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Interventions addressing system and patient factors in the Emergency Department: A scoping meta-review

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Interventions addressing system and patient factors in the Emergency Department: A scoping meta-review.

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Abstract

Objectives: Emergency Department (ED) performance measurement is important for continuous improvement in the delivery of quality healthcare and patient safety. The purpose of this review was to review the literature on measures for evaluating ED performance and obtain an overview of the evidence base for interventions addressing system and patient factors within EDs.

Methods: We conducted a scoping meta-review of the peer-reviewed literature indexed in CINAHL, Cochrane Library of Systematic Reviews, EMBASE, MEDLINE, and SCOPUS (inception to November 16, 2017). We included review articles examining any organizational intervention in an ED. We excluded non-review articles, those examining disease specific interventions, and interventions not in the context of the ED. Three reviewers independently screened 2% of the title and abstracts, and 5% of the full-texts for eligibility and data extraction.

Results: Of the 6098 articles screened, 14 met inclusion criteria. Performance measures were identified and classified into five categories: time, proportion, process, cost, and clinical outcomes. ED interventions addressed team composition (e.g., the addition of physiotherapists), practices and processes (e.g., computerization and scheduling), and patient engagement (e.g., supports for shared decision-making).

Conclusions: Outcome measures were not consistently used to capture ED performance or intervention effectiveness. Interventions addressing system and patient factors have the potential to improve healthcare delivery in EDs. A wide variety of outcome measures is needed to effectively capture ED performance and intervention effectiveness, and thereby

inform future intervention design and implementation. Further research into system and patient interventions is necessary for ongoing healthcare quality and safety improvement.

Keywords: Emergency Department, Performance, Intervention, Quality improvement

Article Summary

Strengths and limitations

- The strengths of this review include the comprehensive search strategy, eligibility criteria and standardised data extraction, which allowed the existing literature to be mapped.
- Scoping reviews that only include systematic reviews do not assess the quality of articles, however, we assessed the methodological rigor of included studies according to the PRISMA checklist.
- Limitations specific to this study include, the possibility that some articles were missed and the exclusion of non-English language articles may have resulted in relevant research being missed and a narrowing of the generalizability of the review results to non-English language contexts.
- It should also be noted that recent papers containing relevant data on ED interventions may not have been included in systematic reviews and as such, may not have been included in this review.
- In addition, the included systematic reviews varied in the quality of papers they reported on which may have resulted in over generalisation of results.

Interventions addressing system and patient factors in the Emergency Department: A scoping meta-review.

Background and Importance

Growing populations, and subsequent rise in burden of disease, place an increasing demand on Emergency Department (ED) services.[1] Consequently, EDs frequently experience patient flow issues such as crowding[2,3] and access block,[4] which compromise patient safety.[5] Measures such as wait-time, length of stay (LOS), patient satisfaction, and patient mortality have been used to evaluate ED performance as well as the efficacy of interventions designed to improve the capacity of EDs to deal with increasing demand.[6,7]

Interventions targeting system factors (e.g., decision-making structure, resource allocation, procedures) and patient factors (e.g., decision-making, treatment preferences, patient involvement) have the potential to improve ED performance, patient safety and clinical outcomes.[8-11] Several reviews have documented improved ED performance and clinical outcomes from interventions such as the expansion or addition of clinical roles and the creation of time-tracked treatment streams (e.g., [1,6,9,11,12]). However, there is a need to synthesize the large volume of literature on ED intervention implementation, and how ED performance and intervention effectiveness are measured.

To effectively measure and improve ED performance, it is important that clinicians and hospital administrators base decisions on evidence. Consequently, it is crucial that clinicians and administrators can easily and efficiently locate research findings to support their decision-making. Scoping meta-reviews allow for the development of a map of the field, summarizing high quality research provided by systematic reviews.[13]

Goal of this Investigation

The purpose of this scoping meta-review was to systematically review the literature on measures for evaluating ED performance, and obtain an overview of the evidence base for interventions addressing system and patient factors within the ED. We aimed to: (1) explore and synthesize the evidence base specifically examining systems and patient factors in ED, as well as identify gaps in the literature; (2) extract data on ED performance measures and their efficacy in measuring performance; and (3) categorize the main types of interventions and their relative success in improving ED performance. Our research questions were: (1) how is

performance in the ED measured?; (2) what interventions have been used to improve ED performance?; and (3) what role do patients play in improving ED performance?

Method

The scoping review methodology allows researchers to address broad research questions and map the literature.[13] We adopted the eight-step scoping meta-review framework developed by Sarrami-Foroushani et al.:[13] (1) Conduct a preliminary non-systematic review, (2) build a search strategy, (3) search the academic literature databases, (4) classify and exclude studies based on titles and abstracts, (5) save the refined database of references, (6) revise the search strategy, (7) select and review the full text papers, and (8) thematically analyze the selected texts and write the report.

Step 1: Conduct a preliminary non-systematic review

We began by mapping the field to identify factors related to ED performance, focusing on system changes and patient engagement. While both system and clinical treatment factors (e.g., factors relating to the use of a tool or specific disease/ injury management) can improve patient outcomes, quality improvement initiatives independent of a specific treatment process have the potential to improve patient safety across the ED. We started with a non-systematic preliminary review to establish the availability of systematic reviews related to ED performance and identify key search terms.

Step 2: Build a search strategy

Based on our preliminary review, we produced a comprehensive list of 72 terms and phrases and included Medical Subject Headings (MeSH; See Table 1.). We searched five electronic databases from inception to date of search (November 16, 2017): CINAHL, Cochrane Database of Systematic Reviews, EMBASE, MEDLINE, and SCOPUS for English language publications. Non-systematic review papers, opinions, books, chapters, discussions, and letters were excluded.

Table 1. Academic Database Search Strategy

"Emergency service" OR "hospital rapid response team" OR "non-emergency" OR "emergency" AND "Patient" OR "preference" OR "health" OR "engagement" OR "activation" OR "empowerment" OR "expectation" OR "health literacy" OR "satisfaction" OR "patient participation" OR "compliance" OR "benefit" OR "cooperation" OR "communication" OR "collaboration" AND "Organizational" OR "assessment" OR "intervention" OR "innovation" OR "evaluation" OR "education" OR "system" OR "effectiveness" OR "implement" OR "delivery" OR "change" OR "framework" OR "technology" OR "lean thinking" OR "training" OR "program evaluation" OR "management" OR "health care" OR "safety" OR "mortality" OR "protocol" OR "policy" OR "guideline" OR "procedure" OR "prevention" OR "interdisciplinary" OR "benchmark" OR "nurse" OR "capacity" OR "risk" OR "team" OR "workflow" OR "standard" OR "performance" OR "crowding" OR "time" OR "bed" OR "boarding" OR "measure" OR "target" OR "overflow" OR "workload" OR "overcrowding" OR "medical error" OR "alert fatigue" OR "audit" OR "health personnel" OR "near miss" OR "quality" OR "administration" OR "care" OR "outcome"

Step 3: Search the academic literature databases

Our database search identified 9,602 references, which we downloaded to a database using a reference manager software tool (Endnote X8). We removed 3,504 duplicates resulting in 6,098 references remaining.

