Journal of Turkish

Operations Management

A study on supply chain applications in the health sector

Betül Mutlu[1]*, Bahar Özyörük[2]

[1] The Scientific and Technological Research Council of Turkey, Turkish Management Science Institute Gebze/Kocaeli, Turkey
e-mail: betul.mutlu@tubitak.gov.tr, ORCID No: https://orcid.org/0000-0002-6450-9223
[2] Gazi University, Faculty of Engineering, Department of Industrial Engineering, Cankaya/Ankara, Turkey,
bahar@gazi.edu.tr, ORCID No: https://orcid.org/0000-0001-5434-6697
*Corresponding author

Article Info

Article History:

Received: 08.05.2021
Revised: 17.12.2021
Accepted: 10.02.2022

Keywords:

Supply Chain,
Healthcare,
Literature Review,
Service System

Abstract

Supply chain management (SCM), which has been used in every field from the past to the present and whose contribution to both production systems and service systems is an undeniable concept, is important for systems. The concept of supply chain (SC) has made a name for itself in the production systems in the past years, and it provides efficiency, time management, customer satisfaction, coordination, etc. It has been drawing attention that SC applications are frequently used in service systems in recent years. The use of this applications, especially in service systems, will make a difference in the health sector, which serves an important purpose and is seen to be at a more important point in speed and plan compared to other sectors. Because speed is very important in the health sector from procurement decision to purchasing, from purchasing to storage, from storage to transportation of products and finally to the final consumer. The fact that the speed factor can be at the desired level requires all stakeholders to be in coordination. Ensuring the flow of information of the coordinated stakeholders through a common system is very important for the flow of material information and needs. For this reason, in this study, SCM of health industry is mentioned first. Afterwards, a comprehensive literature study was shared. Finally, the part of how this subject can be shaped in the future is discussed.

1. Introduction

Regardless of the sector the business is in, every business has a purpose of existence. The most important of these aims is to ensure the continuity of the business. Two factors are very important to ensure the continuity of the business. One of them is profitability and the other is prestige. There are policies that businesses must have and implement to ensure both profitability and prestige. Especially at this stage, businesses should be careful about customer satisfaction. Because ensuring customer satisfaction increases the percentage of customers who buy the product or service again. This then contributes to the increase in profitability and prestige.

However, customer satisfaction is not easy to achieve, especially in recent years, due to the increase in purchasing power, the existence of a competitive environment and the awareness of the service and / or product buyer, as there are too many businesses providing the same service. For this reason, it is not enough for businesses to be good in the market alone. The aforementioned business is only one insider of the supply chain. It is very significant that it ensures coordination with its stakeholders. A failure made by its stakeholders can affect all insiders of the SC. For this reason, SC and SCM is one of the issues that the business should focus on. Recently, emphasizing the importance of these concepts, it is seen that especially large-scale enterprises have made investments to stand out from their competitors, taking into account the increasing technology level for these concepts. Technologies of the

DOI: 10.56554/jtom.934939

industry 4.0 concept are at the top of these investments. For example, the internet of things is a technology that is used quite frequently in the field of logistics and provides great benefits. Likewise, cloud computing technologies that enable large volumes of data to be stored are indispensable for companies. Coordination in supply is of great importance, and in this context, the use of vertical and horizontal integration that provides integration inside and outside the company makes a great contribution.

2. Supply chain management in the healthcare sector

In general, it is possible to separate systems into production systems and service systems. The different structures of these systems from each other also differentiate the desired benefits from SCM. It is easier to use effectively in production systems, especially in mass production systems, compared to service systems. The reason for this is that the suppliers and material flows are planned according to these estimates, since the demand estimation can be made. However, this situation is a little more ambiguous in service systems. Especially when evaluated in terms of the health sector, effective management of SCM, hospital etc. Because there are more factors affecting SCM. At the same time, uncertainty prevails due to some special circumstances.

The aims of businesses in the health sector are to perform minimum cost-related transactions and operations without sacrificing quality and service level. While all these are taken into consideration, minimizing the number of patients / injured and maximizing the number of patients served for polyclinics at specified levels are among the other goals of healthcare enterprises. Speed is very important in realizing all of these. Speed includes not only the speed of the healthcare personnel, but also the speed of all members of the chain serving this sector. For example, blood, medical supplies, necessary equipment, medicine, etc. It can change of the patient's condition positively and negatively for an emergency patient. The significance of SCM in this industry is once again revealed when the event is generalized not for one patient but for all patients. In the aforementioned example, the rapid implementation of this application can be achieved by planning all these needs before in the relevant hospital or by having reliable supplier relations, which is one of the functions of SCM. The elements of SCM in the health industry are given in Figure 1.

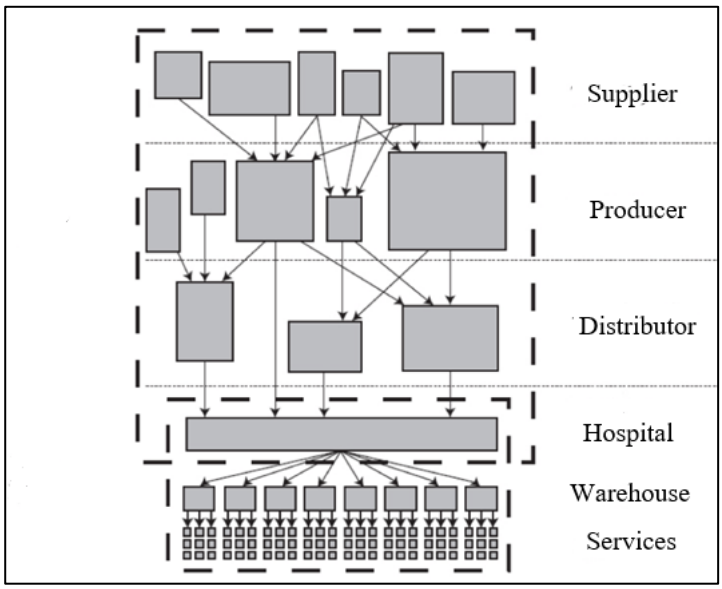

Figure 1. Supply chain elements in the health sector (Unal, 2017)

As seen in Figure 1, the structure of SCM for the health sector is a bit more complex. For this reason, more effort is made to manage this complex structure. Other reasons for the complex structure in the health sector are as follows:

- First of all, the primary purpose of the sector is to protect and improve human health,
- Variability of demand,
- The error-proof nature of the service or the urgent need for it
- Being based on excessive specialization,
- Including experts from different sectors as well as health professionals,
- High dependency of professionals from different fields of expertise
- The need for advanced cooperation are other qualities that can be considered specific to the health sector.

DOI: 10.56554/jtom.934939

Apart from all these, both intangible and concrete services are provided in the health sector. For example; While health care, which is an intangible service in the treatment of a patient, is supported by concrete products such as medicine; tangible products and intangible services are also provided in pharmacy. However, health sector SCM has some unique features. First of all, while the final product in the SC is the "basic service", the end users of the supplied materials are the doctors, nurses and other healthcare professionals who are the "internal customers" of the system (Schneller & Smeltzer, 2006).

