



Mapping research on healthcare operations and supply chain management: a topic modelling-based literature review

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Abstract

The literature on healthcare operations and supply chain management has seen unprecedented growth over the past two decades. This paper seeks to advance the body of knowledge on this topic by utilising a topic modelling-based literature review to identify the core topics, examine their dynamic changes, and identify opportunities for further research in the area. Based on an analysis of 571 articles published until 25 January 2022, we identify numerous popular topics of research in the area, including patient waiting time, COVID-19 pandemic, Industry 4.0 technologies, sustainability, risk and resilience, climate change, circular economy, humanitarian logistics, behavioural operations, service-ecosystem, and knowledge management. We reviewed current literature around each topic and offered insights into what aspects of each topic have been studied and what are the recent developments and opportunities for more impactful future research. Doing so, this review help advance the contemporary scholarship on healthcare operations and supply chain management and offers resonant insights for researchers, research students, journal editors, and policymakers in the field.

Keywords Healthcare · Supply chain · Operations · Topic modelling · Literature review

1 Introduction

Effective and efficient delivery of healthcare services is essential to counteract emergent diseases and promote healthy lives and the well-being of a population, particularly amid the COVID-19 outbreak. Many healthcare systems across the globe strive to efficiently utilise available resources and improve processes through more integrated operations involving all key stakeholders. As such, in the past few decades, research on healthcare has grown exponentially and has become a self-sustained discipline in operations and supply chain management (OSCM). Healthcare OSCM is a network of healthcare providers, pharmaceutical manufacturers, drug suppliers, distributors, and logistics service providers that are involved in the

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process of acquiring and transforming raw material into finished products, adding value, and facilitating the flow of products and services to the end-customer. With the rapid growth of research on healthcare OSCM, the extant studies have been conducted in various directions and expanded over a dozen of academic journals.

As the field has grown, a corresponding growth in systematic literature reviews in healthcare has occurred, especially in the past six years. For example, Narayana et al. (2014) reviewed 99 articles (published between 2000 to 2011) on the pharmaceutical supply chain and explore that most studies focus on efficiency improvement with growing interest in process analysis and technology implementation. Volland et al. (2017) presented a review of 145 articles (published between 1998 and 2014) on material logistics in hospitals and suggested further work on the concepts of supply and procurement, inventory management, and distribution and scheduling. Ali et al. (2018) conducted a review of 88 articles (published between 2009 and 2018) on cloud computing in hospitals and devised a framework on opportunities, issues, and applications of cloud computing-enabled healthcare systems. Malik et al. (2018) reviewed 22 articles (published between 2001 and 2015) on the application of data mining in healthcare service delivery and revealed that application of data mining is narrow-focused (workforce scheduling and quality of care), thereby suggesting further research on the broader application of data mining. Moons et al. (2019) presented a review of 56 articles (published between 2010 and 2016) on logistics performance measurement in the internal hospital supply chain, specifically inventory management and distribution activities in the operation theatre. Diwas Singh et al. (2020) offered a review of 70 empirical articles (published between 1999 and 2018) from three journals (*Management Science*, *Manufacturing and Service Operations Management*, and *Production and Operations Management*) and suggested the need for more empirical research on personalised medicine, value-based healthcare, and digitisation of healthcare. Keskinocak and Savva (2020) mapped the healthcare research published between 2009 and 2018 from a single journal (*Manufacturing and Service Operations Management*) and suggested the need to develop and apply new OM methods for the improvement of healthcare service.

The existing literature reviews have different scopes and emphases focusing on a specific topic (e.g., material logistics in hospitals, data mining, only empirical papers, etc.). In other words, they are not designed to capture latent topics (hidden topics) that reside in large volumes of scholarly data. Expanding upon some knowledge from the existing reviews, this paper seeks to advance our understanding of the key research topics that have been addressed in healthcare OSCM using a topic modelling-based literature review. Topic modelling with Latent Dirichlet Allocation (LDA) has been found as an effective method to algorithmically and automatically uncover the abstract topics that reside in a large and unstructured collection of articles (Antons et al., 2016; Blei, 2012; Zhang, 2012). LDA topic modelling builds upon rigorous statistical foundations which allows topic generation with little human intervention and/or manual processing (Blei, 2012; Zhang, 2012). Such an automatic method creates more meaningful and realistic topics and ensures the reliability and validity of outcomes as opposed to manual methods (Griffiths & Steyvers, 2004). LDA has been successfully applied for topic modelling in the information science field (Yan, 2014), marketing (Tirunillai & Tellis, 2014), statistics (De Battisti et al., 2015), tourism (Guo et al., 2017), decision sciences (Chae & Olson, 2018), computer science (Guo et al., 2017), and hydropower research (Jiang et al., 2016). However, to date, we have only seen a very limited application of topic modelling-base literature in OSCM fields (e.g., Chae & Olson, 2018; Lee & Kang, 2018), particularly in the healthcare context, to explore the significant topics hidden in a large sample of articles and to locate gaps for further research in each topic. As such, this study aims to: (1) uncover the latent topics residing in the articles published on healthcare OSCM, (2) examine the topic

trend/evolution over time including hot, cold, and steady topics, and (3) find opportunities for more impactful research on each topic through a review of the literature around each topic. Driven by these core aims; the following research questions are posed:

1. What are the emergent topics of research in the field of healthcare OSCM?
2. How has research on each topic evolved over the past two decades?
3. What are the opportunities for more impactful future research in the area?

Our study is among the few that offers a topic modelling-based review of literature, which allows us objectively to uncover hidden patterns of research that pervade in a large collection of studies and to explore the development of literature on each topic. The paper advances our understanding of how the literature on different topics in the field of healthcare OSCM has evolved over time and what are the recent trends, knowledge flow, and opportunities for insightful research on each topic. We find an increasing focus and need for further investigation on some emergent topics, such as patient waiting time, COVID-19 pandemic, Industry 4.0 technologies, sustainability, risk and resilience, climate change, circular economy, humanitarian logistics, behavioural operations, service-ecosystem, and knowledge management. In terms of research methods, our analysis shows the increasing interest of researchers in the Markov method, mixed-integer programming, simulation, queueing model and stochastic programming in exploring multidimensional issues of healthcare OSCM. In addition, our analysis suggests that the past three years have also seen some empirical contributions in the area, including structural equation modelling, longitudinal study, and action research; thus, encouraging empirical researchers for more fruitful contributions on the topic.

Our study offers valuable research directions to researchers, journal editors, and policymakers in the field of healthcare OSCM. Researchers can observe whether their recent research topics are hot, cold, or steady, which will allow them to select appropriate topics for more productive forthcoming study in the area. Particularly, some early-career researchers find it difficult to keep up with the growing literature in their fields of research and familiarise themselves with a huge volume of literature in identifying the subject area on which they can focus or apply for research grants. The information from our topic modelling can be a useful tool for these researchers to understand recent developments in the field and then select more appropriate topics. Our findings can also be helpful to PhD students, who often face difficulties in topic selection due to time pressure. Journal editors can view if the extant research is consistent with their editorial policy, and they may even choose to launch a new editorial vision and direction. Our list of hot topics can be a valuable reference tool to launch special issues in the journals. Discovering underlying topics and tracking their evolution could also be of great interest to policymakers (e.g., government agencies) and industry. The information on which research themes and methods are growing or declining in popularity over time (Table 3 and Fig. 4) can support governmental funding agencies for grants allocation to promising areas. Likewise, firm managers and the industry as a whole can use this information to formulate promising R&D strategies and more informed investment decisions.

