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The impact of the COVID-19 pandemic on global supply chains

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ABSTRACT

The unforeseen COVID-19 pandemic has wreaked havoc on global supply chains. Since the onset of the pandemic, researchers have been actively investigating and publishing findings on the various supply chain challenges the virus poses. Despite the increasing number of publications on this topic, a lack of comprehensive literature reviews hinders a clear understanding of the areas that have already been explored and those requiring further study. The current review presents an analysis of prior research addressing the impact of the COVID-19 pandemic on supply chain operations. A thorough search identified 74 new studies published on or before September 28, 2020. This review summarizes each study's research focus, methodology, background, and theoretical frameworks. Our findings indicate a scarcity of empirically conducted and theoretically grounded studies, limiting the generalizability of the results. Most recent research emphasizes supply chains for essential products and healthcare supplies, which faced significant demand during the pandemic. In contrast, the supply chains of non-essential items and small businesses have been mainly overlooked.

Keywords: COVID-19, SARS-CoV-2, Pandemic, Epidemic, Lockdown, Supply Chain, Supply Chain Management, Healthcare Industry, Disruptions

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The impact of the COVID-19 pandemic on global supply chains

1. Introduction

The introductory section provides a foundation for the research, presenting the background, research problem, and underlying research questions. It also outlines the research methodology adopted in the study.

1.1 Background of the Study

The healthcare supply chain differs significantly from the supply chains of other industries. While it involves tracking the acquisition and movement of goods from origin to destination, many of these supplies directly impact life and death-situations. Moreover, maintaining the healthcare supply chain incurs substantial costs for healthcare providers (Hashmi et al., 2020a, b). Healthcare institutions promote public health by improving patient care regarding quality, accessibility, and reliability. To meet the growing demand for high-quality services, healthcare systems must continuously invest in and develop their supply chain processes (Hashmi & Mohd, 2020). Healthcare organizations, particularly those in regions where healthcare expenditures constitute a significant share of gross domestic product (GDP), are encouraged to reduce costs without compromising service quality (Carter & Rogers, 2008; Rashid et al., 2020). Global medication expenditures will surpass $1.4 trillion within the next decade. In their definition of the pharmaceutical supply chain (PSC), Uthayakumar and Priyan (2013) describe it as: "The integration of all operations involved in the movement and transformation of pharmaceuticals from raw materials to the end user, as well as accompanying information flows, through better supply chain linkages."

Below figure 1 represents the international decision support initiative and earlier procurement

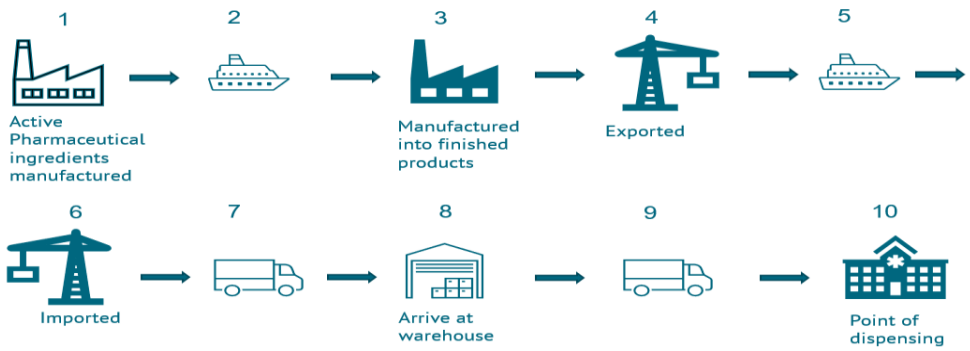

Figure 1: International decision support initiative and earlier procurement

1.1.1 The impact of COVID-19 on the pharmaceutical and healthcare supply chain

The COVID-19 pandemic has triggered unprecedented responses from national governments worldwide, resulting in a global economic downturn and disruptions to business operations. These circumstances have jeopardized the supply of critical medicines and essential goods, with the impact being most severe in impoverished countries. This highlights the complex and globalized nature of the pharmaceutical and healthcare supply chain. The international healthcare sector is growing at a faster pace compared to other industries. However, inequality persists in medical systems globally, underscoring the

need for efficient inventory control and supply chain management. There is an increasing but fragmented focus on healthcare logistics (de Vries & Huijsman, 2011; Rashid, 2016; Rashid & Amirah, 2017). Disparities in healthcare systems remain a significant issue, necessitating better supply chain management. The pharmaceutical supply chain is heavily influenced by distributors and wholesalers, with over 90% of traditional medications sold through these channels (Rashid et al., 2019). A typical pharmaceutical supply chain involves key stages such as drug fabrication, encapsulation (where active ingredients are combined with recipients), and distribution to customers in stock-keeping unit (SKU) form (Shah, 2004; Hashmi et al., 2021a, b). Historically, global pandemics have caused significant disruptions, as seen from events such as the Black Death, Smallpox, Cholera, HIV, and SARS. COVID-19, like these previous pandemics, has profoundly impacted human life and global economies. The World Health Organization (WHO) declared a global pandemic on March 20, 2020, COVID-19 infected 72 million people and caused 1.61 million deaths by December 11, 2020. As of February 23, 2021, WHO reported 111 million confirmed cases worldwide. The pandemic has disrupted economies and industries, with the pharmaceutical sector no exception. COVID-19 has severely impacted supply chains due to the uncertainty and unpredictability of the virus's spread. This has resulted in physical and psychological stress for manufacturing and supply chain management employees. Pandemics such as COVID-19 occur approximately once every century, causing widespread devastation, but they also present opportunities for social and economic transformation (Wang, 2023)—figure 2 Comparative analysis of COVID-19 with previous viruses. The Black Death, "Smallpox, Cholera, HIV," and "SARS are just a few" instances "of worldwide pandemics that have" arisen over the years.

Epidemic event	Year of outbreak	Infected cases	Fatalities	Mortality rate (%)	Transmission level (avg. no. of persons)
Spanish flu	1918	500,000,000	39,000,000	2	1.4–1.6
SARS	2003	8098	774	10	2–5
MERS	2012	2494	858	35	0.6–1.3
COVID-19	2019	67,493,598	1,543,629	2.2	2–6.47

Figure 2: Comparative analysis of COVID-19 with previous viruses in term of primary epidemiological parameters

1.1.2 Global health and economic sectors: the impact of pandemics

Global health and economic sectors have long been challenged by the devastating effects of pandemics. However, solutions have historically been found through controlling the spread of these diseases and developing effective defenses against them (Khan et al., 2021). The long-term effects of pandemics, however, often take years to overcome, delaying a return to normalcy. For instance, the Black Death devastated more than twenty million people in the middle east between 1347 and 1352. This plague severely strained the relationships between landowners and peasantry in Italy, as fewer people were available to plow fields and harvest crops. As a result, peasants began demanding higher wages, a request many landowners ultimately accepted. This shift led to beneficial economic outcomes, including improved living standards for peasants, higher demand for vegetables, fruits, and clothing, and increased agricultural and industrial production (Chip Routt et al., 1993; Agha et al., 2021). While initially causing strain on the hoarded supply chain, these changes eventually had a favorable impact on the economy. In the past, deadly infections were feared not only for their health consequences but also for the lack of a reliable supply chain to address such crises. For example, during earlier pandemics, many nations lacked the infrastructure to respond effectively to public health emergencies. By contrast, modern advancements in supply chain management have made it possible to respond swiftly to pandemics. In China, for instance, a hospital was

constructed in just ten days during the COVID-19 pandemic, showcasing the effectiveness of the country's robust supply chain (Das et al., 2021; Haque et al., 2021; Martin et al., 2012). This efficient supply network significantly reduced casualties during a national medical emergency (Martin et al., 2012). Unlike previous pandemics, when nations were less developed and lacked resilient supply chains, advancements in logistics and infrastructure today have enhanced the capacity to manage public health crises effectively.

1.1.3 The fragility of the medical supply chain during pandemics

Pandemics have consistently posed serious threats to global health systems, exposing vulnerabilities in the medical supply chain. The COVID-19 pandemic, in particular, has highlighted the fragility of the medical supply system, which relies heavily on active pharmaceutical ingredients (APIs). For instance, the United States pharmaceutical industry imports over 80% of its API requirements from China and India, the world's largest API suppliers. Since China was the first country significantly impacted by COVID-19, the pandemic-induced lockdowns and export restrictions severely disrupted healthcare procurement activities. To address the growing demand for ventilator support for COVID-19 patients, regulatory bodies like the United States Food and Drug Administration (FDA) and the International Association of Healthcare System Pharmacists (ASHP) released a "shortage list" of critical ICU prescription drugs and COVID-19 treatments. This list included medications like dopamine, dobutamine, fentanyl, propofol, and midazolam. In January alone, these shortages accounted for 87% of the total gap in pharmaceutical availability. ASHP further identified over 200 medications in short supply, including hydroxychloroquine (HCQ) and chloroquine (CQ), commonly used for treating metabolic diseases like inflammatory arthritis. Although the scarcity of HCQ and CQ was quickly resolved, other critical medications, such as dexamethasone, remained in limited supply as COVID-19 infections surged.

The pandemic also caused a severe strain on the supply chain for personal protective equipment (PPE), such as protective glasses, surgical masks, gowns, and N95 respirators. Demand for these essential items skyrocketed, resulting in significant shortages. To address this, the American Society of Health-System Pharmacists (ASHP) conducted surveys through the Section of Pharmacy Practice Leaders (SPPL) to assess the availability of pharmacy supplies, particularly PPE and ICU medications. The findings revealed acute shortages of critical items, highlighting the urgency of implementing effective supply chain strategies to meet healthcare demands during such crises. Effective deterrent measures, such as health education and policy interventions, are crucial in mitigating the rapid spread of pandemics. However, for these measures to succeed, cohesive and persuasive policies must be implemented to adequately educate and prepare the population. The supply chain is a network of businesses involved in various processes and activities that add value to products and services delivered to the end consumer through upstream and downstream links. A robust supply chain strategy integrates key operations like procurement, production, and transportation to ensure seamless functioning. Maintenance of infrastructure, processing facilities, manufacturing plants, research and development centers, and distribution hubs all play vital roles in the supply chain structure (Alrazehi et al., 2021; Stock et al., 2000; Ali & Waqas, 2022; Swoboda & Sinning, 2020).

