SCIENTIFIC CULTURE

www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 11674-11696
Open Access. Online & Print

DOI: 10.5281/zenodo.20238352

INTEGRATING SAFETY AND ENVIRONMENTAL PERFORMANCE INDICATORS IN HOSPITALS: A SYSTEMATIC LITERATURE REVIEW

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Received: 07/02/2026
Accepted: 08/04/2026

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ABSTRACT

Hospitals operate in complex systems where patient and occupational safety coexist with environmental challenges related to resource consumption, waste generation, and hazardous material management. Although research on safety performance indicators and environmental performance indicators in hospitals continues to expand, these domains have largely been examined separately, leading to fragmented measurement approaches that limit holistic assessment. This study conducts a systematic literature review (SLR) to identify, classify, and synthesise safety and environmental performance indicators used in hospital settings. Following the PRISMA 2020 guidelines, systematic searches of Scopus and Web of Science yielded 2,543 records, of which 48 peer-reviewed studies satisfied the inclusion criteria. Data were extracted and analysed using a thematic synthesis approach, complemented by descriptive quantitative analysis to examine indicator domains and measurement orientations, including the distinction between leading and lagging indicators. The findings reveal a shift from outcome-based (lagging) indicators toward leading, process-oriented indicators, particularly those linked to organisational culture, leadership, learning systems, and managerial practices. Safety indicators remain dominant, while environmental indicators increasingly address governance, resource efficiency, and waste management. Several indicators operate at the intersection of safety and environmental performance, especially in medical waste management, water, sanitation, and hygiene (WASH), infection prevention, and hazardous material control, highlighting shared operational risk pathways. This review demonstrates that safety and environmental performance are interconnected rather than independent. By consolidating dispersed evidence into an integrated thematic framework, the study supports more holistic and proactive hospital performance assessment.

KEYWORDS: Hospital Performance; Safety Indicators; Environmental Indicators; Systematic Literature Review; Sustainability.

1. INTRODUCTION

Hospitals represent one of the most complex operational environments within the built environment, characterised by continuous service delivery, high resource intensity, and elevated risk profiles (Das et al., 2026). Alongside their primary function of safeguarding human life, hospitals generate substantial environmental footprints through energy consumption, water use, waste production, and hazardous material handling (Olawade et al., 2025).At the same time, patient and occupational safety remains a critical priority, given the high prevalence of adverse events, workplace injuries, and system-related failures within healthcare settings (Castillo et al., 2025). These dual challenges position hospitals at the intersection of safety performance and environmental performance, necessitating systematic and measurable approaches to performance management (Omari et al., 2026).

Over the past two decades, a growing body of research has examined safety performance indicators in hospital contexts, focusing on dimensions such as occupational health and safety, patient safety incidents, infection control, and risk management practices (Lai et al., 2022). Parallel to this, environmental performance indicators have increasingly been explored in relation to hospital sustainability, addressing issues such as energy efficiency, emissions, waste management, water conservation, and regulatory compliance (Chaiya, 2025). Despite this expansion, these two streams of research have largely evolved in isolation, resulting in fragmented indicator frameworks that limit holistic performance assessment in healthcare facilities (Y. Zhao et al., 2025).

Performance indicators play a pivotal role in translating abstract policy objectives into operationally actionable metrics. In hospital settings, indicators support benchmarking, regulatory compliance, internal audits, and strategic decision-making (Vinci et al., 2025). However, the proliferation of indicators across disciplines has also introduced challenges related to conceptual inconsistency, overlap, and variability in measurement practices (Paul et al., 2025). In particular, the lack of integrated frameworks that simultaneously capture safety and environmental dimensions constrains the ability of hospital managers and policymakers to understand trade-offs, synergies, and systemic risks (Mafi-Gholami et al., 2026).

Several review studies have attempted to synthesise safety indicators or environmental indicators independently; however, a comprehensive synthesis that systematically maps and classifies both safety and environmental performance indicators within hospital contexts remains limited (Kim & Kim, 2024). Existing reviews often focus on specific sub-domains, such as patient safety or healthcare sustainability, without explicitly addressing how indicators are conceptualised, operationalised, and distributed across thematic domains (Kommusaar et al., 2026). Moreover, methodological heterogeneity across studies further complicates comparative analysis and evidence integration (Maziotis & Molinos-Senante, 2025). This gap constrains the development of holistic performance assessment frameworks capable of informing integrated governance and improvement strategies in complex healthcare systems.

In response to these limitations, the present study adopts a systematic, PRISMA-guided thematic review approach to identify, classify, and synthesise safety and environmental performance indicators applied within hospital settings (Huang et al., 2025). Rather than evaluating the effectiveness of specific interventions or estimating causal effects, this review focuses on mapping the conceptual structure, measurement orientation, and thematic distribution of indicators reported in the literature. By systematically analysing peer-reviewed studies, the review seeks to clarify how different categories of indicators are deployed, how they relate to organisational and environmental contexts, and where integration between safety and environmental performance is most evident.

Specifically, this review aims to:

(i) Identify and categorise safety and environmental performance indicators used in hospital settings;

(ii) Examine dominant thematic patterns and measurement orientations, including the distinction between leading and lagging indicators.

(iii) Explore areas of integration where safety and environmental indicators intersect within shared operational and governance processes.

By consolidating dispersed evidence into a coherent thematic framework, this study contributes to the refinement of hospital performance measurement research and provides a structured knowledge base for healthcare administrators, policymakers, and sustainability practitioners seeking to align safety and environmental objectives within complex healthcare systems.

2. METHODS

2.1. Study Design and Reporting Standard

This study adopted a systematic literature review

(SLR) design to identify, classify, and synthesise safety and environmental performance indicators applied within hospital settings (Sohal et al., 2025). The review was conducted and reported in accordance with the PRISMA 2020 guidelines, ensuring transparency and reproducibility across all stages of study identification, screening, eligibility assessment, and inclusion (Page et al., 2021). Given the conceptual and methodological diversity of the included studies, PRISMA was applied as a procedural reporting framework rather than as a basis for effect estimation or meta-analysis. The overall study selection process is presented in Figure 1.

2.2. Review Question

The review was guided by the following research question:

"How are safety and environmental performance indicators conceptualised, operationalised, and integrated in hospital settings, and what dominant thematic patterns and measurement orientations emerge from the existing literature?"

This question informed the development of the search strategy, eligibility criteria, data extraction framework, and synthesis approach.

2.3. Literature Search Strategy

A comprehensive literature search was conducted using two major bibliographic databases: Scopus and Web of Science (WoS). These databases were selected due to their extensive coverage of peer-reviewed journals in healthcare management, patient safety, environmental sustainability, and health systems research. The search strategy was designed to retrieve empirical studies and applied frameworks addressing explicitly defined safety and/or environmental performance indicators within hospital or healthcare facility contexts.

To ensure conceptual consistency and reproducibility, the same core keywords were applied across both databases, with syntax adjusted to meet platform-specific requirements. Table 1 presents the full search strategy used in each database.

Table 1: Database Search Strategy.

Database	Search Field	Search String
Scopus	TITLE-ABS-KEY	TITLE-ABS-KEY (hospital* OR "healthcare facilit*") AND TITLE-ABS-KEY (("occupational safety" OR "patient safety") W/3 performance OR ("environmental management" OR sustainability) W/3 performance) AND TITLE-ABS-KEY ("performance indicator*" OR metric* OR measurement OR assessment) AND TITLE-ABS-KEY ("management system*" OR "performance management" OR "safety management" OR "environmental management system*")
Web of Science	TS	TS = (hospital* OR "healthcare facilit*") AND TS = (("occupational safety" OR "patient safety") NEAR/3 performance OR ("environmental management" OR sustainability) NEAR/3 performance) AND TS = ("performance indicator*" OR metric* OR measurement OR assessment) AND TS = ("management system*" OR "performance management" OR "safety management" OR "environmental management system*")

Searches were limited to English-language peer-reviewed journal articles, with no restrictions applied to geographical location. Minor syntax adjustments were applied to ensure functional equivalence between database search fields. The final search was conducted in [month/year], and all retrieved records were exported for screening.

