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Review

Strategies to improve the quality of nurse triage in emergency departments: A systematic review

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ABSTRACT

Aim: This systematic review aimed to assess the impact of implementation strategies for nursing triage on quality outcomes and to examine barriers and facilitators to their implementation in the emergency department (ED).
Data sources: Embase, PubMed, CINAHL, Cochrane Library, Web of Science, PsycINFO and ProQuest Dissertations & Theses.
Methods: This systematic review included quantitative and qualitative studies published from January 1990 to April 2024 that evaluated strategies to improve ED triage. Study quality was assessed with the Mixed Methods Appraisal Tool (MMAT). The benefits of the strategies were reported using descriptive statistics (quantitative studies) and themes and subthemes (qualitative studies). Barriers and facilitators were identified using the Behavior Change Wheel framework.
Result: Three main implementation strategy categories to improve the quality of nursing triage were identified: education (64%), technology (30%), and audit and feedback (6%). All strategies demonstrated short-term benefits, including increased triage accuracy and improved triage knowledge and skills. The most frequently reported barriers were workload and overcrowding, while facilitators included nurses' experience, interprofessional collaboration, and a culture of continuous improvement.
Conclusion: Comprehensive approaches, including education, technology, and regular audits with feedback, are associated with improved triage quality outcomes. Continuous training, active nurse participation in tool development, and the use of validated audit tools are essential. These measures could ensure rigorous nursing triage in EDs and enhance care safety by optimizing patient prioritization as they enter healthcare systems. This review underscores the need for further research on implementation strategies to enhance effective and safe patient prioritization in the ED.

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1. Introduction

The emergency department (ED) is a critical gateway for individuals seeking urgent care and is one of the primary entry points into the healthcare system [1]. As the global demand for emergency care continues to rise [2], efficient triage has become essential to ensure timely and appropriate patient management. According to the National Center for Health Statistics, there were approximately 131 million ED visits in the United States in 2020, which corresponds to an average of 40 visits per 100 people [3]. In Canada, ED visits reached 15.5 million in 2024 [4].

Patients may present to the ED for a variety of reasons, from minor and low acuity conditions to time-sensitive and life-threatening illnesses and injuries [5]. To ensure safe access to the ED and maintain efficient patient flow, accurate triage is essential to provide a correct assessment and prioritization of each patient based on the severity of their symptoms and the urgency of their condition [1,6]. The priority level assigned to each patient following triage is directly linked to how quickly the patient should be treated [7]. In the simplest terms, the most critical patient must be the first to access care and treatment. The purpose of the triage process is to rapidly identify patients at risk of decompensation and to direct appropriate resources to patients. Accurate triage assessment results in appropriate and safe care and can be considered a marker of a highly effective emergency care system [7]. The nurse performing triage is also integral to the nursing role, and as such, the accuracy of triage depends on the nurse's knowledge base and expertise across the lifespan and varying acuity levels [8].

Triage systems are generally categorized into five levels. Five validated scales are widely recognized worldwide, including the Australasian Triage Scale (ATS) [9], the Canadian Triage and Acuity Scale (CTAS) [9], the Emergency Severity Index (ESI) [10], the Manchester Triage Scale (MTS) [11], and the South African Triage Scale (SATS) [12]. The priority level assigned by the triage nurse is one of many important factors that determine the wait time for medical care or re-evaluation by a nurse (e.g., for CTAS: P-1: immediate, P-2: 15 min, P-3: 30 min, P-4: 1 h, P-5: 2 h) [13,14]. In order to accomplish this, the triage nurse will use clinical judgment, experience, training, decision-making skills, and a valid triage scale [15,16]. In this context, patients sent back to the waiting room after triage may become unstable after prolonged wait times [17]. Therefore, it is crucial for the triage nurse to reassess patients in the waiting room, as their health status is dynamic and may deteriorate. All patients awaiting a complete assessment of their health status should be monitored, and their priority level updated according to any changes in their condition [18].

An error in triage can have negative impacts on patients and healthcare systems outcomes [19–23]. Indeed, triage errors result in patients spending more time in the ED and an increase in hospital admissions [23]. This is mainly due to a deterioration in the condition of the patients during the waiting time in the ED compared to those who received an error-free triage [24]. Other authors suggest that triage errors may increase the risk of mortality, particularly in pediatric cases, up to 18 % [16,19,23,25,26]. In this regard, although considerable time and effort have been devoted to the development of triage scales, less attention has been paid to the assessment of triage quality [27]. With this in mind, it is important to ensure that continuous improvement processes are in place to monitor the quality of the triage process.

Several implementation strategies have been recommended to optimize nursing practices with respect to triage, including audit and feedback [28], education [29,30], reminder systems, simulation [31,32], and electronic decision support tools based on artificial intelligence (AI) [33].

1.1. Objectives

The objectives of this systematic review were two-fold: 1) to assess the impact of implementation strategies of nursing triage on quality outcomes, and 2) to identify barriers and facilitators of these implementation strategies in EDs.

2. Methods

We conducted our systematic review in accordance with the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions [34]. Our systematic review was conducted in collaboration with a research team that included experts in nursing triage (n = 3), emergency nursing (n = 3) and emergency medicine (n = 2), as well as implementation science and quality improvement (n = 4). Our review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [35]. Our protocol was registered a priori with the Open Science Framework Registries (https://doi.org/10.17605/OSF.IO/S59Q6) and the review protocol was published [36].

2.1. Information sources and search strategy

We search the following databases to identify original studies: Excerpta Medica Database (Embase), PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycINFO (Ovid), Cochrane Library, Web of Science, and ProQuest Dissertations & Theses. The final search strategy was organized according to the PICO framework: Population (P) – nursing and emergency department; Intervention (I) – strategies to improve triage quality; Comparison (C) – no specific comparator; and Outcome (O) – effects of the strategies on triage quality. These four key concepts guided the selection of search terms and databases. The search strategy was reviewed and validated by an information specialist and a health sciences librarian with recognized expertise in systematic search strategies. An example of the search strategy for PubMed is presented in supplemental digital file 1. Since validated triage scales (i.e., CTAS, ESI, MTS, ATS and SATS) began to be implemented in the mid-1990 s, we systematically searched databases from January 1990 to April 2024.

2.2. Eligibility criteria

We included published studies on strategies to improve nursing triage, such as the implementation of decision-support tools, educational interventions for triage nurses, the use of standardized triage protocols in emergency departments, and audits and feedback mechanisms. We considered a range of potential quality improvements and implementation strategies, as outlined in previous systematic reviews [37,38]. Only studies using recognized and validated triage scales (i.e., CTAS, ESI, MTS, ATS and SATS) were included. They also needed to assess quality outcomes (i.e., triage accuracy, triage documentation, triage time) with the following designs: experimental (RCT), quasi-experimental, quantitative descriptive, qualitative, and mixed methods. There was no language restriction. For the few articles that were not in French or English, the translation software DeepL Translate (Cologne, North Rhine-Westphalia, Germany) was used. However, after translating the abstracts, these articles were not retained.

We excluded studies that were not conducted in the ED (e.g., pre-hospital triage, simple triage and rapid treatment (START), telephone triage). We also excluded studies focusing on mass casualty triage. This type of triage is not usually performed by nurses, and different scales are used than those used for nursing triage.

2.3. Data selection and processing

All articles (titles and abstracts) were managed using the Covidence software platform (Veritas Health Innovation, Melbourne, Australia). We identified and removed duplicates using electronic and manual screening [39]. The selection was pilot-tested by two independent reviewers (SO, FS) using an iterative approach on 10 % of the citations until reaching the 75 % agreement needed for the screening process to begin [40]. Titles, abstracts and then full texts were screened by the two independent reviewers (SO, FS) to determine whether articles were relevant or not, based on the eligibility criteria. Any disagreement was resolved through discussion among reviewers and, if necessary, in consultation with a third senior reviewer (MB).

2.4. Data management

We developed a standardized data extraction form that was iteratively pilot tested by two reviewers with methodological and clinical expertise (SO, FS) on a sample of five studies until a 75 % agreement was achieved. These reviewers independently extracted information on the following aspects of included studies: study characteristics (country, study design, sample size), the types of strategies used (e.g., educational, technological, audits and feedback), along with the associated quantitative results (e.g., proportions, means) and/or qualitative results (text coding, themes and subthemes, author interpretations). Additionally, barriers and facilitators to the implementation of strategies were also identified.

2.5. Confidence in cumulative evidence

The quality of the evidence was critically appraised by two independent reviewers (SO, FS) with the Mixed Methods Appraisal Tool (MMAT) v.2018 [41,42]. The MMAT is used to evaluate any type of study (RCTs, quantitative nonrandomized, quantitative descriptive, qualitative and mixed methods) according to five criteria rated as yes, no or can't tell [41]. As recommended, studies meeting $< 4/5$ MMAT criteria were considered low quality, while studies meeting $\geq 4/5$ MMAT criteria were considered high quality. Any disagreements on eligibility, extracted data or quality have been resolved through discussion between the two reviewers and in consultation with a senior reviewer (MB) when necessary.

2.6. Data synthesis

Data analysis and synthesis were performed in two steps. The first step involved categorizing the types of outcomes presented in the selected studies. To achieve this, all outcomes from the selected articles were recorded and systematically grouped into categories (e.g., triage accuracy, individual capability) and subcategories (e.g., triage knowledge, communication with teams/patients). This categorization process was conducted by two review authors (SO, AL) and subsequently validated by a third author (MB) to ensure accuracy and consistency. In the second step, the impact of each strategy (educational, technology-based, audit and feedback) was assessed to determine whether it had a positive or negative effect on each outcome (e.g., triage accuracy, triage knowledge, and documentation).

We employed the Behavior Change Wheel (BCW) framework to categorize the barriers and facilitators of implementation strategies aimed at improving the quality of triage [43,44]. In this review, the BCW was used to identify strategies that could enhance Capability, Motivation, and Opportunity in nurses, ultimately driving behavior change to optimize triage quality [44]. Capability is a personal attribute that, alongside opportunity, enables or facilitates behavior (e.g., performing all triage steps, understanding triage protocols, and recognizing various health conditions) [45]. Opportunity refers to environmental factors that, together with capability, enable or facilitate behavior (e.g., clear communication mechanisms for the triage process, and a culture of continuous quality improvement) [45]. Motivation encompasses mental processes that energize and direct behavior (e.g., the ability to work under pressure and maintain performance under continuous stress) [45].

2.7. Deviation from initial protocol

Our initial plan was to conduct a realist review, in which observed associations are analyzed using context-mechanism-outcome (CMO) configurations to explain how different contexts and mechanisms influence outcomes positively or negatively [46]. However, we were unable to apply the CMO framework because the selected studies did not specifically document the barriers that needed to be addressed or the facilitators that should have been strengthened by the implementation strategies for nursing triage. Instead, they primarily described the barriers and facilitators related to the use of these strategies. Given this limitation, we opted for a systematic review to assess the impact of these strategies on triage quality, while also examining the associated barriers and facilitators to their implementation in EDs.

3. Results

In our systematic review, 10,393 records were identified. After removing duplicates, 7,464 records were screened. Following the screening of titles and abstracts, 7,187 studies were excluded. A total of 277 full-text articles were then assessed for eligibility, and 230 were excluded (supplemental digital file 2). The primary reason for exclusion was the absence of an implementation strategy to improve nursing triage (n = 178). Ultimately, 47 studies were included. The flowchart describing article searching, screening, and selection is presented in Fig. 1.

3.1. Study characteristics

The characteristics of the 47 included studies [33,47–92] are detailed in Table 1. The time frame for the studies ranges from January 2004 to April 2024. More than 70 % (n = 34/47) of the studies included in this systematic review were conducted from 2015 to 2024. Most studies were conducted in North America, more specifically in Canada (n = 9, 19 %) and the United States (n = 9, 19 %), and in the Middle East (n = 11, 23 %), more specifically in Iran (n = 8, 17 %).

