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Cold Chain Logistics: The Case of Turkish Airlines Vaccine Distribution

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Purpose: *The world is going through unprecedented times since the beginning of the COVID-19 pandemic. Billions of people will be vaccinated in the next few years. This mass vaccination effort requires setting up complex cold chain organizations and meticulous coordination of distribution networks. Keeping coronavirus vaccines at appropriate temperatures during the distribution process is not easy; however, it is one of the key factors battling against COVID-19. The purpose of this paper is to discuss and identify the essential logistics capabilities of cold storage and logistics service providers during the COVID-19 vaccine distribution.*

Methodology: *First, we identify the prominent risks that cold chain distributors encounter during vaccine transportation by conducting an in-depth literature review and an interview with the vice president of one of the largest air cargo companies in the world. Then we discuss logistics capabilities for the mitigation of these risks. Finally, we explore the Turkish Cargo's cold chain footprint enlargement strategy during the pandemic.*

Findings: *Cold chain logistics requires special attention to specific capabilities due to the nature of the cargoes being transported. On-time delivery time, special storage and transport equipment, and process monitoring ability are among the core capabilities for cold chain logistics service providers. Ensuring the reliable and effective distribution of temperature-sensitive vaccines is crucial since millions of lives depend on them.*

Originality: *This study is one of the first papers investigating the cold chain capabilities of air cargo distributors during the COVID-19 pandemic.*

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1 Introduction

Humanity is experiencing an unusual human death toll, unprecedented economic costs, disruption of lives and livelihoods, and sociological and psychological damage worldwide due to the COVID-19 pandemic since late 2019 (Teijaro & Farber, 2021; WHO, 2021). The coronavirus SARS-CoV-2 has infected more than 158 million people, caused over 3.2 million deaths, and changed many aspects of our lives since its discovery (COVID-19 Map - Johns Hopkins Coronavirus Resource Center, 2021). Despite all the lockdowns and restrictions in many countries, the COVID-19 disease continues to spread and becomes a global problem due to the rapidly increasing infected patients. Many healthcare systems are unable to meet the patients' demand against the high morbidity rate (Landi et al., 2020). The first effective COVID-19 vaccines were approved for human use within a year after the disclosure and global expansion of the new type of coronavirus (Heinz & Stiasny, 2021). Now, an unusual number of individuals need to be vaccinated to reach herd immunity and protect the entire global community. Hence, the manufacturing and distribution of huge quantities of effective vaccines have become a critical global issue (Corey et al., 2020). According to WHO (2021), more than 200 COVID-19 vaccine candidates are in the research process as of February 2021. However, not all candidate vaccines are expected to be successful against the COVID-19 virus, and none of the suppliers has the capacity to meet the global demand alone. Hence, countries may not have a wide variety of vaccine types to choose from at first; however, their options will grow as supply increases in time. Some of these vaccine types, especially the messenger ribonucleic acid (mRNA) vaccines, must be kept at low storage temperature to maintain their freshness and efficacy. In this respect, cold chain storage and transportation become a critical issue for the safe movement of these vaccines, especially to the remote areas from the origin of production or refrigeration facilities. Cold chain logistics companies play a crucial role in the COVID-19 vaccine distribution process, and they must have certain capabilities to maintain effective, safe, and on-time delivery.

The main purpose of this paper is to provide an extensive literature review on the challenges that logistics service providers encounter during vaccine transportation and

address the prominent logistics capabilities that logistics service providers (LSPs) must focus on to maintain flawless pharmaceutical logistics operations. Each of these research questions below addresses the motivation behind this study.

- RQ 1: What are the COVID-19 vaccine distribution challenges that LSPs encounter during their logistics operations?
- RQ 2: How do LSPs eliminate these challenges and maintain effective logistics performance?
- RQ 3: How did Turkish Cargo manage to adapt its logistics operations rapidly and establish robust logistics operations?

Our main motivation is to investigate key strategic capabilities that improve operational efficiencies, such as the speed of vaccine distribution and reliable delivery. Maximizing operational efficiencies during the COVID-19 pandemic is crucial for saving millions of lives; hence air cargo companies must evaluate the current situation of their strategic capabilities to improve operational efficiencies.