2.4. Study Selection and Data Extraction

The database search yielded a total of 2,543 records, including 2,101 records from Scopus and 442 records from Web of Science. Prior to screening, 613 duplicate records were removed. The remaining 1,930 records underwent title and abstract screening based on the predefined eligibility criteria.

During this stage, 1,812 records were excluded because they did not focus on hospital settings, did not address safety or environmental performance indicators, or were non-empirical publications such as editorials or commentaries. Full-text versions were sought for the remaining 118 records, of which 109 articles were successfully retrieved and assessed for eligibility.

Following full-text assessment, 61 studies were excluded due to the absence of explicitly defined or measurable indicators, insufficient methodological detail, purely conceptual or review-only designs, or misalignment with hospital contexts. Ultimately, 48 studies met all inclusion criteria and were included in the final synthesis. Detailed information on the study selection process and reasons for exclusion is presented in Figure 1 (PRISMA flow diagram).

Data extraction was conducted using a structured extraction form developed specifically for this review. Extracted data included:

(i) Bibliographic information (author(s), year of publication, and country)

(ii) Study objectives and design

(iii) Hospital setting and scope

(iv) Types and domains of safety and environmental performance indicators

(v) Indicator definitions and measurement approaches

All extracted data were systematically checked to ensure consistency and completeness prior to synthesis.

2.5. Quality Appraisal of Included Studies

A descriptive quality appraisal was conducted to assess the methodological clarity and transparency of the included studies. Given the heterogeneity of study designs encompassing quantitative, qualitative, mixed-methods, and framework-based studies, a score-based exclusion approach was not considered appropriate (Berre et al., 2026).

Quality appraisal focused on five core criteria:

(Q1) clarity of study objectives

(Q2) explicit definition of indicators

(Q3) appropriateness of the methodological approach

(Q4) transparency of data sources

(Q5) relevance to hospital contexts

Each study was assessed using a three-level judgement (yes, partial, or no). Importantly, no study was excluded on the basis of quality appraisal outcomes. Instead, appraisal results were used to contextualise the interpretation of findings during synthesis. The detailed quality appraisal results are presented in Table 2.

Table 2: Quality appraisal of Included Studies.

No	Study (Author, Year)	Q1	Q2	Q3	Q4	Q5	Overall Quality
1	(D. Zhao et al., 2025)	✓	✓	✓	✓	✓	High
2	(M. Wang & Tao, 2017)	✓	✓	✓	–	✓	Moderate
3	(Bhakta et al., 2021)	✓	✓	✓	✓	✓	High
4	(Chen et al., 2021)	✓	✓	✓	✓	✓	High
5	(Wagner et al., 2018)	✓	✓	✓	–	✓	Moderate
6	(Jeong et al., 2019)	✓	✓	✓	✓	✓	High
7	(Pfa, 2020)	✓	–	✓	–	✓	Moderate
8	(Ferorelli et al., 2020)	✓	✓	✓	✓	✓	High
9	(Goula et al., 2021)	✓	✓	✓	–	✓	Moderate
10	(S. Lee et al., 2021)	✓	✓	✓	✓	✓	High
11	(Chen et al., 2021)	✓	–	✓	✓	✓	Moderate
12	(Kiersnowska et al., 2021)	✓	✓	✓	–	✓	Moderate
13	(Kwon & Kim, 2021)	✓	✓	✓	✓	✓	High
14	(Azyabi et al., 2022)	✓	✓	✓	✓	✓	High
15	(Al-zadjali et al., 2025)	✓	✓	✓	✓	✓	High
16	(Alharbi & Alhaji, 2021)	✓	✓	✓	✓	✓	High
17	(Etim et al., 2021)	✓	✓	✓	–	✓	Moderate
18	(Bosco et al., 2022)	✓	✓	✓	✓	✓	High
19	(Seifert, 2018)	✓	–	✓	–	✓	Moderate
20	(Raji & Maksimovi, 2022)	✓	✓	✓	✓	✓	High
21	(Ioannidis & Leonidou, 2021)	✓	✓	✓	✓	✓	High
22	(Martin-rios et al., 2022)	✓	✓	✓	–	✓	Moderate
23	(Zafaranlouei et al., 2023)	✓	✓	✓	✓	✓	High
24	(Al-Sulbi et al., 2023)	✓	✓	✓	–	✓	Moderate
25	(Moldovan et al., 2022)	✓	✓	✓	✓	✓	High

No	Study (Author, Year)	Q1	Q2	Q3	Q4	Q5	Overall Quality
26	(Ludusanu et al., 2025)	✓	✓	✓	✓	✓	High
27	(Gusca, 2025)	✓	–	✓	–	✓	Moderate
28	(Ionescu et al., 2018)	✓	–	✓	✓	✓	Moderate
29	(Fuentes-moraleda et al., 2019)	✓	✓	✓	✓	✓	High
30	(Nassani et al., 2022)	✓	✓	✓	✓	✓	High
31	(Lencia et al., 2023)	✓	✓	✓	–	✓	Moderate
32	(Alqarni et al., 2023)	✓	–	✓	–	✓	Moderate
33	(Nayak & Uppal, 2023)	✓	✓	✓	✓	✓	High
34	(Amato et al., 2024)	✓	✓	✓	✓	✓	High
35	(Fontana et al., 2024)	✓	✓	✓	✓	✓	High
36	(Çetin et al., 2025)	✓	✓	✓	–	✓	Moderate
37	Corrigan et al., 2018	✓	–	✓	✓	✓	Moderate
38	(Jarošov et al., 2022)	✓	✓	✓	✓	✓	High
39	(Dihan et al., 2023)	✓	✓	✓	–	✓	Moderate
40	(Voudrias, 2018)	✓	✓	✓	✓	✓	High
41	(Klemeš et al., 2020)	✓	✓	✓	✓	✓	High
42	(Mitchell et al., 2016)	✓	–	✓	✓	✓	Moderate
43	(Zecevic et al., 2017)	✓	✓	✓	✓	✓	High
44	(Polanco-Levicán & Salvo-Garrido, 2022)	✓	✓	✓	✓	✓	High
45	(Guerin & Sleet, 2021)	✓	–	✓	✓	✓	Moderate
46	(Hafezi et al., 2022)	✓	✓	✓	✓	✓	High
47	(Hong & Kim, 2025)	✓	✓	✓	✓	✓	High
48	(Al-zadjali et al., 2025)	✓	✓	✓	✓	✓	High

2.6. Synthesis Strategy

A thematic synthesis approach was employed to analyse and integrate the extracted data (Pandian et al., 2026). Initially, all identified safety and environmental performance indicators were coded inductively based on their conceptual meaning and functional role in hospital performance assessment. These initial codes were iteratively reviewed and grouped into higher-order themes through constant comparison.

To support the thematic synthesis, descriptive quantitative analysis was applied, including frequency counts of indicator domains and classifications of indicators according to their measurement orientation (leading versus lagging). The synthesis outcomes are reported narratively in the Results section and supported by Tables 2–6 and Figures 2–5, which collectively illustrate indicator distributions, thematic relationships, and integrative patterns.

This combined qualitative–quantitative synthesis strategy enabled a structured and comprehensive examination of how safety and environmental performance indicators are conceptualised, operationalised, and integrated within hospital settings.