Of the 47 included studies: 41 (87 %) were quantitative and mainly used a quasi-experimental design, four (8 %) were qualitative, and one (2 %) used a mixed-method design. When the number of nurses assigned to a specific intervention was specified, the sample size ranged from 3 [33] to 132 [79], (mean = 34, median = 33). When the strategy involved measuring triage quality, the number of triages assessed ranged from 138 [47] to 229 744 [58] (mean = 10 765, median = 573).

3.2. Methodological quality of the studies

For this systematic review, 55 % (n = 26) of the studies were classified as high quality ($\geq 4/5$*), while 45 % (n = 21) were considered low quality ($< 4/5$*). Among the quasi-experimental studies (n = 37), the most frequently unmet criterion was related to confounding factors (criterion 4), with only 21 % (n = 8) of the studies adequately identifying or accounting for these factors in their statistical analyses. For the qualitative studies (n = 4), three criteria were lacking in 50 % of the studies (n = 2): the appropriateness of qualitative data collection methods to address the research question (criterion 2), the derivation of findings from the data (criterion 3), and the substantiation of result interpretations by the data (criterion 4). The methodological quality of each included article, along with an explanation of each score based on the MMAT, is presented in Table 2.

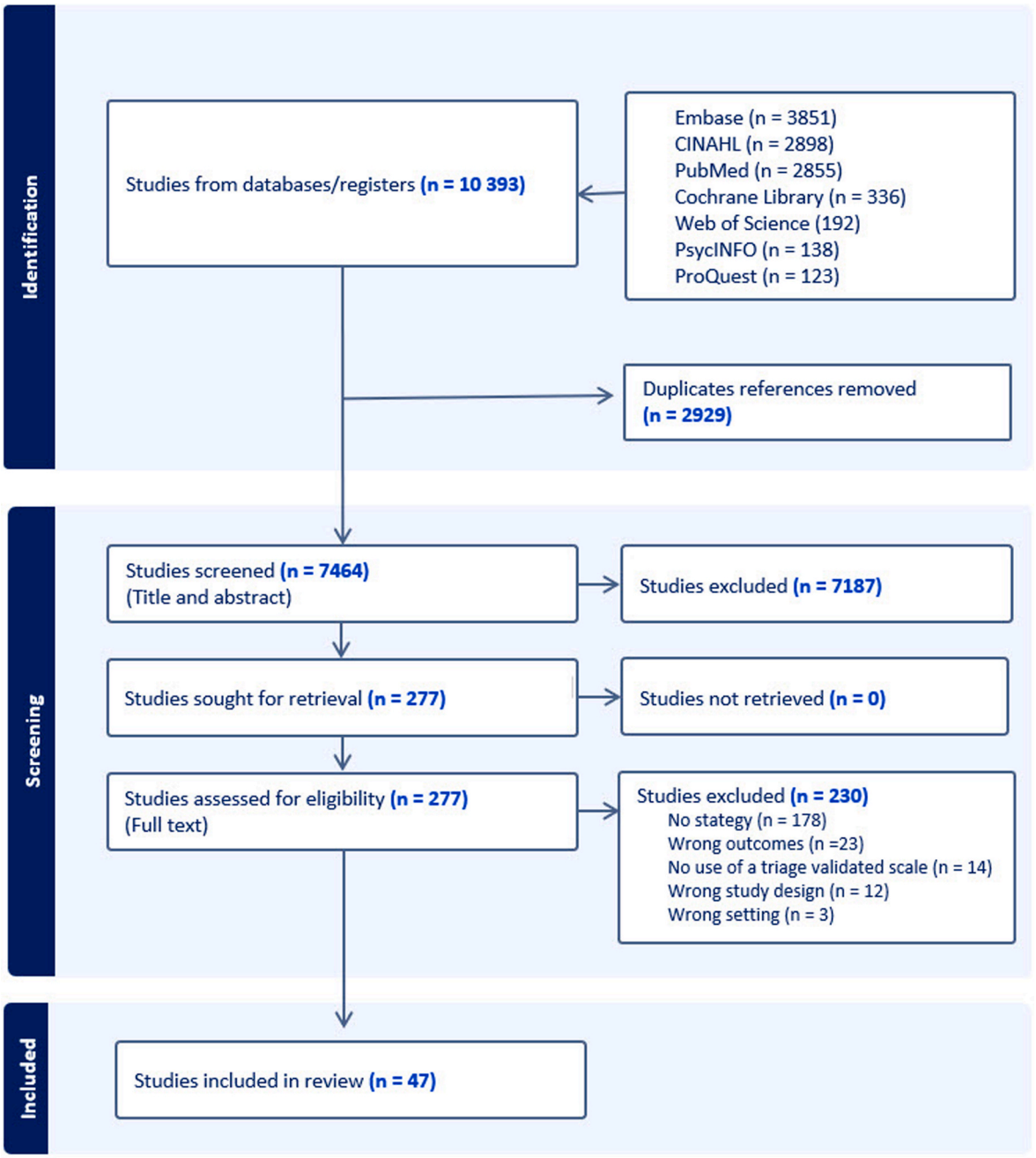

Fig. 1. The flowchart describing article searching, screening, and selection.

3.3. Strategies to improve triage quality

Three main categories of strategies to improve nursing triage emerged from data extraction and analysis. These strategies included education, technology, and audit with feedback (Table 3). The following section will present the impact of implementation strategies on quality outcomes (Table 4) categorized according to the three categories of strategies.

3.4. Educational strategies

Most studies (34, 72 %) presented in this review used educational strategies (n = 25, 54 %) [47–49,51–53,57,59,62–67,70–73,76,78,79,82,88,89,93] or a combination of educational strategies and technology (n = 9, 19 %) [33,55,61,68,77,80,81,84,85]. The following modalities were used to deliver educational strategies: group-based courses (n = 24, 71 %), synchronous and/or asynchronous online education (n = 9, 26 %), simulations (n = 4, 11 %), and gaming activities (n = 1, 3 %).

Various outcomes related to educational strategies were measured immediately after providing education in the majority of studies (n = 30/34, 88 %). Among these outcomes, triage accuracy was the most frequently assessed. Notably, all educational strategies improved triage accuracy [33,47–49,53,55,57,61,62,64–67,70–73,77–81], except in one study [89]. Some authors also investigated whether nurses' personal capacities improved following the implementation of an educational strategy. In this regard, knowledge related to the triage process was the most frequently studied outcome [52,59,63,65,67,68,76–78,82,84,85,88,90], followed by triage skills, including the assignment of an appropriate triage level and compliance with the triage process [52,63,70,77]. The findings of certain studies also highlighted those educational strategies enhanced nurses' personal confidence in triage [33,48]. Some authors also highlighted that educational strategies

Table 1
Synthesis of study characteristics (n = 47).

Characteristics	n (%)
Year	
2020–2024	17 (36)
2015–2019	17 (36)
2010–2014	6 (13)
2004–2009	7 (15)
Continents	
North America	18 (38)
Middle East	11 (23)
Europe	6 (13)
Asia	6 (13)
Oceania	4 (9)
South America	2 (4)
Study Design	
Quasi-experimental	37 (80)
Qualitative	4 (8)
Experimental (RCT)	3 (6)
Quantitative descriptive	2 (4)
Mixed method	1 (2)
Strategies	
Educational	25 (54)
Technology	10 (21)
Educational + Technology	9 (19)
Audit and feedback	3 (6)

improved communication among team members involved in triage [49,52].

Overall, all educational strategies demonstrated at least one positive effect on the quality of nursing triage. However, one study that included follow-up assessments one year after the implementation of educational strategies did not report favorable outcomes [65].

3.5. Technological aids

Almost half (n = 19, 40 %) of studies included this review investigated strategies to improve triage using various technological aids [33,50,55,56,58,60,61,69,74,75,77,80,81,83–87,91]. These technologies included software used by nurses or the integration of artificial intelligence (AI) to assist them in the triage process by suggesting questions based on the reason for consultation and proposing triage priorities according to the data collected.

Similar to educational strategies, triage accuracy was the most studied outcome regarding the improvement of triage quality related to technological aids [50,55,56,58,60,61,69,75,77,80,81,86,91]. Various studies have consistently demonstrated the positive impact of technological aids on triage accuracy by reducing triage errors [86,87] and the proportion of inaccurate triage cases (under-triage or over-triage) [75,80,81]. Similarly, positive effects were reported on team communication and triage documentation [87].

Time-related aspects of triage (waiting time before and after triage, as well as triage duration) were also assessed in a few studies. Notably, both the time before triage [56] and the waiting time after triage were reduced with technological aids [74]. Some results from included studies focusing on this strategy also revealed contradictory findings. Regarding triage time, Mandirola Brieux, Guillen [74] showed that triage time (3.7 min vs. 2.5 min, $p = 0.001$) can be reduced with technological aids. However, other studies reported an increase in triage time (1.47 min vs. 1.79 min, $p = 0.01$) with the use of these technologies [86]. In addition, the use of technological aids was associated with a reduction in waiting time before admission to the intensive care unit (ICU) in one study [58].

3.6. Audit and feedback

A small proportion of studies (n = 3, 6 %) included in this review assessed audit and feedback as a quality improvement strategy [54,83,92]. The interval between audits ranged from daily [91] to a period of six months [54] to one year [83]. Positive outcomes associated with the audit and feedback strategy included the standardization of triage [54,83,92], improved documentation of vital signs, and enhanced communication with patients regarding their estimated waiting time and the triage process [54]. A pre-post quasi-experimental study also demonstrated that appropriate triage prioritization increased by nearly 15 % following the implementation of daily triage audits, compared to the period preceding the audit and feedback strategy [92].

3.7. Barriers and facilitators to improving triage quality

Thrity-five (74 %) studies described the barriers and facilitators to implementation strategies used to improve triage. Since barriers and facilitators showed considerable similarities across strategy categories, they were analyzed all together, as shown in the following Fig. 2. This approach provided a comprehensive overview of the key factors to consider during the implementation process. The following sections describe the barriers and facilitators in terms of the BCW's Capability, Opportunity and Motivation (COM) components [44].

3.7.1. Capability

Regarding the capability component, the considerable time required to adapt to the use of strategies, whether technological or related to the audit process, was reported as a barrier to their implementation [50,56,61,86,87,92]. For instance, the application of training received became more challenging, and feedback processes might not take place, particularly when nurses faced high cognitive loads or lacked sufficient time for reflection. The most frequently identified facilitator in the included studies was the importance of providing nurses with continuing education throughout their careers, rather than relying solely on initial or refresher training [55,59,60,62,66,76,78,82]. Another consistent finding related to facilitators, observed across all three types of strategies, emphasized the significance of fostering a culture of continuous improvement within the organization to increase the likelihood of optimizing triage quality [55]. This observation was particularly noted in studies which examined both educational strategies and technological aids. Additionally, nurses' years of experience were repeatedly highlighted as an influential factor [33,76]. Experience exceeding three [78] or five years [53] of triage was considered a facilitator, as it likely enhances confidence and decision-making abilities in triage. In contrast, limited experience, particularly less than five years of triage experience [53], was associated with greater challenges, potentially acting as a barrier to effective strategy implementation.

3.7.2. Opportunity

Regarding the opportunity component, overcrowded EDs and excessive workload stand out as two of the most frequently cited barriers. Some studies also reported that the implementation of educational and technological strategies aimed at improving triage processes was hindered by dysfunctional environments [61,65,70,84,85], characterized by a lack of equipment and an inefficient triage setup, which is known to negatively impact on the quality of triage. Similarly, insufficient staffing in EDs have been identified as a significant obstacle to implementation strategies aimed at improving triage quality, particularly educational strategies as well as audit and feedback [49,54,57,82]. Additionally, the integration of new technologies, if not user-friendly or

Table 2
Quality assessment of qualitative studies using the mixed methods appraisal tool.

