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How the COVID-19 pandemic revealed vulnerabilities in global healthcare logistics, and what lessons can be derived from the diverse responses of countries to avoid shortages of critical medicines and equipment in global health crises?

Graduation thesis for a double degree program

Natalia Ximena Franco Reina

Bogota, Colombia

2024

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Natalia Ximena Franco Reina

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Glossary

Global healthcare logistics: The organization and management of medical resources and equipment at an international level to respond to health emergencies.

Supply chain: The network of processes and actors that ensure the production, transport, and distribution of essential goods.

Supply chain resilience: The ability of the supply network to adapt and continue functioning in the face of severe disruptions.

Personal protective equipment (PPE): Items such as N95 masks, gloves, and gowns used by healthcare workers to protect against infections.

Strategic stockpiles: Pre-established reserves of critical supplies to guarantee availability during emergencies.

Public health emergency preparedness: The set of plans and measures designed to respond quickly and reduce the impact of health crises.

Glosario

Logística sanitaria global: Organización y gestión de los recursos médicos y equipos a nivel internacional para responder a emergencias de salud.

Cadena de suministro: Red de procesos y actores que aseguran la producción, transporte y distribución de bienes esenciales.

Resiliencia de la cadena de suministro: Capacidad de la red logística para adaptarse y seguir funcionando frente a interrupciones graves.

Equipos de protección personal (EPP / PPE): Elementos como mascarillas N95, guantes, y batas usados por personal de salud para protegerse de contagios.

Reservas estratégicas: Acopio previo de insumos críticos para garantizar disponibilidad durante emergencias.

Preparación ante emergencias de salud pública: Conjunto de medidas y planes para responder rápidamente y mitigar el impacto de crisis sanitarias.

Resumen

Propósito: Analizar las diversas respuestas de los países frente a la escasez de medicamentos críticos y equipos de protección personal durante la pandemia de COVID-19, con el fin de identificar las mejores estrategias para fortalecer y preparar la logística sanitaria global ante emergencias de este tipo y así controlar y evitar futuras pandemias.

Contexto: La pandemia de COVID-19 reveló vulnerabilidades significativas en la logística sanitaria mundial y en la gestión de la cadena de suministro de insumos médicos esenciales. Este estudio busca realizar un análisis comparativo de las distintas estrategias implementadas por países con economías, infraestructuras sanitarias y sistemas políticos similares, con el fin de extraer recomendaciones para los responsables de políticas públicas a partir de los aciertos y fallos encontrados.

Metodología/enfoque: Este trabajo sigue una revisión sistemática de la literatura que incluye artículos y estudios de caso de cinco países: Estados Unidos, Corea del Sur, Nueva Zelanda e Italia. Estos fueron seleccionados por su paridad económica y por la diversidad en sus respuestas frente a la crisis sanitaria. El análisis es de carácter cualitativo, guiado por marcos teóricos de resiliencia de la cadena de suministro y preparación ante emergencias de salud pública, para

evaluar de manera integral el enfoque de cada país.

Hallazgos: La investigación reveló que, a pesar de ser economías desarrolladas, algunos países enfrentaron importantes dificultades debido a factores como sistemas de salud fragmentados, respuestas tardías y una excesiva dependencia de cadenas de suministro globales. En cambio, los países con logística sanitaria sólida, reservas estratégicas y coordinación nacional efectiva gestionaron la crisis con mayor eficacia. Las principales lecciones aprendidas incluyen la necesidad de diversificar las cadenas de suministro, contar con capacidades de respuesta rápida y garantizar una comunicación pública transparente.

Implicaciones de investigación/limitaciones: El enfoque en países de altos ingresos puede dejar de lado los desafíos de las naciones de ingresos bajos y medios. Además, la investigación está limitada por la falta de homogeneidad en los estándares de reporte de datos entre países, lo que puede afectar la aplicabilidad de los resultados. Futuras investigaciones deberían ampliar el alcance geográfico e incorporar análisis cuantitativos.

Implicaciones prácticas: El estudio ofrece recomendaciones para que los gobiernos y responsables de políticas públicas fortalezcan la resiliencia de la logística sanitaria global. Entre las medidas propuestas destacan el establecimiento de reservas estratégicas de insumos esenciales, la mejora de los mecanismos de coordinación nacional e internacional, y la inversión en infraestructura de pruebas y rastreo de contactos.

Palabras clave: COVID-19, SARS-CoV-2, Logística sanitaria global, Escasez de medicamentos y equipos, Insumos médicos críticos, Respuesta sanitaria en crisis, Equipos de protección personal, N95, Guantes, EPP, Resiliencia de la cadena de suministro, Preparación ante pandemias.

Abstract

Purpose: Analyze the diverse responses of countries to the shortages of critical medicines and personal protective equipment during the COVID-19 pandemic in order to identify the best strategies to strengthen and prepare the global healthcare logistics response to emergencies of such type to control and avoid future global pandemics.

Context: The COVID-19 pandemic revealed significant vulnerabilities in global healthcare logistics and supply chain management of critical medical supplies. This study aims to carry out a comparative analysis of the varied strategies that countries with similar economic statuses, healthcare infrastructures, and political systems implemented to address these challenges and propose recommendations to policymakers from the successes and failures found across different countries.

Methodology/approach: This paper will follow a systematic literature review approach involving articles and case studies of five countries: The United States of America, South Korea, New Zealand, and Italy. These countries were chosen due to their economic parity and varied responses to managing the healthcare crisis. The analysis was entirely qualitative, guided by theoretical frameworks of supply chain resilience and public health emergency preparedness, to comprehensively evaluate each country's approach**.**

Findings: The research revealed that despite having developed economies, some nations experienced significant challenges due to factors such as fragmented healthcare systems, delayed

responses, and over-reliance on global supply chains. Meanwhile, countries with pre-existing robust healthcare logistics, strategic stockpiling, and effective national coordination handled the crisis more effectively. The key lessons learned from the varied responses include the need for diversified supply chains, the importance of rapid response capabilities, and the critical role of transparent public communication.

Research implications/limitations: The focus on high-income countries may overlook the challenges faced by low and middle-income nations. Additionally, the study is limited by inconsistencies in data reporting standards across countries, which may affect the applicability of the results. Future research should focus on expanding the geographical scope and include quantitative analyses.

Practical implications: The study offers recommendations for policymakers and governments to enhance global healthcare logistics resilience. These insights to mitigate the impact of future global health crises include establishing strategic reserves of essential supplies, improving national and global coordination mechanisms, and investing in testing and contact tracing infrastructure.

Keywords: COVID-19, SARS-CoV-2, Global healthcare logistics, Medicine and equipment shortages, Critical healthcare supplies, Crisis response in healthcare, Personal protective equipment, N95, Gloves, PPE, Supply chain resilience, Pandemic preparedness.

1. Introduction

The global outbreak of COVID-19 struck the world unexpectedly and rapidly, unfolding with a devastating economic and social impact. From the first reported case back in 2019 in Wuhan, China, the virus' rapid spread led to a nearly universal challenge as most, or possibly all, countries across the globe faced severe issues of healthcare resource availability. Critical medicines and essential medical equipment were dangerously scarce, proving the unpreparedness of healthcare logistics systems to deal with such crises and raising the question of whether more lives could have been saved if there had been a well-established logistics system in place.

The World Health Organization's data (2023) reveals that over 6.8 million reported deaths worldwide resulted from the COVID-19 pandemic in 2020. The crisis exposed the flaws and weaknesses in healthcare systems worldwide, even in countries known for their strong infrastructures and being considered as "developed." Severe shortages of critical medicines, essential medical devices, and personal protective equipment such as gloves, medical face masks and face shields, aprons, goggles, and respirators, among others, left frontline healthcare workers dangerously under-equipped to provide adequate care for COVID-19 patients (Bhaskar et al., 2020). The lack of preparedness and response in anticipating, preventing, detecting, managing, and controlling the COVID-19 outbreak may have contributed to an increase in deaths that could have been prevented.

Given the profound impact of the COVID-19 pandemic on global health, it is crucial to study and analyze the response of various countries to the pandemic. A comprehensive analysis from diverse literature reviews and case studies will provide a better understanding of how different countries navigated the crisis and will allow the investigation to recognize the specific gaps in healthcare logistics that precipitated these challenges. By identifying best practices, strategies, and solutions to fortify global healthcare systems against future pandemics, governments of the world can better prepare to respond to similar crises and protect the health and well-being of all.

As the famous British statesman Winston Churchill once wrote: “Those that fail to learn from history are doomed to repeat it." This study is important so that we can analyze and reflect on our past actions, strategies, challenges, and successes to build better future strategies. Millions of lives were lost back in 2020, and to prevent that from happening ever again, it's necessary to carry out a proper investigation to identify the vulnerabilities and defects of global healthcare logistics and learn from our failures to help countries be better prepared to face global crises such as the COVID-19 pandemic.