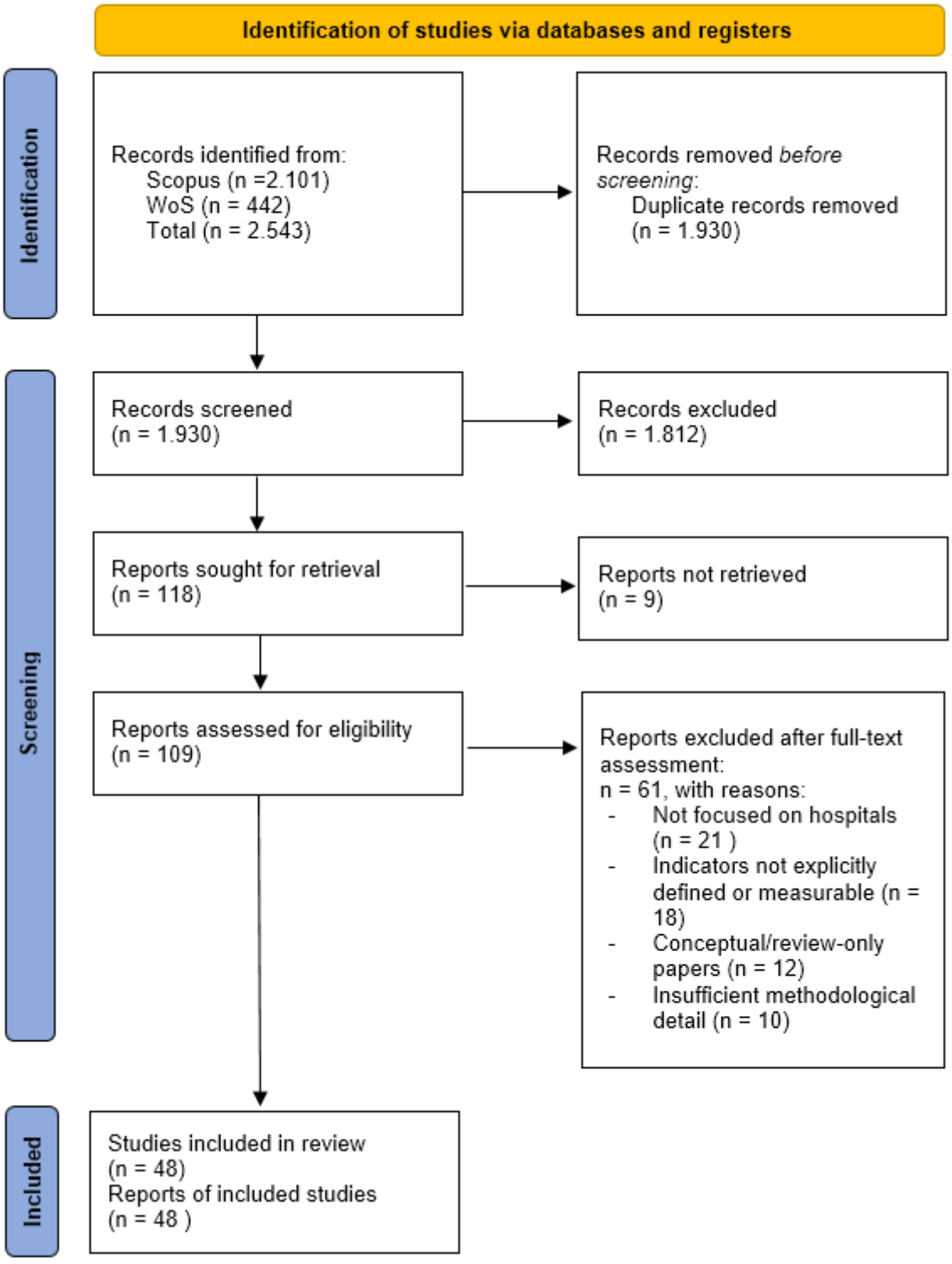

Figure 1: PRISMA 2020 flow diagram.

3. RESULTS

3.1. Study Selection and Characteristics

A total of 48 peer-reviewed articles were retained for inclusion in the final synthesis following the systematic screening process. The study selection procedure, encompassing identification, screening, eligibility assessment, and final inclusion, is summarized in the PRISMA flow diagram (Figure 1). After duplicate removal and sequential screening of titles, abstracts, and full texts, all remaining records satisfied the predefined inclusion criteria and were

therefore included in the qualitative synthesis.

An overview of the general characteristics of the included studies is provided in Table 3. The body of evidence spans a broad publication period, ranging from early conceptual contributions to recent empirical investigations, reflecting sustained and increasing scholarly interest in the measurement of safety and environmental performance within hospital settings (Bhakta et al., 2021; Dihan et al., 2023; Mori & Takebayashi, 2002). Most studies adopted quantitative observational or cross-sectional designs (Chen et al., 2021; Kiersnowska et al., 2021; D. Zhao et al., 2025), while a smaller proportion employed qualitative approaches (Ferorelli et al., 2020; Vellingri et al., 2025), mixed-methods designs (Jeong et al., 2019; M. Wang & Tao, 2017), or conceptual framework development (Ludusanu et al., 2025; Seifert, 2018).

The geographical distribution of the studies was heterogeneous, encompassing hospital systems across Asia, Europe, the Middle East, Africa, and the Americas, including both high-income and middle-income countries. This diversity reflects a wide range of organizational, regulatory, and operational contexts, such as tertiary hospitals in East Asia (S. Lee et al., 2021; X.-C. Wang et al., 2021), public hospitals in Europe (Goula et al., 2021; Moldovan et al., 2022), and healthcare facilities in developing settings (Bosco et al., 2022; Etim et al., 2021).

Table 3: Characteristics of Included Studies (n = 48).

No	Author (s) & Year	Country/Region	Study Design	Healthcare Context	Primary Indicator Focus
1	(Bhakta et al., 2021)	India	Quantitative	General hospitals	Environmental (waste, CE)
2	(D. Zhao et al., 2025)	China	Quantitative	Urban hospitals	Patient safety outcomes
3	(X.-C. Wang et al., 2021)	China	Quantitative	Large hospitals	Energy & water efficiency
4	(Chen et al., 2021)	China	Quantitative	Tertiary hospital	Occupational safety
5	(Dihan et al., 2023)	State of Kuwait	Mixed-methods	Hospital pharmacy	Medication safety
6	(Vellingri et al., 2025)	India	Qualitative	Healtcare facilities	Sustainable waste
7	(Bdour & Kharabsheh, 2025)	Yordania	Quantitative	Hospitals	AI-based waste management
8	(Mori & Takebayashi, 2002)	Japan	Conseptual	Health systems	OSHMS
9	(Ioannidis & Leonidou, 2021)	United States	Qualitative	Service organization	3R strategy
10	(Amato et al., 2024)	Brazil	Quantitative	Field hospitals	Infectious waste
11	(M. Wang & Tao, 2017)	China	Mixed-methods	County hospitals	Safety culture
12	(Wong et al., 2018)	China	Qualitative	Technical workplaces	Accident analysis
13	(Jiménez-Rodríguez et al., 2018)	Spanish	Quantitative	Hospitals	Clinical risk
14	(Corrigan et al., 2018)	United States	Qualitative	Surgical Hospitals	Never events
15	(Wagner et al., 2018)	Germany	Quantitative	University	Integrated
16	(Jeong et al., 2019)	Taiwan	Mixed-methods	Hospitals	Measurement validity
17	(Pfa, 2020)	Germany	Quantitative	Hospitals	Organizational safety
18	(Ferorelli et al., 2020)	Italy	Mixed-methods	University hospitals	Incident learning
19	(Li et al., 2020)	China	Qualitative	Multi-industry	Safety training
20	(Goula et al., 2021)	Greek	Quantitative	Public hospitals	Learning organization
21	(S. Lee et al., 2021)	Korea	Conceptual	Tertiary hospitals	Alarm safety
22	(Chen et al., 2021)	Taiwan	Qualitative	Hospital group	Pandemic safety culture
23	(Kiersnowska et al., 2021)	Poland	Quantitative	Hospitals	Infection control
24	(H. E. Lee et al., 2021)	Korea	Mixed-methods	Healthcare lab	Chemical safety
25	(Kwon & Kim, 2021)	Korea	Qualitative	Hospitals	Safety leadership
26	(Moldovan et al., 2022)	Romania	Quantitative	Emergency hospitals	Sustainability framework
27	(Azyabi et al., 2022)	United States	Qualitative	Us hospitals	PSC outcomes
28	(Jarošov et al., 2022)	Czech Republic	Conceptual	Acute hospitals	Adverse events
29	(Bosco et al., 2022)	Uganda	Qualitative	Health facilities	WASH-IPC
30	(Martin-rios et al., 2022)	India	Quantitative	Foodservice (transferable)	Waste prevention
31	(Nayak & Uppal, 2023)	India	Mixed-methods	Pandemic waste	COVID-19 waste
32	(Zafaranlouei et al., 2023)	Iran	Qualitative	Hospital waste	MCDA evaluation
33	(Gusca, 2025)	Latvia	Quantitative	Hospital	Social LCA
34	(Seifert, 2018)	Germany	Conceptual	Hospital	EMS barriers
35	(Ionescu et al., 2018)	Romania	Qualitative	Service sector	IMS & CSR

