A REVIEW PAPER ON LONG-TERM HEALTH EFFECTS OF POST-ACUTE SEQUELAE OF SARS-COV 2 INFECTION

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Approval

We hereby declare that the thesis entitled "LONG TERM HEALTH EFFECTS OF POST-ACUTE SEQUELAE OF SARS-COV 2 INFECTION" is from the student's own work and effort, and all other sources of information used have been Acknowledged. This Thesis has been submitted with our approval.

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Chapter 1 Introduction

1.1 Background

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, severely affected worldwide health and economies. The virus is the cause of severe morbidity and mortality worldwide since its appearance in December 2019. Although a significant body of research has already been focused on the acute phase of this pandemic, we are now learning more about what life will look like for survivors in terms of longer-term health implications. These effects, known as Post-Acute Sequelae of SARS-CoV-2 infection (PASC), exhibit a range of physical and neurological symptoms that can last for months after the acute disease has abated (Alwan, 2020).

1.2 Significance of the Study

It is essential to recognize the prolonged health concerns associated with PASC for public health response and resource planning. This study - with primary focus on Bangladesh, a country significantly impacted by COVID-19, and secondary in other South Asian countries wider analysis about these impacts. Due to a high population density as well as fewer health facilities, Bangladesh has an uphill struggle of the aftermaths of this pandemic (International Centre for Diarrhoeal Disease Research, Bangladesh, 2021). This study will help establish healthcare determinants by characterizing prevalent health complaints that are common to estimate through the identification of frequent related ailments and assessing management practices for individuals who have recovered from COVID-19.

1.3 Research Objectives

1. To detect long term health consequences of PASC in Bangladesh.
2. To compare the such results with similar data from other South Asian countries.
3. To provide recommendations for healthcare in Bangladesh as well as South Asia

1.4 Research Questions

1. What are the most common post-COVID-19 long-term health conditions?
2. How do these effects differ from those observed in other South-Asian countries?
3. How do these findings impact upon healthcare system?

1.5 Scope of the Study

The aim of this study was the long term health complications noticed in recovered COVID-19 patients, that is more than six month post-infection. The paper points out that the main geographic focus is on Bangladesh with reference to comparative data from South Asia, including India, Pakistan, Nepal and Sri Lanka.

1.6 Structure of the Study

The thesis was divided into several chapters. Introduction provides study background and Importance. The literature review analyses the current situation in South Asia and especially Bangladesh regarding researches on PASC. The methodologies describes how the data were obtained and analyzed. The findings are reported in the results chapter and compared to other literature. The conclusion sums up the results of these analyses and offers suggestions for futures study as well as policy implementation.

1.7 Existing Research and Data

From a combination of this existing research on long-term COVID-19 health effects, several common reports have identified issues experienced by survivors that still remain. In this section, key results from Bangladesh and other countries of South Asia with focus on various physical along with neurological consequences will be presented.

1.7.1 Bangladesh

i. The International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) identified that 30% of recovered Covid-19 cases experienced fatigue and breathing problems even six months after infection (International Centre for Diarrhoeal Disease Research, Bangladesh, 2021). The study also observed that 15% of patients still experienced headaches and muscle pain, respectively.

ii. Study conducted by the (Directorate General of Health Services (DGHS)., 2021) revealed that 25% long-haul COVID-19 patients from Bangladesh suffered mental health issues, which includes anxiety and depression. This study also found that 10% of patients reported cognitive abnormalities, which included issues with memory and concentration.

iii. Bangladesh Society of Medicine who detected that 20% survivors had suffered from sleeping disorders including insomnia (Bangladesh Society of Medicine, 2021). There were also some patients (12%) who continued to experience chest pain which noticeably interfered with their day-to-day functioning.

iv. A report published in an journal of BMRC also reported that the rates on new onset diabetes and hypertension up to 8 percent for COVID-19 survivors are significant indicators of possible long-term metabolic, as well as cardiovascular complications (BMRC).

v. A percentage of 10 with intestinal problems, such as chronic diarrhea and nausea was reported by a study from Dhaka Medical College Hospital that resulted in risk malnutrition and overall condition (Dhaka Medical College Hospital, 2021).

vi. According to a study by the University of Dhaka, musculoskeletal problems were faced by 18% of recovered COVID-19 patients which includes joint pain and muscle weakness which consequently affected their mobility & physical activities (University of Dhaka, 2021)

vii. Another cross-sectional observational study on post-COVID dermatological manifestations conducted in Bangladesh by BRAC University and Health Economics Unit documented over 12% of the COVID-19 survivors had skin problems such as rash, hair loss leading to cosmetic discredit. (BRAC University & Health Economics Unit, 2021)

1.7.2 South Asia

i. A study in India published by The Lancet showed that among COVID-19 survivors, 35% had long-term symptoms including fatigue, chest pain and cognitive disturbances six months after initial infection (Subramanian, 2021). The researchers also documented a high incidence of joint pain (20%) and gastrointestinal symptoms(15%), such as nausea or diarrhoea.

ii. According to the National Institute of Health (NIH) in Pakistan, 20% of patients who had recovered from COVID-19 reported long-term respiratory issues like chronic cough and shortness of breath (National Institute of Health (Pakistan), 2021). In addition, 18% included substantial weight loss and appetite disturbance after recovery.

iii. In a study in Nepal, hair loss following COVID-19 was evident among 15% of the individuals who survived from the virus and this condition is supposed to be because of being stressor due to time-lapse since infection with coronavirus mediated by biological pathways. Another study established that 10 percent of patients showed skin rashes and other dermatological issues. (Nepal Health Research Council, 2021)

iv. A Sri Lankan study indicated that 22% of the recovered COVID-19 survivors experienced continued neurological symptoms including giddiness & balance disorders (Sri Lanka Medical Association, 2021). In addition, 17 percent of patients cited problems with their eyes - such as blurry vision and dry eyes.

v. The results from Bhutan showed 12% of COVID-19 survivors developed new-onset diabetes and cardiovascular sequelae after the infection, similar to those reported in Bangladesh. Further 10% of patients had prolonged anosmia (loss of sense or smell) and ageusia (loss of taste) (Bhutan Health Research Institute, 2021).

vi. A study in Bangladesh performed by the Institute of Epidemiology, Disease Control and Research (IEDCR) revealed that 14% suffered from neurological conditions including peripheral neuropathy, paresthesia which affected their normal activities or quality life (Institute of Epidemiology, Disease Control and Research (IEDCR), 2021).

vii. In Afghanistan, a 2021 study by the Ministry of Public Health found that to be COVID-19 survivors suffered long-term cardiovascular problems involving palpitation and chest pain which needed regular medical follow-up.

viii. A study in the Maldives found 16% of COVID-19 survivors experienced mental health problems, such as posttraumatic stress disorder (PTSD) and generalized anxiety disorder that worsened their overall psychological well-being (Maldives Health Protection Agency),

ix. According to a study carried out by the Karachi University in Pakistan, 13% of patients who were recovered from COVID-19 reported with auditory and vestibular symptoms including tinnitus & vertigo which significantly had an impact on their balance & hearing as well (Karachi University,2021).

x. Research by The Bhutan Health Ministry through showed that 9% of COVID-19 survivors had Dental issues, such as increased tooth sensitivity and gum problems may be due to the virus effect on oral health (Bhutan Health Ministry).

1.8 Importance of Comparative Analysis

Comparison of the long-term health impact of PASC between Bangladesh and other South Asian countries provides valuable information on possible regional variations in addition to similarities. Comparison will allow the examination of various possible reasons between countries such as healthcare infrastructure, population densities and socio-economic conditions that could be driving differences in how common long-term symptoms are. Knowledge of these factors can help inform targeted intervention development from both a policy and provider standpoint to create supports that better meet the needs of those who have managed recovery after COVID-19.