In the same breath, the objectives of health SCM are as follows.

• To provide medical products and supplies at the right place, at the right moment, in the desired amount, under the appropriate conditions at the lowest cost,
• Trying to decrease the cost and time of medical products or supplies without sacrificing quality,
• Maximizing the space required for patient care while minimizing storage space,
• To enhance the quality of health care service,
• To decrease inventory costs as much as possible,
• To increase sustainable profitability and competitive power.

SC processes in the health sector are as follows:

• Demand management,
• Purchasing and supplier relationship management,
• Storage,
• Inventory management,
• Distribution,
• Patient relationship management
• Reverse logistics
• Green logistics

After giving general information on SCM in the health industry, it is important to procure information on important transactions regarding the sector mentioned in the subsections in order to understand the structure.

2.1.Demand forecasting and order management in healthcare

Demand forecasting in the healthcare industry is a very difficult process. For this reason, hospitals and health centers should be very careful in their policies for demand management. Although an approximate estimate is made for the materials of standard operations, the uncertain demand, especially for emergencies, forces the healthcare team and hospital personnel in this regard and causes them to make efforts to take various measures. Because many different applications and different services are offered together in hospitals and it is not possible to compensate for the problems that may occur in the service due to the lack of materials. In order to determine the demand that may occur in health services, it is necessary to know the specific features of health services and what the demands will be in the future. These features are:

• Variability
• Seasonality
• Variation
• Concurrency

By using quantitative and qualitative observations regarding demand, estimates are made for products that are used continuously, but not for each product. Placing an order after estimates, tracking and planning this order at the right time also promote the efficient realization of SCM in this sector.

2.2.Planning

Planning is one of the issues that should be focused on in the health sector as it is important in every sector. Healthcare team, administrative team, suppliers, distributors, materials and equipment, retailers, patients, in short, all members in the SC need to be planned correctly. The fact that the planning category is too much makes this situation difficult, but the creation of efficient plans greatly benefits both the hospital management and the person receiving the service. Planning activities vary according to the planning period. Ozkul and Secim (1994) give an example of the procedures to be performed in a hospital according to the planning time as follows. He explained with examples such as equipment-maintenance planning, planning of the healthcare team, weekly shift charts and monthly surgery planning in the short term; procurement of material requirements in the medium term; establishing additional facilities purchasing a tomography device, enhancing the number of operating rooms in the long term.

DOI: 10.56554/jtom.934939

2.3. Purchasing

It is one of the most significant members of SCM. Because in order to provide some services, materials, equipment, medical devices, etc. is needed. Especially in this sector, since there is a very sensitive issue such as the life of the patient and in some cases there are irreversible stages, purchasing activities should be made from the right supplier at the right time. It is important to choose the appropriate supplier to do these. In the same breath, the issue of reducing the cost by considering the mentioned issues while making the purchase is also important for the hospital management.

2.4. Inventory management

Another subject of health management is stock management. As it is known, excess stocks in enterprises bring about inventory costs. Lack of stocks can cause huge losses especially in this sector. For this reason, the use of stock tracking system in order to control the stocks of hospitals and suppliers will minimize these losses. Businesses that enable this stock tracking system to work in an integrated manner throughout the entire chain are one step ahead of their competitors

2.5. Warehouse management

Warehouse management concept is closely related to stock management. To ensure effective warehouse management, hospitals,

- Selection of warehouse location,
- Warehouse dimensions, shelf systems, stacking machines (forklifts, etc.)
- Barcode automation systems RFID,
- Product collection models,
- It is expected to pay attention to issues such as stock management.

2.6. Shipment and Distribution

After the planning and execution of all operations, the product, material, equipment, etc. It is important that things are shipped and distributed smoothly. The necessity of transporting some materials used in the health sector under certain conditions (cold storages, etc.), especially during distribution, makes this issue more important for hospital management and patients.

3. Literature research on supply chain management in the healthcare sector

SCM concept has started to be applied primarily in manufacturing enterprises. When this issue is evaluated for the health sector, it is a newer issue compared to production systems. SC applications in the health sector started with purchasing processes, and then the benefits of SCM for the manufacturing area forced the health sector to take advantage of this concept. The content of the studies of the researchers on the Helathcare Sector' SCM is claried below. In this study, studies between 2000-2020 were examined. One of the most important reasons for this is that the SC has been integrated with production systems in the past years. For this reason, there are not many studies involving hospital systems in the SC of the past years. In this study, the papers were searched in the Google Scholar database. The keywords used are: hospital supply chain, hospital supply chain management, health suppl chain, health supply chain management, medical supply chain, medical supply chain management. The studies are as follows.

Most of the studies conducted are theoretical studies on SCM for hospitals. In the first studies, studies were conducted that generally address the benefits of its application to hospitals and the difficulties encountered during the application phase. For example, Chandra and Kachkal (2004) contributed to the literature by researching the trends, problems and solutions of health sector SCM from a logistics perspective in their study. They dealt with SC decisions in the long, medium and short term, and they mentioned what decisions should be made at this stage. They discussed the sub-headings of SCM such as demand & demand forecasting, purchase order, supplier selection, logistics and management of inventory. Ford and Scanlon (2006), explained suggestions and problems related to the concept approach in purchasing operations in the health sector. Especially in the 21st century, they expressed the importance of SCM and its contribution to businesses. By comparing the health sectors and other

DOI: 10.56554/jtom.934939

sectors, the difficulties in the implementation phase of the concept approaches were mentioned by the reason of the complex structure of the health sector.

Vries and Huijsman (2011) also conducted a theoretical study on health sector's SCM. The aim of this study is to show the difference between the health sector and the industrial sectors' SCM in practice. The study shows that SCM is more difficult due to the fact that health sectors have a more complex structure contrasted with other sectors. Aronsson et al. (2011) explained what should be considered when developing an SC in healthcare and what are the effects of lean and agility concepts as process strategies for creating and developing an SC in this area. In order for these approaches to be applied correctly, they drew attention to the integrity of the SC, its integration and customer focus.

Kim and Kuwon (2015) conducted a study to reveal how SCM works in the health industry in the United States. In the study, academic studies in the last 10 years were examined in detail. However, the researchers, who stated that this situation cannot be explained only with academic studies, also revealed the SC applications in the sector. In the Yanamandra (2018) study, the benefits of supply chain applications were mentioned. It has been stated that these applications are not very common in the Health sector. A supply chain model has been developed in the health sector. Marques et al. (2020) reviewed 74 papers on supply chain management in the healthcare sector, which were published in different journals between 2006 and 2016. When the examined articles were evaluated, it was seen that the studies on the network structure, blood supply chain managemrnt were few. At the same time papers are classified by different subjects.

