

Review in Occupational Health

Key performance indicators in occupational health and safety of hospitals: A scoping review with meta-analysis

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Abstract

Introduction: This study aimed to synthesize and map what was reported in the international literature on the relationship between Key Performance Indicators (KPIs) and hospital Occupational Health and Safety (OHS).

Methods: For this scoping review, PubMed, Medline, and Scopus were searched. We did separate random-effects meta-analyses for institutional outcomes using the KNIME software.

Results: Of the identified 6,698 records, 10 were eligible, and data were available for 10, all with a low to moderate risk of overall bias. A particularly low correlation between Protective and Preventive Services (PPS) and KPI studies in hospital OHS was demonstrated. For the correlation KPI score – Occupational Physician (OP) score, KPI score – Risk Assessment (RA) score, and OP score – RA score, the values are 0.999, 0.595, and 0.408, while the p-values are 0.0185, 0.778, and 0.893, respectively. Data analysis found that studies of KPIs in OHS in hospitals did not sufficiently consider the institutional representations of PPS, safety technician (ST), OP, Occupational Health and Safety Management Systems (OHSMS), and RA and how they interact with the planning and implementation processes of the KPIs.

Discussion and Conclusions: This study found through data analysis that studies of KPIs in OHS in hospitals did not adequately consider PPS, ST, OP, OHSMS, and RA and how these elements interact with planning and implementing these KPIs. The contribution to knowledge in this research filled this gap identified in the literature.

Keywords: Key Performance Indicators; occupational health and safety; occupational health and safety management systems; risk assessment.

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INTRODUCTION

Key performance indicators (KPIs), in various forms and standardizations, have evolved into an essential tool for the study of occupational health and systems (OHS) management in the field of hospital health services and various areas of entrepreneurship and organizations [1-6]. On the other hand, PPS (protective and preventive services) provided mainly by STs and OPs, OHSMS, and RA in OHS, are institutional elements that support administrations to achieve the avoidance of occupational risk and to ensure safe OHS conditions in the organizations and businesses they manage [7].

Modern management systems, OHSMSs, which integrate leadership, workers, and all operational processes and monitoring, play a significant role in managing OHS issues [4,5,8-10]. OHSMSs in hospitals are essential in promoting the OHS of workers [11].

An organization's OHS performance measures the impact of OHS activities on work, the adequacy of safety controls [6], and changes in RA [11]. By measuring its performance, OHS becomes a key issue involved in the integration of the management systems of organizations and businesses [5] within an expanded theoretical framework [12] or through the implementation of an appropriate strategy [13]. Performance measurement evolved with quantified KPIs [14], adjusted to organizational goals, and according to [6], are valid, low-volatility, sensitive to change, cost-effective, and understandable indicators.

KPIs are used to measure the performance of an organization in some areas, such as the comprehensive evaluation of all the performances of a company [5], hierarchical evaluation by choice [4], or with an emphasis on OSH legislation combined with modern qualitative methods [15].

The main elements that led to the development of KPIs and the characteristics of KPIs in hospitals are summarized in Table 1.

Table 1. The development of KPIs and their main characteristics.

Authors	Development of KPIs	KPI's characteristics
Liu & Itoh (2013)	KPIs for employee satisfaction and safety culture	Errors incidents, work hazards, sickness absence, long-term sickness absence, mental-physical sickness, and staff wellbeing
Schultz et al. (2016)	KPIs develop over time based on statistics.	Measurable KPIs for process improvement
McLinton et al. (2019)	Using indicators related to recognition of psychological incidents.	Exhaustion, burnout, bullying rather than needle sticks or falls.
Wagner et al. (2019)	Development of occupational safety environment	Psychosocial working conditions, leadership, and occupational safety environment
McKeeby et al. (2022)	Indicators maintaining the hospital workforce in a safe state of health.	Focus on staff protection during the pandemic.
Khapre et al. (2022)	Specification of indicators for OSH	Emphasis on vaccination and educational procedures

Podgórski argues that several dozen KPIs should be limited to the necessary ones since measuring many indicators is ineffective. This scholar has proposed a framework for key performance indicators that groups all indicators into the following categories (symbols) and

subcategories (main components). Nowadays, several systematic reviews examine KPIs with a particular focus on hospitals but not on the effect of KPIs on OHS in hospitals. This demonstrates a gap in the literature that will be filled by this study.