1.1.4 Supply chain management in healthcare: challenges and opportunities

Supply chain management (SCM) has been extensively practiced across various industries. Over the past decades, the healthcare sector has increasingly focused on adopting diverse supply chain practices in response to continuous changes in their nature, context, and requirements (Merikanto et al., 2022; Rashid et al., 2022a, b). The supply chain has proven to be an effective strategy for minimizing and eliminating the spread of viruses. This is largely due to advancements in the manufacturing, distribution, and storage of goods on a global scale. However, the COVID-19 pandemic has revealed significant weaknesses in many nations' healthcare systems. In several severely impacted countries, healthcare systems have been pushed beyond their limits, leading to the delegation of authority and decentralization of health services in an

attempt to manage the growing death toll and chaos (Baloch & Rashid, 2022; Boccia et al., 2020; Rashid & Rasheed, 2022). This ongoing crisis has exposed vulnerabilities within global capitalism, highlighting delayed responses to emergencies and systemic inefficiencies (Hashmi, 2022; Yang et al., 2020). In developed countries, healthcare systems have been overwhelmed by a surge in cases, while in underdeveloped nations, decades of neglect and underfunding of public health have exacerbated the situation (Gates, 2020).

1.1.5 The pharmaceutical supply chain in Pakistan

Pakistan gained independence in 1947 and subsequently established its pharmaceutical sector's supply chain infrastructure. Initially, the country had only 20 operational and manufacturing pharmaceutical units. The number has grown to hundreds, reflecting significant expansion in the industry's distribution network. Pakistan has 759 pharmaceutical production facilities, which meet approximately 70% of the country's pharmaceutical demand. Among these facilities are 25 multinational corporations holding the same market share as domestic businesses. Sindh alone is home of 183 pharmaceutical companies. Despite this growth, the pharmaceutical sector in Pakistan faces several challenges. These include:

a) Lack of modern technology,
b) Insufficient power supply,
c) A shortage of skilled labor,
d) Red tape around exports,
e) Limited availability of local raw materials,
f) Currency depreciation,
g) Fixed pricing by the Drug Regulatory Authority of Pakistan (DRAP) and
h) Weak infrastructure.

To overcome these challenges, the government and industry stakeholders must implement innovative strategies that reinvigorate the therapeutic sector. By doing so, Pakistan's pharmaceutical industry can significantly improve productivity and efficiency (Rasheed & Rashid, 2022).

1.1.6 COVID-19 in Pakistan

The world is grappling with the COVID-19 pandemic, which has profoundly affected people's lives and economies worldwide. The implementation of nationwide lockdowns has disrupted various economic activities, forcing businesses to shut down and causing a significant reduction in imports, exports, foreign direct investment (FDI), and remittances. These factors have increased unemployment and poverty in many countries, including Pakistan. Pakistan is striving to manage this global challenge; however, concerns persist that the nation's economy will face severe setbacks, potentially derailing its growth trajectory. The closure of businesses and the resulting decline in economic activities pose significant risks to the socio-economic fabric of the country. The economic repercussions of the pandemic are further evident in Figure 3, which illustrates global market spending and growth trends from 2007 to 2021. This figure highlights the dramatic shifts in economic activity, showing the sharp declines in various sectors, including healthcare and pharmaceuticals, during the pandemic.

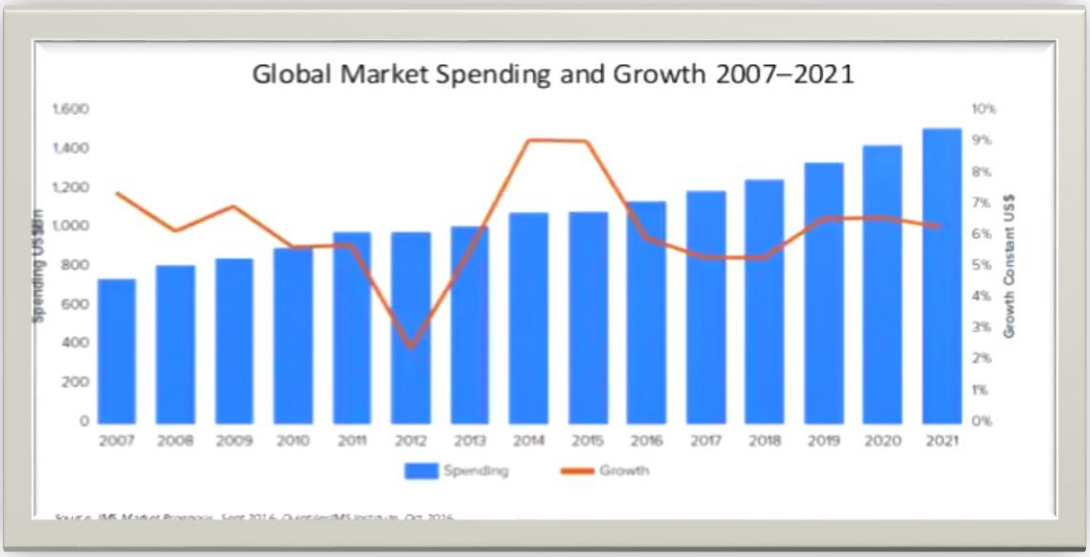

Figure 3: Global market spending & growth 2007 – 2021

The COVID-19 pandemic has wreaked havoc globally, pronounced impacting nations with fragmented and poorly equipped healthcare systems (Armocida et al., 2020; Rasheed & Rashid, 2023). In such countries, the situation is exacerbated by decentralization and inadequate healthcare facilities. The virus's rapid spread has transformed it into a major global crisis, particularly in regions ill-prepared to manage such emergencies (Lai et al., 2020; Khan et al., 2022; Rasheed et al., 2023). As the Director-General of the World Health Organization, Tedros Adhanom Ghebreyesus, stated: "We cannot continue to finance fear while neglecting readiness." Despite global healthcare spending amounting to $7.5 trillion annually, the pandemic has served as a stark reminder of the fragility of healthcare systems worldwide. For Pakistan, the pandemic has highlighted the country's inadequate health infrastructure, which has struggled under immense pressure during this period (Spinelli & Pellino, 2020; Rashid & Rasheed, 2023). As per WHO, on July 15, 2020, Pakistan reported approximately 255,769 COVID-19 cases and 5,386 fatalities. The first confirmed cases of COVID-19 in Pakistan were reported in February 2020. Figure 4 provides a province-wise breakdown of confirmed COVID-19 cases in Pakistan, illustrating the regional disparities in infection rates and the varying impact of the virus across different areas.

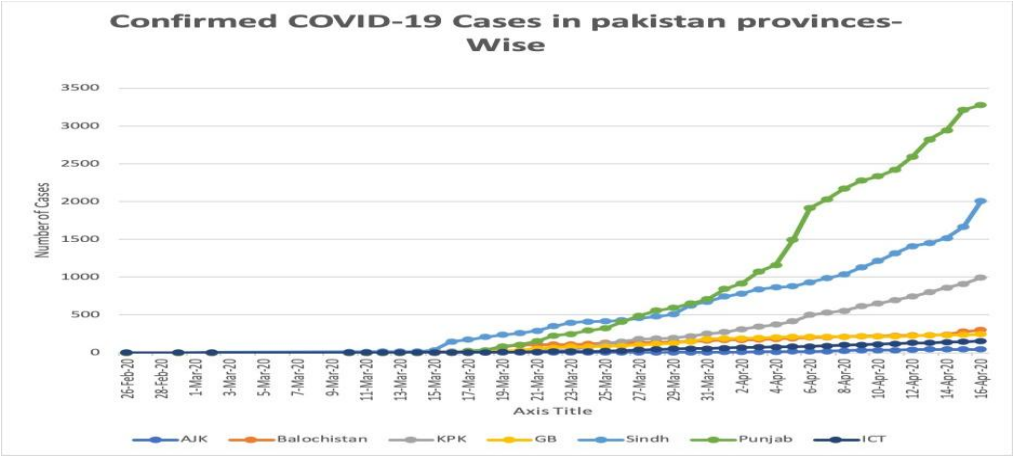

Figure 4: Confirmed COVID-19 cases in Pakistan provinces wise

On March 17, 2020, Pakistan recorded its first significant single-day increase in COVID-19 cases, with 134 confirmed infections, bringing the total to 184. These cases were traced back to quarantine camps near the Taftan border crossing with Iran, raising concerns about the inadequacy of quarantine protocols. On April 6, 2020, Pakistan recorded its highest number of daily cases at 577. During the lockdown, access to and utilization of healthcare facilities were severely restricted due to the enforcement of lockdown measures aimed at curbing the spread of the COVID-19 virus. This restriction resulted in significant hardships for people, including the closure of Outpatient Departments (OPDs), limited transportation options, unavailability of essential medicines, uncooperative medical staff, and widespread fear of contracting the COVID-19 infection. Figure 5 presents data on the various problems faced by the population in accessing healthcare facilities during the COVID-19 period, highlighting that 17% of individuals reported receiving inadequate treatment due to fears of contracting the virus. Additionally, 14% cited transportation difficulties as a barrier to accessing care, while 7% mentioned shortages of medicines and uncooperative medical staff. These statistics underscore the profound healthcare challenges faced by Pakistani citizens during the pandemic.