Some studies have mentioned the necessity of using information technologies in order to run health SC. For example, McGrath and More (2001) mentioned the inadequacy of the use of information technologies in the health sector. At the same time they mentioned the necessity of a system in which pharmaceutical data were collected. In relation to this, they took a pharmaceutical company operating in Australia and showed at what stage this company is in the SC and made recommendations for data / system integration. Kim (2005), focused on the necessity of common sharing systems regarding material planning in a hospital in his study. He drew attention to the concept of supplier management especially in terms of tracking stocks and emphasized that hospitals should benefit from technologies such as RFID for the tracking system to work effectively. Kitsiou et al. (2007) stated in their study that integration is an important building stone of health SCM, but they expressed their opinion that it is also difficult to be integrated. For this reason, the necessity of investment in information technology systems for integration in the SC was also mentioned. Finally, information on what transactions can be done when integrated is provided for each member of it.

In their study, Kritchanchai and Krichanchai (2010) talked about the advantages that hospitals gain from managing the stock of the supplier in the health sector. For this reason, they have proposed a structure in which the stock management is provided by the supplier in a new hospital established in Thailand in 2010. They revealed the differences from the traditional SC structure and mentioned the necessity of creating a common interface between the hospital and the supplier for this. At the same time, they also mentioned studies examining supplier-managed stock policy in the literature. On the other hand, Mathew et al. (2013) examined the SC of developing countries in the health industry and touched on the new trends in this area. At the same time, this study concentrates new trends to optimizing costs in healthcare SC operations.

Dev et al. (2019) proposed a framework for "Big Data Architecture", which contribute to an efficient approach in managing the SC under a dynamic platform. Researchers have visualized the arrangement of an RFID enabled and cloud ERP system for Big Data business units for a SC inventory system. RFID technology in the process, service level of resources, stock levels, setup time, idle time, etc. Ensures real-time information on various parameters related to current values are evaluated with TOPSIS, a multi-criteria decision making method, helping companies to find important key performance indicator in real time throughout the SC. Lin and Ho (2020) argued that due to the rapid development of information and communication technologies, medical supply chain management operations should also be carried out online. It is aimed to introduce the Collaborative Planning, Forecasting and Replenishment (CPFR) application model to the health sector, and in this context, the AHP technique was used to determine the critical factors.

Some studies conducted with health SCM have dealt with subheadings of the SC. For example, Puschmann and Alt (2001) mentioned customer relations management, which is a subtitle of health industry's SCM, and suggested the establishment of a CRM system to ensure an impact SCM. Important effects of the CRM system such as profitability, continuity and cost minimization in SCM in the health industry were mentioned. In the study of Dacosto-Clara (2002), the methods determined by the administrators to decrease the cost without reducing the standard of the services provided by the Quebec health center were evaluated. The methods are as follows. The first method assigns a greater budget priority for stock control, package picking, and internal distribution, so purchasing services have comparatively few resources. In the second method, contract and product order processes are applied differently from the first method with the actuation of more personnel. A preliminary analysis of

DOI: 10.56554/jtom.934939

Quebec's purchasing departments is also shown. Mustaffa and Potter (2009), mentioned stock strategies in health systems. They mentioned that the products that are kept in stock for a long time are spoiled for the companies working with stock, and the problems such as the production on time and the inability to buy the desired product at the right time by the reason of the demand uncertainty in the inventories managed by the supplier. For this reason, it has been determined that businesses that implement stockless work strategies without cost loss attach great importance to supply relations. Turhan and Vayvay (2009), mentioned that the primary aim of this SC is not only to reduce the procurement's cost and to improve cash flow, but to provide the appropriate medicine, medical supplies or special surgical materials must be at the right place at the right time. In this context, a service-based architectural structure has been proposed for supplier-managed stocks that fulfill the aforementioned objectives and decrease stock costs. Miah et al. (2014) focused on purchasing decisions in the health industry's SCM. The aim of this study is to develop a conceptual framework. It was emphasized that selection of supplier is important for the purchasing decision. A decision support system has been established for this.

Some of the researchers turned to survey studies in order to analyze the situation of hospitals working in this sector. Bhutta et al. (2006) carried out a study consisting of 651 samples in total in order to understand the situation of small and medium-sized health centers in Pakistan. In this study, 651 companies were asked questions about the sub-headings of SCM in the health industry and their answers were evaluated. As a result, it was shared that 71% of them did not perform well in SCM. Bakar et al. (2010) carried out a study to measure the SC quality of two public hospital laboratories. In the study, questions were asked to both hospitals. These questions are divided into two categories. One of them is related to the characteristics of the laboratory and the other is related to the suppliers of the hospital. The laboratories of the hospitals were compared by giving equal weight to each of the questions. As a result, 71% of them perform well in SCM. Lee and Fernando (2015) drew attention to the medical SC system. Regarding this issue, they received answers by directing the questionnaire questions to 133 companies that are part of the medical tourism sector in the Malaysian region and evaluated the results. As a result, they found that SC coordination and information sharing have a direct effect on institutive performance. Anne and Juliana (2019) conducted a study in Kenya on SC integration. The aim of the study is to analyze the effect of SC integration dimensions on the operational indicator of the hospital under study. For this purpose, questionnaire questions formed to 164 people working in the hospital examined were directed and analyzed statistically. As a result, it was explained that supplier integration, customer integration and internal integration have a significant effect on operational performance and this effect is 42.9%. Bakar et al. (2010) conducted a study to measure the SC performance of two public hospital laboratories. In the study, questions were asked to both hospitals. These questions are divided into two categories. One of them is related to the characteristics of the laboratory and the other is related to the suppliers of the hospital. The laboratories of the hospitals were compared by giving equal weight to each of the questions.

In some studies, e-commerce and e-procurement concepts have been mentioned in the health industry. For example, Holmes and Miller (2003) stated in their study that the cost in the health sector is quite high for the USA and other countries. They emphasized that the concept of e-commerce will reduce these costs by referring to the good analysis of the SC for these costs. They talked about the status of e-commerce for this sector in the future. Breen and Crawford (2005) emphasized the importance of e-commerce and e-procurement systems for the evolvement of patient SC of the health industry. They have presented their contributions to the literature by considering the hospitals working with these systems. In particular, they found that this contribution greatly benefits quality improvement and customer relationships.

Some researchers have done studies involving simulation. Unlike other studies, Rytila and Spens (2006) focused on blood supply, which is a special issue in the health sector, and established a simulation model that includes blood supply processes. For the purpose of use this SC impressively, especially due to the deteriorating nature of blood, they analyzed and shared it with the literature. Finally, they also investigated the effect of this situation on cost items. Kumar et al. (2008) discussed the situation of a group of companies with more than 10 hospitals in Singapore and branches in Europe and Asia. The findings of their study, mentioned that managers reduce their material purchases in order to provide cost minimization, and they examined the costs spent for procurement. After all these examinations, they simulated the current structure of the hospital and created a model that would benefit cost minimization and rearranged the SC.