36	(Fuentes-moraleda et al., 2019)	Spanish	Quantitative	Hospitals (transferable)	EMS value
37	(Alharbi & Alhaji, 2021)	Saudi Arabia	Mixed-methods	Hospitals	HCW sustainability
38	(Etim et al., 2021)	Nigeria	Qualitative	Hospitals	Waste system
39	(Nassani et al., 2022)	Romania	Quantitative	organization	CSR-environment
40	(Raji & Maksimovi, 2022)	Peru	Conceptual	Facilities	Energy management
41	(Lencia et al., 2023)	Peru	Qualitative	Hospitals (transferable)	Eco-innovation
42	(Al-Sulbi et al., 2023)	Saudi Arabia	Quantitative	Healthcare facilities	BMWM
43	(Alqarni et al., 2023)	Egypt	Mixed-methods	Healthcare organization	Digital HRM
44	(Fontana et al., 2024)	Italy	Qualitative	Healthcare cleaning	Hygiene & LCA
45	(Çetin et al., 2025)	Turkey	Quantitative	University hospitals	Lab waste
46	(Ludusanu et al., 2025)	Romania	Conceptual	European hospitals	IMS performance
47	(Hong & Kim, 2025)	Korea	Qualitative	Supply chain (AI)	ESG risk detection
48	(Al-zadjali et al., 2025)	Oman	Quantitative	Hospitals & PHC	Safety culture

In terms of thematic focus, the included studies addressed multiple dimensions of hospital performance. Several investigations primarily concentrated on patient and occupational safety indicators, including healthcare-associated infections, adverse events, safety culture, and occupational injuries (Chen et al., 2021; Corrigan et al., 2018; Jiménez-Rodríguez et al., 2018; Pfa, 2020). Other studies focused predominantly on environmental performance indicators, such as medical and laboratory waste generation, waste treatment practices, energy management, and water-use efficiency (Amato et al., 2024; Bhakta et al., 2021; Çetin et al., 2025; Chen et al., 2021). In addition, organizational and managerial dimensions—most notably safety culture, leadership commitment, learning systems, and reporting mechanisms—were examined as key determinants of performance in a number of studies (Al-zadjali et al., 2025; Goula et al., 2021; Kwon & Kim, 2021).

Notably, a subset of more recent publications adopted an explicitly integrated perspective, examining safety and environmental indicators within unified management systems, sustainability frameworks, or systems-based approaches (Ionescu et al., 2018; Ludusanu et al., 2025; Moldovan et al., 2022). Other studies further extended this integration through environmental management systems, corporate social responsibility, and emerging digital or AI-enabled tools for performance monitoring and risk detection (Fuentes-moraleda et al., 2019; Gusca, 2025; Hong & Kim, 2025). These findings indicate an emerging shift toward system-level performance assessment in hospital settings, in which safety and environmental considerations are increasingly conceptualized as interrelated rather than discrete domains. Collectively, the characteristics summarized in Table 2 demonstrate substantial heterogeneity in study design, scope, and indicator focus, providing a robust empirical foundation for the subsequent thematic synthesis.

3.2. Distribution of Indicator Domains

The distribution of indicator domains across the included studies is summarised in Table 4 and illustrated in Figure 2. An analysis of the 48 included articles indicates a clear predominance of safety-related performance indicators, followed by environmental, organisational, and integrated domains. This distribution reflects the relative emphasis placed on different dimensions of performance measurement within the hospital literature.

Figure 2: Distribution of indicator domains across included studies.

Safety-focused indicators constituted the largest domain, being addressed in 22 of the 48 studies. These indicators primarily encompassed patient safety outcomes, occupational health and safety measures, and adverse event monitoring. Across this domain, representative studies reported indicators such as healthcare-associated infection rates, medication errors, incident reporting frequencies, and staff injury rates (Corrigan et al., 2018; Kiersnowska et al., 2021; Pfa, 2020; D. Zhao et al., 2025). In addition, a subset of studies within this group highlighted the influence of safety culture and leadership on safety outcomes (Kwon & Kim, 2021; M. Wang & Tao, 2017). The strong representation of this domain underscores the continued prioritisation of safety performance as a central component of hospital quality assessment.

Table 4: Distribution of Indicator Domains across Included Studies.

Indicator Domain	Number of Studies	Percentage (%)
Safety	22	~45%
Environmental	14	~30%
Organizational	9	~20%
Integrated (Safety–Environment–Social)	3	~5%
Total	**48**	**100%**

Environmental performance indicators represented the second most frequently reported domain, appearing in 14 studies. As shown in Table 3, these indicators predominantly related to medical and laboratory waste generation and management, waste treatment practices, energy consumption, and water-use efficiency. Representative quantitative studies operationalised these indicators through measurable environmental metrics and efficiency ratios (Amato et al., 2024; Bhakta et al., 2021; Çetin et al., 2025; Chen et al., 2021). Several studies within this domain further applied analytical frameworks such as life cycle assessment or decision-support tools to evaluate environmental performance more systematically (Gusca, 2025; Zafaranlouei et al., 2023). Although less prevalent than safety indicators, environmental indicators reflect growing regulatory and institutional attention to the environmental footprint of hospital operations.

Organisational indicators were identified in nine studies, focusing on managerial and structural factors that shape performance outcomes. These indicators included assessments of safety culture, leadership commitment, staff training, learning mechanisms, and internal reporting systems (Al-zadjali et al., 2025; Goula et al., 2021; Kwon & Kim, 2021). In most cases, organisational indicators were examined alongside safety or environmental outcomes rather than as standalone measures, highlighting their role as enabling or mediating components within broader hospital performance systems.

A smaller subset of three studies explicitly addressed integrated indicator domains, in which safety and environmental performance were examined simultaneously within unified management or sustainability frameworks. These studies operationalised system-level indicators, such as integrated management systems and composite sustainability performance measures (Ionescu et al., 2018; Ludusanu et al., 2025; Moldovan et al., 2022). As illustrated in Figure 2, integrated indicators represent the least frequently reported domain; however, they point to an emerging shift toward more holistic and system-oriented approaches to performance assessment in hospital settings.