The proposed research design is based on the qualitative approach, and two sources of empirical data are used: interviews and a case study. Reliable and valid research designs are obtained through extensive literature reviews. Following the extended research framework proposed by Mohr & Khan (2015), we illustrated our extended research framework in Figure 1.

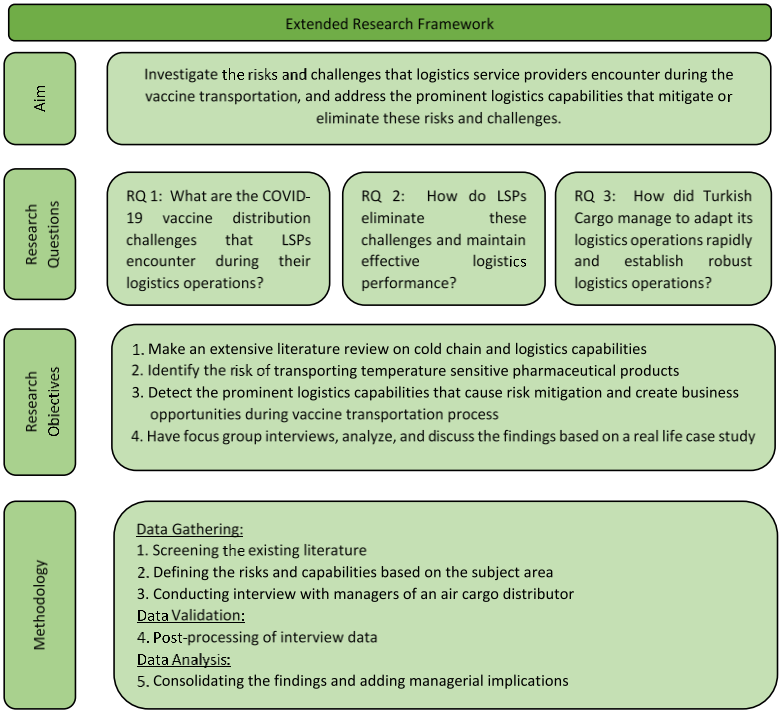

Figure 1: Extended Research Framework (adopted from Mohr & Khan, 2015)

This paper discusses cold logistics service providers, their essential cold storage and distribution capabilities, and the possible risks they encounter during COVID-19 vaccine distribution. This study is organized as follows: Section 2 reviews the cold supply chain. Section 3 presents the capabilities of cold logistics service providers and their importance during the COVID-19 vaccine distribution. Section 4 discusses the Turkish Cargo case. Section 5 discusses the implications on research and practice, while the conclusion is summarized in Section 6.

2 Cold Supply Chain

Cold chain management becomes an important aspect of supply chain management in recent years. The goods in cold chains include but are not limited to pharmaceutical products, chilled food, and frozen food. Unlike traditional supply chains, the goods that are moved by cold chains have a short shelf life, and they are more vulnerable to surrounding factors such as temperature, humidity, and lighting intensity. For this reason, the use of refrigeration and dehumidification systems throughout the entire cold chain is essential to preserve the useful life of products (Tsang et al., 2018). Cold chain logistics activities set the stage for the safe transportation of temperature-sensitive goods and products along the supply chain. The cold chain evaluates the link between temperature and perishability (ShipCalm, 2019). The frozen food industry has been growing rapidly in Ireland, and these foods require either frozen or chilled cold chains to their optimum quality (Gormley, Brennan, and Butler, 2000).

The shelf life of perishable food products is highly dependent on the temperature conditions during storage and transportation processes of supply chain operations. Lead time, optimal temperature conditions during the logistics operations, and effective monitoring of the cold chain environment are the most critical factors to ensure efficient cold chain operations (Montanari, 2008). The cold supply chain management focuses on the cost-efficient storage and transportation of temperature-sensitive products such as food, vegetables, confectionaries, flowers, and medicines (Hariga, As' ad and Shamayleh, 2017).

