Health Care: Emerging Supply Chain Solutions?

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ABSTRACT

This research study examines the supply chain for health care before, during, and after the COVID-19 pandemic. The goal is to identify changes needed for the future. The study found a need for enhanced partnerships among the private and public sectors, including those with the government, to develop a strong supply chain for the health area in the United States in advance of the next crisis. While saving money, health care providers, hospitals, and associations now recognize that the just-in-time (JIT) lean framework was detrimental to providing health care services during the pandemic. The health area recognizes the need for more supplies made in America. Yet, there is a recognition that it may be impossible or impracticable to move everything to onshore manufacturing. Finally, the research identifies the need for technological solutions that includes real-time visibility from end-to-end.

Keywords: Health care, Supply chain, Operations, Pandemic

SUPPLY CHAIN FOR HEALTH CARE: WHAT HAVE WE LEARNED?

From the beginning of the COVID-19 pandemic in early 2020, the supply chains, both in the United States and globally, were strained with a failure to meet the health care demands for gloves, masks, gowns, and other needs. The pharmaceutical supply chain also was stressed (Louissant, 2021). According to Francis et al. (2021), the earliest indications that something was amiss in the supply chain for health care occurred in February 2020, when the U.S. Food and Drug Administration began monitoring COVID-19 and became concerned about its affect on the supply chain for health care. The focus at the beginning was on the supplies for testing and equipment required to detect disease (Francis et al., 2021). The traditionally used sources of products became overburdened quickly, and manufacturers and distributors were required to put allocations into place in the attempt to distribute equitably products that were scarce (Francis et al., 2021). Reports at that time cited problems with the supply chain in the United States, including a lack of goods manufactured in the U.S. (Binder 2021). However, some believe that working in partnership with other countries will be required to ensure resilience for the supply chain (Binder 2021).

According to Hannah (2021), the focus on efficiencies for health care supply chains has made them global and leaner. While the efficiency cost the supply chain for health care in terms of resilience, especially during the COVID-19 pandemic, a black swan event occurred (Hannah 2021). According to Olivares-Aguila and Vital-Soto (2021), a black swan event is characterized by being outside regular expectations, having extreme impacts retrospectively. The COVID-19 pandemic demonstrated the fragility of the supply chain for health care, as it became characterized by shortages of crucial medical goods including personal protective equipment (PPE) (Bhaskar et al., 2020; Hannah 2021). According to Hannah (2021), these shortages led domestic manufacturers and other groups to develop new resources to supply PPE and other vital supplies. The reality was that the COVID-19 pandemic revealed the vulnerability of the supply chain for health care that already existed (Miller et al., 2020). The result of the supply chain for health care vulnerability during COVID-19 was reactive solutions that revealed the need for future planning (Miller et al., 2020).

RESEARCH OBJECTIVE AND QUESTIONS

The objective of the research in this study is to examine the condition of the supply chain for health care during the COVID-19 pandemic and to determine what changes are needed in the future.

The research questions in the present study include:
(1) What occurred in the supply chain for health care during the COVID-19 pandemic?
(2) What supply chain management changes are needed to ensure effectiveness of the future supply chain for health care?

The significance of this study is the information revealed about how the supply chain for health care can help businesses and government prepare to cope with future situations such as the COVID-19 pandemic when the supply chain becomes stressed by demand.

BACKGROUND OF THE STUDY

According to Hannah (2021), when conditions are constant in the health care industry, hospitals and other care facilities work collaboratively via a group purchasing organization with contracts with limited number of large distributors. The large distributors make purchases from wholesalers and sometimes have direct contracts with manufacturers to supply what goods and equipment are needed (Hannah, 2021). The manufacturing process supplies are generally made overseas and are shipped to the regional hubs of distributors and then delivered periodically to the individual facilities for health care (Hannah, 2021). As a result, the facilities held only enough supplies for a few days up to a week. However, when a situation such as COVID-19 arises, supply availability can become stressed (Hannah, 2021). During COVID-19, PPE was sent by caseloads globally, and there was no slack in which the supply chains could adjust, resulting in the system stretching, and then finally, snapping (Hannah, 2021).

Prices on isolation gowns grew by 2,000%, with prices on the N95 masks, produced by 3M, increasing by more than 6,000% (Hannah, 2021). In May of 2020, the estimated monthly manufacture of N95 masks reached approximately 75 million per month; however, the demand for N95 masks was nearly 300 million per month (Gereffi, 2021). By October of 2020, during the first year of COVID-19, a nonprofit survey indicated that approximately 70% of health care facilities could not get some types of PPE (Hannah, 2021). New suppliers arose to meet some of the needs, including some distillers that previously made vodka shifting production to hand sanitizer, other businesses started producing masks, and a global group of hobbyists and enthusiasts began making PPE and other health supplies (Hannah, 2021). Barriers to acquiring supplies included vendor-approval processes that were cumbersome, distant corporate offices, and rules on funding (Hannah, 2021). As a result, the demands for N95s and other health care products realized an increase of 14,302% in 2020 (LaPointe, 2021). Part of the problem was port closures and delays at ports, which are still ongoing problems (LaPointe, 2021).