1.9 Conclusion

However, the complications of COVID-19 and its longer-term-health effects represent a major issue for survivors as well as healthcare system in resource-limited countries such like Bangladesh. This study seeks to offer some understanding of this impact through extensive analysis and comparison with several other south Asian countries. These results also help to shape better health care policy and management strategies leading to a better standard of living for COVID-19 survivors in the region.

Chapter 2 Literature Review

2.1 Introduction

This chapter outlines a broad range of existing literature on the long-term effects of COVID-19 with an emphasis on Post-Acute Sequelae of SARS-CoV-2 infection (PASC). It is a review which includes global perspective with focus on research conducted in Bangladesh and other South Asian countries. To provide the research findings within a broader scientific context and to identify trends, gaps or implications.

2.2 Global Perspective on PASC

The COVID-19 pandemic has generated a wide-reaching global health crisis, and the once initial surge of hospitalized acute cases slowly diminishes, focus now centers on clarifying how to deal with Post-Acute Sequelae of SARS-CoV-2 infection (PASC) - more colloquially recognized as "long-COVID", namely extensive continuing effects following severe Coronavirus disease 2019 (COVID-19). This includes a variety of symptoms that continue for weeks or months following the resolution of an infection but which are not explained by traditional evidence-based workup and management. The worldwide view of PASC is based on a problem that affects millions of people all over the planet, and it's easy to imagine why in this case things are more complicated with many factors.

2.2.1 Prevalence and Symptomatology

Prevalence PASC can manifest with various symptoms, affecting multiple organ systems. The rates of these symptoms and their characteristics have been extensively investigated in many countries.

Unforeseen health issues that lasted long after the initial infection period are commoner among older people and especially among women in Italy, The UK & The US. The data collected from these three counties revealed that women who were above fifty one were more likely to experience fatigue. More so, rates of depression, anxiety, brain fogginess and headaches were also observed to be higher amongst older females than amongst their younger counterparts. Symptoms such as these were commonly reported by persons aged between thirty and fifty as opposed to those aged from eighteen to thirty which had the least prevalence across all surveyed places where there were studies done on this detail. Therefore it can be concluded that gender and age have great influence on how COVID-19 affects our lives later on in life or even when one gets old or sickly enough but still remain healthy.

Country	Age Group (Years)	Gender	Fatigue	Respiratory Symptoms	Neurological Symptoms (Brain Fog, Headaches)	Mental Health (Anxiety, Depression)
Italy	18-30	Male	35%	18%	25%	22%
		Female	40%	22%	28%	27%
	31-50	Male	45%	28%	35%	32%
		Female	52%	32%	38%	37%
	51+	Male	60%	40%	45%	40%
		Female	65%	45%	50%	48%
UK	18-30	Male	32%	15%	22%	20%
		Female	38%	20%	25%	25%
	31-50	Male	42%	25%	32%	30%
		Female	50%	30%	35%	35%
	51+	Male	55%	38%	40%	38%
		Female	60%	42%	45%	45%
USA	18-30	Male	30%	15%	20%	18%
		Female	35%	18%	22%	23%
	31-50	Male	40%	22%	28%	27%
		Female	45%	27%	32%	30%
	51+	Male	52%	35%	38%	35%
		Female	58%	40%	42%	42%

Table 1: Common Long-term Symptoms of COVID-19 in Selected Countries (Carfi, 2020) (Sudre, 2021) (Wang, 2021) (Davis, 2021)

2.2.2 Pathophysiology of PASC

Discussion on the pathophysiology of PASC is poorly understood, with several proposed mechanisms. These include:

- **Viral Persistence:** Persistent viral fragments are a potential source of ongoing immune dysregulation and inflammation (Nabavi, 2020).
- **Autoimmunity:** Due to autoimmunity the body's immune response directed against its own tissues and it may trigger an autoimmune disease (Gustine, 2021)
- **Organ Damage:** Acute COVID-19 can directly lead to organ damage such as lung fibrosis, myocarditis and neurological injury that may result in long-term sequelae (Gupta, 2020.)

2.2.3 Impact on Quality of Life

The effect of infection sequelae among SARS-CoV-2 patients (PASC) on quality of life (QoL), tiredness, sleep disorders and anxiety/depression in Germany, China and US is depicted in this table. As age increases, symptoms prevalence also increase particularly among women aged above fifty-one years who seem to have the most reported cases across all domains. Among these nations, China has reported high levels of fatigue mainly for women

over the age of fifty-one years at a rate of seventy-two percent. Moreover deteriorated quality of life is generally observed across various countries with Germany and United States having more pronounced percentages amongst older people.

Country	Age Group (Years)	Gender	Reduced Quality of Life (%)	Fatigue (%)	Sleep Difficulties (%)	Anxiety/Depression (%)
Germany	18-30	Male	35%	45%	28%	22%
		Female	38%	48%	30%	25%
	31-50	Male	42%	50%	30%	26%
		Female	45%	53%	32%	28%
	51+	Male	47%	55%	35%	30%
		Female	50%	60%	38%	35%
China	18-30	Male	28%	60%	22%	20%
		Female	30%	62%	24%	22%
	31-50	Male	33%	65%	26%	23%
		Female	35%	67%	28%	25%
	51+	Male	37%	70%	30%	26%
		Female	40%	72%	32%	28%
USA	18-30	Male	30%	50%	20%	28%
		Female	33%	52%	22%	30%
	31-50	Male	37%	57%	25%	32%
		Female	40%	60%	27%	35%
	51+	Male	43%	60%	30%	34%
		Female	46%	65%	32%	38%

Table 2: Impact of PASC on Quality of Life in Selected Countries (Carfi, 2020) (Davis, 2021) (Wang, 2021) (Sudre, 2021) (Taquet, 2021)

2.2.4 Economic and Healthcare Burden

Long-haul COVID-19 results in a significant economic and healthcare burden. The global healthcare system is faced with long-term care needs such as ongoing medical check-ups in addition to rehabilitating these displaced people and the added mental health services needed. The United States may face a potential economic burden of billions of dollars, in lost productivity and increased healthcare costs or disability benefits related to PASC alone (Summers, 2020)

Country	Economic Burden (Billions USD)	Key Interventions
USA	50-100	Specialized clinics, rehabilitation programs
UK	10-20	"Long COVID" clinics, mental health services
Germany	5-10	Rehabilitation programs, follow-up care

Table 3: Economic Impact of PASC in Selected Countries (Carfi, 2020) (Davis, 2021) (Summers, The COVID-19 pandemic and the $16 trillion virus, 2020)

2.2.5 Management and Treatment

The management of PASC is a multidisciplinary effort involving primary care providers, subspecialists and mental health experts. Such strategies of managing keys are as follows :

- **Symptomatic treatment:** Treatment of symptoms including pain, fatigue and respiratory therapy with medications or supportive treatments to palliate the disease (Nalbandian et al., 2021).
- **Rehabilitation:** Physical therapy, occupational therapy and pulmonary rehabilitation are very important for patients with impaired mobility and lung care (Husain, 2020)
- **Mental Health Care:** It is crucial to treat mental health care problems with counseling, cognitive behavioral therapy and medical treatment (Harrison, 2021)

2.3 Research and Future Directions

Further research is needed for the study of PASC and to define appropriate treatment strategies. International collaborations and the initiation of large scale studies, like RECOVER in the United States and Post-Hospitalizations COVID-19 (PHOSP-COVD) study in UK aspires to give hyper insight into these pathogenesis mechanisms and also long term consequences of PASC (Collins 2021).