A cold supply chain is a branch of logistics and supply chain operations that requires a set of facilities and equipment for maintaining ideal movement conditions for goods within an optimal temperature range from the point of origin to the destination point. A cold supply chain is also named a temperature-controlled supply chain and is mostly used to transport food products. This kind of supply chain is exposed to many risks and uncertainties such as product perishability, product diversity, relatively short shelf lives, the need for multiple raw material suppliers, compulsory monitoring requirement of the supply chain operations, and large distribution network. Hence, the characteristics of the cold chain bring about the high risk of food waste, increased cost, and human health

risks due to the possible food spoilage (Tsai & Pawar, 2018). According to Montanari (2008), a cold chain is “the equipment, processes and information management used to protect chilled and frozen foods.” Saravanan & Anubama (2017. pp. 1) define a cold chain as “the transport and storage chain between the initial production and the final consumer of temperature-controlled perishable goods” or “a supply chain of perishable items.” The possibility of product spoilage and the extra operating conditions and cold chain requirements are the two main differences between traditional supply chains and cold chains. The infrastructure of a typical cold chain is given in Figure 2.

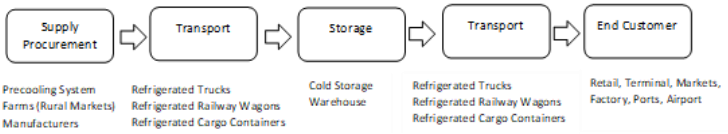

Figure 2: Infrastructure of a cold chain (adopted from Brzozowska et al., 2016)

The frozen foods or items are always maintained in the required temperature range in the production, transportation, storage, sales, and consumption periods in a cold chain logistics system to protect the food quality ad prevent food loss. Hence, a cold chain logistics system requires complex processes, higher investment, and superior management skills than conventional logistics operations (Zhou, 2021).

The spoilage or deterioration of fresh food results in essential economic losses and health problems. Hence, fresh food supply chains must set up cold chains to slow down the food decay and deal with these problems. The cold chain system requires to invest in refrigeration facilities, temperature-controlled trucks, warehouses, and retail shelves (Wang & Zhao, 2021).

The introduction of Industry 4.0 and emerging digital technologies transform conventional logistics operations into smart logistics systems. The Internet of Things and the Internet of Services (IoT & IoS), sophisticated sensor systems, and cloud-based technologies have altered the way companies perform their logistics operations and turn them into more efficient, productive, and customer-focused activities (Demir, Paksoy

and Kochan, 2020). Figure 3 depicts the operational and sensor network views of a cold supply chain for pharmaceutical products.

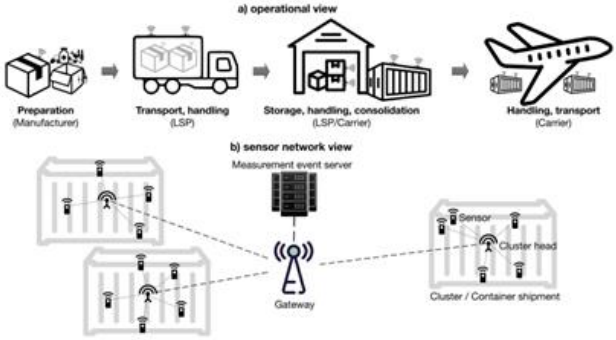

Figure 3: Operational and sensor network views of a cold pharmaceutical air SC (Konovalenko, Ludwig and Leopold, 2021)

Cold Chain Management (CCM) is the logistics management activities of perishable products such as food, medicine, blood, and flowers, which are time-sensitive and required to be kept in special storage conditions. Monitoring the logistics process is essential due to the spoilage risk of these products (Shabani, Saen and Torabipour, 2012). The real-time monitoring systems introduces several advantages to cold chain operations (Chaudhuri et al., 2018):

11. Logistics operations cost is reduced,
12. Loss of product value is minimized, and the total value of an item is maximized,
13. Optimal decision-making process is supported,
14. Quality failures/problems are identified.