Some researchers have emphasized the importance of the green SC and the necessity of simplification in this sector. Muduli and Barve (2012) discussed the green SC of the health industry They have focused on the necessity of waste management since health wastes that cause unwelcome effects on people and the environment are contagious and dangerous. However, they found that the obstacles in the implementation of waste management were too many and shared these difficulties with the literature. These challenges are addressed by reasons such as lack of strategic planning, poor regulatory measures, lack of green procurement regulations, waste use and reuse, lack of management unity, lack of facilities, lack of institutional regulation, financial constraints, insufficient awareness and programs on this subject, resistance to change. They have explained these challenges. Machoda et

DOI: 10.56554/jtom.934939

al. (2014) discussed the minimization of waste management's costs in the healthcare industry. For this, they turned to lean SCM. 83 studies examining lean SCM of the healthcare sector and other sectors were examined and the contribution of the issues discussed in these articles to cost and waste minimization was discussed. Afterwards, a model for the lean change process was proposed. Guimaraes and Carvalho (2013) stated in their study that there is a harmony between SCM thinking and lean thinking in healthcare services. Considering the complexity of the operations carried out in the hospital, they stated that some operations in the SC can be performed with outsourcing within the framework of a simple thought. At the same time, the researchers stated that there are very few lean practices in the health sector and that there is a gap in this area in the literature.

Some of the researchers talked about blockchain applications for counterfeit drugs in the healthcare industry. Clauson et al. (2018) stated in their studies that reliability is very important in the health sector as in every sector. They emphasized that especially human life is very important and some mistakes are not compensated, so this issue should be focused on meticulously. For this reason, they said that some precautions should be taken especially for counterfeit drugs, and they gave an example of "blockchain" applications for these measures. Blockchain applications applied in different sectors in terms of healthcare sector have been evaluated. The importance of the concept of internet of things has been emphasized in this subject. Celiz et al. (2018), put emphasis on the importance of blockchain technology in the management of procurement, which constitutes an important part of the SC in the health industry. They stated that the purchasing process is critical for this industry, and that blockchain technology contributes to the visibility and traceability of the purchasing process, and to increase flexibility in preventing counterfeit medicine purchases. Related to this, a four-layer model is presented and the results are evaluated in the study.

With some studies, they have conducted studies involving the health sector and disaster logistics. For example, VanVactor (2012) emphasized that health services required for rescue of the injured are very important in disaster logistics. At this stage, attention was drawn to the integration of the insiders in the SC, and in the same breath, the necessity of the decisions taken by the managers and the policies implemented accordingly for the rapid evacuation of the beneficial after the disaster was mentioned. A strategic level policy has been proposed for this situation. Oksuz and Satıoglu (2020), created a two stage stochastic model for the evacuation of the injured after the disaster, taking into account the triage classification. They set an example for Istanbul by working on different earthquake scenarios to validate the model. Stating that the hospital capacities were insufficient after the disaster, they drew attention to the measures to be taken in this regard.

Some researchers have contributed to the literature by using operational techniques in their studies. For example, Malmir et al. (2016) stated that the need for medical equipment is important in the hospital SC and therefore emphasized the necessity of quality management. In their work, they modeled the strategies of suppliers that meet the needs of hospitals using the Game Theory method. They simulated the learning process of medical equipment suppliers through the markov chain, and the equipment SC involved in market competition. Finally, they touched on the reward and punishment system implemented by the medical equipment SC quality management for hospitals, aiming to encourage firms to adopt high quality strategies by analyzing the action of the simulation model and calculating profits. Azadeh et al. (2016) presented an integrated approach to analyze the impact of macro ergonomics drivers in the health SC with data envelopment analysis. For this reason, health standards and macro-ergonomics drivers have been modeled with a mathematical programming method. This method can analyze the effect of macro ergonomics drivers on SCM of health industry, and this method ranks the respective performance efficiencies of each hospital SC. In the study, it was determined that the most effective factor in hospital SCM is teamwork. Additionally, the researchers believe this study will help managers identify weaknesses in SCM systems and identify target strategies for the SCM system in this area.

Nematollahi et al. (2017), handled the pharmaceutical SC structure in their studies and modeled a two-stage situation consisting of supplier, retailer and customer. While modeling, they showed that the demands were uncertain and suitable for normal distribution and thus they created a stochastic model. At the same time, researchers frequently emphasized in their studies that stochastic studies should be carried out due to the uncertain demand for the drug in the literature, but this situation was insufficient. Alizadeh et al. (2020) emphasized in their studies that the efficient envisagement of the medical SC network can reduce the dangers caused by the accumulation of waste. In this study, the medical products ordered by the customers are handled by considering biological risks. A model has been created that includes the cost of stock, sterilization and distribution areas, transportation costs, medical supplies, disposal of municipal medical waste. Yazdani et al. (2020) emphasized that medical wastes are harmful and that they should be dumped in appropriate places. For this reason, they evaluated alternative locations by using DEMATEL, in order to choose the most suitable one among alternative places.

In recent years, some of the researchers have turned to medical SC's. For example, Ferrer and Medhekar (2012) mentioned an issue that is different from other studies in their study. They focused on the factors that influence

DOI: 10.56554/jtom.934939

the global healthcare SCM. The researchers emphasized that medical services gained a global dimension in the study, which is why they stated that SCM gained momentum in this area and the SC structure of the participants became more complex. They also drew attention to the fact that this sector is one of the rare sectors that generate income for developing countries. Many factors such as low cost, government incentives and individual investment contribute to this area in countries such as Thailand, India, Singapore, Malaysia, Poland, Austria and Saudi Arabia. Researchers have likened the medical tourism service to a product within the scope of SCM, considering that many of the operational objectives found in a manufacturing SC can be easily applied to the medical tourism SC to some extent. Carmagnola et al. (2012) evaluated Italian patients in the medical tourism industry. He stated that Italian patients were receiving dental services abroad and a questionnaire study was conducted for these patients. The purpose of conducting the survey study is to understand what are the attractive factors for Italian patients to receive services abroad. On the other hand, Jaapar et al. (2017) conducted a survey to measure the profiles of patients who went to Malaysia and want to receive dental medical services, to determine their travel motivation and to measure satisfaction. Ahmadimanesh et al. (2020) have turned to the SC of dental tourism, which is a subcomponent of medical SC. Customers are grouped in their work. A working mathematical model that does not maximize profit has been developed that includes accommodation and medical centers. A case study was carried out in Iran to verify the proposed model. The researchers emphasized that there is no modeling in the studies interested in the SC in the dental industry and that this is the first modeling study in this field.

In this study, journals in google scholar and science direct were researched. The keywords used while researching are as follows: Health supply chain/management, medical supply chain/management, dental supply chain/management, hospital supply chain/management, medical tourism. In the study, only articles and papers were used and theses were excluded from the scope of the research. The aim of the study is to examine the details of the studies on the health supply chain and to identify the gaps in this area.