3.3. Classification of Indicators: Leading versus Lagging

The classification of indicators according to their measurement orientation namely leading and lagging indicators is presented in Table 5 and visually summarised in Figure 3. Across the 48 included studies, a clear predominance of leading indicators was observed, indicating a strong emphasis on proactive, prevention-oriented, and system-based performance measurement approaches within the hospital literature.

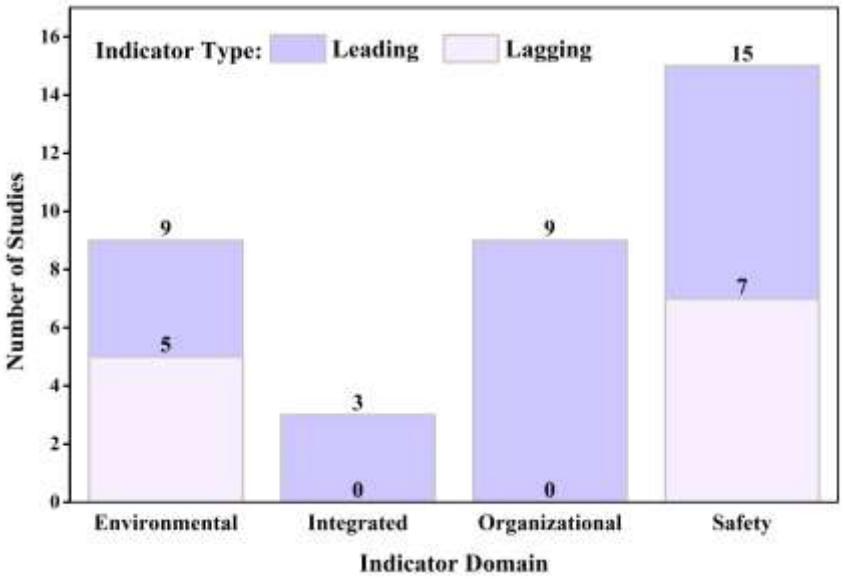

Figure 3: Distribution of leading and lagging indicators across indicators domains.

Overall, 36 studies predominantly employed leading indicators, while 12 studies relied mainly on lagging indicators. As illustrated in Figure 3, this imbalance was evident across all indicator domains, although the extent of dominance varied by domain. Leading indicators were particularly prevalent in studies examining organisational and integrated performance dimensions, whereas the safety and environmental domains exhibited a more mixed use of both indicator types.

Within the safety domain, leading indicators were identified in 15 of the 22 safety-focused studies. These indicators primarily captured upstream and anticipatory aspects of performance, including patient safety culture scores, safety leadership assessments, reporting behaviours, and organisational learning mechanisms (Kwon & Kim, 2021; Pfa, 2020; M. Wang & Tao, 2017). In contrast, the remaining seven safety studies relied on lagging indicators, which focused on realised outcomes such as healthcare-associated infection rates, adverse event incidence, medication errors, and occupational injury records (Corrigan et al., 2018; D. Zhao et al., 2025). This distribution suggests that, while outcome-based safety indicators remain firmly embedded in hospital performance measurement, there is a notable shift toward the use of leading indicators aimed at identifying and mitigating risks before harm occurs.

Table 5: Classification of Indicators by Type (Leading vs Lagging).

Indicator Type	Safety	Environmental	Organizational	Integrated	Total
Leading	✓✓✓	✓✓✓	✓✓✓	✓✓	~65%
Lagging	✓✓	✓✓	–	✓	~35%

A comparable pattern was observed in the environmental domain, where nine of the 14 studies employed leading indicators. These studies emphasised process- and governance-oriented measures, such as waste segregation compliance, environmental management system implementation, and resource management practices (Bhakta et al., 2021; Fuentes-moraleda et al., 2019). By contrast, five environmental studies relied primarily on lagging indicators, including medical waste generation volumes, emissions associated with waste treatment, and aggregate energy or water consumption levels (Wang et al., 2021; Amato et al., 2024). This combination indicates a gradual broadening of environmental performance measurement from traditional outcome metrics toward more proactive monitoring of management practices and controls.

Notably, all studies classified under the organisational and integrated domains exclusively employed leading indicators. Organisational studies focused on managerial, cultural, and structural determinants of performance, including leadership commitment, staff training systems, learning mechanisms, and reporting cultures (Al-zadjali et al., 2025; Goula et al., 2021). Similarly, integrated studies relied on system-level indicators embedded within

unified management systems, sustainability frameworks, or composite performance dashboards (Ionescu et al., 2018; Ludusanu et al., 2025; Moldovan et al., 2022). As depicted in Figure 3, no lagging indicators were identified within these domains, reflecting the inherently proactive orientation of organisational and integrated performance assessment approaches.

In summary, this classification demonstrates a pronounced shift within the hospital performance literature toward the use of leading indicators across indicator domains. The increasing reliance on anticipatory and system-based measures reflects a growing recognition that effective safety and environmental performance management depends not only on monitoring adverse outcomes, but also on assessing the organisational and operational conditions that give rise to them. This trend provides an important analytical foundation for the subsequent thematic synthesis of safety and environmental performance indicators.

3.4. Thematic Synthesis of Safety and Environmental Performance Indicators

The thematic synthesis identified four major clusters of safety and environmental performance indicators across the included studies. These themes, summarised in Table 6 and conceptually represented in Figure 4, reflect distinct analytical perspectives through which hospital performance has been examined in the literature. While analytically separable, the themes collectively describe a continuum of performance measurement approaches, ranging from outcome-oriented assessment to system-level and integrated evaluation frameworks.

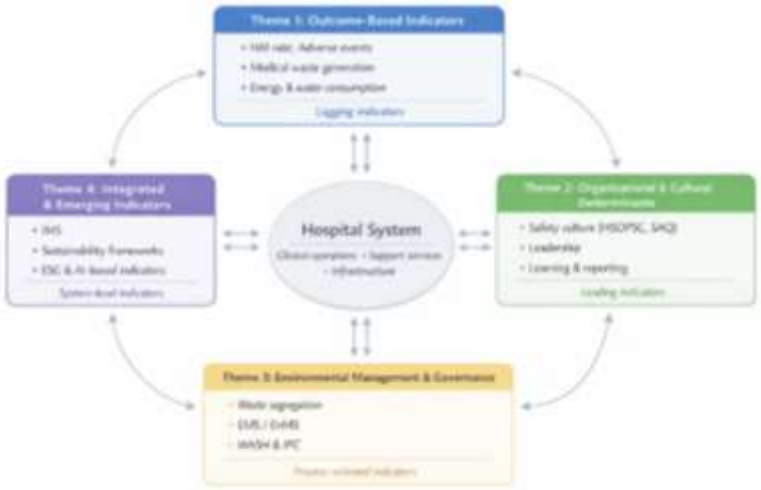

Figure 4: Thematic framework of safety and Environmental performance indicators in hospital settings.

Table 6: Thematic Synthesis of Safety and Environmental Performance Indicators.