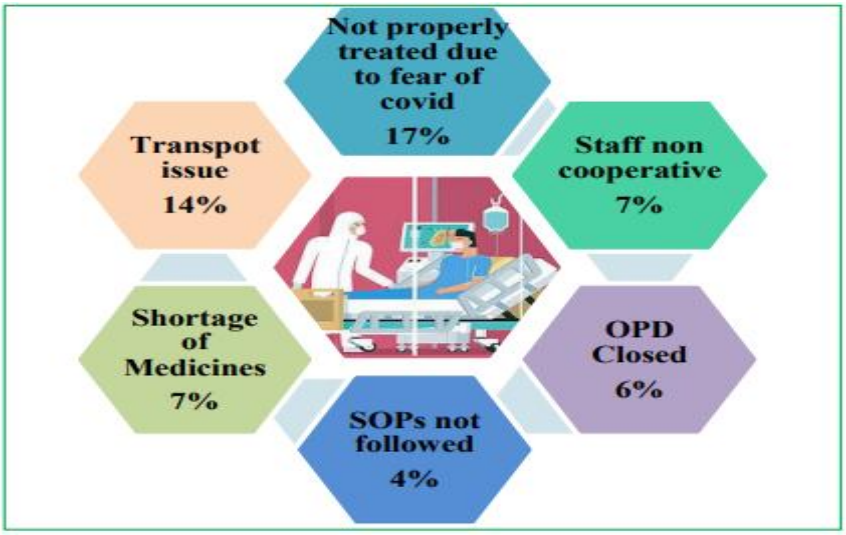

Figure 5: Problems faced by population for access/usage of health facilities during COVID period (%):

1.1.7 Reasons for not using health facilities during the COVID-19 period

Fear of contracting the COVID-19 infection was reported by 52% of families as the primary reason for avoiding healthcare facilities during the pandemic. This was followed by 29% of families stating that there was no need to visit health facilities due to staying at home (refer to Figure 6). Additionally, 28% of respondents attributed their decision to lockdown restrictions, while 19% cited a lack of affordability as a barrier to accessing healthcare services.

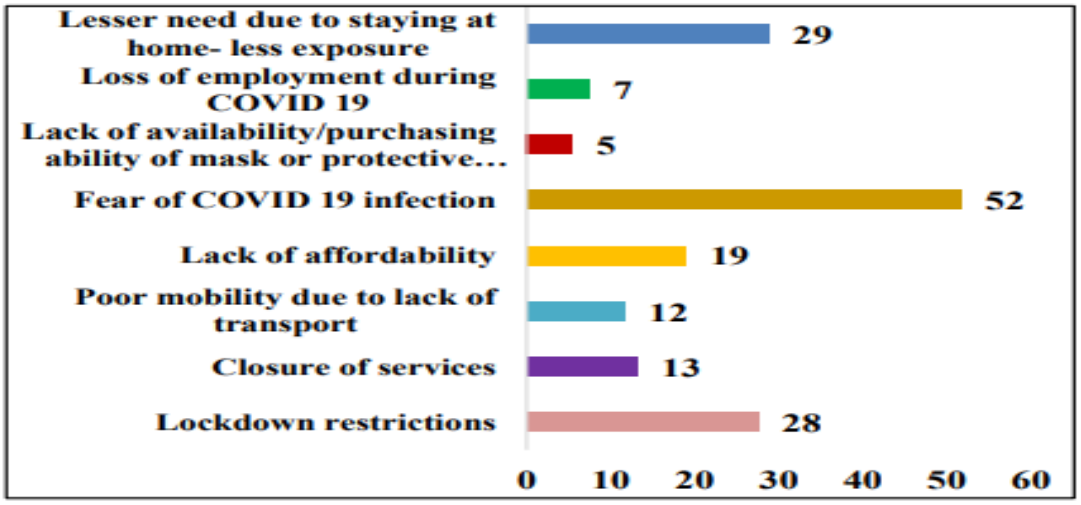

Figure 6: Reason for not using health facilities during COVID-19 period

1.1.8 Impact of COVID-19

As a middle-income country with weak healthcare infrastructure and a population of 197 million, Pakistan faces significant challenges due to COVID-19. The pandemic has severely threatened the country's pharmaceutical sector, which heavily relies on imported Active Pharmaceutical Ingredients (APIs). Approximately 80% of these APIs are sourced from China, the world's largest API producer, with Wuhan as a key manufacturing hub (Aljuneidi et al., 2023). Amid the pandemic, China halted API shipments to focus on its internal battle against the virus. This created widespread concerns, especially among smaller pharmaceutical companies in Pakistan that lacked sufficient stock to sustain production. A local business in Islamabad expressed anxiety over running out of supplies, while larger companies seemed less concerned. A spokesperson for Getz Pharma stated, "We're not worried about manufacturing capacity." However, the suspension of API imports led to a sharp increase in raw material prices, potentially disastrous for smaller businesses. In addition, concerns arose about the quality of APIs as global regulatory bodies struggled to monitor manufacturing during the pandemic. With weakened oversight, there was a risk of substandard APIs entering the market. This issue is not new; 2018 Pakistan's government identified 250,000 DPT vaccines from China as substandard. Similar incidents, such as selling faulty COVID-19 testing kits by Shenzhen Biotechnology to Spain and discovering defective masks in the Netherlands, highlight the dangers of substandard medical products during crises. In addition to API shortages, Pakistan's pharmaceutical industry faced challenges in procuring packaging materials. Glass and plastic factories shut down during the lockdown, and essential items like rubber stoppers were primarily imported from China. Many of these imported materials failed to meet FDA standards, making them unsuitable for use by major pharmaceutical companies. Furthermore, the pandemic exacerbated Pakistan's dependency on imported personal protective equipment (PPE). Basic items such as surgical masks, safety goggles, and other protective gear were in short supply, and the country lacked high-quality local manufacturers capable of producing these essential goods. COVID-19 has exposed the vulnerabilities of Pakistan's pharmaceutical sector, leaving the nation grappling with a critical shortage of raw materials and medical supplies.

1.1.9 Shortage of medicines and supply challenges amid COVID-19

The drug Hydroxychloroquine, previously touted by President Trump as a preferred treatment for COVID-19, has run out in Pakistan. Many individuals started using it as a precautionary measure, despite its known side effects, such as heart palpitations and kidney failure. The misuse of Hydroxychloroquine has led to widespread concerns, as the medication was being administered as a preventive measure without

proper guidance. On March 20th, the Drug Regulatory Authority of Pakistan (DRAP) issued a notice stating that Hydroxychloroquine should only be sold by licensed pharmacies on a prescription basis. However, this notice came too late. Social media users had already been sharing unverified claims about its benefits and even recommended dosages, which posed significant risks due to improper use. This situation underscores the urgent need to raise public awareness about the proper usage and risks associated with such medications. Other essential medicines, including Azithromycin, Loratadine, Flurbiprofen, and Levofloxacin, are also in short supply. Public awareness about the importance of Vitamin C consumption to boost immunity against COVID-19 should be prioritized. A pharmacy owner shared, "My sensor detects issues before they become a supply shortfall. This gives us time to find alternatives for at-risk pharmaceuticals and maintain supply once the immediate danger subsides." Unfortunately, hoarding of common medicines has given rise to a black market, where prices have skyrocketed. Medications like Cefixime, Panadol CF, and Panadol Extra are being sold at inflated prices, with drugs previously costing Rs. 45 now selling for Rs. 100. While some ethical pharmacy owners in Karachi's Nazimabad area claim to avoid overcharging, they also report a rapidly diminishing stock of essential medicines, creating a critical dilemma for the population.

Distribution challenges further exacerbate the issue. Despite no government restrictions on distribution trucks, they are being denied entry into certain areas. For instance, last Wednesday, a pharmaceutical company’s truck was refused entry into Mingora, and similar problems were reported in Azad Jammu and Kashmir (AJK) on Friday. Although local authorities addressed the issue, these delays result in wasted time, energy, and resources. In some cases, individuals have been producing fake IDs to pose as pharmaceutical employees, enabling them to secure free transportation across cities. These IDs are essential for pharmaceutical "booking" personnel who visit various locations to collect orders and coordinate with relevant departments. Without timely and accurate order bookings, the supply chain suffers significant disruptions. Another government notice revealed that some distributors operate without proper licenses and source supplies outside their designated districts ("zillas"). This practice has led to unnecessary logistical complications, further straining the supply chain during a critical period.

1.1.10 Quack practices and the issue of counterfeit medicines amid COVID-19

The prevalence of quacks in the country has long been a challenge for public health. These unlicensed practitioners often use injections as a primary form of therapy, claiming to provide immediate relief. Injections are frequently preferred over tablets due to their quicker pain relief. However, this preference is exploited by quacks who use injections as a means to gain the trust of unsuspecting patients. The rising costs of medicines may further exacerbate this issue, encouraging these unqualified practitioners to prescribe even more expensive injections, potentially worsening the health outcomes of patients. Contraband medicines are another significant concern in Asia, posing a severe threat to public health. The aftermath of COVID-19 has witnessed a surge in counterfeit medicines circulating in the market. For instance, a counterfeit version of Wyeth Pakistan Ltd.’s Prevnar Vial vaccine, which is designed to protect against pneumococcal diseases caused by Streptococcus pneumonia, has been found in circulation. These fake vaccines can endanger lives. For more information, the Drug Regulatory Authority of Pakistan (DRAP) website provides resources on identifying counterfeit medicines. The pharmaceutical industry in Pakistan is grappling with financial challenges. Profit margins for companies have shrunk due to the continued depreciation of the rupee. A representative from Getz Pharma expressed concerns that the rising cost of Active Pharmaceutical Ingredients (APIs) and packaging materials has further compounded these financial pressures. Many API manufacturers and packaging suppliers have already announced price increases, adding to the burden on pharmaceutical companies. The global pandemic has also disrupted supply chains, leading to delays and halting international supplies and equipment trade. According to Ivanov (2020), most firms now rely on internal suppliers to meet client demands. However, the slowdown in global distribution networks has resulted in severe challenges for businesses, threatening the viability of many companies. The sudden shutdown of international markets has had a catastrophic impact on global and local supply chains, further destabilizing industries.