Studying various countries and their varied responses to the crisis will help us get a broader understanding of what worked and what didn’t work while also providing an overview of the differential gap between developing and developed countries. The purpose of this study is to analyze diverse responses of countries to the shortages of critical medicines and equipment during the pandemic in order to identify the best strategies to strengthen and prepare the healthcare response to emergencies of such type to control and avoid future global pandemics.

1.1 Importance Of This Study

The pandemic exposed significant weaknesses in health logistics worldwide, revealing the challenges that different countries of the world faced to ensure the supply of essential medicines and equipment. As the pandemic unfolded, it became evident that there was a lack of preparedness at a global level and that no country had the necessary organization or logistics to handle a situation of such magnitude, leading to disruptions in the supply chain of different countries.

This paper aims to explore the multiple ways in which the pandemic exposed the weaknesses of global health logistics, emphasizing the importance of adaptability and rapid action when faced with emergencies like COVID-19. By exploring and analyzing the diverse actions and responses of countries across the globe, we aim to provide valuable insights that can help

understand how health logistics systems can be adapted and improved to prevent shortages in the face of possible future critical situations. This research is intended to contribute ideas and explore international strategic planning to improve and fortify the preparedness of health logistics systems for future global health emergencies.

This study is also linked to Corporate Social Responsibility (CSR), as its objective is to identify best practices, strategies, and solutions to avoid shortages of essential medicines and medical equipment during global health crises, aligned with the United Nations' 17 Sustainable Development Goals (SDGs), precisely the third goal, which emphasizes on "Ensuring healthy lives and promote well/being for all at all ages." By evaluating the inefficiencies in healthcare logistics during the COVID-19 pandemic and studying how different countries managed the crisis, the study highlights the significance of learning from diverse approaches to fortify global healthcare systems against future pandemics and promote the well-being of all.

Moreover, the study is also aligned with the SDG 17, which emphasizes "Strengthening the means of implementation and revitalizing the global partnership for sustainable development" (2024). This research aims to highlight the importance of international collaboration and coordination to support the development of a more unified global response to health crises. Enhancing global health security by ensuring the continuity of medical supply chains and thus minimizing the economic impact of health crises. This contributes to building a stronger, more resilient global healthcare logistics system that safeguards public health in all countries, regardless of their individual capacities.

2. Literature Review

Over the past two decades, the healthcare supply chain management trend prioritized keeping supply inventories low to support a just-in-time (JIT) methodology, however shortly after the Pandemic started, hospitals from all over the world suddenly found themselves running out of

critical supplies (Nadeau, K. L., 2023), which instantly resulted in hospitals demanding these supplies from others. Since most hospitals were going through the same situation, it led to the global crisis in which hospitals were relying too much on others to be able to keep running and trying to respond to the excess demand.

Cohen and van der Meulen Rodgers (2020) emphasized that supply shortages were the most visible impact of the pandemic on healthcare supply chain management, with healthcare organizations struggling to find personal protective equipment (PPE), especially gloves, medical masks, goggles or face shields, gowns, and N95 respirators. Furthermore, "providing solutions for the shortages in the supply chain for one-time-use PPE is extremely complex." (Rowan & Laffey, 2020)

The shortage of PPE endangered health workers worldwide, not only leaving them vulnerable to infection and increasing the risk of transmission, further exacerbating the health crisis, but some studies exploring the implications of PPE shortage suggest that healthcare workers faced increased stress and anxiety that even lead to decreased quality of patient care due to the fear and uncertainty engendered by the shortages (Ranney et al., 2020)

The World Health Organization (WHO) confirms that COVID-19 deaths were a key indicator for tracking and understanding the evolution of the pandemic. However, due to the logistics and record-keeping systems, it was complicated to record these deaths; several countries used different tests but that made comparisons difficult. For this reason, a key factor and methodology used by most countries was to use excess mortality as a more accurate measurement because excess mortality is defined as the difference in the total number of deaths in the situation vs deaths of non-COVID-19 conditions (Mathieu et al., 2020). Therefore, it's essential to take into account both indicators for this investigation to carry out a more reliable and detailed analysis regarding the evolution and impact of the pandemic (2023).

One of the main issues of the pandemic was the shortage of the necessary products to assist the population. Supply chains were not secure, nor were the preparedness or responsiveness of

different countries to address the situation, and in the midst of the crisis, absurd amounts of basic supplies needed to confront the illness were unavailable. With this in mind, one of WHO's solutions was to work alongside various countries to encourage an increase in production, such as easing export restrictions, facilitating product distribution, and providing support and guidance to supply chains, especially in the most critical countries (Herrera, 2023).

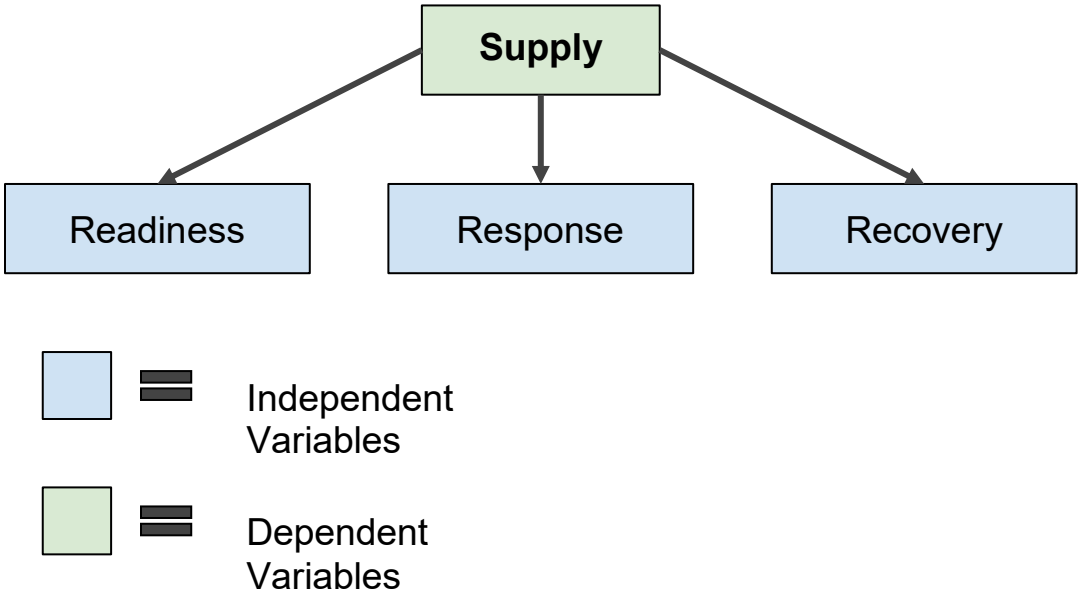
Nevertheless, in countries like Italy, healthcare workers experienced high rates of infection and death partly because of inadequate access to PPE. In which frontline clinicians were faced with making difficult decisions about who will and who won't receive care (Balmer et al., 2020). Furthermore, the lack of access to PPE not only contributed to the horrific impacts of the COVID-19 pandemic but due to the value and importance of allocating the resources adequately; doctors were forced to face big ethical dilemmas to choose the most "appropriate" patients to receive the care needed from specific machines or materials needed. Nevertheless, while Italy was "the worst affected country in the world outside of China" (Balmer et al., 2020), it was far from being the only country in which healthcare workers were faced with such ethical decisions.

2.1 Theoretical Frameworks In Healthcare Logistics

There are several theoretical frameworks to study healthcare logistics in the context of pandemics. For starters, the Supply Chain Resilience Theory (SCRES), first introduced by Christopher and Peck (2004) which emphasizes the ability of supply chains to anticipate, prepare, respond and recover in response to changing environments. This framework highlights the importance of building resilient supply chains that can withstand disruptions of global health crises, like the one caused by the COVID-19 pandemic. This theory has been key in analyzing how healthcare systems managed a sharp spike in demand for medical equipment & supplies (Ivanov & Dolgui, 2020).

Figure 1.

Supply Chain Resilience Model



Note. Source created independently. Adapted from *Theory of Supply Chain Resilience*. Christopher, M. and Peck, H. (2004) Building the Resilient Supply Chain. The International Journal of Logistics Management, 15, 1-14. (https://doi.org/10.1108/09574090410700275). In the public domain

Christopher and Peck's (2004) Supply Chain Resilience model outlines the essential phases for building and maintaining a resilient supply chain. The model is structured around three main phases: readiness, response, and recovery. These three phases are represented in *Figure 1* as the blue boxes, which act as independent variables, that directly affect the dependent variable, which is the Supply Chain Resilience and is represented as the green box in *Figure 1*.

This model is important because it analyzes the key elements that contribute to the success of building supply chain resilience. The model will be adapted specifically to understand the context of global healthcare logistics during the COVID-19 pandemic, which will reveal the extent at which each of the countries mentioned failed to build an adequate supply chain resilience, hence contributing to the shortage of equipment and medicines during this time.