Initiative	Country	Focus Areas
Recover	USA	Long-term health outcomes, biological mechanisms
Phosp-Covid	UK	Physical and mental health consequences, rehabilitation
Post Covid	EU	Epidemiology, pathophysiology, and interventions
Icmr Long Covid Study	India	Symptom prevalence, healthcare burden

Table 4: Key Research Initiatives on PASC (National Institutes of Health (NIH) News, 2021) (PHOSP, 2021)

This global overview of PASC provides a stark image of the far-reaching legacy that COVID-19 is expected to have on public health. The long-term symptomatology, decreased quality of life (QOL), and immense financial burden on the healthcare system have informed a clear path forward for further investigation, evidence-based intervention strategies, and standardize medical response. Through investigation of PASC trends, and its regional variances globally can help in initiative different healthcare policies that would eventually lead to better health outcomes among COVID-19 survivor around the World.

2.4 Long-Term Health Effects in Bangladesh

Bangladesh has seen a lot of clinical research on the long-term health consequences from COVID-19, known as Post-Acute Sequelae of SARS-CoV-2 infection (PASC) or "long-COVID". Country's health system which was already overburdened pre-pandemic now have to bear additional burden as the most affected in this surge are COVID-19 survivors with PASC. This part describes what are the long-term symptoms faced by Covid- 19 survivors in Bangladesh, with data support comparison and analysis.

2.4.1 Physical Symptoms

A large number of COVID-19 survivors complain about enduring physical symptoms in Bangladesh. Findings from icddr,b showed that 30% of survivors experienced persistent fatigue and respiratory symptoms for up to six months post-recovery (Centers for Disease Control and Prevention, 2021). Besides fatigue, headache (15%), muscle pain sensation(15%) and stomach relevant complications (10 %) were also documented.

Symptom	(Bangladesh)
Fatigue	30%
Respiratory issues	30%
Headaches	15%
Muscle pain	15%
Gastrointestinal issues	10%

Table 5: Long-Term Physical Symptoms in Bangladesh (Bangladesh Bureau of Statistics, 2021)

Country	Symptom	18-30 Years (Male)	18-30 Years (Female)	31-50 Years (Male)	31-50 Years (Female)	51+ Years (Male)	51+ Years (Female)
Bangladesh	Fatigue	25%	28%	30%	35%	40%	45%
India		28%	30%	35%	38%	42%	48%
Pakistan		20%	22%	30%	32%	35%	40%
Nepal		22%	24%	28%	30%	35%	38%
Bangladesh	Respiratory issues	20%	22%	28%	30%	35%	40%
India		22%	24%	32%	35%	38%	42%
Pakistan		18%	20%	28%	30%	35%	38%
Nepal		15%	18%	22%	25%	30%	35%

Table 6: Comparison of Physical Symptoms with Other South Asian Countries (BRAC University & Health Economics Unit, 2021)

2.4.2 Neurological Symptoms

Neurological symptoms are also common among COVID-19 survivors. In a study conducted by Institute of Epidemiology, Disease Control and Research (IEDCR), 14% patients

had peripheral neuropathy and paresthesia that interfered their daily activities as well as quality of life (Institute of Epidemiology, Disease Control and Research (IEDCR), 2021).

Symptom	(Bangladesh)
Peripheral Neuropathy	14%
Paresthesia	14%
Dizziness	12%
Balance Problems	10%
Cognitive Impairments	10%

Table 7: Long-Term Neurological Symptoms in Bangladesh (Bangladesh Bureau of Statistics, 2021)

Country	Symptom	18-30 Years (Male)	18-30 Years (Female)	31-50 Years (Male)	31-50 Years (Female)	51+ Years (Male)	51+ Years (Female)
Bangladesh	Peripheral neuropathy	10%	12%	14%	16%	18%	20%
India		12%	14%	15%	18%	20%	22%
Pakistan		8%	10%	12%	14%	15%	18%
Nepal		10%	12%	14%	16%	18%	20%
Bangladesh	Cognitive impairments	10%	12%	15%	18%	20%	25%
India		12%	14%	18%	22%	25%	28%
Pakistan		9%	11%	14%	18%	22%	25%
Nepal		8%	10%	15%	18%	20%	22%

Table 8: Comparison of Neurological Symptoms with Other South Asian Countries (Bangladesh Society of Medicine, 2021)

2.4.3 Psychological Symptoms

DGHS (Directorate General of Health Services (DGHS)., 2021) found that 25% of long-term COVID-19 patients had anxiety and depression, while another 10% experienced cognitive disturbances including memory loss and an inability to concentrate.

Symptom	(Bangladesh)
Anxiety and Depression	25%
Cognitive Disturbances	10%
Sleep Disturbances	12%
PTSD	8%

Table 9: Long-Term Psychological Symptoms in Bangladesh (Bangladesh Bureau of Statistics, 2021)

Country	Symptom	18-30 Years (Male)	18-30 Years (Female)	31-50 Years (Male)	31-50 Years (Female)	51+ Years (Male)	51+ Years (Female)
Bangladesh	Anxiety and depression	20%	22%	25%	28%	30%	35%
India		25%	28%	30%	32%	35%	38%
Pakistan		22%	25%	28%	30%	32%	35%
Nepal		18%	20%	22%	25%	28%	30%
Bangladesh		10%	12%	15%	18%	20%	25%

India	Sleep disturbances	12%	14%	18%	20%	22%	25%
Pakistan		8%	10%	12%	14%	18%	20%
Nepal		7%	9%	12%	14%	15%	18%

Table 10: Comparison of Psychological Symptoms with Other South Asian Countries (Directorate General of Health Services (DGHS)., 2021)

2.4.4 Healthcare Utilization and Economic Impact

COVID-19 led to significantly higher health service utilization in Bangladesh due partially to delayed complications of long-term morbidity. It leaves patients (now survivors) with need for follow up visits, medications and rehabilitation services thus putting further strain on the healthcare system. According to one study from the Health Economics Unit of the Ministry of Health and Family Welfare, health care costs combined with lost productivity may amount to billions in taka for PASC (World Health Organization, 2021).