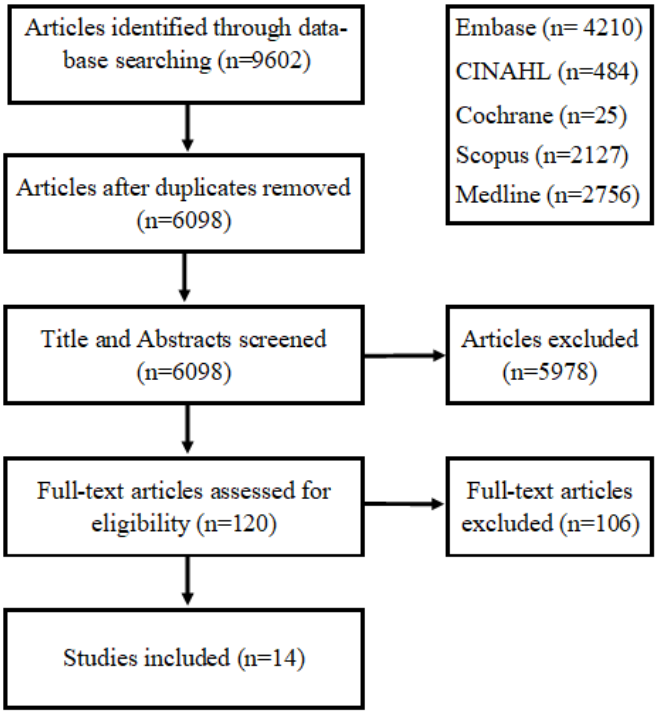

Figure. 1 Scoping-meta review search and paper selection flow diagram

Step 4: Classify and exclude studies based on titles and abstracts

Two reviewers (blinded) independently assessed reference titles and abstracts to determine potential inclusion eligibility (See Table 2). To establish interrater consistency 2% of the references were independently assessed by all three reviewers. Differences were resolved by discussion. Abstracts flagged as potentially relevant by reviewers underwent full-text review. A total 5,978 references were excluded, leaving a database of 120 citations (See Figure. 1).

Table 2. Inclusion Criteria

1. Academic articles
2. English language
3. Full text is available
4. Is a review (e.g., systematic review, meta-analysis, narrative review)
5. Discusses organizational changes to staffing practice/ performance/ processes
6. Emergency Department context

Step 5: Save the refined database of references

The database was saved for subsequent work in related topics of interest. A copy of the database, containing title and abstract of the 120 full text articles, is available from the lead author, on request.

Step 6: Revise the search strategy

During the scoping meta-review process, study selection criteria can be developed iteratively,[13] such as limiting inclusion to reviews published in the last two years. We did not modify our search strategy.

Step 7: Select and review the full text papers

A single reviewer (blinded) evaluated the full texts (N=120) of potentially eligible studies. To establish interrater consistency, 5% (N=6) of the full texts were independently assessed by all three reviewers. We appraised the methodology to exclude papers that did not systematically review the literature or were not systematic reviews (N = 26). We also excluded papers that were not relevant to the topic (N = 106), leaving 14 papers for analysis: three literature reviews (e.g., integrative review) and 11 systematic reviews. The methodological rigor of the included systematic reviews was assessed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.[14] The included papers were assessed as having satisfied (✓), not satisfied (x) or partially satisfied (~) each of the 27 items in the PRISMA checklist. The pattern of ✓, x and ~ reflects the degree to which the paper satisfies the PRISMA checklist.

Step 8: Thematically analyze the selected texts and write the report

Data from the 14 papers were extracted to a spreadsheet, and the findings analyzed to provide a synthesis of how ED performance is measured, and the different system and patient interventions used to improve ED performance.

Results

A total of 14 review articles examining interventions in the context of the ED were included in the scoping meta-review. The reviews originated in Hong Kong (n=1), USA (n=5), Australia (n=5), UK (n=2), and Sweden (n=1). Table 3 summarizes the aims and main findings of the 14 review articles included in the scoping meta-review. The methodological

rigor of the included systematic reviews was generally high with only one paper of low methodological quality (see Table S1 for the results of the PRISMA assessment of included studies). The core criteria for the reporting of systematic reviews was typically fulfilled. However, the PRISMA items that were consistently not satisfied by the included papers were more relevant to meta-analyses and as such, were not necessarily applicable to systematic reviews with a narrative analysis.

Table 3. Summary of the 14 Included Articles

Reference	Country	Type of Review	Primary and Secondary Aims	Included Papers	Main Findings
Cohen (2009)	USA	Systematic Review	To examine the scope (role and value) of pharmacy practice/ services in the ED and to describe the limitations of economic, humanistic, and clinical outcomes data.	17	Pharmacy services in ED include clinical pharmacy services, responding to medical emergencies, providing consultations, identifying and reducing medication errors, conducting medication histories at admission. Some services were cost saving or cost avoiding.
Dexheimer (2013)	USA	Systematic Review	To outline the current literature on the use of mobile devices in ED	10	There is limited evidence that supports the use of mobile devices in ED.
Elder (2015)	Australia	Systematic Review	To explore 3 strategies designed to promote patient throughput in the ED	21	Advanced practice nursing roles, physician assisted triage, and medical assessment unit's models of care can reduce ED LOS and LWBS. Confounding factors such as site-specific staff requirements, patient acuity, hospital processes impact on patient throughputs.
Fillmore (2013)	USA	Systematic Review	To examine clinical decision support interventions impact on inpatient costs.	78	Studies reported improvements in an explicit measure or proxy measure of financial impact. Few studies directly measure financial impact of interventions.
Flynn (2012)	UK	Systematic Review	To evaluate the approaches, methods, and tools used to engage patients or their surrogates in shared decision making in the ED	5	Decision support interventions were associated with improvements in patient's knowledge and satisfaction, preferences for involvement, and engagement in decision making. Computerized decision support interventions reduced healthcare use without evidence of harm. Studies did not report lack of feasibility in shared decision making in ED.
Jennings (2015)	Australia	Systematic Review	To examine the impact of NP services on cost, quality of care, satisfaction, and wait time in ED.	14	NP services in ED have a positive impact on quality of care, patient satisfaction, and wait times. More research is needed to draw conclusions about cost benefit analysis.
Khangura (2011)	UK	Systematic Review	To examine the effects of locating primary care professionals in the hospital ED to provide care for patients with non-urgent health problems compared with usual care.	3	Conflicting results with neither safety or patient outcomes examined. Not enough evidence to draw conclusions for policy or practice.
Kilner (2011)	Australia	Systematic Review	To identify the effect an ED physiotherapy	11	There is insufficient evidence to support benefits of an ED physiotherapy service at the systems/