The first phase of the model is referred to as the *Readiness phase.* This phase focuses on the previous preparation to an anomaly in the supply chain, as the main idea is to prepare the supply chain to be able to anticipate and mitigate any potential risks or disruptions before they occur. To do so, it mentioned three key elements that need to be prepared.

The first is a key assessment where a thorough analysis has to be done to be able to identify any potential risks and vulnerabilities within the supply chain. The second element is the adequate resources allocation. It's extremely important that all key resources are available even during emergencies, this is why it's essential to have a good inventory, a list of backup suppliers, emergency funds, etc. Finally, the last element refers to: visibility and redundancy. Visibility refers to the ability to understand the whole supply chain, every connection, every node and link. As stated by Cristopher (2004) there is frequently only a limited exchange of information between adjacent entities in a network" which creates a large threat as it reduces the opportunity of collaboration and understanding between all parties to identify potential risks and vulnerabilities early. Additionally, redundancy involves having surplus capacity and inventory in case of a disruption. According to Cristopher (2004) "Conventionally surplus capacity and inventory have been seen only as "waste" and are therefore undesirable," however, creating an effective strategy of additional capacity and/or inventory can be extremely beneficial in the creation of resilience within the supply chain. (Christopher, 2004)

The next phase is the *Response phase*, which focuses on the reaction and immediate actions taken during an emergency/disruption. The immediate goal of this phase is to minimize the impact of the disruption and quickly stabilize the supply chain to continue normal action as soon as possible. (Christopher, 2004). This phase also consists of three key elements.

The first key element is the flexibility and adaptability in a supply chain. This refers to the ability to adjust key operations quickly according to changing conditions or unexpected disruptions to maintain continuity of operations. This may include flexibility in logistic channels (multiple

transportation options or suppliers/partners), production (adjust schedules), and inventory (buffer stocks or have the capacity to increase inventory levels immediately when needed).

The second key element of the response phase according to Christopher (2004) is the *Communication and Coordination.* Although they have been mentioned in further detail in the response phase, communication and coordination are also clearly present in the readiness phase as it will lay the groundwork to an effective response further on. As stated by Christoper (2004) "traditionally supply chains have been characterized by arms-length, even adversarial, relationships between players." Therefore, it's a challenge to create effective collaborative working but the main idea is to be able to exchange information among stakeholders across the supply chain to ensure that everyone is aware of potential risks, of previously established plans, and most importantly of procedures during disruptions. In return, there will be a high level of "supply chain intelligence" that will know how to act and respond to emergencies. (Christoper, 2004; Khan et al., 2018).

The last key element of the response phase is the *agility*, which is how quickly the supply chain processes are reconfigured to maintain continuity once there is a disruption. Supply chain agility can be defined as "the ability to respond rapidly to unpredictable changes in demand or supply" (Christopher, 2004). During this phase, agility is key as it involves reconfiguring resources, adjusting production schedules, switching between different suppliers or logistic channels if necessary. (Benjamin et al., 2015)

The final phase of the model is the *Recovery phase*, where the primary focus is on restoring the supply chain to its original state or if possible to improve it after the disruption has occurred. To build a good recovery, there are three key elements that are needed: contingency planning, knowledge management, and adaptability and growth.

A contingency planning involves developing detailed plans and procedures to be executed in the event of a disruption, as it will serve as a clear guide to help the supply chain recover quickly and effectively. Therefore, it's necessary to have pre-defined strategies and resources in place to

manage the recovery process and restore normal operations. To create a good contingency planning, it's necessary to identify critical processes (Benjamin et al., 2015), ensure good resource allocation (Benjamin et al., 2015), establish a good communication and coordination across the whole supply chain (Khan et al., 2018), conduct regular training sessions and exercises to ensure familiarity across all stakeholders (Khan et al., 2018), and finally, a continuous review and update contingency plans to ensure that they remain relevant and effective (Benjamin et al., 2015; Cristopher, 2004).

The second key element of the recovery phase is the knowledge management, which makes reference to a continuous learning from disruption and development of better plans and solutions for the future. Knowledge management in the recovery phase is the whole process of capturing, organizing, and utilizing knowledge gained from the disruption experienced to improve future preparedness and response. Hence, it directly relates to the contingency plan and the overall future resilience of the supply chain. (Ke, Y et al., 2023)

The final key elements of the recovery phase are adaptability and growth, which understands that a disruption is an opportunity to improve the supply chain performance and drive growth. When knowledge management and adaptability are integrated, there is a powerful synergy that enhances a greater resilience in the supply chain. (Karl, et al., 2018). On the one hand, knowledge management ensures that there are lessons learned from the disruptions, while adaptability and growth enables the supply chain to apply these lessons to improve its performance and resilience over time (Ke, Y et al., 2023). In other words, adaptability and growth refers to the practical side of applying directly lessons learned across all supply chain processes.

Therefore, based on the article "Building the Resilient Supply Chain" by Christopher Martin in 2004, the model above was proposed in order to understand the elements that impact directly the resilience of the supply chain and to be able to understand the performance of different countries across the three phases during the COVID-19 pandemic.

Also, the Public Health Emergency preparedness (PHEP) framework model introduced by Landesmand (2005), outlines logistic and supply chain strategies to effectively respond to a pandemic. In his model, Landesmand includes components such as stockpiling essential supplies, ensuring a robust force of transportation and distribution networks and most importantly, maintaining clear and efficient communication and coordination across the government and healthcare providers (Nelson et al., 2007).

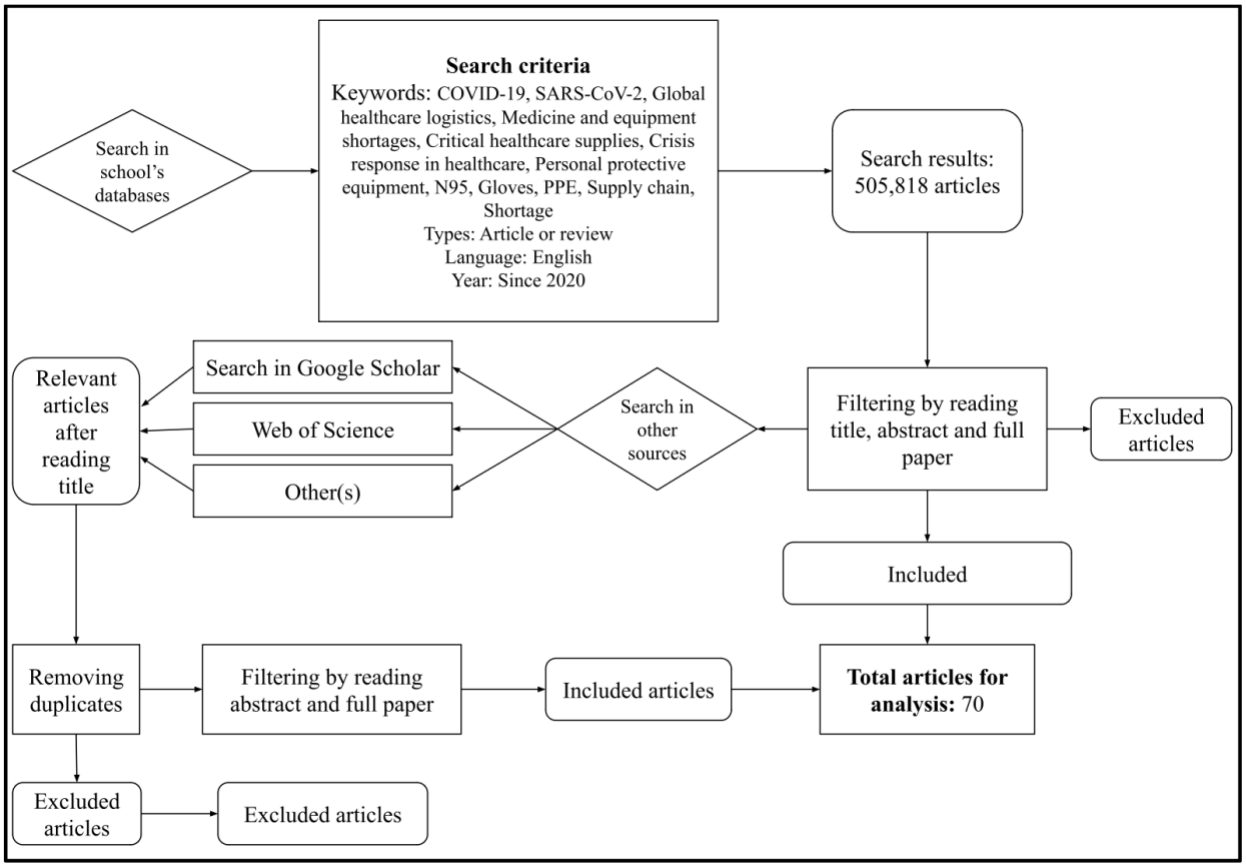
3. Methodology

3.1 Methodology proposed

In order to provide a comprehensive and in-depth understanding of the vulnerabilities in global healthcare logistics revealed by the COVID-19 pandemic and to derive lessons for future crisis preparedness and response, this paper will follow a systematic literature review (SLR) approach as illustrated in *Figure 2*. The methodology for this study consists of researching relevant articles from multiple research bases like Rennes School of Business Learning Center, Google Scholar, and the Learning and Research Resource Center from Universidad del Rosario which provides access to databases such as Scopus and the Web of Science among others that contain important and relevant academic literature. Different types of articles will be considered, ranging from research articles, review articles, and discussion papers to mention a few.

