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Logistics in healthcare: a selected review of literature from 2010 to 2022

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Abstract

In recent years, healthcare systems have faced problems procuring medicines, and medical materials, cooperation with suppliers, rising costs, and disposal of medical waste. One of the health system's goals is optimisation without reducing the quality of service for the patient. Supply chain and logistics, a scientific and economic activity that optimises supply, storage, inventory management, transportation, demand forecasting, and distribution, have played a significant role in optimising the health system in the last few years. Motivated by the recent pandemic of COVID 19 and resulting supply, storage and inventory problems, a review of selected scientific literature available on scientific databases ScienceDirect of Elsevier and Web of Science of Clarivate Analytics was conducted. Scientific literature dealing with medical waste and connected logistic activities were included in the review. A growing trend of research in this field has been perceived in the last three years, thus proving that the real healthcare sector is becoming aware of logistics problems and their importance.

Keywords: Public services; Healthcare system; Supply chain; Logistic; Waste management; Literature review.

1. Introduction

Logistics concepts as the coordination of a complex operation involving many people, facilities, or supplies are increasingly finding their application in a healthcare system. This can be seen in the growth of scientific research published in recent years. The recent pandemic of COVID-19 has shown all the shortcomings of healthcare systems and associated logistics concepts. Nowadays, efficient and sustainable healthcare systems have become an important goal of all governments. The healthcare system is mainly a public system, financed by government's money and under its jurisdiction. To evaluate the performance of their healthcare system, States institutions publish statistical data and information. As stated by Forde I. et al. (2013) and Medin et al. (2013.), those data identify problems in the healthcare system and rank the healthcare institutions. Healthcare management systems incorporate health institutions' operational activities, planning, and capacity. Implemented inventory systems, demand forecasting, resource allocation, waste handling and disposing of systems, and capacity planning, mostly

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correspond to the actions of implemented logistics concept. So, bottlenecks in the healthcare system are inevitable if a poor logistics concept is executed or it is not improved over time. Even before the COVID-19 pandemic, authors Sahin and Mata (2015) referred that healthcare services are becoming increasingly crucial due to the high demand and higher financial expenditures for their implementation and quality.

The healthcare industry is under constant pressure from current demographic development, politics and public to increase service levels and decrease escalating costs. One of the most critical institutions in the healthcare system in the hospital. Hospitals usually consist of different sections (department or unit) like pharmacy, operating rooms, intensive care, emergency unit, infectious diseases, surgery, orthopaedics, transfusion, hospital kitchen, and other departments, where patients are provided with services such as control and diagnosis, drug treatment, critical care, operations and other. Due to the large capacity of accommodation units for patients needed, many employees, and many health services provided there, implementing a sustainable logistic concept in hospitals is indispensable. In each department, logistic processes necessary for the overall functioning of the hospital are performed, as stated by Saha and Pradip (2019). Logistics activities in the hospital are often performed by medical staff, which thus takes up part of their time devoted to patient care.

As stated, the healthcare system is mainly funded by the government, thus aspire lower costs with a high-quality service level. Volland et al. (2017) identified that hospitals account for 29% of total healthcare expenditure at national levels and that of all hospital costs, more than 30% are related to logistics activities. This makes logistic activities costs the second largest after the cost of medical staff. That is why optimising hospital logistics and logistics in the entire healthcare system is considered significant by the academic community and the real sector. Studies from Norway, Finland, Denmark, Sweden, France, Australia, and the United States, which were carried out from 1996 to 2012 by Medin et al. (2013) and Häkkinen et al. (2013), showed that optimisation of logistic activities could reduce material and finance costs, significantly increase productivity, reduce returns and other. Burns et al. (2002) and Moon (2004) have identified several factors that lead to poor application of known supply chain techniques in health care, such as regulatory issues, outdated information technologies (IT), poor inventory and distribution management, lack of management involvement, no culture of process improvement, etc. When examining recently published scientific papers, similar factors can be identified.

