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SYSTEMATIC REVIEW

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Key performance indicators of hospital supply chain: a systematic review

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Abstract

Background Performance measurement is vital for hospitals to become service-oriented, operate efficiently, attract customers, increase revenue, and improve both clinical and non-clinical outcomes, enabling them to succeed in the competitive healthcare sector. Key Performance Indicators (KPIs) play a crucial role in monitoring, assessing, and enhancing care quality and service delivery. However, identifying suitable KPIs for performance measurement can be challenging for hospitals due to a lack of comprehensive sources. Although many studies have explored KPIs, few have specifically addressed performance indicators within the hospital supply chain.

Objectives This systematic review seeks to identify and categorize the current knowledge and evidence concerning KPIs for the hospital supply chain.

Methods Seven bibliographic databases (PubMed, Scopus, Science Direct, Web of Science, Embase, ProQuest, and IEEE Xplore) were utilized in this research. The initial search identified 3661 articles; following a review of the titles, abstracts, and full texts, 32 articles were selected. Additionally, backward reference list checks were performed on the selected studies. Relevant studies were included based on the objectives, and data extraction was conducted using a form created in Word 2016.

Results A total of 64 KPIs for the hospital supply chain were identified. The performance indicators were categorized into financial ($n=37$), managerial ($n=15$), and clinical ($n=12$) categories.

Conclusions This comprehensive review successfully identified 64 KPIs, highlighting their potential to advance clinical practice and enhance patient care in hospitals. Further research is essential to establish a standardized methodology for KPI development within the hospital supply chain.

Keywords KPIs, Performance measures, Hospital supply chain, Healthcare systems

Introduction

Healthcare systems, particularly hospitals, are complex entities with unique characteristics, where various units collaborate to execute a wide array of tasks and processes. The nature of hospitals is inherently complex due to the unpredictable environment they operate in. Unlike industrial settings, healthcare services are characterized by variability in patient needs and treatment outcomes [1]. Furthermore, the internal hospital supply chain is both unique and intricate, facing operational challenges such as the high cost of medical products and devices used in surgical procedures, unpredictable demand for medical supplies, and difficulties in inventory management due to emergency situations. The hospital supply chain (HSC) involves the management of "information, supplies, and capital associated with the procurement and transfer of services from suppliers to end users, aimed at achieving both clinical and

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non-clinical outcomes." This supply chain integrates logistics and clinical operations within the hospital to ensure effective care delivery [2].

Healthcare systems foster a competitive market for hospitals, making performance measurement based on HSC infrastructures crucial for enhancing various performance aspects, including financial management and clinical outcomes. The motivation for this research stems from the need to improve the efficiency and effectiveness of hospital operations in a rapidly changing healthcare landscape. As hospitals face increasing pressures from regulatory changes, financial constraints, and evolving patient expectations, there is a pressing demand for robust performance measurement systems. Performance measurement equips hospital managers with insights into their hospital's performance, identifies weaknesses and strengths, and pinpoints areas for improvement. Thus, a comprehensive performance measurement system is vital for hospitals to adapt and thrive in competitive healthcare environments. This can be achieved through the use of effective tools such as Key Performance Indicators (KPIs), which provide a measurable framework for monitoring performance [3].

KPIs are metrics established for performance measurement, enabling an organization to assess its progress against predefined strategic and operational objectives. In hospitals, it is critical to select KPIs that align with the institution's goals, mission, and policies to ensure that performance measurement supports the overall objectives of the hospital [4]. A hospital KPI serves as a tool to manage, track, monitor, evaluate, modify, and transform healthcare process performance to ensure safety, efficiency, effectiveness, quality, increased patient and provider satisfaction, and ultimately, clinical outcomes. KPIs allow hospital managers to visualize quantitative and qualitative data in a manner that aids both operational and strategic decision-making [5, 6].

Changes in healthcare settings, including an aging population, resource inadequacies, healthcare provider shortages, lack of skilled personnel, declining reimbursement, lack of financial incentives, and strategic planning and management challenges, are inevitable. Modern healthcare organizations must possess adequate information about their intangible assets, such as clinical workflows, staff skills, patient satisfaction, and economic outcomes. To address these evolving challenges, continuous performance monitoring using KPIs is essential for improving processes and ensuring better outcomes [5]. KPIs play a critical role in evaluating, planning, and controlling through information support, clarity, and decision-making support for managers. They help hospital managers create action plans, facilitate daily operational decisions, and provide a roadmap linked to long-term success factors [7].

Although some KPIs for healthcare/hospital management have been identified through case studies, cross-sectional studies, or expert interviews, the findings remain insufficient [8]. Shawahna et al. [9] developed a set of KPIs for assessing pharmacists' contributions to epilepsy care in clinics, while Mahmodabadi et al. [4] identified performance indicators for hospital pharmacies in Iran, categorizing them into managerial, clinical (patient safety), and financial domains (income, costs, and financial utilization) [4, 9]. A cross-sectional observational study analyzed six key indicators include accessibility, timeliness, satisfaction, workload, outcomes, and safety to assess Primary Health Care performance in Oman [10].

While various reviews have been conducted, there is currently no comprehensive systematic review specifically addressing KPIs for the hospital supply chain. For instance, a recent scoping review identified evidence related to developing key performance indicators for digital health interventions [11]. An umbrella review classified hospital performance indicators into dimensions such as efficiency, effectiveness, patient-centeredness, safety, responsive governance, staff orientation, timeliness, and other dimensions [12]. Consequently, this systematic review, conducted in 2023, aims to fill this gap by reviewing studies that focus on hospital supply chain KPIs. The objective is to provide evidence-based data to promote the use of these KPIs in hospital operations. By systematically reviewing existing literature, this study seeks to offer insights that can guide hospital administrators in selecting and implementing effective KPIs, ultimately enhancing their operational performance and patient care. Although this review does not encompass all elements of a full systematic review, it adopts rigorous methods, including a review protocol, structured search strategy, clearly defined inclusion and exclusion criteria, and comprehensive data extraction processes, in line with systematic review practices [13].

Methods

Study design and registration

This study was conducted as a systematic review, following a systematic methodology aligned with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guideline [14]. A preliminary search was conducted in the Cochrane Library, PROPOSO, Nature Protocols, Protocols.io to confirm that no similar study had been previously published. The study protocol was pre-registered (Fallahnezhad et al. 2023) with the Open Science Framework (OSF) (Registration DOI: https://doi.org/10.17605/OSF.IO/C6QUY),

and any deviations from the protocol were documented and reported transparently [15, 16]. Although systematic reviews do not meet al.l the requirements of a full systematic review, this approach was selected to ensure a focused and rigorous examination of the available literature on hospital supply chain Key Performance Indicators (KPIs).