1.2 Research Problem

The new coronavirus pandemic has prompted countries worldwide to enforce lockdowns, shutting down airlines and sealing borders entirely (Merikanto et al., 2022; Rashid et al., 2023). The World Trade Organization (WTO) projected that global trade would decline between 13% and 32% in 2020 as COVID-19 disrupted economic operations and daily life on an unprecedented scale. The COVID-19 outbreak has introduced significant challenges to the healthcare sector, particularly in supply chain management. The pandemic has caused disruptions in pricing, production, and the availability of goods, severely impacting the financial sector and resulting in industrial shutdowns, office closures, and travel restrictions (Gupta & Bedi, 2020). These disruptions and reduced sales for smuggled goods have strained global supply chains even further (Gupta & Bedi, 2020; Khan et al., 2023a, b). Like the 2003 SARS outbreak, COVID-19 has presented unique challenges to the world's most interconnected economies. The pandemic's effects are already visible in the healthcare industry. A surge in demand for sanitizers, protective masks, medical equipment, and oxygen machines has exposed critical vulnerabilities in the supply chain. High demand, limited supply, and disrupted cross-border product movement have further compounded the situation (Gupta & Bedi, 2020; Hashmi, 2023; Haq et al., 2023).

In contrast to many other nations, Pakistan's government has implemented relatively modest restrictions. Measures include canceling public events, initiating public awareness campaigns, and regulating international travel. In response, manufacturers, research laboratories, and universities pool resources and adapt their systems to support these initiatives. COVID-19 and its associated mitigation measures implemented by governments, organizations, and healthcare systems have impacted manufacturing and distribution networks across various industries (Jiang et al., 2023; Rasheed et al., 2024a, b). Two critical elements of supply chain management, production and delivery, remain essential to the healthcare sector. Both elements depend on the human workforce required to operate manufacturing equipment (Majeed & Ozturk, 2020; Rashid & Rasheed, 2024). However, COVID-19 has significantly disrupted these processes. Safety concerns have prevented workers from reporting to their jobs, and movement restrictions have hindered the delivery of essential goods. With the number of COVID-19 cases rising daily, it is evident that the healthcare supply chain in Pakistan will need to be reinforced. Additional equipment and resources must be available to effectively address the ongoing crisis.

1.3 Research Question

This investigation seeks to address the following key research questions about the impact of COVID-19 on the healthcare supply chain:

a) What is the impact of the global COVID-19 pandemic on the healthcare supply chain?

b) Which parts of the supply chain have been hit the hardest by the pandemic?

c) How prepared were supply chain organizations for a large-scale supply chain disruption before COVID-19, and how prepared are they for potential future impacts?

1.4 Purpose of the Study

This study focuses on examining the impact of an international pandemic on the healthcare supply chain. Healthcare comprises a network of economic sectors that deliver goods and services aimed at curative treatment, preventive care, rehabilitation, and therapeutic interventions. For patients, access to essential medications is critical. Delays in receiving prescription medicines can jeopardize patient health and compromise the quality and safety of care. India, as the largest global provider of generic medications, imports 70% of its Active Pharmaceutical Ingredients (API) from China. This dependency implies that medicine shortages are inevitable as the pandemic disrupts supply chains. In response, the International Agency has urged EU pharmaceutical companies to raise awareness about the adverse impacts of

production disruptions in China and other regions on medicine supplies within EU member states. Furthermore, companies must notify EU authorities about potential shortfalls and ensure accountability. This research is further expanded to explore how every aspect of the healthcare supply chain is affected by the pandemic in the context of the selected region. COVID-19, a member of the coronavirus family, has long been known to cause symptoms ranging from respiratory illnesses to more severe disorders. The study highlights the pandemic's impact on global supply chains, focusing specifically on manufacturing, imports and exports, labor, and the broader economy within Pakistan. It delves into supply chain management challenges and adaptations in the healthcare industry.

1.5 Significance of the Study

This quantitative investigation of the parameters influencing the COVID-19 pandemic's effects on the healthcare supply chain is vital for future research. Limited studies currently exist on this subject, making this analysis a significant contribution. The study aims to identify the specific impacts of COVID-19 on the healthcare supply chain and suggest measures to address these challenges effectively.

1.6 Definition of Terms

a) COVID-19: COVID-19 stands for "Coronavirus Disease 2019," a highly contagious respiratory illness caused by the SARS-CoV-2 virus.

b) SARS-CoV-2: The virus responsible for causing COVID-19 is known as the "Severe Acute Respiratory Syndrome Coronavirus 2" (SARS-CoV-2).

c) Pandemic: A worldwide spread of an infectious disease, surpassing the scale of an epidemic.

d) Epidemic: A sudden outbreak of an infectious disease within a specific population or geographic area.

e) Lockdown: An emergency measure restricting movement within certain regions to limit disease exposure or transmission. During an epidemic, individuals are advised to stay at home.

f) PPE (Personal Protective Equipment): Specialized clothing and equipment that protect individuals from health hazards, such as infections transmitted through physical contact or airborne particles.

g) Supply Chain: A network that connects a firm with its suppliers to manufacture and deliver a product to the end user.

h) Supply Chain Management (SCM): The strategic coordination of business processes within an industry’s supply chain network to optimize efficiency and effectiveness.

i) Healthcare Industry: Businesses within the healthcare sector that provide medical services, manufacture medical equipment or pharmaceuticals, offer health insurance, or support patient healthcare delivery.

j) Pakistan’s Pharmaceutical Industry: All enterprises, businesses, and corporations involved in the pharmaceutical supply chain in Pakistan.

2. Literature Review

This section reviews previous research and scholarly works relevant to the current study, which focuses on the healthcare sector supply chain. The supply chain plays a critical role in the healthcare industry. Supply Chain Management (SCM) is considered the foundation of the healthcare sector. The availability of medical supplies in the right quantity and at the right time significantly impacts the quality of care provided (Mathur et al., 2018; Rashid et al., 2024c). Over the past decade, the healthcare industry

has undergone significant transformations. According to the study "Supply Chain Management in Healthcare" (De Vries & Huijsman, 2011; Rashid et al., 2024d), these changes have been driven by increasing market competition, growing patient engagement, and the need to provide healthcare services more effectively and efficiently. Furthermore, research indicates that implementing supply chain strategies can enhance overall customer satisfaction. Customer satisfaction is defined as the process of fulfilling consumers' expectations and needs (Omoruyi & Mafini, 2016; Rashid et al., 2024e). However, challenges such as miscommunication, lack of collaboration, ineffective strategic alliances, and inadequate information exchange continue to hinder the efficiency of the healthcare supply chain (Yanamandra, 2018; Rashid et al., 2024f). Pakistan's pharmaceutical industry is expanding rapidly. Companies that focus on adapting to continuously evolving consumer behaviors are expected to maintain a dominant position in the market. This growth model aligns with the strategies adopted by well-established national pharmaceutical companies. Based on these trends, it is reasonable to predict that Pakistan's pharmaceutical sector will follow a similar trajectory. Supply Chain Management (SCM) is essential for organizations across all industries (Aronsson et al., 2011). As stated by Aronsson et al., (2011), SCM ensures cost efficiency and competitive advantage for businesses. However, the healthcare sector has been slow to adopt SCM strategies, focusing primarily on addressing immediate challenges rather than gaining a long-term competitive edge. As the number of patients continues to rise, SCM in healthcare has become increasingly complex. One of the key barriers to effective supply chain implementation in the healthcare sector is the lack of SCM education and executive support.

Logistics management accounts for 30% to 40% of total healthcare industry expenditures (Aronsson et al., 2011). Managing logistics without a well-structured SCM framework is a significant challenge for any organization. The primary goal of SCM development is to optimize operational processes and address potential inefficiencies between companies (Aronsson et al., 2011; Rashid et al., 2024g). SCM ensures the smooth distribution of goods between organizations, which is crucial for maintaining an uninterrupted supply of medical products and services within the healthcare sector. Effective supply chain management is particularly critical in the healthcare sector, as hospitals must coordinate care for patients who require continuous monitoring and treatment. Managing healthcare operations requires seamless collaboration among multiple departments through a well-integrated communication network (Aronsson et al., 2011; Rashid et al., 2024h). This literature review provides insights that can be applied to the present study. The COVID-19 pandemic serves as a compelling example of how a global crisis can disrupt all aspects of healthcare SCM. This research specifically examines the impact of the COVID-19 outbreak on the healthcare supply chain in Pakistan.

2.1 COVID-19's Impact on the Healthcare Supply Chain

2.1.1 Forecasting

Efficient scheduling plays a crucial role in managing the epidemic effectively and balancing the demand and supply within global supply networks. Panic purchasing and stockpiling have occurred as a result of the pandemic, compounded by the bullwhip effect, leading to significant disruptions across entire supply chains (Wang et al., 2020). Foresight is essential for supporting evidence-based governmental decisions, optimizing resource utilization, and guiding critical yet contentious decisions such as lockdowns and social distancing measures. However, this remains a challenging task for governments and supply chain managers due to the dynamic nature of the pandemic, which can escalate its severity and exacerbate its consequences (Pinson & Makridakis, 2022).

2.1.2 Sourcing and procurement

Customers may experience shortages of essential supplies, along with less apparent consequences such as production shutdowns and limitations on input materials, components, and finished goods. Supply

shortages result from contagious diseases, lockdowns, and restrictions on the movement of people and resources, influencing manufacturers on a global scale. Import restrictions on goods and services have significantly affected global supply chains. To mitigate these disruptions, there has been a temporary shift toward regional sourcing and an increased emphasis on local healthcare manufacturing (Steele et al., 2020).

