
Air Cargo Safety Logistics and Healthcare Supply Chain Resilience Operations: A Significant Policy Lessons

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Abstract

The paper is tailored to picture and portray aviation logistics best practices in an ambit of healthcare supply chain, comparative analysis of aviation and healthcare logistics systems, and critical influencing variables. The study argued for the encouragement of strategic movement of air cargo operations that can enhance the efficiency, visibility, adaptability, and continuity of healthcare supply chains, particularly for time- and temperature-sensitive medical products such as vaccines, pharmaceuticals, blood products, and emergency medical supplies. The research found the benefits of healthcare avia-cargo logistics to include fundamental improvement in emergency and disruption preparedness, reduction in delivery delays, enhancement of goods integrity, and continuous support of patient care in the case of diseases outbreak. The study in its entirety made a robust contribution to research advancement in healthcare avia-cargo logistics through scholarly multidimensional approach. The paper concluded with empirical recommendations for both healthcare managers, policy-formulators, aviation cargo handlers and logistic chain service providers.

Keywords: Healthcare Supply Chain Resilience; Aviation Logistics; Air Cargo Safety; Logistics Management; Risk Management

1. Introduction

The need for more responsive and resilient logistics structures to tackle the hydra-headed challenges that have been posed by geopolitical and governance instability, natural disasters, infrastructural deficits, the pandemics and among others to healthcare supply chains cannot be overemphasised. In bridging the gap therefore, aviation logistics, at large and air cargo operations in particular, has shown the capacity to establish rapidity, security, and reliability in the management and movement of essential goods in a daunting situation through a thorough Safety Management System (SMS), risk identification and management, a coordinated operational framework. Hence, it is emphasised that;

Healthcare logistics, which is primarily aimed at patient care, represents a number of activities in the area of supply chain management. Hospitals are a key link in the supply chain, where they are the end customer, the supply chain from the manufacturer through all bottlenecks. A complete description of the distribution of medical supplies can be summarized into an external and internal supply chain. The external circuit represents the supply of the necessary commodities and ends at the distribution point. The internal circuit continues to the nursing units of the hospital supply chain. Currently, two basic forms are used for the distribution of supplies to the level of nursing units, through the regions, or through the supply from the humanitarian warehouse. The acquisition, storage, and distribution processes depend on the material availability on the market and the level of the maintained stocks. Modern technologies enable continuous collection of requirements and are the basis of a proactive approach to the solution, which allows the use of all accessible air transport, military and civilian capabilities, according to the criteria of the user or end customer (Korecki, Smrż and Pecháček, 2020).

Following this development, logistics is considered as the backbone of any nation, as it ensures free flow of goods and services required for the functioning of industries and the economy (Sharma, Gupta and Jha, 2020). Over the years, several remarkable research were conducted in diverse fields like politics and administration, economy and business management, personality studies, and organizational behaviour. However, logistics have tremendously expanded human knowledge regarding the healthcare sector of the economy. De Vries and Huijsman (2011) said, from the supply chain management perspective however, our body of knowledge regarding the health care sector still seems to be rather fragmented. They maintained that although many health care organisations have recognized the importance of adopting supply chain management practices, the application of techniques, methods and best practices originally developed in an industrial setting clearly is often problematic. Without doubt, the complexity of the technologies being used, the existence of multiple stakeholders, a dynamic internal and external environment and distinctive characteristics of health service operations often impede a straight forward application of industrial oriented supply chain management practices. The many problematic projects aiming at implementing integrated planning systems regarding patient flows and establishing partnership relationships between different health service organisations are a clear indication of the difficulties health care organisations are facing when adopting a multifaceted supply chain management philosophy (De Vries and Huijsman, 2011).