In recent years, several authors have contributed to reviewing the literature on hospital logistics. Volland et al. (2017.) reviewed relevant literature on handling physical products in hospitals, such as medical equipment, medicines, medical supplies, food, sterile items, laundry, surgical supplies, and waste. Ageron et al. (2018) state that the logistics function in hospital system management is getting an important place in the last 15 years and that inventory management, information management and warehouse technology for storing goods are the most important criteria for improving efficiency in hospitals. Moons et al. (2018) studied the literature on hospitals' internal supply chain to define performance measures for hospitals' supply chain, while Dixta et al. (2019) did the same but extended the scope to the entire healthcare supply chain. In addition to the issues already identified by other authors, they recognised issues such as lean and agile operations and the use of information technology, tracking and visibility of medical drug flows, supply management cold chains and risk management. A selected literature review in scientific databases was conducted to contribute to the scientific research in the healthcare logistics field. The main goal was to identify scientific trends and quantify article types and scientific fields dealing with logistics issues in healthcare. A critical review of published work is not undertaken in detail, as our aim was to provide a general overview of research in this area. Many papers have been studied, many more than are indicated here. Health care logistical issues are published in a variety of academic fields and journals that are not the primary focus of our interest and which we may have omitted from this review. Since we focused primarily on publications in the technical field, we used the search philtres in the databases to differentiate the research field. Research is presented in five chapters. After introductory considerations, the applied methodology is described. The following section presents research results in tables and graphs with the respective explanations. The paper concludes with a results summary and a brief discussion.

2. The methodology of research

From 1st February and 1st May 2022, an extensive search of scientific databases, ScienceDirect of Elsevier and Web of Science (WoS) of Clarivate Analytics was made. These databases were chosen because journals, proceedings, and books are considered the most reliable source of scientific knowledge in the academic and research community. Due to the high selection criteria, these databases are highly valued and are often used not only in the research process but also to judge scientific productivity. The publishing period in research is taken from 2010 till May 2022. The steps in this research are shown in Figure 1.

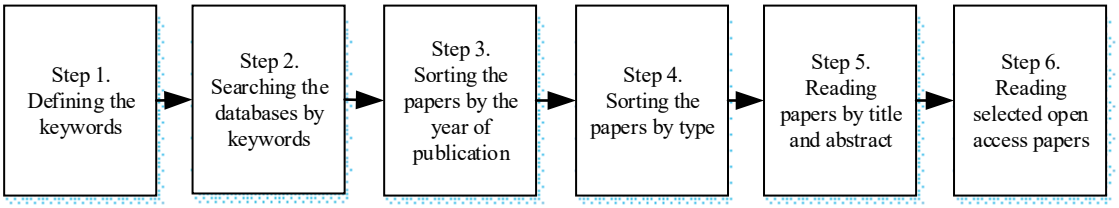

Fig. 1. Steps in research.

The first keywords used in this search were Public services AND Supply Chain OR Logistics. After that, a keyword Healthcare search was made from the results. At the end of the obtained results, the keyword Waste management was included in the search. Analysed set of research results by keywords is presented in Figure 2.

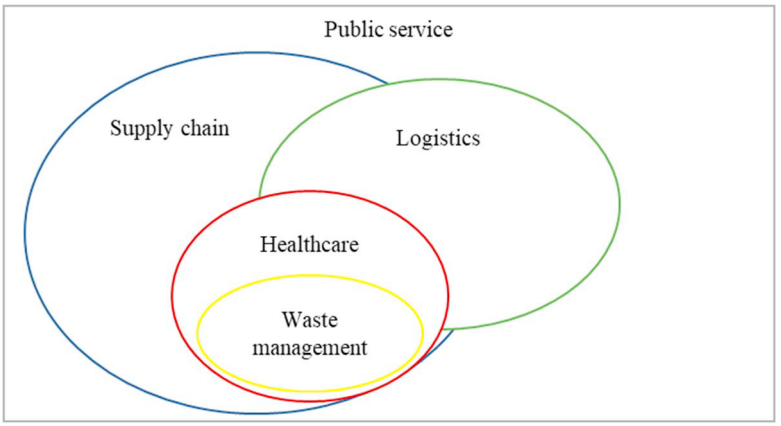

Fig. 2. Analysed sets of results by keywords.

In the following chapters explanation of the steps taken are explained and discussed.

3. Results of research

In the following text, the search results are presented. The chronological order of the search by author keyword was: Public services AND Supply chain OR Logistic, then Healthcare AND Logistic AND Supply chain, and then Healthcare AND Logistic AND Supply chain AND Waste management. Table 1 presents the total number of all types of published papers from the period 2010 to May 2022.

Table 1. Published papers by author keywords from 2010 to May 2022 in ScienceDirect and Web of Science database.