Temperature change in a cold chain during storage and transportation can cause food spoilage and create risks to the consumers' health. Food shelf life and optimum quality of pharmaceuticals are affected by the immediate fluctuations in temperatures (Konovalenko, Ludwig and Leopold, 2021). Perishable products should be transported with extra attention since these products impose challenges to the cold supply chain

operations due to their nature. For instance, continuous monitoring of the transportation conditions is a critical factor that ensures the quality of products such as produce, dairy, or meat. A small deviation from the required transportation conditions can cause the lack of quality standards resulting in waste and profit loss. Furthermore, the deterioration of pharmaceuticals and other bioproducts can create harmful situations for human health (Mejjaouli & Babiceanu, 2018).

The undesired temperature conditions such as incorrect refrigeration in the cold chain cause food-borne illnesses. Temperature monitoring and control during transportation operations can help minimize the risk of food-borne illnesses since most harmful microorganisms cannot grow in cold temperatures (Rediers et al., 2009).

Products are stored and transported at very low temperatures in cold chains; hence, refrigerated warehouses and trucks are required. Large quantities of energy are used to power these refrigeration systems, and this results in high carbon dioxide (CO2) emissions and high global warming potential due to the Hydrofluorocarbon (HFC) gases used by refrigeration systems (Saif & Elhedhli, 2016). Due to rising social and environmental awareness, companies develop strategic plans to be part of the low-carbon economy, respond to global warming and maintain sustainable operations. Cold chain logistics companies should focus on balancing customer satisfaction and carbon emissions for their vehicle routing strategy to reduce the contribution to the greenhouse effect (Wang & Wen, 2020).

2.1 Cold Chain Literature Review

Babagolzadeh et al. (2020) study the impact of increasing carbon emission due to the storage and transportation processes in the cold supply chain by incorporating demand uncertainty. Bishara (2006) investigate the current practices and trends in pharmaceutical cold chain management. Dai, Wu and Si (2021) focus on the cold transportation systems and dynamic characteristics of the vaccine supply chain. Hariga, As' ad and Shamayleh (2017) study the lot sizing optimization problem of a cold chain with a single facility, distribution center, and retailer. Saif & Elhedhli (2016) formulate a mathematical model to assist the design of a cold supply chain by focusing on its economic and environmental effects. Wang & Zhao (2021) introduce an optimization

model for a cold supply chain to maximize the profit of its members. The authors focus on determining the optimal investment levels of cold chain build-up and advertisement and optimal pricing. Zhang et al. (2020) study the cold chain transportation mode selection problem in a multi-period setting with independent perishable product demands. James & James (2010) focus on the relationship between the cold chain and climatic change by reviewing the literature. The authors investigate the impact of the cold chain on global climate change and the effect of climate change on the cold chain. Shabani, Saen, and Torabipour (2012) propose a mathematical model to evaluate the performance of sales agents and select the best agent under non-discretionary factors. Chaudhuri et al. (2018) present a comprehensive literature review to analyze the data collection and decision-making processes in cold chain management. Ji & Guo (2009) study the cold chain and its security features and discuss essential food chain problems in China. The authors analyze cold chain transport security under four elements: the carriage of goods factors, transport factors, human factors, and environmental factors. Wen et al. (2019) propose a multi-criteria decision-making model for the selection problem of drug cold chain logistics suppliers from the perspective of risk aversion.

Montanari (2008) proposes structured frameworks that help decide the less costly configuration to manage a cold chain. Ferretti et al. (2018) develop a mathematical model and present a novel portable refrigerated unit to keep the goods throughout the cold chain. The performance of this refrigerated unit at the different stages of the cold chain is evaluated to understand its environmental impacts. Saravanan & Anubama (2017) study MCDM methods for selecting and ranking an alternative logistics service provider for a manufacturer that operates in the pharmaceutical industry. Singh, Gunasekaran and Kumar (2018) present a hybrid MCDM approach for selecting cold chain logistics service providers under a fuzzy setting. Li & Chen (2011) explore potential applications of RFID technology in pharmaceutical cold-chain logistics. The following section discusses the essential supply chain capabilities of LSPs for their vaccine distribution operations during the COVID-19 pandemic.