METHODS

The method used for the research in the present study was the literature review method. According to Snyder (2019), research must be constructed on and related to the knowledge that exists in every discipline; however, business research, due to its rapid acceleration, is somewhat interdisciplinary and fragmented, making it challenging to stay abreast of current research, and to evaluate the evidence for particular research and for that reason, the literature review is a method that has gained in relevance. Diverse types of literature reviews exist, including narrative reviews, and for the present study, a narrative literature review is used (Snyder, 2019). The narrative review is also known as a semi-systematic literature review,which is useful when examining every published article relevant to the subject under study (Snyder, 2019). The semi-systematic review also is helpful to understand how research in an area has evolved across time, which is particularly applicable in the present study seeking to determine how the supply chain for health care can develop more resiliency as we advance past the situation with COVID-19 and associated supply chain issues. The semi-systematic review in the present study examines literature review sources published in journal articles, business, government, and other relevant publications. Boolean search term ‘AND’ was used with the following search terms:

- Supply chain for health care AND resiliency
- Supply chain for health care AND COVID-19

- Developing a Resilient Heath Care Supply Chain AND Strategies

LITERATURE REVIEW

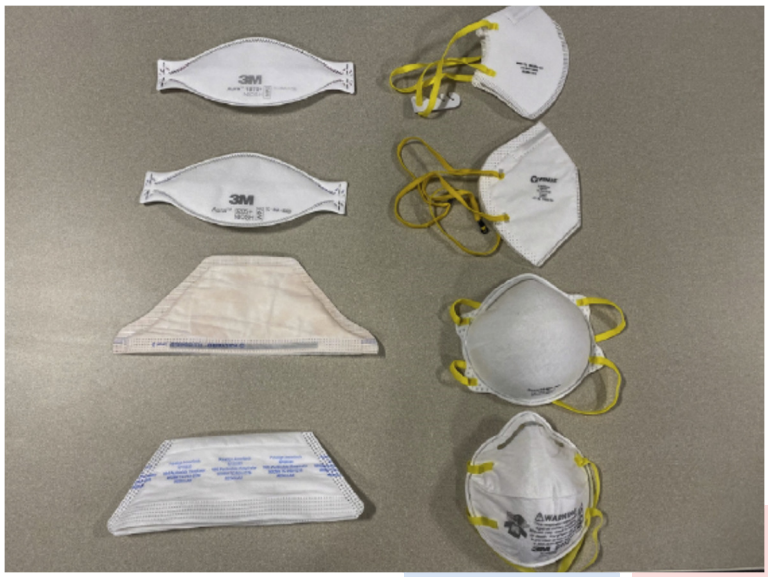
The Problems and Challenges

According to Mahmoodi et al. (2021), the COVID-19 pandemic had an effect that was extraordinary on every business and supply chain across the globe and caused a crisis in the health care system. While supply chain disruptions have occurred prior to the pandemic due to other events such as natural disasters, bankruptcy by suppliers, and others, tthe impact of the COVID-19 pandemic was different due to its length (Mahmoodi et al., 2021). An attempt was made by organizations in various industry segments to stabilize supply chains by using risk assessments and putting business continuity plans into place. Factors that resulted in the slow response of supply chains for health care during the COVID-19 pandemic were identified by Mahmoodi et al. (2021) and included : (a) chokepoints at ports and bottlenecks in trucking that resulted in critical supply deliveries being stalled; (b) a lack of a sufficient number of workers in producing and transporting products due to workers being sick or not going to work; (c) bans on exports that various countries put into place combined with stockpiling the critical supplies resulting in shortages in areas in need of the products; (d) lack of supply chain for health care resiliency attributed to companies being in pursuit of strategies that were cost-focused and resulting in supply chain redundancy; (e) a reliance on a limited number of manufacturers of products that were essential; (f) an over-reliance on offshore manufacturing for the most essential products and the raw materials to make those products; (g) a lack of transparency in assessing the centralized supply, including the U.S. Department of Health and Human Services Strategic National Stockpile; and (h) poor coordination and alignment among local, state, and federal agencies and health care organizations resulting in a fragmented approach for ordering and fulfillment (Mahmoodi et al., 2021).

Francis et al. (2021) reported that differences between the supply chain for health care and the supply chains of other industries include that the supply chain for health care has a minimal capacity to predict needs for supplies based on demand and the only accurate planning is budgetary since it is quite impossible to plan accurately for patients in an exact number treated on any given day, week, or month. Secondly, the supply chain for health care plans only on a ‘just in case’ basis instead of the exact number of needed products (Francis et al., 2021). Additionally, a need exists for transparency between suppliers and health care providers, with an absence of an ability to view the inventory and what is in transit, further complicating the capacity to ensure the availability of supplies. Moreover, suppliers are unaware of the demand level of consumers (Francis et al., 2021).