Quantitative non-randomized study designs (n = 37)

Citation	Q1	Q2	Q3	Q4	Q5	Quality
Arroabarren, E. *et al.* (2018)	Yes	Yes	Yes	Yes	Yes	*****
Bennett, *et al.* (2014)	Can't tell	Can't tell	No	Can't tell	Yes	*
Bird, C. *et al.* (2009)	Yes	Yes	Yes	Can't tell	Yes	****
Brosinski, C. *et al.* (2017)	Yes	Yes	Yes	Yes	Yes	*****
Burgess, L. *et al.* (2019)	Yes	Yes	Yes	Yes	Yes	*****
Campbell, D. *et al.* (2022)	Yes	Yes	No	Can't tell	Yes	***
Çetin, S.B. *et al.* (2023)	Yes	Yes	Yes	Yes	Yes	*****
Clarke, D. E. *et al.* (2006)	Yes	Yes	Can't tell	Can't tell	Yes	***
Crabtree, J. *et al.* (2023)	Yes	Yes	No	Can't tell	Yes	***
Davis, S. *et al.* (2022)	Yes	Yes	No	Yes	Yes	****
Dong, S. L. *et al.* (2007)	Yes	Yes	Yes	No	Yes	****
Dong, S. L. *et al.* (2005)	Yes	Yes	Yes	Can't tell	Yes	****
Ebrahimi, M. *et al.* (2016)	Can't tell	Yes	No	Can't tell	Yes	**
Gandhi, S *et al.* (2019)	Can't tell	Can't tell	No	No	Yes	*
Ghanbarzehi, N. *et al.* (2016)	No	No	No	No	Yes	*
Grossmann, F. F. *et al.* (2014)	Yes	Yes	Yes	Yes	Yes	*****
Hill, Carol S. *et al.* (2017)	Yes	Can't tell	No	No	Yes	**
Hoffman, S. *et al.* (2022)	Yes	Yes	Yes	No	Yes	****
Hussein, H. A. *et al.* (2019)	Yes	Yes	Yes	Yes	Yes	*****
Hosseinia, S. A. *et al.* (2022)	Yes	Yes	Yes	No	Yes	****
Ivanov, O. *et al.* (2021)	Yes	Yes	Yes	Yes	Yes	*****
Jang, J. *et al.* (2021)	Yes	Yes	No	Can't tell	Yes	***
Jang, J. *et al.* (2020)	Yes	Yes	No	No	Yes	***
Kim, H. J. *et al.* (2019)	Yes	Yes	Yes	No	Yes	****
Malyon, L. *et al.* (2014)	Yes	Yes	Yes	Can't tell	Yes	****
Mandirola B., H. F. *et al.* (2015)	Can't tell	Can't tell	No	No	Yes	*
McLeod, S. L. *et al.* (2020)	Yes	Yes	Yes	Can't tell	Yes	****
McNally, S. (2006)	Yes	Yes	Yes	Can't tell	Yes	****
Moon, S. H. *et al.* (2024)	Yes	Yes	Yes	Can't tell	Yes	****
Moon, S. H. *et al.* (2022)	Yes	Yes	Yes	Can't tell	Yes	****
Rahmati, H. *et al.* (2013)	Yes	Yes	Yes	Can't tell	Yes	****
Recznik, C. T. *et al.* (2019)	No	Yes	No	Can't tell	Yes	**
Recznik, C. T. *et al.* (2018)	Yes	Yes	No	No	Yes	***
Tran, N. *et al.* (2019)	Yes	Yes	No	Can't tell	Yes	***
Yazdannik, A. *et al.* (2020)	Yes	No	No	No	Yes	**
Yazdannik, A. *et al.* (2018)	Yes	Can't tell	No	No	Yes	**
Zaboli, A. *et al.* (2023)	Yes	Yes	Yes	Yes	Yes	*****

Notes: Q1: Are the participants representative of the target population? Q2: Are measurements appropriate regarding both the outcome and intervention (or exposure)? Q3: Are there complete outcome data? Q4: Are the confounders accounted for in the design and analysis? Q5: During the study period, is the intervention administered (or exposure occurred) as intended?

Qualitative study designs (n=4)

Citations	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Quality**
Agnihotri, T. *et al.* (2021)	Yes	Yes	No	Yes	Yes	****
Atack, L. *et al.* (2004)	Can't tell	No	No	No	Yes	*
Bowers, S. (2011)	Yes	No	No	No	Can't tell	*
Çetin, S.B. *et al.* (2024)	Yes	Yes	Yes	Can't tell	Yes	****

Notes: Q1: Is the qualitative approach appropriate to answer the research question? Q2: Are the qualitative data collection methods adequate to address the research question? Q3: Are the findings adequately derived from the data? Q4: Is the interpretation of results sufficiently substantiated by data? Q5: Is there coherence between qualitative data sources, collection, analysis and interpretation?

Quantitative randomized controlled trials (RCT) designs (n=3)

Citations	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Quality**
Delnavaz, S. *et al.* (2018)	Yes	Yes	Yes	No	Yes	****
Javadi, M. *et al.* (2023)	Yes	Yes	Yes	Yes	Yes	*****
Rankin, A. J. *et al.* (2013)	Yes	Yes	No	Can't tell	Yes	***

Notes: Q1: Is randomization appropriately performed? Q2: Are the groups comparable at baseline? Q3: Are there complete outcome data? Q4: Are outcome assessors blinded to the intervention provided? Q5: Did the participants adhere to the assigned intervention?

Quantitative descriptive (n=2)

Citations	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Quality**
Cicolo, E. *et al.* (2019)	Yes	Can't tell	Can't tell	No	Yes	**
Varndell, W. *et al.* (2019)	Yes	Yes	Yes	Can't tell	Yes	****

Notes: Q1: Is the sampling strategy relevant to address the research question? Q2: Is the sample representative of the target population? Q3: Are the measurements appropriate? Q4: Is the risk of nonresponse bias low? Q5: Is the statistical analysis appropriate to answer the research question?

Mixed methods study designs (n=1)

Citations	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Quality**
Atack, L. *et al.* (2005)	No	Yes	Yes	No	No	**

Notes: Q1: Is there an adequate rationale for using a mixed methods design to address the research question? Q2: Are the different components of the study effectively integrated to answer the research question? Q3: Are the outputs of the integration of qualitative and quantitative components adequately interpreted? Q4: Are divergences and inconsistencies between quantitative and qualitative results adequately addressed? Q5: Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?

Table 3
Characteristics of included studies (n = 47).

Author, year and country	Study design and sample size	Strategies	Outcomes[a]	MMAT Score
1- Agnihotri, T. *et al.* (2021), Canada	Qualitative, n = 8 Nurses	Educational and technology(Paper-based triage system VS an electronic decision-support tool (eCTAS))	− ↑ accuracy and consistency of triage − ↑ confidence	****
2- Arroabarren, E. *et al.* (2018), Spain	Quasi experimental pre and post study with intervention, n = 138 patients Pre = 69 Post = 69	Educational(Pediatric anaphylaxis triage)	− ↑ accuracy of triage **Pre: 36.2 %; Post: 72.2 %,**	*****
3- Atack, L. *et al.* (2004), Canada	Qualitative	Educational(Web-based course on CTAS)	− ↑ confidence − "It's made me change my whole approach. I think I'm more efficient and thorough with my assessments.'' − ↑ accuracy and consistency of triage	*
4- Atack, L. *et al.* (2005), Canada	Mixed method(Interview and audits) , n = 23 nurses Audits = 367	Educational(CTAS online course)	− ↑ communication with team and patients − ↑ accuracy of triage (78 %, had improved their triage practice)	***
5- Bennett, *et al.* (2014),UK	Quasi experimental pre and post (audit) study with intervention, n = 800 Pre = 400 Post = 400	Technology(Triage Computerised Clinical Decision Support in the Emergency Department (CCDSS))	− ↑ accuracy of triage **Pre: 60.5 %; post: 85.2 %** − ↑ Pain assessment and management **Pre: 35.0 %; post: 97.7 %**	*
6- Bird, C. *et al.* (2009),UK	Quasi experimental pre and post (audit) study with intervention, n = 212 Pre = 106 Post = 106 (Pre/post 1 year)	Educational (Importance of measuring vital signs in children + card printed with vital signs based on advanced paediatric life support (APLS))	− ↑ documentation of vital signs **Pulse = Pre: 53 %; Post:75 %** **RR = Pre: 31 %; Post: 60 %** **capillary refill time = Pre: 13 %; Post:26 %** **oxygen saturation= Pre: 42 %; Post 70 %**	****
7- Bowers, S. (2011), UK	Qualitative,Nursing students	Educational(Triage Game)	− ↑ communication − ↑ triage skills and knowledge	*
8- Brosinski, C. et al. (2017), USA	Quasi experimental pre and post (audits) study with Intervention, n = 15 nurses Audits = 828 Pre = 388 Post = 440 (pre/post 1 month)	EducationalRefresher training for all ED nursing staff on ESI level designation.	− ↑ accuracy of triage − ↓ under triage Decrease of 23.8 % ESI 1= Pre: 33.3 %; Post: 0 % ESI 2= Pre: 77.3 %; Post: 21.1 % ESI 3= Pre: 43.1 %; Post: 14.5 % ESI 4= Pre: 13.5 %; Post: 7.5 %ESI 5 = NA	*****
9- Burgess, L. *et al.* (2019), Australia	Quasi experimental pre and post (audits) study with intervention, n = 200 Pre = 100 Post = 100 (Pre/post 6 month)	Audit and feedback	− ↑ Standardized documentation Pre: 90 %; post: 92 %, − ↓ time of triage **Pre:5 min; Post:4 min** − ↑ communication with team and patients Pre: 29 %; Post: 35 % − ↑ documentation of vital signs Pre: 48 %; Post: 68 %	*****
10- Campbell, D. *et al.* (2022),USA	Quasi experimental pre and post study with intervention, n = 33 nurses Audits = 495	Educational and technology(Mobile technology)	− ↑ accuracy of triage Pre:78.0 %; Post:80.0 %	***
11- Çetin, S.B. *et al.* (2024), Turkey	Qualitative research n = 14 nurses	Technology(Computer-based triage decision support system)	− ↑ Standardized documentation − ↑Facilitating the triage decision − ↑ communication − ↑ team collaboration − ↓ error	****
12- Çetin, S.B. *et al.* (2023), Turkey	Quasi experimental pre and post study with intervention, n = 30 nurses Audits Pre = 16 409 Post = 7 765	Technology(Computer-based triage decision support system)	− ↑ accuracy of triage **Pre:57.8 %; Post:64.9 %,** − ↓ triage error **Pre:42.2 %; Post:35.1 %** − ↑ time of triage **Pre:1.47 min; Post:1.79 min**	*****
13- Cicolo, E. *et al.* (2019), Brazil	Exploratory-descriptive research, n = 10 nurses	Technology(Electronic triage vs manual)	− ↑ accuracy of triage Pre: 72 %, Post: 75 %, − ↓ time to triage **Pre: 3.179 min; post: 2.425 min**	**
14- Clarke, D. E. *et al.* (2006),Canada	Quasi experimental pre and post educational, n = 10 Nurses Audits	Educational (A 3 h formal educational session regarding mental health and illness)	− ↑ accuracy of triage (mental health) − ↑ Mental health problems patients triaged as non-urgent and requiring afterwards hospitalization: Pre: 50 %; Post:20 %)	***

(*continued on next page*)

Table 3 (*continued*)