Many papers in the literature mainly focus on the operational capabilities of pharmaceutical transportation and miss the strategic and environmental capabilities such as flexibility and environmental sustainability. We include operational, strategic,

and environmental logistics capabilities to fill the gap. Furthermore, we explore the Turkish Cargo's cold chain footprint enlargement strategy and essential capabilities to introduce a real-life case study. We conduct literature reviews from Emerald, Taylor & Francis, EBSCO, ScienceDirect, and Web of Science.

3 Logistics Service Capabilities during COVID-19

The development of COVID-19 vaccination is the most critical effort to fight against the epidemic. In addition, efficient, safe, and timely delivery of the vaccines from their point of origin to the point of consumption requires a challenging effort, and it is a matter of life and death for the patients infected with the virus. The transportation processes and methods of COVID-19 vaccines are much more complex and difficult to control than regular supply chains. The transportation process in a vaccine supply chain includes storage factories, cargo stations, airplanes, and warehouses. A coordinated global strategy is vital for the delivery of vaccines. In this sense, the air cargo industries play a crucial role in realizing the fast and safe transportation of the COVID-19 vaccines (Dai, Wu, and Si, 2021).

The transportation and storage phases of the logistics operations arise the quality risk for some medicines due to the failure of providing special storage conditions. The drug cold chain logistics system is responsible for ensuring the quality of the medicines by storing and transporting them from production to the consumption point at the recommended temperature. Drug cold chain logistics is differentiated from the traditional supply chain by its characteristics such as small lot size, multi-batch process, time sensitivity, high operation costs, coordination difficulties, operation unpredictability, and process monitoring challenges. Drug cold chain logistics hold many risks and uncertainties due to its operational characteristics and equipment requirements. Hence, selecting a drug cold-chain logistics supplier with the lowest potential risk is an essential move to ensure the quality and safety of medicines and avoid business risk (Wen et al., 2019).

Pharmaceutical supply chains carry valuable and sensitive cargoes. The quality of pharmaceutical products is compromised when they are exposed to inappropriate

temperatures. Too long exposure to incorrect temperatures causes the loss of effectiveness for most medicines and vaccines. Time is an essential constraint for pharmaceutical shipments due to the possibility of spoilage and quality loss; hence air transport is the best solution compared to other modes of transportation. Pharmaceuticals are carried in cold chains to minimize quality loss. Each operator in the cold chain must install cold storage facilities and equipment and guarantee that temperature remains within the required range (Haan et al., 2013). The typical flow of goods and payment in a pharmaceutical cold supply chain is illustrated in Figure 4.

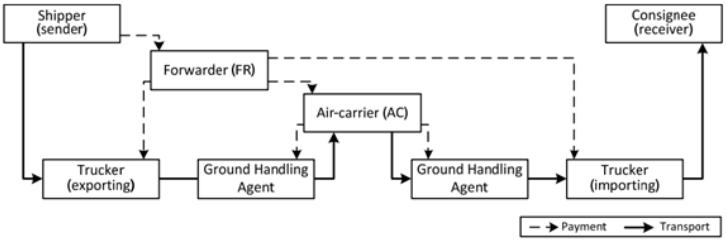

Figure 4: Flow of goods and payment in a pharmaceutical cold supply chain (Haan et al., 2013)

A typical pharmaceutical cold supply chain includes a shipper, forwarders, an air-career, truckers, ground-handling agents, and a consignee. There might be some problems among these players during the cold chain processes, such as incorrect or unnecessary storage conditions, unavailable facility or equipment, or battery problems of the temperature-controlled containers (Haan et al., 2013).

The risk of transporting temperature-sensitive pharmaceutical products can be categorized under operational, product, people, information, and execution risk.