			service has on health outcomes.		provider level. At the patient level, there is evidence of improved pain control and reduced disability in the short term.
Kleinpell (2008)	USA	Systematic Review	To examine the literature relating to the impact and outcomes of the role of NP and PA in acute and critical care settings.	31	Existing research supports the use of NP and PA in acute and critical care settings.
Ko (2011)	Australia	Systematic Review	To examine whether the use of safety checklists used by medical care teams improves patient safety, compared with usual care.	9	There were improvements in patient safety arising from the use of safety checklists, but these findings were not consistent across the literature or for all outcomes. There were variations in setting, checklist design, education training, and outcomes measured.
McCaughey (2015)	USA	Literature Review	To review the relevant existing literature on capacity management related to EDs, identify strengths and weaknesses in approaches, and provide practical recommendations for health service administrators implementing capacity management.	22	There is extensive operations literature to draw on that can address scheduling and patient throughput, including studies that consider electronic and technological solutions to capacity management problems. All solutions have the potential to positively influence the quality of patient care, including satisfaction.
Oredsson (2011)	Sweden	Systematic Review	To explore which interventions improve patient flow in EDs	33	Introducing fast track for patients with less severe symptoms reduces wait time, LOS, and LWBS. Team triage has the potential to reduce wait time, LOS, and LWBS. There is limited evidence that streaming into different tracks, POCT, and nurse requested x-rays reduces wait time and LOS.
Tai (2011)	Hong Kong	Review	To examine whether trauma teams make a difference in the context of the trauma system.	2	There is no evidence that particular components of the team are essential. Trauma teams likely have to most impact on patients with moderate trauma severity and survival probability.
Walter (2015)	Australia	Integrative Review	To identify the scope, context, and impact on patient and health service outcomes of the specialist trauma nurse	56	There is diversity in scope and context of practice with positive impacts on patient and health service outcomes

Note: ED, Emergency Department; LOS, Length of Stay; LWBS, Left Without Being Seen; NP, Nurse Practitioner; PA, Physician Assistant; POCT, Point of Care Testing

Overview of included reviews

Most of the reviews reported more than one performance measure. Eight reviews examined interventions of ED team composition, five examined interventions of elements of practices and processes, and one examined patient engagement.

How is performance in the ED measured?

The review of the literature identified five key ways ED performance is measured: time, proportion, process, cost, and clinical outcomes (Table S2 presents a full list of the performance measures used in each category, including the purpose, issues and general recommendations).

Time-based measures. Time-based measures record time stamps/ intervals, and sub-cycle intervals.[6] Measures of time intervals varied, however, the most commonly used were length of stay (LOS) in ED and wait time. Time-based measures of performance are often used because they can be directly related to resources consumed and used to calculate financial impact.[17] However, Walter and Curtis[17] proposed that using time-based measures such as LOS, as a measure of ED performance, can be problematic as nonclinical factors (e.g., discharge destination) contribute to time intervals, independent of patient illness or injury. Furthermore, Ko et al.[18] highlighted that relatively well-accepted outcomes such as LOS have been defined and measured in different ways by the literature. Consistent with this, Kilner[16] emphasized the need for greater transparency in the description of the processes and tools used to collect time-based outcomes data is needed.

Proportion-based measures. Proportion-based measures record elements of ED performance rates.[5] The most commonly reported proportion-based measures were rate of diagnostic testing and readmission rate. Khangura et al.[19] suggested that comparisons based on proportion outcomes (e.g., medication errors) should be evaluated with caution as proportion rates depend on the patients presenting (i.e., their characteristics and condition complexity) and the care providers (i.e., Nurse Practitioner (NP), Emergency Physician).

Process-based measures. Process-based measures document elements of ED process performance.[6] Direct and indirect measures of quality of care, including patient and provider satisfaction, were commonly reported ED process performance measures. Jennings et al.[15] found process measures (e.g., quality of care) varied in definition, measure and were not consistently used as a measure of service effectiveness. Furthermore, Kilner[16] noted the reporting of outcome measure reliability was sometimes omitted (e.g., patient satisfaction measures).

Cost-based measures. Cost-based measures indicate the financial implications of health care provided. The most commonly reported was cost of care delivery, however, others include cost of diagnostic tests or treatments, and cost avoidance (characterized as the cost of

events avoided and/ or the cost and probability of harm[22]). Interventions may improve the quality of healthcare services at no additional cost to the institution, however, authors[6,8,22] argued that the summarization and generalization of cost outcomes data is limited in usefulness because each institution used different methods to calculate cost savings and cost-avoidance (e.g., historical data to calculate estimated costs/ savings, actual institutional data, proxy costs).

Patient charges, rates of adverse events, and LOS, are often used as proxy cost measures.[8] Fillmore et al.[8] argued, however, that proxy measures do not always reflect actual costs, as shorter LOS may not coincide with a decrease in costs. When self-report cost measures were used, Kilner[16] found the measures' reliability was not reported. Jennings et al.[15] emphasized that information about funding models is essential for making comparisons between different types of care providers (e.g., NPs, General Practitioners (GPs), Physiotherapists) and between international contexts (e.g., UK, USA, and Australia) and interpreting cost of care.

Clinical outcome based measures. Clinical-based measures indicate the medical outcomes for patients of the health care provided. For example, patient mortality and pain intensity score. Jennings et al.[15] reported clinical outcome measures were influenced by wait times. In addition, Jennings et al.[15] and Kilner[16] found the reliability of outcome measures (e.g., pain intensity, quality of life) were often not reported and there were poor patient response rates. Importantly, Tai et al.[23] suggested that clinical outcome measures may not reflect the intervention's impact on patient care. For example, after trauma team assessment, injuries may not require rapid intervention and as such, the role of the trauma team is not reflected in patient outcome statistics. Conversely, no intervention will improve care for some patients.[23]

What interventions have been used to improve ED performance?