Setiawan and Purba reviewed studies with KPIs in 50 journals and found gaps. Among 50 papers, they found only 1 paper mentioned in RA. Asih et al. systematically reviewed KPIs in organizations, including hospitals, oriented more towards cost reduction [14].

PPS (provided by ST and OP) are the specialist internal or external support services provided to employers to address occupational risk and ensure they meet their OSH duties under their statutes or legislation [7]. Some alternatives for individuals to perform ST and OP tasks are given [10] as follows:

- The company's senior manager/entrepreneur/owner undertakes PPS activities personally.
- One or more employees are designated to develop PPS activities.
- Establishment of an Internal Protection and Prevention Service (IPS).
- Hiring of an external Protection and Prevention Service (EPS).
- Joint Protection and Prevention Services (JRPS).

In Europe, Occupational Medicine Services are provided by Occupational Physicians (OP) or Occupational Medical Doctors who have been registered with the transposition of Directive 89/391/EEC in the national networks of these countries [10]. OPs receive an additional specialization on OHS issues, often through distance or short training, to provide the services of their new specialty to workers [16].

Zungu et al. [17] noted that specialist OP employment significantly impacts increasing protection for OHS in public hospitals [18,19].

Another factor in using KPIs in OHS is the OHSMS systems implemented in many companies worldwide since the mid-1980s [9]. Several standards have been developed to analyze OSH in organizations. The standards impact KPIs in organizations and companies are based on [5].

Mohammadfam et al. [20] linked the quality of OHSMS to KPIs in certified organizations and conducted an extensive literature survey on this issue. Although OHSMS has been implemented for over twenty years, its modern development and dissemination depend on its effectiveness and narrowing the range of measured safety factors to become more specific and specialized assessments to help reduce occupational accidents and diseases [9].

The implementation of the risk assessment (RA) in OSH in organizations and enterprises was introduced by Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work based on a fundamental principle: The employer shall own an assessment of the risks to safety and health at work, including those facing groups of workers exposed to particular risks [21].

RA is widely used to prevent occupational hazards. Its methodology may vary depending on the characteristics of the company, but it follows the five basic steps:

- Identify hazards
- Assess risk
- Reduce risk
- Document the results
- Evaluation of the preventive and protective measures

The most used relationship, according to UNI ISO 31000:2018 for risk assessment is:

$$\text{Risk} = \text{Gravity (or Consequence)} \times \text{Frequency (or Likelihood) of the adverse effect}$$

RA is performed by a specialized team of specialists in collaboration with OPs. The team of experts contributes findings and suggestions for increasing the efficiency of the business and finding the KPIs appropriate for the type of business or organization [5].

METHODS

This review utilized a scoping review methodology, enabling the mapping of key concepts and characteristics of the impact of KPIs on OHS in the hospitals.

The review used the Joanna Briggs Institute (JBI) methodology for scoping reviews, refined by Peters et al. [22] and following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [23].

Review Question

This scoping review aimed to synthesize and map what was reported in the international literature on the relationship between KPIs and hospital OHS.

Inclusion criteria

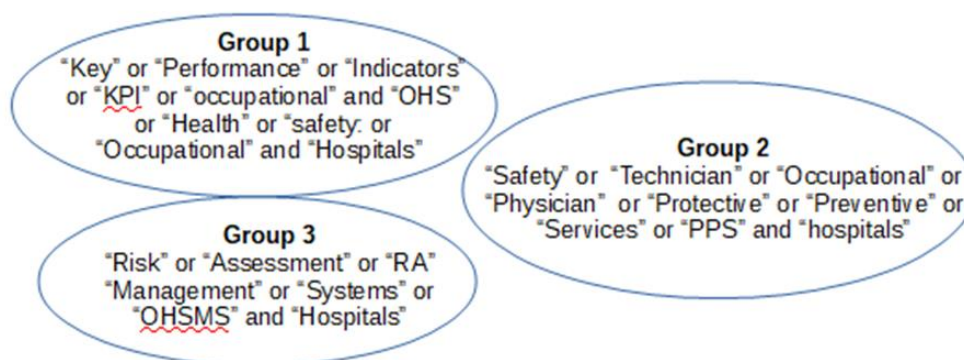
Studies using KPIs in OHS in hospitals were included (regarding the examination subject relating to OHS) and with direct correlation to OHS.