The rest of the paper is structured as follows. Section 2 elaborates on the research methods, covering data collection, screening and analysis procedures. Section 3 outlines results which include word cloud, key term matrix, topic labelling, and evolution of each topic over time. Section 4 provides discussion, while Sect. 5 offers a review of literature and opportunities for further research. The study is concluded in Sect. 6.

2 Method

As mentioned earlier, this study employs the topic modelling method. The superiority of the topic modelling method has been evidenced in other fields, for example, Latent Semantic Analysis (LSA) (Deerwester et al., 1990), Non-Negative Matrix Factorization (NMF) (Lee & Seung, 1999), and probabilistic topic modelling. LSA uses singular value decomposition and a traditional matrix factorization technique to reduce the dimensionality of documents (Deerwester et al., 1990). Unlike singular value decomposition, in NMF, the transformed and reduced version of documents contains no negative elements (Lee & Seung, 1999). Probabilistic topic modelling is a recent development in topic modelling where words and documents are described through probabilistic topics, and a topic is described in terms of a probability distribution over a vocabulary of words (Hofmann, 2001; Lee & Kang, 2018). Latent Dirichlet Allocation (LDA) is the most popular probabilistic topic modelling algorithm. A comparison of LSA, NMF, and LDA suggests that LDA has the greatest ability to maintain topic coherence and to generate predominant topics that handle the issue of polysemy, the overlapping of words with multiple meanings (Stevens et al., 2012). LDA has been successfully applied in the information science field (Yan, 2014), marketing (Tirunillai & Tellis, 2014), statistics (De Battisti et al., 2015), tourism (Guo et al., 2017), decision sciences (Chae & Olson, 2018), computer science (Guo et al., 2017), and hydropower research (Jiang et al., 2016). Borrowing knowledge from adjacent areas, this study employs LDA in healthcare. The analysis is completed in four main steps: data collection; text pre-processing; word cloud; and topic modelling.

2.1 Data collection

The analysis aims to uncover the landscape of healthcare research published in good quality international journals in the field of operations and supply chains. The data were collected from Scopus on 25 January 2022, which is one of the largest abstracts and citation databases of academic papers (Ali & Gölgeci, 2019; Ferreira, 2018; Ali et al., 2021a, 2021b). To retrieve a broad range of literature on the topic, a large set of keywords was developed based on the authors' extensive knowledge of the field and review of the extant literature in the field. These keywords included: healthcare, AND operations AND "supply chain" OR hospital OR pharmaceutical OR drug OR medicine AND model OR framework OR Stochastic OR Simulation OR "linear programming" OR Heuristic OR mathematical OR optimization OR "numerical model" OR "nonlinear programming" OR "decision tool" OR "decision analysis" OR "discrete event" OR multi-objective OR multi-objective OR multi-attribute OR multi-criteria OR MCDM OR MCDA OR qualitative OR quantitative OR "case study" OR empirical. Quotation marks were placed on the keywords comprised of more than one word (e.g., "linear programming") to ensure that search engines consider them as one word.

Initially, we did not limit the timespan because we sought to capture a wide range of publications. The search query generated 663 articles. We excluded the three articles published before 2000 to set the time interval between 2000 and 25 January 2022 (the date of data collection). Next, we carefully read the title and abstract of each article and excluded irrelevant articles. We also excluded articles in non-English languages. Extreme care was taken to include the articles that focus on healthcare OSCM. The inclusion and exclusion criteria resulted in the final set of 571 articles as shown in the supplementary file. Table 1 presents the distribution of these articles.

Table 1 Distribution of articles across 20 selected journals

SN	Journal title	Articles
1	European Journal of Operational Research	87
2	Journal of the Operational Research Society	71
3	Production and Operations Management	58
4	Annals of Operations Research	38
5	Manufacturing and Service Operations Management	35
6	Journal of Operations Management	34
7	International Journal of Production Research	32
8	Omega (United Kingdom)	32
9	International Journal of Information Management	31
10	Journal of Cleaner Production	30
11	International Journal of Operations and Production Management	28
12	International Journal of Production Economics	27
13	Decision Sciences	17
14	Transportation Part E: Logistics and Transportation Review	15
15	Supply Chain Management	11
16	Journal of Purchasing and Supply Management	08
17	International Journal of Logistics Management	08
18	International Journal of Physical Distribution and Logistics Management	04
19	Journal of Supply Chain Management	03
20	International Journal of Manufacturing Technology and Management	02
Total articles		571

The articles selected from Scopus were validated using other databases, such as Web of Science, Google Scholar, ProQuest, and EBSCO to ensure that no important articles were missed in the review. The validation process also helped confirm that Scopus contains a greater number of related articles on the topic of healthcare OSCM compared to other databases, so it was used as a preferred database for this research.

2.2 Data pre-processing

Once the articles are collected from Scopus, some pre-processing of data collected is required to conduct further analysis. First, since our search result included the article's title, keywords and abstract, we merged them as a single document. Second, we removed all punctuation and numbers and transformed all characters into lower-case. Third, we eliminated all “stop-words,” whose main role is to make a sentence grammatically correct, e.g., articles (a, an, the) and prepositions (of, by, from, etc.) and general words that repeatedly appear in most articles, e.g., “and,” “paper”, “find”, “effect”, and “discuss”. These words are not semantically meaningful, yet they create trouble in the analysis process. This step is important because without applying stop-word elimination, our analytical method could result in a big proportion of these unwanted words in the word cloud as well as in the topic matrix.

2.3 Word cloud

Word cloud with R-package is a text mining method to find the most frequently used keywords in sampled articles. A word cloud was designed to allow a visual interpretation of main themes and their trajectories in our review transcripts over the four different periods (2000–2004, 2005–2009, 2010–2014, 2015–2022). As mentioned earlier, we also included articles published until 25 January 2022. Data file for each period was imported into a popular R package, word cloud (Hornik & Grün, 2011) with default Dirichlet hyperparameters. The following functions in the R-package were applied to create word clouds: tm for text mining; snowballC for text stemming; Wordcloud2 for generating word cloud images; RColorBrewer for colour palettes.