The incredible complexity involved in providing care to patients coupled with the need for devices, drugs, and products that number in the tens of thousands makes the supply chain for health care more problematic (Francis et al., 2021). The health care supply chain is complicated due to the need to accommodate each physician’s preference for specific devices or products combined with backorders, stock-outs, and recalls of products and devices, and a “high degree of interproduct variability that impedes the ability to switch between products quickly. For example, N95 masks from different vendors require user-specific fit testing and training” (Francis et al., 2021, p. 188). Figure 1 illustrates differences that exist in N95 masks.

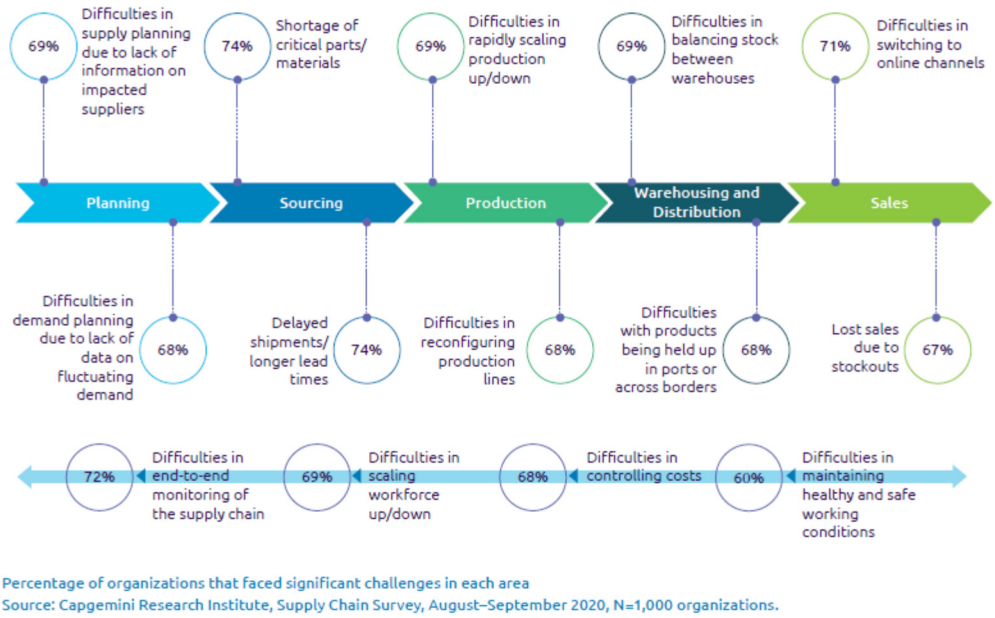
Figure 1
Differences in and Comparison of N95 Masks



(Source: Francis et al., 2021)

Finally, the supply chain for health care has difficulties associated with regulatory burdens compared to other sectors of the economy (Francis et al., 2021). Challenges that supply chains faced during the COVID-19 pandemic included those in Figure 2.

Figure 2
Challenges to Supply Chains



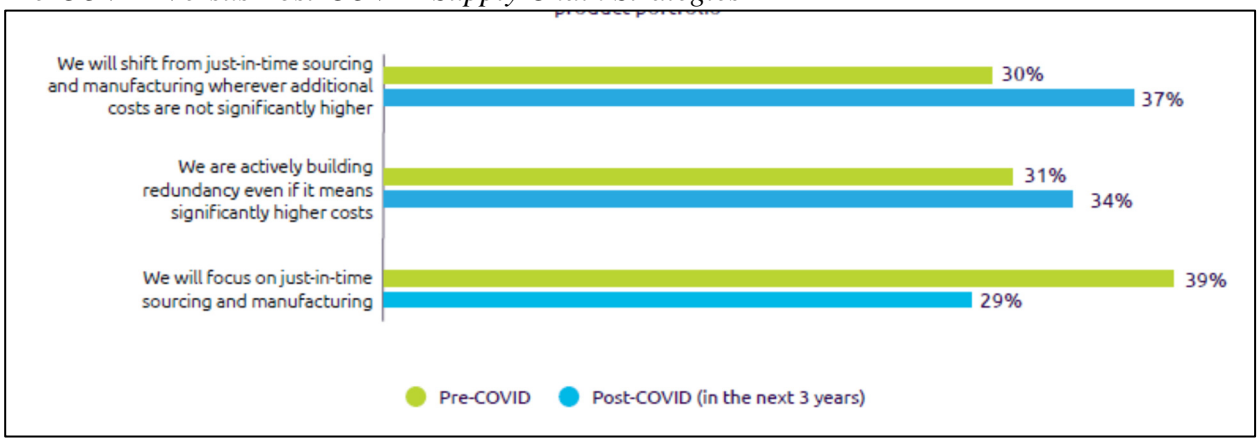
(Source: Capgemini Research Institute, 2020)