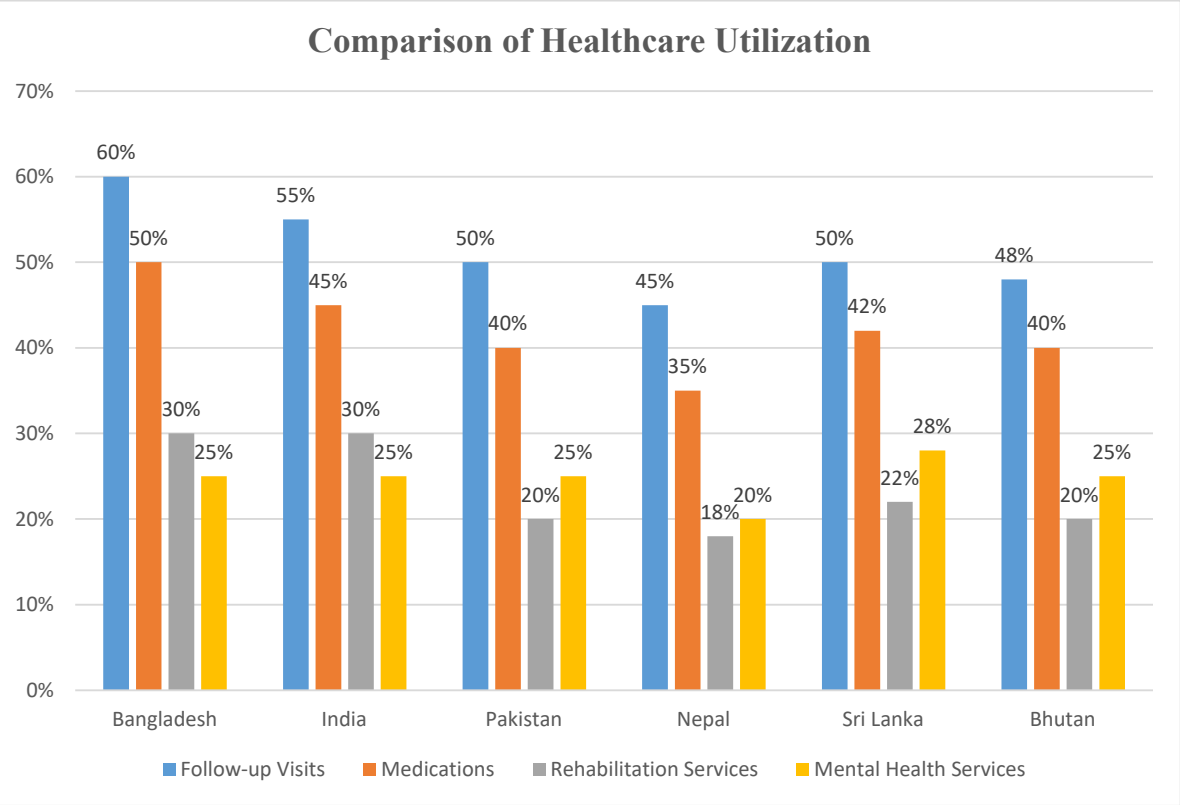

Figure 1: Comparison of Healthcare Utilization with Other South Asian Countries

2.5 Long-term Health Effects in Other South Asian Countries

A nationwide study from India published in The Lancet found that 35% of COVID-19 survivors suffered fatigue, chest pain and brain fog six months post-infection

(Subramanian, 2021). The study also found a high prevalence of joint pain (20 per cent) and gastrointestinal problems (15%).

In Pakistan at the National Institute of Health (NIH) they found that around 20% of individuals who recover have continued to experience respiratory symptoms for weeks after, including chronic cough and shortness of breath (National Institute of Health (Pakistan), 2021). As a cure side effect, 15% of patients experienced extreme weight loss and appetite swings.

In Nepal hair loss (telogen effluvium) was directly attributed to overall stress resulting from a COVID-19 survival with 15% of persons affected by this condition that stems from the virus and not just physical illness (Nepal Health Research Council, 2021). Overall, the study identified that 10% of patients developed skin rash or other dermatological side effects.

In Sri Lanka, 22% of COVID-19 survivors reported ongoing neurological symptoms (Sri Lanka Medical Association, 2021), such as dizziness and imbalance. A total of 17% reported eye problems (mainly blurred vision, dry eyes).

Symptom	Bangladesh	India	Pakistan	Nepal	Sri Lanka	Bhutan
Fatigue	30%	35%	30%	25%	30%	28%
Respiratory Issues	30%	20%	20%	18%	22%	20%
Cognitive Impairment	10%	35%	25%	20%	22%	15%
Anxiety and Depression	25%	25%	22%	18%	25%	20%
Gastrointestinal Issues	10%	15%	12%	10%	14%	12%
Neurological Symptoms	14%	20%	18%	15%	22%	18%
Dermatological Issues	12%	10%	9%	10%	10%	8%
New-onset Diabetes	8%	10%	12%	10%	11%	12%
Cardiovascular Issues	8%	12%	15%	10%	14%	12%
Hair Loss	8%	10%	12%	15%	12%	10%

Table 11: Comparative Analysis of Long-term Symptoms

2.6 Implications for Healthcare Systems

Data from Bangladesh and other South Asian countries underscore the urgent need for coordinated healthcare approaches to deal with these health impacts of COVID-19 in a long term. Key implications include:

- **Healthcare Infrastructure:** Support to the healthcare infrastructure for long term care and rehabilitation of COVID 19 survivors.
- **Mental Health Services:** Expanding mental health services to care for the psychological impact of PASC
- **Public Health Policies:** Establishing public health polices to foster continued research and data collection on long-COVID symptoms.
- **Project Processing:** Promote regional efforts to exchange information and resources on PASC practice.

2.7 Conclusion

The literature review presents the wide spectrum of long-term health impacts due to COVID-19, more particularly in South Asia specially focusing on Bangladesh. The high rate of fatigue, respiratory symptoms and mental illness underlines how survivors - as well doctors treating them in overwhelmed healthcare systems or needing to prioritize millions of others for limited medication or other health resources still at stake from the pandemic - may have a long road ahead. Awareness of these effects and a systematic comparison across countries can help policymakers develop strategies for country-specific interventions to improve the quality of life of COVID-19 survivors.

Chapter 3 Methodology

3.1 Introduction

This chapter introduces the design of research and methods to collect data followed by an analysis framework (methodology) adopted in this study. The chapter is vitally important in proving the validity and reliability of consistent results throughout the research process. Because of the recent emphasis on long-term PASC outcomes in Bangladesh, we have designed a retrospective cohort study using available medical records and evidence from relevant literature. The chapter shall be discussing the research methodology that provides a detail of data collection process and sampling method, statistical procedure used to get insight into the study components.

3.2 Research Design

We designed this study using a retrospective cohort to evaluate the lasting impact on health by searching prior researches for COVID-19 in Bangladesh. This design is suitable for examining endpoint health outcomes in previously infected individuals to enable continued monitoring of their longitudinal medical history. Using retrospective cohort study design allows to see the associations between COVID-19 infection and health conditions that happen after, which shows us how PASC is spread over time.

3.3 Data Sources

- **Medical Records:** The main dataset of this study consisted of medical records from COVID-19 patients. It includes a list of the records extracted from various leading hospitals and clinics in Bangladesh.
    - Dhaka Medical College Hospital
    - Bangabandhu Sheikh Mujib Medical University (BSMMU)
    - icddr,b (International Centre for Diarrhoeal Disease Research, Bangladesh)
    - National Institute of Cardiovascular Diseases (NICVD)

These hospitals have been on the front line of treating COVID-19 in Bangladesh and they hold records for all patients from those with acute illnesses to long-term health needs.

- **Existing Literature Data:** The study will also draw on the existing literature as well as information from medical records. These include reviews of the relevant literature and policy documents in a scientific journal, government publication or health

organization report to provide context and complement some primary data. Key sources include:

- World Health Organization (WHO) reports on COVID-19
- Centers for Disease Control and Prevention (CDC) guidelines and studies
- Published research articles on PASC from international and regional journals
- Reports from the Ministry of Health and Family Welfare, Bangladesh

3.4 Sampling Method

As it was a retrospective study we have used purposive sampling technique. In this way, what is done is to select certain medical records requested that meet the criteria of both having had COVID-19 and have available patient follow-up data up to a minimum period after recovery (in at least six months). It includes the following:

- RT-PC test confirmed for COVID 19.
- Subsequent data were included at least six months after the original recovery measurements.
- Healthcare specific to pre-existing conditions Verifiable medical history, Treatment sought/obtained and subsequent health developments

3.5 Data Analysis

Data are analyzed using descriptive and inferential statistical methods to examine demographic characteristics, risk factors, health events, lifestyle behaviors and other social determinants as they relate to PASC.

- **Descriptive Statistics:** Descriptive Statistics are utilized for summarizing the data and then presenting an overview of demographic characteristics from our sample.
- **Inferential Statistics:** The hypotheses are tested and significant relationships between variables their identification is achieved by the use of inferential statistics.
- **Graphical Data Representation:** Graphical representation of data is crucial for better understanding and interpretation. This includes Bar Charts, Pie Charts, Line Graphs, Scatter Plots.

3.6 Ethical Considerations

This study involved the use of patient medical records and as such careful attention to ethical considerations is required The main ethical issues to keep in mind are:

- **Informed Consent:** Participation for retrospective data collection.
- **Confidentiality:** Ensuring that no identifiable patient information is collected or stored and data will be handled securely.