2.4 Topics modelling

To extract the predominant topics from the 571 sampled articles, LDA’s generative process model was applied (Blei, 2012). Figure 1 demonstrates the process and its main variables where η is the parameter of the Dirichlet prior for the per-topic word distribution. K is the defined number of topics, while β_k is a distribution of words over a topic. W represents the observable variable—the words in each article. $W_{d,n}$ is the n th word in article d . α is the parameter of the Dirichlet on the per-article topic distribution. θ_d is a distribution of topics for the d th article. $Z_{d,n}$ is the topic assignment for the n th word in article d . Some variables are interdependent, that is, W (the observed word) depends on β (the distribution of topics) and Z (the topic assignment for the word), on θ (the topic proportion for the document). This process can be represented by the joint distribution of latent and observed variables through the following Figure and equations:

$$p(\beta_{1:K}, \theta_{1:D}, z_{1:D}, w_{1:D}) = \prod_{i=1}^k p(\beta_i) \prod_{d=1}^D p(\theta_d) \left(\prod_{n=1}^N p(z_{d,n}|\theta_d) p(w_{d,n}|\beta_{1:K}, z_{d,n}) \right) \quad (1)$$

The generative process aims to explore the topic structure (θ , z , and β), which can explain W . Given the observed variable (W), the posterior distribution is estimated with the following equation:

$$p(\beta, \theta, z|w) = \frac{p(\beta, \theta, z, w)}{p(w)} \quad (2)$$

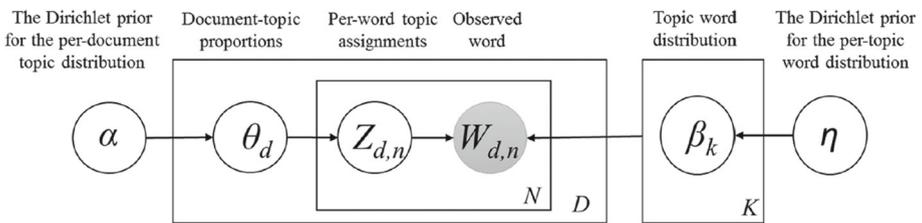


Fig. 1 The graphical representation for LDA. Adapted from Blei (2012)

The purpose of Fig. 1 and Eqs. 1 and 2 herein is to demonstrate the analysis process followed by LDA. To perform the analysis objectively and automatically, we used the R-package topic-models along with the tm package (Hornik & Grün, 2011). This analytical process produces a document term matrix for the desired number of topics.

3 Analysis and results

This section presents the analysis and the results of data processing, which consist of word cloud, topic modelling, and topic labelling.

3.1 Word cloud

As presented in Fig. 2, the word clouds show some noticeable changes between 2000 and 2022 in the healthcare literature. In the first period (2000–2004), the popular terms include strategy, logistics, risk, simulation, integer, programming, operations, reengineering, information, inventory, and planning. While a few terms in the first period and second period (2005–2009) are similar (e.g., reengineering, outsourcing, supply, chains, healthcare, strategy, logistics), several new terms became popular in the second period which includes sustainability, warehousing, reverse, heuristic, stochastics, empirical, knowledge, humanitarian, among others.

The third period (2010–2014) shows some important changes, where several new terms (e.g., behavioural, literature, reviews, multilevel, action, structural, equation, Markov) emerged, and other terms (e.g., reengineering, outsourcing, strategy) disappeared. Some

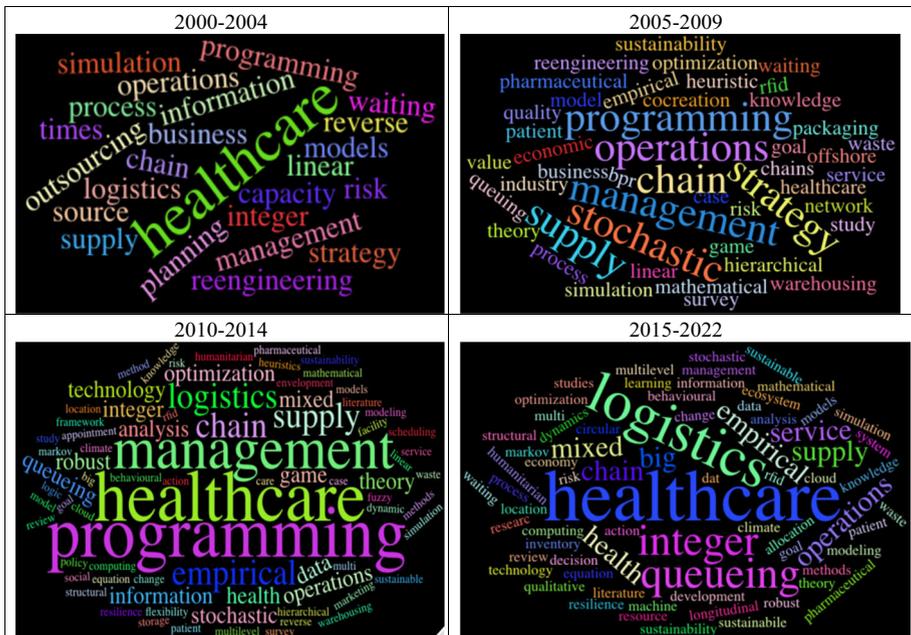


Fig. 2 Word cloud demonstrating changing pattern of terms over time (2000–2022)

five terms were selected, where each term represents a distribution weight (per-topic term probability).

3.3 Topic labelling

We conducted topic labelling based on the ‘LDA topic matrix’ that produced 34 topics (see Fig. 3). Each topic constitutes five terms with different distribution weights. Since the term “healthcare,” “operations,” “supply,” and “chain” appeared in most topics, we decided not to use any of them in labelling the topics. Further, while topic labelling in Table 2, we used the numbering/sequence of topics exactly following the sequence of topics in the ‘LDA topic matrix’ (Fig. 3). To briefly illustrate the process of topic labelling, we discuss a few examples of topic labelling. From Fig. 3, the top terms in Topic#1 are queuing and waiting, followed by hospital, patient, process; therefore, the topic is labelled the “patient’s waiting time”. Topic#2 includes top terms, such as RFID, big, data followed cloud, computing; therefore, we label the topic as “Industry 4.0”. Industry 4.0 refers to the fourth industrial revolution with the growing use of autonomous technologies such as cloud computing, big data analytics, internet supported RFID and others. Topic# 3 encompasses sustainability, economic, sustainable; hence, it is labelled as sustainability.

Likewise, Topic#8 is labelled “risk and resilience” since the top terms are risk, adaption, resilience supported by healthcare and readiness. Topic#18 is labelled “Stochastic programming” because its top terms are stochastics, programming, followed by model, method, and chain. We adopted a similar process for labelling all 34 topics as demonstrated in Table 2.

3.4 Topic dynamic/evolution over time

In this section, we introduce the hot, cold, and steady topics (research themes and methods) to provide researchers with an idea of where trends are going (hot) and not going (cold). Exploring the dynamic changes in different topics over time can offer directions for more impactful research on healthcare. We identified three patterns of topic evolution including hot, cold, and steady. For this purpose, we employed a bivariate correlation between the frequency of keywords and time period using four different time periods, namely 2000–2004; 2005–2009; 2010–2014; 2015–2022 (Fig. 3). Scopus database was used to collect the information on the frequency of keywords (for each topic shown in Fig. 3 and Table 2) in each time interval.

Hot, cold, and steady topics (which include ‘research themes’ and ‘research methods’ as shown in Table 3) were identified based on the direction of the trendline on each topic and the value of slope (Fig. 4).

Hot topics show a trendline moving upward and a positive slope (x-value). Examples of the hot topics related to research themes include the Patient’s waiting time, Industry 4.0 technologies, Sustainability, Circular economy, Behavioural OSCM (OSCM), Risk and resilience, Climate change, and research methods that constitute Markov method, Simulation, Stochastic programming, among others.