Database	ScienceDirect	Web of Science
Public services AND Supply chain OR Logistic	142,601	455,217
Healthcare AND Logistic AND Supply chain	3,192	249
Healthcare AND Logistic AND Supply chain AND Waste management	959	26

As can be seen from data in table 1 number of available research in the logistics or supply chain field in public service is higher on WoS. More papers are found published in the ScienceDirect database by filtering the results using additional keywords. That is why further review of the published research is limited to the ScienceDirect database. The growing interest in logistic issues in healthcare can be seen in the rise of published research in the last eleven years (Table 2). A significant increase of 403,6% in published research is visible in recent years (2010-2012 vs 2019-2021). Analysing interest in the study of waste management under healthcare logistics, the same growth trends can be seen (rise to 349% from 2010). This shows that the researcher's community recognise this topic and associated problems.

Table 2. A number of published papers by author keywords from 2010 to May 2022 in the ScienceDirect database.

Keywords	Healthcare AND Logistic AND Supply chain	Healthcare AND Logistic AND Supply chain AND Waste management
2010 - 2012	274	90
2013 - 2015	420	112
2016 – 2018	621	191
2019 – 2021	1,380	404
2022	497	162

The type of published paper shows the purpose and scope of topics as well as the actuality of issues in the real sector (Table 3 and Figure 3). A significant share of research papers (59,5% and 50,2%) on topics is visible.

Table 3. Number of published papers by type and author keywords from 2010 to May 2022 in ScienceDirect database.

Keywords	Healthcare AND Logistic AND Supply chain	Healthcare AND Logistic AND Supply chain AND Waste management
Review articles	395	160
Research articles	1,899	481
Book chapters	358	156
Conference abstracts	142	59
Other	398	103
TOTAL	3,192	959

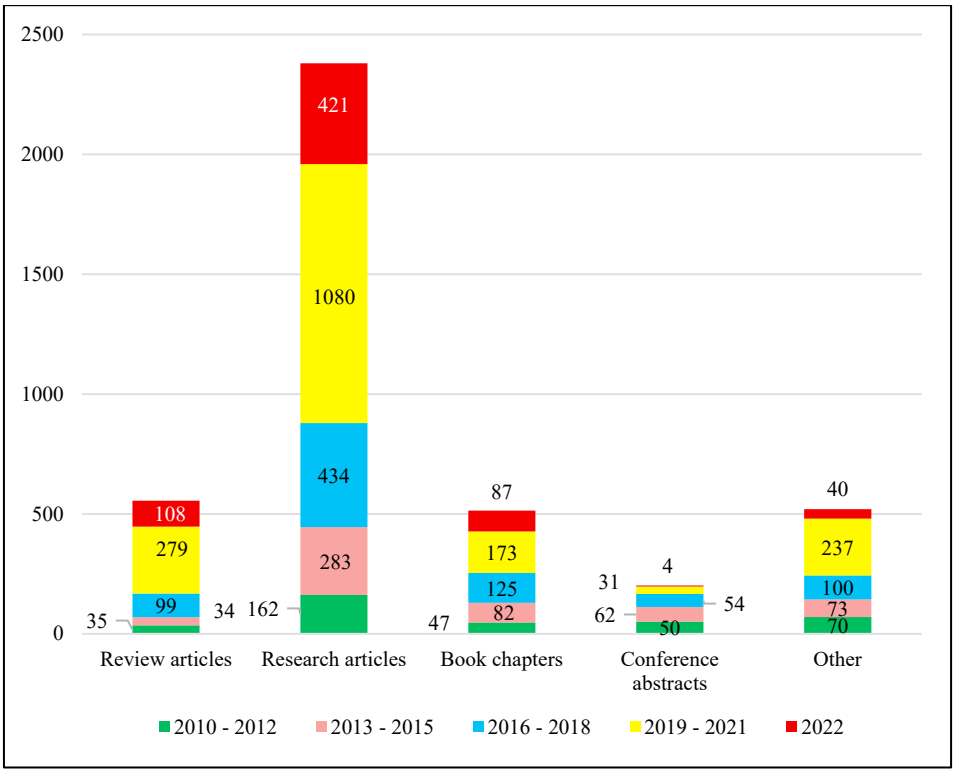

Fig.3. A number of published papers by type from 2010 to May 2022 in the ScienceDirect database.