Author, year and country	Study design and sample size	Strategies	Outcomes[a]	MMAT Score
	Pre = 3282 Post = 3498			
15- Crabtree, J. *et al* (2023), USA	Quasi experimental pre and post study educational, n = 42 nurses	Educational (Educational session on ESI, 4 to 5 h)	− ↑ triage knowledge **Pre: M = 35.37/45, SD = 1.76** **Post: M = 41.84, SD = 0.37**	***
16- Davis, S. *et al. (*2022), Canada	Cohort study (triage), Audits = 229744 (30 months)	Technology(Human supervision vs computer-generated score)	− ↓ of admissions in the CTAS 4–5 categories − ↓ ICU consultations in the CTAS 4–5 categories	****
17- Delnavaz, S. *et al.* (2018), Iran	Randomised controlled trial G1 (Role playing): n = 25G2 (Lecture) : n = 25	Educational(Scenario based triage education by lecture vs role playing)	− ↑ triage-related knowledge **G1 = Pre:18.08 %; post:78.89 %** **G2 = Pre:16.00 %; post:51.30 %**	****
18- Dong, S. L. *et al.* (2005), Canada	prospective observational study, N = 37 nurses Audits = 693	Technology(Novel Computer Triage Program (eTRIAGE) with Standard Triage)	− ↑ accuracy of triage Compared with the CTAS expert panel: Nurses agreement K = 0.263 With eTriage K = 0.426	****
19- Dong, S. L. *et al.* (2007), Canada	prospective study, Phase 1: N = 77 nurses Audits= Pre = 513 Post = 569 Phase 2: N = 8 nurses Audit= Pre = 555 Post = 577	Educational and technology(Electronic triage system)	− ↑ accuracy of triage Phase 1 = Kw = 0.55 Phase 2 = Kw = 0.65	****
20- Ebrahimi, M. *et al.* (2016), Iran	Quasi experimental pre and post study with intervention, N = 35 (5 nurses and 30 emergency medical staff) Audits = 156 Pre = 78; Post = 78	Educational(two-day triage workshop)	− ↑ accuracy of triage Nurses **Pre:42.3 %; Post:93.6 %** Medical staff **Pre:37.2 %; Post:79.5 %**	**
21- Gandhi, S. *et al.* (2019), India	Quasi experimental pre and post intervention, N = 50 nurses	Educational(Triage training)	− ↑ triage skills **good= Pre: 70 %; Post: 100 %** **Average= Pre: 14 %, Post: 0 %** **poor= Pre: 16 %, Post 0 %** − ↑ triage knowledge **Good= Pre: 70 %; Post: 100 %** **Average= Pre: 12 %, Post: 0 %** **Poor= Pre: 18 %; Post: 0 %**	*
22– Ghanbarzehi, N. *et al.* (2016), Iran	Quasi experimental pre and post intervention, n = 35 (5 nurses and 30 emergency medical staff) Audits = 156 Pre = 78 Post = 78	Educational(Triage training)	− ↑ accuracy of triage **Pre: K = 0.20; post: K = 0.62**	*
23– Grossmann, F. F. *et al.* (2014), Switzerland	Quasi experimental pre and post intervention, n = 33 nurses Pre = 16; Post = 17 Audits = 913 Pre = 519; Post = 394	Educational(Education on triaging the elderly in the ED)	− ↑ accuracy of triage Pre: 22.5 %, Post: 24.2 % − ↑ triage-related knowledge Pre: 4.9/6; Post: 5.3/6 − ↑ documentation of vital signs Pre:15.9 %; Post: 88.6 %	*****
24- Hill, Carol S. *et al.* (2017), USA	Quasi experimental pre and post intervention, n = 20 nurses	Educational(Triage knowledge and implementation)	− ↑ accuracy of triage Pre: 5 %; Post: 45 % − ↑ the implementation of standing Pre: 5 %; Post: 75 %	**
25- Hoffman, S. *et al.* (2022), USA	Quasi experimental pre and post study educational, n = 40 nursesauditspré=75; post 75	Educational(ESI competency assessment)	− ↓ accuracy of triage G1 = 74.6 %; G2: 72.0 % − ↑ triage error **Pre:25.3 %; Post:28.0 %**	****
26- Hussein, H. A. *et al.* (2019), Iraq	Quasi experimental pre and post control group n = 60, IG = 30, CG = 30	Educational(Information related to the triage system in the ED)	− ↑ triage-related knowledge **CG= Pre: NS, Post: 0.33** **IG= Pre: 0.36, Post:0.78** − ↑ accuracy of triage **CG= Pre: NS, Post 0.29** **IG= Pre 0.30, Post 0.82**	*****
27- Hosseini, S. A. *et al.* (2022), Iran	Quasi experimental pre and post Intervention, n = 21 nursesG1: Face to face (n = 5)G2: Multimedia (n = 6)G3: Pamphlet (n = 10) Audits = 4383 Pre = 2062; Post = 2321	Educational and Technology(Face to face, pamphlet and multimedia training)	− ↑ triage-related knowledge **G1 = pre: 58.36; post: 71.68** G2 = pre: 51.75; post: 63.63 G3 = pre: 54.21; post: 52.68	****
28- Ivanov, O. *et al.* (2021), USA	Quasi experimental intervention, G1: nurses G2: Machine learning (Kate)	Technology(Machine learning (Kate) and clinical natural language processing)	− ↑ accuracy of triage **G1 = 59.8 %; G2: 75.7 %** − ↓ under triage **G1 = 104 %; G2: 41 %**	*****

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Table 3 (*continued*)

Author, year and country	Study design and sample size	Strategies	Outcomes[a]	MMAT Score
	Audits = 729 site A: 368; site B: 361		− ↓ over triage **G1 = 14.4 %; G2: 9.7 %**	
29- Jang, J. et al. (2020), Korea	Quasi experimental pre and post intervention, n = 27 nurses	Educational(Simulation Education Program Based on KTAS)	− ↑ triage skills Clinical decision-making ability **Pre: 2.66 SD; Post: 3.95 SD** Evaluate and re-evaluate **Pre: 2.69 SD; Post: 3.93 SD**	***
30- Jang, *et al.* (2021), Korea	Quasi experimental pre and post intervention, n = 48 nurses Pre = 11 – 12 Post = 12–13 Audits = 1200 Pre = 600 Post = 600	Educational(Problem-Based Learning)	− ↑ accuracy of triage Pre: Kw: 0.69–0.67; Post: Kw 0.82–0.83	***
31- Javadi, M. *et al.* (2023), Iran	Randomized controlled trial pre and post educational, n = 74 nurses G1 = 37 nurses G2 = 37 nurses	Educational (lecturing − G1 and flipped classrooms −G2)	− ↑ triage-related knowledge (max:10) **G1= Pre: 7.38, Post: 8.22, post (1 month): 8.17** **G2= Pre: 7.48, Post: 9.29, post (1 month): 9.21** − ↑ professional capability (max:135) **G1= Pre: 128.41, Post: 132.24, post (1 month): 132.84** **G2= Pre: 129.89, Post: 136.68, post (1 month): 140.27**	*****
32– Kim, H. J. *et al.* (2019), Korea	Quasi experimental pre and post study with two groups, n = 59 IG = 30 CG = 29	Educational(Web-based KTAS learning program)	− ↑ accuracy of triage **IG = Pre: 52.00; Post: 77.00** **CG = Pre: 55.17; Post: 62.76** − ↓ of under-triage **IG = Pre: 4.50; Post: 2.43** **CG= Pre: 4.14; Post: 4.41**	****
33– Malyon, L. et al. (2014), Australia	Quasi experimental pre, mid, and post Intervention, n = 61 nurses Audits = 600 Pre = 200 n = 34 nurses Mid = 200 n = 35 nurses Post = 200 n = 36 nurses	Educational(Introducing the emergency triage education kit and the pediatric physiological discriminator table)	− ↓ missing data (triage) **Pre: 56 %, Mid: 53 %, Post: 7 %** − ↑ accuracy of triage Accurate **Pre: 54 %, Mid: 69 %, Post: 72 %** Under triage **Pre: 24 %, Mid: 16 %, Post: 8 %** Over triage **Pre: 21 %, Mid: 15 %, Post: 20 %**	****
34- Mandirola B., H. F. *et al.* (2015), Argentina	Quasi experimental study with two groups, N = 30 nurses GC = 15 IG = 15Audits 1772	Technology(Nursing Software for Emergency Triage (NSET))	− ↓ triage time **GC: 3.7 min., IG: 2.5 min.** − ↓ waiting time of patients GC: 97 min., IG: 28 min − ↓ Left without being seen (LWBS) indexGC: 4.76, IG: 3.98	*
35- McLeod, S. L. et al. (2020), Canada	Quasi experimental pre and post Intervention, Audits = 1,491 Pre = 752 Post = 739	Technology(Real-time electronic decision-support tool (eCTAS))	− ↑ Interrater of nurse's triage Pre: Kw 0.71; Post: Kw 0.91 − ↑ accuracy of triage Pre: 75.4 %, Post: 92.7 % − ↓ of undertriage Pre: 12.6 %; post 2.2 % − ↓ of overtriage Pre: 12.0 %; post 5.1 %	****
36- McNally, S. (2006), Australia	Quasi experimental pre and post Intervention, n = 21 nurses	Educational (Teaching session, 40 h)	− ↑ triage-related knowledge **Pre: 15 %, post: 48 %** − ↑ complication-related knowledge **Pre: 85 %, post: 100 %**	****
37- Moon, S. H. *et al.* (2022), Korea	Quasi experimental pre and post with two groups, n = 66 IG = 31 CG = n = 35	Educational and technology(Triage Education Application)	− ↑ Triage skills: **IG= Pre: 79.51; Post 86.25** **CG= Pre: 82.88; Post: 82.54** − ↑ triage-related knowledge **IG= Pre: 20.35; Post: 22.41** **CG= Pre: 22.22; Post: 22.28** − ↑ Triage accuracy **IG= Pre: 3.90; Post 4.77** **CG= Pre: 4.03; Post: 3.80**	****
38- Moon, S. H. *et al.* (2024), Korea	Quasi experimental pre and post intervention, n = 27 nurses	Technology(Game-based triage educational app)	− ↑ Triage accuracy (Max:6) **Pre: 4.30; Post 5.33** − ↑ triage-related knowledge (Max:31) **Pre: 21.11; Post 22.70** − ↑ Triage skills: (Max:150) **Pre: 83.70; Post 90.93**	****

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Table 3 (*continued*)

Author, year and country	Study design and sample size	Strategies	Outcomes[a]	MMAT Score
			− ↑ Critical thinking: (Max:175) **Pre: 115.41; Post 119.48**	
39- Rahmati, H. et al. (2013), Iran	Quasi experimental pre and post intervention (2 days and 6 weeks) n = 50Pre, Mid (2 days), Post (6 weeks)	Educational(Triage Education)	− ↑ Triage accuracy Pre: 10.7/20; Mid: 17.8/20; Post 16.1/20 − ↑ triage-related knowledge Good= Pre: 14 %; Mid: 98 %; Post: 76 % Moderate= Pre: 72 %; Mid: 2 %; Post: 24 % Poor= Pre: 14 %; Mid: 0 %; Post: 0 %	****
40- Rankin, A. J. *et al.* (2013), Canada,	Randomised controlled trial, n = 132 Nurses IG = 65 CG = 67 Audit = 377 Pre = 132 Post = 124	Educational(6-week Web-based CTAS)	− ↑ Triage accuracy IG: 72.1 %; CG: 67.3 % − ↑ of over-triage **IG: n = 42, CG: n = 17** − ↓ of under-triage **IG: n = 9, CG: n = 43**	***
41- Recznik, C. T. *et al.* (2018), USA42- Recznik, C. T. et al. (2019), USA	Quasi experimental pre and post study with two groups n = 25 nurses G1= Paper then simulation, n = 11 G2= Simulation then paper, n = 14	Educational and technology	− ↑ Triage accuracy G1= Pre: 44.3 %; Post:75.0 % G2= Pre: 38.3 %; Post: 71.4 % − ↓ of under-triage G1= Pre: 27.3 %; Post: 19.3 % G2= Pre: 32.1 %; Post: 24.1 % − ↓ of over-triage G1= Pre: 28.4 %; Post: 5.7 % G2= Pre: 29.5 %; Post: 4.5 %	*****
43- Tran, N. *et al.* (2019), USA	Quasi experimental pre and post n = 16	Educational(Education project for ED nursing staff using the ESI triage tool)	− ↑ triage-related knowledge Pre: 68 %; Post: 96 %,	***
44- Varndell, W. *et al.* (2019), Australia	Descriptive, exploratory study comprising of retrospective audit data, Audit 3952 n = 14 local administrators n = 26 auditors representing 13 EDs	Audit and feedback, technology(Triage Quality Assessment Software)	− ↑ Triage accuracy − Overall TQAS triage decision accuracy was 58.3 %, with a moderate level of consistency demonstrated (KW = 0.57). − Over-triaging occurred more frequently (22.9 %) than under-triaging (12.4 %). − Triage decision accuracy was slightly higher in pediatric (16 years and under) than adult presentations (60.0 %vs.54.8 % respectively).	****
45- Yazdannik, A. *et al.* (2018), Iran 46- Yazdannik, A. *et al.* (2020), Iran	Quasi experimental pre and post with two groups n = 70 G1 = Electronic, n = 35 G2 = Workshop, n = 35	Educational and technologyMobile-based training VS standard	− ↑ triage-related knowledgeG1= Pre: 11.0/20; Post: 18.4/20G2= Pre: 12.0/20; Post: 15.7/20	****
47- Zaboli, A. *et al.* (2023), Italy	Quasi experimental pre and post daily auditing, Audits = 1773 Pre = 904 Post = 869	Audit and feedback	− ↑ accuracy of triage **Pre = 694 (76.8 %); Post: 785 (90.3 %)** − ↓ triage error **Pre: 210 (23.2 %); Post:84 (9.7 %)**	*****

Notes: a= Statistically significant results are presented in **bold** ($p < 0.05$).
Abbreviations: ATS.
= Australasian Triage Scale, **CTAS** = Canadian Triage and Acuity Scale, **IG** = Intervention Group, **CG** = Control Group, **ED** = Emergency Department, **ESI** = Emergency Severity Index, **G1** = Group 1, **G2** = Group 2, **K** = Kappa. **Kw** = Weighted Kappa. **RR** = Respiratory Rate, **NA** = Not Applicable, **NS** = Not Specified, **TQAS** = Triage Quality Assessment Software.

adequately supported, could further hinder the adoption of strategies aimed at improving triage quality. Educational, technological, and audit and feedback strategies benefit from organizational support, such as managers providing protected time for training on these strategies [51,54]. Combined with a well-established culture of continuous improvement [51,94], this support is described as critical for promoting high-quality triage practices.