The number of contributions on these topics (themes and methods) increased almost continuously from 2010 to 2014, with a dramatic increase on some topics (e.g., patient waiting time, sustainability, circular economy, etc.) between 2015 and 2022.

Cold topics, on the other hand, imply the opposite pattern to these hot topics; they show declining trendline and negative slope values, perhaps due to the relative lack of interest of researchers in recent times.

Table 2 Topic labelling

Topic#	Frequent words	Topic labelling
1	Queueing; waiting; hospital; COVID-19; patient	Patients waiting time and COVID-19
2	Rfid; big; data; cloud; computing	Industry 4.0 technologies
3	Sustainability; economic; sustainable; supply; chains	Sustainable operations and supply chain
4	Circular; reverse; economy; logistics; operations	Circular economy
5	Service; co-creation; system, value, network	Service-ecosystem
6	Knowledge; supply; information; healthcare; chain	Knowledge management
7	Behavioural; operations; supply; healthcare; chains	Behavioural OM/SCM
8	Risk; disruption; failure; resilience, readiness	Risk and resilience
9	Logistics; humanitarian; supply, healthcare; chains	Humanitarian logistics
10	Pharmaceutical; supply; healthcare; industry; chains	Pharmaceutical supply chains
11	Healthcare; change; climate; process; adaption	Climate change
12	Markov; model; healthcare; supply; process	Markov method
13	Logistics; service; chain; healthcare; operations	Healthcare logistics service
14	Simulation; model; operations; supply; chain	Simulation
15	Literature; systematic; reviews; healthcare; supply	Literature reviews
16	warehousing; storage; warehouse; modelling; study	Warehousing
17	Programming; mixed; integer; healthcare; operations	Mixed-integer programming
18	Stochastic; programming; model; method; chain	Stochastic programming
19	Queueing, model; process; healthcare; operations	Queueing model
20	Reengineering; bpr; process; healthcare; operations	Business process reengineering
21	Programming; Math; model; methods; operations	Mathematical programming
22	Structural; modelling; equation; supply; chain	Structural equation modelling
23	Empirical; survey; studies; case; healthcare	Empirical research in healthcare
24	healthcare; action; study; chains; supply	Action research
25	Outsourcing; source; offshore; supply; chains	Outsourcing
26	Heuristic; programming; methods; healthcare; study	Heuristic
27	Hierarchal; programming; linear; modelling; healthcare	Hierarchal linear programming
28	Modelling; multilevel; methodology; chains; healthcare	Multilevel modelling
29	Studies; longitudinal; method; healthcare; supply	Longitudinal studies

Table 2 (continued)

Topic#	Frequent words	Topic labelling
30	Game; theory; modelling; healthcare; study	Game theory modelling
31	Healthcare; multi; methods; studies; chains	Multi-methods/ Mixed-methods studies
32	Marketing; packaging; chains; study; service	Packaging
33	Strategy; operations; supply; healthcare; chain	Strategy
34	Programming; goal; model; healthcare; chains	Goal programming

Examples of cold topics associated with research themes include warehousing, marketing, outsourcing, business process reengineering, strategy, operation strategy, and research methods of heuristics and game theory model among others. These topics enjoyed significant attention between 2000 and 2015, but their proportions have been steadily decreasing over the past five years (Fig. 4).

Finally, steady topics show a rise in the beginning but there is no rise or fall in trendlines over the past 5 or more years; perhaps, their importance has not been increased over time.

Overall, two topics depicted a steady growth over the past 5 or more years including goal programming and multi-level analysis. As can be seen in Fig. 4, the trendline for goal programming modelling increased up to 2009, while no remarkable increase was observed since then. Likewise, the trendline for multi-level analysis shows an upward trend until 2014; however, no growth has been demonstrated since then.

While not investigated in this study, it can be speculated that these topics may lose the interest of research and likely become a cold topic in future. Drawing upon trendline and slope for each topic in Fig. 4, we have presented all 34 topics under three main categories: hot, cold, and steady (Table 3). For better clarity of expression, we have segregated the topics into themes and methods. While both themes and methods are both important, our focus is on research themes in this analysis and discussion.

4 Discussion

Over the last two decades, research on healthcare OSCM has seen spectacular growth. In light of the burgeoning literature on the topic, this study was motivated to explore recent developments, trends, and core topics of research in the area. The study was driven by three key research questions. Addressing the first research question, we explored 34 core topics on which extant research on the topic has been conducted over the past decades. For the second research question, our topic modelling analysis has resulted in the identification of hot, cold, and steady topics in empirical research healthcare OSCM (Table 3 and Fig. 4). Thirteen topics of research themes show an upward trend, and nine of them (Patient waiting time, Industry 4.0, Sustainable OSCM, Behavioural OSCM, Risk and resilience, Humanitarian logistics, Climate change, Healthcare logistics, and Literature reviews) start with a relatively flat value (close to 0) before showing a rising trend from around 2010. The other four topics (Circular economy, Service ecosystem, Knowledge management, and Pharmaceutical OSCM) show a gradual upward trend from the early 2000s. Five research topics belong to cold topics. Outsourcing and operations strategy shows an almost linear declining trend, while both Marketing and Warehousing show a bell-shaped trend whose popularity rose in the early 2000s but fell after

Table 3 Hot, cold, and steady topics/methods

Topics	Trendline	Slope (x-value)
<i>Hot topics (research themes)</i>		
Patients waiting time and COVID-19	Upward	Positive
Industry 4.0 technologies	Upward	Positive
Sustainable operations and supply chain	Upward	Positive
Circular economy	Upward	Positive
Service-ecosystem	Upward	Positive
Knowledge management	Upward	Positive
Behavioural OSCM	Upward	Positive
Risk and resilience	Upward	Positive
Humanitarian logistics	Upward	Positive
Pharmaceutical supply chain	Upward	Positive
Climate change	Upward	Positive
Healthcare logistics	Upward	Positive
Literature reviews	Upward	Positive
<i>Cold topics (research themes)</i>		
Outsourcing	Downward	Negative
Business process reengineering	Downward	Negative
Marketing	Downward	Negative
Warehousing	Downward	Negative
Operations strategy	Downward	Negative
<i>Hot topics (research methods)</i>		
Markov method	Upward	Positive
Mixed-integer programming	Upward	Positive
Simulation	Upward	Positive
Stochastic programming	Upward	Positive
Queueing model	Upward	Positive
Mathematical programming	Upward	Positive
Structural equation modelling	Upward	Positive
Empirical research	Upward	Positive
Longitudinal study	Upward	Positive
Action research	Upward	Positive
Mixed-method studies	Upward	Positive
<i>Steady topics (Steady methods)</i>		
Goal programming	Steady	Positive
Multilevel analysis	Steady	Positive
<i>Cold topics (research methods)</i>		
Heuristic	Downward	Negative
Game theory model	Downward	Negative
Hierarchical linear programming	Downward	Negative