Publication type under “Other” (Encyclopedia, Book reviews, News, Conference info, Short communications, Correspondence, Discussion, Editorials, Mini-reviews, Practice guidelines, Case reports, Video articles, Data

articles) includes published works that do not represent specific scientific add value. The rise of published research papers is evident, and it will be interesting to see the results at the end of 2022. There are, in total, 2,380 research and 555 review paper published. Share of review paper compared to a research paper is even during the years, approx. to 25%. As healthcare issues are commonly understood as part of medicine or business management, analyses of papers published per research area were conducted. Figure 4 shows that most of the published paper falls under the medical and density research areas (1255, 245), but engineering and decision science research fields follow (431,170). It implies that issues in healthcare logistics and connected waste management ask application of engineering views and methods.

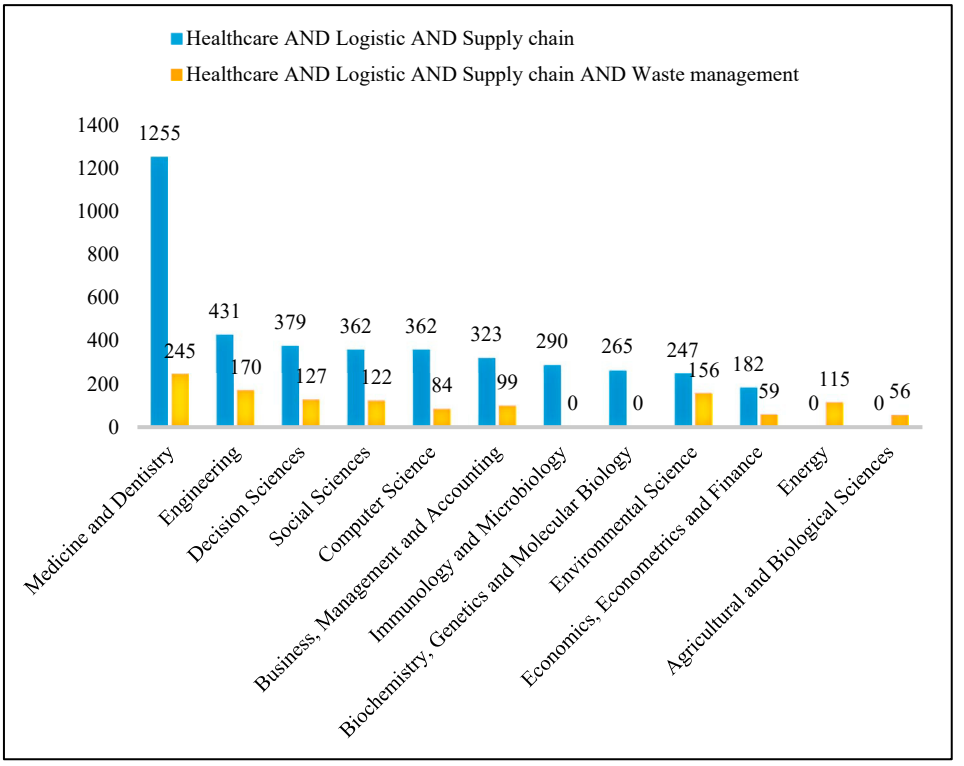

Fig 4. Published papers by author keywords in research areas from 2010 to May 2022 in the ScienceDirect database.

The database search revealed that there are 679 open access studies with the specified keywords "Healthcare AND Logistic AND Supply chain" and 150 open access research with the keywords "Healthcare AND Logistic AND Supply chain AND Waste management". After reviewing, we found that only 171 studies have complementary keywords to the issues described in the paper. To gain the best possible insight into the field, the most frequently cited papers were studied in detail.

4. Discussion

To analyse topic trends, a certain number of published papers are separated and studied. Most cited authors on this topic are Volland et al. (2017), Vries and Huijsman (2011), Häkkinen et al. (2013), Scavarda et al.(2019), Moons et al. (2018), Gebicki et al. (2014.) and regarding waste management in the healthcare Windfeld Steen et al. (2015), Ali et al. (2017), and Sharma et al. (2020). The common conclusion can be pointed out upon reading and analysing researched issues. Logistics issues in hospitals are the most represented. Rosales et al. (2014) write that hospitals are part of complex supply chains that include the process of decision-making, purchasing, storage, distribution and inventory control of medicines and medical supplies. As supply chain management represents broader research scope, many authors use commonly known supply chain definitions in defining hospital supply chain management, including Vries and Huijsman (2011), Moons et al. (2018), Ageron et al. (2018), Castro et al. (2020), Volland et al. (2017), Zgaya et al. (2016). The author Marques et al. (2019) provides a literature review on healthcare supply networks. They identified horizontal and diagonal links within and between different types of supplies (health services, medicines, medical supplies, and blood supplies). They also suggest future studies focusing on the analysis of network flows. The hospital supply chain is characterized by three cycles, and external and internal supply chains can be distinguished (Figure 5), according to Castro et al. (2020). The first cycle includes

