged regions have significantly less access to Information and Communications Technology (ICT) compared to urban and wealthier areas. This inequality extends to poorer households as well. Based on the most recent Household Income and Expenditure Survey (HIES) data, updated to 2020, it can be estimated that approximately 12.70 percent of impoverished households lack access to even a single mobile phone [48]. The poorest and second lowest percentiles of wealth have faced the hardest hit in economies with a noticeable presence of students from rural areas. The primary causes of this are the lack of dependable internet connections and the difficulties associated with online learning, which hurt these students' chances of obtaining a degree. Furthermore, economies with a high percentage of unskilled laborers within the workforce also experience significant limitations in terms of both learning and earning potential. For this reason, the closure of schools leads a significant portion of the affected students towards opportunities in unskilled employment.

The closure of schools has generated an impact on labor productivity as well. Since the start of the pandemic, there has been a significant decrease in the participation of women in the workforce, particularly among working mothers who have had to care for their children. The increased dependency on virtual learning due to school closures has arisen in a situation where women having young children have chosen to step back from their jobs. While the eventual return to traditional in-person schooling could potentially boost labor force participation rates, the possibility of this outcome remains uncertain. This uncertainty is especially relevant in developing

economies, where many kids have not received vaccinations. When a considerable proportion of the working force is employed in unskilled labor, both learning and earning are significantly impacted. Forecasts for Bangladesh indicate that skilled employment may experience a decline of 3.18 percent, and unskilled labor employment may see a decline of 3.16 percent by the year 2030. Regarding the magnitude of the change, Bangladesh is projected to encounter a notable decline in GDP in South Asia, following India, with an estimated decrease of approximately $13.84 billion by 2030. Meanwhile, India is anticipated to undergo the most substantial GDP decline in South Asia, with a projected decrease of about $98.84 billion by 2030. Moreover, the country's skilled employment is expected to decrease by 0.244 percent in 2023 and further by 0.759 percent in 2025 [49].

According to the report, school closures cause a decline in the global GDP and employment possibilities. The research titled "Potential Economic Impact of COVID-19-Related School Closures," done by the Asian Development Bank (ADB), reports that the GDP has shrunk by 3.1 percent as compared to the baseline scenario without COVID-19 because of the lost revenue from these closures. This reduction amounts to a global decline in GDP of 0.19 percent in 2024, 0.64 percent in 2028, and 1.11 percent in 2030. By the year 2030, it is estimated that the world economy will have lost 943 billion dollars due to school closures caused by the COVID-19 epidemic [49].

Due to financial hardships brought on by pandemic control measures, the COVID-19 pandemic may have a more significant effect on schooling. The South Asian Network on Economic Modeling (SANEM) used the latest Household Income Expenditure Survey (HIES) to calculate that, before the crisis, 8.4 million students' families (23.90 percent) lived in poverty. With a prolonged crisis and a three-month lockdown starting from March 25, 2020, causing a 25.0 percent drop in yearly per capita income, SANEM predicts that the number of student families below the poverty line could increase to 43.90 percent. This implies that an additional 7.70 million student families could fall into poverty during this crisis, bringing the total to 16 million students living in the poverty line [48].

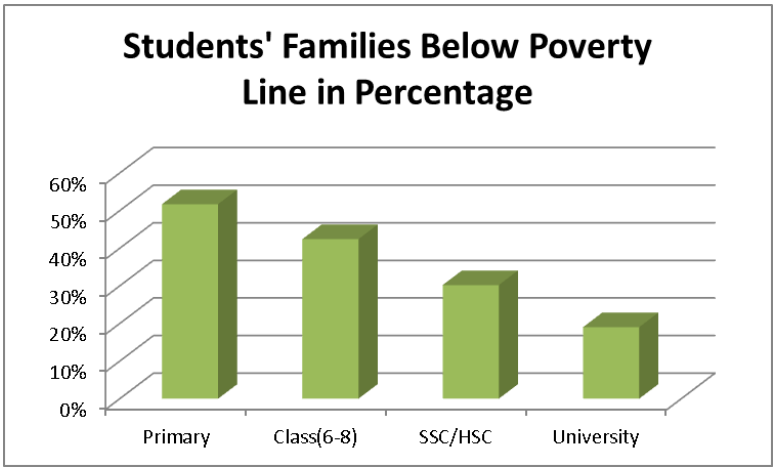

Figure 5. Students' families below the poverty line

In Figure 5, the horizontal axis shows the educational levels, and the vertical axis shows the percentage of children whose families earned less than the poverty line in COVID-19. The percentage is high at the primary school level and low at the university level. The primary students are unable to work and be paid. Thus, their livelihood is only managed by the guardians. Nevertheless, university students can work and support their families.