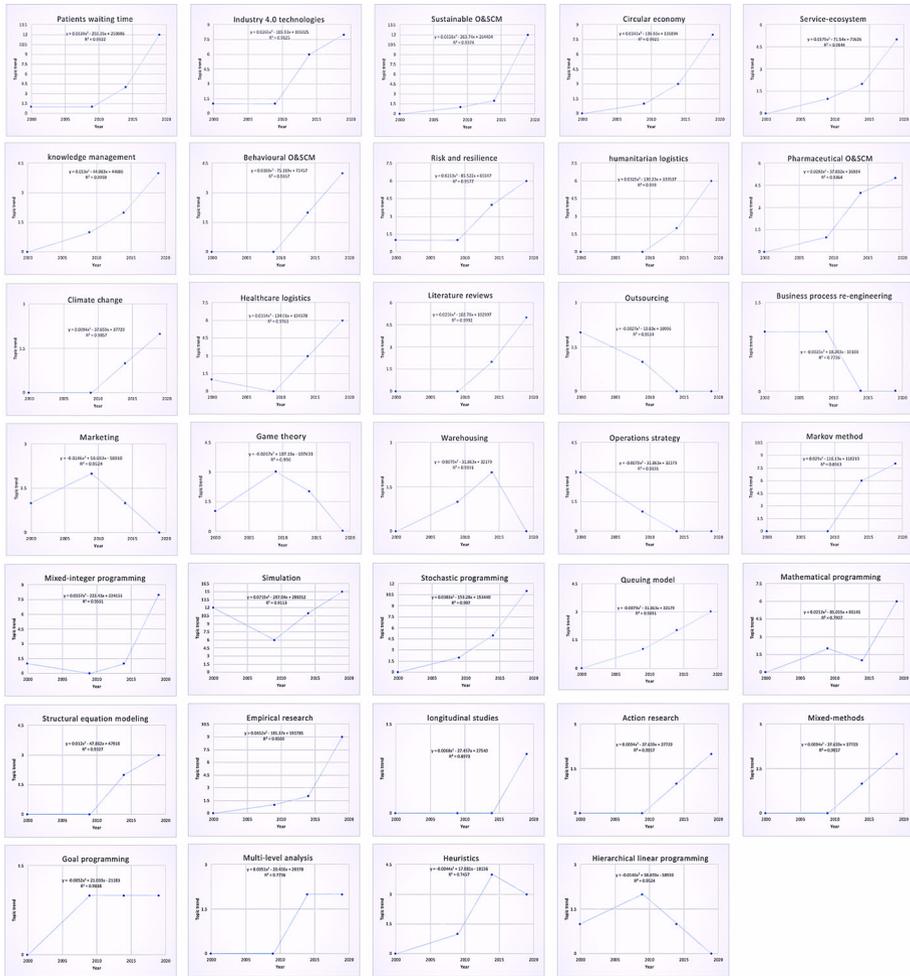


Fig. 4 Topic trend/dynamic over time

2010 and 2015, respectively. Business process reengineering was a popular topic during the early 2000s but, since 2010, shows a declining trend. It is important to note, however, that being identified as a cold topic does not suggest that the topics are not important and should be abandoned. The results provide more of an indication about the interest (trends) of researchers’ interests rather than the importance of the topics themselves. It is also interesting to see that most of the changes of the trends (either upward or downward) of the topics took place around 2010.

Finally, in response to the third research question, we offered a review of the literature and identified numerous opportunities for further research (Sect. 5). Our findings show a shift of current research from traditional topics of operations management (Business process reengineering, Marketing, Outsourcing, Heuristics) to emergent topics such as Patient waiting time, Industry 4.0 technologies, Sustainable operations, Risk and resilience, Climate change, and Circular economy. In general, the shift in topics seems to show a move away from

traditional, efficiency-focused research toward broader goals of superior customer service and system's effectiveness. While each of the three groups of topics deserves discussion, in this section, we discuss the hot research topics as well as provide recommendations of avenues for fruitful future research. It should be noted that although the topic "literature reviews" was a hot topic, we do not include it in our discussion below as the extant research related to it has already been discussed in the introduction section.

5 Literature review and opportunities for further research

The following section provides a brief synthesis of current literature around emergent research topics that are recovered through topic modelling, and it offers numerous opportunities for further research in the field.

5.1 Patients' waiting time and COVID-19

This research topic covers two interrelated and emerging issues: patient waiting time and COVID-19 outbreak. With a rapidly growing population of aged people, healthcare systems have been facing pressure for more health services resulting in patients' long waiting times. Therefore, determining methods to ameliorate waiting time has been high on the agenda of most developing and developed economies. Correspondingly, in recent years, mostly building upon simulation and Markov as the primary method of research, considerable studies appeared around the issues of patients' waiting time, such as patient's admission process (Chae, 2019; Vissers et al., 2007); surgery procedures (VanBerkel & Blake, 2007); patient inflow and outflow in the emergency department (Abo-Hamad & Arisha, 2013); no-shows of patients and overbooking (Topuz et al., 2018); outpatient appointment scheduling (Shehadeh et al., 2019); time overestimation for the emergency procedure (Gartner & Padman, 2019); walk-in patients treatment (Pan et al., 2019); patient readmission and discharge planning model (Gu et al., 2019); resource planning model to reduce waiting time of patients (Hejazi, 2021); load smoothing of scheduled admission to the reduced number of beds required and probability of delay (Asgari & Asgari, 2021), and modelled association between length of appointment interval and no-shows of patients (Pan et al., 2021).

Overall, although the existing studies have captured several important issues related to patient waiting time, we identify the need for further research on this significant topic. For example, there is potential to develop an integrated model investigating how multiple factors such as general service time, equipment breakdown, high attrition of hospital staff, variability in patient's arrival time, and unpunctuality of already booked patients cumulatively contribute to patients' waiting time. Further research can also devise a model at the intersection of patients' waiting list management, operations theatre scheduling, and patient waiting time for surgery. While the literature on simulation and mathematical modelling continues to grow, there is also an opportunity to further expand empirical research for testing causal links between various factors and their combined effect on patient waiting time. For example, empirical research can test links among customers' heterogeneous behaviour and their service time in scheduling appointments. Further, a unified model capturing non-value-added practices at both micro and meso levels would be fruitful future research in reducing patient waiting time. While research on bedding and staffing is growing, there is a need to optimise bed and staff requirements amid the global pandemic. Another potential research area is to examine the longitudinal effect of hospital staff's training on patients' waiting time.

Likewise, given the outbreak of COVID-19, the recent literature of healthcare OSCM has been rapidly growing on the topic. Pamucar et al. (2022) proposed a model for supplier selection amid COVID-19. Fan and Xie (2022) generated an optimization model for COVID-19 testing facility design and planning. Ghaderi (2022) offered a framework for public health intervention in the wake of the pandemic. Govindan et al. (2020) developed a decision support system and fuzzy interface system to help with demand management in the healthcare supply chain amid the COVID-19 crises. Nagurney (2021a) modelled labour shortage due to COVID-19, resulting in reduced food harvest and supply. Tavana et al. (2021) presented a mixed-integer programming model for the equitable distribution of COVID-19 vaccine in developing countries. Salarpour and Nagurney (2021) constructed a stochastic model to study competition among different countries for medical supplies amid COVID-19 crises. Nagurney (2021b) offered a supply chain network optimization model to manage labour in electronic commerce during the COVID-19 pandemic. Thakur (2021) developed a model to manage hospital waste during the COVID-19 outbreak. Choi (2021) used a sense-and-response specific OR model to demonstrate the specific actions needed to deal with the COVID-19 outbreak.