Table 1. Summary of supply chain studies in health sector

Author(s)	Year	Journal	Country	Subject	Method
McGrath and More	2001	34th Hawaii International Conferences	Australia	Health SC, information technologies	Case Study
Puschmann and Alt	2001	34th Hawaii International Conferences	Switzerland	Health SC, RFID	Review
Dacosto-Clara	2002	International Journal of Health Planning and Management	Canada	Health supply chain	Case Study
Holmes and Miller	2003	The First International Conference on Electronic Business	California	Health SC, e-commerce	Review
Chandra and Kachkal	2004	Proceedings of the Sixteenth Annual Society of HealthSystems Management	USA	Health SC	Review

DOI: 10.56554/jtom.934939

		Engineering Forum			
Kim	2005	International Conference on Electronic Commerce and Web Technologies	Korea	Health SC, RFID	Review
Breen and Crawford	2005	International Journal of Quality & Reliability Management	UK	Health SC, e-commerce	Review
Rytila and Spens	2006	Management Research News	Finland	Blood SC	Simulation
Bhutta et al.	2006	Supply Chain Management: An International Journal	Pakistan	Health SC	Survey Analysis
Ford and Scanlon	2006	Academy of Management Best Conference Paper	USA	Health SC, purchase	Review
Kitsiou et al.	2007	International Journal Value Chain Management	Greece	Health SC, information technologies	Review
Vanany	2008	Proceedings of The 9th Asia Pasific Industrial Engineering & Management Systems Conference	Indonesia	Health SC, RFID	Review
Kumar et al.	2008	Supply Chain Management: An International Journal	Singapore	Health SC	Survey analysis
Mustaffa and Potter	2009	Supply Chain Management: An International Journa	UK	Health SC, inventory management	Case Study

DOI: 10.56554/jtom.934939

Turhan and Vayvay	2009	European and Mediterranean Conference on Information Systems	Turkey	Health SC, information technologies	Case Study
Bakar et al.	2010	International Journal of Productivity and Performance Management	Malaysia	Health SC	Survey Analysis
Kritchanchai and Krichanchai	2010	The International Journal of Logistics Management	Thailand	Health SC, inventory, information technologies	Case Study
Vries and Huijsman	2011	Supply Chain Management: An International Journal	Netherlands	Health SC	Review
Aronsson et al	2011	Supply Chain Management: An International Journal	Sweden	Health SC, lean	Review
Muduli and Barve	2012	International Conference on Environment Science and Engieering	India	Green SC in the healthcare industry	Review
VanVactor	2012	Disaster Prevention and Management	USA	Health SC, disaster logistic	Case Study
Ferrer and Medhekar	2012	GSTF Journal on Business Review	Australia	Medical tourism	Survey Analysis
Carmagnola et al.	2012	Minerva Stomatologica	Italy	Medical tourism	Case Study
Mathew et al.	2013	Semantich Scholar	USA	Health SC	Review
Guimaraes and Carvalho	2013	Strategic Outsourcing: An International Journal	Portugal	Health SC, lean	Review

DOI: 10.56554/jtom.934939

Machoda et al.	2014	Independent Journal Of Management & Production	Brazil	Health SC, medical waste management	Case Study
Miah et al.	2014	Operations And Supply Chain Management	Australia	Health SC, purchase	Review
Lin and Ho	2014	Production Planning & Control	Taiwan	Medical SCM	AHP
Lee and Fernando	2015	Tourism Management	Malaysia	Medical SC	Case Study
Kim and Kuwon	2015	Management Review: An International Journal	USA	Health SC	Review
Malmir et al.	2016	6th International Conference on Information Systems, Logistics and Supply Chain	Iran	Health SC	Case Study
Azadeh et al.	2016	Applied Ergonomics	Iran	Health SC	Case Study
Nematollahi et al.	2017	Journal of Cleaner Production	Iran	Health SC	Case Study
Jaapar et al.	2017	Tourism Management	Malaysia	Medical tourism	Case Study
Clauson et al	2018	Blockchain in Healthcare Today	USA	Health SC, blokchain	Review
Celiz et al.	2018	IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference	Peru	Health SC, internet of things	Review
Yanamandra	2018	Supply Chain Forum: An	United Arab Emirates	Health SC	Review

DOI: 10.56554/jtom.934939

		International Journal			
Dev et al.	2019	Computers & Industrial Engineering	India	Health SC, RFID	Review
Anne and Juliana	2019	International Journal Of Research In Business And Social Science	Kenya	Health SC	Case Study
Oksuz and Satioglu	2020	International Journal of Disaster Risk Reduction	Turkey	Health SC, disaster logistic	Case Study
Alizadeh et al.	2020	Computers & Industrial Engineering	Iran	Health SC, biological risks	Case Study
Yazdani et al.	2020	Computers & Industrial Engineering	Spain	Health SC, medical waste management	Case Study
Ahmadimanesh et al.	2020	Tourism Management	Iran	Medical tourism	Case Study
Marques et al.	2020	Production Planning & Control	Brasil	Health SCM	Review

In Table 1, the studies described in the text of the health SC are summarized according to their subject and method. When the studies in the literature are evaluated, the following results emerge.

• Studies in the health sector on SCM are not as old as production systems.
•Although most of the studies are theoretical, they have been observed in recent years in practical studies. However, it is noteworthy that the application-oriented studies are generally survey studies.
• It has been observed that studies on mathematical modeling in this area are less than other studies. At the same time, the insufficiency of stochastic studies has been emphasized in the literature due to the uncertainty of demand in the health sector.
• When the studies are evaluated on a yearly basis, the integration of information technologies with the SC is generally mentioned every year. One of the most important reasons for this can be explained as the increase in need with the developing technology level.
• Another issue in the health sector is the importance of lean SC. However, the researchers determined that this issue is gap in the literature.
• The damages of medical wastes are included in the health sector. In this regard, it has been determined that models including mathematical modeling are insufficient.
• At the same time, medical tourism is one of the trending topics in recent years and there are very few studies in this area involving mathematical models.

Considering the evaluations, it has been determined that some studies in the literature are insufficient in number. Research in this field will contribute to the literature and will guide businesses in countries.

In addition to these, the distribution of the examined papers according to their subjects is shown in the graphic below.

DOI: 10.56554/jtom.934939

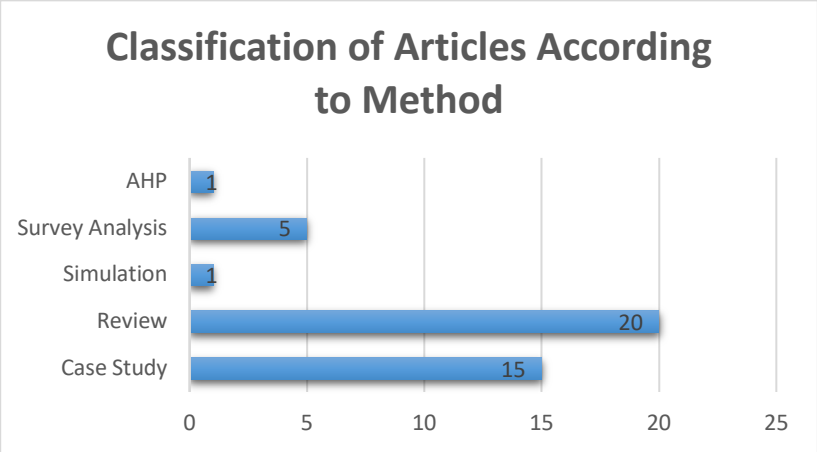

Figure 2. Classification of Articles According to Method

The distribution of the examined papers according to the journals is shown in the graphic below. As can be seen in the graph, there are mostly papers in the Supply Chain Management: An International Journal.