Interventions designed to improve ED performance change either the team composition or the practices and processes within the department (Table S3 summarizes the data extracted from the 14 review articles included in this scoping review). The data extracted includes intervention characteristics, performance measures, intervention effectiveness, quality of evidence, missing measures, recommendations, and future research suggestions.

Interventions to change team composition. Several interventions involved the addition of allied health professionals (i.e., Pharmacists, Physiotherapists) in the ED

practitioner team.[16,22] Pharmacists performed roles within the scope of generalist-trained clinical pharmacists such as providing pharmacotherapy consultation, tracking medication due times and taking medication histories.[22] Studies reported medication histories were more accurate and complete when taken by pharmacists than ED providers, a relative risk reduction in the number of medication errors, and the avoidance of costs associated with processes and errors.[22]

Musculoskeletal complaints are one of many reasons patients attend ED.[16] Physiotherapists have specialized knowledge and skills and perform a range of roles within ED such as managing acute and subacute musculoskeletal conditions/ injuries.[16] There is no evidence that the provision of physiotherapy services in ED (compared with routine ED care) is cost effective.[16] There is weak evidence, however, that the inclusion of physiotherapists in ED reduces hospital admissions, increases diagnostic accuracy, provider and patient satisfaction, and improves patient health status at three month follow-up.[16] The inclusion of allied health professionals to the multidisciplinary ED team reduces treatment delays, improves processes, reduces errors and improves the quality of healthcare delivered.[16,22] Standardization of documentation methods (i.e., paper/ computer-based, computer programs) and clarifying the cost and/ or savings of including allied health professionals in the ED team is needed.[22]

In addition to allied health professionals in the ED, research examined the impact of expanding nursing roles (e.g., NP, Physician assistant (PA), clinical initiative nurse (CIN), Trauma Nurse) and employing GPs on ED performance.[15,3,17,19,20] In EDs, NPs and PAs perform a number of roles such as patient assessment, physical examinations, prescribing and performing diagnostic tests and procedures.[3,20] While some studies report shorter ED visit times, greater medical history accuracy, and greater patient satisfaction with NP services,[15,20] other studies report little impact on LOS, a reduction in waiting time, time to diagnosis and treatment, and unexpected representations.[3] Studies also documented no difference in NP and medical practitioners' assessments, diagnostic test requests and interpretation, treatment or cost of care.[15,20] Comparing treatment delivered by NP and medical registrar, studies reported a reduction in the number of patients who did not wait for treatment and a reduction in unscheduled returns but no difference in missed injury rate or inappropriate management when treatment is delivered by NPs.[15] The multidisciplinary approach and advanced skills of NPs, PAs, and Trauma Nurses had a positive impact on healthcare delivery and patient outcomes.[15,3,17]

The introduction of GPs into the ED is another response to overcrowding.[19] Most studies reported GPs order fewer diagnostic investigations (i.e., blood tests, x-rays), admitted fewer non-urgent patients to the hospital, and made fewer referrals to hospital specialists or consultants than regular Emergency physicians when treating non-urgent cases in the ED.[19] While GP care in ED did not influenced patients' subsequent healthcare use, studies reported a reduction in costs by employing GPs compared with regular Emergency physicians for the treatment of non-urgent cases.[19] The employment of GPs in ED to provide care for non-urgent cases has the potential to free hospital and ED resources for more urgent medical problems.[19]

Trauma teams are comprised of emergency medical specialists, an emergency medical trainee, a general surgeon specialist and trainee, an orthopedic surgeon and an intensive care physician.[23] Trauma teams gather expert care providers to optimize the potential for life saving care for trauma patients.[23] The involvement of a trauma team in emergency care was found to make the most difference for patients with a moderate probability of survival.[23] Trauma team activation did not make measurable difference to patients with very low or high probability of survival.[23]

Interventions to change practices and processes. The increasing introduction of technology into the healthcare system influences practitioners' provision of care.[21] Hand-held devices, such as tablets and smartphones, provide practitioners with clinical decision support as well as the ability to access patient information.[8,21] Studies have evaluated hand-held devices for a range of uses such as in a triage support system, use in the patient's room, and in the consultation room.[21] There is weak evidence that efficiencies including improved communication, guideline accuracy, error reduction and an improvement in direct or proxy measures of cost (e.g., process measures associated with adverse events) arise from the use of hand-held devices.[8,21] Hand-held devices have the potential to enhance clinical outcomes and reduce ED costs, however, the included studies highlighted the need for their use to be thoroughly evaluated. Future research should explore issues such as accessibility, patient privacy, and the lack of evidence of direct cost/ saving.[21]

Clinical decision support systems (e.g., computer programs, safety checklists) are designed to aid clinical decision-making with most ED interventions focusing on drug selection and radiology utilisation.[8] Computer clinical decision support systems supported more effective drug selection, radiology utilization and reduced ED costs.[8] Paper-based

checklists (i.e., safety checklists, medical checklists) used during care in ED supported the application of in-dwelling urinary tract catheter and during post-endoscopy.[18] Studies reported increases in the appropriate use of catheters and a reduction in patient LOS, using a paper-based checklist.[18]

The ordering and processing of diagnostic tests is an aspect of care which can be made more efficient through Point-of-Care Testing (POCT) and Nurse-requested x-rays.[5] POCT involves moving laboratory analysis to the ED.[5] There is moderate evidence that POCT reduces the turn-around-time for diagnostic tests which facilitates diagnosis.[5] However, the impact of POCT on patient LOS depends on the laboratory tests available.[5] If patients also need central laboratory analysis to complement POCT, then POCT had no effect on patients' LOS[5]. Nurse-requested x-ray processes typically allow registered nurses to request examinations of injuries to limbs (e.g., below the knee or elbow).[5] When a nurse requested an x-ray, LOS and time-to-diagnosis was reduced for patients that did not need an x-ray, but not for patients needing an x-ray.[5]