Many teachers lost their employment after the closure of the schools. Some departed because

they were stressed and struggled with technology, while others lost jobs due to insufficient money. Even after two years of closures, most teachers in the study still didn't have jobs, demonstrating the uncertain nature of the teaching job market.

Influence on early marriage

Amidst the COVID-19 pandemic, the incidence of child marriage in Bangladesh has seen a disturbing increase, predominantly due to girls spending more time at home as a result of the closure of educational institutions. It's worth noting that Bangladesh holds the unfortunate distinction of having the fourth highest prevalence of child marriage globally [50]. The pandemic has further exacerbated this critical situation for countless girls. Bangladesh ranks among the top 10 countries in terms of child marriage rates [51].

Disturbingly, over 50% of Bangladeshi women currently in their mid-20s were wed before their 18th birthday, and nearly 18% were married off before the age of 15 [50]. Moreover, the rate of child marriages has surged by up to 220% during the July-September period amid the ongoing pandemic [51]. Even before the COVID-19 outbreak, approximately 100 million girls remained at risk of child marriage over the next decade, despite notable reductions in several countries in recent years [52].

According to a Financial Express report, a girl had eight friends in a village school prior to the outbreak. When the school resumed on September 12, she was alone in her class. She waited for her friends for a few days, but they didn't come back. It turns out that all her friends got married while the school was closed. This violates the laws against child marriage. Many newspapers have written about numerous instances during the pandemic where people violated this guideline [53]. Girls' general well-being, education, and health are severely harmed by child marriage. Beyond the immediate physical risks associated with early pregnancies, such unions often curtail educational opportunities, perpetuating cycles of poverty and reinforcing gender disparities. Moreover, the psychological toll of forced marriages can lead to anxiety, depression, and trauma, hindering girls' mental well-being and long-term prospects. To break this cycle of harm, concerted efforts are needed to promote gender equality, protect girls' rights, and provide comprehensive support to those affected by child marriage.

Case study of dropouts

The most severely affected of all educational institutions were the kindergartens. During the pandemic, thousands of kindergartens have shuttered, and unfortunately, the majority of them are unlikely to resume business. Teachers of these kindergartens have been forced to take menial or odd jobs to survive during the pandemic. Inquiries into household intentions regarding the return of their children, who were attending school before the government-imposed closures in March 2020, reveal that over 13% of current enrollees are considering discontinuing their education. Additionally, approximately two-thirds of these potential dropouts have no intentions of resuming their education after leaving. This trend of dropping out is prevalent across various grade levels. It's worth noting that male students exhibit a slightly higher likelihood of discontinuing their education (14%) compared to female students (13%). Furthermore, among students residing in slum areas, a significant 17% are contemplating dropping out. In contrast, in August 2020, only less than 1% of the students planned to drop out [54]. From the BANBEIS data [36], a comparison of the dropout rates in the primary level for the last six years is shown in Figure 6.