As shown in Figure 2, planning difficulties included planning for supplies as the information was lacking on suppliers and how they were impacted by fluctuations in demand. As a result, there was a critical shortage of materials and parts in the sourcing area and delayed shipments with longer lead times. In production, supply chain difficulties included the need to rapidly scale up or down production and problems with reconfiguring the production lines. In warehousing and distribution, the issues included balancing the stock between the warehouses and products stalled at borders and ports. Finally, in sales, the problems involved switching to online channels and lost sales due to items being out of stock (Capgemini Research Institute, 2020). Although Figure 2 represents companies not necessarily involved in the supply chain for health care, problems that existed across the board in the general supply chains also impacted the supply chain for health care.

Of businesses polled by Capgemini Research Institute (2020), statements in the Figure 3 revealed how they addressed issues with the supply chains going forward in comparison to their strategies before the COVID-19 pandemic.

Figure 3

Pre-COVID Versus Post-COVID Supply Chain Strategies



(Source: Capgemini Research Institute, 2020)

As shown above in Figure 3, mong the businesses polled, an increase was noted in firms that intend to shift from the use of just-in-time (JIT) sourcing and manufacturing, along with a growth in the number of businesses that are building redundancy in their supply chains, even when costs are significantly higher. The number of companies that intend to focus on JIT sourcing dramatically decreased post-COVID (Capgemini Research Institute, 2020). The American Hospital Association (2021) also recommended shifting from just-in-time supply chain practices because the lean framework fails to ensure an available buffer stock when a crisis occurs.

A governmental document (Austin et al., 2021) revealed that before the COVID-19 pandemic, the public health supply chain had vulnerabilities and points of failure that included: (a) JIT practices and no resilience mitigation; (b) disruptions to imports and exports that resulted in problems with distribution and delivery of products; (c) visibility lacking into the sub-tier suppliers, including the availability of raw materials, and the conditions of labor; (d) end-user behavior that was rigid and included problems with conserving critical items; and (e) high costs of entry into the market placing limitations on participants. Overall, the supply chain for health care lacked resiliency, with vulnerabilities existing in all areas of the supply chain (Austin et al., 2021).

Supply Chain Resilience

According to Iakovou and White (2020), supply chain resilience requires rapid detection of issues, a response to problems, and recovery from issues. Supply chain resiliency requires supply chain control that is data-driven and end-to-end, along with the integration of the supply chain, visibility, and transparency. However, those controls alone are insufficient to ensure resilience (Iakovou & White, 2020). The ability to view the progression and location of raw materials and semi-finished goods in the manufacturing process, along with where finished products are in the supply chain is necessary, beginning with suppliers who provide health care chain suppliers through to customers of the customers is vital. However, supply chain resilience must begin before any problem occurs and requires planning for scenarios (Iakovou & White, 2020). Supply chain resilience requires redundancies, including safety stocks, emergency

stockpiles, and diversification of sourcing and suppliers (Iakovou & White, 2020). However, supply chain resiliency may cost more than focusing only on operating margins and efficiencies, that can result ilean and often brittle supply chains that are offshored (Iakovou & White, 2020). The COVID-19 pandemic and disruption of the supply chain for health cares has resulted in policymakers stating that the supply chain for health care and those critical goods should return to the United States; however, others claim that a complete reshoring would not be suitable and would result in the United States being less competitive (Iakovou & White, 2020).

The government of the United States also could play a role in increasing supply chain resiliency, according to Iakovou and White (2020), by using policy interventions when it comes to supply chain mapping for supplies that are critical to the economic security and health of the population thereby identifying threats and possible vulnerabilities; investing in the national logistics infrastructure, including roads, ports, and railways; and focusing on cybersecurity, environmental sustainability, and shortages of skills among workers. The U.S. government could invest more heavily in public-private partnerships for manufacturing and ensure readiness to use the latest in technologies (Iakovou & White, 2020). According to Austin et al. (2021), *Executive Order 14001*, 'On a Sustainable Public Health Supply Chain,' sets out three specific strategic goals which are listed in Figure 4.

Figure 4

Goals of Executive Order 14001, Section 4 'On a Sustainable Public Health Supply Chain'

Goal 1: Build a diverse, agile public health supply chain and sustain long-term U.S. manufacturing capability for future pandemics;

Goal 2: Transform the U.S. Government's ability to monitor and manage the public health supply chain through stockpiles, visibility, and engagement; and,

Goal 3: Establish standards, systems, and governance to manage the supply chain and ensure fair, equitable, and effective allocation of scarce resources.