Streaming is another process which can increase the efficiency of care provision in Eds.[5,6] Streaming involves the allocation of patients to different streams (processes; e.g., fast-track) according to set criteria following triage.[5] Fast-track and mid-track subunits incorporate NPs, PAs and cross-trained nurses to provide care to non-urgent patients within a designated area of the ED.[6] Implementation of fast track (also called Rapid Assessment Clinic) reduced wait time and LOS for fast-track patients.[5] While wait time and LOS remained unchanged for patients not selected for fast-track, the number of patients who left without being seen decreased.[5] Other scheduling processes include the triage of patients based on acuity and severity, the use of electronic systems to improve team coordination, and the creation of regional coalitions to manage patient flow through various systems.[6] The creation of new triage protocols, cross training triage nurses, and linking the triage process to immediate ED bed assignment have also been used to manage patient flow through ED.[6]

Physician Assisted Triage (PAT, also called team triage) and Medical Assessment Units (MAUs) have also been implemented to enhance patient flow through ED.[3,5] PAT implementation studies have reported improvements in patient LOS, satisfaction, time to diagnostic testing and consultation, re-presentation within 48 hours and 'left without being seen' rates.[3,5] MAUs allow patients who are medically stable to be fast-tracked to specialists

or members of multidisciplinary teams.[3] Research reported a reduction in LOS, wait times, ward admissions, ED bed occupancy, and costs when MAUs were implemented.[3]

What role do patients play in improving ED performance?

The relationship between patients and clinicians is complex and influences the provision of care in Eds.[10] Shared decision-making involves patient engagement in the decision process, with both the patient and clinician sharing information and discussing treatment options to reach an agreement about which treatment option to implement.[10] Studies reported that compared with usual care, patients provided with decision aids (e.g., paper-based treatment option information) were more engaged in decision-making, had greater risk knowledge (i.e., of diagnostic test and disease) and greater clinician explanation satisfaction.[10] Compared with usual care, patients provided with decision aids were exposed to fewer diagnostic tests and reduced healthcare utilization (i.e., returning to the ED within 7 days).[10] While the evidence is limited, interventions designed to increase patient engagement in healthcare decisions can have positive system and patient outcomes.[10]

Discussion

Emergency Departments often experience system performance issues (e.g., crowding, access block) that have the potential to compromise patient safety.[24] When deciding how to solve system problems, it is import that clinicians and hospital administrators consider evidence-based performance measures and interventions, yet processing the large amount of published research on the topic can be burdensome for a busy ED clinician. Scoping reviews are one approach to synthesising and exploring the literature, mapping key concepts and gaps in research.[13] The aim of this scoping review was to better understand how ED performance is measured, what interventions have been used to improve ED performance, and what role patients might have to play. Our synthesised findings highlight the lack of consistency in measures used for evaluating ED performance. It is also clear from this scoping review, that clinicians and hospital administrators have a range of performance interventions to choose from. However, the benefits of implementing these interventions remains unclear due to the inconsistent use of measures across intervention studies. Consequently, future implementation studies should look to incorporate multiple types of outcome measures to clarify the impact of interventions and optimize the measurement of ED performance.

The synthesis of the literature identified two categories of ED performance intervention: team composition, and practices and processes. A ‘rich picture’ was generated

from our findings, to provide a visual overview of the relationship between the types of interventions and the outcome measures used to establish performance effectiveness (See Figure 2). Information regarding the different types of interventions and the performance measures used were mapped against the two identified categories of intervention as a way of indicating how each intervention has been measured. The rich picture depicts that a range of interventions have been trialled in EDs. The rich picture also indicates the utilization of different combinations of outcome measures to establish performance effectiveness. Finally, the rich picture highlights the strength of the evidence supporting intervention implementation, suggesting more research is needed to establish intervention effectiveness. In addition to characterising past ED interventions, the rich picture provides a framework for designing future interventions to improve ED functioning. As a tool for communication, our rich picture can be used by teams of health professionals to facilitate discussion to explore and develop a shared understanding of how ED performance may be measured and possible interventions that might be implemented.

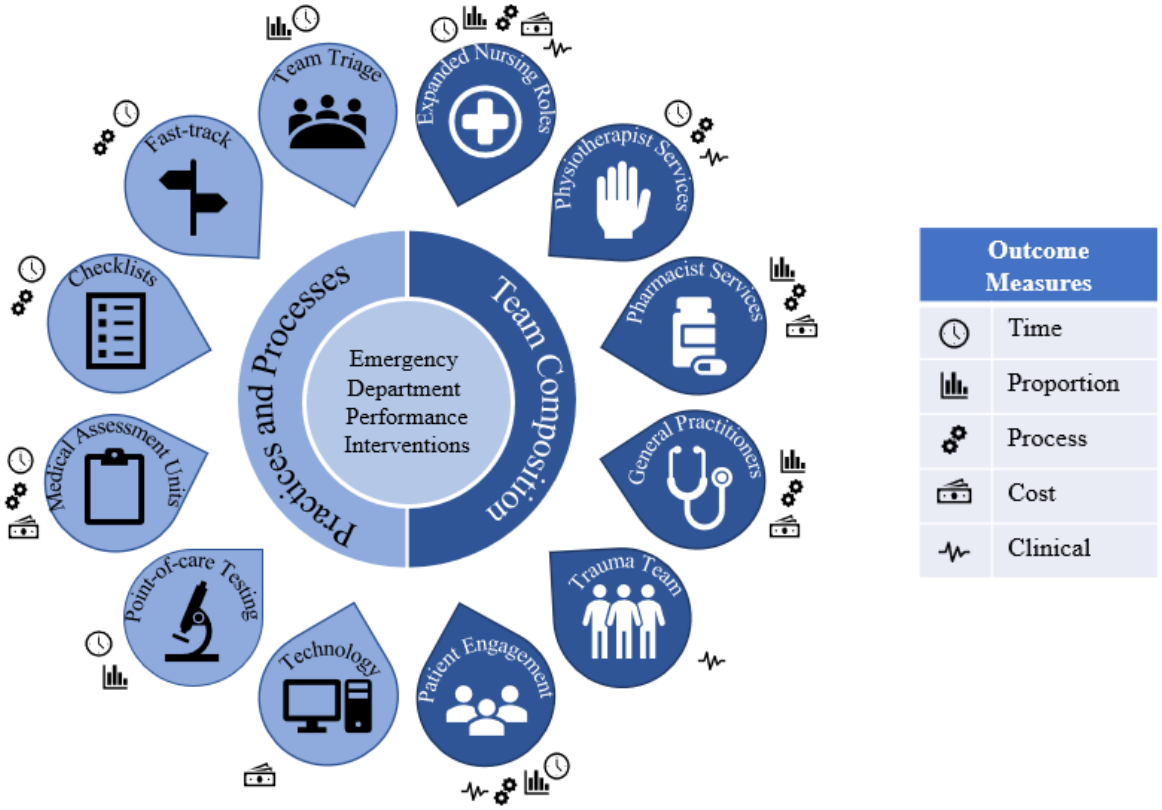

Figure 2. Rich picture of ED interventions and outcome measures.