moving different goods and services from one or more suppliers until they arrive in the hospital's main warehouse or storage place (one part is external and one leg in the internal supply chain). The second cycle includes moving goods and services from the hospital's main warehouse or storage place to different hospital departments. The third cycle consists of the movement of goods and services from hospital departments to the patient's home, where it is finally consumed. It is a common conclusion stated in Moons et al. (2018), Ageron et al. (2018), and Castro et al. (2020) that hospitals carry large and different types and quantities of goods like food, medical drugs, pharmaceutical products (tablets and capsules), medical equipment, medical instrument for operation rooms and medical materials (injections, syringes, gloves, surgical kits, surgical clothes and sterile tools), maintenance equipment for the hospital, bedding and different type of waste. Hospital staff who perform logistical activities are expected to ensure storage of goods in the right place, just-in-time distribution of goods where and when necessary, and proper disposal of generated waste.

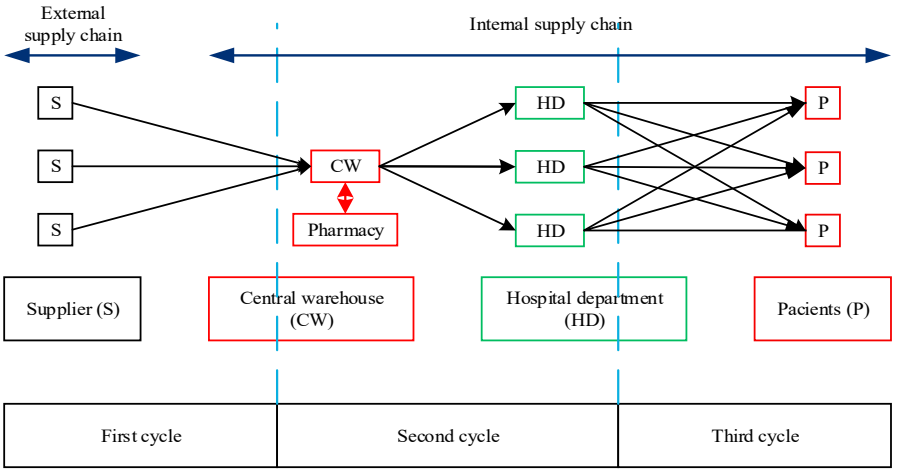

Fig. 5. Three cycles in the hospital supply chain

The quality level of patient care depends largely on the availability of products (medicines, equipment, etc.) in hospitals. Therefore, the efficiency of hospital supply chains should be at a high level. The application of simulation models in healthcare is demonstrated by Abukhousa et al. (2014), aiming to evaluate decision-making on various issues to reduce supply chain costs. Gebicki et al. (2014) presented the use of a self-developed event-driven simulation (using SIMPL) to evaluate the performance of inventory policies in the hospital's central warehouse and main pharmacy. The results show that intelligent, consistent decisions based on demand and cost analysis lead to better outcomes, including patient safety. Granlund and Wiktorsson (2013) present advances in transferring technologies and knowledge from manufacturing to internal hospital logistics (e.g., high-speed packaging of tablets with integrated automatic storage) and claim that this can improve efficiency in hospitals and that some solutions for patient transport and waste treatment can be implemented. Another authors, Rais et al. (2017), propagates the transfer of general logistics knowledge to hospital logistics. They tested the optimisation of document courier services using a fixed and a flexible routing approach.Activities of hospital supply chain management must be carried out in such a way that they do not affect the level of quality of service provided to the patient, as stated by Moons et al. (2018), Ageron et al. (2018), Castro et al. (2020), Scavarda et al. (2019), Medin et al. (2013), Häkkinen et al. (2013) and Sahin et al. (2015). Bélanger et al. (2018) investigated possible locations in a hospital's care unit for the storage of medical supplies to optimise logistical performance without compromising patient care.