Exclusion criteria

- 1) Studies using KPIs in hospitals, but these are not OHS-oriented
 - 2) Studies that include KPIs in many types of businesses and among them in hospitals, but not exclusively, because of which they extend conceptually far from the studied topic
 - 3) Meta-analyses on the subject or related issue
 - 4) Systematic Reviews on the subject under consideration or related
- We included only published studies, published in English and French.

The Keywords were grouped into three groups to gather all the available information for processing (Figure 1).

Figure 1. The three groups of keywords are used to gather all the available information for processing.



Electronic searches

Electronic searches were conducted for eligible studies within each of the following databases:

- PubMed (1996 to 22nd September 2023)
- Scopus (1900 to 05th September 2023)
- Heal-link (1999 to 12 September 2023)
- Google Scholar (2004 to 21 September 2023)

Register PROSPERO was searched (<https://www.crd.york.ac.uk/PROSPERO/>) and the gray literature openGrey (formerly openSIGLE) source.

Outcomes were assessed on a 5-point scale for frequency of outcomes, and relevant literature references were reviewed. We used filters to select studies from the last 15 years. Data was searched for PPS, OP, ST, OHSMS, and RA.

Conversions

Institutional representation data and scores required conversion to numerical data for further use. Table 2 was, therefore, designed to report the memo of codes on the items considered in the study.