2.1.3 Transportation

Global restrictions implemented to curb the spread of COVID-19 have negatively affected the movement of goods, people, and information. In an interconnected world, well-functioning supply networks are vital for economic development and prosperity. The pandemic continues to pose a severe threat to supply chains, inevitably impacting how transportation infrastructure is utilized at different levels (Ivanov, 2020). COVID-19 has led to significant disruptions in mobility, shipping volumes, and overall logistics capacity (de Vos, 2020; Loske, 2020).

2.1.4 Inventory management

The significant risks posed by COVID-19 have severely impacted supply chain management, particularly in maintaining adequate inventory levels and preventing stock outs. Panics buying by consumers and other supply chain constraints have exacerbated this issue. Many companies are striving to adopt appropriate ordering practices in response to the pandemic's effects on inventory management. Organizations are modifying their supply chains by enhancing localization, reducing dependencies on single or multiple suppliers, and investing in infrastructure production technologies to address these challenges.

2.1.5 Warehousing

The pandemic has forced warehouses to operate efficiently despite reduced workforces and social distancing requirements (Singh et al., 2021). These constraints have ripple effect on supply chains, leading to stockouts and delivery delays. Concerns regarding labor shortages, unfulfilled pre-existing orders, and price hikes have accelerated the need for businesses to optimize operations and do more with fewer resources.

2.1.6 Distribution

The pandemic has introduced new challenges to distribution channels. Continuing business as usual may endanger staff or necessitate increased reliance on suppliers. Demand for distribution has declined sharply due to social distancing and government-recommended isolation measures. However, the demand for various products and services, such as healthcare goods, sanitization products, toilet paper, pre-packaged food, delivery applications, videoconferencing tools, telecommunications, and home entertainment, has surged. As a result of increased demand, distribution workers face heightened exposure to infection. The pandemic has also accelerated the shift toward e-commerce, prompting companies to invest in digital sales training and online capabilities (Guan et al., 2020).

2.2 The Global Pharmaceutical Industry

The global pharmaceutical industry is one of the most complex and research-intensive sectors. Innovation has long been the backbone and cornerstone of this industry (Dunlap et al., 2014). Within the pharmaceutical sector, key players include independent companies engaged in research and development, pharmaceutical manufacturers, and medical and healthcare device producers. The primary objective of the pharmaceutical industry is to lead in the discovery, development, production, and marketing of drugs and other medical products (Kolb & Sharpless, 2003). While the industry has its own regulatory frameworks in

place, it is also subject to strict oversight by various government regulatory organizations. Improperly controlled pharmaceuticals, treatments, and other medical products can have detrimental effects on public health. Additionally, policy miscalculations can lead to excessive costs for governments (Kolb & Sharpless, 2003; Rashid et al., 2024i). The distribution network for essential medicines in developing countries plays a crucial role in ensuring accessibility and availability of life-saving drugs. However, supply chain inefficiencies, logistical barriers, and inadequate infrastructure often hinder the smooth delivery of medicines to remote areas. Figure 7 illustrates the complex distribution network, highlighting the key intermediaries involved, including pharmaceutical manufacturers, wholesalers, and local healthcare providers. Understanding these distribution challenges is vital for policymakers and stakeholders to enhance the efficiency of pharmaceutical supply chains and ensure that essential medicines reach those in need.

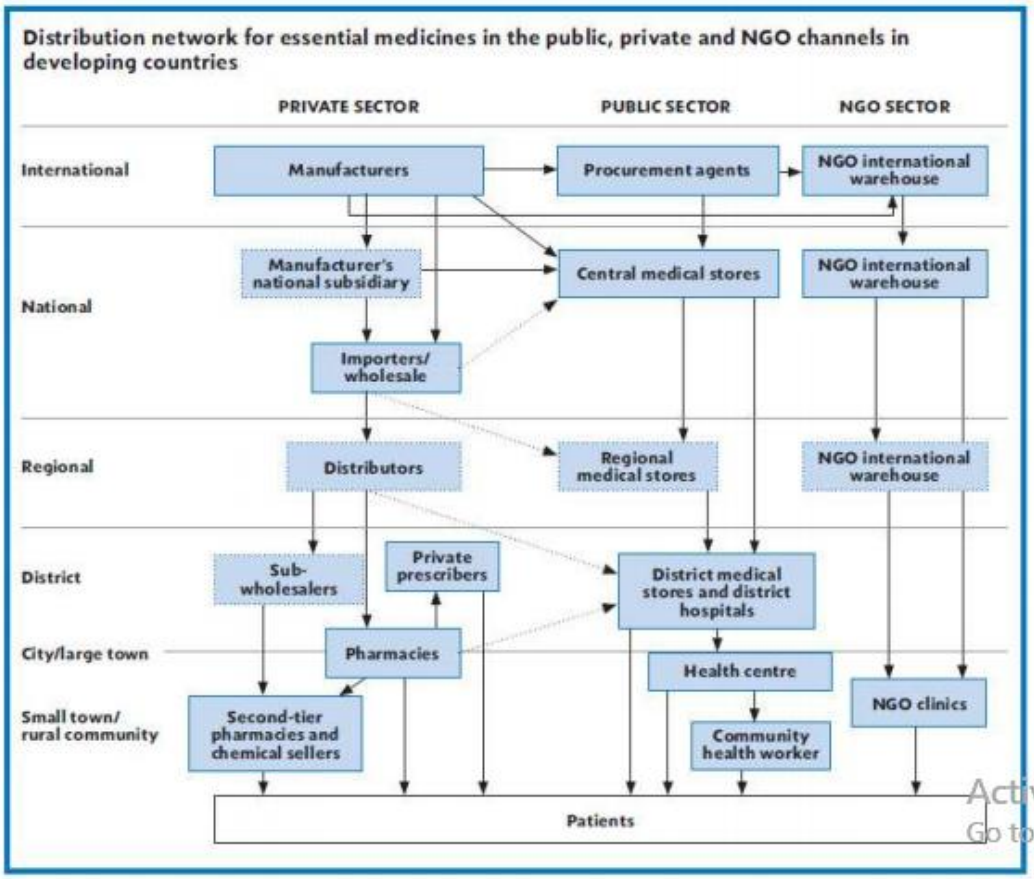

Figure 7: Distribution network for essential medicines in developing countries

2.3 Regulation of Pharmaceuticals

To approve or restrict the entry of a medicine or other pharmaceutical product into the market, multiple regulatory measures are in place. Recent trends indicate that the number and complexity of regulations governing pharmaceutical companies and the broader industry are increasing. This trend has both positive and negative implications, as it aims to protect individuals while also imposing constraints on corporations (Guler & Nerkar, 2012). Government regulations in the pharmaceutical industry can have both favorable and adverse effects. On one hand, they ensure improved sanitation, accuracy, and affordability of drugs. On the other hand, excessive regulation can create financial burdens and limit accessibility.

2.4 Pakistan's Pharmaceutical Industry

Pakistan's pharmaceutical sector stands to benefit significantly from improved supply chain performance. Enhanced efficiency leads to cost-effective operations, reduced expenses, and higher profit margins. These improvements enable pharmaceutical companies to invest in research and development initiatives, ultimately enhancing product quality. Sustained progress in the pharmaceutical industry is crucial for maintaining and supporting its long-term growth. Most annual pharmaceutical sales in Pakistan are driven by efficient anti-infective drugs, followed by medications for digestive and metabolic disorders. Approximately 60% of revenues come from domestically produced pharmaceuticals, whereas 95% of Active Pharmaceutical Ingredients (APIs) are imported.

2.5 The Healthcare Industry in Pakistan Compared to the International Pharmaceutical Industry

Apart from major multinational corporations like Abbott, Merck, and GlaxoSmithKline, most pharmaceutical companies in Pakistan are relatively smaller and less well-known. Many companies operate as subsidiaries of global firms or localized enterprises that distribute active pharmaceutical ingredients to manufacturers, who produce and distribute the final pharmaceutical products (Khan et al., 2012). Some global firms fully own local pharmaceutical operations, further integrating Pakistan's international pharmaceutical supply chain role. Pakistan plays a crucial role in supplying raw materials to global pharmaceutical manufacturers. However, profit margins tend to decline as one moves up the supply chain hierarchy. Companies that supply raw materials to drug manufacturers earn lower profits compared to those producing finished pharmaceutical products (Khan et al., 2012). While Pakistan is a significant supplier of raw materials, the government and private sector need to take greater initiatives to ensure the long-term growth and sustainability of the pharmaceutical industry. Strengthening local manufacturing capabilities could enhance value addition and improve economic outcomes for the sector.

2.6 Pakistan's Economy

The Pakistani economy stands to benefit significantly from an improved pharmaceutical supply chain. Enhanced pharmaceutical production and distribution efficiency would lead to better accessibility to medicines and healthcare products, contributing to a healthier population. As a result, government expenditure on healthcare could decrease, reducing financial strain on public resources (Warnecke et al., 2008). Furthermore, a thriving pharmaceutical industry would create a more lucrative investment environment, fostering expansion and job creation. These factors would contribute to sustained economic growth in Pakistan. The pharmaceutical sector's contribution to economic growth is also reflected in broader global trends. Figure 8 illustrates the percent variation in the global GDP rate from 2005 to 2021, highlighting fluctuations influenced by economic conditions, policy decisions, and global crises such as the COVID-19 pandemic. These variations emphasize the importance of resilient industries, including pharmaceuticals, in stabilizing economic performance. As Pakistan strengthens its pharmaceutical sector, it can mitigate external economic shocks and contribute positively to national GDP growth.