From the research, the topics to be written about can be categorised into the influence of logistic activities on hospital cost, inventory management, warehousing, on-time distribution and forecasting techniques for hospital needs. Zgaya et al. (2016), Moons et al. (2018), and Franco et al. (2020) write that optimizing hospital supply chain costs, achieving and maintaining high-quality care for patients can be achieved through proper and accurate procurement, using on-site and on-time distribution, joint procurement with other healthcare institutions, establishing consolidated shipments during ordering and procurement, standardization of purchased equipment, inventory management, using of forecasting techniques for hospital needs, using of information technologies such as hospital information system, electronic patient record, warehouse management system, joint business process planning, information sharing between hospital departments, and harmonized management at all levels hospitals.

Central warehouse or storage space and inventory management are crucial to optimising the supply chain and reducing hospital costs without lowering the quality of patient care. Lucchese et al. (2020) propose a hybrid model

based on the Facility Location Problem (FLP) in a Location Routing Problem (LRP) to minimise logistics costs in the healthcare supply chain and conclude that a centralised distribution system may not be an optimal solution.

In recent years, there has been a steady increase in the number of hospital networks in the USA and Europe, as noted by Tlahig et al. (2013) when presenting a study on configuration alternatives for sterilisation services within a hospital network (one decentralised and one centralised sterilisation service). Restructuring the location of facilities and better resource allocation are increasingly becoming the focus of hospital management. The networking of hospitals seems to offer interesting possibilities for solving cost and quality issues. Due to the economic crisis and the overwhelming share of pharmaceutical costs in healthcare costs, collaboration between hospitals in negotiations with suppliers and centralisation of warehouses is a new trend, write Iannone et al. (2014). They advocate for a network central pharmacy that negotiates with suppliers (volume discounts), takes orders from hospitals in the network and stores and distributes medicines as needed. Centralisation of the warehouse with the integrated information system (automatic prescriptions and medicine cabinets) is advocated by Ferretti et al. (2014). Hospitals in Spain (Barcelona) have tested the proposed model for cost reduction (result: up to 50% tender costs, 7.8% in purchasing, up to 50% less stock), organisation (result: up to 2% higher utilisation of nursing staff, up to 50% less administrative errors) and improvement of service quality.

Venkateswaran et al. (2013) presents the implementation of the Lean tool (Hybrid 5S and Traditional 5S) in different hospital warehouses. Both approaches led to an increase in stock turnover (up to 30% for Hybrid 5S and up to 43% for Traditional 5S). The Hybrid 5S approach led to additional improvements, including 15.7% space savings. Rosales et al. (2014) conducted a study on replenishing vending machines with medical supplies. By using the hybrid strategy (a low-cost periodic replenishment with a high-cost continuous replenishment), several benefits were observed in the hospitals, such as reducing out-of-stocks, increasing nurse satisfaction by 25%, improving inventory accuracy by more than 50% and improving patient billing. Borges et al. (2018) also studied lean practises and principles in healthcare

Medicines account for a large part of the costs in health care and hospitals. The reason for this is the considerable cost of these products, their storage, the control requirements and the often conflicting objectives in decision-making between the various stakeholders, write and discuss Kelle et al. (2012).Gebicki et al. (2014) and Jurado et al. (2016) in their papers estimated that the pharmaceutical department spent about 20-35% of the budget of public hospitals and argued that inventory management and especially medical drugs, pose two types of risks: drug shortages (demand exceeds supply), or too many drugs (reserve exceeds demand).

The authors Kelle et al. (2012) and Guerrero et al. (2013) have proposed different models for hospital and pharmacy inventory problems (Markov chain, heuristic algorithm).

Inventory management in hospitals is characterised by turnover losses, periodic reviews with short lead times and limited storage capacity, write Bijvank and Vis (2011). The authors developed a capacity model (service level is maximised subject to a capacity constraint, hence the authors develop a simple inventory rule to determine reorder levels and order quantities) and a service model (required capacity is minimised subject to a service level constraint). Vries (2011) also looks at the redesign of inventory management and examines allocation, decision-making processes, the behaviour of the parties involved in the inventory system and the communication processes between many different stakeholders (department managers, planners, pharmacists, unit managers, healthcare professionals, recruitment and others). Moons et al. (2018) identified that inventory management costs between 10% and 18% of total hospital net income. Inventory management, according to Saha and Pradipa (2019), should be balanced, avoid shortages and ensure efficiently the whole process is carried out because too much or low stock level needed for patient care can cause problems such as treatments delays, deteriorating patient health and causing the death of the patient in the worst case.