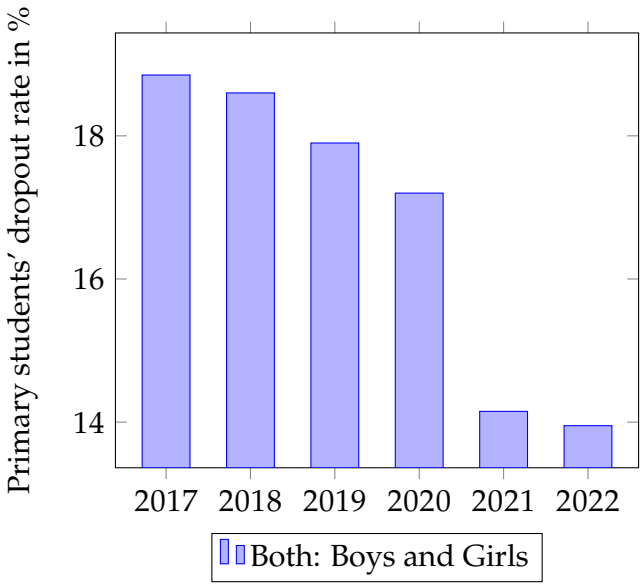

Figure 6. Primary-level student dropout rates, 2017-2022

From the BANBEIS data [36], a comparison of the dropout rates in the secondary level for the last six years is mapped in Figure 7.

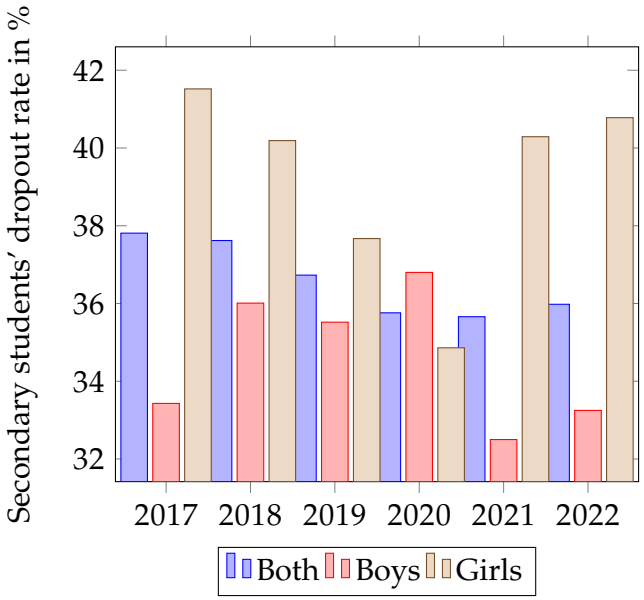

Figure 7. Secondary-level student dropout rates, 2017-2022

Due to the inability to commence their college sessions, students are grappling with concerns about the potential truncation of their academic year. Consequently, many students are forced to juggle multiple unstable jobs such as construction work, garment sector employment, bus driving, auto-rickshaw driving, and so on. This has led to a regrettable situation where numerous students have dropped out of school, leaving them unprepared for the HSC examination.
Throughout 2022, plenty of factors combined to elevate the dropout rates among girls in higher secondary schools. Economic hardships exacerbated by the COVID-19 pandemic, unequal access

to technology for remote learning, societal pressures forcing girls to shoulder domestic duties, increased risks of early marriage and pregnancy, and elevated mental health challenges all converged to hinder girls' educational aspirations. These hurdles underscore the critical necessity for focused interventions aimed at improving females' educational achievements and eliminating long-standing institutional disparities.

In particular, a comparison between boys' and girls' dropout rates in the higher secondary level for the same time interval is displayed in Figure 8.

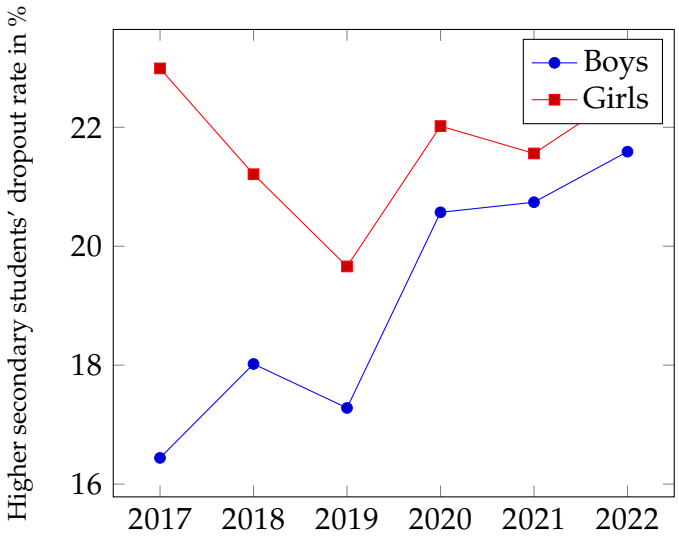

Figure 8. Higher secondary-level dropout rate comparison: Boys vs Girls

Bangladesh's dropout rate is declining as a result of the government consistently strengthening the educational system. Due to the start of COVID-19 in 2020, students were admitted to schools and colleges early. Thus, the dropout rate does not increase. Dropout rates decreased in 2021 due to auto passes, online courses, etc. However, in 2022, all families experience financial hardship, girls get married, and males begin working to support the family, which causes a small increase in dropout rates. Since girls got married, the dropout rate for females from second to higher secondary schools is particularly high in 2022. They are unable to enroll in college anymore.