To sum up, while the past research continues to grow on COVID, it would be interesting to explore how to extenuate potential risks and develop shockproof healthcare systems to deal with unanticipated outbreaks such as COVID-19 and similar future incidents. In this regard, it is worth exploring how such a topic as Industry 4.0 technologies could be applied across the healthcare system to capture data from wide sources and help the decision-making process in the event of a pandemic, including contact tracing, the identification of the outbreak location. Some potential areas of research amid COVID-19 include but are not limited to patient inflow and outflow in the emergency department; outpatient appointment scheduling model; models on time estimation for the emergency procedure; walk-in patients' treatment model; patient admission and discharge planning model; resource planning model to reduce waiting time of patients; load smoothing of scheduled admission to the reduced number of beds required and probability of delay. Besides, pharmaceutical SCM would be the ultimate hope for the recovery and possibly eradication of the virus that allows us to go back to normal life. It would be insightful to examine how pharmaceutical supply chains were affected by COVID-19 and develop a recovery model dealing with such a situation. In particular, if/when a pharmaceutical solution to COVID-19 emerges, research is needed to help understand the best ways to rapidly scale up and distribute the materials on a scale that has never been seen before. It is also of interest to study whether synergy in logistics could be achieved between the public organisations and the growing number of private companies that have entered the healthcare business. Future research should continue to incorporate the healthcare and hospital view into operations management and transfer established concepts from other industries into healthcare while accounting for industry specifics. Again, the links between this and COVID-19 are both obvious and critical.

5.2 Industry 4.0 technologies

Industry 4.0 or the fourth industrial revolution refers to fully automated and in-connected technologies such as the Internet of Things (IoT), cloud computing, big data analytics, blockchain, artificial intelligence, among others (Ali & Govindan, 2021; Ali et al., 2021a, 2021b). Industry 4.0 technologies can enhance the level of service in the industry through real-time information sharing, visibility, traceability, agility, and connectivity within a firm's boundary and across the supply chain (Govindan et al., 2022). Given this, growth in research on the role

of Industry 4.0 technologies in healthcare service provision is evident, such as Sultan (2014) developed a conceptual framework on the potential of cloud computing in the advancement of healthcare services. Chong et al. (2015) modelled variables that influence the adoption of IoT (e.g., RFID) in healthcare. Priya and Ranjith Kumar (2015) used big data analytics to predict the progression of atherosclerotic disease, the narrowing and hardening of arteries due to the accumulation of plaque on the artery wall. Fan et al. (2018) recognised the factors affecting the adoption of artificial intelligence-based medical diagnosis support systems. Kochan et al. (2018) modelled on how cloud computing improves visibility and responsiveness in hospital SC. Galetsi et al. (2020) developed a theoretical framework for the realisation of big data analytics.

The research on Industry 4.0 is growing with the advent of new technologies and provides fruitful opportunities for further research. The models on big data should incorporate data of all inter-connected functions in healthcare, instead of just focusing on a single function or silo approach. For example, the impact of Industry 4.0 on the entire healthcare supply chain can be modelled. This is important to understand how interaction with different functions/partners through Industry 4.0 technologies influence healthcare productivity. Most of the current research focuses on big data and cloud computing which needs to be expanded to other Industry 4.0 technologies, such as blockchain, cyber-physical systems and the Internet of Things in healthcare OSCM. There is a lack of a holistic model testing the combined impact of all Industry 4.0 technologies on the healthcare system and an investigation into if there is a trade-off for investing between various digital technologies would be helpful. Future research can also investigate how machine learning techniques impact diagnostic, maintenance, and prognostics systems in healthcare settings. Research highlights the intricate issues of human–machine interaction at the workplace (Arslan et al., 2021); we suggest further research on how to maintain trustworthiness and to harmonise productive human–machine interactions and reduce workers' resistance to automated machines in the healthcare settings. We also highlight the need for further research on the application of artificial intelligence in healthcare OSCM.

5.3 Sustainable operations and supply chain

Today sustainability is a growing concern of most organisations and therefore the topic of sustainability has received increasing focus from researchers from operations management. Healthcare systems worldwide face pressing challenges of service quality and cost issues as well as safe disposal of waste. As such, in recent times considerable attempts have been made to realise sustainability in the healthcare system. Chauhan and Singh (2016) employed a hybrid model for the selection of sustainable locations to dispose of healthcare waste. Anuar et al. (2018) offered a conceptual framework demonstrating the link between lean practices and a sustainable healthcare system. Malekpoor et al. (2018) modelled a sustainable healthcare treatment plan. Thorsen and McGarvey (2018) investigated the effectiveness of fixed and mobile dentistry for the financial sustainability of the healthcare system. Mousa and Othman (2020) found a positive impact of green human resource management practices on a sustainable healthcare system.

While research on healthcare sustainability is growing, there is still space for further research. For instance, more studies are needed that simultaneously investigate the impact of all three dimensions (social, environmental, economic) of sustainability through a single model. Prospective studies can also investigate the combined impact of synchronous business activities including green human resource management, green marketing, and green

production on healthcare sustainability. There is also an opportunity to develop a sustainable performance measurement and management model in healthcare.

5.4 Circular economy

The circular economy is a recent concept aimed to eliminate waste through the make, use, recycle and reuse approach. It helps to overcome a take-make-dispose linear pattern of production and consumption. The healthcare industry inevitably generates waste that may become hazardous to both public health and the environment. Therefore, the circular economy has recently gained significant attention in healthcare literature. For example, Kumar and Rahman (2014) suggested RFID supported process reengineering for waste management ensuring circular economy. Jensen et al. (2019) discussed the healthcare refurbish system as a means to reduce waste. Dehghani et al. (2019) suggested that transhipment can reduce waste and save substantial costs compared to no-transhipment. Viegas et al. (2019) identified the need for research on the circularity of end-of-use medicine in the pharmaceutical supply chain.

Although research circular economy has witnessed mounting attention, there is still room for further research. For instance, there is a need to develop a model that could make the circularity of outdated medicine more visible through all stages of reverse flow and re-manufacturing. Also, healthcare literature lacks studies modelling processes and decision-making for circular economy implementation at micro and meso levels. Prospective research can also explore the healthcare staff's perception of the circular economy. It would be interesting to investigate how healthcare professionals are prepared to deal with the circular economy and how they might contribute to reducing wastage in reverse flow.

5.5 Service ecosystem

With its root in marketing, the service ecosystems concept is defined as “relatively self-contained, self-adjusting systems of resource-integrating actors connected by shared institutional logics and mutual value creation through service exchange” (Vargo & Akaka, 2012, p. 207). That is, the service ecosystem generates value for all the actors in a network through resource integration, value co-creation, and co-innovation. The service ecosystem concept has received a great deal of attention in healthcare literature. Nudurupati et al. (2015) elaborate on the process of value co-creation through strategic alliance and collaboration with multi-stakeholders. Albarune et al. (2015) suggested a value-based supply chain for integrated hospital management. Chae (2019) suggested digital innovation as a promising source of resource sharing and value creation among actors in an ecosystem. Lee et al. (2020) showed a positive relationship between the previous year value-based purchasing penalty and the current year care process improvement in the hospital.