Research questions and objectives

The research question that guided the preparation of this study was: What are the key performance indicators (KPIs) relevant to the hospital supply chain, and how can they be categorized into financial, managerial, and clinical domains? The primary objective was to identify and categorize KPIs into relevant domains (financial, managerial, clinical) to support evidence-based decision-making in healthcare management. We utilized the PICOS mnemonic strategy, focusing on Population (hospital supply chain), Intervention (performance indicators), Comparison (various aspects of KPI usage), Outcome (categorization and effectiveness of KPIs), and Study Design (peer-reviewed studies) to formulate our research questions and objectives.

Databases and search strategy

To ensure comprehensive coverage of relevant studies, we searched seven scientific databases: PubMed, Scopus, ScienceDirect, Web of Science, Embase, ProQuest, and IEEE Xplore, for articles published between 2013 and December 3, 2023. Additionally, grey literature was reviewed, and backward reference list checking was performed to identify relevant sources.

The search strategy used Medical Subject Headings (MeSH) terms where applicable (in PubMed) and keywords such as "Key Performance Indicators," "hospital supply chain," and related terms. These terms were combined using Boolean operators ("OR" and "AND"). The detailed search strategy, including search terms and filters applied, is shown in Table 1. The searches were conducted by two independent researchers (MF, ML) to ensure consistency and thoroughness.

Inclusion and exclusion criteria

To enhance methodological rigor, the following inclusion criteria were applied:

Original, peer-reviewed studies published in English (This choice was made to ensure consistency and accessibility, as the authors have limited resources for translating non-English studies, and the focus is on the English-speaking healthcare context.)
Studies with full-text availability.
Studies reporting KPIs used in various aspects of the hospital supply chain.
Studies with clear outcomes related to KPI performance in hospital supply chain contexts.
Studies with clear outcomes related to KPI performance in hospital supply chain contexts.

The exclusion criteria were refined based on reviewer comments:

Non-English language studies were excluded due to the lack of translation resources and the focus on the English-speaking healthcare context.
Studies without full text available, conference abstracts, editorials, or other non-journal article types (e.g., dissertations, opinion pieces, posters) were excluded.
Studies focusing on disease-specific KPIs rather than supply chain management were excluded.

Study screening and selection

The screening process followed the 2020 PRISMA guidelines.

In the initial phase of this systematic review, a total of 3,661 articles were identified from various databases, including PubMed ($n=746$), Scopus ($n=1,596$), IEEE Xplore ($n=17$), ProQuest ($n=51$), Web of Science ($n=188$), Embase ($n=321$), and Science Direct ($n=742$). After removing duplicate records ($n=209$), the remaining 3,452 records were screened for relevance.

Table 1 The search strategy

Strategy	#1 AND #2 AND #3
#1	Key performance indicator **OR** Performance Measures **OR** Performance Metrics **OR** Quality Indicators, Healthcare.
#2	Supply chain **OR** logistics **OR** delivery **OR** distribution **OR** transportation **OR** Hospital Distribution Systems **OR** Materials Management, Hospital **OR** supply and distribution **OR** Supply, Hospital Central **OR** Hospital Equipment and Supplies **OR** Food Supply **OR** blood supply **OR** Delivery of Health Care **OR** Drug Delivery Systems.
#3	health care **OR** hospital **OR** pharmaceutical **OR** procurement **OR** Health Care Sectors **OR** Health Care Cost **OR** Health Care Quality **OR** Outcome Assessment, Health Care **OR** Health Care Reforms **OR** Healthcare Evaluation Mechanisms **OR** Health Care Quality, Access, and Evaluation **OR** Health Care Economics and Organizations **OR** Process Assessment, Health Care **OR** Delivery of Health Care, Integrated **OR** Administration, Hospital **OR** Pharmacy Administrations.

All records were imported into an EndNote library, and duplicate entries were removed. Study selection was conducted in three phases by two independent researchers (MF, ML), Title screening was conducted to remove studies not relevant to KPIs in hospital supply chains. This step was essential to narrow down the results from broad searches. Abstract screening eliminated studies that did not meet the inclusion criteria based on a deeper analysis of relevance to the research question.

During the screening process, a significant number of records were excluded due to inconsistencies with the aim of the study. Specifically, 3,373 records were removed based on poor consistency of titles, while an additional 39 records were excluded due to poor consistency of abstracts. Following this, 40 reports were assessed for eligibility, out of which 8 were excluded due to inconsistencies with the full texts. Full-text screening involved reviewing the selected articles in detail to confirm their inclusion.

Any discrepancies between the researchers during any phase were discussed and resolved through consensus, and if unresolved, a third researcher was consulted. Ultimately, a total of 32 studies were included in the review and participated in the data collection and analysis. Highly cited studies were given additional scrutiny to prevent selection bias. The study selection process is illustrated in Fig. 1 (PRISMA flowchart).

Data extraction and synthesis

Data extraction was conducted using a customized data extraction form developed in Word 2016, based on the PRISMA guidelines. Key data points extracted included Study characteristics (author, year, country, methodology), KPI categories (financial, managerial, clinical) and Outcomes (measures of performance in the hospital supply chain). Two researchers (MF, ML) extracted the data independently to ensure consistency. Any discrepancies were discussed and resolved through consensus. If disagreement persisted, a third researcher was consulted. Data synthesis involved categorizing KPIs into three primary domains: financial, managerial, and clinical. This thematic analysis was conducted to organize the KPIs meaningfully, ensuring clarity and applicability for healthcare administrators. Additionally, studies were assessed for bias using the Joanna Briggs Institute (JBI) critical appraisal checklist to evaluate methodological quality and potential bias.

Bias and quality assessment

To assess the methodological quality of the included studies, two researchers conducted a bias assessment using tools such as the Risk of Bias (RoB) tool from Cochrane for randomized studies and the JBI critical appraisal tool for non-randomized studies. Studies were assessed based on factors such as selection bias, reporting bias, and outcome bias. The results of these assessments were considered during data synthesis and interpretation to mitigate potential biases influencing the review's conclusions.

Results

The study selection process is illustrated in Fig. 1 (PRISMA flowchart), which provides a comprehensive overview of the search, screening, and selection stages. Out of the initial 3,661 articles identified, 32 studies were ultimately included after applying inclusion and exclusion criteria. The exclusion of duplicates and irrelevant articles at various stages ensured that only studies aligned with the research question on hospital supply chain KPIs were included.