4 COVID-19's impact on education with polynomial interpolation

With the help of polynomial interpolation, we plot the number of students who took the Secondary School Certificate (SSC) and Higher Secondary Certificate (HSC) exams in the relevant years to demonstrate the impact of COVID-19 on Bangladesh's educational system. For SSC students:

Year (x)	2018	2019	2020	2021	2022
Students (y)	20,31,899	16,94,652	20,40,28	22,27,113	20,21,006

For calculation, we convert the above data into the Table 5.

Table 5. SSC students participated in Final Exams in 2018-2022

x	18	19	20	21	22
y	2.031899	1.694652	2.040028	2.227113	2.021006

The corresponding Lagrange interpolating polynomial for SSC students is

$$\begin{aligned} p_1(x) &= 2.031899\frac{(x-19)(x-20)(x-21)(x-22)}{24} + 1.694652\frac{(x-18)(x-20)(x-21)(x-22)}{-6} \\ &\quad + 2.040028\frac{(x-18)(x-19)(x-21)(x-22)}{4} + 2.227113\frac{(x-18)(x-19)(x-20)(x-22)}{-6} \\ &\quad + 2.021006\frac{(x-18)(x-19)(x-20)(x-21)}{24} \\ &= 0.02525054166666664x^4 - 2.109694583333329x^3 + 65.87597895833312x^2 \\ &\quad - 9.110671099166661x + 4710.460643. \end{aligned}$$

For HSC students:

Year (x)	2017	2018	2019	2020	2021
Students (y)	11,83,686	13,11,457	13,36,629	13,67,377	11,15,705

For simplicity, we convert the above data into the following list (Table 6).

Table 6. HSC students participated in Final Exams in 2018-2022

x	17	18	19	20	21
y	1.183686	1.311457	1.336629	1.367377	1.115705

The corresponding Lagrange interpolating polynomial for HSC students is

$$\begin{aligned} p_2(x) &= 1.183686\frac{(x-18)(x-19)(x-20)(x-21)}{24} + 1.311457\frac{(x-17)(x-19)(x-20)(x-21)}{-6} \\ &\quad + 1.336629\frac{(x-17)(x-18)(x-20)(x-21)}{4} + 1.367377\frac{(x-17)(x-18)(x-19)(x-21)}{-6} \\ &\quad + 1.115705\frac{(x-17)(x-18)(x-19)(x-20)}{24} \\ &= -0.01651129166666667x^4 + 1.239881416666671x^3 - 34.89048370833336x^2 \\ &\quad + 436.0935415833342x - 2041.554638000004. \end{aligned}$$

Now, plotting these polynomials, $p_1(x)$ and $p_2(x)$ using MATLAB, we get

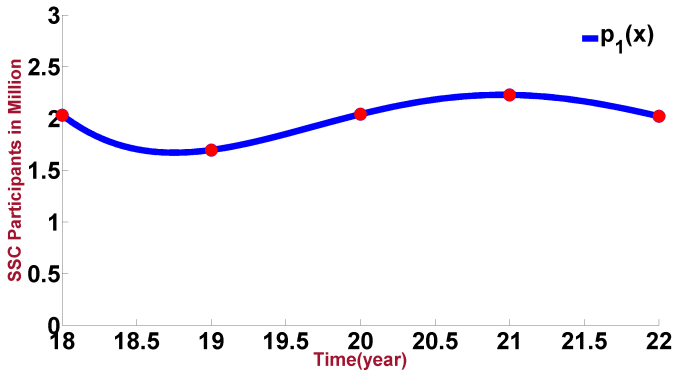

Figure 9. Participants in SSC examination

In Figure 9, participants in the SSC examination from the year 2018 to 2022 have been shown graphically. The number of students that have taken in millions and years has been converted from 2018 (equivalent to 18), 2019 (equivalently 19 in the plot), and likewise. Clearly, in the year 2022, the number of participants has dropped significantly.