Further to the above, healthcare distribution frameworks are essential parts of contemporary healthcare structures which create opportunity for the availability of medical and pharmaceuticals, and equipment supplies. According to Marques, Martins and Araújo (2020), these networks encompass a wide range of activities that include procurement, storage, and

transportation of medical products as well as the management of inventory to prevention of shortages and wastes. It is worthy to state that transport is the dominant pillar in Supply Chain as it comprises of streams revenue creation, enhancement of operational flexibility, and “optimization of logistics infrastructure capacity, thereby highlighting the importance of operational resilience in a crisis period (Herold et al., 2021). This becomes germane because, effective distribution networks are instrumental to the maintenance of uninterrupted access to healthcare services, mostly in underdeveloped, rural, semi-urban and urban and centres. It is important to maintain that one major healthcare delivery activities are the incorporation of supply chain management principles and practices for the development of productivity and expenditures reduction. For example, Leaven, Ahmmad and Peebles (2017) and Abu Zwaïda, Pham and Beauregard (2021) said, activities like real-time data monitoring, management strategies, demand prediction, and provision for healthcare officials to allow the prevention of disruption in supply.

The healthcare supply chain is defined as information, supplies and finances related to the acquisition and flow of goods and services from the supplier to the end user to enhance clinical outcomes while controlling costs (Schneller et al., 2023). Due to the specificity of health services, the supply chain is not limited to physical goods (drugs, pharmaceuticals, medical devices, health aids, etc.) but also concerns the flow of patients (Beier, 1995). Turhan and Vayvay indicate that management of the healthcare supply chain is different from other industries due to its tendency for misalignment, high costs for healthcare providers and heavy dependence on third parties (Turhan and Vayvay, 2012). The healthcare supply chain is decentralised, characterised by a lack of coordination mechanisms (financial or contractual) among physicians, hospitals and patients, and is subjected to significant regulatory pressure (Dobrzykowski, 2019).

Currently, Supply Chain (SC) management has become an integral part every successful organization including the private and government businesses. This occurs majorly due to an astronomical growth in degree of competition in the market domain (Dorgham et al., 2022). Policy makers and researchers of late picked interest in the study of supply chain development and trend following the above posited postulation. As a result of the fact that consumers are an essential component of any supply chain, meeting the customers' demands is often seen as one of the most important objectives of supply networks (Dwivedi et al., 2021). When seen from this angle, the idea of responsiveness stands out as one of the most essential criteria in the supply chain. The capability of a supply chain to satisfy the demand of consumers within a certain time frame is referred to as its responsiveness (Gamal, Abd El-Gawad and Abouhawwash, 2023). In a nutshell, supply chain networks are complex socio-technical systems as they are formed by a large number of diverse and dynamically interacting elements (e.g., companies, procedures, people, technologies), subject to high uncertainty from the external environment (Senna et al., 2023; Yaroson et al., 2021). It is pertinent to note that decentralization and the usage of meagre principles of production thereby tightening the procedures and exposition to quick and unexpected variability propagation. Also, Healthcare Supply Chain (HSC) has a distinctive social relevance as their reliability and stability directly impact public health (Furstenau et al., 2022). The COVID-19 pandemic has again given visibility to the intervention of the aviation cargo logistics and the vulnerabilities of the HSC as stockouts of vital drugs and supplies were pronounced in many countries of the world. The pandemic, as well as other significant threats to SC performance (e.g., natural disasters, strikes, wars, cyber-attacks), have also made it clear the need for HSC resilience, which is an emergent property of complex socio-technical systems, essential for their survival and acceptable performance under expected and unexpected conditions (Senna et al., 2023). Resilience is also necessary due to more prosaic variabilities (e.g., traffic jams,

production delays) and it has a history of scientific investigation in SC management (Furstenau et al., 2022).