3.7.3. Motivation

The most significant barrier identified was the stress level of nurses during triage. When ED nurses struggled to manage their stress effectively, it negatively impacted the implementation of strategies aimed at improving triage quality [57,58,66]. As for facilitators related to motivation, effective interdisciplinary collaboration, characterized by seamless and constructive communication, was found to facilitate the implementation of both educational strategies and audit and feedback processes [52,54,87]. Specifically, when team members collaborate effectively, they are more motivated to change their behaviors in ways that improve the quality of triage, and strong communication can help establish and reinforce best practices [54].

4. Discussion

This systematic review aimed to assess the impact of implementation strategies of nursing triage on quality outcomes, as well as the barriers and facilitators to their implementation, with the goal of improving the quality of nursing triage in EDs. Nearly half of included studies were rated as being of low methodological quality. Most of the studies focused on the evaluation of educational strategies, followed by technology, and audit and feedback. All three types of strategies demonstrated a positive impact on triage accuracy, a reduction in under- and over-triage, as well as an improvement in triage knowledge and skills. Educational strategies and technological aids also had a positive impact on adherence to time-related standards in triage. Regarding the barriers that may hinder the implementation of these strategies, overcrowded environments (Opportunity component of the BCW framework) and high stress levels in

Table 4
Impact of implementation strategies on the quality outcomes of nursing triage.

Outcomes/Strategies	Educational	Technology	Audit and feedback
Triage accuracy			
Accuracy of triage	↑ [1-22] ↓ [23]	↑ [6,8,18,21,22,24-31]	↑ [32]
Triage error	↑ [23]	↓ [30,33]	↓ [32]
Under triage	↓ [5,16,17,20-22]	↓ [21,22,29]	–
Over triage	↓ [21,22], ↑ [20]	↓ [21,22,29]	–
Individual capability			
Triage skills	↑ [14,18,34,35]	–	–
Triage knowledge	↑ [11,13,18,19,34-43]	–	–
Confidence	↑[1,3]	–	–
Critical thinking	–	↑ [31]	–
Team capability			
Communication with team/ patients	↑ [4,34]	↑ [33]	↑ [44]
Teamwork	–	↑ [33]	–
Documentation			
Documentation	↑ [11,17,45]	–	↑ [44]
Standardized documentation		↑ [33]	↑ [44,46]
Interventions			
Implementation of standing orders	↑ [12]	–	–
Pain assessment and management	–	↑ [24]	–
Triage efficacy and outcomes			
Time before of triage	–	↓ [25]	–
Triage time	–	↓ [47], ↑ [30]	↓ [44]
Waiting time of patients (after triage)	–	↓ [47]	–
Left without being seen	–	↓ [47]	–
Facilitating triage decision	–	↑ [33]	–
Time to ICU consultation and admission	–	↓ [26]	–

Notes: ↑ = An increase in outcomes was observed, with some results reaching statistical significance while others did not,
↓ = A decrease in outcomes was observed, with some results reaching statistical significance while others did not,
– = Has not been studied with this strategy.

Références

1. Agnihotri T, Fan M, McLeod S, et al. Impact of an Electronic Decision-Support System on Nursing Triage Process: A Usability and Workflow Analysis. *The Canadian journal of nursing research = Revue canadienne de recherche en sciences infirmieres.* 2021;53(2):107–113.
2. Arroabarren E, Álvarez-García J, Anda M, De Prada M, Ponce C, Alvarez-Puebla M. Impact of Specific Training in Anaphylaxis for Triage Nursing Staff in the Pediatric Emergency Department of a Tertiary Hospital. *Journal of Investigational Allergology & Clinical Immunology.* 2018;28(6):401–406.
3. Atack L, McLean D, LeBlanc L, Luke R. Preparing ED nurses to use the Canadian triage and acuity scale with Web-based learning. *Journal of Emergency Nursing.* 2004;30(3):273.
4. Atack L, Rankin JA, Then KL. Effectiveness of a 6-week Online Course in the Canadian Triage and Acuity Scale for Emergency Nurses. *Journal of Emergency Nursing.* 2005;31(5):436–441.
5. Brosinski CM, Riddell AJ, Valdez S. Improving triage accuracy: a staff development approach. *Clinical Nurse Specialist.* 2017;31(3):145–148.
6. Campbell D, Fetters L, Getzinger J, Perko A, Slater S. A Clinical Nurse Specialist-Driven Project to Improve Emergency Department Triage Accuracy. *Clinical nurse specialist CNS.* 2022;36(1):45–51.
7. Clarke DE, Brown A-M, Hughes L, Motluk L. Education to improve the triage of mental health patients in general hospital emergency departments. *Accident and emergency nursing.* 2006;14(4):210–218.
8. Dong SL, Bullard MJ, Meurer DP, Blitz S, Holroyd BR, Rowe BH. The effect of training on nurse agreement using an electronic triage system. *Canadian Journal of Emergency Medicine.* 2007;9(04):260–266.
9. Ebrahimi M, Ghanbarzehi N, Gorgich ZG, Darban F, Shirzadi F. The effect of triage training on the performance of triage nurses and emergency medical staff of Iranshahr. *International Journal of Medical Research & Health Sciences.* 2016;5 (9):190–196.
10. Ghanbarzehi N, Balouchi A, Sabzevari S, Darban F, Khayat NH. Effect of triage training on concordance of triage level between triage nurses and emergency medical technicians. *Journal of Clinical and Diagnostic Research: JCDR.* 2016;10(5):IC05.
11. Grossmann FF, Zumbrunn T, Ciprian S, et al. Undertriage in older emergency department patients–tilting against windmills? *PloS one.* 2014;9(8):e106203.
12. Hill CS. *Standardization of Triage*, University of Mount Olive; 2017.
13. Hussein HA, Hassan HS. Effectiveness of an Education Program on Nurses' Knowledge about the Triage System in Emergency Department of Qalat Salih Hospital. *Prof RK Sharma.* 2019;13(1):218.
14. Jang J-H, Kim SS, Kim S. Educational simulation program based on Korean triage and acuity scale. *International journal of environmental research and public health.* 2020;17(23):9018.
15. Jang K, Jo E, Song KJ. Effect of problem-based learning on severity classification agreement by triage nurses. *BMC nursing.* 2021;20(1):1–9.
16. Kim H-J, Kang H-Y. Effects of a web-based Korean triage and acuity scale learning program on triage self-efficacy and triage performance ability for nurses in emergency department. *Journal of Korean Academy of Nursing.* 2019;49 (2):171–180.
17. Malyon L, Williams A, Ware RS. The Emergency Triage Education Kit: Improving paediatric triage. *Australasian Emergency Nursing Journal.* 2014;17 (2):51–58.
18. Moon S-H, Cho I-Y. The Effect of Competency-Based Triage Education Application on Emergency Nurses' Triage Competency and Performance. Paper presented at: Healthcare2022.
19. Rahmati H, Azmoon M, Meibodi MK, Zare N. Effects of triage education on knowledge, practice and qualitative index of emergency room staff: A quasi-interventional study. *Bulletin of Emergency & Trauma.* 2013;1(2):69.
20. Rankin JA, Then KL, Atack L. Can Emergency Nurses' Triage Skills Be Improved by Online Learning? Results of an Experiment. *Journal of Emergency Nursing.* 2013;39(1):20–26.
21. Recznik CT. *Comparison of Two Methods of Pediatric Triage Education*, Duquesne University; 2018.
22. Recznik CT, Simko LC, Travers D, Devido J. Pediatric triage education for the general emergency nurse: a randomized crossover trial comparing simulation with paper-case studies. *Journal of Emergency Nursing.* 2019;45(4):394–402.
23. Hoffman S, Voss JA, Hendrickx L, Gibson N. Effect of Emergency Severity Index Annual Competency Assessment on Mistriage. *Journal of Nursing Care Quality.* 2022;37(4):356–361.
24. Bennett P. *A quantitative study investigating the effects of computerised clinical decision support in the emergency department.* University of Salford (United Kingdom); 2014.
25. Cicolo EA, Peres HHC. Electronic and manual registration of Manchester System: reliability, accuracy, and time evaluation. *Revista Latino-Americana de Enfermagem.* 2019;27.
26. Davis S, Ju C, Marchandise P, Diagne M, Grant L. The Effect of Human Supervision on an Electronic Implementation of the Canadian Triage Acuity Scale (CTAS). *The Journal of Emergency Medicine.* 2022;63(4):498–506.
27. Dong SL, Bullard MJ, Meurer DP, et al. Emergency Triage: Comparing a Novel Computer Triage Program with Standard Triage. *Academic Emergency Medicine.* 2005;12(6):502–507.
28. Ivanov O, Wolf L, Brecher D, et al. Improving ED emergency severity index acuity assignment using machine learning and clinical natural language processing. *Journal of Emergency Nursing.* 2021;47(2):265–278. e267.
29. McLeod SL, McCarron J, Ahmed T, et al. Interrater Reliability, Accuracy, and Triage Time Pre- and Post-implementation of a Real-Time Electronic Triage Decision-Support Tool. *Annals of emergency medicine.* 2020;75(4):524–531.
30. Çetin SB, Cebeci F, Eray O. The effect of computer-based decision support system on emergency department triage: Non-randomised controlled trial. *International Emergency Nursing.* 2023;70:101341.
31. Moon S-H, Kim SO. Enhancing triage accuracy in emergency nurses: The impact of a game-based triage educational app. *International Emergency Nursing.* 2024;72:101398.
32. Zaboli A, Sibilio S, Magnarelli G, et al. Daily triage audit can improve nurses' triage stratification: A pre–post study. *Journal of Advanced Nursing.* 2023;79 (2):605–615.
33. Bişkin Çetin S, Cebeci F. Nurses' experiences of using a computer-based triage decision support system in the emergency department. *Nursing in Critical Care.* 2024.
34. Bowers S. Making a game of urgent care: Simulation for nursing students. *Emergency Nurse.* 2011;19(7).
35. Gandhi S, Jothimani K. A study to evaluate effectiveness of triaging the triage: reducing waiting time to triage in the command post to emergency department in selected hospitals. *International Journal of Nursing Education.*