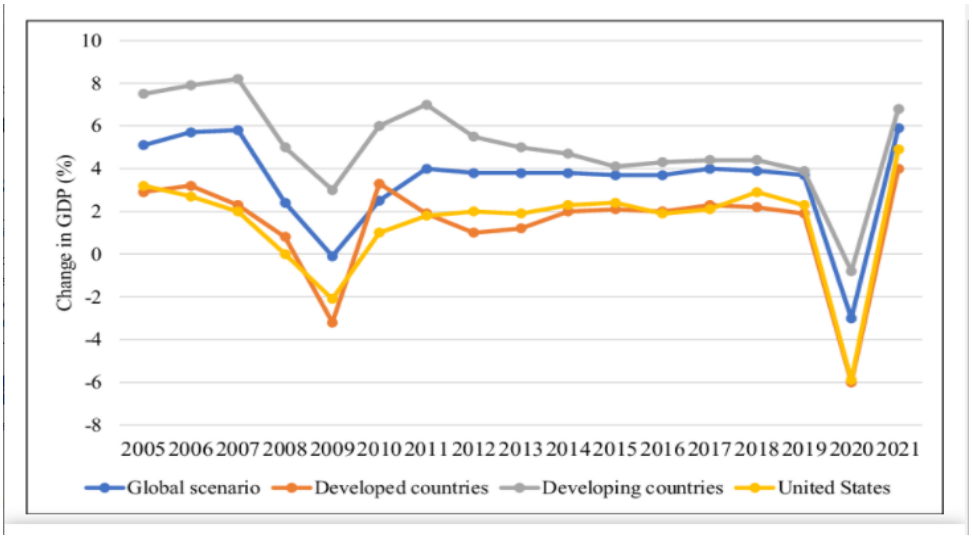

Figure 8: Percent variation in global GDP rate from 2005 to 2021".

2.7 Supply Chain Theory

The Pakistani economy stands to benefit significantly from an improved pharmaceutical supply chain. Enhanced pharmaceutical production and distribution efficiency would lead to better accessibility to medicines and healthcare products, contributing to a healthier population. As a result, government expenditure on healthcare could decrease, reducing financial strain on public resources (Warnecke et al., 2008). Furthermore, a thriving pharmaceutical industry would create a more lucrative investment environment, fostering expansion and job creation. These factors would contribute to sustained economic growth in Pakistan. The pharmaceutical sector's contribution to economic growth is also reflected in broader global trends. Figure 8 illustrates the percent variation in the global GDP rate from 2005 to 2021, highlighting fluctuations influenced by economic conditions, policy decisions, and global crises such as the COVID-19 pandemic. These variations emphasize the importance of resilient industries, including pharmaceuticals, in stabilizing economic performance. As Pakistan strengthens its pharmaceutical sector, it can mitigate external economic shocks and contribute positively to national GDP growth. The supply chain was chosen as the primary focus for this study because its objective is to examine how a global health crisis affects the healthcare industry. The supply chain is one of the most critical tools to import and export pharmaceuticals between countries. Due to the COVID-19 pandemic, many borders were closed, significantly impacting supply chains. Supply chain management involves the coordination of facilities and distribution decisions, carrying out functions such as material procurement, material transformation into intermediate and finished products, and product distribution to consumers (Moosivand et al., 2019). The primary goal of supplier selection is to establish a strong relationship between buyers and suppliers, reduce procurement uncertainties, and enhance the efficiency of a financial system (Kirytopoulos et al., 2008).

There are two types of supply chains: supplier-oriented and customer-oriented. The first category includes all activities related to product creation and the acquisition of components and materials. At the same time, the second is recognized as a marketing channel involving wholesalers, retailers, and customers who ensure the product reaches the end user. The healthcare industry's supply chain has faced unprecedented challenges due to resource shortages, which have been cited as a primary cause of disruptions. As a result, supply chain management in the healthcare sector has encountered significant difficulties, with COVID-19 expected to have lasting effects on its efficiency and reliability. The fundamental goal of developing supply chain management (SCM) is to create solutions for possible technical issues between businesses (Albhirat et al., 2024; Aronsson et al., 2011). In terms of operations,

the healthcare industry is highly interconnected. The primary objective of SCM is to facilitate smooth coordination between multiple firms as they distribute products. This highlights the importance of linkages and interactions in supply chains. However, at times, uncertainty and mistrust can arise, further complicating supply chain operations. Figure 9 illustrates the supply chain management process in the healthcare system, detailing the various stages involved in procurement, manufacturing, distribution, and customer access. An efficient supply chain management system ensures the timely availability of essential medicines and medical equipment, which is crucial for handling health crises like COVID-19. Strengthening this process in Pakistan can enhance the country's ability to respond effectively to future healthcare challenges.

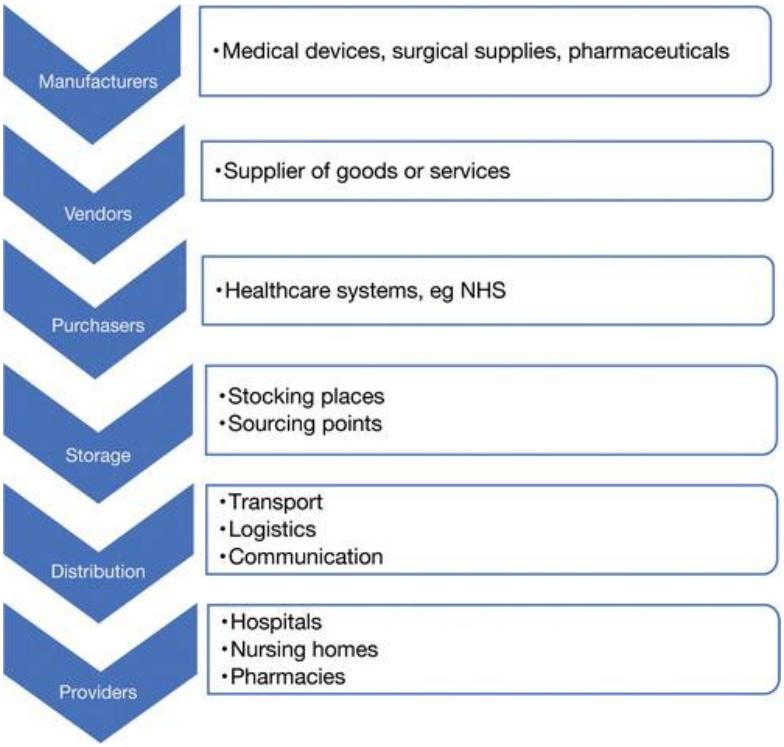

Figure 9: Supply chain management process in healthcare system

2.8 Supply Chain Unpredictability

Supply chain unpredictability can make it extremely difficult to accurately identify and track demand. For example, in the case of government-related supply chains, there is always an element of uncertainty (Matthews et al., 2016). This occurs because medical goods companies sell directly to the country's Ministry of Health, which relies on financial and other government resources for support. Since the Ministry of Health provides a large number of medical stores, this affects the overall medical supply chain (Pankevich et al., 2014). A medical supply chain that is fully controlled by the healthcare industry presents significant challenges in terms of management and oversight. The difficulty in estimating demand can also be attributed to uncertainty in the supply chain of healthcare goods and services. This challenge directly impacts decisions regarding production quantities. Demand forecasting is complex due to unpredictability, making it even harder to meet individual patient needs (Pankevich et al., 2014). These challenges are further exacerbated by financial instability and excessive operational complications. Additionally, inefficiencies in the hospital supply chain contribute to economic burdens, social concerns, and negative environmental impacts.

2.9 Business Network Theory

Establishing strong linkages in a supply chain is fundamentally supported by business network theory. In recent decades, the Business Network Concept has become one of the most influential frameworks for procurement and supply chain management globally. This concept is primarily used to define relationships among organizations, suppliers, clients, and consumers. In this research, business network theory has been applied to analyze the healthcare supply chain. Essentially, the supply chain operates as a business network. It starts with vendors and progresses through the healthcare industry's "internal chain," moving from manufacturers to distributors and hospitals, ultimately reaching the end consumers patients. Vendors, as illustrated in figure 10, form the foundation of the supply chain. Products and medical supplies are delivered to hospital receiving docks, where they are sorted by department. Once received, they are immediately transferred to the relevant departments, typically on a daily basis. After hospitals, pharmacies serve as the final distribution point before medications reach patients. Pharmaceutical companies procure medications from distributors or directly from manufacturers and assume physical custody of the products. To ensure product safety and efficacy, pharmacists must store them properly before dispensing them to consumers (Wang et al., 2020). The healthcare supply chain structure, as depicted in figure 10, illustrates the various stages involved in the procurement and distribution of medical supplies. It highlights the interdependencies between manufacturers, distributors, hospitals, and pharmacies, demonstrating how an efficient network is essential for ensuring timely access to critical medications and healthcare products. Disruptions at any stage can create bottlenecks, delaying patient care and impacting the overall effectiveness of the healthcare system.

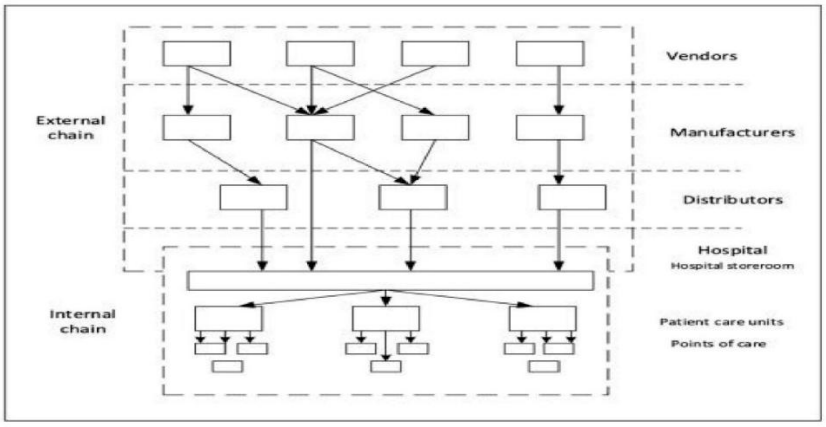

Figure 10: Healthcare supply chain structure

2.10 The Healthcare Supply Chain

The supply chain in the healthcare industry differs significantly from that of other industries. Products are primarily ordered to maximize availability and meet market demands rather than to minimize inventory holding costs. This means that delivery is based on the clinical preferences of healthcare providers and their training. In the business system, the supply chain is also influenced by government policies and the movement of materials between institutions. This flow coordinates raw materials and end-users. The successful operation of such a system necessitates inter-organizational control designed to enhance the overall efficiency of healthcare organizations. To become a regional leader in the pharmaceutical industry, Pakistan's national pharmaceutical sector must enhance its supply chain management performance at an international level. Pakistan has more than 600 pharmaceutical companies in operation, though the exact

number fluctuates over time. Notably, more than half of these companies are government-owned, which plays a significant role in shaping the industry (Usman Awan et al., 2009).