Consequent upon the COVID-19 epidemic, critical stakeholders across the global economy have realized how important faster healthcare delivery systems and architecture are to issues of public health, social cohesion, faith in governments, and economic development. Therefore, this research study investigates HSC in the context of avia-cargo health services (hereafter referred to as aviation logistics healthcare supply chain), which have complex SC due to the highly regulated internationally, large and wide variety of products and services it rendered and the fastest advancement in technological dynamics. Embarking on this study into healthcare systems has the potential to enhance the circumstances of the aforementioned factors, particularly during current challenging times (Nayeri et al., 2021). According to the studies that have been conducted, the primary focus in the healthcare supply chains that existed prior to the adoption of Industry 5.0 was on the implementation of contemporary technologies (such as the Internet of Things, Big Data, and Blockchain) in order to ensure efficient time management on operations, cost reduction strategy, and effective healthcare systems (Dorgham et al., 2022).

This study shall discuss gap and importance of aviation logistics and healthcare supply chain resilience; derivatives and lessons from air cargo safety and healthcare operations; policy inferences and remarkable recommendation for practice and further research.

2. The Gap and Importance of Aviation Logistics and Healthcare Supply Chain Resilience

Aviation Logistics focuses at the role of the air cargo business and its role in global supply chains and logistics. Thus, as global economies are constantly evolving, the supply chain business with its transport partners must be proactive for the future (Sales, 2016). The healthcare industry has witnessed a cemental and dynamic growth within the last ten years as a result of increased competition, the growing influence of patient-associations and a necessity to deliver health services in a more efficient and effective way, thereby making many healthcare organisations to commenced programmes and projects in that will address patient logistics, clinical pathways, data interchange and vertical integration (Aptel and Pourjalali, 2001). Moreover, the redesign of hospital services and the implementation of integrated care programmes are frequently addressed as being critical strategies to decrease resource utilization and improve health care quality. Clearly, not only in practice but also from a theoretical point of view the area of health service operations has changed significantly (De Vries and Huijsman, 2011).

Aviation logistics and healthcare supply chain resilience does not only deal with the carriage of medicine and drugs but also involves the activities that concern the movement of patient from one medical centre to another. According to Skowron-Grabowska et al. (2022), striving to ensure the continuity of healthcare encompasses the need for patients to flow within the health system. Patient transfer is carried out in two forms: a primary form, where the patient is transferred from the place of injury or illness to the hospital, and a secondary form, where the patient is transferred to another hospital (Hale, Hall and Dunn, 2019). For instance, safe patient flow, in terms of both primary and secondary transfers between hospitals, requires efficient logistics based on cooperation within the partner network of entities participating in the provision of health services (Ageron, Benzidia and Bourlakis, 2018). Thus, patient logistics as a field in the area of operations and supply chain management concerns all planning and control decisions aimed at matching supply and demand throughout the entire

healthcare supply chain, in particular the coordination of activities between healthcare organizations (De Vries and Huijsman, 2011).

The COVID-19 outbreak in the beginning of 2020 brought an unequaled disruption of supply chains, clearly exposing the vulnerability of the globalized economy which is characterized by multifaceted and intertwined product and material flows (Ivanov and Dolgui, 2020b; Queiroz et al., 2020; Singh et al., 2020 cited in Herold et al., 2021). As a network of organizations mutually and co-operatively working to manage the flow of materials and information from suppliers to end users, it should be stressed that global supply chains and the associated complex material flow predominately rely on logistics infrastructure (mainly transport and warehouse services) provided by logistics service providers (LSPs) (Christopher, 2011; Herold et al., 2021). LSPs play and have played a crucial role in the past decades, as companies increasingly focus on their core competencies and have outsourced their logistics functions for transport and warehousing efficiency, flexibility and capacity purposes (Gkanatsas and Krikke, 2020).

3. Lessons from Air Cargo Safety and Healthcare Operations

The reliability of air medical transport depends on many independent factors, such as weather conditions, and factors related to operations management, such as fuel logistics. The COVID-19 pandemic has fundamentally changed the medical procedures associated with medical air transport (Skowron-Grabowska et al., 2022).