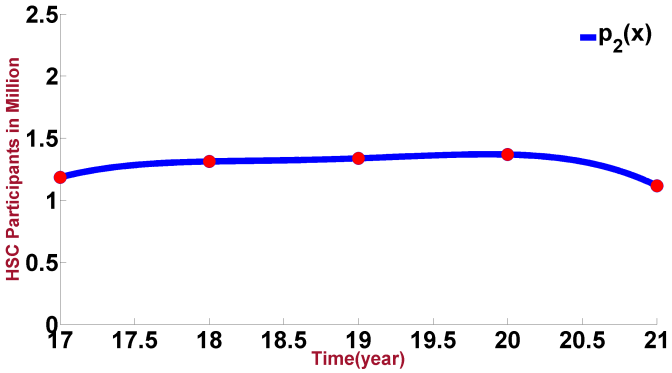

Figure 10. Participants in HSC examination

The number of students taking the HSC exam each year from 2017 through 2021 is graphically represented in Figure 10. The number of students is reported in millions and the years have been converted from 2018 to 18, 2019 to 19. The year 2021 shows a dramatic decline in participation from the previous years.

The devastating impact COVID-19 has had on education in Bangladesh is shown at a glance in declining enrollment in the country's two most important public exams, the Secondary School Certificate (SSC) and Higher Secondary Certificate (HSC) tests. Many pupils dropped out of school in 2020 as the onset of COVID distracted them. Long-term effects were visible in SSC 2022 and HSC 2021. Since they live in a third-world country, not all kids have access to the necessary resources to continue their education. Those who were in Class 10, in college, or previously registered for the HSC when COVID-19 began managed to keep studying, hence the number of students taking the tests did not drop much. But many children who had been inspired to continue their education by passing the JSC or JDC, SSC, or equivalent exams at the beginning of COVID-19, couldn't continue much after that and gave up on their plans to enroll in secondary school or higher secondary school. This explains the dramatic swing in turnout for the SSC 2022 and the HSC 2021.

5 Mitigate the impacts of COVID-19 on education

It's been two and a half years since COVID-19 was declared a global pandemic. The COVID-19 virus was a catastrophic event that has changed the course of human history in numerous ways. Major changes in people's daily routines, places of employment, educational opportunities, and access to medical treatment have resulted from the pandemic. The pandemic has inflicted significant damage on the educational sector. To mitigate its devastating impact, unique and innovative strategies were implemented during and after the crisis.

Minimization of the lost learning

After it became clear that there was no chance of schools reopening any time soon, educational institutions all around the world started to shift their focus to online education. Even before the onset of COVID-19, the field of educational technology had been experiencing substantial growth and widespread adoption. Global tech investments in this sector had surged to $18.66 billion in

2019, and the entire online education market was anticipated to reach a substantial $350 billion by the year 2025 [55]. Learning online has been demonstrated to improve retention and reduce time spent studying, suggesting that the changes brought about by the coronavirus may be here to stay. In many nations, the widespread availability of television has led to the introduction of television and even radio-based programs designed to motivate students to study. Regarding Bangladesh, MoE, and MoPME launched remote learning programs via "Sangsad TV" and on their web platforms: e-connect, Facebook, and YouTube to guarantee learning continuity during school closures. The first TV-based broadcast under this initiative aired on March 29, 2020 [56]. Many universities have reduced the length of their semester from six to four months to cope with the lost time. While in the yearly system, it was reduced to eight months. Bangladesh's government administered its SSC and HSC examinations in 2021 and 2022 on a shortened curriculum to make up for lost instructional time, and it plans to do the same in 2023.