Service ecosystem research is a growing area of research in the healthcare context; thus, offering opportunities for further expansion. For example, the influence of contextual behavioural factors in value co-creation and unlocking innovation needs further investigation. Also, service ecosystem research needs to be expanded from the organisational level to the entire healthcare system. For example, how resource integration practice can be integrated into a multitude of value co-creation processes in the healthcare networks. Moreover, the role of advanced technologies and servitisation in the healthcare service ecosystem has yet to be investigated.

5.6 Knowledge management

Knowledge management refers to the process of generating, transferring, and managing knowledge and information in an organisation or network. Knowledge management becomes a major driver of performance and productivity where front-line workers are required to provide customised services tailored to the need of individual clients such as healthcare. As such, the literature has witnessed considerable growth in literature on knowledge management in healthcare settings. Gagnon et al. (2016) empirically corroborated a positive association between knowledge management on staff practices and quality of healthcare. Mura et al. (2016) found that knowledge exchange and assets have a positive impact on workers' innovation, such as idea generation, idea promotion and idea implementation. Avgerinos and Gokpinar (2017) argued that knowledge transfer capability in a team positively influences healthcare productivity. Hiranrithikorn and Sutdewan (2019) expound that access to information and knowledge has a positive influence on healthcare supply chain skills. Despite considerable contributions to knowledge management, there is still significant room for further research. A few models are investigating the impact of knowledge sharing on the quality and productivity of healthcare performance. Qualitative research can be conducted to explore the barrier and enablers of knowledge sharing in healthcare. Future research can use multi-method research investigating the relationship between social capital, culture, and knowledge management.

5.7 Behavioural operations

Research on behavioural operations is well-received, particularly from healthcare service perspectives. Healthcare systems have two main stakeholders: staff and patients. The research suggests that the findings of healthcare modelling may not be reliable without considering the behaviours of the main stakeholders (Brailsford et al., 2012). For example, a simulation model suggesting the effectiveness of a new drug will be unreliable if it does not consider patient behaviour; some patients may not complete the prescribed course of medication, and potential side effects of medicine should be shown. As such, healthcare literature has seen an emergence of interest in understanding both human behaviour in practice and how to capture it in operations research models. Brailsford et al. (2012) used a simulation model capturing behavioural factors of a patient while treating breast cancer. Based on a review of literature, Kunc et al. (2018) identified scarcity of research on behavioural aspects of healthcare. Harper (2019) used a queuing model to assess how healthcare workers behave and treat patients, especially when such professionals encounter changing workloads, service queues, and other factors that impact service quality.

To sum, behavioural operational research has become an important research topic in healthcare but significant room for further research in the area remains intact. Specifically, we suggest more research with detailed models on the nexus between behavioural interventions on healthcare practice. Future research can model workforce adaptive behaviours and productivity. We agree that the incorporation of behavioural factors is important to increase the reliability of the healthcare model because of the increasing influence of human behaviours in healthcare operations. Future research can also examine the behavioural consequences of inter-organisational interaction in complex healthcare systems.

5.8 Risk and resilience

Healthcare systems are susceptible to operational failures in services offered to patients when a shortage of medicine and equipment occurs, or when the execution of such systems is incorrectly managed. Given the divergent risks emerging from a variety of sources, there is an increasing focus on risk mitigation and the development of resilient healthcare. Nemeth et al. (2011) developed a model for healthcare crises management and resilience. Mahjoub et al. (2014) found risk mitigation in healthcare through a risk-sharing agreement between pharmaceutical companies and healthcare service providers. Saedi et al. (2016) suggested an optimal inventory policy to reduce drug shortage risks. Rubbio et al. (2019) examined the role of digital technologies in developing healthcare resilience. Rahimian et al. (2019) investigated an appropriate level of risk-aversion through robust optimization. Zhang et al. (2020) formulated a model which helps to reduce overtime risk during surgery in a hospital.

While research on risk and resilience in healthcare is growing, there is still substantial room for more impactful future research. Most models investigate risk and resilience in isolation. Others focus on particular functions such as hospital surgery. As such, a quantitative model that simultaneously investigates risk and resilience focusing on the key supply chain actors in healthcare is lacking. Future research can also use a mixed-methods approach where qualitative research can explore various risk factors and resilience strategies, while quantitative research can test the interrelationship between risk and resilience in explaining healthcare performance.

5.9 Humanitarian logistics

Humanitarian logistics refers to the transportation, delivery, and distribution of supplies in the event of natural disasters or another emergency to the affected area and people. Given the unprecedented incidents such as floods, cyclones, disease outbursts, the humanitarian logistics in healthcare (e.g., supplies of medicines, medical equipment, sterile items, linen, and food) has gained significant attention in recent times. For example, Naor et al. (2018) found strategies for effective humanitarian logistics in healthcare, such as quickly sending a team to the disaster area to gather firsthand information on the unique situations of disaster followed by the main delegation staff carrying effective disaster relief service. Prasad et al. (2018) suggested effective healthcare intervention to deal with disease outbreaks in a community. Cherklesly et al. (2019) assist with the design of a community healthcare network, increasing the service coverage for underserved areas in adverse situations.

Although research on humanitarian logistics has been progressing steadily, we highlight the need for further research on healthcare OSCM. A fruitful future research avenue is modelling the role of volunteers and NGOs in humanitarian logistics from a healthcare perspective. Also, interviews with disaster area patients can provide additional insights into the real-world phenomenon. Further research can also develop a model of budget allocation as the community service demand increases drastically due to a natural disaster. It would be interesting to investigate the nexus among service compliance rate, disease rate, and total cost by disaster type.

5.10 Pharmaceutical OSCM

A pharmaceutical supply chain involves firms, processes, and operations involved in the design, development, and distribution of life-saving drugs. It is one of the critical supply

chains since it is related to the life and health of people. The success of healthcare services directly depends on well-managed pharmaceutical supplies. Therefore, the management of the pharmaceutical supply chain has become a popular topic in healthcare literature. Jia and Zhao (2017) highlighted the issue of drug shortage due to lack of collaboration between pharmacies and pharmaceutical manufacturing and supplier. Nematollahi et al. (2018) also found a positive link between hospital service level and efficient pharmaceutical supply chain. Viegas et al. (2019) discussed the significance of a coordinated pharmaceutical supply chain for the reverse flow of end-of-life medicine. Recently, Zandkarimkhani et al. (2020) formulated a model to redesign the pharmaceutical supply chain network in the wake of demand uncertainty.