Source: Austin et al., 2021

Austin et al. (2021) noted three specific resilience elements for the public health supply chain: robustness, agility, and visibility. Each of those elements is included in Figure 5.

Figure 5

Three Specific Public Health Supply Chain Resilience Elements

Robustness	Agility	Visibility
The U.S. Government is actively mitigating the risk and severity of potential supply chain shocks to prevent shortage and disruption	*The U.S. Government is prepared to respond to shocks when they occur to limit shortage and disruption*	*The U.S. Government can monitor the supply chain against defined targets, foresee threats, and make data-informed decisions*
• Manufacturing on-/near-shoring level • Raw material and equipment on-/near-shoring level • Manufacturer multi-sourcing • Raw material and equipment supplier multi-sourcing • Supply chain security	• Stockpiling status • Warm Manufacturing capacity availability • Product standardization and simplification • Decision-making strength and readiness	• Existence of supply target(s) or targeted capabilities • Manufacturer visibility • Raw material and equipment visibility • Scenario analytics capability • Market awareness • Private-sector engagement

Source: Austin et al., 2021

As shown Figure 5, robustness involves the government working to actively mitigate the severity and risk of shocks to the supply chain toward preventing disruption and shortages, including activities of onshore or near-shoring manufacturing activities, onshore and near-shoring of equipment and raw materials, and multi-sourcing for equipment and raw materials toward building supply chain security (Austin et al., 2021).

Concerning agility, the United States government is preparing to respond to any shocks in the supply chain for health care by stockpiling, supporting manufacturing availability and capacity, standardizing and simplifying products, and using decision-making to build readiness and strength (Austin et al., 2021). Standardization of products can be helpful considering problems experienced with the lack of standardization of the N95 masks reported to have had requirements due to differences in design for training and fit specific to users (Francis et al., 2021).

Concerning visibility in the supply chain for health care, the government of the United States could assist by monitoring the supply chain regarding defining targets, being aware of foreseen threats, and making decisions informed by data (Austin et al., 2021). The government can ensure visibility with supply targets that already exist or by targeting capabilities, providing manufacturer visibility, along with equipment and raw materials. Furthermore, the government can use scenario analytics, market awareness, and engagement with private industries to increase supply chain visibility (Austin et al., 2021). However, the government cannot ensure a resilient supply chain for health care as health care organizations and stakeholders also have to work to build a supply chain's resilience.

According to Forbes (2021), the key to developing supply chain resilience is proper sourcing. Part of the problem with the breakdown in the supply chain for health care during COVID-19 were practices of China's government, which had used inspections of all suppliers of PPE and provided guidelines that they must follow to gain certification for exporting their products. The problem arose as the list of approved suppliers changed regularly, and disruptions and delays occurred (Forbes, 2021). The supply chain for health care can avoid those problems

by ensuring they are sourcing from reputable suppliers that can provide a consistent and reliable supply.

Scala and Lindsay (2021) conducted a study to examine how resilience is present in the supply chain for health care when disruptions occur and to understand readiness in the future. The average health care facility or hospital uses different kinds of equipment and supplies in the thousands representing approximately 40% of the total operating budget (Rakovska & Velinova, 2018; Scala & Lindsay, 2021). The study reported by Scala and Lindsay (2021) involved hospitals in Scotland, revealing that the hospitals had problems with sourcing products and often had to turn to alternative providers, emphasizing the need for agility and flexibility. The respondents also noted the problem with the lean supply chains in the health care industry because the demand was so high that the lean practices resulted in a disruption. Furthermore, the study participants cited the need for more supply chain redundancy (Scala & Lindsay, 2021). Ultimately, Scala and Lindsay (2021) stated that the primary findings in the study included demonstrating how strategies, such as agility, flexibility, collaboration, and redundancy, contributed to a supply chain's resilience.

The Capgemini Research Institute (2020) reported that supply chain resiliency requires the features shown in Figure 6.

Figure 6

Resiliency Factors in the Supply Chain

Source: Capgemini Research Institute, 2020

As shown in Figure 6, visibility across the entire supply network is required for resiliency in the supply chain, as is agility or the speed of response in the supply chain to changes in the environment. In addition, diversification of suppliers and modes of transportation are required, along with contingency planning or the capacity to anticipate and respond to any disruptions that occur (Capgemini Research Institute, 2020).

Al-Talib et al. (2020) examined how the Internet of Things (IoT) technology could help in building resilience in supply chains. They asserted that due to the significant advances in technology, the use of IoT, cloud computing, and big data technologies supply chain-wide present new opportunities for risk mitigation, managing complexity, and increasing transparency. Moreover, intelligent technologies support monitoring and control of production remotely and product tracking of throughout production and shipment (Al-Talib et al., 2020). The increase in visibility and collaboration using connectivity in real-time supports supply chain resilience. Al-Talib et al. (2020) stated that supply chain resilience could occur via the factors of (a) visibility, (b) flexibility, (c) control, and (d) collaboration.