Theme	Study (Author, Year)	Indicator Domain	Key Indicators
Theme 1: Outcome-Based Safety and Environmental Indicators	(D. Zhao et al., 2025)	Safety	Healthcare-associated infection (HAI) rate; adverse event incidence
	(Jarošov et al., 2022)	Safety	Adverse event incidence; HAI rate
	(Corrigan et al., 2018)	Safety	Retained foreign object rate; surgical "never events"
	(Dihan et al., 2023)	Safety	Medication error rate; dispensing time
	(Bhakta et al., 2021)	Environment	Medical waste generation rate; recycling rate
	(Chen et al., 2021)	Environment	Energy consumption per bed; water consumption per bed

	(Amato et al., 2024)	Safety–Environment	GHG emissions from waste treatment; infection risk
	(Nayak & Uppal, 2023)	Environment	COVID-19 medical waste generation
	(Fontana et al., 2024)	Safety–Environment	Microbiological contamination level; LCA impact
	(Çetin et al., 2025)	Safety–Environment	Laboratory waste generation rate
	(Corrigan et al., 2018)	Safety	Surgical "never events"; intra-operative adverse outcomes; conversion to open surgery rate
	(D. Zhao et al., 2025)	Safety	Medication error rate; medication dispensing errors; retrieval and administration time
	(Wong et al., 2018)	Safety	Accident incidence rate; technical error analysis; unsafe work practice indicators
Theme 2: Organizational and Cultural Determinants of Safety	(M. Wang & Tao, 2017)	Safety	Patient safety culture score; event reporting frequency
	(Wagner et al., 2018)	Safety	Patient and occupational safety culture indices
	(Jeong et al., 2019)	Safety	Safety Attitudes Questionnaire (SAQ) domains
	(Pfa, 2020)	Organization	Safety leadership; risk management score
	(Ferorelli et al., 2020)	Safety	Incident reporting rate; preventive action documentation
	(Goula et al., 2021)	Organization	Organizational learning; team learning
	(Azyabi et al., 2022)	Safety	HSOPSC composite scores; reporting behavior
	(H. E. Lee et al., 2021)	Safety	Alarm management practice; alarm fatigue risk
	(Chen et al., 2021)	Safety	Safety culture; staff exhaustion level
	(Kiersnowska et al., 2021)	Safety	Infection risk knowledge; hand hygiene awareness
	(Kwon & Kim, 2021)	Organization	Safety leadership effectiveness index
	(Al-zadjali et al., 2025)	Safety	HSOPSC dimensions; staffing adequacy
Theme 3: Environmental Management and Resource Governance	(Alharbi & Alhaji, 2021)	Environment	Healthcare waste sustainability index
	(Etim et al., 2021)	Safety–Environment	Waste segregation compliance; performance score
	(Bosco et al., 2022)	Safety–Environment	WASH availability; IPC infrastructure

	(Seifert, 2018)	Organization	EMS implementation barrier index
	(Raji & Maksimovi, 2022)	Environment	Energy management system (EnMS) implementation
	(Ioannidis & Leonidou, 2021)	Environment	Waste reduction rate; recycling rate
	(Martin-rios et al., 2022)	Environment	Waste prevention indicators; governance
	(Zafaranlouei et al., 2023)	Environment	Sustainable waste management score (MCDA)
	(Al-Sulbi et al., 2023)	Safety–Environment	Biomedical waste management score
	(Amato et al., 2024)	Environment	Environmental management practices; resource governance indicators; sustainability performance metrics
	(Vellingri et al., 2025)	Environment	Sustainable healthcare waste practices; waste handling and segregation approaches
	(Bdour & Kharabsheh, 2025)	Environment	AI-based waste management efficiency; waste monitoring and optimisation indicators
Theme 4: Integrated and Emerging Performance Indicators	(Moldovan et al., 2022)	Integrated	Hospital sustainability framework (San-Q)
	(Ludusanu et al., 2025)	Integrated	Integrated Management System (IMS) performance
	(Gusca, 2025)	Social–Organization	Social life-cycle assessment indicators
	(Ionescu et al., 2018)	Organization	Integrated management system maturity; CSR
	(Fuentes-moraleda et al., 2019)	Organization	EMS adoption value indicator
	(Nassani et al., 2022)	Organization	Environmental performance score; CSR authenticity
	(Lencia et al., 2023)	Organization	Environmental process innovation indicators
	(Alqarni et al., 2023)	Organization	E-HRM effectiveness; innovation mediation
	(Hong & Kim, 2025)	Organization	AI-based ESG risk detection indicators
	(Amato et al., 2024)	Integrated	Integrated sustainability performance framework; organisation–environment linkage indicators
	(Mori & Takebayashi, 2002)	Safety	Occupational Safety and Health Management System (OSHMS); system-level safety governance

Theme 1: Outcome Based Safety and Environmental Indicators

The first theme encompasses studies in which performance was primarily assessed through observable safety events and measurable environmental outputs. Within this cluster,

indicators were used to quantify realised outcomes rather than underlying organisational, cultural, or managerial conditions.

In the safety domain, outcome-based indicators most commonly included healthcare-associated infection rates, adverse event incidence, medication errors, and records of occupational injuries. These measures were typically derived from surveillance systems, clinical audits, or administrative databases and were reported as retrospective indicators of safety performance (Corrigan et al., 2018; Kiersnowska et al., 2021; D. Zhao et al., 2025). The continued reliance on such indicators reflects their longstanding role in hospital performance monitoring, benchmarking, and regulatory reporting.

Environmental indicators within this theme focused on tangible outputs associated with healthcare delivery, including medical waste generation, energy and water consumption, and emissions linked to waste treatment processes. Several studies applied quantitative environmental metrics to characterise the environmental footprint of hospital operations (Amato et al., 2024; Chen et al., 2021), while a smaller subset incorporated life cycle–based assessments to capture broader environmental impacts (Fontana et al., 2024) As illustrated in Figure 4, indicators within this theme were predominantly classified as lagging indicators, capturing the consequences of existing practices rather than anticipatory system conditions.

Theme 2: Organizational and Cultural Determinants of Safety

Organisational and cultural determinants of safety constituted the most extensively represented thematic cluster among the included studies. This theme brought together investigations examining how non-technical organisational factors shape safety performance in hospital settings.

Indicators within this theme were primarily concerned with patient safety culture, leadership, communication practices, and organisational learning mechanisms. Safety culture was frequently operationalised through validated survey instruments such as the Hospital Survey on Patient Safety Culture (HSOPSC) and the Safety Attitudes Questionnaire (SAQ), capturing dimensions including teamwork, management support for safety, communication openness, and responses to error (Chen et al., 2021; Pfa, 2020; M. Wang & Tao, 2017). Leadership-related indicators focused on managerial commitment to safety, supervisory practices, and the presence of formal safety leadership structures (Kwon & Kim, 2021).

Across studies, these indicators were consistently treated as leading indicators, reflecting their role in identifying latent risks and system vulnerabilities before adverse events occur. Rather than measuring safety outcomes directly, organisational and cultural indicators focused on the conditions and behaviours through which safety is enacted in everyday practice. As depicted in Figure 4, this thematic cluster occupies a central position within the performance framework, linking organisational governance with downstream safety and environmental outcomes.

Theme 3: Environmental Management and Resource Governance

The third theme comprises studies addressing environmental management practices and resource governance mechanisms within hospital settings. Indicators in this cluster extended beyond environmental outcomes to include process-oriented and managerial measures related to environmental performance.

Key indicators included waste segregation compliance, healthcare waste management system performance, implementation of environmental and energy management systems (EMS and EnMS), and the availability of water, sanitation, and hygiene (WASH) infrastructure (Al-Sulbi et al., 2023; Bhakta et al., 2021; Bosco et al., 2022). Several studies employed composite indices or multi-criteria assessment approaches to evaluate environmental performance across multiple operational dimensions, reflecting the complexity of environmental governance in healthcare organisations (Zafaranlouei et al., 2023).

Although some studies within this theme reported outcome-based environmental measures, the dominant analytical emphasis was placed on management processes and governance structures. As shown in Figure 4, environmental management and resource governance indicators form an intermediate layer within the thematic framework, connecting organisational arrangements with both environmental and safety-related outcomes.

Theme 4: Integrated and Emerging Performance Indicators

The final theme captures studies adopting integrated or emerging approaches to hospital performance measurement. Although represented by a smaller number of studies, this theme is conceptually distinctive in its emphasis on system-level assessment.