Moons et al. (2018) believe that hospitals with a single central inventory management system for all materials can reduce inventory level, time, and labour costs, simplify, or standardise inventory flows, control inventory, ensure the safety and availability of medical supplies, reduce errors of medical staff, and increase their satisfaction.

In the paper, the most used methods for analysing and reducing hospital inventory are VMI/CMI, ABC, VED (Vital, Essential, and Desirable) AHP multi-criteria decision-making, Matopoulos and Michailidou (2013), Bhako et al. (2012), Saha and Pradip (2019) and Ageron et al. (2018). Matopoulos and Michailidou (2013), Bhako et al. (2012) describe how this method brings direct and indirect financial benefits to hospitals, "about 10% savings per year compared to the past", and how it increases overall supply chain performance by reducing inventory, improving customer service, shortening the ordering cycle, and increasing fill rates.

The technology used in hospital warehouses to manage inventory and optimise warehousing and operations such as KANBAN and Advanced Warehouse Systems with RFID and Bar-Code is studied. RFID technology can facilitate patient identification, tracking of products from the point of collection to the healthcare facility, blood transfusion for a specific patient, reduction of errors in patient care, including adverse drug reactions, allergies,

patient-drug mismatches and drug dosing errors, and monitoring of all steps related to blood collection and transfusion, according to Wamba Fosso et al. Some hospitals in North America use a combination of RFID technology and an efficient inventory system called 2Bin, write authors Rosales et al. (2014). According to Castro et al. (2020), introducing these systems reduced stocks by 30% and decreased delivery time to hospital wards by 66%.

In their paper, Azzi et al. (2013) examines the current and future possibilities of self-management or outsourcing of logistics operations in centralised healthcare networks. They evaluate three different scenarios: Logistics Self-Management (LSM), partial logistics outsourcing and full logistics outsourcing (TLO), where they perform a quantitative and a qualitative assessment. The sensitivity analysis shows that logistics outsourcing is often the most economical choice. The research results presented by Kriegel et al. (2013) are consistent with the above. According to the authors, contract logistics services will increasingly outsource secondary and tertiary services and create an expanded range of services in the hospital sector that can be offered and delivered.

It is noticeable that the applicability of methods such as demand forecasting in hospital capacity management, Barros et al. (2021) and digitalisation, Beaulieu & Bentahar (2021), are being explored. With the outbreak of the global pandemic COVID 19, studies appeared on the applicability of Industry 4.0 in healthcare logistics, Ahasan et al. (2022). During the pandemic period, the number of research papers on healthcare supply chain resilience increased, Spieske et al. (2022), Zamiela et al. (2022) and on minimising the impact of disruptions, Lal et al. (2021), Fattahi et al. (2022).

According to Farzadkia et al. (2018) and Mihai (2020), medical waste management is receiving increasing attention in the overall waste management process because improper collection, handling, sorting, and disposal can expose patients, medical staff, and people who work with waste to severe injuries, infections, diseases, and even death. According to Moons et al. (2018), in the last few years, due to increased logistic activities and the number of different types of waste in hospitals, the share of these costs in total hospital costs has risen to between 25% and 30%, and in some cases up to 45%. So, hospital waste management can be the fourth cycle of the supply chain in healthcare. It will involve collecting, sorting, and removing waste by internal transport from the place of origin to the area of collection. At the point of collection, waste is taken over by companies specializing in waste disposal.

“Healthcare institutions like hospitals, laboratories, research centres, mortuaries, autopsy centres, animal research, testing laboratories, blood banks, as well as nursing homes for the elderly citizens are generating a different class of waste, which needs to be appropriately segregated and treated”, according to Bhagawati et al. (2015), Windfeld and Brooks (2015), and Zamparasa et al. (2019). Most of the medical waste is generated in hospitals. According to Chertier et al. (2014), non-hazardous is 85% of total hospital waste, 10% is infectious, and non-infectious considered hazardous is 5%. Logistic processes in medical waste management systems have an essential function due to the characteristics of medical waste that influence transport restrictions, storage possibilities, and safety reasons. Due to the proper management of all classes of medical waste and especially hazardous waste at the place of origin and disposal, knowledge of logistic processes such as sorting, storage, separation, transport, and knowledge of waste management technologies are required, according to Farzadkia et al. (2018) and Sharma et al. (2020).