2019;11(4):149–153.
36. Delnavaz S, Hassankhani H, Roshangar F, et al. Comparison of scenario based triage education by lecture and role playing on knowledge and practice of nursing students. *Nurse education today.* 2018;70:54–59.
37. Hosseini A, Mojtahedzadeh R, Mohammadi A, Gharib M. Effective triage training for nurses: comparison of face to face, pamphlet, and multimedia training. *Journal of e-Learning and Knowledge Society.* 2022;18(1):101–106.
38. McNally S. Triage education: From experience to practice standards. 2006.
39. Tran N. *Implementing ESI Education Project for Nurses in the Triage Process*, Walden University; 2019.
40. Yazdannik A, Mohamadirizi S, Nasr-Esfahani M. Comparison of the effect of electronic education and workshop on the satisfaction of nurses about Emergency Severity Index triage. *Journal of Education and Health Promotion.* 2020;9.
41. Yazdannik A, Dsatjerdi EI, Mohamadirizi S. Utilizing mobile health method to emergency nurses' knowledge about emergency severity index triage. *Journal of Education and Health Promotion.* 2018;7.
42. Crabtree J. *Staff Education Project: The Emergency Severity Index*, Walden University; 2023.
43. Javadi M, Gheshlaghi M, Bijani M. A comparison between the impacts of lecturing and flipped classrooms in virtual learning on triage nurses' knowledge and professional capability: an experimental study. *BMC nursing.* 2023;22 (1):205.
44. Burgess L, Kynoch K, Hines S. Implementing best practice into the emergency department triage process. *International journal of evidence-based healthcare.* 2019;17(1):27–35.
45. Bird C, Shea A, Michie C, George G. A simple intervention improves the recording of vital signs in children presenting to the emergency department. *Emergency Medicine Journal.* 2009;26(10):698–700.
46. Varndell W, Hodge A, Fry M. Triage in Australian emergency departments: Results of a New South Wales survey. *Australasian emergency care.* 2019;22 (2):81–86.
47. Mandirola Brieux H, Guillen S, La Rosa F, Moreno C, Benitez S. Nursing Software for Emergency Triage (NSET). In: *MEDINFO 2015: eHealth-enabled Health.* IOS Press; 2015:942–942.

EDs were the primary factors reported (Motivation component of the BCW framework). It is important to emphasize that these barriers can affect nurses' ability to apply newly acquired knowledge and use feedback to improve their practice. Regarding facilitators, the review highlights the importance of prioritizing long-term strategies over short-term measures (Capability component of the BCW framework), particularly in the areas of audit and feedback, as well as education.

4.1. Educational strategies

Educational strategies have been associated with various benefits in improving nursing triage. However, less than a quarter (n = 4/25) of studies on educational strategies included follow-up assessments beyond the immediate post-implementation phase, with most focusing on nurses' knowledge of the triage process [51,71,73,78]. As a result, determining the true impact of these strategies on improving nursing triage quality remains challenging. Short-term follow-up assessments may overestimate changes in clinical practice [95], highlighting the importance of studying the sustainability of implementation strategies. Several authors have reached similar conclusions, highlighting the lack of evidence on whether the long-term effects of educational strategies persist, particularly in high-stakes environments such as ED, where decision-making pressure and cognitive overload may affect skill retention and application [95,96]. More specifically, findings from a systematic review indicated that no previous studies have evaluated the effectiveness or sustainability of educational or training programs for frailty prevention and management [97]. Future research should explore other implementation strategies, such as audit and feedback or new technologies, to enhance nursing triage quality.

4.2. Technological aids

An increasing number of technological aids are being developed to support nurses in performing triage. For example, Ivanov, Wolf [69] employed machine learning and clinical natural language processing to develop a triage system called KATE. In addition to achieving approximately 25 % better triage outcomes compared to those performed by nurses, the AI-based triage system is not influenced by external pressures that could lead to undertriage. However, while it can help mitigate certain racial and social biases that negatively impact triage accuracy, AI systems are not entirely free from bias and may reflect the data on which they were trained. Several research groups are exploring different approaches to addressing bias in AI for health equity [98,99]. The involvement of nurses and other healthcare professionals, along with improvements in the data used to train AI systems, is crucial to ensuring rigorous oversight of AI use and preventing it from reinforcing existing biases [100]. To ensure that nurses remain the guardians of triage prioritization, continuous monitoring of these new technologies is essential. Moreover, as AI continues to integrate into various technological fields, we recommend that emergency nurses assert their role and become integral members of research teams developing these technological aids.

4.3. Audit and feedback

Only three studies [54,92,94] in this review addressed audit and feedback. This can be explained, at least in part, by the lack of validated measurement tools to assess the quality of nursing triage [17,101]. The audit and feedback process typically involves one or more cycles, including the measurement of current practices based on best practice criteria, provision of feedback, implementation of change, and ongoing monitoring [102]. It is important to note that the success of audit and feedback process depends on local arrangements that promote both measurement and action [103]. Zaboli, Sibilio [92] demonstrated that daily auditing not only leads to a reduction in error rates, thereby ensuring patient safety, but also improves triage performance. Therefore, developing instruments to assess triage quality as a means of fostering a culture of audit and feedback appears as an innovative strategy. The term "culture" refers to fostering engagement among team members, ensuring that audit and feedback are seen not merely as control measures but as tools for continuous improvement [104]. After the audit phase, it is crucial to identify both the strengths of the triage process and the areas requiring improvement. These insights should then inform the development of targeted training objectives.

Interestingly, the range of strategies identified in this review to support nursing triage quality appears limited compared to the broader array of implementation strategies previously assessed in systematic reviews of nursing practices. For example, a recent systematic review and *meta*-analysis examined the effects of the 19 Cochrane Effective Practice and Organization of Care (EPOC) healthcare professional-level implementation strategies on nursing practice [37]. Several evidence-based strategies, such as patient-mediated interventions, local opinion leaders (champions), continuous quality improvement, and tailored interventions addressing site-specific barriers and facilitators, were absent from the studies included in this review. Given the growing interest in enhancing triage quality, future research should consider expanding the range of strategies under investigation, incorporating more diverse and context-sensitive approaches.

4.4. Barriers and facilitators to improving triage quality

Considering both barriers and facilitators is crucial when implementing new strategies to improve triage quality, as these factors are key

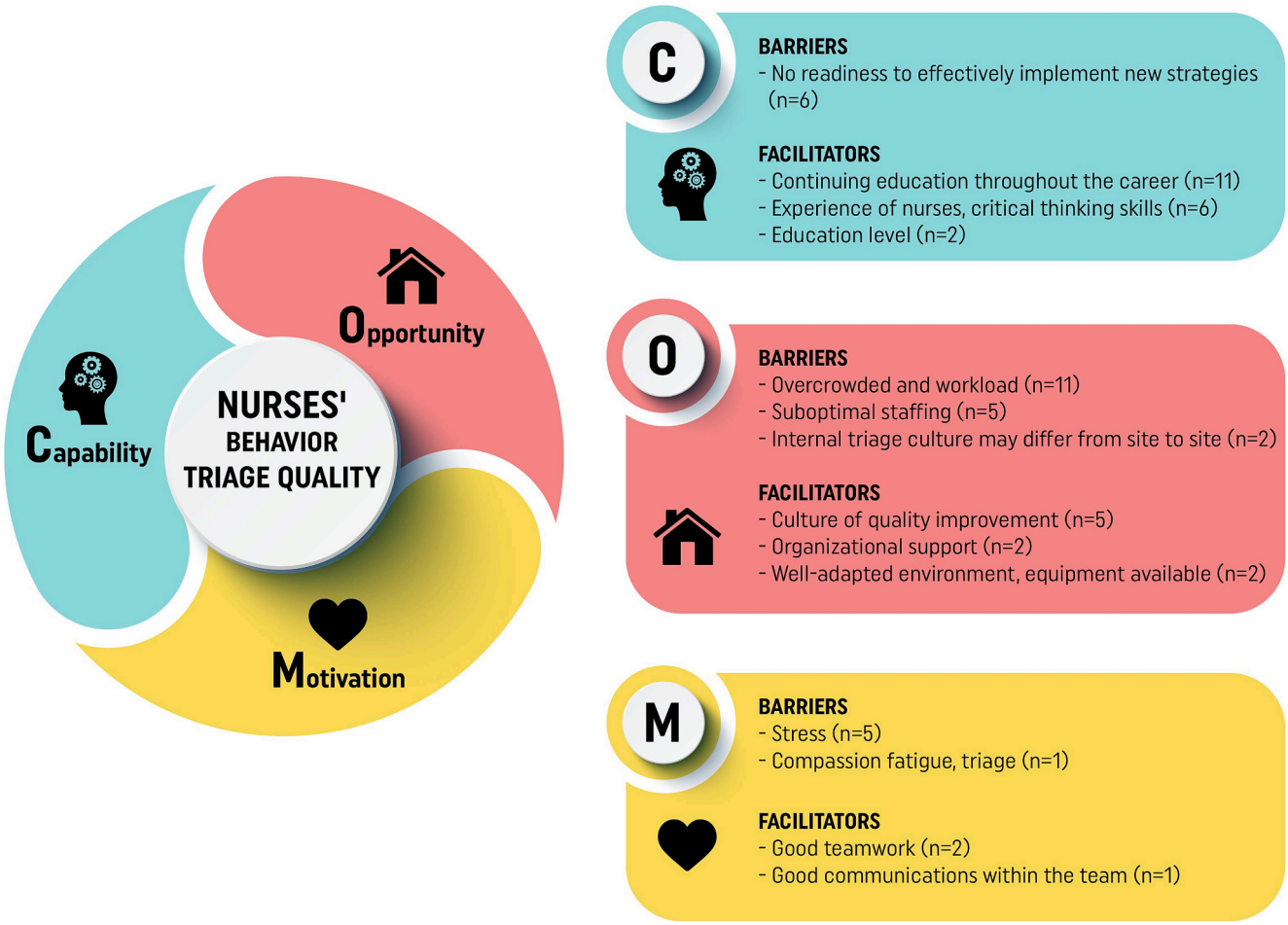

Fig. 2. Barriers and facilitators to improving triage quality, capability, opportunity and motivation.

determinants of healthcare professionals' behaviors in the development of such strategies [105]. Various authors have identified that the barriers and facilitators most commonly associated with practice improvement are related to healthcare professionals and the organizational context [106,107]. The most commonly reported barrier in this systematic review was ED overcrowding and workload, a concern also highlighted by several authors [108,109]. Overcrowding and workload must be considered when implementing strategies to ensure they do not place an additional burden on triage nurses. For instance, when introducing technological aids into triage, it is crucial that their design does not further increase nurses' workload. Additionally, the time required to adapt to new technologies has been identified as a barrier in this systematic review [50,86,87]. These findings align with broader evidence on the implementation of health technologies, which highlights infrastructure issues, psychological barriers, and workload as major obstacles [110]. Conversely, training, assessing perceived usefulness and willingness to use among healthcare professionals are essential enablers for the successful adoption of health technologies [110].

Regarding facilitators, this systematic review highlights the importance of triage nurses' experience in minimizing the risk of triage errors [33,76,78]. Other authors have emphasized that senior triage nurses possess well-developed heuristics and advanced critical thinking skills [109,111]. It is therefore recommended not to assign nurses with limited experience to triage. In this regard, some emergency nursing associations recommend a minimum of one to two years of experience in the ED before allowing a nurse to work in triage [112].

Another facilitator frequently highlighted in this review was the importance of nurses engaging in ongoing education and training related to nursing triage [55,59,60,62,66,76,78,82]. This finding is consistent with conclusions drawn from other reviews, which have shown that training and education to enhance triage knowledge are key to ensuring accurate results [95,109]. However, follow-up is necessary to confirm the sustainability of knowledge and behavioral changes [95].

5. Strengths and limitations

This systematic review provided a comprehensive overview of the various implementation strategies employed worldwide to improve the quality of nursing triage. The methodological rigour underpinning this review ensures that the findings are comprehensive and offer valuable insights for both future research and clinical practice. Specifically, the review identifies gaps in the existing literature, providing a foundation for future studies to explore innovative approaches to enhancing triage quality. From a practical perspective, the findings provide ED clinicians and managers with actionable strategies to refine and optimize triage processes, ultimately improving patient care outcomes.