Figure 2.

Search methodology for finalizing the articles for analysis



Note. Source created independently. Adapted from *COVID-19 pandemic related supply chain studies: A systematic review*. Chowdhury, P., Paul, S. K., Kaisar, S., & Moktadir, M. A. (2021). (https://doi.org/10.1016/j.tre.2021.102271). In the public domain.

The methodology for this study will be predominantly qualitative given the challenges in gathering quantitative data like the availability and distribution of critical medicine and equipment during the pandemic, stock levels, distribution timelines, and shortage durations for different countries; as well as a lack of access to official reports, government documents, and healthcare records to supplement the collected data. Moreover, as mentioned before, most countries used different data recording methods making comparisons difficult.

Therefore, the proposed methodology for this study will be conducting a thorough literature review and case studies to evaluate the impact of the COVID-19 pandemic on global healthcare systems and the responses of various countries. To achieve this, this study will be divided into six phases:

I. Literature review

The most important aspect of this study is to identify and evaluate relevant literature on how COVID-19 revealed vulnerabilities in global healthcare logistics in order to derive lessons and suggestions from the diverse responses of countries to avoid shortages of critical medicines and equipment in global health crises.

This will be achieved by selecting a diverse range of studies/case studies that evaluate countries with notable successes or failures in managing healthcare logistics and their varying responses to the pandemic while considering factors like economic status, healthcare infrastructure, and geographic location.

II. Comparative analysis

This phase will focus on 5 specific countries: The United States of America, South Korea, China, New Zealand and Italy. These countries were chosen due to the differences in location, economic status, strategies, and available research information during the COVID-19 pandemic and their take on healthcare resource availability.

Conducting a comparative analysis will bring to light the differences between high-income nations with ‘well-developed’ healthcare systems, while also providing evidence of the success and/or failure of the different strategies used by each. This will allow us to understand which strategies may have been appropriate if carried out in a better way, and also which strategies should be completely removed for future reference.

III. Lesson extraction: vulnerability assessment and recommendations for policymakers

The next phase will identify specific points of failure and vulnerabilities in global healthcare logistics that were revealed by the pandemic. This identification of vulnerabilities will then allow the investigation to recognize the most relevant clusters, in order to group and categorize them into border themes such as supply chain disruptions, coordination challenges, and resource allocation. Once we understand the main vulnerability categories, we can evaluate the effectiveness of existing contingency plans and emergency response strategies in mitigating these vulnerabilities and focus specifically on these issues.

In this phase, findings will be synthesized to draw out the lessons and best practices by focusing on the strategies that showed promise in enhancing the resilience of healthcare supply chains that can be applied to strengthen global healthcare logistics in the future.

Afterward, recommendations for policymakers on preparing for and managing future health crises will be proposed. These recommendations will consist of suggesting frameworks for enhancing collaboration, transparency, and efficiency in global healthcare logistics, possibly presenting new approaches to sourcing, inventory management, analytics, and technology.

IV. Conclusion

The conclusion will consist of summarizing key vulnerabilities, lessons learned, and actionable strategies to enhance global healthcare logistics resilience in the face of future pandemics or crises.

V. Suggestions for future research

Lastly, in this phase, we will identify areas for future research and highlight research gaps that were uncovered during the study.

4. Comparative Analysis

To answer the question*, How the COVID-19 pandemic revealed vulnerabilities in global healthcare logistics, and what lessons can be derived from the diverse responses of countries to avoid shortages of critical medicines and equipment in global health crises?* Five countries with similar economic status, well-established healthcare systems, significant global influence and high levels of development were chosen. The United States of America, South Korea, China, New Zealand and Italy make this comparative analysis less broad as assessing how high income nations with well-developed healthcare systems and substantial resources managed the challenges posed by the pandemic. Aside from their economic parity, these countries also offer a geographically diverse perspective: they are located in different continents- North America for The United States; Asia for South Korea and China, Oceania for New Zealand, and Europe for Italy. Allowing to examine how global supply chain disruptions impacted these regions differently, revealing whether their geographical location mitigated or worsened the challenges posed by the pandemic.

All five countries are classified by the United Nations as developed economies with high GDP's, indicating significant economic resources and advanced healthcare systems. Nevertheless, the pandemic highlighted vulnerabilities in their healthcare logistics, specifically in terms of supply and distribution of critical medical equipment and medicine. The GDP per capita growth data graph from the World Bank (see figure) highlights the economic parity of these countries showing their capability to respond to a global health crisis as it should have been the case with the COVID-19 pandemic.

Figure 3 *GDP per capita growth (annual %) United States, Italy, Korea, Rep., China, New Zealand*

Note. Source World Bank national accounts data, and OECD National Accounts data files (2024). (https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?utm_source). In the public domain.

However, these countries were chosen not only because of their economic similarities but also due to their diverse responses to the pandemic. Various sources suggest that while countries such as The United States and Italy were not able to handle the pressure of the crisis on their healthcare logistics despite their wealth and longstanding healthcare systems. Countries such as South Korea and New Zealand provided a roadmap for best practices and resilient supply chains. China on the other hand, offers a dual perspective in which it was the worst affected country by the virus and initially had a poor response to the crisis. However they later responded with effective

containment strategies and most importantly, solutions to deal with the shortages of personal protective equipment (PPE) and disrupted supply chains.

This mix of success and failure across these economically similar yet geographically diverse countries make them ideal for analyzing how global healthcare logistics can be improved to prevent future shortages of critical medicines and equipment during future health crises. Understanding which factors contributed to the success of New Zealand and South Korea while comparing the reasons why the United States and Italy failed can help derive recommendations for policymakers to enhance global preparedness.

4.1 United States of America

According to the United Nations (2024), The United States of America is a developed country. In fact, as of 2022, the country was the wealthiest in the world in terms of GDP, representing 25% of the world's entire wealth. Nevertheless, the United States recorded one of the highest numbers of COVID-19 cases and deaths globally (Elflein, 2023). Their response to COVID was marked by significant challenges, including delayed initial response, political polarization, an unclear action path, and, most importantly, healthcare system strain.

When the World Health Organization (WHO) declared COVID-19 a pandemic, the current President Donald Trump repeatedly minimized the severity of the virus, making statements such as "this is going away without a vaccine" (The Washington Post, 2020) or "Currently, there are insufficient funding sources designated for the federal government to use in response to a severe influenza pandemic." (October 2019). Therefore, we can immediately see that the United States failed to prepare a successful readiness phase because they did not take a risk assessment regarding the potential risks and vulnerabilities within the supply chain to be able to combat the pandemic as the threat of COVID-19 was not taken seriously. They failed to identify/predict the impact that the pandemic was about to have on their healthcare system, and on their medical supply chain.

Additionally, there was a poor resource allocation and planning as stated that there are insufficient funding sources to respond to a severe pandemic (Trump, 2019).

In the peak of the pandemic, The New England Journal of Medicine published an article on critical supply shortages, stating that there were not enough ventilators for patients with COVID-19 or personal protective equipment for healthcare workers. Towards the end of April 2020, there was an important shortage of respirators, gloves, face shields, gowns, and hand sanitizer as a result of global supply chain problems to the extent that healthcare providers had to resort to social media to secure adequate supplies of PPE (Ranney et al., 2020b). They did not ensure that necessary resources including inventory and emergency funds were available to treat the threat as soon as possible so they started off with a bad readiness phase which implied that their next steps would be more complicated as they would now have to respond to the disruption without good preparation.

These shortages were further exacerbated by the reliance on international supply chains, particularly as China, which produced more than half of the world's face masks, halted exports in response to its own needs (Ranney et al., 2020b). This shows a poor *Response phase* because it lacked flexibility and adaptability, which are key elements to build a resilient supply chain in this phase. First of all, there was no flexibility in logistic channels as stated above, where half of the world's face masks relied upon one single supplier instead of having multiple options or suppliers in order to quickly adapt to adjust to the increased demand. Dependency on one supplier may have been the biggest reason for a shortage of medical equipment and supplies in such a critical time. Also, there were no buffer stocks and they didn't have the capacity to increase inventory levels immediately when needed which then pushed healthcare providers to resort to social media to secure supplies (Ranney et al., 2020b).