For the government of Bangladesh to get pupils back into the classroom, the first thing they did was begin the vaccination process for those students. A university vaccination program was launched to vaccinate university students. On November 2, the campaign to vaccinate 12-17 year old in school started. They had to register through their schools to be vaccinated [57]. Shortcomings of the measures taken:

The lack of access to technology and the internet is the main barrier to e-learning for pupils from low-income families. So it was not a remedy for all students and contributed to inequality. Those lucky enough to have access to online instruction eventually grew bored with it due to a lack of stimulation and the isolation that came from not having regular one-on-one instruction. Examiners were severely harmed due to the truncated public examination curriculum. They are deprived of the opportunity to learn about the subject matter that was cut from the curriculum, even though it is crucial to their future education.

Based on these findings, some interventions can be proposed aimed at preventing the long-term effect of lost learning. One of the most cost-effective ways to boost academic performance and learning recovery is through a school-wide high-dose, one-on-one tutoring program. Adapt lessons to meet the requirements of individual students and place an emphasis on building essential skills. Lengthening the school year, adding make-up days, and expanding instructional blocks are all potential strategies for helping students to aid in their academic recovery. Develop a schedule for keeping tabs on each student's development. Persistent professional development that emphasizes the individual needs of teachers in terms of both methodology and expertise. Instead of arbitrarily removing topics from the public test curriculum, we must emphasize keeping in place the most foundational topics to ensure that students are not left struggling in the future. Since many universities have shortened their academic year, hybrid learning is a great way to help students manage the added workload and yet finish the required coursework in a reasonable amount of time, assuring that all students can participate in hybrid classes.

Hypothetical solutions are presented to show the window of opportunity available to educational systems to recover learning loss. These methods may prove crucial in reversing the damage done by the pandemic and preventing similar catastrophes in the future.

Mitigation of the negative impact on economy

To address the economic crisis, many low- to middle-income countries have employed various solution methodologies to mitigate the economic challenges brought about by the COVID-19 pandemic. Governments have implemented measures such as cash transfers, tax relief, and increased spending on infrastructure and social welfare programs to boost economic activity and support affected individuals and businesses. Central banks have lowered interest rates,

expanded liquidity support programs, and implemented quantitative easing to stabilize financial markets and stimulate lending and investment. Middle-income countries have sought support from international financial institutions, bilateral partners, and multilateral organizations to access additional funding and technical expertise to address the economic fallout of the pandemic.

When the pandemic lasts a long time, spending less on education goes against what this field needs. Insufficient spending in this field to lessen the effects of COVID-19 will have long-term consequences. The lack of resources in the nation could cause education to be negatively impacted by the epidemic than in other nations. If the government doesn't step in with effective short-term and long-term strategies, young people now might be less productive and earn less money in the future. The country should make a plan of action to solve this. For example:

Ensuring that every student returns to their educational institutions. Prioritizing proactive governmental measures, such as updating existing stipend programs, investigating opportunities for "education loans", running communication campaigns, actively engaging with families in need, etc. The government should establish an "Education Loan" program. If students' families can qualify for the 'Education loan' then they won't have to worry about money. So, there won't be any monetary barriers to pupils attending schools. Furthermore, we can employ several tactics aimed at getting students back into the classroom. We could, for instance, broadcast TV commercials intended to raise public consciousness. To raise awareness and get parents to take their kids back to school, we can re-promote cartoons like the Meena cartoons, village theater productions, and announcing campaigns. Investing in the education of its citizens strengthens the country as a whole. Now, the country risks seeing a decline in its educated population if many children and teenagers do not return to school or enroll in higher education. Workers with little education and skills will be produced. The country's gross domestic product will fall.

There is a pressing need for the government to boost its allocation for education in Bangladesh. Currently, the country's spending on education, both in terms of its proportion to GDP and as a percentage of total tax revenue, ranks among the lowest globally. Regrettably, the allocation for education as a portion of GDP has dwindled, dropping from 2.18 percent in the revised budget of FY20 to a mere 2.09 percent in FY21 (Financial Year 2021) [48]. A budget to spend 2.5 percent of GDP on education should be passed. Spending on education must account for a sizable amount of our total budget. Reopening schools that have been forced to close or compensating those in financial distress should both receive funding from this plan. Also, it's important to allocate funds to raise educators' pay. Take action to re-engage the teaching workforce in our schools. Motivating former educators to return to the classroom is important. A national teaching shortage is possible if many current educators decide not to work in schools again. This will harm the education of the pupils, especially those in distant areas. They won't be able to finish school. Once again, schools will be closed. As a result, the national economy will suffer.