Unlike multinational pharmaceutical giants such as Pfizer, Johnson & Johnson, or GlaxoSmithKline (GSK), Pakistan's pharmaceutical industry operates as an integrated sector composed of various units contributing to drug manufacturing. Within the pharmaceutical supply chain, the primary operational component is the production unit (Khan et al., 2012). Understanding the role of these units within the supply chain structure is essential for evaluating the overall performance of pharmaceutical companies. Efficient integration of the various processes involved in drug synthesis, production, and distribution is crucial for optimizing supply chain management (Shah, 2004). In the pharmaceutical industry, operational units include periodic re-evaluation, implementation, political influence, blending, granulation, homogenization, and compression/injection molding (Wilson et al., 2012). Pakistan's largest pharmaceutical companies are wholly or partially owned affiliates of foreign corporations (Khan et al., 2012). The country's economic and geopolitical instability has significantly impacted the growth and expansion of the pharmaceutical sector. Inflation, fluctuations in foreign exchange rates, and currency devaluation often disrupt supply chain operations, ultimately affecting the profitability of pharmaceutical firms.

Despite its ongoing development, Pakistan's pharmaceutical industry is gradually improving its supply chain efficiency and supplier relationships (Ali & Waqas, 2022). Over the past two decades, the industry's ownership structure has shifted. While foreign corporations initially dominated the market, today, approximately 55% of pharmaceutical businesses are owned and managed by Pakistani enterprises, with the remaining 45% controlled by international firms. Pharmaceutical support industries work indirectly with the pharmaceutical sector by supplying raw materials and components. As Pakistan's pharmaceutical industry expands, new and existing support firms are expected to experience growth, leading to increased job opportunities and higher corporate tax revenue for the government. However, despite progress, several challenges persist. The local pharmaceutical industry can only meet approximately 45% of domestic drug demand, necessitating imports to cover the remaining 55% from countries such as the United States, Germany, and other European nations. The government and local businesses cannot afford the risk of end-product shortages (such as medicines and essential pharmaceuticals). Addressing these supply chain challenges is crucial for ensuring long-term sustainability in Pakistan's pharmaceutical sector.

2.11 Logistic Integration Theory

Logistic management strategies regulate the flow of products, services, and materials between the point of origin and the consumption site to meet customer requirements. As a result, logistics management influences all supply chain activities (Archetti & Speranza, 2014). These interconnected responsibilities must be coordinated to ensure optimal supply chain performance. A well-coordinated flow of materials from suppliers allows enterprises to maintain a seamless production process (Han et al., 2013). A global pandemic is a prime example of how logistics challenges can arise in supply chain management, distribution, and inventory control. The COVID-19 pandemic has highlighted critical routing issues within the supply chain. Logistics is vital in managing staff working hours, enabling them to focus on essential activities. A healthcare organization's performance is closely linked to its logistical capabilities. Technological advancements have enabled hospitals to optimize supply chain flows. To successfully industrialize healthcare, it is crucial to implement flexible and adaptable logistics procedures that adjust to changing market conditions.

Logistical integration approaches healthcare from a fluid architectural standpoint. Most hospitals prefer fluid architecture as it facilitates logistics more effectively (Boccia et al., 2020). Healthcare supply chain management relies on logistics in the same manner as other sectors. To integrate nursing stations into the system, elements such as medications, information, and materials can be grouped. When a patient

contacts a healthcare provider for assistance, an order is placed under their name, ensuring a seamless supply chain process. As shown in Figure 9, a conceptual model is a structured representation that researchers use to describe the natural course of the phenomenon under examination. It explains how the researcher intends to approach their study problem (Legowo et al., 2020). Conceptual models consist of interrelated concepts that illustrate relationships between variables and how the researcher aims to address the research challenge (Amirah et al., 2024; Legowo et al., 2020). The COVID-19 pandemic has caused significant disruptions in the supply chain, as depicted in Figure 9. It has also influenced the three key conceptual variables. In this conceptual framework, there is an underlying connection between the variables. In a causal relationship, one factor directly affects another. Here, COVID-19 has a direct impact on three components: "Shortage in Medical Deliveries," "Supply Chain Uncertainty," and "Freight and Shipping," as indicated by the arrows in Figure 9. Additionally, an indirect effect exists in this scenario. Due to "Supply Chain Uncertainty," COVID-19 indirectly affects business network stability and sales performance. As "Supply Chain Uncertainty" increases, it contributes to "B2B Business Uncertainty," which in turn causes fluctuations in "Revenue Slowdown." Below are some hypotheses for the conclusion of self-regulating variables on needy variables:

H1: Shortages in medical supplies and uncertainty significantly impact COVID-19.

3. Research Methodology

Research methodologies primarily follow either an inductive or deductive approach. The inductive approach, also known as inductive reasoning, focuses on observations and the emergence of concepts towards the conclusion of a study. Unlike deductive reasoning, it is better suited for qualitative research, as it involves identifying observation patterns and developing hypotheses based on those patterns. This method entails subjective reasoning, acknowledging the existence of multiple truths (Martínez Rivas et al., 2017; Rasheed et al., 2025a). In contrast, the deductive approach is typically used in quantitative research, involving data analysis, identifying patterns and relationships, and assessing the impact of independent variables on dependent variables. Deductive reasoning moves from broad generalizations to specific findings, following an objective approach that begins with an existing theory and develops a methodological framework to test hypotheses (Rashid et al., 2021). This study employs a deductive approach as it aligns with the research problem and provides a structured framework for hypothesis testing. Deductive studies begin with a set of hypotheses, followed by applying various research methods to evaluate their validity. This approach is particularly suitable for studies with time constraints, as it allows for a systematic and logical progression from theory to empirical testing. As illustrated in Figure 11, the deductive research process follows a structured path from theoretical framework to hypothesis formulation, data collection, and hypothesis testing. This structured approach ensures methodological rigor, allowing for a clear validation or rejection of the proposed hypotheses.

A descriptive research design will be employed for this study, as it effectively captures the current status of a variable without attempting to alter individuals, conditions, or events (Jais et al., 2024; Mertler, 2016). This approach is appropriate for characterizing people, situations, conditions, or events within the research context. The sampling design consists of non-probability sampling techniques, specifically convenience sampling and snowball sampling, to ensure efficient data collection. Convenience sampling will be used to select initial respondents based on their availability, minimizing time constraints while improving study efficiency (Nazri et al., 2024). The target population includes key stakeholders in Pakistan’s pharmaceutical manufacturing industry, such as supervisors, marketing professionals, pharmaceutical retailers, and licensees, who will provide insights into supply chain management (SCM) through structured questionnaires. The study sample also includes executives from pharmaceutical enterprises, including manufacturers, wholesalers, and retailers, alongside other stakeholders involved in pharmaceutical production and distribution. While additional businesses in Pakistan’s pharmaceutical supply chain, such as automakers, suppliers, and vendors, were considered, their perspectives may not fully

represent the sector but still provide valuable industry insights. The sample size will range between 100 and 150 participants, which is adequate for analysis using SPSS (Rashid et al., 2025a). To ensure relevance, all respondents must be employed in Pakistan's pharmaceutical sector with a minimum of four years of industry experience and at least two years with their current employer. Participants with less than one year of experience may be included based on their educational background. The study will aim for gender balance to minimize external influences unrelated to SCM. All participants will be over 21 years old and employed in various pharmaceutical industry roles. Data collection will be conducted randomly, without considering social status, prestige, or corporate hierarchy, as securing knowledgeable professionals for research participation remains a challenge (Esfahbodi et al., 2016).

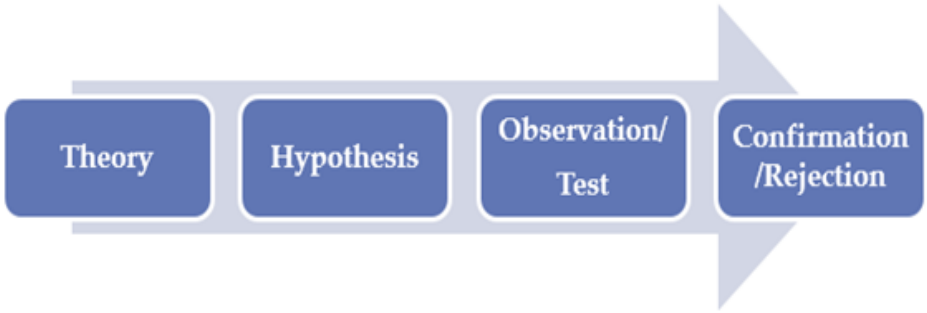

Figure 11: Hypothesis process

3.1 Data Collection Tool

A questionnaire will serve as the primary data collection tool, with participants required to provide informed consent before sharing their personal information and responses. They will be assured of confidentiality, and fictitious names will replace real ones to protect their identities. Data analysis will be conducted using IBM SPSS software, employing statistical techniques such as regression analysis, correlation analysis, factor analysis, T-tests, and ANOVA. Given the potential for Common Method Bias (CMB) due to high correlations among research variables (Ngah et al., 2024a; Podsakoff et al., 2003), a Confirmatory Factor Analysis (CFA) will be performed to assess its presence (Lance et al., 2010). Additionally, multi-collinearity analysis will determine whether independent variables exhibit significant correlations, as multicollinearity can impact result significance and will be carefully examined (Rashid et al., 2025b). Ethical considerations will be strictly observed throughout data collection. Participants' anonymity will be maintained by ensuring their real names are neither disclosed in the research report nor shared with the research team, instead using fictitious names or identification codes. They will be fully informed about the research process, including the nature of the interview and the types of questions they will be asked, and their prior consent will be obtained for both audio and written recordings. Participation in the study will be entirely voluntary, with the right to withdraw without future consequences. The research will uphold the principle of non-maleficence, ensuring no physical or psychological harm to participants. Moreover, data confidentiality will be a priority, with all responses remaining strictly confidential and any sensitive information excluded from analysis and reporting.