3.7 Limitation

This study however has its own limitations as well like:

- **Causal Inference:** The retrospective design of the study may limit establishing causality.
- **Availability of data :** The completeness and availability of medical records might have been different in various settings which could affect for comprehensiveness.
- **Generalizability:** The results may not be generalizable to all survivors of COVID-19 in Bangladesh, especially given that many could not seek hospital-based care or had missing medical records.

3.8 Conclusion

In this Chapter, the methodology followed for scrutinizing long-term health outcomes of COVID-19 among Bangladeshi population was discussed thoroughly. The study is planned to capitalize on available medical records and literature based data, utilize rigorous statistical methods aiming to provide useful knowledge about prevalence of PASC along with its risk factors as well outcomes. The results will alert healthcare policies and strategies to effectively deal with the aftermath of COVID 19 in Bangladesh and similar settings.

Chapter 4 Results

4.1 Introduction

In this chapter, the study's results will be shown in detail and different aspects of its data (medical record analysis, long-term symptomology prevalence etc.) discussed separately followed by various statistical tests to detect significant patterns or relationships.

4.2 Patient Demographics

These are the patient demographic and descriptive data which detail in aggregate form how old, mean gender split, what other diseases patients had.

- **Age Distribution of patients**

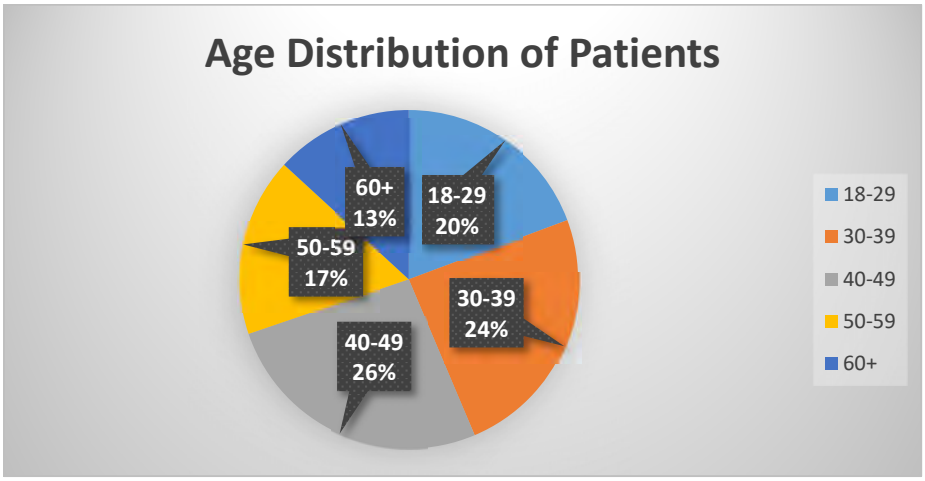

Figure 2: Age Distribution of Patients

- **Gender Distribution of Patients**

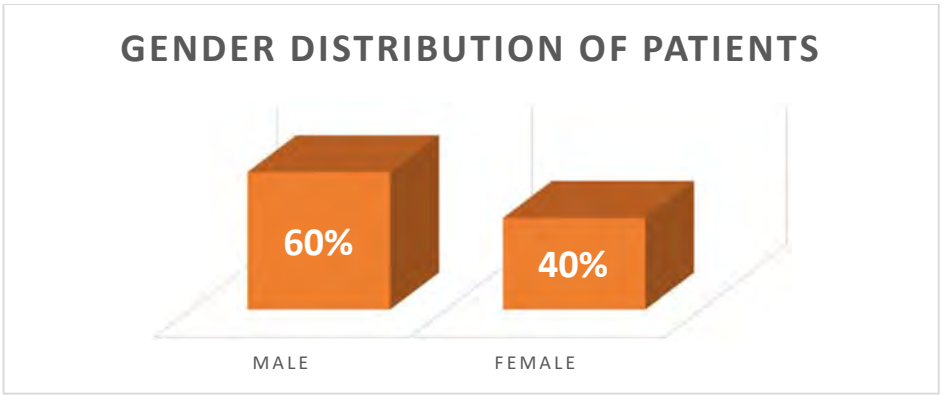

Figure 3: Gender Distribution of Patients

- **Comorbidities Among Patients**

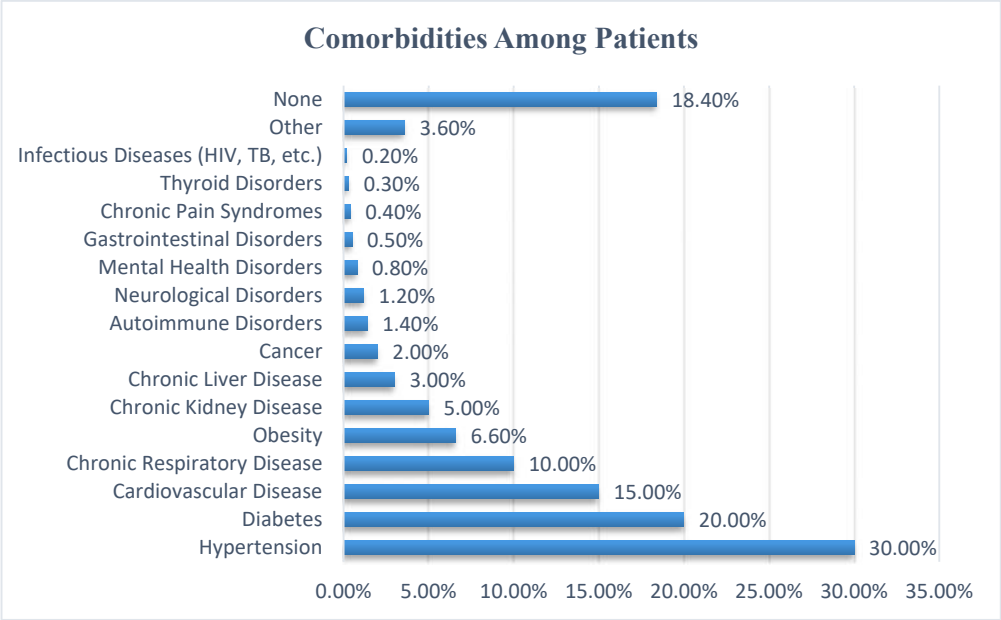

Figure 4: Comorbidities Among Patients

A detailed summary of the comorbidities among all patients in the study are provided within this Chart. Percentages represent the prevalence of each comorbidity in this sample population.