The risk of bias for each included study was evaluated using the JBI Critical Appraisal Checklists, focusing on key methodological aspects such as congruity between research components, data collection, and ethical approval. Studies were rated as "High," "Moderate," or "Poor" based on a scoring system tailored to each study type. Abbreviations (Y, N, N/A) were used to summarize the responses, and quality ratings were assigned according to predefined thresholds, as detailed in Tables 4, 5, 6 and 7 (Appendix 1).

Characteristics of included studies

Table 2 provides a detailed summary of the 32 included studies, highlighting essential information such as study objectives, design, country of origin, and publication year. The studies were geographically diverse, with the majority from Iran (6 studies) [4, 5, 17–20], United States (6 studies) [21–26], and Canada (4 studies) [27–30]. Two were studies conducted in China [8, 31]. One study each was conducted in Nigeria [32], Belgium [33], Ghana [34], Malaysia [3], Chile [35], Brazil [36], Saudi Arabia [37], Greece [38], Italy [39], Oman [10], India [7], Palestine [9], Pakistan [40], and Norway [41]. Most studies employed a mixed-method approach (12 studies) [5, 9, 17, 19, 20, 23, 27, 30, 34, 35, 40, 41], followed by cross-sectional (7 studies) [10, 18, 24–26, 28, 32], and case studies(5 studies) [3, 8, 31, 33, 37]. There were three quantitative studies [21, 36, 39] and three qualitative studies [4, 7, 22]. Additionally, there was only one analytical study [38] and one observational retrospective study [29]. The publication years ranged from 2013 to 2022, with the highest number of studies published in 2019.

The categories of KPIs for hospital supply chain

In total, 64 KPIs were identified and categorized into three main domains: financial, managerial, and clinical.

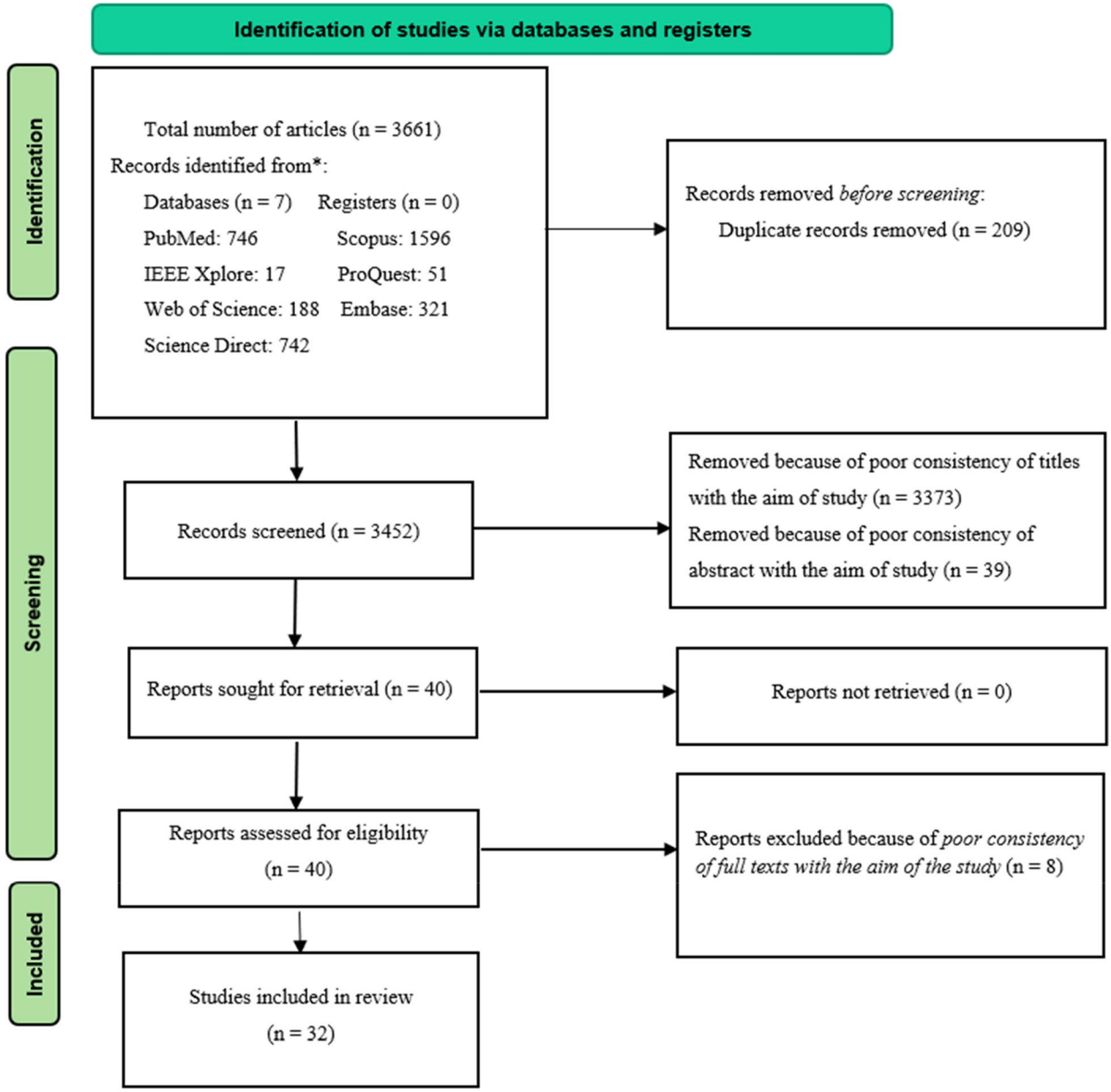

Fig. 1 PRISMA flowchart

The performance indicators (sixty-four in total) were reported in three primary categories: financial, clinical, and managerial. Most of performance indicators were related to financial (thirty-seven indicators), managerial (fifteen indicators), and clinical (twelve indicators) categories, respectively. The classification of the hospital supply chain indicators is illustrated in Table 3.