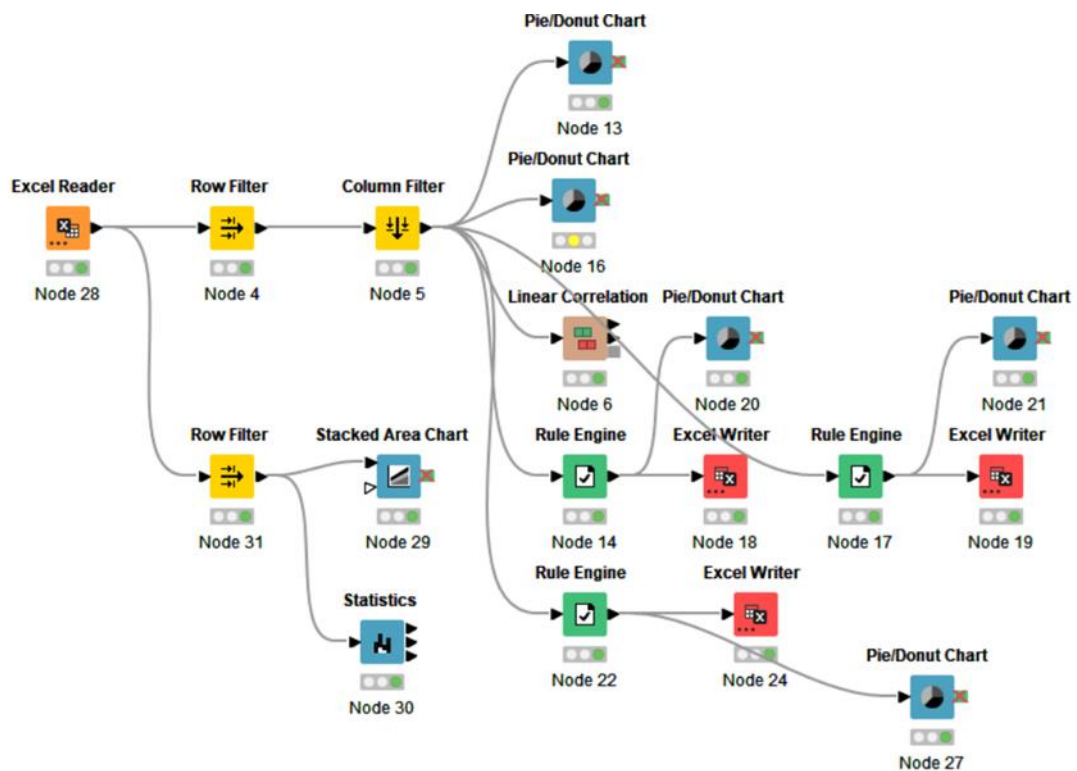
Data analysis

The random-effect model for meta-analysis [24] was deemed more appropriate for our study. We computed basic measures of descriptive statistics, quantitatively correlated various variables, programmed nodes to characterize outcomes, and graphically depicted the results. These were conducted using KNIME software. We used KNIME software for quantitative informational analysis of the data. KNIME is a free and open-source platform that we use to design computational workflows that integrate information collected from various sources in a single tool [24].

KNIME is often used in studies using KPIs [25]. The intermediate results were used in KNIME software. A researcher designed the data flow of the software.

This workflow, shown in Figure 2, leads to the statistical measures and to finding the elements of institutional representation in the results. We extracted information on the characteristics of the studies and the results included in the study.

Figure 2. The workflow of the research.



Eliminate the risk of reporting personal crises

Care was taken in the study to eliminate the risk of reporting personal crises. The cross-search method of the reviewed studies was used to assess the risk of bias in the included studies. The quality of the evidence was assessed with the Robvis risk of bias tool, a recognized visualization tool that avoids the risk of bias in studies [26].

Impact measures

The impact measures are as follows:

Max, mean, standard deviation, variance, skewness, and kurtosis were calculated for the OP and RA scores.

Pearson's correlation coefficient and p-value coefficients were used through KNIME software for the KPI Score - OP Score, KPI Score - RA Score, and OP Score - RA Score pairs. We created a table of data and assessment KPIs, PPS, and RA in OSH in the reviewed studies. This table was used to visually display the results of individual studies and syntheses.

Sensitivity meta-analyses

We conducted sensitivity meta-analyses restricted to recently published studies (studies within the last 15 years) to examine the registration of null effects. To incorporate studies with null outcomes (automatically included in our study analyses), we also performed sensitivity analyses for null outcomes, demonstrating the effect of null outcomes of certain variables (such as ST and OP) on final outcomes. Finally, a modified Robvis tool was used to assess the risk of bias for each included study. Participants were considered to be the reported studies (<https://www.riskofbias.info/welcome/robvis-visualization-tool>).

Table 2. Legend of codes on the objects examined in the study.