This was further exacerbated later in the second semester of 2020, when the president announced that the United States would redirect funds to other global health priorities and officially withdraw from the World Health Organization. (Gostin et al., 2020) This reaction is part

of the second phase of the model, which is referred to as the *Response phase.* And this particular action of withdrawing from the World Health Organization affected one of the key elements of the Response phase, which is the Communication and Coordination element. A Global pandemic required global cooperation and a global supply chain community in order to combat the disruption across the world, it required support, share of knowledge and effective communication among stakeholders to respond swiftly to disruptions. However, the United States did not take this into consideration and instead acted on their own which further impacted the global supply chain for medical equipment. This decision was heavily criticized on a national and a global level as it further isolated the US on the international stage and potentially undermined the global efforts to combat the pandemic.

Additionally, according to some sources, the public health federal agency under the Department of Health and Human Services, better known as the CDC (Centers for Disease Control and Prevention), was subject to potential political interference on several occasions. For example, the CDC published guidance suggesting that people exposed to COVID-19 did not necessarily need testing (Geyman, 2021). Although this was withdrawn shortly after; stating it was published by mistake, on another occasion, under the PPE supply shortages, the CDC recommended healthcare providers use N95 respirator masks only during aerosol-generating procedures, to reuse masks intended for single use, respirators and in cases of critical resource scarcity, using scarves or bandanas (Ranney et al., 2020b). These guidelines and recommendations further increased the risk of healthcare workers being exposed to the virus, especially when being around patients with confirmed or suspected COVID-19 while also undermining public confidence in the CDC.

Unfortunately, this shows the lack of transparency within the supply chain as it directly affected many stakeholders across the process while negatively impacting the crisis. A key element from the *Recovery phase* of the SCRM which was not managed adequately is knowledge management, which means learning from disruptions to develop better plans and solutions for the future. The United States instead of developing a clear and transparent solution, it misinformed the public due to political interference, which instead of reducing stress in the supply chain, it had the contrary effect because it exposed more people to the crisis, which in return could get infected

and hence increase the demand further of the already scarce resources of medical supplies. This shows the importance of a good *Recovery phase* and most importantly a clear and transparent message to all stakeholders to build better contingency plans in the future.

The response to the pandemic also brought light to deep-rooted issues within the existing US healthcare system. According to Geyman (2021) in the article, *COVID-19 Has Revealed America's Broken Health Care System: What Can We Learn?*, the pandemic exposed the longstanding problems of American healthcare as they operate primarily on a privatized market-based model and medical-industrial complex were ill-equipped to respond effectively to the pandemic, leading to widespread inequality in care access and outcomes. Low-income and minority communities were the most affected during this period, evidenced by their disproportionately high rates of infection and death. For example, African American, Latinos, and Native American communities faced infection rates sometimes three times higher than those in white communities (CDC, 2021).

Despite its wealth and advanced healthcare infrastructure, the pandemic also revealed systemic inequities, particularly in terms of access to testing and healthcare (Geyman, 2021). High-income individuals had better access to testing and treatment, while minorities and low-income individuals faced significant challenges when seeking care. The US public health messaging was inconsistent and sometimes contradictory, which led to public confusion and mistrust. The country's response was fragmented, and it lacked a unified and coordinated national strategy to control the spread, protect public health, and ensure an adequate source of medical supplies.

4.2 China

China is perhaps the most important country in this study to understand the vulnerabilities in global healthcare logistics exposed by the pandemic, firstly for being the country of origin of the Sars-CoV-2 virus and most importantly, for being the world's largest manufacturer of Personal

Protective Equipment (PPE) which had significant implications both domestically and internationally (Zhou et al., 2020).

On one hand, China faced harsh criticism regarding the delay in their initial response and strict censorship of information (Liu & Saltman, 2020). China's response was marked by a combination of quick governmental actions and challenges as local authorities in Wuhan failed to report the emerging outbreak sooner, allowing the virus to spread rapidly in the early days. According to the second phase of *Response,* communication and coordination are key elements to build a resilient supply chain, hence a lack of these demonstrates a rather weak *Response* phase from China. Ensuring effective communication and coordination among all stakeholders is important to respond swiftly to disruptions, especially in a global supply chain where China was the world's largest manufacturer of PPE. However, as stated above, due to political reasons the communication and coordination was ineffective, which in return, affected the global supply chain.

According to Liu and Saltman (2020) these delays in initial reporting rather than being merely logistical were a result of bureaucratic and political constraints. For instance, some sources suggest that President Xi Jinping was aware of the novel virus and its potential to spread in early January but he was accused of inaction and most gravely, of suppressing civil society by preventing local leaders from disclosing information about the growing outbreak without his approval (Riley et al., 2021). This action, or lack thereof, contributed to the rapid spread of the virus within the country while also proving that a centralized control in critical situations where information can be withheld from the public by political considerations can lead to significant consequences. As stated by the model, communication between all stakeholders in the supply chain is key, and this case demonstrates the importance of the role that governments play in facilitating or disrupting the resilience of supply chains. Hence, it demonstrates the significance of establishing clear communication and coordination pathways with all stakeholders across the supply chain.

Despite China's known status as the "world's factory" because of their vast manufacturing capabilities, the pandemic exposed weaknesses in their medical supply chains as when the demand for personal protective equipment (PPE), ventilators and other medical supplies spiked, there was a shortage both domestically and globally. The shortage further demonstrates that China had a poor *Readiness phase* from the Supply Chain Resilience model as there was a poor resource

allocation, where no additional stock or inventory was available to meet the new demand. (Cristopher, 2004)

On the other hand, China's stringent lockdown measures were effective in controlling the virus but had a significant social and economic impact. According to the Supply Chain Resilience Model (SCRM), agility is one of the key elements of the *Response phase*, which emphasizes how quickly the supply chain processes are reconfigured to maintain continuity. China's response was agile because they were able to reconfigure their processes in order to recuperate continuity within their country. However, they sacrificed the global supply chain to meet their local demand. China's economy was disrupted primarily in manufacturing and exports which had global implications, and even if China was eventually able to work up the production, this demonstrated the fragility of global supply chains during a global crisis and even more, the risks of having such a heavy dependence on a single country for critical supplies (Riley et al., 2021). China's struggles emphasized how interconnected global supply chains are and the cascading effects that a crisis in one country can have on the rest of the world.

China's focus on scaling up production and controlling the domestic situation meant that global necessities were initially sidelined. Nevertheless, the Chinese government was able to prevent catastrophic shortages of medical supplies by taking an aggressive and centralized approach. For starters, the country was able to leverage its manufacturing capabilities to ensure the availability of critical medical supplies such as personal protective equipment, ventilators and other medical supplies. Strict regulations were imposed to prioritize the most affected regions to receive them and most remarkably, the government was able to ensure the swift construction of the Huoshenshan and Leishenshan hospitals in under two weeks to handle the surge of COVID-19 patients (Liu & Saltman, 2020) . Other key elements from the *Response phase* that China was good at, was the flexibility and adaptability elements as they were able to utilize flexible operations to quickly adapt to the changing conditions. As stated above, they were able to leverage its manufacturing capabilities to meet the demand of critical medical supplies and equipment , while also finishing the construction of two hospitals. This shows their incredible capacity of flexibility, adaptability and also agility to reconfigure their supply chain processes. Hence, it shows a well defined and resilient supply chain under the *Response phase.*

Additionally, it shows that China was able to handle a good *Recovery phase* from the SCRM as their contingency plan (one of the key elements of this phase) was accurate as it helped them quickly recover from disruptions within their domestic supply chain, while using that opportunity to improve supply chain performance by increasing production and even mobilizing resources to build improved hospitals to attend the crisis. This shows a good *Response phase* and also a good *Recovery phase.*

The shift from being the epicenter of the crisis to becoming once again the major supplier to the rest of the world highlights the duality of China's response in mitigating and exacerbating the global crisis. Although China faced the disruption of its healthcare supply Chain, particularly due to an unprecedented demand for medical supplies, China adopted a multi-faceted approach that enabled them to manage the demand.

4.3 South Korea

South Korea is among the most successful and widely praised countries for their response to the COVID-19 pandemic. While their success can be attributed to many factors, their well-coordinated healthcare logistics and protocols to identify new cases and prevent widespread outbreaks led to a decrease in their infection incidence rate and, most importantly, ensured their healthcare system was not overwhelmed (Palaniappan et al., 2020). South Korea is a great example of a country with a successful *readiness phase* of the SCRM model, because they were able to conduct proper risk assessments to identify potential vulnerabilities within the supply chain due to the disruption of the COVID-19 and quickly understood the risk of a overwhelmed healthcare system so they were ready to mitigate and avoid this potential risk. This was possible as well due to a good visibility and redundancy as they maintained high levels of visibility across the supply chain to understand where the critical processes were in order to reduce the likelihood of the disruption, which in this case it was for the medical supplies and the overall healthcare system.

Even before the first COVID-19 cases were confirmed in South Korea, the government had started preparing by activating a national crisis management system, increasing the production of test kits, and preparing hospitals to handle potential surges in patients (Palaniappan et al., 2020). This action showed a proper combination of a successful *readiness phase* and *response phase* of the SCRM model because it showed how their preparedness for possible disruption led to a quick response across the supply chain to increase production.