Annex 9 to the Chicago Convention in its Chapter 4 has several provisions pertaining to cargo which comes under the purview of ICAO. With a view to facilitating and expediting the release and clearance of goods carried by air, Contracting States are required to adopt regulations and procedures appropriate to air cargo operations and shall apply them in such a manner as to prevent unnecessary delays (Abeyratne, 2018). SARPs on Facilitation were first adopted by the Council on 25 March 1949, pursuant to the provisions of Article 37 of the Convention on International Civil Aviation (Chicago, 1944), and designated as Annex 9 to the Convention with the title “Standards and Recommended Practices — Facilitation” (ICAO, 2023). They became effective on 1 September 1949. To begin with, States are advised that with respect to cargo moving by both air and surface transport under an air waybill, Contracting States should apply the same regulations and procedures and in the same manner as they are applied to cargo moving solely by air.

According to the findings of Herold et al (2021) work, LSPs have built their reactions and actions to the COVID-19 outbreak around five main themes that include the creation of revenue streams, enhancement of operational transport flexibility, enforcement of digitalization and data management, optimization of logistics infrastructure, and improvement of personnel capacity. These pillars as noted by Herold et al (2021) build the foundation to LSP resilience that enables supply chains to stay resilient during an external shock of high impact and low probability.

The analysis revealed mainly similar actions regarding the handling transport capacity and personnel capacity, but mainly the larger LSPs were able to create additional revenue streams through, e.g. the acquisition of airplanes to provide extra transport capacity for PPE and medical equipment requested by governments. It was observed that LSP operations, in particular in sea-rail- and airfreight, are still characterized by limited innovation capabilities and a low level of digitalization. Air cargo safety and healthcare operations share a common goal: guaranteeing that critical products reach the right destination safely, securely, and on

time. The following are critical derivatives for both theorists and practitioners of healthcare supply chains from air cargo safety perspectives. These are but not limited to:

- **Prioritization of Risk Management.** Air cargo uses systematic risk assessments to identify and reduce hazards before they become incidents. Healthcare supply chains can adopt similar proactive risk management practices by identifying vulnerabilities such as supplier disruptions, cold chain failures, or inventory shortages before they affect patient care (Igboanugo, Akobundu, 2020; Filani et al., 2022; Wang et al., 2023).
- **Maintenance of the End-to-End Traceability.** Air cargo relies on tracking systems to monitor shipments throughout their journey. Healthcare organizations benefit from end-to-end visibility for medicines, vaccines, blood products, and medical devices, enabling faster recalls, reducing losses, and preventing counterfeit products from entering the supply chain (Krohn, 2022).
- **Enforcement of Standard and Recommended Practices (SARPs).** Strict compliance with standardized handling, packaging, documentation, and loading procedures minimizes errors in air cargo as maintained by the International Civil Aviation Organisation (ICAO), International Air Transport Association (IATA) and States' Civil Aviation Authority (CAAs). According to Schneller et al (2023), healthcare operations can improve safety and quality by implementing standardized procedures for procurement, storage, transportation, and distribution of medical supplies.
- **Adherence to Stipulated Regulations, Compliance, Safety and Trust.** Air cargo operations must comply with strict international regulations governing dangerous goods, cargo screening, and aircraft safety. Healthcare supply chains must follow regulations for pharmaceuticals, medical devices, patient safety, and product traceability (Botta, 2023). Strong compliance programmes reduce operational risks, improve quality, and build stakeholder confidence (Hopp, Brown and Shore, 2022).
- **Technological Dependency and Data Analytics.** Air cargo operators use technologies such as IoT sensors, barcode/RFID tracking, predictive analytics, and automated alerts to improve safety and operational efficiency (Krohn, 2022). Healthcare supply chains can use these technologies to monitor temperature-sensitive products, forecast demand, optimize inventory levels, and detect potential disruptions before they impact patient care.
- **Capacity Building, Process Improvement and Increase Performance.** Air cargo personnel receive regular training on safety procedures, emergency response, and handling specialized cargo (Jałowiec et al., 2021). Healthcare staff require ongoing training in inventory management, cold chain handling, infection control, and new technologies (Jałowiec et al., 2021). Essentially, an investment in workforce development and continuous improvement in processes strengthens operational efficiency and safety.