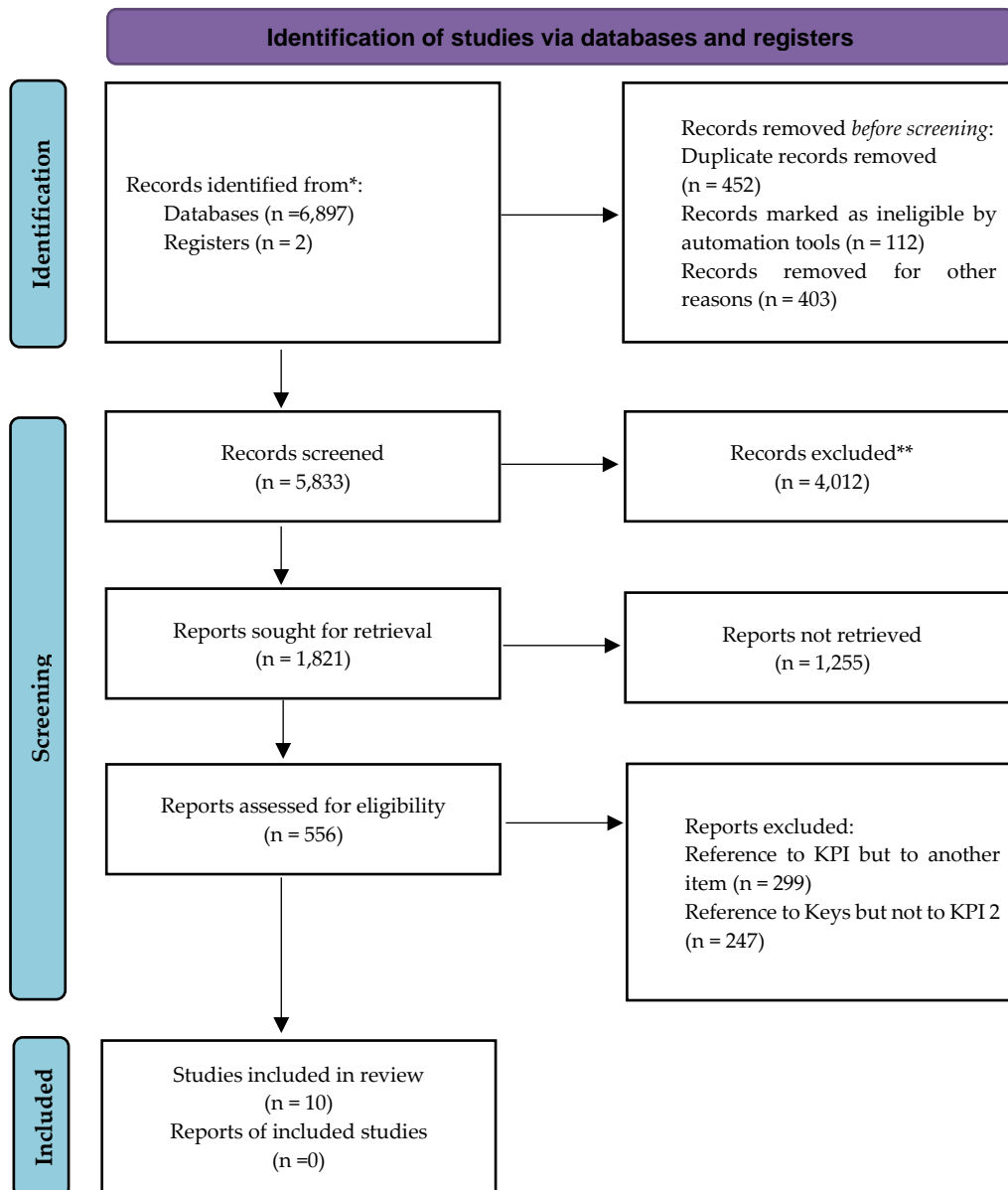
The subject of the examination	Licenses	General OSH	Existence of KPI's	List of assigned KPI's	PPS/ST	PPS /OD or OP	OHS Management system	OSH Assessment
1=Healthcare system	0= Non-reference	1 Effectiveness and quality of radiation safety programs	0=NO (None or unclear existence)	1= Use of Hazardous Materials	0=NO (No or unclear reference)	0=NO (No or unclear reference)	0=NO (No or unclear reference)	0=No No or vague correlation
2=Radiation safety	1= National license for radiation protection	2= Effect of psychosocial factors on OSH	1=YES	2= Impact on Quality/Efficiency	1=YES (Explicit reference)	1=YES (Explicit reference)	1=YES (Explicit reference)	1=YES
3= Psychosocial factors	2= Personnel fitness certificate	3= Culture and/or climate	Score (0-5)	3=Effect on Supervision and Training	Score (0-5)	Score (0-5)	Score (0-5)	Score from 0 to 5
4=Dialysis operation		4= Training		4= impact on best practices				
5= Training and vaccination in achieving indicators		5=Vaccination		5= effect on climate				
6= Leadership		6= Role of leadership		6= Preventive health/human resources				
7=Climate OSH		7= Various OHS hospital issues						

RESULTS

Identification stage

We started from the identification stage with 6,897 studies. After screening the three substages, we identified 556 papers with KPI in the OHS. In the included stage, we arrived at 10 studies. Figure 3 shows the identification of studies via databases and registers.

Figure 3. Identification of studies via databases and registers.