This review has several limitations. The first half of the included studies were of low quality, reducing confidence in the findings. This highlights the need for future research employing robust methodologies to better assess the effectiveness of implementation strategies aimed at improving triage quality. Second, the studies did not explicitly aim to identify barriers and facilitators in the development of these strategies. Consequently, some critical factors influencing implementation may have been underexplored or insufficiently addressed, potentially limiting the comprehensiveness of the findings. Finally, another limitation concerns the geographical distribution of the included studies. Most research was conducted in North America and the Middle East, which restricts the generalizability of the findings to other regions. This

geographic concentration poses challenges in developing universally applicable strategies for improving triage quality across diverse healthcare settings, as many triage educational interventions were adapted to specific locations and populations. Finally, the impacts of the interventions were assessed almost exclusively in the short term. The lack of long-term data limits the generalizability of the results and their applicability to clinical practice, particularly regarding the sustainability of effects and the effectiveness of implementation strategies over time.

6. Conclusions

This systematic review highlights three main implementation strategies for improving nurse triage quality: education, technology, and audit with feedback. The most significant effects of these strategies in nursing triage include increased triage accuracy, a reduction in under- and over-triage, and improved triage knowledge and skills. Although educational strategies are widely used, their long-term impact on nursing triage practice, beyond improving knowledge, as well as their impact on patient- and system-important outcomes, has yet to be demonstrated. Future studies should therefore incorporate longitudinal designs of various strategies to allow stakeholders to adopt those that have a sustainable impact on triage quality. Technological aids show promise but require active involvement from nurses and clinicians in their development and implementation to ensure their relevance and usability. Additionally, the limited availability of validated audit instruments highlights the need for further research to support their clinical application for the provision of relevant feedback. To enable the implementation of these strategies, the specific context of the ED, which involves a large flow of patients and little time to make decisions critical to their well-being, must be taken into consideration. A culture of continuous quality improvement and team collaboration is also essential. Addressing these challenges requires a structured approach that emphasizes ongoing quality monitoring, targeted training initiatives, and recognition of the pivotal role of ED nurses in optimizing patient access and care.

Ethical considerations

This systematic review utilized previously published data to assess strategies for improving nurse triage in the ED. Since no participants were recruited, neither an informed consent process nor formal ethics approval was required.

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CRediT authorship contribution statement

Simon Ouellet: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Maria Cécilia Gallani:** Writing – review & editing, Writing – original draft, Supervision, Methodology. **Guillaume Fontaine:** Writing – review & editing, Writing – original draft. **Éric Mercier:** Writing – review & editing, Writing – original draft. **Alexandra Lapierre:** Writing – review & editing, Writing – original draft. **Fabian Severino:** Writing – review & editing, Writing – original draft, Data curation. **Céline Gélinas:** Writing – review & editing, Writing – original draft. **Mélanie Bérubé:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

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References

[1] Wolf LA, Delao AM, Perhats C, Moon MD, Zavotsky KE. Triaging the Emergency Department, not the patient: United States Emergency nurses' experience of the triage process. J Emerg Nurs 2018;44(3):258–66.
[2] Varner C. Emergency departments are in crisis now and for the foreseeable future. 2023;195(24):E851-E2.
[3] Cairns C, Ashman JJ, King JM. Emergency Department Visit Rates by Selected Characteristics: United States, 2020; 2022.
[4] Canadian Institute for Health Information. NACRS emergency department visits and lengths of stay 2022 [Available from: https://www.cihi.ca/en/nacrs-emergency-department-visits-and-lengths-of-stay.
[5] Hooker EA, Mallow PJ, Oglesby MM. Characteristics and trends of emergency department visits in the United States (2010–2014). J Emerg Med 2019;56(3):344–51.
[6] Visser LS, Montejano AS. Fast Facts for the Triage Nurse, Second Edition : an Orientation and Care Guide. New York: Springer Publishing Company; 2018. Available from: https://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=5607536.
[7] Visser LS, Montejano AS. Fast facts for the triage nurse : an orientation and care guide in a nutshell. 2 ed. New York: Springer Publishing Company; 2021.
[8] Wolf L, Delao A, Perhats C, Baker K, Olson CM. Development of nurse-sensitive, emergency department–specific quality indicators using a modified Delphi technique. J Nurs Care Qual 2022;37(4):E59–66.
[9] Ebrahimi M, Heydari A, Mazlom R, Mirhaghi A. The reliability of the Australasian triage scale: a meta-analysis. World J Emerg Med 2015;6(2):94.
[10] Mirhaghi A, Heydari A, Mazlom R, Hasanzadeh F. Reliability of the emergency severity index: meta-analysis. Sultan Qaboos Univ Med J 2015;15(1):e71.
[11] Mirhaghi A, Mazlom R, Heydari A, Ebrahimi M. The reliability of the Manchester triage system (MTS): a meta-analysis. J Evid Based Med 2017;10(2):129–35.
[12] Hinson JS, Martinez DA, Cabral S, George K, Whalen M, Hansoti B, et al. Triage performance in emergency medicine: a systematic review. Ann Emerg Med 2019;74(1):140–52.
[13] Bullard MJ, Chan T, Brayman C, Warren D, Musgrave RNE, et al. Revisions to the Canadian emergency department triage and acuity scale (CTAS) guidelines. CJEM 2014;16(06):485–9.
[14] Mirhaghi A, Heydari A, Mazlom R, Ebrahimi M. The reliability of the Canadian triage and acuity scale: meta-analysis. NAJMS 2015;7(7):299–305.
[15] Corbett A, Quinn Griffin MT. Triage nurse expertise. Nursing Concept Analysis: Applications to Research and Practice. New York, UNITED STATES: Springer Publishing Company; 2016. p. 249–55.
[16] Stanfield LM. Clinical decision making in triage: an integrative review. J Emerg Nurs 2015;41(5):396–403.
[17] Hodge A, Hugman A, Varndell W, Howes K. A review of the quality assurance processes for the Australasian triage scale (ATS) and implications for future practice. AENJ 2013;16(1):21–9.
[18] Solheim J. Emergency Nursing: The Profession, The Pathway, The Practice. Tau ST, editor. Indianapolis, IN, USA: Sigma Theta Tau; 2016. 463 p.
[19] Hitchcock M, Gillespie B, Crilly J, Chaboyer W. Triage: an investigation of the process and potential vulnerabilities. J ADV NURS 2014;70(7):1532–41.
[20] De Freitas L, Goodacre S, O'Hara R, Thokala P, Hariharan S. Interventions to improve patient flow in emergency departments: an umbrella review. Emerg Med J: EMJ 2018;35(10):626–37.
[21] Swedish Council on Health Technology A. Triage Methods and Patient Flow Processes in Emergency Departments : a Systematic Review. [Place of publication not identified]: Swedish Council on Health Technology Assessment (SBU); 2010. Available from: https://www.ncbi.nlm.nih.gov/books/NBK447967.
[22] Pollyane Liliane S, Luciana P, Veridiana Bernardes F, Rosali Isabel Barduchi O, Suzel Regina Ribeiro C. Triage in an adult emergency service: patient satisfaction. Revista da Escola de Enfermagem da USP [Internet]. 2016; 50(3):[427-33 pp.].