Table 1: Risk of transporting temperature-sensitive pharmaceutical products (adapted from wto.org. 2021)

Type of Risk	Example
Operational	- Scarcity of air cargo capacity - Delayed/cancelled flights - Breakdowns in operational processes - Unsecured environment
Product	- Absence of stability data and experience of new Product development - Integrity of the product and security of doses - Lack of specialized packaging to protect product
People	- Limitations of available manpower - Lack of appropriate training and relevant knowledge
Information	- Lack of coordinated approach and information sharing - Lack of reliable document and data exchange between stakeholders and lack of full supply chain data visibility
Execution	- Lack of all-party collaboration

Type of Risk	Example
	- Broken or unstructured communication channels
	- Lack of preparedness for receiving shipments

The transportation of medical products is one of the main concerns for the pharmaceutical industry. Pharmaceutical logistics management is responsible for organizing complex operations and ensure the low-cost flow and storage of medical supplies. Medical suppliers work with 3PL providers to focus on their core business, improve logistics capability, add product value to the enterprise, and increase customer service levels. Hence, selecting a 3PL partner is of great importance for medical enterprises (Liao et al., 2020). Organizations want to focus on their core businesses in recent years.

For this reason, they establish cooperation with 3PL service providers. A 3PL service provider is an external company hired to perform some or all of the logistics activities on behalf of the employer. Some important selection criteria should be taken into consideration for the 3 PL service providers selection process. These criteria are; transportation and warehousing cost, logistic infrastructure and warehousing facilities, customer service and reliability, network management, material handling capabilities, quality control and inspection, automation of processes, innovation and effectiveness of cold chain processes, IT applications for tracking, and tracing and flexibility of processes (Singh, Gunasekaran and Kumar, 2018).

Logistics service providers must continuously improve their service operations due to the ever-changing customer requirements and harsh market environment (Chen, Fung and Yuen, 2019). Teece et al. (1997. pp. 516) define dynamic capabilities (DCs) as “the firm’s ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments.” These dynamic capabilities help companies to create, implement and protect their assets and enhance business performance in the long run (Teece, 2007). Due to the potential risks and uncertainties in cold chain transport, logistics service providers must have specific capabilities to ensure smooth and reliable

operations, especially during unexpected situations such as pandemics. Saravanan & Anubama (2017) categorize factors for the effective cold chain operations of insulin distribution into seven groups: on-time delivery, responsiveness, flexibility, price, quality, and technology. Ship ABCO (2018) correlates the quality standards in the cold chain industry with high-quality shipping requirements: shipping speed, guidelines for temperature, and compliance regulations. The selection of a cold chain logistics service provider for a pharmaceutical enterprise depends on various factors. When comparing the candidate logistics companies, some factors in their service level must be taken into consideration. These factors are consistent and reliable transportation, trusted experience, proactive best practices, security, and continuous improvement (Expak Logistics, 2018). Some of the most important capabilities for the vaccine distribution operations of cold chain service providers are given in Table 2.

Table 2: Capabilities for the vaccine distribution operations of cold chain logistics service providers

Capability	Definition	Source
Delivery Reliability	the probability of satisfying the announced delivery time	Xiao and Qi (2012)
Delivery Speed	the ability to reduce the time between order receipt and customer delivery to as close to zero as possible	Morash (2001)
Expedited Delivery	the ability to expedite shipments or partial shipments	Morash (2001)
Resilience	the ability of a supply chain to return to normal operating performance, within an acceptable period of time, after being disturbed	Brandon-Jones et al. (2014)

Capability	Definition	Source
Robustness	the ability of the supply chain to maintain its function despite internal or external disruptions	Brandon-Jones et al. (2014)
Strategic Flexibility	the ability of the organization to adapt to substantial, uncertain, and fast-occurring environmental changes that have a meaningful impact on the organization's performance	Aaker and Mascarenhas (1984)
Visibility	the ability to track the identity, location, and status of entities transiting the supply chain, captured in timely messages about events, along with the planned and actual dates/times for these events	Francis (2008)
Information Capability	the ability of a focal company to identify, utilize, and assimilate both internal and external information to facilitate the information sharing activities among supply chain partners and develop inter-organizational relational competency	Youn et al. (2014)
Widespread Distribution Coverage	the ability to achieve and serve customers effectively at a broad geographic area	Multaharju and Hallikas (2015)
Environmental Sustainability	The ability to meet the resource and services needs of current and future generations without compromising the health of the ecosystem	Morelli (2011)