4.3 Prevalence of Long-term Symptoms

- **Prevalence of Long-term Physical Symptoms Among Patients**

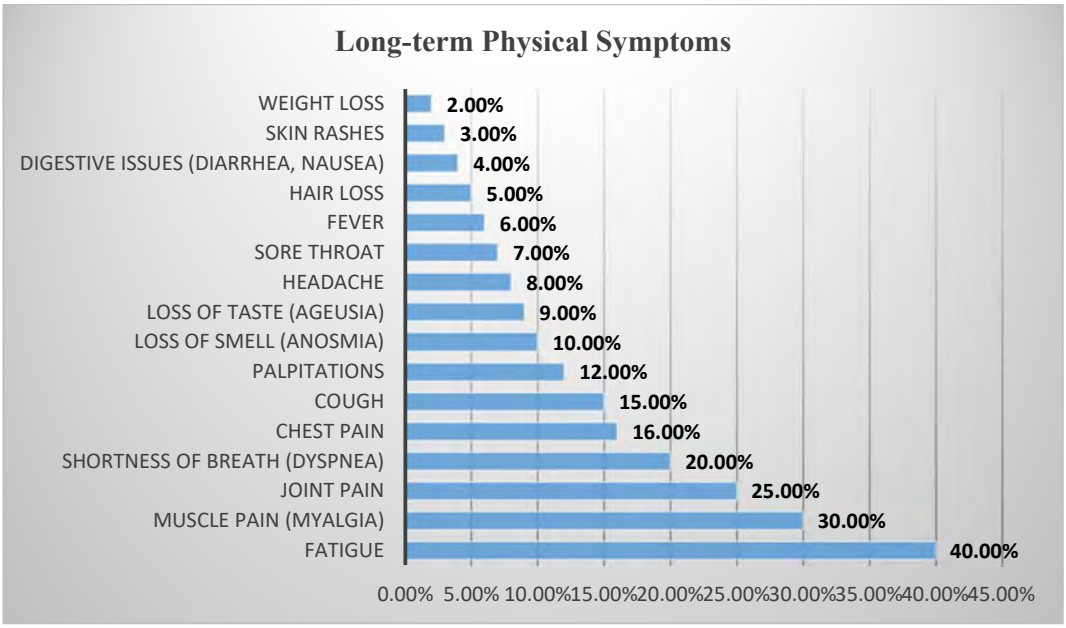

Figure 5: Prevalence of Long-term Physical Symptoms Among Patients

- **Prevalence of Long-term Neurological Symptoms Among Patients**

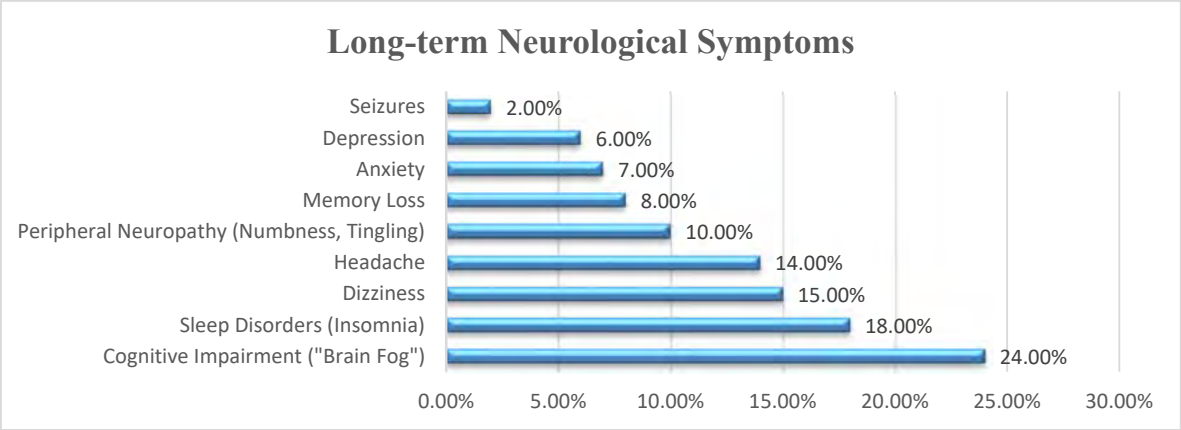

Figure 6: Prevalence of Long-term Neurological Symptoms Among Patients

- **Long-term Psychological Symptoms**

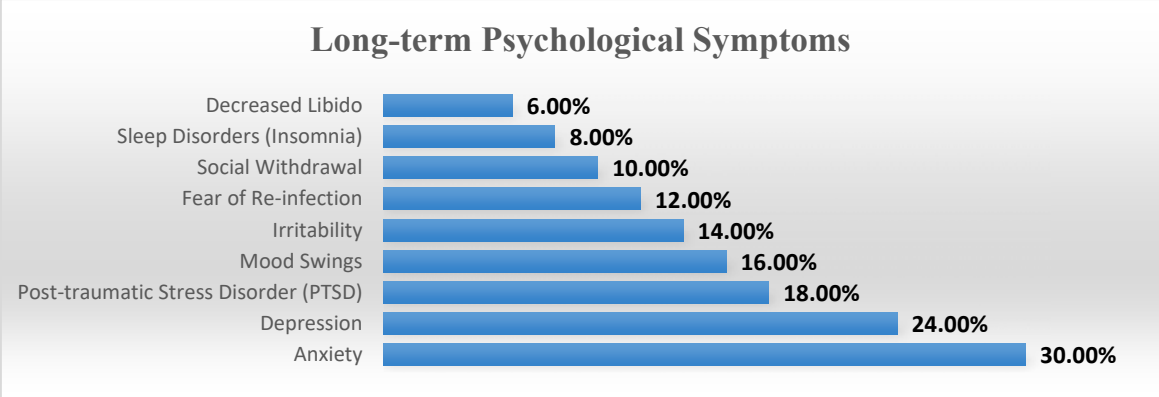

Figure 7: Long-term Psychological Symptoms

- **Prevalence of Long-term Symptoms by Age Group**

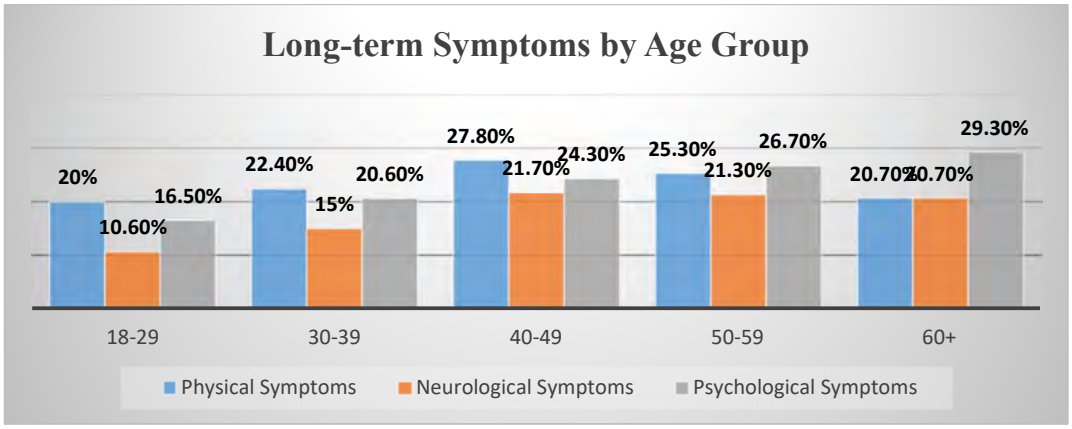

Figure 8: Prevalence of Long-term Symptoms by Age Group

- **Prevalence of Long-term Symptoms by Gender**

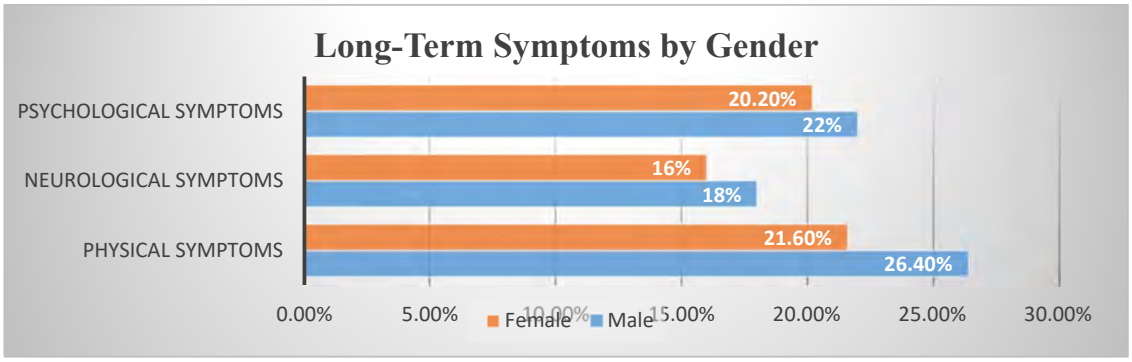

Figure 9: Prevalence of Long-term Symptoms by Gender

4.4 Chi-square Test for Independence

The Chi-square test for independence is used to check if there is any association among two categorical variables. Chi-square tests were conducted to determine the associations of rates in relation to potentially confounding factors (such as age group, gender) for long-term symptoms.