Financial KPIs

Financial KPIs were the most frequently reported ($n=17$), underscoring the critical role of financial sustainability in hospital supply chain management [3–5, 7, 8, 18–20, 25, 26, 28, 30, 31, 33–35, 38]. These indicators often focus on measuring cost efficiency, return on investment (ROI), and resource utilization, which are essential for maintaining operational budgets and ensuring profitability in hospital settings. Financial KPIs are crucial for hospitals to align supply chain activities with budget constraints while maintaining high-quality car. Studies such as Mahmodabadi et al. [4] emphasize that controlling costs without compromising care quality is a critical challenge for hospital managers. Moreover, Behrouzi et al. [3] identified that

Table 2 Characteristics of the included studies

Row	Authors	Year of publication	Country	Study design	Title	Objective/es
1	Tayyab et al. [41]	2022	Pakistan.	Mixed-method study.	Key Determinants of Quality in the Pharmaceutical Supply Chain.	The purpose of this study was on the interface between the pharmaceutical manufacturers and its supply chain. The main questions were: 1: What are the critical success factors in pharmaceutical supply chain quality management? 2: How SCQM relates to supply chain performance and business results in the pharmaceutical sector?
2	Dolatabad et al. [21]	2022	Iran.	Mixed-method study.	Analyzing the key performance indicators of circular supply chains by hybrid fuzzy cognitive mapping and Fuzzy DEMATEL: evidence from healthcare sector.	The purpose of this study was to present a multi-layer fuzzy-based decision-making approach to enhance the hospital Circular Supply Chain (CSC) performance by focusing on intensive care units (ICU) via key performance indicators analysis.
3	Victor et al. [7]	2021	India.	Qualitative and exploratory study.	DASHBOARD VISUALISATION FOR HEALTHCARE PERFORMANCE MANAGEMENT: BALANCED SCORECARD METRICS.	The purpose of this study was to create a conceptual framework in the digital dashboard format in order to mitigate the shortcomings in stressful hospital environment for hospitalization demands.
4	Al Rashidi et al. [10]	2020	Oman.	Cross-Sectional Observational Study.	Assessment of Key Performance Indicators of the Primary Health Care in Oman: A Cross-Sectional Observational Study.	The purpose of this study was to evaluating the current performance of PHC service by using KPIs to identify the potential challenges that need to be confronted, highlight the valuable lessons learnt and propose steps towards further PHC improvement.
5	Bell et al. [27]	2020	United States.	Retrospective cross-sectional study.	Association of Patient-Centered Medical Home designation and quality indicators within HRSA-funded community health center delivery sites.	The purpose of this study was to determine is there a positive association between clinical performance and PCMH status as the proportion of a CHC's designated delivery sites increases?
6	Yung et al. [30]	2019	Canada.	Retrospective observational pilot study.	Impact of a Layered Learning Practice Model on Delivery of Clinical Pharmacy Key Performance Indicators under a Tertiary Care Centre Oncology Service.	The purpose of this study was to quantify clinical productivity, as measured by proportions of eligible patients receiving cpKPIs and absolute numbers of completed cpKPIs, across scenarios involving pharmacists working with and without pharmacy learners.
7	Amos et al. [35]	2019	Ghana.	exploratory sequential mixed methods study.	Performance measurement of facilities management services in Ghana's public hospitals.	The purpose of this study was to explore and measure the performance of Facilities Management (FM) services in Ghana's public hospitals.

Table 2 (continued)

Row	Authors	Year of publication	Country	Study design	Title	Objective/es
8	Shawahna et al. [9]	2019	Palestine.	Mixed method/ observational study.	Development of key performance indicators to capture in measuring the impact of pharmacists in caring for patients with epilepsy in primary healthcare: A Delphi consensual study.	The purpose of this study was to develop and achieve formal consensus on a core set of KPIs that can be captured in measuring the impact of pharmacists in caring for patients with epilepsy (PWE) visiting epilepsy clinics as outpatients in primary healthcare practice.
9	Spackman et al. [31]	2019	Canada.	Mixed-method study.	Developing key performance indicators for prescription medication systems.	The purpose of this study was to KPIs that evaluate the effectiveness of a prescription medication system.
10	Mahmodabadi et al. [4]	2019	Iran.	Qualitative study.	Development of Managerial Key Performance Indicators for A Hospital Pharmacy Digital Dashboard.	The purpose of this study was to determine suitable performance indicators for Iranian hospital pharmacies.
11	Behrouzi et al. [3]	2019	Malaysia.	case study.	Identification and ranking of specific balanced scorecard performance measures for hospitals: A case study of private hospitals in the Klang Valley area, Malaysia.	The purpose of this study was to fill that gap by identifying and ranking a specific set of performance measures that are feasible and relevant for private hospitals.
12	Jiang et al. [32]	2019	China.	case study.	A large group linguistic Z-DEMATEL approach for identifying key performance indicators in hospital performance management.	The purpose of this study was to 1, introduce the linguistic Z-numbers for dealing with the vagueness and uncertainty of experts' uncertain assessments on the direct relations between indicators. 2, aggregate the evaluations of large-scale experts by a maximizing consensus method to improve group consistency. 3, an extend DEMATEL method was utilized to analyze the causal interdependence among indicators and find out KPIs for improving healthcare system. Finally, apply the proposed large group linguistic Z-DEMATEL approach to a rehabilitation hospital, and verify it by sensitivity analysis of the results and comparative analysis with other relevant methods.
13	Núñez et al. [36]	2018	Chile.	Mixed-method study.	Emergency departments key performance indicators: A unified framework and its practice.	The purpose of this study was to improve the performance of EDs using KPIs.
14	Romeo et al. [40]	2018	Italia.	Descriptive, quantitative study.	Radiologic team performance index: A new paradigm in KPI evaluating radiology examination volumes department performance: Results of Sicilian regional healthcare system survey.	The purpose of this study was to create a Key KPI defined Radiologic Team Performance Index (RTPI) able to compare the activity and efficiency of ROU operating under different environments and with different resources.