Recent published papers that have yet to be incorporated in systematic reviews have identified other promising interventions designed to improve patient flow include the introduction of scribes to perform documentation tasks,[25] the addition of a nursing "Expeditor" or "Navigator" role, and a "Physician Float" role to assist with patient throughput.[26-28] Changes to handover practices (i.e., bedside versus centralized), timing/ visualization of feedback, flexible bed management, and discharge processes and practices have also been demonstrated to improve system and patient outcomes.[29-31] Given the complex and dynamic nature of EDs, however, it is likely that flexible multifaceted interventions incorporating team composition, practice and process, and patient engagement factors, along with real time performance feedback are needed to optimize an ED's capacity to meet ED demands.

While the use of all five types of outcome measures would provide clinicians, hospital administrators and researchers with the most insight into ED performance and intervention effectiveness, implementation of the full suite of measures may not be possible. Existing literature reported a wide variety of each type of outcome measure, making comparisons between studies and/ or institutions and subsequent interpretation challenging. The lack of consistent measures is a barrier to system and patient changes in ED.[6] Therefore, greater rigor, consistency and transparency in measures used and the calculation of outcome measures is needed. Future research should aim to establish rigorous, consistent and transparent outcome measures that would allow for greater comparison across studies and provide clinicians with guidance on measuring performance.

Hospital administration, managers and clinicians work to ensure the facility runs efficiently and in compliance with hospital policies as well as state and national regulations. This includes finance, human resources, and clinical performance. For example, dealing with staffing, budgets, patient issues, and technology. Effective performance measurement and intervention implementation requires hospital administrators and clinicians to base decisions on evidence. By synthesising existing literature, this scoping review offers a broad up to date overview of the evidence base for measures of ED performance and interventions addressing system and patient factors, thereby facilitating improvements to performance measurement, intervention implementation and decision making in a complex system characterised by multiple stakeholders and competition for resources.

Strengths and Limitations

To date, there has been no comprehensive review of ED performance measures and interventions. The strengths of this review include the comprehensive search strategy, eligibility criteria and standardised data extraction, which allowed the existing literature to be mapped. The limitations of scoping reviews are primarily methodological. Generally, scoping reviews that only include systematic reviews do not assess the quality of articles. However, we assessed the methodological rigor of included studies according to the PRISMA checklist. Comparisons of systematic review methodological rigor assessed using PRISMA should be interpreted with caution as the applicability of items depends on the type of review. In addition, the comprehensive use of PRISMA when reporting a systematic review may depend on the individual journal's publishing requirements. It should also be noted that recent papers containing relevant data on ED interventions may not have been included in systematic reviews and as such, may not have been included in this review. Limitations specific to this study include, the possibility that some articles were missed and the exclusion of non-English language articles may have resulted in relevant research being missed and a narrowing of the generalizability of the review results to non-English language contexts. In addition, the included systematic reviews varied in the quality of papers they reported on which may have resulted in over generalisation of results. It is also acknowledged that successful interventions are more likely to be published than unsuccessful interventions. This review demonstrates the need for future research to clarify meaningful measures of ED performance, as well as effective system and patient interventions. Finally, this scoping review highlights the need for future efforts to establish consistent meaningful measures of ED performance and intervention effectiveness. For example, the literature does not provide guidance on how to best measure cost or clinical outcomes. Measures of cost and clinical outcomes are increasingly important for informing clinicians' and administrators' decisions about ED performance and intervention effectiveness.

Understanding the mechanisms that support optimal ED performance is crucial for healthcare delivery.[6] ED performance has been captured by time, proportion, process, cost and clinical outcomes. However, inconsistencies in outcome measures used by the literature make comparisons and interpretations difficult. Interventions designed to improve ED performance typically address team composition or practices and processes. To establish the effectiveness of ED interventions and inform system changes and decision-making, a comprehensive range of meaningful performance outcome measures needs to be used.

Systems and patients benefit from ED interventions through improved efficiency and care delivery.[6] Finally, our rich picture is available to illustrate ‘at a glance’ the types of ED interventions and performance measures that are described in the literature.

Author Statement

Data Statement: A copy of the database, containing title and abstract of the 120 full text articles, is available from the lead author, on request.

Conflicts of interest: To the best of our knowledge, no conflict of interest, financial or other, exists.

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Author Contributions

EA contributed to the study concept and design. EA conducted the review, including data acquisition, analysis and interpretation. EA drafted the manuscript and contributed significant critical revision and contribution of important intellectual content. EA had full access to the all of the data and can take responsibility for the integrity of the data and the data analysis.

BB conducted the review, including data acquisition, analysis and interpretation. BB contributed significant critical revision and contribution of important intellectual content. BB had full access to the all of the data and can take responsibility for the integrity of the data and the data analysis.

RC-W contributed equally to the study concept and design. RC-W conducted the review, including data acquisition, analysis and interpretation. RC-W contributed significant critical revision and contribution of important intellectual content. RC-W had full access to the all of the data and can take responsibility for the integrity of the data and the data analysis.

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Supplementary Material

Table S1. Assessment of quality using PRISMA checklist

Checklist Section		Study													
		Cohen (2009)	Dexheimer (2013)	Elder (2015)	Fillmore (2013)	Flynn (2012)	Jennings (2015)	Khangura (2011)	Kilner (2011)	Kleinpell (2008)	Ko (2011)	McCaughey (2015)	Oredsson (2011)	Tai (2011)	Walter (2015)
Title	Title	✓	X	✓	✓	✓	✓	X	✓	~	✓	~	✓	X	~
Abstract	Abstract	✓	X	✓	✓	✓	✓	✓	✓	✓	✓	~	✓	X	✓
Introduction	Rationale	✓	✓	✓	✓	~	✓	✓	✓	✓	✓	✓	✓	✓	✓
Method	Objectives	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Protocol and registration	X	X	X	X	X	~	✓	X	X	✓	X	X	X	X
	Eligibility criteria	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Information sources	~	✓	~	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	~
	Search	X	✓	✓	✓	~	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Study selection	~	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	~	✓
	Data collection process	✓	X	✓	✓	✓	✓	✓	X	✓	✓	X	X	X	✓
	Data items	~	X	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	~	✓
	Risk of bias in individual studies	X	X	✓	X	✓	✓	✓	✓	X	✓	X	✓	X	X
	Summary measures	✓	X	X	X	X	X	✓	X	X	X	X	X	X	X
	Synthesis of results	X	X	X	X	X	X	✓	X	X	X	X	X	X	✓
	Risk of bias across studies	X	X	✓	✓	✓	✓	✓	✓	X	✓	X	✓	~	X
	Additional analyses	X	X	X	X	X	X	✓	X	X	X	X	X	X	X
Results	Study selection	~	~	✓	✓	✓	✓	✓	✓	✓	✓	~	✓	~	✓
	Study characteristics	✓	X	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	~	✓
	Risk of bias within studies	X	X	✓	✓	✓	✓	✓	✓	X	✓	X	✓	X	X

