AN OVERVIEW OF IMPROVING LOGISTICS PROCESSES IN HEALTH FACILITIES: ISSUES, SOLUTIONS, AND CHALLENGES

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ARTICLE INFO	ABSTRACT
	Internal logistics processes in health facilities are complex and important to ensure health services and high-quality patient care. Therefore, the review is focused on issues, solutions and challenges related to logistic processes in health facilities. This review follows the PRISMA guidelines. Relevant studies were searched in the citation databases Web of Science and Scopus. The search was limited to articles published in English between 2000 and 2023. Based on the search and selection process, a total of 26 articles were included in the review. A qualitative content analysis was carried out. In this period analytical research dominates over design research. In terms of research strategies, a qualitative approach is preferred. The problem contexts addressed in the articles have been divided into five thematic areas. Most articles can be classified in the area dealing with sociotechnical interaction in internal logistics. The solutions presented in found articles can be divided according to the type of artefact into (1) formal approaches focused on models and algorithms, and (2) sociotechnical approaches focused on design of implementation frameworks. Challenges include the comparison of proposed solutions or their configurations in different problem contexts and regions. Further research should focus on organisational issues in internal logistics. Although the improvement of internal logistics in health facilities is a topic that has seen an increase in researcher interest over the last decade, there is a need to build a theoretical base on the findings of this research, which has been done only to a very limited extent. In terms of the use of new technologies, high persistence in the use of older IT-based solutions and rigidity can be observed in the implementation of new solutions.

I. INTRODUCTION

Internal logistics processes in health facilities are complex and important to ensure health services and high-quality patient care [1]. These processes can be improved through organisational changes, introducing new technological solutions or modifying procedures. To support processes in health facilities, information technology (IT) is very often implemented and must be used properly by healthcare staff. If ITs is not set up correctly in the organisation or if this set-up is circumvented, it can have negative consequences for the organisation. Not only in the healthcare industry, setting up the social and technical components of a sociotechnical system constitutes a challenge [2]. The diverse and extensive (sociotechnical) logistics systems and associated processes that are used in a particular health facility, increase the complexity of health and logistics management.

Properly configured internal logistics processes in health facilities can provide benefits, including but not limited to increased patient safety in medication administration, improved patient care, or reduced healthcare and healthcare facility operating costs [3]. Healthcare facilities are following the lead of manufacturing firms by applying approaches such as lean, business process reengineering, benchmarking [4] or deploying advanced systems based on IT and mathematical models to optimise these processes. The above underlines the relevance and importance of the topic of internal logistics processes.

Therefore, it is appropriate to prepare an overview that will address the issues, solutions and challenges related to logistics

processes in health facilities over the last two decades. Before that, however, it is necessary to determine whether a similarly focused review article has not been published in the last decade.

Based on the keywords in the Methods and Materials section focusing on review articles, no thematically related or similarly focused overview was found in the Web of Science (WoS) and Scopus citation databases. Rather, review articles focus on benefits and critical success factors [5] or the importance of measuring internal logistics performance in hospitals [3]. It is therefore reasonable to prepare an overview that addresses the issues, solutions and challenges related to logistics processes in health facilities over the last more than two decades. An overview of such focus is beneficial for scholars who will be able to better navigate this topic area and further enable them to focus their analytical or design research on relevant areas and link it to other scholarly literature.

The article aims to review the issues, solutions, and challenges related to logistic processes in health facilities. Therefore, the authors focused on identifying problem contexts addressed in the thematically relevant articles, proposed technological solutions and challenges for future research. The following research questions (RQ) were proposed:

- RQ 1: What are the problem contexts addressed in the articles?
- RQ 2: What are the proposed technological solutions for solving problem contexts?
- RQ 3: What are the challenges for future research?

Answers to these research questions are beneficial for managers in health facilities as well as scholars who focus their research on improving logistics processes in health facilities. Managers get an overview of issues and types of proposed solutions. Scholars will find out what areas of research are covered and how much and what further research efforts are needed.