Delivery reliability and delivery speed are crucial capabilities since millions of lives depend on the safe and on-time delivery of the vaccines. The transportation sector has

been disrupted because LSPs were directly affected by the COVID-19 virus. Resilient and robust supply chains have the ability to recover rapidly after the first impact of the pandemic and continue their operations amidst the pandemic. Strategic flexibility is directly associated with the efficient use of organizational resources. In case of an unexpected event, a flexible company can allocate its resources to the departments that need them most. Monitoring the processes of a cold supply chain is a vital factor due to the nature of the cargoes being transported. Hence, the visibility of a cold chain is one of the most critical capabilities, and it is an indispensable feature for successful cold chain operations. Vaccines are time and temperature-sensitive products, and they need to be delivered on time and under specified temperature ranges. Information capabilities of a cold chain service provider facilitate the dissemination of information to the stakeholders during the distribution of the vaccines. The economic and social impacts of COVID-19 are on a global scale. Since immunization efforts are required worldwide, the vaccines need to be distributed in geographically dispersed areas.

For this reason, widespread distribution coverage becomes a critical capability for a cold chain. Finally, cold chains must adopt environmentally friendly processes. For instance, integrating low global warming potential refrigerants and minimizing carbon dioxide (CO_2) emissions are essential steps that cold chain service providers must take.

4 Turkish Cargo Case

The aviation industry has a key role in delivering COVID-19 vaccines worldwide. The global distribution of vaccines and the organization of the logistics operations are complicated processes. This process becomes even harder for the vaccines that are required to be stored in freezing temperatures. Fifteen thousand flights and 15 million cooler boxes are needed to complete the transportation of 10 billion doses of vaccines. Turkish Cargo, a subsidiary of Turkish Airlines, has become one of the prominent and rapidly growing companies in the vaccine distribution business. The company strives to maintain global food, medicine, and medical product transportation without any disruption during the pandemic. The company uses wide-body passenger planes by removing seats to increase carriage capacity against high demand (Turkey News, 2020).

In November 2020, Turkish cargo carried seven containers of COVID-19 vaccines from the manufacturer country, China, to Brazil. The containers were equipped with cooling systems that keep the vaccines within the required temperature range. Turkish Cargo's cold chain is ensured by "TK Pharma" solutions designed to transport pharmaceuticals at world-class standards (Sahin, 2020). Pharmaceutical products need to be cared for with particular attention during the flight and loading/unloading and preserved carefully while being held at a cargo terminal. TK Pharma offers active and passive solutions for the transportation process of pharmaceuticals (TK Pharma, 2020).

Table 3: TK Pharma Active and Passive Solutions (TK Pharma, 2020)

Active Solutions	Active Temperature-Controlled Container	Pharmaceutical products such as vaccines, insulin, and anti-cancer drugs are carried within a specified temperature range in active temperature-controlled containers. Therefore, temperature fluctuations that might be experienced during the transportation process can be rapidly reported to the customers via a data recording system.
	Thermal Dolly	Thermal Dolly is active temperature-controlled equipment used to transfer the time and temperature-sensitive cargo from the temperature-controlled rooms at the cargo terminals to the aircraft cargo ramp or vice versa.
Passive Solutions	Single-Use Thermal Cover	The single-use thermal cover protects temperature-sensitive pharmaceutical products from the external environment by isolating the heat.

Turkish cargo has conducted 2,900 cargo transportation flights in 2020. As of February 2021, the company has carried 50,000 tons of health products and medical equipment worldwide since the beginning of the pandemic. As the vaccination ramps up in many countries, air carriers become key players in global logistics activities. As a result, Turkish Cargo has increased its global market share in medical transportation to 7.5% throughout the pandemic (Daily Sabah, 2021a).

Figure 5: Temperature-controlled containers carrying China's Sinovac COVID-19 vaccines are loaded onto a Turkish Cargo plane at Ataturk airport before departing to Brazil, in Istanbul on November 18, 2020 (Daily Sabah, 2021b)

Turkish Cargo carries UNICEF's (United Nations International Children's Emergency Fund) Covid-19 vaccines and health equipment worldwide. The company offers a unique service quality and the widest range of flight networks in the air cargo industry (Turkish Cargo, 2021). In March 2021, Turkish cargo carried 1.7 million doses of UNICEF-supplied vaccines from India to the Democratic Republic of Congo (Ergocun, 2021). Furthermore, the company carried hundreds of thousands of syringes from Barcelona, Spain, to the capital city of Tunisia, Tunis, and COVID-19 vaccines from Amsterdam to Kyiv, Tbilisi, and Amman on behalf of UNICEF. The company claims that it has the daily capacity to carrying up to 40 million doses of COVID-19 vaccines (Daily Sabah, 2021b).