I performed data transformation using the quantification method [27]. From the study of the data, I created Table 3.

Table 3. Data, evaluation of KPI's and PPS and RA in OSH in the reviewed studies.

Researchers	Year	General OSH		KPI's data		PPS, ST, OP, OHSMS and RA in OSH								
		The subject of the examination	Licenses	General OSH	Existence and Width KPI	List of assigned KPI' s	Rating PPS/ST	Reference Protection/ve Safety/ST	Rating PPS/OP or OD	Search (O)P - (O)D	OHSMS (rating)	Search Management System	Existence/Rationale OSH Assessment	Search RA/Assessment
Schultz et al.	2016	1	1	1	1	1	0	0	0	0	0	0	1	0
		2	2		(5)	2,3,4	0	0	0	0	0	0	(3)	5
McLinton et al.	2019	3	0	2	1	2	0	0	0	0	0	0	0	1
				3	(4)	5,6	0	0	0	0	0	0		1
Liu & Itoh	2013	4	0	3	1	2	0	0	0	0	0	1	1	0
					(4)	3,6	0	0	0	0	0		(1)	29
Khapre et al. *	2022	5	0	4	1	4	0	0	1	3	0	0	0	0
				5	(1)	7	0	0	(3)	0	0	0	0	11
Wagner et al.	2019	3	0	2		2	0	0	0	0	1	1	1	0
		6		3	1	5	0	0	0	0	1	1	(4)	14
McKeeby et al.	2021	5	0	5	1	2	0	0	0	0	0	1	0	0
					(3)	3,7	0	0	0	0	0	0		0
Mousavi et al.	2021	1	0	5	1	2	0	0	0	0	1	10	1	2
				6	(5)	4,5	0	0	0	0	(4)		(2)	11
Wong et al.	2018	1	0	7	1	2	0	0	0	0	1	2	0	0
					(5)	3,4,6	0	0	0	0	(2)			1
Moda, et al.	2021	7	0	7	1	2	0	0	0	0	1	12	1	0
					(3)	3,4	0	0	0	0	(4)		(2)	5
Aslan, I.	2022	1	0	7	1	2,3	0	0	0	0	1	18	1	19
					(5)	4,5,6	0	0	0	0	(5)		(5)	25

In Table 3, researchers and their papers were shown alongside the general OHS data reported in each study, i.e., the OHS field to which it refers, any professional licenses involved with OSH, and the individual or specific topics considered. The results of their study were presented in terms of scoring the existence of explicit reference to PPS, ST, OP, OHSMS, and RA in OSH in separate

columns: PPS (ST), PPS (O Physician or OD), (OHS)M(S), RA indicating the number of references to each variable found in the text of each study.

Analysis of the studies

The analysis of studies considering PPS data with OHS in hospitals gives much lower incidence results (10% positive correlation) than studies considering RA data with OHS in hospitals (100% correlation, albeit slight). This heterogeneity between study results demonstrates that the authors take much less account of the effect of PPS (human factor) than OHSMS and RA (system factor).

We reported confidence in the results, as the findings confirm that the studies are sufficiently relevant to institutional representation in hospitals and lead to the rejection of the original hypothesis.

The sensitivity analysis performed using studies other than those showing bias showed consistent results with the analysis of the primary studies (100% even slight correlation of reporting of OHSMS and RA items in the KPIs studies).

We used basic statistical measures for the variables. The results of these measures are shown in Table 4. I studied the correlation between different variables. The results of correlation coefficients and p-values are shown in Table 5. The correlation coefficient (r) between the KPI and OHSMS scores was 0.45, with a statistical T of 1.45 and a p-value of 0.18, showing no strong correlation or generalizability of the results. The correlation coefficient (r) between KPI Score and RA Score was 0.36 with a T statistic = 0.12 and p-value = 0.29, showing no strong correlation or generalizability.

Table 4. Statistics information.

Variable	Min	Max	Mean	Std. Dev.	Variance	Skewness	Kurtosis	Overall sum
OP Score	0	3	0.3	0.948	0.899	3.16	10	3.0
RA Score	0	5	1.7	1.828	3.344	0.689	-0.766	17.0

Table 5. Correlation values between survey variables.