	Results of individual studies	X	X	✓	✓	✓	✓	✓	~	✓	✓	X	✓	X	X
	Synthesis of results	✓	X	X	X	X	X	X	X	X	✓	X	X	X	X
	Risk of bias across studies	X	X	X	✓	✓	✓	✓	X	X	✓	X	✓	X	X
	Additional Analysis	X	X	X	X	X	X	✓	X	X	X	X	X	X	X
Discussion	Summary of evidence	✓	~	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Limitations	✓	X	✓	✓	✓	✓	✓	✓	~	✓	✓	✓	✓	X
	Conclusions	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Funding	Funding	X	X	X	✓	X	✓	X	X	X	✓	X	X	X	X

Table S2. ED Performance Measures

Category of Metric	Types of Metric	Most commonly used	Study	Purpose	Issues	General recommendations
Time/ Interval based	Wait time, median length of hospital stay, LOS (in ED/ total), time to assessment and treatment, time-to-diagnostic test, turn-around-time, time-to-diagnosis, transfer time to other units, documentation time, clinical wait time; physician time spent accessing information, estimated hours of patient boarding, lab order to results time, registration time, triage time intervals, time to discharge, total time on ambulance diversion, patient off stretcher times, hospital LOS	LOS and wait time.	(3,5,6,8,10,15-21)	To measure time stamps/ intervals, and sub-cycle intervals of time.	Assumed to be directly related to resource use and financial impact. Non-clinical factors (e.g., discharge destination) contribute to time intervals independent of injury. The literature has defined and measured time/ interval measures in different ways.	Greater transparency in the description of the measurement process and tools used to collect data, for example, on arrival to discharge time, and time spent with a clinician.
Proportion based	Trauma team activation rate, readmission rate, medication errors, patient treatment preference, patient decision making, rate of diagnostic test, rate of delayed or missed diagnosis, subsequent primary care use/ ED reattendance, patient education for self-management/ appropriate service use, unexpected patient returns, missed injury rate, unscheduled returns to ED, left-without-being-seen (DNW; number, percent), number of errors (e.g., clinical history taking), number of patients to be seen, daily ED occupancy levels, admitted and not admitted patients, number of patients in the waiting room per hour	Rate of diagnostic test and readmission rate	(3,5,6,10,15,18,19,22)	To measure performance rates for elements of ED processes.	Rates depend on the patients presenting (i.e., their characteristics and the complexity of their condition) and the availability of care providers (i.e., General Practitioners, Nurse Practitioners, Emergency Physician).	
Process based	Access time, user perception of speed, guideline accuracy, error reduction, medication history	Direct and indirect measures of	(3,5,6,10,15,16,18-22)	To measure ED process (quality of care) performance.	Process measures such as quality of care varied in definition and measure. Process measures were not	

	accuracy, types of tests ordered, patient satisfaction, provider satisfaction; accuracy of diagnostic test interpretation, clinical documentation, impact of physician recommendations on patient preferences, patient knowledge, patient involvement in decision process, admission to hospital, consultations/ referrals to hospital based specialists, arrangement of follow up care, quality of care (patient satisfaction+ follow up health status + adverse event rate) – indirect measures of QoC: accuracy of x-ray interpretation, inappropriate management of patients, presence and documentation of disease indicators, triage category/code, CIN documentation, patient perceptions of quality of care, patient disposition/ characteristics, duration of presenting condition, patient registration times, mode of arrival, admission profiles	quality of care: patient and provider satisfaction.			consistently used as a measure of service effectiveness. The reliability of process measures was sometimes not reported.
Cost based	Cost-avoidance, cost of care delivery, cost of diagnostic tests/ treatment/ referrals, cost of process measures associated with adverse events, patient charges, resource utilization, bed costing, bed utilization	Cost of care delivery. Proxy measures of cost (e.g., patient charges, rate of adverse events, LOS) are also used.	(3,6,8,15-17,19,22)	To measure the financial implications of the healthcare provided.	The literature uses a variety of methods to calculate cost savings and cost-avoidance. The reliability of these measures is often not reported. Different economic funding models are used which makes comparison difficult. Proxy measures of cost do not always reflect actual costs.
Clinical outcomes based	Mortality; laceration care; health status; pain intensity; adverse event after discharge; treatments given, diagnosis	Mortality, pain intensity, and adverse event after discharge.	(3,6,8,10,16,19,20,23)	To measure the medical outcomes for patients of the health care provided.	The reliability of outcome measures (e.g., pain intensity, quality of life) were not reported. Clinical outcome measures are influenced by wait times. Clinical outcomes such as mortality may not reflect the impact of the intervention on patient care.