II. MATERIALS AND METHODS

This review was prepared according to PRISMA guidelines [6] and did not require ethics or institutional review board approval because data were collected by reviewing published peer-reviewed journal articles and papers from conference proceedings. The authors focused on international citation databases Web of Science and Scopus and the period from 2000 to 2023. Databases were searched on February 10, 2024, and only papers available in English were included. The keywords and queries used for searching databases are listed in Table 1.

Table 1: Search strategy in citation databases.

Citation databases	Used keywords / Query strings
Web of Science	"logistic process" OR "logistical process" (Topic) and "hospital" OR "clinic" OR "health facility" OR "healthcare center" OR "healthcare centre" (Topic)
Scopus	TITLE-ABS-KEY (("logistic process" OR "logistical process") AND ("hospital" OR "clinic" OR "health facility" OR "healthcare center" OR "healthcare centre"))

Source: Authors, (2024).

The searched articles were imported to the web-tool Rayyan (www.rayyan.ai) where the selection according to the abstract was carried out. Duplicate entries were removed. In the case of higher content matching, the source that most comprehensively summarized the given topic was selected based on the evaluation of the full text – an example could be the publication of a conference paper and an extended article in a journal. In that case, only the journal article was selected. Screening was conducted by examining the abstract in terms of inclusion criteria in Table 2 and defined research questions. The full text was used where it was impossible to decide on inclusion or exclusion based on the abstract.

Table 2: Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Type of article	Research journal article or conference paper	Any type of review, conference abstract or editorial material
Period	1 January 2000 to 10 February 2024	Before 1 January 2000 and after 10 February 2024
Language	English	All other languages
Research topic	Analytical and design research focused on improving logistics processes in health facilities	Any other
Multiple versions	Latest version	Previous versions

Source: Authors, (2024).

Inclusion in the review was verified based on full-text examination by both authors (Z.S. and K.S.) in mutual cooperation. Analytical and design-oriented articles relevant to the focus of this article were included. Figure 1 presents a flow diagram of the selection process. A complete list of all included papers can be found in the Appendix and supplementary material [7].
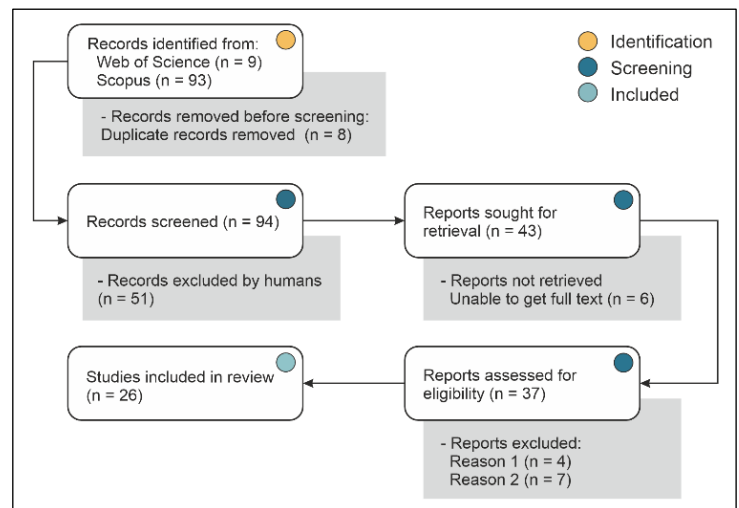
Notes: Reason 1: Several almost identical articles based on the same data were found. The paper that offered more detailed results was selected for the authors' overview. Reason 2: The article is not thematically relevant in its focus.

Figure 1: Flow diagram of the systematic review.

Source: Authors, (2024).

The information found was entered into a pre-prepared form, which included the following information: authors, year of publication, title of the work, country (first author's country of origin), research methodology, identified issues or article aim,

technological solution of the problem context, results, and challenges for future work (see Appendix). A qualitative analysis of content was carried out to interpret text data through the systematic classification process.