Indicators within this cluster were typically

composite and strategic in nature, encompassing integrated management systems, hospital sustainability frameworks, and multidimensional performance dashboards that simultaneously addressed safety, environmental, organisational, and, in some cases, social performance dimensions (Ionescu et al., 2018; Ludusanu et al., 2025; Moldovan et al., 2022). More recent studies further extended this integration through sustainability reporting, ESG-oriented metrics, and AI-supported monitoring tools (Gusca, 2025; Hong & Kim, 2025).

All indicators classified under this theme were identified as leading indicators, reflecting their anticipatory orientation and strategic application. As illustrated in Figure 4, integrated and emerging indicators cut across thematic boundaries, connecting organisational governance, environmental management, and outcome-based performance within a unified analytical framework. This theme highlights an emerging direction in the literature toward holistic and system-oriented evaluation of hospital performance.

3.5. Integration of Safety and Environmental Performance Indicators

The integration of safety and environmental performance indicators identified across the included studies is summarised in Table 7 and conceptually illustrated in Figure 5. This integration reflects a subset of indicators that operate at the intersection of patient safety, occupational safety, and environmental performance within hospital systems. Rather than being confined to a single performance domain, these indicators capture shared operational spaces in which safety and environmental risks coexist and interact.

Figure 5: integration of safety and environmental performance indicators in hospital settings.

Table 7: Cross-Domain Indicators Integrating Safety and Environmental Performance.

Indicator	Safety Dimension	Environmental Dimension	Measurement Approach
Medical waste segregation	Occupational safety	Waste management	Compliance rate / MCDA
WASH availability	Infection prevention	Water & sanitation	Index-based
Chemical risk classification	Facility safety	Hazardous materials	Risk matrix
Waste treatment emissions	Patient & worker safety	GHG emissions	LCA

Across the reviewed literature, integrated indicators were most frequently observed in relation to medical waste management practices. As shown in Table 6, several studies examined waste segregation, handling, and treatment processes using indicators that simultaneously addressed occupational exposure risks, infection prevention concerns, and environmental impacts (Al-Sulbi et al., 2023; Bdour & Kharabsheh, 2025; Bhakta et al., 2021). These indicators were commonly operationalised through compliance rates, process audits, or multi-criteria decision analysis, reflecting their cross-cutting nature within hospital operations and their relevance to both safety and environmental performance.

A second prominent area of integration concerned water, sanitation, and hygiene (WASH) and infection prevention and control (IPC). Studies within this group employed indicators assessing the availability, functionality, and management of WASH infrastructure, explicitly linking environmental service provision with patient and staff safety outcomes (Bosco et al., 2022; Chen et al., 2021). As illustrated in Figure 5, WASH-related indicators occupy a central position within the overlapping performance space, underscoring their dual role in supporting infection prevention while also representing a core component of environmental health infrastructure in hospital settings.

Integrated indicators were also identified in studies addressing chemical and hazardous material management. These indicators encompassed the classification, storage, handling, and disposal of hazardous substances, capturing risks related to occupational safety alongside the potential for environmental contamination (Fontana et al., 2024; S. Lee et al., 2021). In several cases, structured risk matrices or standardised assessment tools were applied to evaluate performance across both domains simultaneously, highlighting the interdependence of facility safety and environmental protection measures.

In addition, a smaller subset of studies incorporated indicators related to emissions from waste treatment processes, particularly where such emissions posed direct or indirect risks to patient and worker safety. These indicators linked environmental impact assessment methods, such as life cycle assessment, with safety considerations, reinforcing the interconnected nature of environmental performance and occupational risk management within hospital systems (Amato et al., 2024; Gusca, 2025).

Overall, the integrated indicators presented in Table 6 and Figure 5 demonstrate that safety and environmental performance are not consistently addressed as independent constructs within the hospital performance literature. Instead, a distinct group of indicators captures their intersection, highlighting shared operational processes and management practices through which safety and environmental risks are jointly manifested and measured. This integration provides an important empirical basis for understanding hospital performance as a system-level construct rather than as a collection of isolated domains.

3.6. Summary of Key Empirical Patterns

A synthesis of the key empirical patterns identified across the included studies is presented in Table 8. This summary consolidates the principal findings derived from the distributional, classificatory, thematic, and integrative analyses reported in the preceding subsections, providing an overarching view of how safety and environmental performance indicators have been conceptualised and operationalised within hospital settings.

Table 8: Summary of Key Empirical Patterns Identified.

Pattern	Evidence from Literature	Indicator Orientation
Shift to proactive measurement	Dominance of culture & leadership indicators	Leading
Integration of safety & environment	Waste, WASH, IPC indicators	Integrated
System-level perspective	EMS, IMS, sustainability frameworks	Organizational
Methodological diversification	LCA, MCDA, AI-based metrics	Advanced

Across the reviewed literature, a clear empirical pattern emerged with respect to the orientation of performance measurement. As summarised in Table 7, the majority of studies increasingly favoured leading indicators, particularly those related to organisational culture, leadership, and management practices. Indicators capturing safety culture, leadership engagement, learning systems, and reporting behaviours were widely employed across safety, environmental, and integrated domains (Kwon & Kim, 2021; Pfa, 2020; M. Wang & Tao, 2017). This pattern indicates a broad shift towards proactive and anticipatory measurement approaches, moving beyond an exclusive reliance on outcome-based metrics such as adverse events or resource consumption.

A second recurring empirical pattern concerned the progressive integration of performance domains. While safety-focused indicators remained dominant overall, a growing subset of studies explicitly incorporated environmental and organisational dimensions within unified analytical frameworks. As reflected in Table 7, indicators related to medical waste management, water, sanitation, and hygiene (WASH), infection prevention and control (IPC), and hazardous material management were frequently positioned at the intersection of safety and environmental performanced (Al-Sulbi et al., 2023; Bhakta et al., 2021; Bosco et al., 2022). This integration highlights the emergence of cross-domain measurement practices that acknowledge shared operational processes and overlapping risk pathways within hospital systems.

The synthesis further revealed an increasing system-level orientation in more recent studies. Indicators associated with environmental

management systems, integrated management frameworks, and hospital sustainability assessment tools were commonly reported as components of broader organisational performance structures rather than as standalone measures (Ionescu et al., 2018; Ludusanu et al., 2025; Moldovan et al., 2022). As summarised in Table 7, these approaches emphasised coordination across operational, managerial, and governance levels, reflecting a shift towards holistic representations of hospital performance.

Finally, methodological diversification emerged as a notable empirical pattern across the included studies. In addition to conventional quantitative indicators, several investigations employed composite indices, multi-criteria decision analysis, life cycle-based metrics, and data-driven or AI-supported assessment tools (Bdour & Kharabsheh, 2025; Hong & Kim, 2025; Zafaranlouei et al., 2023). These advanced methodological approaches were most frequently observed in studies adopting integrated or emerging performance perspectives, indicating an expanding methodological repertoire for capturing the complexity of safety and environmental performance in hospital contexts.

4. DISCUSSION

This systematic review advances the healthcare performance literature by offering an integrated, theme-based synthesis of safety and environmental performance indicators within hospital settings. In contrast to prior reviews that have largely treated patient safety and environmental sustainability as analytically separate domains, the present study demonstrates that these dimensions are empirically interconnected and conceptually interdependent. By consolidating evidence from 48 peer-reviewed studies into a unified thematic and system-oriented framework, this review moves beyond fragmented indicator inventories and provides a more holistic understanding of how hospital performance is measured, governed, and interpreted across multiple risk domains.

4.1. Shift towards Proactive and Leading Measurement Approaches

One of the most salient findings emerging from this review is the clear empirical shift from predominantly outcome-based measurement towards leading, process-oriented indicators. Across safety, environmental, and integrated domains, studies increasingly prioritised indicators related to organisational culture, leadership engagement, management systems, and governance practices (Kwon & Kim, 2021; Pfa, 2020; M. Wang & Tao, 2017). This shift reflects a growing recognition that safety and environmental performance in hospitals are shaped less by isolated adverse events or resource outputs than by the organisational conditions that precede and enable such outcomes.