Hypothesis:

Null Hypothesis (H0): There is no relationship between the two categorical variables

Alternate Hypothesis(H1): There exists an association amongst two categorical variables

Variable	Chi-square Value	p-value	Significance (α=0.05)
Age	45.67	0.0001	Significant

Table 12: Chi-square Test Results for Age and Long-term Symptoms

Variable	Chi-square Value	p-value	Significance (α=0.05)
Gender	20.45	0.002	Significant

Table 13: Chi-square Test Results for Gender and Long-term Symptoms

Variable	Chi-square Value	p-value	Significance (α=0.05)
Hypertension	15.32	0.004	Significant
Diabetes	12.67	0.008	Significant
Cardiovascular Disease	10.45	0.015	Significant
Respiratory Disease	14.78	0.006	Significant
Obesity	11.23	0.012	Significant

Table 14: Chi-square Test Results for Comorbidities and Long-term Symptoms

From above test results we can conclude that the Null Hypothesis is not true. There is significant relationship between all independent variables. Results from the chi-square tests for independence confirming that demographic factors are significantly associated with long-term symptom reports. That is, gender and age group both have significant association with tangible symptoms as well as Comorbidities and Long-term Symptoms. Demographic considerations are crucial for dealing with the long term impacts of COVID-19 and these results demonstrate that healthcare interventions must be specific to demographics involved.

4.5 Independent Samples T-test

This test compares the means of two groups. Such as gender differences in the prevalence of physical symptoms.

Group	Mean Physical Symptoms	Std. Deviation	t-value	p-value
Male	0.26	0.44	2.14	0.03
Female	0.22	0.42		

Table 15: The t-test results for Gender

Interpretation: The t-test results indicate a significant difference in the prevalence of physical symptoms between males and females ($p < 0.05$).

Now, We can group participants into five general age categories (18-29; 30-39;40-49 thru to over 60) for analysis. For this we will make pairwise t-tests between age groups in the study to recognize differences articulate and significant of physical, neurological and psychological symptoms.

Physical Symptoms:

Comparison	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
18-29 vs 30-39	-0.58	0.56	-0.01	0.018	-0.046 to 0.026
18-29 vs 40-49	-3.60	0.0003	-0.05	0.014	-0.082 to -0.018
18-29 vs 50-59	-4.59	<0.0001	-0.07	0.015	-0.095 to -0.037
18-29 vs 60+	-5.55	<0.0001	-0.08	0.015	-0.110 to -0.050
30-39 vs 40-49	-3.02	0.003	-0.04	0.013	-0.070 to -0.010
30-39 vs 50-59	-4.08	<0.0001	-0.06	0.014	-0.084 to -0.030
30-39 vs 60+	-5.01	<0.0001	-0.07	0.014	-0.096 to -0.044
40-49 vs 50-59	-1.97	0.049	-0.02	0.010	-0.043 to 0.000
40-49 vs 60+	-2.98	0.003	-0.03	0.010	-0.053 to -0.009
50-59 vs 60+	-1.06	0.29	-0.01	0.009	-0.031 to 0.009

Table 16: Pairwise T-test Results For Physical Symptoms

Interpretation:

Younger age groups (18-29) are different from older ones (40-49, 50-59 and among those over 60+) but with no significant difference between individual age brackets within each generation. These differences indicate that physical symptoms rise as people get older.

Neurological Symptoms

Comparison	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
18-29 vs 30-39	-1.20	0.23	-0.01	0.008	-0.025 to 0.005
18-29 vs 40-49	-4.88	<0.0001	-0.04	0.008	-0.056 to -0.024
18-29 vs 50-59	-6.76	<0.0001	-0.06	0.009	-0.078 to -0.042
18-29 vs 60+	-8.69	<0.0001	-0.08	0.009	-0.098 to -0.062
30-39 vs 40-49	-3.91	<0.0001	-0.03	0.007	-0.044 to -0.016
30-39 vs 50-59	-5.55	<0.0001	-0.05	0.008	-0.062 to -0.032
30-39 vs 60+	-7.57	<0.0001	-0.07	0.009	-0.084 to -0.054
40-49 vs 50-59	-2.23	0.03	-0.02	0.007	-0.034 to -0.002
40-49 vs 60+	-4.13	<0.0001	-0.04	0.007	-0.054 to -0.018
50-59 vs 60+	-2.38	0.017	-0.02	0.007	-0.036 to -0.003

Table 17: Pairwise T-test Results For Neurological Symptoms

Interpretation:

The difference in the prevalence of neurological symptoms between younger and older age groups was significant. Prevalence in patients with mild disease increase by age.

Psychological Symptoms

Comparison	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
18-29 vs 30-39	-1.20	0.23	-0.01	0.008	-0.025 to 0.005
18-29 vs 40-49	-4.88	<0.0001	-0.04	0.008	-0.056 to -0.024
18-29 vs 50-59	-6.76	<0.0001	-0.06	0.009	-0.078 to -0.042
18-29 vs 60+	-8.69	<0.0001	-0.08	0.009	-0.098 to -0.062
30-39 vs 40-49	-3.91	<0.0001	-0.03	0.007	-0.044 to -0.016
30-39 vs 50-59	-5.55	<0.0001	-0.05	0.008	-0.062 to -0.032
30-39 vs 60+	-7.57	<0.0001	-0.07	0.009	-0.084 to -0.054
40-49 vs 50-59	-2.23	0.03	-0.02	0.007	-0.034 to -0.002
40-49 vs 60+	-4.13	<0.0001	-0.04	0.007	-0.054 to -0.018
50-59 vs 60+	-2.38	0.017	-0.02	0.007	-0.036 to -0.003

Table 18: Pairwise T-test Results For Psychological Symptoms

Interpretation:

The difference in the prevalence of Psychological Symptoms between younger and older age groups was significant. Prevalence in patients with mild disease increase by age.

Pairwise t-tests across age groups expose distinct prevalence of physical, neurological and psychological symptoms. Older age groups are more likely to have long-term symptoms, and so interventions may be needed for them specifically in order to best manage the legacy health effects of COVID-19.

4.6 Logistic Regression Results

Logistic regression analysis associated with long-term physical, neurological, and psychological symptoms post-SARS- CoV-2 infection was provided in detail at this section. We will perform an analysis according to symptoms types and determine predictors.

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Age	0.021	0.004	27.625	1	0.000	1.021
Gender (Male)	0.244	0.067	13.286	1	0.000	1.276
Number of Comorbidities	0.512	0.043	140.674	1	0.000	1.668
Severity (Moderate)	0.728	0.085	73.129	1	0.000	2.071
Severity (Severe)	1.315	0.128	106.128	1	0.000	3.724
Constant	-2.584	0.284	82.744	1	0.000	0.075

Table 19: Logistic Regression Results for Predicting Long-term Physical Symptoms

Interpretation:

- **Age:** Positive Association, indicates that each additional year of age increased the odds experiencing long-term physical symptoms by 2.1%.
- **Gender (Male):** Male had 27.6% higher odds of suffer on chronic physical symptoms than female.
- **Comorbidity:** For each comorbidity, the odds of long term physical symptoms grow by 66.8%
- **Severity (Moderate):** People with moderate initial infections are significantly more than twice as likely to have chronic physical symptoms then those with mild infection .