Regarding the *readiness phase*, they ensured a good resource allocation by being able to maintain a good inventory of medical supplies, but also by being able to increase the production of test kits and other potential surges in patients (Palaniappan et al., 2020), which it's proof that they must have had emergency funds which allowed them to be this prepared. Also, it was proof of a good *response phase* because of their flexibility to adapt to an increase in production and to prepare hospitals to receive surges in patients. Not only were they flexible and adaptable, but also very agile because they were able to quickly reconfigure the supply chain processes by understanding the key points of the chain to maintain continuity of the service, instead of having shortages and hospitals with overcapacity as it was seen in other cases. Finally, this response was also possible due to good communication and coordination across stakeholders as they activated the national crisis management system even before the first cases were confirmed, which showed their transparency and willingness to act fast and coordinated.

The country's previous experience with the Middle Eastern Respiratory Syndrome (MERS) outbreak in 2015 influenced its early preparedness. Lessons from the challenges faced during the MERS outbreak included establishing robust protocols, like the widespread use of surgical masks, public awareness campaigns, and the establishment of drive-through testing clinics (Palaniappan et al., 2020). South Korea has not only been a good example of a good *readiness and response phase*, but also it's perhaps the best example of a great *recovery phase* as its previous experience with the MERS outbreak in 2015 allowed them to be prepared for a potential threat like the COVID-19. A good *recovery phase* according to the SCRM model includes a contingency plan that involves developing detailed plans and procedures to be executed in the event of a disruption, which was activating the national crisis management system that acted as a guide to help them

contain the virus but also to help the supply chain recover quickly and effectively to continue operations as needed.

Another key element from the *recovery phase* that was very present in how South Korea acted, was the way they handled knowledge management. This element refers to continuous learning from disruption and development of better plans and solutions for the future. Thanks to their understanding and learning from their previous disruption in 2015, South Korea was able to capture, organize and utilize the knowledge gained during that experience to improve future preparedness and response to disruptions, which was the case for the COVID-19 as they were able to demonstrate their improved resilience of the supply chain. This experience provided a critical foundation into the country's rapid and effective response to the COVID-19 pandemic.

One of the most remarkable aspects of South Korea's response was their extensive and efficient testing infrastructure, which included over 40 drive-thru testing centers. At the peak, South Korea was able to conduct up to 20,000 tests per day, far more tests than any other country at the time. This was possible due to an effective resource allocation and also a good visibility across the supply chain because they quickly understood one of the first necessary actions to control the disruption, which started at identifying who had COVID-19, hence, the importance of having good inventory for testing supplies. These testing centers were not only innovative but also very effective, as every individual test took 10 minutes, and results were available the next day (Palaniappan et al., 2020). Other than being fast and efficient, the success of these testing methods was that they allowed little to no contact with healthcare workers, which significantly reduced the possibility of transmission of COVID-19. This testing method/protocol showed good agility because they reconfigured the supply chain processes not only to maintain continuity by reducing the possibility of transmission of COVID-19, but also by incrementing efficiency by understanding the importance that time and results played in the overall pandemic.

The government also implemented stringent infection control protocols, which included mandatory use of personal protective equipment (PPE) for healthcare workers, frequent disinfection procedures, and the establishment of specialized isolation wards for COVID-19

patients (Palaniappan et al., 2020). These measurements ensured that healthcare workers remained protected which helped them maintain a robust workforce throughout the pandemic. This proactive response to control infection was key in keeping the healthcare system from being overwhelmed by the crisis.

In addition to its testing and healthcare protocols, South Korea also took advantage of its technological superiority by implementing data-driven approaches to manage the pandemic effectively. A centralized data integration system called the Epidemiological Investigation Support System (EISS) was established to streamline the process of gathering and analyzing data from various sources, including mobile location data, credit card transactions and even CCTV footage (Palaniappan et al., 2020). South Korea understood the importance of adaptability and growing (key element of the *recovery phase* from the SCRM model) from previous experiences, so they were able to use their technological superiority as an opportunity to improve supply chain performance as they were able to gather and analyze data more effectively to adapt to the disruption and manage the pandemic effectively. This system facilitated rapid contact tracing, enabling authorities to quickly identify and isolate potential COVID-19 cases.

South Korea addressed the scarcity of PPE and other essential medical supplies by collaborating with private companies. The private sector played a crucial role in producing and distributing medical supply. Many companies pivoted their manufacturing capabilities to produce face masks, sanitizers, and other critical items, to ensure a steady supply of essential items. South Korean Biotech companies also played a significant role by rapidly developing and scaling up the production of COVID-19 test kits, for both domestic and export, positioning the country as a global leader in pandemic response (Palaniappan et al., 2020). South Korea was able to understand the importance of communication and coordination (part of the *response phase*) with all stakeholders across the supply chain, as they were able to work together with many companies that understood the importance of shifting production to ensure a steady supply of essential items. They recognized that a Global pandemic required global cooperation and a global supply chain community in order to combat the disruption across the world, so they were not just able to shift production to meet

local demand, but they were able to scale up the COVID-19 test kits to contribute to a better response across the world.

Apart from their operational and logistical strategies, South Korea's response was characterized by clear and consistent public communication (Palaniappan et al., 2020). Public trust in the government's response was a result of the government maintaining transparency by regularly updating the public on the current status and the measures to be implemented. This transparency fostered high levels of public trust which ensured compliance with public health measures. Also, South Korea is considered one of the most educated countries in the world (Palaniappan et al., 2020). Their education system is one of the most advanced in the globe and many argue this played a role in their successful pandemic response. This was due to the fact that their population had the right understanding of the importance of public health practices, rapidly adopting measures like mask usage and social distancing. The combination of clear, transparent communication and a well-educated public contributed to ensuring protocols were followed and social order was maintained contributing to the overall success.

South Korea's response has set a global benchmark for how to manage a pandemic effectively. By being adaptable and seeking continuous improvement based on new information and the experiences of other nations, they maintained a strong response throughout the crisis. The country serves as the best example of a resilient supply chain, as it did a great job in all three phases of the model.

4.4 New Zealand

New Zealand is also considered one of the most successful countries in managing the pandemic. Their success can be attributed to a number of factors such as swift action, strong communication with the public and a unified health logistics but most importantly, their approach based on suppression rather than mitigation of the virus. That is to say, that New Zealand's goal

was the elimination of COVID-19 rather than stopping its spread (Jefferies et al., 2020). Their first action towards this goal was to implement strict border restrictions even before the World Health Organization's (WHO) advised to do so, and, following the first confirmed local case in February, 2020 New Zealand implemented a national lockdown within 26 days. All incoming travelers were forced into mandatory quarantine, and non-citizens were completely banned from entering the country (Baker et al., 2020).

Just like South Korea, New Zeleand was able to act quickly due to their good contingency plan which may have been developed beforehand for potential emergencies, because even before it was advised to implement strict border restrictions New Zeleand had already placed their plan to action. This suggests that they had plans in place to quickly recover from disruptions and that they had use a good knowledge management to continuously learn from previous disruptions (own or foreign disruptions) to develop better plans and solutions for the future, which in this case was effective as they were able to minimize and contain the impact of the COVID-19 from the beginning.

By March 2020, New Zealand enforced a nationwide level 4 lockdown, making it one of the strictest in the world. This lockdown impacted schools, businesses and all public spaces, bringing the country into a standstill (Baker et al., 2020). These measures helped prevent the healthcare system from becoming overwhelmed and thus avoid severe shortages of critical medical equipment and medicines as many other countries during this time (Jefferies et al., 2020).

Moreover, the country's healthcare logistics and supply chain management played a crucial role in the country's successful response to the pandemic as the government took steps to secure and stockpile essential supplies such as personal protective equipment, ventilators and testing kits early on. New Zeleand also had a good *readiness phase* according to the SCRM model because it carried out a risk assessment (first element of the *readiness phase*) to identify potential risks in essential supplies such as the PPE, ventilators and testing kits. They also ensured a good resource allocation to ensure that all of these supplies that were at risk, had enough inventory (stockpile

these essential supplies), backup suppliers, and to do so they must have had an emergency fund in order to cover these actions. Hence, showcasing an excellent *readiness phase.*

Their proactiveness ensured their system was well-equipped to handle the widespread in COVID-19 cases, avoiding the severe shortages many other countries experienced (Wilson et al., 2020). In addition to this, New Zealand implemented a robust testing infrastructure and contact tracing such as the NZ COVID Tracer app, which allowed them to identify and isolate COVID-19 cases preventing further transmission (James et al., 2020). The *recovery phase* also includes two important elements, which are: knowledge management, adaptability and growth. New Zealand was able to use proper knowledge management to continuously learn from the disruption, identify weak points and tackle them to develop better solutions which led to the creation of the NZ COVID Tracer app. They understood the importance of identifying and isolating COVID-19 cases, and they were able to adapt and grow from the disruption so they developed the app to improve their response to the pandemic. The success of the app was bolstered by high levels of public participation resulting from strong government communication and public trust in the government to handle the pandemic (Smith et al., 2020).