Table 2 (continued)

Row	Authors	Year of publication	Country	Study design	Title	Objective/es
15	de Mendonça Lima et al. [37]	2018	Brazil.	quantitative study.	Development and validation of key performance indicators for medication management services provided for outpatients.	The purpose of this study was to develop and validate KPI instrument for medication management services provided for outpatients in Brazilian context.
16	Emmert et al. [26]	2018	United States.	Cross-sectional, observational study.	A cross-sectional study assessing the association between online ratings and clinical quality of care measures for US hospitals: results from an observational study.	The purpose of this study was to adding further knowledge on whether both quantitative and qualitative patient satisfaction results displayed on US hospital rating websites demonstrate an association with clinical performance measures.
17	Hartveit et al. [42]	2017	Norway.	Mixed-method/ explorative study.	Quality indicators for the referral process from primary to specialized mental health care: an explorative study in accordance with the RAND appropriateness method.	The purpose of this study was to develop quality indicators measuring the impact of referral information from primary care to specialized mental health care to explore how the quality of this information can affect the quality of mental health care for adults.
18	Si et al. [8]	2017	China.	case study.	Identifying Key Performance Indicators for Holistic Hospital Management with a Modified DEMATEL Approach.	The purpose of this study was to develop a hybrid multiple criteria decision-making (MCDM) approach, called linguistic evidential DEMATEL, to analyze the total relations of performance indicators and identify KPIs for healthcare performance improvement.
19	Backman et al. [29]	2016	Canada	Descriptive, cross-sectional study.	Measuring and improving quality in university hospitals in Canada: The Collaborative for Excellence in Healthcare Quality.	The purpose of this study was to describe the successes and the challenges in the development of the Collaborative for Excellence in Healthcare Quality (CEHQ), an initiative to achieve higher quality of care in university hospitals in Canada.
20	Christodoulakis et al. [39]	2016	Greece.	Descriptive, analytical study.	"Big data" in health care Assessment of the performance of Greek NHS hospitals using key performance and clinical workload indicators.	The purpose of this study was to calculate performance indicators for the Greek NHS hospitals, adjusted according to their clinical workload using the DRG data, thus providing corrections to the current assessment of hospital performance and allowing comparison between the various different types of hospitals. The study also examined whether and to what degree the initial indicators are affected by the introduction of the DRG data.

Table 2 (continued)

Row	Authors	Year of publication	Country	Study design	Title	Objective/es
21	Karami et al. [5]	2016	Iran.	Mixed-method study.	Development of key performance indicators for academic radiology departments.	The purpose of this study was to develop a standard set of KPIs for academic radiology departments in using the Delphi technique.
22	Kress et al. [33]	2016	Nigeria.	Descriptive, cross-sectional study.	Assessment of Primary Health Care System Performance in Nigeria: Using the Primary Health Care Performance Indicator Conceptual Framework.	The purpose of this study was to identify main causes of PHC dysfunction, highlight areas of future research, and provide a framework by which the future policy agenda can be constituted.
23	Melnyk et al. [22]	2016	United States.	Descriptive, quantitative study.	A Study of Chief Nurse Executives Indicates Low Prioritization of Evidence-Based Practice and Shortcomings in Hospital Performance Metrics Across the United States.	The purpose of this study was to describe: (a) the EBP beliefs and level of EBP implementation by chief nurse executives (CNEs), (b) CNEs' perception of their hospitals' EBP organizational culture, (c) CNEs' top priorities, (d) amount of budget invested in EBP, and (e) hospital performance metrics.
24	Gale et al. [24]	2016	United States.	Mixed-method study.	Developing Program Performance Measures for Rural Emergency Medical Services.	The purpose of this study was to building on national efforts to develop EMS performance measures. Also, to identify measures relevant to the rural communities and hospitals supported by the Flexibility Program.
25	Fernandes et al. [28]	2015	Canada.	Mixed-method study.	Development of Clinical Pharmacy Key Performance Indicators for Hospital Pharmacists Using a Modified Delphi Approach.	The purpose of this study was to develop national cpKPIs to advance clinical pharmacy practice and improve clinical outcomes.
26	De Pourcq et al. [34]	2015	Belgium.	case study.	Measuring process performance in hospitals.	The purpose of this study was to develop a methodology to supply an operational dashboard linking KPI's of an upstream patient process with downstream value-added data. In fact, this study contributed to the development of a dashboard for the process of hip surgery.
27	Azami-Aghdash et al. [18]	2015	Iran.	Mixed-method study.	Developing performance indicators for clinical governance in dimensions of risk management and clinical effectiveness.	The purpose of this study was to develop and select indicators to evaluate the clinical governance model in the domains of risk management and clinical effectiveness.

Table 2 (continued)

Row	Authors	Year of publication	Country	Study design	Title	Objective/es
28	Khalifa et al. [38]	2015	Saudi Arabia.	Case Study/ qualitative survey and thematic analyses.	Developing Strategic Health Care Key Performance Indicators: A Case Study on a Tertiary Care Hospital.	The purpose of this study was to describe in details the complete process of developing a group of strategic KPIs to monitor and improve the performance of a tertiary care hospital, including different services. This project aimed at centralizing and standardizing KPIs to provide higher management with information and support evidence based strategic decision making.
29	Azadmanjir et al. [19]	2015	Iran.	Descriptive, cross-sectional study.	A Map for Clinical Laboratories Management Indicators in the Intelligent Dashboard.	The purpose of this study was to design national model of hospital laboratory dashboard in the context of HAKIM innovation model, which is the critical element to develop a clinical laboratory dashboard.
30	Wiler et al. [23]	2015	United States.	Descriptive, qualitative study.	Emergency Department Performance Measures Updates: Proceedings of the 2014 Emergency Department Benchmarking Alliance Consensus Summit.	The purpose of this study was to review and update key definitions and metrics for ED performance and operations.
31	Safdari et al. [20]	2014	Iran.	Mixed-method study.	Development of Balanced Key Performance Indicators for Emergency Departments Strategic Dashboards Following Analytic Hierarchical Process.	The purpose of this study was to develop a balanced set of KPIs for use in ED strategic dashboards following an analytic hierarchical process(AHP).
32	Horng et al. [25]	2013	United States.	Prospective before-after, quasi-experimental /Cross-Sectional study.	Prospective evaluation of daily performance metrics to reduce emergency department length of stay for surgical consults.	The purpose of this study was to evaluate whether a quality improvement process driven by a daily performance metric e-mail would be associated with a change in ED LOS for surgical consult patients.