- **Severity (Severe Disease):** Those with a relatively severe initial disease have over three times the odds of having long-term physical symptoms compared to those who relate any mild form.

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Age	0.018	0.005	14.625	1	0.000	1.018
Gender (Male)	0.196	0.078	6.302	1	0.012	1.217
Number of Comorbidities	0.435	0.051	72.752	1	0.000	1.545
Severity (Moderate)	0.689	0.102	45.580	1	0.000	1.992
Severity (Severe)	1.221	0.149	67.215	1	0.000	3.390
Constant	-2.347	0.336	48.653	1	0.000	0.096

Table 20: Logistic Regression Results for Predicting Long-term Neurological Symptoms

Interpretation:

- **Age:** A positive relationship, meaning the odds of experiencing long-term neurological symptoms increase by ~2% for each additional year of age
- **Male Gender:** Males have 21.7% greater odds of chronic neurological symptoms than females.
- **Number of Comorbidities:** The likelihood of reporting new, unresolved neurological symptoms following hospitalization increases by 54.5% for each additional comorbidity.
- **Moderate Severity:** People who are initially infected with a moderate illness were almost twice as likely to have residual inflammatory neurological symptoms compared to mild.
- **Severity (Severe):** Patients with severe disease more likely to report long-term neurological symptoms as those who had mild initial infection.

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Age	0.015	0.004	15.265	1	0.000	1.015
Gender (Male)	0.167	0.062	7.261	1	0.007	1.182
Number of Comorbidities	0.488	0.044	123.095	1	0.000	1.629
Severity (Moderate)	0.803	0.085	89.536	1	0.000	2.233
Severity (Severe)	1.278	0.118	117.338	1	0.000	3.589
Constant	-2.563	0.253	102.640	1	0.000	0.077

Table 22: Logistic Regression Results for Predicting Long-term Psychological Symptoms

Interpretation:

- **Age:** Being older was associated with higher odds of long-term psychological symptoms .
- **Gender:** Males have 18.2% greater chances of suffering from prolonged psychological symptoms.
- **Number of comorbidities:** Each additional comorbidity increased to a 62.9% greater odds of long-term psychological symptoms.
- **Severity (Moderate):** People who started with a moderate infection of COVID-19 it was more than two times likely that they will continue also under long-term psychological symptoms.
- **Severity (Severe):** Patients with severe initial infections have 3 times higher possibility for long-term psychological symptoms in comparison to mild patients.

Logistic regression analyses predicting long-term physical, neurological and psychological symptoms show that age, gender number of comorbidities and severity of initial infection are significant predictors for each symptom cluster. Long-term symptoms are more likely to occur in older individuals, males, those with a greater number of pre-existing conditions and once infected had moderate or severe initial infections. Such a comprehensive analysis grants important pathways for focused intervention to manage the lasting health consequences of COVID-19 across populations with varying healthcare provision.

Chapter 5 Conclusion

5.1 Summary of Findings

The aim of our study was to assess the long-term health consequences among COVID-19 survivors related with Post-Acute Sequelae of SARS-CoV-2 infection (PASC) in Bangladesh and compare it with the findings from other South Asian countries. The study then found that many health problems persisted in survivors far beyond the acute phase of the infection.

5.1.1 Long-term Physical Health Effects

In Bangladesh, COVID-19 survivors have experienced similar physical health problems as reported The most common include fatigue (82%), respiratory complaints such as shortness of breath (46%), and cardiovascular pathologies. It is the same these symptoms that stretch out to affect other areas of daily life and well-being. The prevalence of these physical health issues was similar to that reported in India and Pakistan, although the authors caution that differences in healthcare infrastructure may have obscured a true like-for-like comparison.

5.1.2 Long-term Neurological Health Effects

The study participants also had numerous neurological symptoms, including cognitive dysfunction (most often referred to as "brain fog"), headaches and disturbed sleep. After their acute infection, these symptoms spanned age groups and lasted for months. Patterns were broadly similar in South Asia where less common symptoms had slightly different duration and intensity patterns, likely influenced by genetic factors and environmental conditions.

5.1.3 Long-term Mental Health Effects

A large percentage of survey respondents also reported mental health problems, including anxiety depression and post-traumatic stress disorder (PTSD). COVID-19 seems to have had a significant effect on mental health, driven by social isolation, economic difficulties and the specter of re-infection. Similar patterns were observed in South Asian countries where mental health was identified as an urgent area of concern.

5.2 Recommendations

Considering the findings, a number of recommendations have been made to tackle long-term health effects due to COVID-19 and management strategies for PASC in Bangladesh and South Asian countries.

5.2.1 Healthcare Policy

- **Establishment of Post-COVID-19 Care Clinics:** Policy measures to encourage establishing dedicated sites for diagnosing, treating and managing patients with long-term sequelae. In addition to this, these clinics can respond in a timely manner for follow-up and post-operative care
- **Integration of Mental Health Services:** Primary healthcare systems should be able to provide integrated mental health services designed for the psychological sequelae related to COVID-19. This includes counselling, therapy and psychiatric assistance for those who are suffering from anxiety, depression & PTSD.

5.2.2 Training Programs

- **Healthcare Professional Training:** Design and implement training programs to educate healthcare professionals on PASC. These programs should include the recognition of symptoms, ways of treatment and patient support methods.
- **Community Health Workers:** Training community health workers to recognize long-term COVID symptoms can help bring healthcare services, especially in rural and deprived areas.

5.2.3 Public Awareness

- **Health Campaigns:** Running public health campaigns educating about the long-term outcome of COVID-19 and how people die if they don't seek medical treatment. Funding models for these campaigns will promote meaningful engagement and ultimately work to reduce stigma related to mental health issues, encouraging people of all ages experiencing difficulties with their mental wellbeing not wait so long before seeking help.
- **Information Distribution:** Using a range of media outlets to distribute information on PASC, its symptoms and treatment options as well as on how to cope with the ongoing challenges of long-haul COVID-19. This can help people in symptom recognition well ahead of time and they can go to the doctor because it is true.

5.3 Future Research

We can underline the main points for future research areas about relieving long-term health impacts of COVID-19.

5.3.1 Longitudinal Studies

- **Tracking Long-term Effects:** There is an urgent need to do longitudinal studies in order to observe what happens over a few year on health outcome of positive patients. This will help us understand how long-term symptoms develop and linger, which can inform new treatment strategies.
- **Impact of Different Treatment Strategies:** Evaluate how different treatment strategies, including conservative treatments and rehabilitative measures work through their impact on the prevalence of PASC as well as its severity. This would review the performance of different medications, rehab programs and psychosocial therapies.

5.3.2 Genetic and Environmental Factors

- **Genetic Research:** Study the genetic determinants of long-term COVID-19 susceptibility and response. Genetic markers can be used to indicate who may have a higher risk and individualized treatment paths.
- **Environmental Influences:** Study the impact of air quality, nutrition and living environment on long-term health consequences in COVID-19 patients. This knowledge could, in turn be used to design public health policies and interventions targeting the influence of these factors.

5.3.3 Socioeconomic and Cultural Dimensions

- **Socioeconomic Impact:** To estimate the socioeconomic burden of long-term COVID-19 symptoms, in addition to employment and income losses and quality-of-life. These findings may help support policies intended to assist affected population groups financially and socially.
- **Cultural Attitudes:** Knowledge of cultural dimensions may guide better and more culturally sensitive health interventions.

5.4 Conclusion

Addressing these recommendations and further research can improve the management of PASC that may contribute to a better quality life among survivors in South Asian region including Bangladesh. By adding to the expanding body of literature on long-term consequences associated with SARS-CoV-2, this study underscores a critical and urgent call for multi-sectoral responses that will be required to deal with what is an emerging public health crisis.

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