4. Results & Findings

4.1 Descriptive Profile of the Data

Numerous researchers have analyzed the descriptive profile of data in this stage. First, the participants' profiles are assessed. Masculine respondents comprise 64.2 percent of the overall, while feminine respondents comprise 35.8%. 7.3 percent of the contestants are within the weeks of 18 and 25,

29.8 percent are within the days of 26 and 35, 32.5 percent are within the ages of 36 and 45, and 30.5 percent are within the ages of 46 and 60. Only 1.3 percent of the respondents have a PhD, while 37.1 percent have a master's degree, 56.3 percent have a bachelor's degree, and 5.3 percent have an intermediate qualification. Respondents' professional experience is divided into four categories: 6.6 per hundred have a lesser amount of than one year of working skill, 19.9 percent have one to three years of work experience, 24.4 percent have three to five years of work skill, and 31.1 in each hundred have more than 5 years of labor experience as you can see in table 1, 2, 3 and 4.

Table 1: Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	97	64.2	64.2	64.2
	Female	54	35.8	35.8	100.0
	Total	151	100.0	100.0	

Source*: SPSS output*

Table 2: Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Intermediate	8	5.3	5.3	5.3
	Graduate	85	56.3	56.3	61.6
	Masters	56	37.1	37.1	98.7
	Phd	2	1.3	1.3	100.0
	Total	151	100.0	100.0	

Source*: SPSS output*

Table 3: Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-25	11	7.3	7.3	7.3
	26-35	45	29.8	29.8	37.1
	36-45	49	32.5	32.5	69.5
	46-60	46	30.5	30.5	100.0
	Total	151	100.0	100.0	

Source*: SPSS output*

Table 4: Work Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 1 years	10	6.6	6.6	6.6
	1-3 years	30	19.9	19.9	26.5
	3-5 years	64	42.4	42.4	68.9
	Greater than 5 years	47	31.1	31.1	100.0
	Total	151	100.0	100.0	

Source*: SPSS output*

4.2 Validation of Model

Each variable was subjected to reliability testing to ensure that the model was consistent. Cronbach's alpha cost ought to be better than 0.7, based on the most recent (Rashid et al., 2025c), indicating model reliability.

4.2.1 Reliability analysis

Table 5: Reliability Statistics

Cronbach's Alpha	N of Items
.774	6

Source*: SPSS output*

Cronbach's alpha value is .774, which is higher than 0.7, as shown in table 5. Each item of the independent variable, COVID 19 are reliable to each items (Ngah et al., 2024b).

Table 6: Reliability Statistics

Cronbach's Alpha	N of Items
.915	12

Source*: SPSS output*

Cronbach's alpha value is 0.915, which is higher than 0.7, as shown in table 6. Each item of the dependent variable. Shortage in medical supplies and uncertainty are reliable to each items (Rahi et al., 2024).

4.3 Hypothesis Testing

Hypotheses were examined using SPSS software and the linear regression test.

4.3.1 R, R – square and adjusted R – square

The R cost of.793 in Table 7 below indicates that the dependent and independent variables have a strong association. R-square measures the precision of regression, and its value indicates that independent variables account for 0.628 % of the change in the reliance on variable (Rashid et al., 2025d; Rasheed et al., 2025b). The adjusted R square indicates the regression's unbiased accuracy. We got 0.626 percent unbiased regression accuracy here.

Table 7: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.793[a]	.628	.626	.44789	.628	251.972	1	149	.000	1.971

a. Predictors: (Constant), COVID.19

b. Dependent Variable: SH.IN.MED.SUP

Source*: SPSS output*

Table 8: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	50.546	1	50.546	251.972	.000[b]
	Residual	29.890	149	.201		
	Total	80.436	150			

a. Dependent Variable: SH.IN.MED.SUP

b. Predictors: (Constant), COVID.19

Source*: SPSS output*

As you can see in Table 8, the sig value is less than 0.05, the significance level is 0.00. (Tunio et al., 2024), the independent factor of COVID 19 is significant to the dependent variable of shortage in medical supplies.

Table 9: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			"Zero-order	"Partial	"Part	"Tolerance	"VIF
1	(Constant)	1.178	.171		6.873	.000					
	COVID.19	.743	.047	.793	15.874	.000	.793	.793	.793	1.000	1.000

a. Dependent Variable: SH.IN.MED.SUP

Source*: SPSS output*

Based on the sig values in Table 9, it has been determined that all of the variables are significant. On the other hand, dependent variables get an influence on the dependent variable. The sig values are all less than 0.05. The VIF value of co-linearity demonstrates that independent variables have a value less than 10, suggesting that there is no multi collinearity, that the model's effects are purity, and that one's influence is unaffected by the effects of other independent variables.

4.3.2 Regression equation

A regression equation has been created from the data in the table above, which is shown below.

Shortage in medical supplies and uncertainty = 1.178 + 0.743 COVID 19

4.3.3 Summary of hypothesis testing

The accepted or rejected hypotheses will be highlighted in Table 10 below.

Table 10: Summary of Hypothesis

Hypotheses	Result
H1: Shortage in medical supplies has a substantial impact on COVID 19.	Accepted

Source*: SPSS output*

5. Conclusion, Discussion, Implications, Limitations and Recommendations

5.1 Conclusion

This study aimed to assess the extent to which the COVID-19 pandemic has impacted Pakistan's healthcare supply chain. Natural disasters, such as the COVID-19 outbreak, have been found to influence the healthcare supply chain significantly. Managing the healthcare supply chain is one of the most complex tasks, as precision is essential; a single error could lead to fatal consequences. In recent months, global attention has been intensely focused on containing the spread of the novel coronavirus. The statistical analysis indicates that the COVID-19 outbreak has significantly impacted the healthcare supply chain. The surge in demand has resulted in shortages of medical supplies, leading to market instability. The uncertain duration of the pandemic further exacerbates this instability. Additionally, a decline in medical product sales has been observed as another consequence of the crisis. Pakistan's medical supply chain has undergone considerable transformations, and government measures to contain the virus have also adversely affected the quality of patient care.

5.2 Discussion

During the lockdown period of the ongoing pandemic, this study examined the impact of COVID-19 on Pakistan's pharmaceutical procurement and supply chain from the perspective of pharmacy employees in both the public and private sectors. Supply chain disruptions were not only observed in the pharmaceutical industry but also across various other sectors before and during the COVID-19 outbreak. These disruptions have severely affected people's daily lives, impacting professionals and consumers alike. The sudden emergence of the pandemic and the subsequent enforcement of lockdowns demonstrated the urgency of halting the spread of the virus. However, the lack of specific logistical measures to mitigate the lockdown's impact led to widespread uncertainty and hardship for the majority of the population. This study highlights the critical role of government intervention in establishing a resilient supply chain system, particularly during crises such as the COVID-19 pandemic. Effective strategies must be developed to attract both local and foreign investments in the pharmaceutical sector, ensuring the availability of essential medicines and healthcare products, including personal protective equipment (PPE). Government commitment and strong leadership are necessary to create favorable conditions for public-private

partnerships (PPPs) in various pharmaceutical and supply chain sectors. Multispectral collaboration between the government, public agencies, and non-governmental organizations is essential to implement sustainable solutions in a sector where minor disruptions can lead to significant economic and human losses due to the distribution of substandard medical products and services. The COVID-19 crisis has forced pharmaceutical companies to temporarily halt production as they seek long-term solutions to maintain uninterrupted supply chain operations. To prevent future pandemics like COVID-19 from disrupting supply chain management, pharmaceutical supply networks must be strengthened in manufacturing, customer demand management, and transportation logistics. Despite its pharmaceutical capabilities, Pakistan has never faced a pandemic of this scale, highlighting the urgent need for more resilient supply chain strategies.

5.3 Implications, Limitations, and Recommendations

This research examines the challenges faced by the healthcare industry during and after the COVID-19 pandemic. One of the key insights gained is the profound effect of a pandemic on the supply chain and industrial systems. COVID-19 is undeniably a crisis requiring innovative and proactive responses from Pakistan's healthcare system stakeholders, including the government, industry, and individuals. Only through collective action can effective solutions be devised to address this challenge.

Like all research studies, this study has several limitations. Firstly, it was conducted within a limited timeframe, restricting the depth of analysis. Secondly, the study had limited participants due to its one-on-one research approach. Thirdly, although the study was conducted in various cities across Pakistan, its scope was not exhaustive. Lastly, the research primarily focused on Pakistan's healthcare industry, limiting its applicability to other sectors.

Future research should explore the impact of COVID-19 and previous pandemics in greater depth, particularly their effects on medical logistics. As more information becomes available about this unprecedented crisis, further studies can build on the findings presented in this paper. Future research could also focus on post-pandemic developments to understand how supply chain dynamics evolve once the immediate health crisis subsides.

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