Table 3 The categories of KPIs for hospital supply chain

Row	Authors	Financial indicators	Clinical indicators	Managerial indicators
1	Tayyab et al. [41]	Not mentioned	1. patient satisfaction 2.Medical error rate	1.Employee satisfaction 2. Inventory availability 3. Number of suppliers
2	Dolatabad et al. [21]	1.Inventory cost 2.Distribution cost	1.Patient wait time 2. Medical error rate	1.Inventory availability 2. Average Length of Stay
3	Victor et al. [7]	1. Return on assets 2. Average daily collections 3. Working capital ratio	1. patient Satisfaction 2. patient complaints 3. Patient wait time	Not mentioned
4	Al Rashidi et al. [10]	Not mentioned	1. patient Satisfaction	1. Patient wait time
5	Bell et al. [27]	1. Total costs per patient	1. patient Satisfaction	1. number of inpatients
6	Yung et al. [30]	Not mentioned	1. patient complaints	1. number of inpatients
7	Amos et al. [35]	1.Prompt/Timeliness release of cash 2.Proportion of budget 3.Cost effectiveness in delivery 4. Budget variance	1.Patient wait time 2. Nosocomial infection 3. Patient complaint	1. employee satisfaction
8	Shawahna et al. [9]	Not mentioned	1. patient complaints 2. physician complaints 3.Number of patient prescriptions 4.drug allergies 5.drug contraindications	1. number of inpatients 2. number of outpatients
9	Spackman et al. [31]	1. drug cost per patient	1.Number of patient prescriptions	1. number of inpatients 2. number of outpatients
10	Mahmodabadi et al. [4]	1. Total drug billing according to wards 2. Total drug billing according to type of drug and equipment 3. Total sale rate according to drugs 4. Costs of drugs based on consumption rate and storage time	1. patient Satisfaction 2. Physician satisfaction 3. drug allergies 4. drug contraindications	1. Inventory availability 2. Consumption rate of drugs and equipment according to diagnosis 3. Number of expired drugs and equipment
11	Behrouzi et al. [3]	1.Return On Investment (ROI) 2.Asset turnover 3.Cash flow 4.Average profit per hospital bed 5.Debt ratio 6.Net Profit Margin 7.Return On Equity(ROE) 8.Cost per patient day 9.Inventory turnover rate 10.Pharmaceutical stock turnover ratio	1.Patient satisfaction 2. Patient wait time 3. patient complaints 4. Nosocomial infection 5.Medical error rate	1.Employee satisfaction 2.Inventory availability 3.Bed occupancy ratio 4.length of stay
12	Jiang et al. [32]	1.Patient medical expenses 2.Net profit margin	1.Patient Satisfaction 2.Patient complaint 3.Nosocomial infection 4. Patient wait time	1.Length of stay 2.Bed occupancy Ratio 3.Employee satisfaction
13	Núñez et al. [36]	1.Quantity of assets	1.Patient complaint 2.Patient Satisfaction 3. Medical error rate 4. Nosocomial infection	1.Employee satisfaction 2.Bed occupancy ratio 3.length of stay 4. Inventory availability
14	Romeo et al. [40]	Not mentioned	Not mentioned	1.staff satisfaction
15	de Mendonça Lima et al. [37]	Not mentioned	1. Patient satisfaction 2. Patient quality of life 3. Patient clinical status	Not mentioned
16	Emmert et al. [26]	1. Amount of Costs	1. patient Satisfaction 2. Patient wait time 3.Nosocomial infection	1.Inventory availability
17	Hartveit et al. [42]	Not mentioned	1.patient Satisfaction 2. Patient wait time	Not mentioned
18	Si et al. [8]	1. Financial effectiveness	1. Patient satisfaction 2. Patient complaints 3. Patient Wait time 4. Medical error rate 5. Nosocomial infection	1.Employee satisfaction 2.Length of stay 3.Bed occupancy ratio

Table 3 (continued)

Row	Authors	Financial indicators	Clinical indicators	Managerial indicators
19	Backman et al. [29]	1. cost per patient	1. Nosocomial infection 2. Patient Satisfaction 3. Patient wait time	Not mentioned
20	Christodoulakis et al. [39]	1. cost per hospital day 2. drug cost per patient	Not mentioned	1. number of inpatients 2. number of outpatients 3. total Length of stay
21	Karami et al. [5]	1. Total costs of salary and benefits 2. Total cost of expendable	1. Patient wait time 1. patient complaints 3. physician complaints	1.employee complaints
22	Kress et al. [33]	Not mentioned	1. Patient wait time	1.Inventory availability
23	Melnyk et al. [22]	Not mentioned	1. patient infection 2. Patient Satisfaction	Not mentioned
24	Gale et al. [24]	Not mentioned	Not mentioned	1. Inventory availability 2. Number of suppliers
25	Fernandes et al. [28]	Not mentioned	1. Medical error rate	Not mentioned
26	De Pourcq et al. [34]	1. Cost per surgery	1.Patient satisfaction 2.Nosocomial infection	1. length of stay 2. bed occupancy ratio
27	Azami-Aghdash et al. [18]	Not mentioned	1. Medical error rate	Not mentioned
28	Khalifa et al. [38]	Not mentioned	1. Patient Satisfaction 2. Nosocomial infection	1. Number of Beds 2. Number of Admissions 3. Number of Discharges 4. Average Daily Census 5. Total Inpatient Days 6. Average Length of Stay 7. Average Bed Occupancy Rate 8. Bed Turnover Rate
29	Azadmanjir et al. [19]	1.Total cost 2.Total income 3.Net income	1. Number of patient prescriptions	1. The number of inpatients 2. The number of outpatients
30	Wiler et al. [23]	Not mentioned	1. Number of patient prescriptions 2. Patient wait time	1. number of outpatients 2. Number of empty beds
31	Safdari et al. [20]	1.Average cost of care 2.Operating expenses to operating revenues ratio 3.Average income growth rate 4. Change of cost per case	1.Patient satisfaction 2.Patient complaint 3. Patient wait time	1.employee satisfaction 2. length of stay 3. bed occupancy ratio
32	Horng et al. [25]	Not mentioned	1. patient Satisfaction 2. Patient wait time	Not mentioned

financial KPIs play a significant role in private hospitals where financial performance directly impacts service sustainability.

Managerial KPIs

Managerial KPIs ($n=24$) focus on operational efficiency and the effective management of hospital resources [3–5, 8–10, 18–20, 22, 23, 25, 26, 29–32, 34, 35, 37, 38, 40]. These indicators often assess staff satisfaction, inventory availability, and operational metrics like bed occupancy rate and length of stay.

The importance of managerial KPIs lies in their ability to identify areas for process improvement and ensure the smooth operation of the hospital supply chain. Studies such as Karami et al. [5] demonstrated that KPIs like bed occupancy rates are critical for strategic decision-making in academic radiology departments. Similarly Jiang et al. [32] highlighted that inventory availability is a core aspect of supply chain performance, influencing both patient care and financial outcomes.

Clinical KPIs

Clinical KPIs ($n=29$) are essential for measuring the impact of the supply chain on patient care [3–5, 7–10, 17–22, 24–37, 40, 41]. These indicators typically assess patient outcomes, including patient satisfaction, nosocomial infection rates, and medical error rates.