4. Policy Implications of the Study

The consequences of supply chain failures during the COVID-19 pandemic have been widely reported by for example: the BBC on the UK's failure to stockpile (BBC, 2020), the Guardian on hijacked supplies (the Guardian, 2020), and The New York Times on price gouging (The New York Times, 2020). Supply challenges encountered during the pandemic fueled unprecedented policy attention on supply chain resilience (SCR) and

triggered re-evaluation and continuous learning on SCR in order to deal with future crises (Peters et al., 2023).

Through the creation of regulatory frameworks, incentives for sustainability, and emergency response coordination, governments play a crucial role in the optimisation of the healthcare supply chain. Public-private partnerships in the distribution of vaccines during COVID-19, for instance, demonstrated the significance of stakeholder collaboration (Shih, 2020 cited by Rasel et al., 2022). The complexity and dynamism of healthcare supply chain management involve special challenges, such as the lack of consolidation at the provider level, policy issues related to the regulatory authorities, lack of coordination and cooperation between supply chain streams (upstream and downstream), fragmented and inconsistent operation, other chain participants and a high degree of individualisation of activities. In the context of the above, improvement of the healthcare supply chain healthcare is associated with the use of the concept of the logistics chain as a system of transport and warehouse relations, allowing for the development of process aspects that are components of the logistics system. Research confirms that healthcare supply chain performance and agility are influenced by the quality of human capital, both medical and logistic.

The derivatives of the study is a tool for policy makers and implementers across the cosmopolitan public and private sectoral levels to initiate project and programme development incentives that will boost civil avia-cargo logistics and HSC resilience following a decisive socio-economic and technical model. These incentives do not support businesses in achieving the strengthening healthcare supply chain resilience through aviation logistics alone but also provides support air cargo safety and healthcare operations and capabilities. For example, government financial and non-financial incentives could be tied to demands for organizational change in corporations. Given the complexity of this socio-technical approach, policy-makers could also promote collaborative projects between avia-cargo logistics and HSC stakeholders, Research and Development institutions like universities, which could contribute with innovations for coping with the said complexity as well as educating staff that otherwise can hold a too technocentric perspective.

5. Concluding Remarks and Recommendations

The COVID-19 crisis has transformed the delivery of services and goods by public, private, and non-governmental organizations (NGOs), with one of the largest impacts being in air transport systems. The development bestowed the air cargo with a critical role in the transportation of goods and global trade. For example, air carriers transport \$6.8 trillion worth of goods each year, representing 35% of global trade by value; and the range of air cargo loads, in a typical 24 h period, international air cargo transports 80,000 flowers, 140,000 tons of cargo, 200 racehorses, and 1.1 million smart phones (Bartle, Lutte and Leuenberger, 2021).

Patient air transport is one of the key challenges in providing adequate medical care to patients, maintaining its continuity and the availability of highly specialised medical procedures. Therefore, this process requires proper planning of procedures, standards and rules of conduct, organizing human resources, equipment and infrastructure, coordinating the processes of patient interhospital transfer (decision-making, inter-organisational cooperation) and controlling the effectiveness of transfers. From the foregoing discourse, we recommend:

Policy structures that support huge investments in avia-cargo infrastructure, localised production of healthcare essentials like drugs, pharmaceuticals, medical devices, health aids, etc.) but also concerns the flow of patients, and dual sourcing. Furthermore, embracing

regulatory back-up for blockchain can fastrack the combination of blockchain technology into a globalized healthcare network.

Continuous application of advanced technology and its resulting efficiency and transparency should be the main consideration for strengthening healthcare supply chain resilience through aviation logistics and air cargo safety and healthcare operations.

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