1 st variable	2 nd variable	Correlation value	p-value	Degree
KPI Score	OP Score	0.999	0.0185	3
KPI Score	RA Score	0.595	0.778	15
OP Score	RA Score	0.408	0.893	5

DISCUSSION

The validity of our results is significant, as no significant association was found between the items examined in the reviewed studies belonging to known databases or registers. The practical application of the results consists in considering future researchers and policymakers the necessity of strengthening the association of KPIs with the PPS, ST, OP, OHSMS, and RA in hospitals.

We used strict exclusion criteria to get to the core of the issue under consideration. In this way, we excluded studies that examined, e.g., the impact of management in many types of organizations (including hospitals) and referred to the use of KPIs. The themes of such studies and the deviation from the core of our topic, which marginalized studies relevant to reporting on the application of the items under consideration, would have compromised the results' reliability.

Regarding comparison and contrast with previous relevant studies, this review showed that systematic reviews on KPIs, such as [3] and [14], sporadically find significant deficiencies regarding

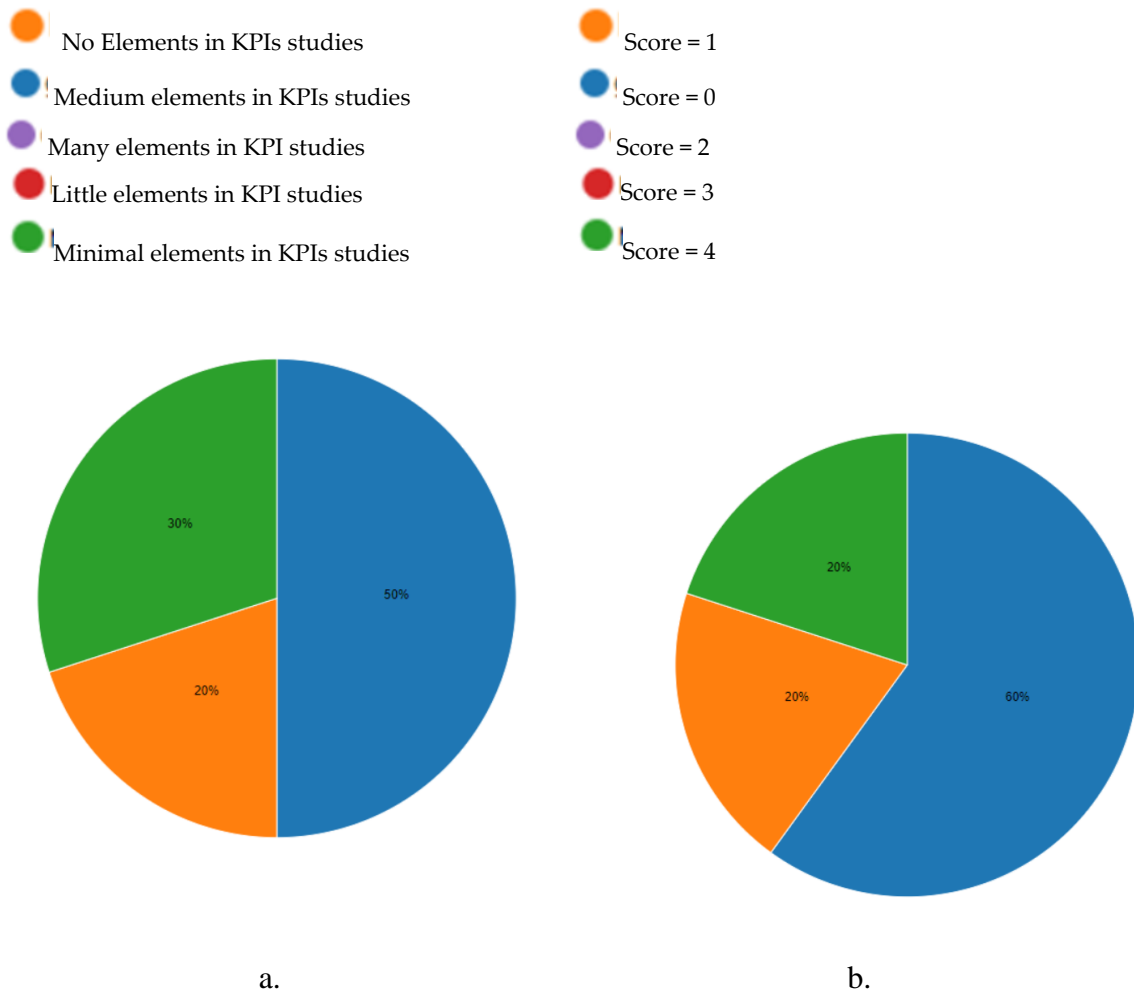
the reporting of the examined data in their studies, which converges with the results of this research. However, the literature did not report systematic studies or meta-analyses on the specific topic we focused on in this review.