'Unemployment' is a curse. We have to work to eliminate unemployment. 'Job-oriented' education should be provided for unemployed students. Work space should also be arranged for them. Students who want to start a business have to arrange 'Student Loans' so that they can get financial support. Those who want to do something themselves should be encouraged. For them 'Student Loan' should be arranged. Students should develop a mindset where they don't approach any task lightly. They can earn their livelihood by engaging in self-reliant activities like agriculture, animal husbandry, fishing, sewing, cottage industry, etc. Thus the unemployment rate of the country will decrease. If the issues are not properly addressed, the demographic dividend for Bangladesh could eventually become a demographic burden in the future. George Laryea-Adjei, UNICEF Regional Director for South Asia, emphasized the importance of collaborative efforts among governments, partners, and the private sector. He emphasized the need to not only align strategies and investment levels correctly but also to construct more robust, efficient, and inclusive

systems capable of fulfilling the fundamental human right of education for all children. This commitment to education should remain steadfast, whether schools are open or closed [58].

Actions required to counter early marriage

During the 2014 Global Girl Summit, Bangladesh declared to reduce the number of girls marrying between the ages of 15 and 18 by less than one-third By 2021. Bangladesh also committed to ending child marriage by 2041. Since then Bangladesh Government has started to develop a National Action Plan. The following steps can reduce child marriage in the context of the hit of the pandemic.

In recent decades, Bangladesh has been making promising improvements in reducing the occurrence of child marriage. Impressive progress was underway with the Child Marriage Restraint Act of 1929 [59] being reformed in 2017 [60]. It has been illegal for a girl under 18 and a boy under 21 to be wed. The new law increases the punishment for committing or assisting in child marriage. As per the recent legislation, in the case of an adult accused, the prescribed penalty entails imprisonment for a maximum of two years, a fine not exceeding BDT 1 lakh, or both. This legal consequence will also extend to guardians, relatives, or the marriage registrar who are implicated in child marriage.

Since Eve-teasing and even rape threats are frequent in the country, marriage is typically seen as a haven for young girls by their parents. The appropriate law enforcement agencies should keep a vigilant eye out for these types of threats and act swiftly if necessary. Many closed-circuit television cameras should be installed in public areas, including roadways, school entrances, and other key locations, to protect the girls. We must ensure that no criminal escapes justice. Government officials should step forward with a sizable budget and well-thought-out plans to protect the families of poor, at-risk girls. Families can be given a monthly stipend, or even a set amount of money, based on their financial situation, so that they are not in a position where they have to sell their daughters off for poverty. Muslim-dominated Bangladesh has intricate cultural dynamics. Emams in mosques should use their platforms to educate the public on the harms of child marriage at a young age. Leaders in rural communities, such as the Union Parishad Chairman, a member of the Union Parishad, or a Word Commissioner have a unique opportunity to speak out against child marriage and educate the populace.

Efforts to re-engage dropout students in education

The government should have prepared a comprehensive long-term strategy to prevent students from dropping out during the pandemic when the likelihood of them doing so was high. In the aftermath of a pandemic, the government can still take the following measures to reduce dropouts and get former dropouts back into school.

Every student who fell behind or quit studying because of the pandemic has to be contacted. It's impossible to do without a thorough survey. A survey detailing their present family, financial, and mental health issues can help to direct the next steps in their care. The high rates of dropout among children from low-income families highlight the need for continuous financial assistance for these households. Monthly payment in addition to possible additional forms of assistance. Without a system of corruption-free, open, and equitable distribution of funds, the good intentions behind this initiative would go to waste and fewer deserving students would be able to complete their education. Teachers should schedule regular meetings with parents to encourage both students and their families to resume their educational pursuits. For kids who come from such impoverished families that they cannot even provide for themselves with a daily meal, the midday meal might be an extremely important factor. The implementation of creative new teaching

strategies can boost the student's engagement in the learning process. Educators throughout the country must receive specialized training on fascinating topics so that students can return to their regularly scheduled lessons with a greater sense of vigor once the pandemic has run its course. Thus, COVID-19 has adversely affected our education sector. We have to take initiatives at the government and private levels to reduce the impacts of COVID-19.