III. RESULTS

Based on the search and selection process, a total of 26 papers were included in the review. Almost half of the articles were published in the last 5 years (2019–2023) and 21 articles in the last decade (2014-2023) as can be seen from Figure 2. From this, it can be concluded that the importance of this field has been increasing, especially in the last decade. As regards the first author's affiliations, authors from universities in Europe dominate (13 papers), followed by North America (6 papers), Asia (5 papers), and South America (2 papers). Thus, supporting the logistics processes of healthcare facilities is a topic that resonates especially in developed countries. Such countries have the financial resources to analyse and implement smart solutions in these facilities as well as the relevant research capacity.
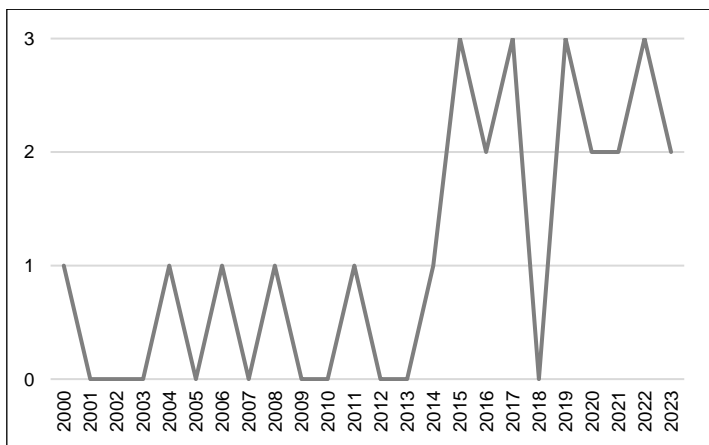

Figure 2: Distribution of the number of articles in individual years (N=26).
Source: Authors, (2024).

As regards the type of research, analytical research (17 papers) dominates over design research (9 papers) where artefacts/solutions are proposed. In terms of research approach, qualitative methods (16 papers) dominate over quantitative methods (10 papers). For this distribution, papers with design research were classified under solution evaluation; simulation and modelling were classified under quantitative approach; and mixed method studies were classified under qualitative approach. The quantitative approach was dominated by simulation and modelling, and the qualitative approach by case studies.

Furthermore, this section is divided into three thematic areas due to the focus of the paper. This involves identification of the problem contexts addressed in the articles, the proposed technological solutions and the challenges for future research.

III.1 PROBLEM CONTEXTS ADDRESSED IN THE ARTICLES

Most of the analytical and design-oriented articles address specific problem contexts associated with a particular health facility or institutional context in a given region. This is matched by the use of case studies as the main research strategy in 10 articles and the dominance of the use of qualitative research methods.

Thematically, the authors divided the articles into five areas and an example was selected for each area, see Figure 3.
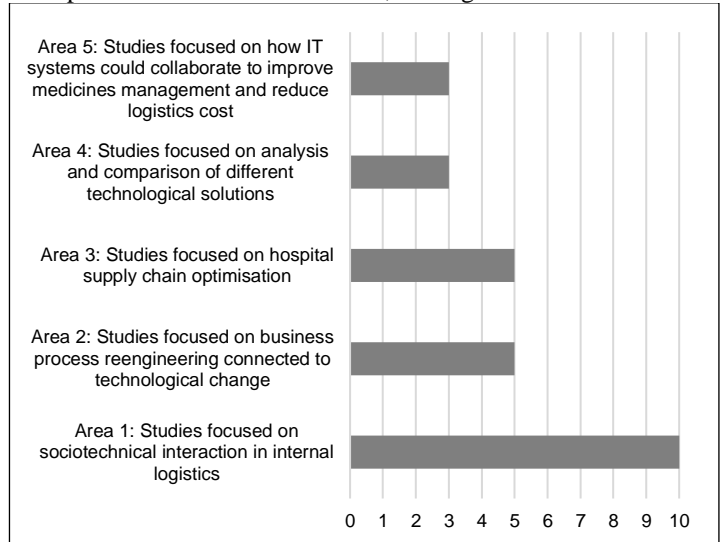

Figure 3: Distribution of the number of articles in identified five problem context areas (N=26).
Source: Authors, (2024).