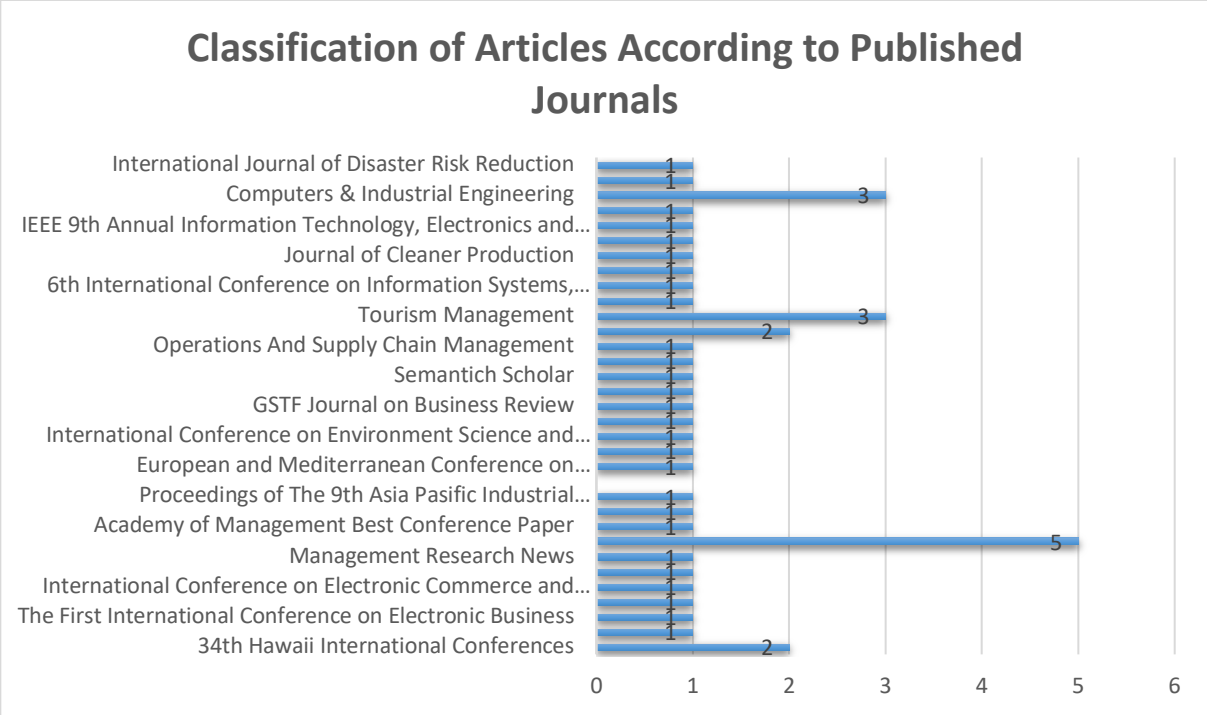

Figure 3. Classification of Articles According to Published Journals

The distribution of the publication dates of the papers is as follows. The year in which the researched papers were published the most was 2020. This shows that the interest in health supply chains is increasing.

DOI: 10.56554/jtom.934939

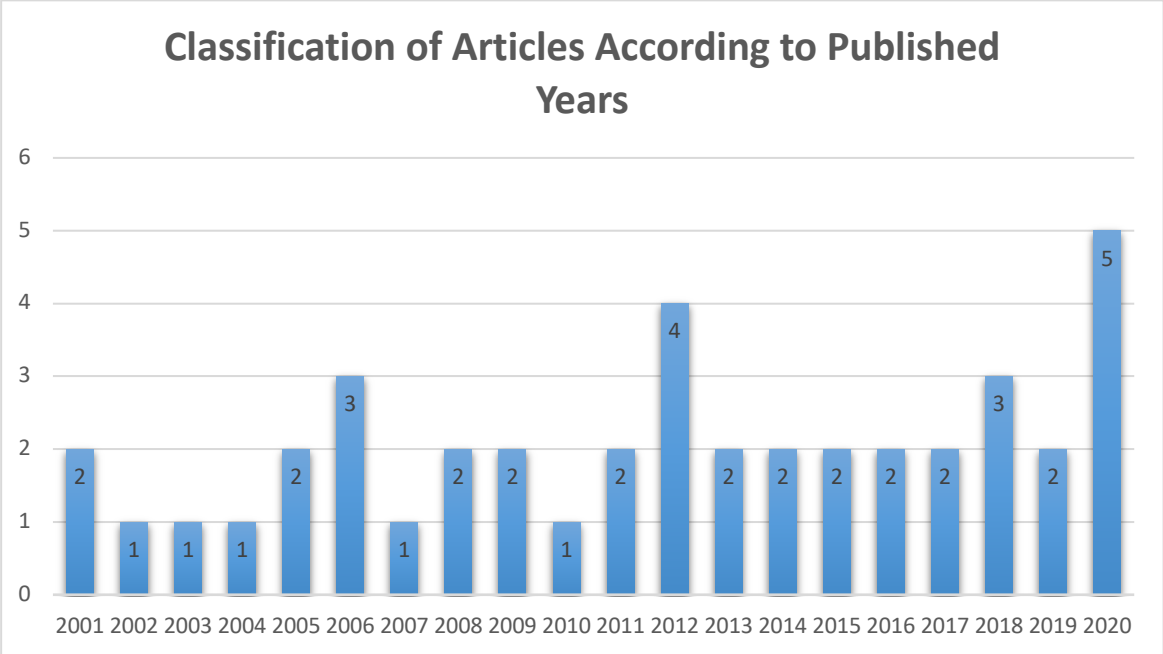

Figure 4. Classification of Articles According to Published Years

The distribution of the countries in which the papers are published is as follows. The country that publishes the most on health supply chain is the USA.