Clinical KPIs are integral to ensuring that the hospital supply chain directly contributes to improving patient outcomes Shawahna et al. [9] demonstrated that

clinical KPIs are particularly important for tracking the effectiveness of pharmacists in epilepsy care. Additionally, Si et al. [8] emphasized the role of KPIs like nosocomial infection rates in holistic hospital management, showing how supply chain inefficiencies can lead to adverse clinical outcomes.

The managerial KPIs identified in this review focus on operational efficiency and resource management within the hospital supply chain. Common managerial indicators include employee satisfaction, inventory availability, length of stay, and bed occupancy ratio, all of which are crucial for optimizing hospital workflows and ensuring the timely availability of critical supplies. For instance, inventory availability was highlighted in multiple studies as a key factor in preventing delays in care and ensuring continuous patient treatment [9, 34, 40]. Additionally, employee satisfaction and staff complaints were seen as important indicators of hospital management effectiveness, directly affecting operational performance and patient care delivery. Length of stay and bed occupancy ratio are also critical indicators for measuring the hospital's capacity to manage patient flow and resource utilization, with higher bed turnover and shorter stays indicating more efficient operation [3, 5, 19].

In contrast, the clinical KPIs identified emphasize the direct impact of supply chain management on patient outcomes. These include metrics such as patient satisfaction, nosocomial infection rates, medical error rates, and patient wait times, all of which are crucial for assessing the quality of care provided. Patient wait time and medical error rate were commonly reported across studies as key indicators of supply chain performance, particularly in ensuring that necessary medical supplies are available when needed [18, 31, 38]. Nosocomial infection rates were highlighted in several studies as indicators of how well the supply chain supports sterile processes and the overall safety of the hospital environment [8, 35, 37]. The balance between managing costs and maintaining high-quality clinical care is evident in the identification of financial indicators like cost per patient and inventory turnover rate, which hospitals use to evaluate both cost-effectiveness and patient care outcomes [3, 33, 36]. Together, these KPIs offer a comprehensive view of hospital supply chain performance, integrating operational efficiency with patient-centered care.

Discussion

This systematic review aimed to identify and classify the categories of hospital supply chain KPIs to make a common language and to identify relevant studies in this direction. Assessing hospital supply chain performance takes into account various aspects and dimensions given the organizational structure and process complexity of such entities and the diversity of the stakeholders involved in service delivery likely to set different concepts for the term "performance". This complexity introduces significant challenges in identifying universally applicable KPIs that effectively capture performance across various dimensions financial, managerial, and clinical outcomes. Consequently, the results of this review indicate that while some commonalities exist, the selection and application of KPIs can vary widely depending on the context and the specific focus of the study. This is even more challenging if we consider the differences in the core features of hospitals (e.g., dimension, ownership, degree of specialty, geographical location, public or private) [12].

Moreover, a key difficulty in defining hospital supply chain KPIs involves selecting the appropriate tool (scale) to establish consensus on the elements that should be incorporated into the final set of indicators. While the importance of multidisciplinary experts in identifying KPIs has been recognized, there is a need for more significant partnership with experts in this domain to highlight the necessities in developing KPIs for the hospital supply chain. A Delphi study might be employed to reach consensus on the key priority KPIs for the hospital supply chain. The Delphi method provides a straightforward, efficient, and economical approach, ensuring respondent anonymity. It can include numerous options and items and is extensively utilized with multidisciplinary and international expert panels [11]. In addition, the role of universities and academics is essential in this matter. This study also highlights a notable deficiency in evidence-based knowledge within this field. Determining KPIs for the hospital supply chain provides conditions for measuring the hospitals' performance from both clinical and non-clinical aspects, ensures progress evaluation based on pre-defined goals and helps managers and policymakers in decision-making by providing timely, accurate, and relevant information [42]. Today, evaluating and estimating hospital performance is essential for effectively planning investments, managing assets, and allocating financial resources. In this context, managers commonly depend on KPIs that assist in the decision-making process by offering metrics on input, output, processes, organizational costs, and financial performance [43].

According to the findings of this research, hospital supply chain KPIs are divided into three categories: financial, managerial, and clinical. The category of financial is highly emphasized and appears to be the most represented category from our review ($n=37$ indicators). Alongside them, the categories managerial ($n=15$ indicators) and clinical ($n=12$ indicators) are also well represented in the included studies. Awareness about budget, income, costs/expenses, turnovers, cash, net profit margin, debts, and other financial indicators are an

influential factor for managers' decision-making. While financial performance may not be a primary measure of success for healthcare institutions or hospitals, it is crucial for reaching their objectives and priorities. Analyzing financial indicators is crucial for assessing the hospital's financial health. It allows managers to identify financial trends over specific periods and make comparisons with other hospitals [44].

Managerial KPIs are metrics that assess the performance of organizational processes and administrative functions within healthcare facilities [45]. These KPIs focus on areas such as resource utilization, staff efficiency, financial performance, and compliance with regulatory standards. Although there are typically fewer managerial indicators compared to clinical ones, their impact on healthcare delivery is substantial. Managerial KPIs such as hospital occupancy rates and average length of stay directly influence resource allocation and operational efficiency. Efficient resource management can lead to reduced costs and improved patient outcomes. A study by Khalifa et al. [37]emphasizes the role of managerial KPIs in strategic decision-making, facilitating the allocation of resources to high-impact areas within a tertiary care hospital. Financial KPIs, including revenue per patient and operating margins, are critical for sustaining healthcare organizations. Effective management of financial indicators ensures that healthcare providers remain viable and can continue offering necessary services. The work of Amos et al. [34] shows how financial performance measures can drive improvements in facilities management services in public hospitals. Additionally, managerial KPIs help ensure compliance with healthcare regulations and standards. Indicators related to clinical governance and risk management are vital for maintaining quality and safety in healthcare. As discussed by Azami-Aghdash et al. [17], the development of performance indicators for clinical governance supports organizations in identifying areas needing improvement and minimizing risks to patient safety.

Clinical KPIs focus on the quality of care delivered to patients and are directly linked to patient outcomes [46]. These indicators measure aspects such as treatment effectiveness, patient satisfaction, and adherence to clinical processes. Clinical KPIs, such as readmission rates and mortality rates, are essential for assessing the quality of healthcare services. They provide direct feedback on patient outcomes and highlight areas needing improvement. Research by Núñez et al. [35] underscores the importance of a unified framework for clinical KPIs to enhance emergency department performance, directly linking indicator tracking with improved patient outcomes. Additionally, clinical KPIs often encompass metrics related to patient safety, such as infection rates and medication errors. Monitoring these indicators enables healthcare providers to implement interventions that enhance patient safety. The work of de Mendonça Lima et al. [36] illustrates the necessity of KPIs in outpatient medication management, emphasizing their role in preventing adverse events. Indicators that assess the efficiency of clinical processes, such as the time taken for diagnosis or treatment initiation, are crucial for optimizing care delivery. Christodoulakis et al. [38] emphasize the measuring clinical workload indicators alongside KPIs can help healthcare organizations better understand their performance dynamics and streamline operations.