Area 1: Studies focused on sociotechnical interaction in internal logistics, where 10 papers can be classified. An example is [8], where the authors use a large-scale qualitative analysis of a selected hospital in Brazil and use this to identify seven major problems mainly related to social aspects and information flows.

Area 2: Studies focused on business process reengineering connected to technological change, e.g. the transition from barcodes to Radio Frequency Identification (RFID) technology, where 5 papers can be classified. An interesting example is [9], which compares different configurations and technology combinations usable for track-and-trace systems and discusses the advantages and disadvantages of these configurations.

Area 3: Studies focused on hospital supply chain optimisation, most often using formal models to support managerial decision making, where 5 papers can be classified. Moons et al. [3] present a formal logistics performance measurement framework that helps to manage the efficiency of particular logistics processes.

Area 4: Studies focused on analysis and comparison of different technological solutions (e.g. use of different readers) or proof of IT concept, where 3 papers can be classified. Careddaa et al. [10] compare the performance of inlays, fixed and handheld RFID readers in selected supply chain processes.

Area 5: Studies focused on how IT systems could collaborate to improve medicines management and reduce logistics cost, where 3 papers can be classified. Romero [11] focused on identification of the main inefficiencies in internal logistics processes and offers RFID-based solutions to solve these problems.

III.2 PROPOSED SOLUTIONS

Engineering approaches bring solutions to problem contexts in the form of a designed artefact. For the articles found, the artefacts can be divided into two types that highlight two distinct approaches to the solution.

1) Formal approaches focusing on models and algorithms: These solutions are mainly used for decision-making support in logistics management [3, 12, 13, 14]. Most often, it involves modelling and simulation in order to support internal logistics. With the development and new possibilities to automate

internal logistics processes, where big data is collected, new opportunities arise to optimise these sociotechnical systems using artificial intelligence approaches and formal models. An example is the creation of an ensemble model combining artificial neural network and particle swarm optimisation [15] in order to reduce the costs of health facilities and increase the serviceability in logistics. The optimisation of autonomous logistics systems is also addressed by the design of an algorithm [16] that aims to solve the fleet sizing and routing problem with synchronisation for automated guided vehicles with dynamic demands.

2) Sociotechnical approaches aiming at designing frameworks: This output represents realistic or conceptual guidelines that serve as support for implementation. The frameworks found describe business process reengineering in the context of RFID implementation [17], [18]. They aim to facilitate the transition of health facilities to RFID, whether this involves stand-alone or hybrid deployments.

However, some papers have looked at instantiating a solution that is already in use in practice [19, 20] in order to improve it – particularly the life cycle of pharmaceutical products. In addition to the aforementioned frameworks focused on business process reengineering, approaches can also be found with respect to a specific solution implementation and focusing on a holistic process view (including processes and activities, organisational structure, technology). An example is a study [21] that aims to reduce the number of errors in the particular logistics warehouse.

III.3 CHALLENGES FOR FUTURE RESEARCH

Improving and optimising logistics processes in health facilities ideally brings two main benefits: improved patient care and reduced costs of operating the health facility. Therefore, even suggestions for future research mention the need to continuously explore the potential of using new IT to improve patient care and to provide more evidence on the appropriateness of using certain metrics to manage logistics processes across process types, organisational boundaries, and regions [3, 19, 22]. This can be achieved by preparing review articles focused on the evaluation and comparison of proposed solutions, especially in the internal logistics of health facilities. These articles can focus on the identification of beneficial and negative factors that influence health care performance aspects [14].

The deployment of IT solutions in this kind of organisations brings certain issues and encounters organisational constraints. Any technological change alters the organisational dynamics and is inherently complex. Therefore, evaluating the economic benefits associated with a particular technological configuration and the cost of adoption in an organisation is also difficult. Therefore, a seemingly never-ending job of hospital managers is to compare different technological configurations and their economic benefits. In this context, for instance, Moatari-Kazerouni and Bendavid [18] suggest conducting a detailed cost analysis to assess the operational cost of implementing the RFID technology for further research. However, any "reduction in the time dedicated to logistics processes or associated errors at the health care departments is a contribution to enhance the health care provided" [21].