Referring to Kalińska-Rolewicz (2016), parts of logistics that are very important in medical waste management are internal and external transport (transportation capabilities, travel distance, frequency of travel, associated costs, acceptable transportation means), conditions and possibilities of disposal (approved and applied treatment methods, costs, a location where medical waste is received and disposed of). “Infectious and hazardous hospital waste is only 15%, but incorrect management of this waste type can become potentially dangerous to patients, medical staff, and healthcare hospital visitors” is concluded by Giaccheta et al. (2013).

Researchers from different countries used methods such as visiting hospitals, interviews with hospital management and medical staff, survey, and research questionnaires to determine and record the quantity of waste generated in hospitals. The hospitals’ medical waste is determined by the daily quantity of waste per bed (kg/bed*day), according to Giacchetta et al. (2013) and Windfeld and Brooks (2015). Andre et al. (2016), Santos Sousa et al. (2019), Kalińska-Rolewicz (2016), Windfeld and Brooks (2015), Vaccari et al. (2017), Zamparasa et al. (2019), Maamari et al. (2015), Farzadkia et al. (2018), presented the results of research on the average amount of hospital medical waste generated by continental areas, where North America hospitals generate 7-10, Latin Americans 4-7, Asian countries 0,3-7,5, Africans 0,3-1,5, and Europeans 1-8 kg/bed*day. Hossain et al. (2011) and Chartier et al. (2014) write that the most critical factors in the medical waste management system and supply chain are: the collection system at the place of waste products, such as the disposal and segregation in appropriate containers or bags, location and condition in storage place, time of waste storage and temperature in storage place, requirements of transport such as suitable vehicles, transportation containers, transportation maximum time and distance, approved disposal method by legal regulations. Santos Sousa et al. (2019) and Ali et al. (2017) emphasised the importance of medical staff education on certain waste types and logistic disposal procedures.

5. Conclusion

The increased interest of the scientific community in the topic and the role of the supply chain and logistics in the healthcare system was influenced by economic trends, population demographics, and finally, the COVID-19 pandemic.

The need and demand for quality medical services, medical devices, medicines, and consumables is a continuous process causally linked to global processes. As healthcare functions like any other industry, healthcare logistics has also encountered many problems in recent years due to increased costs and high demand. Technological progress in medicine, diagnosis and treatment of patients has increased the redesign need and optimisation of the healthcare supply chain, quality logistic support for health services, and proper disposal of the generated medical waste.

As the largest institution in the healthcare system, the hospital consumes the most significant number of medical drugs, medical materials, food, energy, and healthcare services. From all the observed studies, it can be concluded that the hospital can optimise and reduce its costs through knowledge and technology transfer, proper decision making process using simulation and modelling, implementation of lean tools, optimised inventory management, timely and accurate procurement, adequate storage space, collaboration in the hospital network, information technologies, automation of physical and information flow, proper waste segregation and management, collaboration with suppliers and outsourcing of some areas of hospital logistics.

The management of medical waste is receiving increasing attention in scientific research. A unified system for medical waste management at European (and global) level is an important requirement advocated in many studies. Some progress can be seen from observed studies, such as the existing agreements on the use of the European Waste Catalogue in medical waste management. This catalogue defines the basic categorisation of medical waste and the settings regarding selection, collection, labelling and procedures for the different types of medical waste used in healthcare facilities. As far as the topics and directions of the research conducted are concerned, the usual logistical themes can be discerned from the selected papers: Inventory and warehouse management, location and distribution issues, the challenges of digitalisation and cost minimisation. The differences between logistics in healthcare and other sectors are reflected in the strict legal requirements (health regulations, medical regulations, etc.) and the significant quantities of various hazardous products and waste.

In the health sector, awareness of the need to use professional logisticians is generally low. The problems in the health care supply chains created by the pandemic COVID 19 have exposed all the weaknesses in the existing supply chains, and the scientific community has recognised this. The increasing number of publications in the engineering field shows that logistical methods can and should be used regardless of the healthcare complex legal issues. Further research should lead to a detailed categorisation of logistics problems in health care and waste management processes as part of the logistics problem.

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