Nevertheless, the country's ability to maintain a steady supply of critical medicine was not only a result of strategic stockpiling but also effective coordination between the government and the private sector (Boyd et al., 2020). Once again, New Zealand had a great *response phase*, and in this particular action by having good communication and coordination between all stakeholders. They were able to understand the importance of the role that each stakeholder plays, so they decided to coordinate to ensure continuity and efficiency across the supply chain. Seeking efficient distribution of resources across the country, even to 'remote' areas ensuring they had access to the necessary supplies. The country's response prioritized social equity, particularly aiming to protect vulnerable populations as the government was aware that the COVID-19 would exacerbate existing inequalities and have a bigger impact on Māori, Pacific peoples, and lower-income communities, so to address it, health initiatives and resource allocation initiatives were placed (Jefferies et al., 2020).

Likewise, according to Jeffries et al., "New Zealand's response sought to prevent COVID-19 disparities and minimize transit of infection to lower-income Pacific countries" (2020) underscoring New Zealand's efforts to not only protect its own population but also supporting global health efforts. The government collaborated with these countries to provide testing kits, PPE, and other critical supplies, reflecting a broader commitment to regional health security (Cousins, 2020). Regular audits were also implemented to monitor the availability of essential items to respond rapidly to emerging shortages (Boyd et al., 2020). Not only did they communicate and coordinate with local stakeholders, but they also understood the importance of fighting the COVID-19 pandemic across the world with international cooperation. Just like South Korea, they were able to act accordingly to protect their local needs, but also quickly adapt to contribute to the global supply chain community and support global health efforts to contain and/or minimize further negative impacts.

4.5 Italy

Italy was among the countries that were hardest impacted by the COVID-19 pandemic, with one of the highest death rates in the world. By March 11, 2020, Italy had recorded 12,462 confirmed cases and 827 deaths, making it the country with the second-highest number of COVID-19-related deaths after China at the time (Remuzzi & Remuzzi, 2020). Despite government efforts to contain the virus by imposing nationwide lockdowns and being the first European country to do so, these restrictions faced significant resistance from Italian citizens, leading to unrest and protest, most notably prisoners who rioted in prison for restrictions on family visits (Remuzzi & Remuzzi, 2020).

The pandemic placed an enormous strain on Italy's National Healthcare Service (NHS), which was already weakened by years of underfunding, privatization, and fragmentation. Even before the pandemic occurred, it shows that Italy had a terrible *readiness phase,* as they were not prepared for any crisis or potential disruption. The underfunding was proof of absence of

emergency funds, lack of inventory and due to privatization and fragmentation there were probably no backup suppliers to meet essential demand. Probably no risk assessment was done either to identify potential vulnerabilities within the supply chain as the NHS was weak already.

The healthcare system, which is regionally organized, made each local authority responsible for the organization and delivery of health services. This fragmentation contributed to a lack of coordinated national leadership, further complicating the response to the crisis as the disparities in the quality and availability of care across different regions complicated the national response to the pandemic (Armocida et al., 2020). Additionally, they could not have a good *response phase* either because there was a clear lack of communication and coordination across the system, which led to an isolated system across regions, where there was not a real supply chain interconnected network build within the country that could respond to the crisis of the COVID-19 pandemic.

Moreover, Italy's response to the pandemic was almost completely reactive. As a result of years of underfunding, Italy's healthcare infrastructure was weakened leading to limited testing, hospitals in the worst-affected regions quickly becoming overwhelmed, and intensive care units ran out of beds, forcing hospitals to implement triage protocols, which meant that healthcare workers had to make the decision of which patients were to receive treatment, prioritizing patients with the better chances to survive (Remuzzi & Remuzzi, 2020). Therefore, as stated above, it's clear that there was not a *readiness phase* at all so their only option was to try and respond to the crisis and improvise along the way. They did not have any of the three key elements of the *response phase* to build a resilient supply chain; they were not flexible or able to adapt to changing conditions, they had a terrible communication and coordination across their supply chain due to the fragmentation and privatization of the healthcare system, and they were not agile to reconfigure the supply chain processes as they quickly overwhelmed their hospitals and essential supplies. This overwhelming demand led to difficult ethical decisions and, inevitably, in the loss of lives that might have been saved under different circumstances (Vergano et al., 2020).

The emotional and physical toll on healthcare workers was immense in Italy. Many were required to work extended hours in high-stress environments, often without adequate personal protective equipment (PPE), which led to high rates of infection among medical staff. The psychological impact of having to make life-and-death decisions daily, combined with the sheer volume of cases, resulted in significant burnout and, in some cases, post-traumatic stress disorder (PTSD) among healthcare professionals (Rana et al., 2020). Finally, Italy had also failed to have a good *recovery phase* as there was no contingency plan to quickly recover from the disruption, instead they kept improvising without improving which led to the inevitable continuous shortage of essential supplies that resulted in further loss of lives. Despite having more data available everyday, they were not able to use proper knowledge management to learn and develop better plans. Additionally, they did not adapt or grow to improve the performance of their supply chain. This demonstrates that they failed to execute the three elements of the *recovery phase* to build a good resilience in their supply chain, which is why the outcome in Italy was this severe.

Italy faced important challenges in terms of testing and contact tracing. Initially, testing was limited to individuals that showed severe symptoms and therefore individuals with mild or asymptomatic cases went undetected, leading to the virus's 'silent' spread (Giordano et al., 2020). This limited testing capacity also made it difficult to accurately track and register the virus's progression and the infected individuals. While Italy ramped up its testing efforts as the crisis progressed, the initial delays had already allowed the virus to spread frantically. On top of that, Italy's decentralized healthcare system caused some regions to test less extensively than others (Armocida et al., 2020). While Italy also developed digital contact tracing apps such as the *Immuni app*, these were introduced too far in the pandemic and faced issues with public adoption and even data privacy concerns (Pereira et al., 2020).

5. Lesson Extraction

The COVID-19 pandemic put global healthcare logistics to a test, revealing critical weaknesses across the supply chains of even the most developed countries. The lessons drawn from the responses of the United States, South Korea, New Zealand, and Italy to the pandemic helped understand both in which areas healthcare systems succeeded and failed. In order to build more resilient healthcare logistics systems that can better withstand future global crises.

5.1 Vulnerability Assessment and Recommendations for Policymakers

5.1.1 Inadequate Preparedness and Strategic Stockpiling

The pandemic revealed that many healthcare systems, despite being well-established, were dangerously unprepared for a global health crisis of such magnitude. Severe shortages of critical medical supplies, particularly in terms of stockpiling were a consequence of inadequate preparedness and lack of appropriate reserves. Countries like the United States, that followed a 'Just-in-time' inventory model, were ill-prepared when the demand for critical supplies such as ventilators, face masks, and other personal protective equipment skyrocketed. This lack of strategic reserves and inability to keep up with the demand left healthcare workers exposed and some patients without the necessary treatments. The lack of contingency plans and failure to anticipate the crisis exacerbated the impact of the crisis.

The COVID-19 proved that stockpiling is a critical necessity in national security and governments should establish and maintain national reserves of key supplies that can be easily accessed in times of crisis. These stockpiles should be regularly replenished to ensure they are adequate to meet the needs of another health emergency. Governments should also invest in further developing domestic manufacture for critical supplies and reduce their reliance on international suppliers or at least, diversify suppliers to ensure they are not heavily dependent on a single nation as was the case with China. The study also proved that collaboration between the private and public

sector can help governments respond to increased demand while incentivizing investment in the private sector.

5.1.2 Fragmentation and Lack of Coordination

The fragmentation of healthcare systems, in countries like Italy and the United States, also proved to be a significant challenge during the pandemic. As it was the case in Italy where the responses across the regions were inconsistent and some areas were better equipped to handle the crisis than others. Not having a single centralized healthcare system meant that there was a disjointed national response and some regions had to face severe shortages of critical resources and even hospital beds. This lack of unified strategy prevented coordinating measures such as better resource allocation or patient transfers leading to avoidable deaths and overwhelmed healthcare workers. Similarly, the United States's response was also fragmented as each state government took a different approach on lockdowns, testing and resource distribution.

Policymakers should work towards greater centralization of health crisis management to ensure coordinated responses across all regions of a country. Establishing clear lines of authority and a national crisis management framework that outlines the roles and responsibilities of federal, state and local governments during health emergencies could also be key to ensure equal distribution or resource sharing.

5.1.3 Over-Reliance on Global Supply Chains

The pandemic exposed how heavily dependent the world was on China for the production of personal protective equipment, pharmaceuticals and other critical supplies. While having

globalized supply chains allows countries to obtain competitive costs, economies of scale and a wide access to diverse products, the pandemic revealed the risk of depending on international suppliers and not having diversified sources. So ironically, when China was hit by the crisis, exports were restricted to meet domestic demand and thus causing a domino effect of shortages worldwide.