In addition to focusing on the technological component of sociotechnical systems in healthcare organisations, it is also necessary to examine the social aspects. Human factors in particular have been little researched in healthcare logistics [22]. Therefore, further research should focus less on technology and more on organisational issues [23]. In particular, papers from the

last 5 years highlight the need for a sociotechnical perspective especially in the provision of internal logistics.

The possibilities of processing data collected by different systems in hospitals can also help with the optimisation of logistics processes. To this end, it is advisable to base the design of data processing on "real success cases, and analyse the causal links between the analytics capabilities and the organisational benefits" [23].

In the area of designing models to support managers' decision-making and optimising the hospital supply chain, further research should focus in particular on the comparison of the proposed models [13]. Furthermore, it is advisable to incorporate more into the models both subjective and objective weight assessments of the criteria. In other words, more use of subjective stakeholder ratings could be used as additional criteria or inputs to analytical models for effective decision-support systems [3].

IV. DISCUSSION AND CONCLUSION

The results presented in this overview show the approaches applied to improve logistics processes in health facilities. At least brief focus has been given to the technological aspects where high persistence of the use of previously implemented technologies can be observed.

In particular, the articles mention the use of technologies built on barcodes and RFID for monitoring medical inventories and equipment. At the same time, more advanced technologies can be found such as Ultra-Wide Band (UWB), which not only allows its use in the internal logistics of hospitals, but also in the monitoring of the patient's health condition or their movement inside the building [24, 25]. Although UWB was mentioned two decades ago as a technology to change many sectors including healthcare, this has not yet happened according to the authors' findings. Blockchain is also waiting for its greater deployment in practice, which increases the trustworthiness of the activities performed [26]. The healthcare sector is very rigid in this regard.

It can be stated that some authors [21, 27] focus on errors and issues in the field of logistics processes in health facilities to identify obstacles and barriers to logistic logistics management implementation in the medical supplies department and thereby improve the relevant processes. Nevertheless, no publication that would include in its proposal a solution regarding exception handlings related to the processes of internal logistics of health facilities was found. Exceptions are unexpected or unplanned events that can affect or completely interrupt processes. In a healthcare logistics environment, they can impact quality of care, patient safety, and healthcare costs. This could be, for example, the missing RFID of the medicine when sending it to the department, the failure of the automatic filer of the central pharmacy, or the failure of Wi-Fi during the scanning of the barcode when receiving medicines in the department. Exception handling should, therefore, be part of the analysis of the implementation of new technologies, the preparation of staff training and part of the monitoring after implementation. In the supply chain management environment, exceptions handling is an important part of the proposed track system [28]. For the logistics environment in general, a system proposal was presented to support end users in solving exceptions [29]. The system can also help revise existing processes based on the most frequent exceptions. This is also a promising direction for further research.

In conclusion, there is a rapidly growing interest among researchers in improving internal logistics in health facilities, especially in developed countries. Qualitative approach dominates

the research. Nevertheless, theorising and building a theoretical base in this area remains insufficient.

The presented overview also has several limitations. The authors focused only on international citation databases, so a limited number of databases were searched and many regional databases were omitted. At the same time, only papers published in English were included. All these facts could have led to distorted results and conclusions related to the research questions.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Zdenek Smutny and Katerina Svandova.
Methodology: Zdenek Smutny and Katerina Svandova..
Investigation: Zdenek Smutny and Katerina Svandova..
Discussion of results: Zdenek Smutny and Katerina Svandova..
Writing – Original Draft: Zdenek Smutny and Katerina Svandova..
Writing – Review and Editing: Zdenek Smutny and Katerina Svandova
Resources: Zdenek Smutny and Katerina Svandova..
Supervision: Zdenek Smutny and Katerina Svandova..
Approval of the final text: Zdenek Smutny and Katerina Svandova.