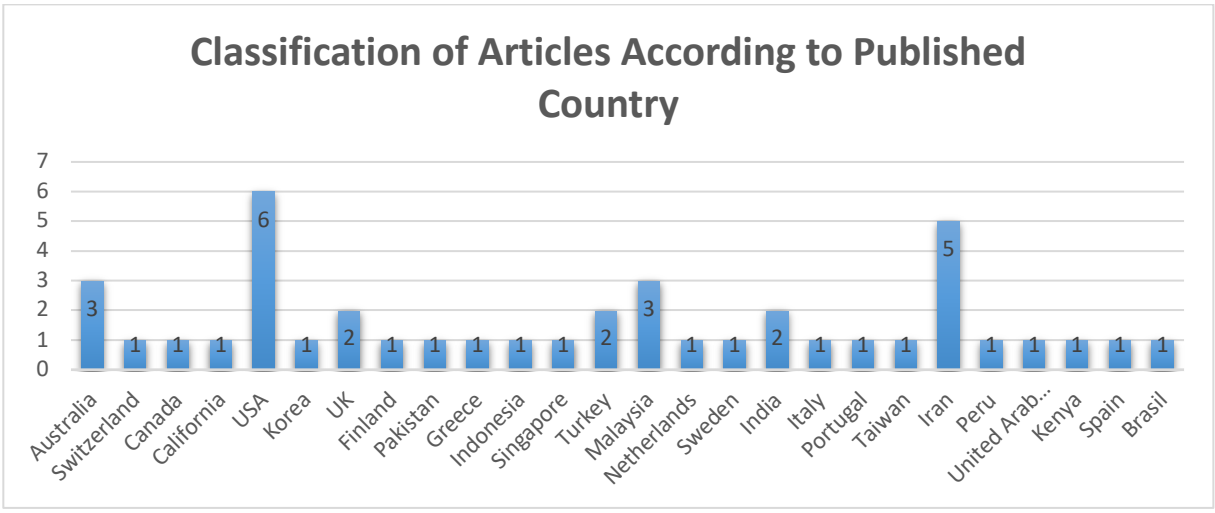

Figure 5. Classification of Articles According to Published Country

4. Conclusion

The contribution of SC for businesses is undeniable. In this study, the issue of SC management in the health industry is mentioned. When the needs in the health industry are evaluated, it will be understood how important the effect of SC applications is.

All changes in the technology level from past to present have revealed the necessity of businesses to invest in information technologies. Investments should also be made in the health sector in this regard. In this way, simultaneous data flow will be possible by ensuring integration between supplier members. This situation provides increase in speed, decrease in cost and patient satisfaction.

DOI: 10.56554/jtom.934939

In recent years, especially where medical treatment costs are high, patients aim to reduce their costs by choosing different countries for treatment. Studies on the mentioned subject are also included in this study.

As a result, studies conducted in this field in the literature were investigated in detail within the scope of this study and evaluated from different angles. Studies in the health sector on SCM are not as old as production systems. Although most of the studies are theoretical, they have been observed in recent years in practical studies. However, it is noteworthy that the application-oriented studies are generally survey studies. It has been observed that studies on mathematical modeling in this area are less than other studies. At the same time, the insufficiency of stochastic studies has been emphasized in the literature due to the uncertainty of demand in the health sector. When the studies are evaluated on a yearly basis, the integration of information technologies with the SC is generally mentioned every year. One of the most important reasons for this can be explained as the increase in need with the developing technology level. Another issue in the health sector is the importance of lean SC. However, the researchers determined that this issue is gap in the literature. The damages of medical wastes are included in the health sector. In this regard, it has been determined that models including mathematical modeling are insufficient. At the same time, medical tourism is one of the trending topics in recent years and there are very few studies in this area involving mathematical models. As a result of the evaluations, deficiencies in this area have been revealed in the literature. These issues will be discussed in the future.

Contribution of Researchers

The present work was established by the authors only without any other contributors.

Conflicts of Interest

The authors declared that there is no conflict of interest.

References

Ahmadimanesh, F., Paydar, M.M. & Asadi-Gangraj, E. (2020). Designing a mathematical model for dental tourism supply chain. *Tourism Management* 75, 404–417. doi: https://doi.org/10.1016/j.tourman.2019.06.001

Alizadeh, M., Makuia, A. & Paydar, M.M. (2020). Forward and reverse supply chain network design for consumer medical supplies considering biological risk. *Computers & Industrial Engineering,* 140, 1-16. doi: https://doi.org/10.1016/j.cie.2019.106229

Azadeh, A., Haghighi, S.M., Gaeini, Z. & Shabanpour, N. (2016). Optimization of healthcare supply chain in context of macroergonomics factors by a unique mathematical programming approach. *Applied Ergonomics,* 55, 46-55. doi: https://doi.org/10.1016/j.apergo.2016.01.002

Bakar, A., Hakim, L., Chong, S. & Lin, B. (2010). Measuring supply chain performance among public hospital laboratories. *International Journal of Productivity and Performance Management,* 59 (1), 75-97. doi: https://doi.org/10.1108/17410401011006121

Bhutta, S., Rana, I. & Asad, U. (2006). SCM Practices and the health of the SMEs in Pakistan. *Supply Chain Management: An Internation Journal*, 12(6), 412-422. doi: https://+doi.org/10.1108/13598540710826344

Breen, L. & Crawford, H. (2005). Improving the pharmaceutical supply chain. *International Journal of Quality & Reliability Management,* 22(6), 572-590. doi: https://doi.org/10.1108/02656710510604890

Carmagnola, D., Filippucci, L., Celestino, S., Carrassi, A., Delia, S. & Lodi, G. (2012). A survey on the experience with dental tourism in a sample of Italian patients. *Minerva Stomatologica*, 61(2), 11-20. Retrieved from: https://pubmed.ncbi.nlm.nih.gov/22274306/

Celiz, C., Cruz, Y. & Sanchez, D.M. (2018). Cloud model for purchase management in health sector of Peru based on IoT and blockchain. *IEEE Explore*, 328-334. doi: https://doi.org/10.1109/IEMCON.2018.8615063.

Chandra, C. and Kachhal, S. K. (2004). Managing health care supply chain: trends, issues, and solutions from a logistics perspective. *Proceedings of the Sixteenth Annual Society of HealthSystems Management Engineering*

DOI: 10.56554/jtom.934939

Forum, 20–21. Retrieved from: //www.semanticscholar.org/paper/MANAGING-HEALTH-CARE-SUPPLY-CHAIN-%3A-TRENDS-%2C-ISSUES-Chandra- Kachhal/87167bb04182279302b1b97d3e52bcb687f0f27c

Clauson, K. A., Breeden, E. A., Davidson, C. & Mackey, T. K. (2018). Leveraging blockchain technology to enhance supply chain management in healthcare: An Exploration of Challenges and Opportunities in the Health Supply Chain. *Blockchain in Healthcare Today*, 1-12. doi: https://doi.org/10.30953/bhty.v1.20.