Despite growth in literature on the pharmaceutical supply chain, significant room for further research still exists, particularly in the context of a recent pandemic. Most of the existing research lacks a holistic view that involves all key stakeholders of the supply chain. There is less focus on upstream networks and processes (Narayana et al., 2014). There is also limited research on integrated new product development in the pharmaceutical supply chain. There is also an opportunity for research to model examining the link between healthcare financing and pharmaceutical supply chain financing such as investment in R&D, production and distribution, between waste management, environmental and pharmaceutical supply chains. Future studies can also model the behaviour of individuals in the robustness of pharmaceutical supply chains. Given that supply chain design is critical in the planning process (Govindan et al., 2017), we suggest designing integrated models that encompass all stages from drug manufacturing to final consumer for robust decision-making in the pharmaceutical supply chain. Another interesting avenue is formulating a model at the intersection of supplier selection and sustainable pharmaceutical supply chain networks.

5.11 Climate change and healthcare

The increased intensity and frequency of disasters due to extreme weather conditions draw our attention to the unprecedented changes in climate which are mainly attributed to excessive greenhouse gas emissions and carbon footprints. To deal with the climate change challenges, greenhouse gas mitigation targets were set to a minimum level in the historic Paris Agreement (Bodansky, 2016). While a lot of research spotlights the emissions reduction in the automotive, energy, and mining industries, the carbon footprint and climate change research has recently received attention. Rezali et al. (2018) discussed the importance of a green healthcare supply chain to reduce the environmental impact of the healthcare industry. Belkhir and Elmeligi (2019) examined 15 pharmaceutical supply chains across different countries and found that the pharmaceutical industry is more emission-intensive than the automotive industry. Tanwar et al. (2019) identify the potential risks and risk mitigation measures in implementing a green pharmaceutical supply chain. Over the past five years, the topic of climate change has received increasing attention in healthcare settings. Most studies on the topic focus on factors contributing to climate change (greenhouse gas emissions, carbon footprint), thus leaving a gap for research models incorporating the business impact of climate risks when they unfold and examining specific risk mitigation measures.

5.12 Healthcare logistics

Healthcare logistics refer to the physical flow of healthcare materials from the pharmaceutical production facility to the healthcare service provider. Logistics cost has been identified as

the second largest cost after personnel in the healthcare system (Ross & Jayaraman, 2009). As such, the importance of material flow in healthcare service is recognised important to add value and reduce the cost of services. Correspondingly, a growth in literature on healthcare logistics is evident. Oumlil and Williams (2011) suggested strategic alliance and consolidation of logistics in the healthcare sector as a strategy to reduced logistics costs. Volland et al. (2017) identified four main domains in which healthcare logistics research exists, including procurement, inventory management, distribution, and supply chain management. Al-Sharhan et al. (2019) expounded on the significance of hospital-supplier integration of inefficient material logistics. Fathollahi-Fard et al. (2019) developed a green home healthcare supply chain model to reduce emissions in logistics. Pohjosenperä et al. (2019) discussed the impact of service modularity in value-creating and improving healthcare logistics service. Zabinsky et al. (2020) developed a model through mixed-integer linear programming to address healthcare scheduling and routing problem. Further research could examine an item-level analysis of different product categories in the regional healthcare units, together with their replenishment models. Such a study is needed to show the true potential of modularity in service offerings of the logistics support organisation.

6 Conclusion

Over the last two decades, research on healthcare OSCM has been continuously advancing making it a self-sustained discipline in the OSCM field. We argue that with this unprecedented development in healthcare literature, the current status and trends in the field need to be mapped. The use of robust statistical and automatic methods for extracting key topics from a large set of articles has been increasingly used in other fields such as finance, marketing, statistics, tourism, and computer sciences. Borrowing the knowledge from these adjacent fields, this study employs probabilistic topic modelling with LDA as an automatic text analytics approach to unpack dominant topics and development trajectories in a large collection of research articles on healthcare OSCM. In doing so, we contribute to the literature on new and rigorous methods for systematic literature review in the field of OSCM. Our sample included 571 articles retrieved from 20 journals in the field of OSCM. The results produced 34 topics on healthcare research. Analysis of dynamic changes in the 34 over the past twenty years suggested 24 hot, 8 cold, and 2 steady topics (see Table 3).

Our findings show a shift of current research from traditional topics of operations management (Business process reengineering, Marketing, Outsourcing, Heuristics) to emergent topics such as Patient waiting for time, Industry 4.0 technologies, Sustainable operations, Risk and resilience, Climate change, and Circular economy. In general, the shift in topics seems to show a move away from traditional, efficiency-focused research toward broader goals of superior customer service and system's effectiveness. The data on research methods shows a larger dominance of modelling research (e.g., Markov, mixed-integer programming, simulation, queueing model, and stochastic) in exploring multidimensional issues of healthcare operations. However, the past three years have also seen some empirical research, including Structural equation modelling, Longitudinal study, and Action research. This shows a positive change in operations research journals from purely quantitative modelling studies to empirical research as well. This recent shift in a strategy not only offers a great opportunity to empirical researchers for publication in some OR journals but also provides sound premises on which to expand the scope and subscription of these journals.

The findings of this research offer useful research directions to researchers, journal editors, and policymakers in the field of healthcare research. Researchers can observe whether their recent research topics are hot, cold, or steady, and accordingly select appropriate topics for more impactful future research in the area. Particularly, some early-career researchers find it difficult to keep up with the growing literature in their fields of research and familiarise themselves with a huge volume of literature in identifying the subject area on which they can focus or apply for a research grant. The information from our topic modelling can be a useful tool for these researchers to understand recent developments in the field and then select more appropriate topics. Our findings can also be helpful to PhD students, who often face difficulties in topic selection due to time pressure. Journal editors can view if the extant research is consistent with their editorial policy, and they may like to launch a new editorial vision and direction. Our list of hot topics can be a valuable reference tool to launch special issues in the journals. Discovering underlying topics and tracking their evolution could also be of great interest to policymakers (e.g., government agencies) and industry. The information on which research themes and methods are growing or declining in popularity over time (Table 3 and Fig. 4) can support governmental funding agencies for grants allocation to promising areas. Likewise, firm managers and the industry as a whole can use this information to formulate promising R&D strategies and to make more informed investment decisions.

We believe that topic modelling is one of the most effective and reliable approaches in revealing the latent (hidden) structure and development of research topics in a field, and recommend that future research can combine the LDA-based models with other text analytics techniques from different text data (e.g., customer feedback, medical records, research reports, business reviews, company descriptions) and interconnection among various business areas (e.g., marketing, supply chain, information systems). For example, sentiment analysis (Pang & Lee, 2008) is deemed a popular text analytics tool in the field of finance (Sul et al., 2017), marketing (Liang et al., 2015), and operations/supply chain (Chae, 2015). The sentiment analysis can be integrated with topic modelling: a two-pronged method using topic modelling followed by sentiment analysis can offer more nuanced findings by revealing both positive and negative aspects of a product and/or service.

As with several studies, there are some limitations of our study. First, given the authors' extensive knowledge of the field and review of the extant literature, full efforts were made to guarantee that all pertinent articles were included in the analysis. However, some articles might have been ignored. Nevertheless, two measures might help mitigate this limitation: (1) the topics are generated based on the frequencies of the keywords/key terms and, therefore, missing a few articles from such a large dataset (571 articles) will not have a significant impact on overall results; (2) the dataset is validated with other databases. Second, the research is limited to healthcare research published in OSCM journals. That is, we excluded the papers and related journals containing healthcare research but not from OSCM perspectives.

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