From the interviews we have conducted with two officials from the upper management of Turkish Cargo, we concluded that the company's most powerful capabilities are resilience, robustness, and flexibility. At the beginning of the pandemic, the company did not lay off any employees; instead, they lower salaries in every position to reduce overall expenses. Hence, the company economizes and keeps the trained human resources needed in the future. Turkish Cargo's robust operational structure allows the company to maintain cargo operations from the beginning of the pandemic. For instance, a cargo operation was conducted with an empty passenger plane on March 20, 2020, at the beginning of the pandemic. As the number of cargo operations increases throughout the

pandemic, the company shifts workers from passenger operations to cargo operations to meet human resource needs. It was stated that some of these personnel shifts are temporary, while some others are permanent.

5 Implications for Research and Practice

This paper investigates the risks and challenges that logistics service providers encounter during vaccine transportation and addresses the prominent logistics capabilities that mitigate or eliminate these risks and challenges. These risks and challenges emerge due to the nature of the cargoes being transported; hence pharmaceutical products should be carried with additional care. The potential contribution of this paper is to identify the most prominent logistics capabilities that mitigate the risks that emerge during vaccine transportation, especially for air cargo operations.

We explore ten logistics capabilities that are essential for air cargo operations. Among these, resilience, robustness, and flexibility constitute the durability and maintenance of Turkish Cargo's air transportation operations since the beginning of the pandemic. The company managed to return to its normal operations shortly after the beginning of the pandemic with the aid of company-wide resiliency.

The suspension of national and international commercial flights harmed many airliners worldwide. Shortly after the commercial flights stopped, Turkish Cargo has started to deliver cargoes, including vaccines, with empty passenger planes. The robust operational structure of the company allows this transition in a relatively short period. The flexible working practice and job rotation help the company balance cargo operations' workload due to the high demand. Some employees are shifted from passenger service to air cargo operations, which need a higher volume of staff.

6 Conclusion

This paper discusses the essential cold chain logistics capabilities for vaccine distribution as the world is going through difficult times due to the COVID-19 pandemic. Drug cold chain logistics is a supply chain system that transports medicines from the point of origin to the consumption point by complying with the required temperature ranges necessary for keeping the quality of medicines. Since medicines and vaccines are temperature sensitive, the transportation process of these medical products must be designed meticulously. In that respect, a drug cold chain logistics service provider must possess various capabilities that create a competitive advantage and put a company forward among its competitors. Delivery reliability, delivery speed, expedited delivery, resilience, robustness, visibility, information capability, widespread distribution coverage, and environmental sustainability are among the most crucial capabilities of cold chain logistics service providers.

Delivering billions of COVID-19 vaccine doses at the right time by meeting storage conditions is the main concern of drug cold chain logistics service providers. Due to the vulnerable characteristics of medical products, the delivery speed and temperature conditions become crucial for the patient safety and quality standards of the vaccines. Turkish Cargo is one of the pioneer companies that undertakes an important responsibility in transporting Covid-19 vaccines worldwide. In addition, the company cooperates with national and international authorities for the struggle against the global pandemic. The company offers air cargo service to 127 countries and maintains operations in the biggest cities of continents (Turkish Cargo, 2020).

There are some limitations to our study. Firstly, we include only one air cargo operator in this paper. Second, the interviews are conducted with the upper management of the focus company. In future research, the researchers should include multiple companies and interviewees from upper, middle, and lower-level management. Including several international cargo companies will help us understand the role of different capabilities based on various operating conditions in different regions. Furthermore, a multi-criteria decision-making model can be proposed to select a subset of prominent logistics capabilities for adverse events such as pandemic-related supply chain disruptions.

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