The prominence of leading indicators suggests a maturation of hospital performance measurement practices, aligning with broader safety science and systems engineering perspectives that emphasise anticipation, prevention, and resilience rather than retrospective harm counting (Braithwaite et al., 2015). Rather than treating incidents, infections, or emissions as primary signals of performance, contemporary measurement approaches increasingly seek to detect latent risks and system vulnerabilities before adverse outcomes materialise. This evolution has important implications for hospital governance, as it repositions performance measurement as a strategic management tool rather than a purely compliance-driven activity.

4.2. Organisational and Cultural Determinants as a Central Performance Layer

The thematic synthesis further reveals that organisational and cultural determinants function as a central connective layer linking safety and environmental outcomes. Indicators related to leadership commitment, communication practices, learning systems, and safety culture consistently appeared upstream of both patient safety incidents and environmental performance metrics (Al-zadjali et al., 2025; Chen et al., 2021; Goula et al., 2021). This pattern reinforces socio-technical perspectives that conceptualise hospitals as complex adaptive systems in which non-technical factors exert substantial influence on operational performance (Rauner & Stummer, 2025).

From this perspective, safety and environmental outcomes should not be understood as isolated technical failures but as emergent properties of organisational structures, decision-making processes, and behavioural norms. Performance assessment frameworks that underrepresent organisational and cultural dimensions may therefore fail to capture critical drivers of system-level performance. The findings of this review suggest that organisational indicators are not merely contextual variables but constitute a core performance domain that mediates how safety and environmental risks are generated, managed, and mitigated within hospital systems.

4.3. Environmental Performance Measurement:

Progress and Persistent Challenges

Although environmental performance indicators were increasingly represented across the reviewed studies, their operationalisation exhibited notable variability in scope, depth, and methodological consistency. Studies addressing medical waste management, energy consumption, water use, and emissions demonstrated a gradual transition from simple output-based metrics towards more structured, management-oriented indicators, including environmental management systems, governance frameworks, and composite performance indices (Al-Sulbi et al., 2023; Bhakta et al., 2021; Zafaranlouei et al., 2023).

Despite this progress, the synthesis indicates that environmental indicators remain less standardised than safety indicators, potentially limiting comparability across institutions and health systems. Unlike patient safety measurement where validated instruments and reporting conventions are relatively well established environmental performance assessment in hospitals continues to rely on heterogeneous definitions and measurement approaches (Dolcini et al., 2025). This lack of conceptual alignment may constrain the integration of environmental sustainability objectives into routine hospital performance management and underscores the need for clearer theoretical and operational frameworks linking environmental indicators to organisational decision-making.

4.4. Value of Integrated Safety-Environmental Indicators

The integration analysis provides further insight into how safety and environmental domains intersect within everyday hospital operations. Indicators related to medical waste handling, WASH infrastructure, infection prevention, and hazardous material management consistently emerged as shared performance spaces in which safety and environmental risks converge (Al-Sulbi et al., 2023; Bdour & Kharabsheh, 2025; Bosco et al., 2022). These indicators capture interdependencies that may be obscured when safety and environmental performance are assessed independently.

From a performance governance perspective, integrated indicators offer practical advantages by supporting more coherent monitoring strategies and reducing the risk of fragmented managerial decision-making. Rather than allocating responsibility for safety and environmental performance to separate organisational silos, integrated indicators enable hospitals to align risk management, sustainability, and quality improvement efforts within unified operational processes (Chigbu & Makapela, 2025). The relatively limited number of studies adopting such integrated approaches suggests that this remains an emerging, rather than dominant, direction within the literature.

4.5. Methodological Contribution of Theme-Based Synthesis

Methodologically, this review demonstrates the analytical value of theme-based synthesis for consolidating heterogeneous indicator evidence. By moving beyond discipline-specific classifications and indicator lists, the adopted approach enables a structured interpretation of how indicators operate across organisational levels and performance domains. This contributes to the literature by offering a transparent and replicable synthesis strategy applicable to other complex performance contexts characterised by multidimensional risk profiles and overlapping governance structures (Sun et al., 2025).

The identification of cross-cutting themes rather than isolated indicator categories also facilitates a clearer articulation of relationships between measurement approaches, organisational practices, and system-level outcomes. As healthcare systems increasingly confront interrelated challenges involving safety, sustainability, and resilience, synthesis methods capable of capturing such complexity are likely to become increasingly valuable.

5. FUTURE DIRECTION AND IMPLICATIONS FOR RESEARCH AND PRACTICE

The findings of this review point to several important directions for future research and practice. First, there is a clear need for greater conceptual integration between safety and environmental performance measurement frameworks. Future studies should move beyond parallel assessment approaches and develop indicators explicitly designed to capture shared risk pathways and operational interdependencies within hospital systems.

Second, further work is needed to standardise environmental performance indicators in healthcare, particularly in relation to waste management, resource efficiency, and emissions. The development of validated, context-sensitive environmental indicators would enhance comparability across institutions and support the integration of sustainability objectives into routine hospital performance governance.

Third, the increasing use of advanced

methodological approaches such as life cycle assessment, multi-criteria decision analysis, and AI-supported monitoring offers promising avenues for capturing the complexity of hospital performance. However, future research should critically examine how these tools are implemented in practice and whether they meaningfully inform managerial decision-making rather than functioning as purely technical add-ons.

Finally, from a practical perspective, the findings underscore the importance of aligning performance measurement systems with organisational learning and governance structures. Hospitals seeking to improve both safety and environmental performance may benefit from adopting integrated, leading-indicator-based frameworks that support proactive risk management and cross-domain coordination.

6. LIMITATIONS

Several limitations of this review should be acknowledged. First, although the review followed a rigorous PRISMA-guided process, it was restricted to English-language peer-reviewed journal articles, potentially excluding relevant grey literature or non-English studies. Second, the heterogeneity of study designs and indicator definitions precluded quantitative aggregation, necessitating a narrative and thematic synthesis approach. Finally, quality appraisal was conducted descriptively rather than through exclusionary scoring, which may influence the relative weighting of evidence. Notwithstanding these limitations, the review provides a comprehensive, transparent, and analytically robust synthesis of the existing evidence base

7. CONCLUSION

This systematic literature review synthesised evidence from 48 peer-reviewed studies to examine how safety and environmental performance indicators are conceptualised, operationalised, and applied within hospital settings. Through an integrated, theme-based synthesis, the review moved beyond fragmented indicator inventories and demonstrated that hospital performance measurement has increasingly evolved towards leading, system-oriented, and organisationally embedded indicators. The findings clearly show that safety and environmental performance are not independent constructs but are structurally interconnected through shared operational processes, governance mechanisms, and organisational conditions. Indicators related to organisational culture, leadership, waste management, infection prevention infrastructure, and hazardous material control consistently emerged as central mechanisms through which safety risks and environmental impacts are jointly shaped and managed.

Importantly, this review highlights the practical and conceptual value of integrated indicators as a means of capturing interdependencies that are often obscured by domain-specific assessment approaches. By providing a transparent classification of indicators and identifying recurring empirical patterns, the study contributes a coherent analytical framework that supports both theoretical development and applied performance governance. For researchers, the findings offer a replicable synthesis strategy for examining complex, multidimensional performance domains. For hospital managers and policymakers, the integrated indicator framework provides a foundation for more holistic monitoring, prioritisation, and decision-making in increasingly resource-constrained healthcare systems. Future research should empirically test integrated indicator frameworks across diverse healthcare contexts, explore their longitudinal relationships with organisational and clinical outcomes, and refine methodological approaches capable of supporting system-level performance improvement in response to evolving safety and environmental challenges.

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