VI. ACKNOWLEDGMENTS

VII. APPENDIX

In this Appendix, a list of articles included in this overview is presented in Table 3. The authors also prepared an online appendix, where more details on individual articles regarding the research methodology, identified issues or article aim, technological solution of the problem context, results, and challenges for future work can be found. The online appendix can be found at https://doi.org/10.5281/zenodo.13294055.

Table 3: Articles included in the overview.

Authors	Year	Title	Country	Research type
Ritchie et al.	2000	The benefits of reverse logistics: the case of the Manchester Royal Infirmary Pharmacy	UK	Analytical research and recommendations
Eymann & Morito	2004	Privacy Issues of Combining Ubiquitous Computing and Software Agent Technology in a Life-Critical Environment	Germany	Analytical research
Fenies et al.	2006	A decisional model for the performance evaluation of the logistic process: application to the hospital supply chain	France	Design research
Jiao et al.	2008	Hospital Linens Inventory Control Re-engineering Based on RFID	China	Design research
Su et al.	2011	Logistics innovation process revisited: insights from a hospital case study	Taiwan	Analytical research
Romero	2014	Improving the Logistics Operations of the Hospital Pharmacy Using a Barcode-Rfid Identification System	Canada	Analytical research
Hargis et al.	2015	Barriers to Administering Intravenous Tissue Plasminogen Activator (tPA) for Acute Ischemic Stroke in the Emergency Department: A Cross-Sectional Survey of Stroke Centers	USA	Analytical research
Pinna et al.	2015	The drug logistics process: an innovative experience	Italy	Analytical research
Romero & Lefebvre	2015	Combining barcodes and RFID in a hybrid solution to improve hospital pharmacy logistics processes	Canada	Analytical research
Dursun	2016	Evaluation of Agile Suppliers Using Fuzzy MCDM Approach	Turkey	Analytical research
Caredda et al.	2016	RFID technology for blood tracking: An experimental approach for benchmarking different devices	Italy	Analytical research
Moatari-Kazerouni & Bendavid	2017	Improving logistics processes of surgical instruments: case of RFID technology	USA	Analytical research
Longaraya et al.	2017	Using MCDA to evaluate the performance of the logistics process in public hospitals: the case of a Brazilian teaching hospital	Brazil	Analytical research
Feibert et al.	2017	Benchmarking healthcare logistics processes – a comparative case study of Danish and US hospitals	Denmark	Analytical research
Moons et al.	2019	Performance indicator selection for operating room supply chains: An application of ANP	Belgium	Analytical research
Dusseljee-Peute et al.	2019	The Value of Radio Frequency Identification in Quality Management of the Blood Transfusion Chain in an Academic Hospital Setting	Netherlands	Analytical research
Feibert & Jacobsen	2019	Factors impacting technology adoption in hospital bed logistics	Denmark	Analytical research
Ham et al.	2020	Identifying integration and differentiation in a Hospital's logistical system: a social network analysis of a case study	Netherlands	Analytical research
Bygstad et al.	2020	Developing and Organizing an Analytics Capability for Patient Flow in a General Hospital	Norway	Analytical research
Reis et al.	2021	Lessons from a Surgical Center SatelliteWarehouse in a	Brazil	Analytical research

		Large Brazilian Public Hospital		
Sirisawat & Hasachoo	2021	The Exploration and Investigation of Logistics Processes and Barriers for Medical Supplies Department: A case of Thai Public Hospital	Thailand	Analytical research
Lopez et al.	2022	Evaluating interaction between internal hospital supply chain performance indicators: a rough DEMATEL-based approach	Canada	Analytical research
Zhou	2022	The overall framework design of automatic logistics system using a hybrid ANN-PSO model	China, Malaysia hospitals	Design research
Aziez et al.	2022	Fleet Sizing of Healthcare Automated Guided Vehicles	Canada	Design research
Rochaa & Regob	2023	Reorganisation of the internal storage and distribution logistics in a hospital	Europe, Portugal	Exploratory and design research
Cappelle et al.	2023	Automated and Interference-Free Inventory Solution using Energy-Neutral BLE Tags	Belgium	Experimental study and design research

Source: Authors, (2024).

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