A potential weakness that may limit this review's power is the publication error because this study's results are not statistically significant. However, this review leaves space for future research activity in further exploring other less widely used databases of the relationship between KPIs, PPS, ST, OP, and RA in OHS in hospitals.

The scatter diagram shows that the KPI and OP scores are not participatory-correlated, while the KPI and RA scores are slightly correlated. Although a correlation is *prima facie* discernible, the OP and some RA values are mostly zero, confirming the non-correlation. The p-value for the correlation KPI- OP scores was 0.0185, indicating statistical non-significance. This correlation suggests that the correlation hypothesis cannot be generalized. Although this correlation is large, its generalization was rejected due to the minimum values found for the OP observations. The values of the correlations KPI Score - RA Score and OP Score - RA Score were 0.778 and 0.89, respectively.

The results can be broadly characterized as unexpected. The proportion of RA and OHSMS severity ratings in the KPI studies gives relatively high percentages in the negative and moderate correlations. The correlation between PPS-ST-OP-OHSMS-RA items in the KPI studies in hospitals is very weak, as shown by the Chart-Pie of Figure 4, which is from no to moderate correlation, which contradicts the original hypothesis. Although we thought that the picture would be different and biased towards the positive correlation of these items, this cannot be confirmed.

Figure 4a and b. Pie charts for the variables on the existence of references: (a) between the PPS-ST/OP-OHSMS-RA items in the KPI studies in hospitals and (b) RA scoring in KPI studies in hospitals.



In this scoping review, studies of OSH using KPI were shown to have taken little to moderate account of the function of PPS, ST, OP, RA, and OHSMS in OSH. Many studies on KPIs in OHS in hospitals can be found in the literature, but no review or meta-analysis on this topic has been undertaken. As the research on OHS in hospitals is growing rapidly, researchers will consider this study in the future to strengthen institutional reporting of these studies.

Future research should include a systematic review of KPIs in OHS for many categories of operations. This will ensure a large amount of data is processed, and more general conclusions are drawn.

CONCLUSIONS

This review found through data analysis that studies of KPIs in OHS in hospitals did not adequately consider PPS, ST, OP, OHSMS, and PA and how these elements interact with planning and implementing these KPIs. Some might argue that the impact of PPS may be embedded in RA, but this is contrary to the process: the PPS constructs the RA, but the OHS is not exhausted in the RA - it involves the independent ongoing contribution of all the reported elements.

The contribution to knowledge in this research filled this gap identified in the literature. The present study correlated with the work of other researchers by extending the systematic review and meta-analysis of KPIs in OHS and hospitals while demonstrating a gap in the literature that should be taken seriously. In this respect, this scoping review contributes to the research by suggesting future

filling of this gap. The practical significance of the present study is paramount because it highlights to future researchers and policymakers the need to make clear and specific reference to the PPS, ST, OP OHSMS, and RA elements and how these elements impact studies addressing KPIs in OHS in hospitals. Additional work will be required to integrate KPIs effectively into OHS processes, especially in hospitals.

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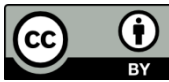
Conflicts of Interest: None declared

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