Katsaliaki et al. (2021) indicated that resilience in the supply could occur by constructing long-term partnerships, using internet technology applications, and developing policies at the governmental level that serve to support flexibility. However, as noted by Kruse et al. (2016), the barriers to applying big data in health care include; (a) ragmented data f; (b) incompatible formats ; (c) heterogeneous data; (d) unstructured and raw datasets; (e) large volumes of data; (f) highly varied data; (g) lack of data transparency; (h) lack of data standardization that limits global sharing of data; and (i) issues with inaccuracies and inconsistencies, among other issues. However, the health care areas of opportunity for big data include the reduction of waste, the ability to predict epidemics early, global sharing, and others (Kruse et al., 2016). Although not mentioned explicitly by Kruse et al. (2016), the global sharing capability could be essential for ensuring resilience in the supply chain for health care.

Solutions

Various solutions have been identified in addressing the problem with the supply chain for health care. More generally, Alkire et al. (2021) recommended using an information technology infrastructure to modernize the supply chain and stated that while the pandemic was in full swing, a primary barrier to effective supply chain responses was the lack of visibility downstream to know the precise quantities of existing medical supplies that were critical and available in the United States at any given time. In addition, the lack of understanding about amounts of existing supplies were various challenges for the supply chain that included a gray market that was rampant in nature, panic buying, and hoarding (Alkire et al., 2021). The knowledge gap resulted in a failure to conserve existing supplies and speed up the manufacturing process. Therefore, lack of information about the medical products' location, production process, and inventory status resulted in a guessing game concerning the location of products in the supply chain (Alkire et al., 2021).

According to Alkire et al. (2021), three required capabilities in the interconnected data network for the medical supply chain include the first capability of coordination between public and private stakeholders in the supply chain, including distributors, manufacturers, and group purchasing organizations, with a need to work collaboratively to ensure interoperability and harmonization in the supply chain data infrastructure nationally (Alikre et al., 2021). In addition, a need exists for standardization of data to reduce ambiguity and misinterpretation, in addition to

acquiring data across the Strategic National Stockpile (SNS) that includes distributors, manufacturers, as well as within health care systems that are linked to data in real-time concerning demand (Alikre et al., 2021).

According to Alikre et al. (2021), the second required capability is automated collection techniques, which require the automated construction of on-call infrastructure. In addition, the automation of data collection and reporting support the quality and consistency of data and issues with consistency, ultimately improving the trust held toward the data. The third capability required is solid feedback mechanisms so data are timely across the supply chain (Alikre et al., 2021).

Hannah (2021) recommended documentation of equipment vetted to safeguard the quality of design and stated that the best possible solution was using digital platforms to compile information. The example was Open Source Medical Supplies (OSMS), a collaborative effort between the manufacturers of medical supplies and practitioners with a digital library listing nearly 200 designs for medical devices and PPE. Advisors vetted the designs in the medical field (Hannah, 2021). Hannah (2021) also noted the importance of identifying alternative suppliers before any significant supply chain disruption and recommended forming relationships with alternative suppliers and adding them to the approved vendor lists to ensure the ability to pivot to those alternative suppliers during events such as the pandemic. Emergency drills also should be held to test the availability of supplies (Hannah, 2021).

Mahmoodi et al. (2021) recommended constructing supply chain redundancy to prepare for incidents like the COVID-19 epidemic. They emphasized the use of technology using digital and analytics solutions in a range to improve the resiliency of the supply chain. Cloud-based platforms can enhance collaboration across all actors in the supply chain by strengthening information sharing of and assisting companies in avoiding price gouging (Mahmoodi et al., 2021). In addition, solutions, such as real-time network visibility using Blockchain, could work to integrate data across the entirety of the supply chain (Bhaskar et al., 2020; Mahmoodi et al., 2021). Mahmoodi et al. (2021) also recommended the creation of a more holistic understanding of inventory by ensuring a higher level of cooperation and information sharing that supported by alignment among all actors in the supply chain. This understanding could serve to bring about improvements and ultimately optimize the supply chain for health care that is presently so fragmented. A centralized distribution center could also align potential demands when supply is constrained to avoid excess reserves in one area and shortages in others (Mahmoodi et al., 2021). A need exists to have better visibility upstream, which can be accomplished by mapping and examining the supply network. Therefore, identifying first-tier and second-tier suppliers and their locations, as well as understanding the flow of inward bound materials and that outbound in the supply network could assist in identifying possible chokepoints (Mahmoodi et al., 2021).