As mentioned before, policymakers should advocate for diversification of global supply chains reducing their dependence on a single country for critical supplies. Working towards a more distributed manufacturing network can help create a more balanced and resilient supply chain. Other initiatives such as free trade agreements for medical goods during crises or developing a shared reserve of essential supplies for countries in need could also be good initiatives.

5.1.4 Delayed Response and Insufficient Testing Infrastructure

One of the most important weaknesses revealed during the pandemic was the delayed response in many countries, especially in regards to testing and tracing infrastructure. In the United States and Italy, testing was not given the priority it should have had which allowed the virus to spread rapidly and undetected. These delays are directly related to higher mortality rates as healthcare systems rapidly became overwhelmed and no targeted containment measures were in place. Additionally, the lack of coordinated contact tracing further hindered containment efforts in countries with decentralized health systems.

Moving forward, policy makers should treat testing as an utmost priority in global health crises, ensuring that everyone has access to safe and efficient testing will ensure better tracing and identification. Governments could invest in technological infrastructure as well and this proved to be a major advantage in countries that handled the pandemic successfully. And lastly, policymakers should also consider establishing partnerships with private sector companies that have the capacity to produce critical resources to ensure these are available when needed the most.

5.1.5 Public Trust and Communication Failures

The pandemic also showed the importance of clear, consistent, and transparent communication as countries like South Korean and New Zealand did for public trust and compliance. In the United States and Italy, communication was mostly inconsistent, politicized and contradictory, leading to mistrust, lack of cooperation and confusion. The challenges in public communication led to higher infection rates and a decreased trust in government institutions as they were subject to political interference. Rather than seeing containment strategies such as mask use in public spaces, lockdowns and social distancing as a tool to contain the virus, people started seeing them as political initiatives.

To maintain public trust, policymakers should always communicate honestly and openly about what is known, what is not known and what actions are being taken to address the situation. Communication channels that share the information accurately, timely and consistently should be a cornerstone of public health strategies, aiming to use a variety of communication platforms to reach a broader audience and ensure all segments of the population can access this information. To reinforce the credibility of official sources, governments could actively address false claims and counter misinformation; acknowledge their challenges and setbacks openly and show a commitment to improving and adapting. These strategies can strengthen public confidence in their government to manage the crisis effectively and understand why measures are being implemented rather than seeing them as mandates.

5.1.6 Ethical Dilemmas and Emotional Impact on Healthcare Workers

Last but not least, the pandemic placed an immense pressure on healthcare workers both physically and mentally. Healthcare workers put their safety on the line by exposing themselves to the virus, were forced to make ethical decisions when the system became overwhelmed and had to endure high-stress neverending shifts. Italy was the country where healthcare workers became the most overwhelmed and had to make the impossible decisions of which patients would receive treatment and which wouldn't. Understandably, these decisions took a huge emotional toll on healthcare professionals as taking life saving decisions under extreme conditions lead to burnout, depression and PTSD. Apart from maintaining the overall effectiveness of the healthcare system, the psychological impact of the pandemic on healthcare workers highlighted how important support systems and ethical guidelines are in critical situations.

Policymakers must give the importance mental health support deserves during crises. By establishing dedicated mental health services for healthcare workers like regular psychological assessments and access to counseling and support groups. Moreover, to alleviate the moral burden on healthcare workers when taking ethical decisions, guidelines based on equity and transparency should be developed in advance. Lastly and most importantly, governments should ensure that under no circumstances healthcare workers lack access to adequate personal protective equipment and other safety measures, allowing them to focus solely on patient care and not having concerns regarding their own safety.

6. Conclusions

The COVID-19 pandemic revealed both systemic vulnerabilities and areas of resilience of global healthcare logistics. This study's comparative analysis of the United States, China, South Korea, New Zealand and Italy provides valuable insights into how countries can better prepare to manage future global health crises.

Results show the importance that preparedness plays in mitigating the impact of global health crises in which nations with well-established healthcare logistics, strategic stockpiling, and contingency plans were able to respond effectively to the crisis, minimizing health and economic disruptions. These countries demonstrated the value of robust testing infrastructures, maintaining strategic reserves and the ability to rapidly adjust its production of essential items rather than the "just-in-time" inventory models employed by countries like the United States, that led to severe shortages of personal protective equipment and ventilators.

The pandemic also revealed the weaknesses and consequences of fragmented healthcare systems as seen in countries like the United States and Italy. The lack of centralized coordination and inconsistent public health measures further exacerbated shortages of critical medical supplies and unqual resource allocation. One key lesson from this study is the need for a more integrated approach to healthcare logistics, where clear authority and coordination is established before a crisis.

Moreover, the over-reliance on global supply chains for essential medical supplies particularly on China, had a domino effect of healthcare systems worldwide. When export restrictions on personal protective equipment and other critical medical supplies were established in China to fulfill national demand, nations around the globe found themselves ill-prepared to fulfill their local demand, revealing that future strategies should focus on diversifying supply chains and investing in domestic manufacturing to ensure resilience gainst global disruptions.

Countries like Italy and the United states failed to recognize the severity of the virus in its early stages, and delayed the implementation of containment and identification strategies such as widespread testing, leading to a rapid undetected spread of the virus. Whereas South Korea’s respd response an action towards testing infrastructure and innovative contact tracing methods proved to be crucial in containing the virus early on.

From the countries that most successfully responded to the COVID-19 pandemic we can learn that clear, consistent and transparent communication with access to all, lead to higher levels of compliance with health measures as it was in South Korea and New Zealand. In contrast, the

politicization of public health information and unclear communication between the government and the public impacted negatively public trust and collaboration. Proving that building and maintaining public trust through honest and timely communication should be a cornerstones of future pandemic preparedness.

The study also revealed the critical need for mental health support systems and ethical guidelines. As countries with the most overwhelmed systems, like Italy, placed huge psychological and ethical burdens on healhcare workers. Policymakers must prioritize the well-being of such an important workforce by ensuring access to adequate personal protective equipment and establishing frameworks to guide ethical decisions during crises.

By learning from both the sucesses and failures of various countries observed during the COVID-19 pandemic, the world can be better prepared to safeguard against future health crisis, ensuring that the devastating impact of this pandemic is not repeated. These lessons provide a roadmap for building more resilient healthcare systems if policymakers commit to implementing the recommendations of this study such as establishing strategic reserves, enhancing coordination mechanisms, and investing in robust testing infrastructure.

Overall, while the COVID-19 pandemic exposed significant flaws in global healthcare logistics, it also highlighted the potential for global collaboration, and resilience. By adopting the lessons learned and making necessary reforms, the world can be better prepared to face future pandemics, ultimately saving lives and preserving global health security.

7. **Limitations**

While this research contributes substantially to the area of inquiry and aimed to cover as much available information as possible, it also has some limitations. Firstly, as only journal articles written in English were considered, other relevant sources such as book chapters, books,

conference papers, and unpublished works were not considered in this research and as a result, this review may not reflect the complete knowledge on the topic. Secondly, to search for the articles, databases such as Scopus, Web of Science, Elsevier and Google Scholar were used; however, this may have resulted in missing some articles that were not available in the databases used. And thirdly, this study was conducted solely focused on the academic point of view, not involving any practitioners in this research.

Moreover, comparing international responses is complicated given the inconsistency in data reporting standards across countries. The differences in how countries defined and measured metrics like testing rates, confirmed cases, and COVID-19 related deaths made it challenging to accurately draw conclusions from the data. Even the Global Health Security Index (GHSI), which was intended to predict how well countries would respond to pandemics, failed to accurately forecast performance due to the index's bias towards high-income countries. The Index did not consider factors such as political leadership, health system capacity, and the specific social and economic contexts within countries (Baum et al., 2021).

These challenges are further exacerbated by the lack of a single, reliable source of information and the perceived biases, meaning that while most sources may argue that a country responded poorly to a crisis, some others might argue that given the circumstances the country handled the crisis appropriately for instance. Also, the selection of countries for this study was based on criteria such as economic status and healthcare infrastructure, overlooking other countries that could have provided valuable insights. By focusing only on economically developed countries, the unique challenges faced by developing countries were not evaluated or understood; nor potential unique/innovative responses from these countries to the pandemic.

Lastly, the study's reliance on qualitative data, such as literature reviews and case studies, may limit the objectivity and empirical understanding of the interpretation of results, even possibly resulting in researchers' bias.

8. **Suggestions for future research**

Future research should focus on a broader geographic scope to include more countries from different income levels to provide a more comprehensive understanding of how global healthcare logistics can be improved across diverse contexts. More research can be carried out focusing on the responses from low and middle-income countries, focusing on the distinct challenges they had to face for their developing economies. Future studies could also benefit from having more quantitative analysis to provide more objective insights and develop metrics that assess supply chain resilience quantitatively.

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