Previous studies have introduced some financial indicators for different parts of hospitals or healthcare settings. For instance, in a mixed-method study, ten financial performance indicators were prioritized using the SAW method. Subsequently, based on the panel of experts, the top five indicators were chosen as KPIs. The identified KPIs included the ratio of total revenue to total cost, the percentage of personnel costs within the total cost, the hospital discount rate (%), average daily expenditures per bed, and the costs associated with drugs and materials [47]. Dubas-Jakóbczyk et al. [48] examined the financial performance of public hospitals in Poland based on ownership and organizational structure and investigated the relationship between financial performance and the identified variables. Total assets, total revenues, total costs, gross profit/loss, and arrears were considered as financial variables per hospital groups. Our findings showed that the increase in the number of financial indicators in the hospital supply chain results from the need for a more detailed and comprehensive analysis of financial and operational performance. These indicators enable managers to allocate resources efficiently and implement management strategies with greater precision, directly impacting the effectiveness of the hospital's supply chain. Also, this development leads to improving the quality of services and patient satisfaction through balancing financial resources and optimizing processes. The balance between financial and clinical aspects enables managers to make effective decisions to improve performance and the quality of healthcare services. However, according to our review, it seems that much more evidence is needed to identify KPIs for the hospital supply chain.

Despite the fewer number of managerial KPIs, their integration with clinical KPIs is essential for a holistic approach to healthcare performance management [8]. Managerial KPIs provide context and support for clinical indicators, ensuring that healthcare organizations can effectively meet patient needs while maintaining operational efficiency. Integrating both sets of KPIs enables

healthcare administrators to make data-driven decisions that enhance both management practices and clinical outcomes. This synergy is supported by the findings of Dolatabad et al. [20], who demonstrated how KPI analysis could enhance circular supply chain performance in healthcare, directly impacting service delivery. Utilizing both managerial and clinical KPIs fosters a culture of continuous improvement within healthcare organizations. For instance, by aligning managerial practices with clinical outcomes, organizations can identify inefficiencies in care processes and work to enhance both patient satisfaction and organizational performance. Yung et al. [29] illustrated how layering performance metrics can drive improvements in clinical pharmacy services within oncology, showcasing the importance of collaboration between managerial and clinical efforts.

Out of thirty-two included studies, six studies were conducted in Iran [1–6]. It should be noted that IT-based solutions (dashboards) have been widely viewed as an opportunity for improvement in the hospital supply chain to mitigate the enormous demand and supply of healthcare in both developed and developing countries. In recent years, clinical dashboards have been rapidly adopted by numerous countries worldwide, with governments and policymakers increasingly acknowledging their potential as visual tools for quickly representing an organization's performance. These dashboards present the latest KPIs on a single screen in a concise, easy-to-comprehend format [7, 8]. Our study showed that Iran has also begun to use health initiatives frequently in recent years [9, 10]) and some studies identified KPIs for the hospital supply chain. Further research is recommended on the design of dashboards and the development of dashboard tools to enhance understanding of the role KPIs play in hospital supply chain management.

The hospital has complex and unique nature with its personnel having different information needs concerning their roles. Therefore, it is essential to pay attention to selecting suitable performance indicators to be monitored by the dashboard [11].

Limitations

There are certain constraints to this current research that future studies could potentially address. One of the primary limitations was the limited access to abstracts and full texts of numerous articles. Despite searching the specified databases, full access to all the databases was not possible. Moreover, the search was conducted exclusively in English, which means relevant articles in other languages might have been overlooked, potentially leading to the omission of some relevant studies. Additionally, although we systematically reviewed the KPIs of hospital supply chains, studies focusing on performance indicators for specific diseases or domains, such as dermatology, were not included due to the scope of the study. During the analysis phase, every effort was made to minimize the risk of bias by having discrepancies discussed between two researchers. However, some issues might have escaped our attention. Furthermore, not all studies were able to encompass all three categories of hospital supply chain performance indicators. Despite these challenges, this systematic review stands as a pioneering effort to synthesize the existing knowledge on this topic comprehensively and uniquely. The decision to include only original studies was made to ensure the provision of practical evidence.

Conclusion and suggestions

This systematic review identified and categorized 64 Key Performance Indicators (KPIs) related to the hospital supply chain, emphasizing the importance of a balanced approach across financial, managerial, and clinical domains. Of the numerous studies available, only 32 met the criteria for inclusion in this review. Each of the included articles explored KPIs within the hospital supply chain, employing a variety of methodologies that reflected the diverse perspectives in this field. Our comprehensive examination revealed a predominance of performance indicators in the financial category (37 indicators), followed by managerial (15 indicators) and clinical (12 indicators). This distribution underscores a critical gap in the existing literature: a relative scarcity of robust, original studies focusing on clinical and managerial KPIs.

New studies are urgently needed to address significant gaps in the research on Key Performance Indicators (KPIs) in the hospital supply chain, particularly in establishing a standardized methodology for developing KPIs that facilitates comparability across studies. While financial indicators are well represented, the limited focus on clinical and managerial KPIs hinders a holistic assessment of hospital performance; therefore, future research should aim to develop and validate KPIs in these domains to ensure comprehensive performance evaluation. Additionally, further studies should explore the implementation, measurement, and evaluation processes of these KPIs in real-world hospital settings to provide insights into practical challenges and successes, ultimately informing best practices that enhance clinical practice and improve patient care quality. Finally, it is crucial for healthcare managers to identify and utilize appropriate performance metrics that drive decision-making, necessitating research focused on the needs and perspectives of healthcare managers in KPI selection and implementation.

Supplementary Information

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Supplementary Material 1.

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Nil.

Authors' contributions
M.F. and M.L. were responsible for the study conception and design. Both M.F. and A.V. independently conducted the search of relevant databases and included the appropriate articles according to the study objectives. M.L. supervised the entire project. Both M.F. and A.V. prepared the first draft of the manuscript. They also conducted data analysis, made critical revisions to the paper for important intellectual content, and supervised the study. All authors have read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Competing interests
The authors declare no competing interests.

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