Additionally, a need exists for supply base diversification. While calls have been made to restore production to the United States, this call will not occur overnight, mainly as the United States sourcing depends on China and India for approximately 90% of active pharmaceutical ingredients (Mahmoodi et al., 2021). However, dual sourcing of raw materials could improve resiliency of the supply chain for health care, and it would be possible to onshore manufacturing of medical products that are necessary, such as face shields and masks, isolation gowns, respirators, medicines used most, and gloves (Mahmoodi et al., 2021). In addition, achieving network agility could be accomplished by setting up sites for alternative manufacturing. Improved transparency and visibility are needed throughout the Strategic National Stockpile. The government should ensure that product availability is more transparent and policy

recommendations, including coordination between various actors in public and private sectors concerning health and socioeconomic activity, should be developed to support surge capacity for medical supplies. In the future, balancing the control of cost and emergency preparedness is needed in the supply chain for health care, and where traditional suppliers are not able to meet demands, other sources should be used (Mahmoodi et al., 2021).

Francis et al. (2021) recommended the development of innovative and new partnerships with suppliers and distributors to build greater resilience in the supply chain for health care, thereby supporting manufacturing of products in the United States, focusing on sourcing strategies to ensure the supply chain is secure and stabilized, and evaluating the next phase in the supply chain for health care model. Austin et al. (2021) stressed the need for the government to provide incentives to support health supplies made in America and emphasized the 'Berry Act' or the focus on manufacturing health care supplies in the United States. The U.S. Department of Health and Human Services' Centers for Medicare and Medicaid Services needs to explore possible strategies toward strengthening the domestic supply chain to stimulate resiliency and encourage health care facilities to purchase PPE and other health care supplies made domestically. In addition, the government should support United States manufacturers during quiet times to ensure those manufacturers and suppliers are available when there is another crisis (Austin et al., 2021). Finally, Austin et al. (2021) noted the importance of building a more robust Strategic National Stockpile of health care supplies while taking the opportunities available to improve supply chain visibility and data toward preventing shortages of critical health care products before they occur. Austin et al. (2021) cited that the need for maintaining visibility throughout the supply chain is of integral importance. The need to streamline coordination with the private sector is also necessary to ensure the supply chain for health care resilience (Austin et al., 2021).

DISCUSSION

The force of the COVID-19 epidemic on top of already vulnerable supply chain for health care resulted in severe disruptions and shortages of crucial medical equipment, such as PPE, isolation gowns, gloves, respirators, and other health care supplies (Mahmoodi et al., 2021; Bhaskar et al., 2020). The situation included chokepoints at ports and trucking bottlenecks, which delayed the delivery of medical supplies, a lack of workers due to sickness, and a ban on exports that were put into place by various countries. The situation became grave for health care providers and patients. The supply chain for health care was lacking in the needed resiliency to effectively respond to the problem with COVID-19 (Austin et al., 2021; Mahmoodi et al., 2021). The supply chain for health care differs from other chains because there is little ability to predict demand (Francis et al., 2021). Moreover, a lack of transparency among the health providers and suppliers resulted in the inability to view inventory and ensure product availability during the pandemic.

Lack of standardization of products, such as N95 masks, also created problems for health care providers, and regulatory burdens exacerbated the situation with identifying alternative suppliers. The just-in-time (JIT) framework used by the supply chain for health care to lower costs only aggravated the problem during the COVID-19 pandemic because of a lack of supply chain redundancy for health care, with no buffer stock available. Most recently, the American Hospital Association (2021) recommended a shift away from the JIT framework. However, the supply chain for health care not only developed problems during the COVID-19 pandemic;

already existing problems came to light (Austin et al., 2021). The issues that existed included lack of supply chain visibility end-to-end, high costs for entry into the market that limited participants, lack of resilience mitigation, and problems at the ports and in the transportation sectors (Austin et al., 2021).

However, supply chain resiliency practices can address the problems in the supply chain for health care and avert similar situations when another health care disaster occurs. In addition, implementing supply chain resilience serves to help with quickly detecting any issues that arise and responding to those issues, ultimately recovering from the problems (Iakovou & White, 2020). Developing supply chain resiliency requires supply chain control driven by data from one end of the supply to the other and throughout the entirety of the supply chain. A need exists to ensure supply chain integration in areas of visibility and transparency and have the capacity to view raw materials and goods that are semi-finished as well as finished products. However, supply chain resilience requires planning and implementation before any crisis occurs.

Scenario planning helps develop a supply chain resiliency framework (Iakovou & White, 2020). In addition, creating redundancies in the supply chain can be accomplished by ensuring emergency stockpiles and safety stocks and verifying the diversification of suppliers and sourcing. If the supply chain for health care develops resiliency, it will have to move away from the just-in-time (JIT) lean framework presently used due to the benefits of lowering costs. However, JIT is not a framework that can develop resiliency.