[23] Ahmad S, Molyneux E, Robertson A. Improved triage and emergency care for children reduces inpatient mortality in a resource-constrained setting. Bull World Health Organ 2006;84(4):314–9.
[24] Ausserhofer D, Zaboli A, Pfeifer N, Solazzo P, Magnarelli G, Marsoner T, et al. Errors in nurse-led triage: an observational study. Int J Nurs Stud 2021;113:103788.
[25] Najafi Z, Abbaszadeh A, Zakeri H, Mirhaghi A. Determination of mis-triage in trauma patients: a systematic review. Eur J Trauma Emerg Surg 2019;45(5):821–39.
[26] Ryan K, Greenslade J, Dalton E, Chu K, Brown AFT, Cullen L. Factors associated with triage assignment of emergency department patients ultimately diagnosed with acute myocardial infarction. Aust Crit Care 2016;29(1):23–6.
[27] Malmström T, Harjola V-P, Torkki P, Kumpulainen S, Malmström R. Triage quality control is missing tools-a new observation technique for ED quality improvement. Int J Qual Health Care. 2017;29(2):295–300.
[28] Robbie F, Martin PE. Audit and feedback interventions. Knowledge translation in health care: moving from evidence to practice. 2 ed: John Wiley & Sons; 2013. p. 183–8.
[29] McNally S. The triage role in emergency nursing: development of an educational programme. Int J Nurs Pract 1996;2(3):122–8.
[30] Javadi N, Rostamnia L, Raznahan R, Ghanbari V. Triage training in Iran from 2010 to 2020: a systematic review on educational intervention studies. Iran J Nurs Midwifery Res 2021;26(3):189–95.
[31] Terenzi C. The triage game. J Emerg Nurs 2000;26(1):66–9.
[32] Uslu Y, Kocatepe V, Unver V, Sagır O, Karabacak U. Hybrid simulation in triage training. Int J Caring Sci 2019;12(3):1626–37.
[33] Agnihotri T, Fan M, McLeod S, Borgundvaag B, Ovens H, McCarron J, et al. Impact of an electronic decision-support system on nursing triage process: a usability and workflow analysis. Can J Nurs Res 2021;53(2):107–13.
[34] Higgins JPT TJ, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.5 (updated August 2024) 2024. Available from: www.training.cochrane.org/handbook.
[35] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.
[36] Ouellet S, Galliani MC, Gélinas C, Fontaine G, Archambault P, Mercier É, et al. Strategies to improve the quality of nurse triage in emergency departments: A realist review protocol. Nursing Open 2023;10(5):2770–9.
[37] Fontaine G, Vinette B, Weight C, Maheu-Cadotte M-A, Lavallée A, Deschênes M-F, et al. Effects of implementation strategies on nursing practice and patient outcomes: a comprehensive systematic review and meta-analysis. IS 2024;19(1):68.
[38] Tricco AC, Antony J, Ivers NM, Ashoor HM, Khan PA, Blondal E, et al. Effectiveness of quality improvement strategies for coordination of care to reduce use of health care services: a systematic review and meta-analysis. CMAJ 2014;186(15):E568–78.
[39] Wichor MB, Dean G, Gerdien BJ, Leslie H, Tanja B. De-duplication of database search results for systematic reviews in EndNote. J Med Library Assoc [Internet] 2016;104(3).
[40] Higgins J, Thomas J, Chandler J, Cumpston M, Li T, Page M, et al. Cochrane handbook for systematic reviews of interventions version 6.2. 2021. Available from: Cochrane, 2021. Available from www.training.cochrane.org/handbook.
[41] Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, et al. The mixed methods appraisal tool (MMAT) version 2018 for information professionals and researchers. Educ Inf 2018;34(4):285–91.
[42] Hong QN, Pluye P, Fàbregues S, Bartlett G, Boardman F, Cargo M, et al. Improving the content validity of the mixed methods appraisal tool (MMAT): a modified e-Delphi study. J Clin Epidemiol 2019;111:49–59.e1.
[43] Michie S, Atkins L, West R. The behaviour change wheel: a guide to designing interventions. Great Britain: Silverback Publishing; 2014.
[44] West R, van Stralen MM, Michie S. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. IS[Internet] 2011. 6(1):[42 p.].
[45] West R, Michie S. A brief introduction to the COM-B model of behaviour and the PRIME theory of motivation. Qeios 2020.
[46] Pawson R, Greenhalgh T, Harvey G, Walshe K. Realist review - a new method of systematic review designed for complex policy interventions. J Health Serv Res Policy 2005;10.
[47] Arroabarren E, Álvarez-García J, Anda M, De Prada M, Ponce C, Alvarez-Puebla M. Impact of specific training in anaphylaxis for triage nursing staff in the pediatric emergency department of a tertiary hospital. J Investig Allergol Clin Immunol 2018;28(6):401–6.
[48] Atack L, McLean D, LeBlanc L, Luke R. Preparing ED nurses to use the Canadian triage and acuity scale with web-based learning. J Emerg Nurs 2004;30(3):273.
[49] Atack L, Rankin JA, Then KL. Effectiveness of a 6-week online course in the Canadian triage and acuity scale for emergency nurses. J Emerg Nurs 2005;31(5):436–41.
[50] Bennett P. A quantitative study investigating the effects of computerised clinical decision support in the emergency department: University of Salford (United Kingdom); 2014.
[51] Bird C, Shea A, Michie C, George G. A simple intervention improves the recording of vital signs in children presenting to the emergency department. Emerg Med J 2009;26(10):698–700.
[52] Bowers S. Making a game of urgent care: simulation for nursing students. J Emerg Nurs 2011;19(7).
[53] Brosinski CM, Riddell AJ, Valdez S. Improving triage accuracy: a staff development approach. Clin Nurse Spec 2017;31(3):145–8.
[54] Burgess L, Kynoch K, Hines S. Implementing best practice into the emergency department triage process. Int J Evid Based Healthc 2019;17(1):27–35.
[55] Campbell D, Fetters L, Getzinger J, Perko A, Slater S. A clinical nurse specialist-driven project to improve emergency department triage accuracy. Clin Nurse Spec 2022;36(1):45–51.
[56] Cicolo EA, Peres HHC. Electronic and manual registration of Manchester system: reliability, accuracy, and time evaluation. Rev Lat Am Enfermagem 2019;27.
[57] Clarke DE, Brown A-M, Hughes L, Motluk L. Education to improve the triage of mental health patients in general hospital emergency departments. Accid Emerg Nurs 2006;14(4):210–8.
[58] Davis S, Ju C, Marchandise P, Diagne M, Grant L. The effect of human supervision on an electronic implementation of the Canadian triage acuity scale (CTAS). JEM 2022;63(4):498–506.
[59] Delnavaz S, Hassankhani H, Roshangar F, Dadashzadeh A, Sarbakhsh P, Ghafourifard M, et al. Comparison of scenario based triage education by lecture and role playing on knowledge and practice of nursing students. Nurse Educ Today 2018;70:54–9.
[60] Dong SL, Bullard MJ, Meurer DP, Colman I, Blitz S, Holroyd BR, et al. Emergency triage: comparing a novel computer triage program with standard triage. Acad Emerg Med 2005;12(6):502–7.
[61] Dong SL, Bullard MJ, Meurer DP, Blitz S, Holroyd BR, Rowe BH. The effect of training on nurse agreement using an electronic triage system. CJEM 2007;9(04):260–6.
[62] Ebrahimi M, Ghanbarzehi N, Gorgich ZG, Darban F, Shirzadi F. The effect of triage training on the performance of triage nurses and emergency medical staff of Iranshahr. Int J Med Res Health Sci 2016;5(9):190–6.
[63] Gandhi S, Jothimani K. A study to evaluate effectiveness of triaging the triage: reducing waiting time to triage in the command post to emergency department in selected hospitals. IJONE 2019;11(4):149–53.
[64] Ghanbarzehi N, Balouchi A, Sabzevari S, Darban F, Khayat NH. Effect of triage training on concordance of triage level between triage nurses and emergency medical technicians. JCDR 2016;10.
[65] Grossmann FF, Zumbrunn T, Ciprian S, Stephan F-P, Woy N, Bingisser R, et al. Undertriage in older emergency department patients–tilting against windmills? PLoS One 2014;9(8):e106203.
[66] Hill CS. Standardization of triage. University of Mount Olive 2017.
[67] Hussein HA, Hassan HS. Effectiveness of an Education Program on Nurses' Knowledge about the Triage System in Emergency Department of Qalat Salih Hospital. Prof RK Sharma. 2019;13(1):218.
[68] Hosseini A, Mojtahedzadeh R, Mohammadi A, Gharib M. Effective triage training for nurses: comparison of face to face, pamphlet, and multimedia training. JE-LKS 2022;18(1):101–6.
[69] Ivanov O, Wolf L, Brecher D, Lewis E, Masek K, Montgomery K, et al. Improving ED emergency severity index acuity assignment using machine learning and clinical natural language processing. J Emerg Nurs 2021;47(2). pp. 265–78. e7.
[70] Jang J-H, Kim SS, Kim S. Educational simulation program based on Korean triage and acuity scale. Int J Environ Res Public Health 2020;17(23):9018.
[71] Jang K, Jo E, Song KJ. Effect of problem-based learning on severity classification agreement by triage nurses. BMC Nurs 2021;20(1):1–9.
[72] Kim H-J, Kang H-Y. Effects of a web-based Korean triage and acuity scale learning program on triage self-efficacy and triage performance ability for nurses in emergency department. J Korean Acad Nurs 2019;49(2):171–80.
[73] Malyon L, Williams A, Ware RS. The Emergency triage education kit: improving paediatric triage. Australas Emerg Nurs J 2014;17(2):51–8.
[74] Mandirola Brieux H, Guillen S, La Rosa F, Moreno C, Benitez S. Nursing Software for Emergency Triage (NSET). MEDINFO 2015: eHealth-enabled Health: IOS Press; 2015. p. 942.
[75] McLeod SL, McCarron J, Ahmed T, Grewal K, Mittmann N, Scott S, et al. Interrater reliability, accuracy, and triage time pre- and post-implementation of a real-time electronic triage decision-support tool. Ann Emerg Med 2020;75(4):524–31.
[76] McNally S. Triage education: From experience to practice standards; 2006.
[77] Moon S-H, Cho I-Y, editors. The Effect of Competency-Based Triage Education Application on Emergency Nurses' Triage Competency and Performance. Healthcare; 2022: MDPI.
[78] Rahmati H, Azmoon M, Meibodi MK, Zare N. Effects of triage education on knowledge, practice and qualitative index of emergency room staff: a quasi-interventional study. Bull Emerg Trauma 2013;1(2):69.
[79] Rankin JA, Then KL, Atack L. Can emergency nurses' triage skills be improved by online learning? Results of an experiment. J Emerg Nurs 2013;39(1):20–6.
[80] Recznik CT. Comparison of Two Methods of Pediatric Triage Education: Duquesne University; 2018.
[81] Recznik CT, Simko LC, Travers D, Devido J. Pediatric triage education for the general emergency nurse: a randomized crossover trial comparing simulation with paper-case studies. J Emerg Nurs 2019;45(4):394–402.
[82] Tran N. Implementing ESI Education Project for Nurses in the Triage Process: Walden University; 2019.
[83] Varndell W, Hodge A, Ryan E, Fry M. The use and feasibility of an online software system to support assessment of accuracy and consistency in applying the Australasian triage scale. Australas Emerg Care 2019;22(3):168–73.
[84] Yazdannik A, Dsatjerdi EI, Mohamadirizi S. Utilizing mobile health method to emergency nurses' knowledge about emergency severity index triage. J Educ Health Promot 2018;7.

[85] Yazdannik A, Mohamadirizi S, Nasr-Esfahani M. Comparison of the effect of electronic education and workshop on the satisfaction of nurses about emergency severity index triage. J Educ Health Promot 2020;9.
[86] Çetin SB, Cebeci F, Eray O. The effect of computer-based decision support system on emergency department triage: non-randomised controlled trial. Int Emerg Nurs 2023;70:101341.
[87] Bişkin Çetin S, Cebeci F. Nurses' experiences of using a computer-based triage decision support system in the emergency department. Nurs Crit Care 2024.
[88] Crabtree J. Staff Education Project: The Emergency Severity Index: Walden University; 2023.
[89] Hoffman S, Voss JA, Hendrickx L, Gibson N. Effect of emergency severity index annual competency assessment on mistriage. J Nurs Care Qual 2022;37(4):356–61.
[90] Javadi M, Gheshlaghi M, Bijani M. A comparison between the impacts of lecturing and flipped classrooms in virtual learning on triage nurses' knowledge and professional capability: an experimental study. BMC Nurs 2023;22(1):205.
[91] Moon S-H, Kim SO. Enhancing triage accuracy in emergency nurses: the impact of a game-based triage educational app. Int Emerg Nurs 2024;72:101398.
[92] Zaboli A, Sibilio S, Magnarelli G, Rella E, Fanni Canelles M, Pfeifer N, et al. Daily triage audit can improve nurses' triage stratification: a pre–post study. J Adv Nurs 2023;79(2):605–15.
[93] Hoffman K, Donoghue J, Duffield C. Decision-making in clinical nursing: investigating contributing factors. J Adv Nurs 2004;45(1):53–62.
[94] Varndell W, Hodge A, Fry M. Triage in Australian emergency departments: results of a New South Wales survey. Australas Emerg Care 2019;22(2):81–6.
[95] Butler K, Anderson N, Jull A. Evaluating the effects of triage education on triage accuracy within the emergency department: an integrative review. Int Emerg Nurs 2023;70:101322.
[96] Gorick H, Rai AS. Training nurses to triage: a scoping review. Emerg Nurse 2024;32(1).
[97] Windhaber T, Koula ML, Ntzani E, Velivasi A, Rizos E, Doumas MT, et al. Educational strategies to train health care professionals across the education continuum on the process of frailty prevention and frailty management: a systematic review. Aging Clin Exp Res 2018;30:1409–15.
[98] Abràmoff MD, Tarver ME, Loyo-Berrios N, Trujillo S, Char D, Obermeyer Z, et al. Considerations for addressing bias in artificial intelligence for health equity. NPJ Digit Med 2023;6(1):170.
[99] Parikh RB, Teeple S, Navathe AS. Addressing bias in artificial intelligence in health care. JAMA 2019;322(24):2377–8.
[100] Byrne MD. Reducing bias in healthcare artificial intelligence. J Perianesth Nurs 2021;36(3):313–6.
[101] Ouellet S, Bélanger G, Bérubé M. Interrater reliability of a tool measuring the quality of nursing triage in the emergency department. Science infirmière et pratiques en santé 2021;4(2):86–100.
[102] Foy R, Skrypak M, Alderson S, Ivers NM, McInerney B, Stoddart J, et al. Revitalising audit and feedback to improve patient care. BMJ 2020;368.
[103] Wagner DJ, Durbin J, Barnsley J, Ivers NM. Measurement without management: qualitative evaluation of a voluntary audit & feedback intervention for primary care teams. BMC Health Serv Res 2019;19(1):419.
[104] Wagner DJ, Durbin J, Barnsley J, Ivers NM. Beyond quality improvement: exploring why primary care teams engage in a voluntary audit and feedback program. BMC Health Serv Res 2017;17:1–10.
[105] Patey AM, Fontaine G, Francis JJ, McCleary N, Presseau J, Grimshaw JM. Healthcare professional behaviour: health impact, prevalence of evidence-based behaviours, correlates and interventions. Psychol Health 2023;38(6):766–94.
[106] Bérubé M, Lapierre A, Sykes M, Grimshaw J, Turgeon AF, Lauzier F, et al. Development and usability testing of a multifaceted intervention to reduce low-value injury care. BMC Health Serv Res 2025;25(1):1–15.
[107] Li S-A, Jeffs L, Barwick M, Stevens B. Organizational contextual features that influence the implementation of evidence-based practices across healthcare settings: a systematic integrative review. Syst Rev 2018;7:1–19.
[108] Bijani M, Khaleghi AA. Challenges and barriers affecting the quality of triage in emergency departments: a qualitative study. GMJ 2019;8:e1619.
[109] Suamchaiyaphum K, Jones AR, Markaki A. Triage accuracy of emergency nurses: an evidence-based review. J Emerg Nurs 2024;50(1):44–54.
[110] Borges do Nascimento IJ, Abdulazeem H, Vasanthan LT, Martinez EZ, Zucoloto ML, Østengaard L, et al. Barriers and facilitators to utilizing digital health technologies by healthcare professionals. NPJ Digit Med. 2023;6(1):161.
[111] Berkowitz D, Morrison S, Shaukat H, Button K, Stevenson M, LaViolette D, et al. Under-triage: a new trigger to drive quality improvement in the Emergency Department. Pediatr Qual Saf 2022;7(4).
[112] Ena. Triage qualifications and competency. J Emerg Nurs 2017;43(6):571–4.