Dacasto-Claro, I. (2002). The performance of material management in health care organizations. *International Journal of Helath Planning and Management*, 17(1), 69-85. doi: https://doi.org/10.1002/hpm.653

Dev, N. K., Shankar, R., Guptac, R. & Dong, J. (2019). Multi-criteria evaluation of real-time key performance indicators of supply chain with consideration of big data architecture. *Computers & Industrial Engineering* 128, 1076–1087. doi: https://doi.org/10.1016/j.cie.2018.04.012

Ferrer, M. & Medhekar, A. (2012). The factors impacting on the management of global medical tourism service supply chain. *GSTF Journal on Business Review,* 2(2), 206-211. doi: https://doi.org/10.5176/2010-4804_2.2.204

Ford, E. W. & Scanlon, D. P. (2006). Promise and problems with supply chain management approaches to health care purchasing. *Academy of Management Annual Meeting Proceedings*, 1-6. doi: https://doi.org/10.5465/AMBPP.2006.27161719

Guimaraes, C. M. & Carvalho J. C. (2013). Strategic outsourcing: a lean tool of healthcare supply chain management. *Strategic Outsourcing: An International Journal,* 6(2), 138-166. doi: https://doi.org/10.1108/SO-11-2011-0035

Holmes, S.Z. & Miller, R. (2003). The strategic role of e-commerce in the supply chain of the health care industry. *International Journal of Services Technology and Management*, 4, 507-517. doi: https://doi.org/10.1504/IJSTM.2003.003629

Jaapar, M., Musa, G., Moghavvemi, S. & Saub, R. (2017). Dental tourism: Examining tourist profiles, motivation and satisfaction. *Tourism Management*, *61*, 538–552. doi: https://doi.org/10.1016/j.tourman.2017.02.023

Kim D. (2005). An integrated supply chain management system: A case study in healthcare sector. *International Conference on Electronic Commerce and Web Technologies*, 218-227. doi: https://doi.org/10.1007/11545163_22

Kitsiou, S., Matopoulos, A., Manthou, V. & Vlachopoulou, M. (2007). Evaluation of integration technology approaches in the healthcare supply chain. *International Journal of Value Chain Management, 1(4)*, 325-343. doi: https://doi.org/10.1504/IJVCM.2007.015091

Kritchanchai, D. & Krichanchai, S. (2010). An adoption of vendor managed inventory in Thailand healthcare industry. *Semantich Scholar*, 1-9. Retrieved from: https://www.researchgate.net/publication/301891301

Kumar, A., Özdamar, L. & Zhang, C.N. (2008). Supply chain redesign in the healthcare industry of Singapore. *Supply Chain Management: An International Journal,* 13(2), 95–103. doi: https://doi.org/10.1108/13598540810860930

Lin, R. and Ho, P. (2014). The study of CPFR implementation model in medical SCM of Taiwan. Production Planning & Control, 25 (3), 260–271. doi: http://dx.doi.org/10.1080/09537287.2012.673646

Machoda, M.L., Scavarda, A. & Vaccaro, G. (2014). Lean healthcare supply chain management: Minimizing waste and costs. *Independent Journal of Management & Production,* 5(4), 1071-1088. doi: https://doi.org/10.14807/ijmp.v5i4.245

Malmir, B., Dehghani, S., Jahantigh, F. F. & Najjartabar, M. (2016). A New Model for Supply Chain Quality Management of Hospital Medical Equipment through Game Theory. *Sixth International Conference on Information Systems, Logistics and Supply Chain*, 1-9. Retrieved from: https://www.researchgate.net/publication/303876132

DOI: 10.56554/jtom.934939

Marques, L., Martins, M. and Araújo, C. (2020). The healthcare supply network: current state of the literature and research opportunities. Production Planning & Control, 31(7), 590–609. doi: https://doi.org/10.1080/09537287.2019.1663451

Mathew, J., John, J. & Kumar, S. (2013). New Trends in Healthcare Supply Chain, *Semantich Scholar*, 1-10. Retrieved from: https://www.semanticscholar.org/paper/New-Trends-in-Healthcare-Supply-chain-Mathew-John/b5c1803e7c5ea48550af03a1c479c555b2381bb7

McGrath, G.M., More, E. (2011). Data Integration Along the Healthcare Supply Chain: The Pharmaceutical Extranet Gateway Project, *Proceedings of the 34th Hawaii International Conference on System Science*, 1-8. Retrieved from: https://www.researchgate.net/publication/232623201

Miah, S.J., Ahsan, K. & Msimangira, A. B. (2014). An approach of purchasing decision support in healthcare supply chain management. *Operations and Supply Chain Management*, *6(2)*, 43-53. doi: https://doi.org/10.31387/oscm0140087

Muduli, K. & Barve A. (2012). Challenges to waste management practices in Indian health care sector. *2012 International Conference on Environment Science and Engieering, 32(1)*, 62-67. Retrieved from: http://ipcbee.com/vol32/011-ICESE2012-D035.pdf

Mustaffa, N.H. & Potter, A. (2009). Healthcare supply chain management in Malaysia: A case study. *Supply Chain Management: An International Journal, 14(3)*, 234–243. doi: https://doi.org/10.1108/13598540910954575

Nematollahi, M., Hosseini-Motlagh, S. M. & Heydari, J. (2017). Economic and social collaborative decision-making on visit interval and service level in a two-echelon pharmaceutical supply chain. *Journal of Cleaner Production, 142*, 3956-3969. https://doi.org/10.1016/j.jclepro.2016.10.062

Oksuz, M. K. & Sataglu, S. (2020). A two-stage stochastic model for location planning of temporary medical centers for disaster response. *International Journal of Disaster Risk Reduction*, 44, 1-13. doi: https://doi.org/10.1016/j.ijdrr.2019.101426

Ozkul A. E., Secim, H. (1994). Sağlık Sistemleri Planlama ve Kontrolü, *Anadolu Ünviversitesi Yayınları, 819*, 176.

Puschmann, T. & Alt, R. (2001). Customer relationship management in the pharmaceutical industry. *Proceedings of the 34th Hawaii International Conference on System Sciences*, 1-9. doi: https://doi.org/10.1109/HICSS.2001.927051.

Rytila, J.S. & Spens, K. M. (2006). Using simulation to increase efficiency in blood supply chains. *Management Research News*, *29(12)*, 801-819. doi: https://doi.org/10.1108/01409170610717826

Schneller, E. S. & Smeltzer, L. R. (2006). Strategic management of the health care supply chain. Wiley&Sons, USA.

Turhan, S.N. & Vayvay, Ö. (2009). Modeling of VMI implementation via SOA in a healthcare supply chain. *European and Mediterranean Conference on Information Systems*, 1-14. Retrieved from: : https://www.researchgate.net/publication/237702861

Unal, A. (2017). Sağlık Sektöründe Tedarik Zinciri Unsurları. Retrieved from: https://satinalmadergisi.com/?s=+sa%C4%9Fl%C4%B1k+sekt%C3%B6r%C3%BCnde+tedarik+zinciri+unsurlar%C4%B1

Vanvactor, J. D. (2012). Strategic health care logistics planning in emergency management. *Disaster Prevention and Management,* 21(3), 299-309. doi: https://doi.org/10.1108/09653561211234480

Vries, J. & Huijsman, R. (2011). Supply chain management in health services: An overview. *Supply Chain Management: An International Journal 16(3)*, 159-165. doi: https://doi.org/10.1108/13598541111127146

DOI: 10.56554/jtom.934939

Yazdani, M., Tavanab, M., Pamučard, D. & Chatterjee, P. (2020). A rough based multi-criteria evaluation method for healthcare waste disposal location decisions. *Computers & Industrial Engineering, 143*, 1-25. doi: https://doi.org/10.1016/j.cie.2020.106394

DOI: 10.56554/jtom.934939