Public and private sector cooperation can develop resilience in the supply chain for health care (Alikre et al., 2021; Austin et al., 2021; Capgemini Research Institute, 2020; Mahmoodi et al., 2021). The factors considered important in constructing supply chain resiliency include robustness, agility, and visibility (Austin et al., 2021; Francis et al., 2021; Scala & Lindsay, 2021), product standardization (Francis et al., 2021), data-informed decision making (Austin et al., 2021), proper sourcing (Forbes, 2021), alternative providers (Scala & Lindsay, 2021), collaboration and flexibility (Scala & Lindsay, 2021), contingency planning and diversification (Capgemini Research Institute, 2020), IoT usage (Talib et al., 2020), and long-term partnerships and government level policies (Austin et al., 2021; Katsaliaki et al., 2021).

The solutions to the supply chain for health care vulnerabilities that became apparent during the COVID-19 pandemic were identified in this study, including using information technology infrastructure to modernize the supply chain for health care in advance of any future crises (Alkire et al., 2021). Ensuring supply chain visibility from one end to the other and everywhere in between is necessary so that all actors in the supply chain can see where products are at any given time. The problem with the supply chain during COVID-19 was the lack of visibility downstream to understand exact quantities of medical supplies that existed at any specific time (Alkire et al., 2021). That lack of information placed a barrier for conserving supplies that did exist. Solutions should include coordination between stakeholders, including manufacturers, distributors, and group purchasing organizations; collaboration in the supply chain on a national basis; standardization of data; ability to access all data about availability in the Strategic National Stockpile and do so in real-time. Automation of data is essential and equipment needs to be standardized . One example presented involved differences in N95 mask designs that presented difficulty due to training required for their use (Hannah, 2021). For example, using an Open Source Medical Supplies (OSMS) database could provide a solution for collaboration between manufacturers of medical supplies and practitioners.

Identification of alternative suppliers will be required and must occur before any significant supply chain disruption happens (Hannah, 2021). Identifying alternative suppliers and

adding them to the approved list of vendors is necessary to streamline moving to those suppliers during situations like the COVID-19 epidemic. Supply chain redundancy is needed and should be augmented with the uses of technology. Analytics solutions and cloud-based platforms ensure information can be readily shared with all stakeholders and implement real-time network visibility using Blockchain (Bhaskar et al., 2020; Hannah, 2021; Mahmoodi et al., 2021).

The reviewed literature revealed calls for more onshore manufacturers of medical supplies (Austin et al., 2021; Mahmoodi et al., 2021) and preparing to manufacture pharmaceutical ingredients in the United States. Public-private partnerships between stakeholders in the supply chain for health care and the government are needed. The government can support manufacturers when things are quiet to prepare for future crises. The public-private partnerships could work together to identify needs in the Strategic National Stockpile and ensure sufficient emergency buffer stock is available when crises occur (Austin et al., 2021). Finally, identifying alternative modes of transportation before any crisis is needed to ensure that health care supplies can reach the necessary destinations promptly (Al-Talib et al., 2020; Austin et al., 2020; Capgemini Research Institute, 2020).

CONCLUSION

The objective of the research in this study was to examine the condition of the supply chain for health care during the COVID-19 pandemic and to determine what changes are needed in the future in supply chain management. The research questions in the present study include those asking:

(1) What occurred in the supply chain for health care during the pandemic?

(2) What supply chain management changes are needed to ensure effectiveness of the future supply chain for health care?

The study found a need for public and private partnerships, including those with the government, to develop a resilient supply chain for the health sector in the United States ahead of the next crisis. The just-in-time (JIT) lean framework currently being used by health care providers, hospitals, and associations, while saving money, was a huge detriment to the supply of health care during the COVID-19 pandemic. Spending money is required to prepare in advance and ensure that the Strategic National Stockpile, along with the buffer stocks of hospitals and other health care organizations, are present so that health care providers are not left scrambling for PPE necessities when a health care pandemic crisis occurs. A sunstantial dependence exists on offshore manufacturing and sourcing of supplies. While it is impossible or impractical to move everything needed to onshore manufacturing, more emphasis should be placed on supplies made in America. The closing of ports during the COVID-19 pandemic resulted in supplies being in short supply. It was fortunate that companies changed their mode of operations and began producing hand sanitizer, masks, and other PPE. Finally, this study concluded that real-time visibility in supply chains from end-to-end using Blockchain, cloud, and other technological solutions is needed to ensure that all stakeholders can view supplies and their availability, delivery times, and always in the supply chain.

RECOMMENDATIONS

The research in the present study has identified several essential recommendations for the supply chain for health care as we advance, including those as follows:

(1) Move away from the just-in-time (JIT) framework toward a more resilient framework that prepares buffer stock in advance of the next crisis in health care;
(2) Implement the use of digital Blockchain, cloud, digital analytics, and other technologies to increase supply chain resilience; and
(3) Work in public-private partnerships to develop supply chain resilience strategies for health care.

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