6 Conclusion

Education is the cornerstone of societal advancement, unlocking individuals' potential to shape a better future for themselves and their communities. The negative consequences of the COVID-19 pandemic have disrupted our educational institutions. The closure of many schools has resulted in widespread job loss among teachers and hindered students' pursuit of talent development. Moreover, economic pressures have made things more difficult for students and their families, highlighting the urgent need to address these issues to ensure equitable access to education and enhance national advancement. This study aimed to underscore the detrimental repercussions of COVID-19 on the education sector and examine potential measures to lessen these consequences. Learning loss can have substantial and enduring consequences, particularly for students from underprivileged circumstances who do not have access to resources for remote learning or other educational support. Proactive steps are required to stop more learning loss and promote educational equity.

Strong educational policies and resources are essential to support all learners in achieving their full potential. Extended periods of isolation, disruptions to daily routines, and the uncertainty brought by the pandemic have led to increased anxiety, depression, and loneliness among students. Authorities must raise awareness about mental health, cultivate a supportive school environment, encourage physical activity and healthy habits, and integrate mindfulness and stress-reduction techniques into the curriculum to enhance students' mental well-being. Economic hardships faced by families as a result of the pandemic have increased the risk of early marriage for some students, particularly girls, as families consider marriage as a way to relieve financial strain or secure their daughters' futures.

By promoting economic independence and ensuring access to quality education, girls can get the freedom to reject early marriage and shape their destinies. The pandemic-induced challenges, such as unreliable internet access and technology, financial hardships, lack of in-person interactions, loss of support networks, and general stress, have led to a rising number of students opting out of education. Meeting these challenges requires collaborative endeavors aimed at narrowing the digital divide, offering specialized assistance to at-risk students, providing sustainable financial support, and reimagining resilient education delivery methods for potential future disruptions. We graphed the drop in the number of students in various board exams due to COVID-19 in Bangladesh and observed the outcomes by using the interpolation method. Our graphical analysis demonstrates the profound effects of COVID-19 on education in Bangladesh, particularly through the noticeable decrease in enrollment for the country's primary public exams, the Secondary School Certificate (SSC), and Higher Secondary Certificate (HSC) tests. In this research, we comprehensively examined the multifaceted effects of COVID-19 on the education sector in Bangladesh and explored potential strategies to mitigate the disruptions due to COVID-19.

Declarations

Use of AI tools

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

Abbreviations

Terms	Description
JSC	Junior School Certificate.
SSC	Secondary School Certificate.
HSC	Higher Secondary Certificate.
IEDCR	Institute of Epidemiology, Disease Control, and Research.
WHO	World Health Organization.
UNESCO	United Nations Educational, Scientific and Cultural Organization.
MOE	Ministry of Education.
NGO	Non-government Organization.
BRAC	Bangladesh Rehabilitation Assistance Committee.
ROSC	Reaching Out of School Children.
TSR	Teacher-Student Ratio.
HSE	Higher Secondary Education.
NER	Net Enrollment Ratio.
GDP	Gross Domestic Product.
BANBEIS	Bangladesh Bureau of Educational Information & Statistics.
SD	Standard Deviation.
ICT	Information and Communications Technology.
HIES	Household Income and Expenditure Survey.
ADB	Asian Development Bank.
SANEM	South Asian Network on Economic Modeling.

Data availability statement

The data used in this study is publicly available.

Ethical approval

The authors state that this research complies with ethical standards. This research does not involve either human participants or animals.

Consent for publication

Not applicable

Conflicts of interest

The authors declare that they have no conflict of interest.

Funding

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Author's contributions

M.K.: Conceptualization, Formal analysis, Original draft preparation, Review and editing, Supervision, S.S.S.: Conceptualization, Software, Formal analysis, Original draft preparation, T.R.N.: Software, Original draft preparation, F.I.: Methodology, Data curation, M.A.R.: Software, Data curation, A.A.A.: Validation, Investigation, Original draft preparation, F.T.: Investigation, Review and editing, M.S.A.: Validation, Resources. All authors have read and agreed to the published version of the manuscript.

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