Note: CIN, Clinical Initiator Nurse; ED, Emergency Department; LOS, Length of Stay; QoC, Quality of Care

Table S3. ED Performance Interventions

Type of Intervention	Study	Aims	Intervention	Measures	Intervention effectiveness	Quality of Evidence	Measures missing	Generalization/ recommendations	Scope for Future Interventions
Team Composition	Cohen, 2009 (22)	To examine the scope (role and value) of pharmacy practice/ services in the ED and to describe the limitations of economic, humanistic, and clinical outcomes data.	The provision of pharmacy services in ED (e.g., Therapeutic consultation, dose and frequency adjustments, patient consultation and information).	Proportion based (i.e., readmission rate, medication errors); Process based (i.e., medication history accuracy); Cost based measures (i.e., cost avoidance).	A reduction in readmission rates when pharmacists were involved in post discharge contact; reduction in the number of medication errors; histories taken by pharmacists were more accurate compared with ED providers; costs were avoided (m = $355,021).	Retrospective or Prospective (no randomized control trials). Unsuccessful interventions may not be published.	Inconsistent measures of cost.	Pharmacists deployed to ED pay for itself in cost-avoidance – improved processes, error reduction, readmission.	Standardization of intervention categories and documentation. Documentation of ED pharmacists' scope of practice on patient specific outcomes and service implementation. Higher level data (e.g., RCT, institutions with and without pharmacy services).
Team Composition	Kilner, 2011 (16)	To examine if a physiotherapy service in ED improves/ affects outcomes.	The provision of physiotherapy services in ED (e.g., management of acute and subacute musculoskeletal conditions, recent burns).	Time based (i.e., wait time); Process based (e.g., patient/ provider satisfaction, admission to hospital); Cost based (i.e., cost of care delivery); Clinical outcomes based (i.e., health status, pain intensity).	A reduction in wait times; increased patient satisfaction; improved diagnostic accuracy (compared with MRI); reduced hospital admissions; no increase in cost effectiveness (no difference in cost); improved health status at 3 months (but not at 6 months); reductions in pain intensity.	Retrospective / prospective cohort studies, descriptive / observational single case study, descriptive cross-sectional, and randomized control trials. Authors report majority of studies included are of poor quality. Limited high-quality evidence.	Minimal or missing descriptions of processes and tools used (including reliability). Measures of cost were researcher-developed; therefore, an objective measure is needed.	There is weak evidence that Physiotherapy services in ED results in short term improvements in patient satisfaction and outcomes. Current evidence does not support widespread integration of physiotherapy services into EDs.	High level evidence examining the effect of physiotherapy services on patient wait time, number of hospital admissions, number of inappropriate referrals to health professionals, ED staff satisfaction.

Team Composition	Elder, 2015 (3)	To examine the effect of three different models of ED care on patient and systems outcomes.	The expansion of nursing scope of practice (e.g., NP, clinical initiative nurse – CIN).	Time based (e.g., Wait time, LOS); Proportion based (e.g., LWBS, rate of diagnostic test); Process based (e.g., Patient satisfaction, CIN documentation); Cost based (i.e., cost of care delivery); Clinical outcomes based (i.e., diagnosis, pain intensity).	Nurse initiated diagnostic tests can reduce ED wait times and LOS and improve patient satisfaction. NPs may be slightly more expensive than physicians, but they can provide safe and effective treatment and care for minor injuries. Effective pain management remains an issue.	Single site studies, small sample sizes, short study periods, children excluded (by 2 studies). Methodological issues: sample size disparity; requirements for NPs cases to be counter-signed and discussed with a physician, non-disclosure of staff reallocation, comparison data collection time line issues, blinding of researchers, and crude cost analysis.	Rigorous research evaluating the impact of nurse-initiated analgesia on ED LOS, LWBS rates, and discharge disposition. The impact of NPs on cost, efficiency, and re-presentation rates.	NPs had a positive impact on outcomes and facilitate patient flow, particularly when incorporated in the triage process. CIN roles promote flow, however, appropriate education, support, and detailed scope of practice is needed.	Interventions effectiveness for outcomes such as re-presentation, re-admission rates, number of reported AE and the overall cost effectiveness. Potentially incorporating a meta-analysis.
Team Composition	Jennings, 2015 (15)	To examine the effectiveness of the NP role in ED.	The inclusion of NPs in ED.	Time based (i.e., wait time); Proportion based (e.g., unexpected patient returns, missed injury rate); Process based (e.g., quality of care, indirect measures of QoC: accuracy of x-ray interpretation, inappropriate	Reduced wait time and LOS. Unplanned representations were higher for NPs than physicians. Higher patient satisfaction for NP care than physicians, and reduced the number of LWBS. There was no difference in cost of care between	Randomized pragmatic trials, observational studies, prospective observational chart audit, descriptive retrospective cohort study, self-administered survey, prospective observational	Total costing is difficult as most NPs carryout the nurse treatment that physicians do not. Consideration for external factors on data collection (i.e., access block), types of patients able to treat. Inconsistent	NP services in ED have been demonstrated to improve patient care quality (patient satisfaction and wait times).	Multicenter studies. Research examining the effectiveness of an emergency NP on key outcome measures such as cost, quality of care, satisfaction and waiting times.

				management of patients); Cost based (i.e., cost of care).	physician, NP, and extended scope physiotherapist services for soft tissue injury management.	study, retrospective audit, retrospective case series, case control study, and an explorative descriptive design. Single site studies, small samples, small numbers of NPs, costs captured indirectly and 8 weeks post injury. QoC was a combination of outcomes, and sample size disparity.	operational definitions in role titles, scope of practice, and levels of intervention. The additional clinical workforce to ED with the inclusion of a NP was not controlled for. Clinical based outcomes were missing.		
Team Composition	Kleinpell, 2008 (20)	To examine the impact of NPs and PAs on patient outcomes.	The inclusion of NP care/ PA care in ED.	Time based (i.e., LOS); Process based (e.g., types of tests ordered, patient satisfaction); Clinical outcomes based (i.e., diagnosis, laceration care).	NPs reduced LOS. There was no difference between NPs and physicians' requests for and interpretation of diagnostic tests, adequacy of treatment. NPs had high patient and provider satisfaction. NPs provided appropriate care and were better at recording medical history and high quality of clinical documentation.	Evidence includes two randomized control trials and a survey study. The designs for 2 studies is unclear.	Missing proportion based and cost-based measures.	Studies demonstrate NP and PA care enhances patient flow through reduced LOS and increases patient satisfaction. Limited studies examining the impact of NPs and PAs in acute and critical care settings – limited generalizability	Author recommendations relate to ICU.

					Fewer patients sought unplanned follow up advice after seeing a NP.				
Practices and Processes	McCaughey, 2015 (6)	To examine approaches to capacity management in ED.	The implementation of cross training nurses and physicians.	N/A	Allows for better transition of patients as well as covering gaps in care providers during high-demand times.	N/A	N/A	N/A	N/A
Team Composition	Walter, 2015 (17)	To examine the role and practice of the specialist trauma nurse and the impact on patient and health systems outcomes.	The implementation of a TNP.	Time based (i.e., LOS, hospital LOS); Cost based (i.e., cost of care delivery); Clinical outcomes based (i.e., patient morbidity, patient mortality)	Compared with physician trauma patient management, TNPs reduced LOS with no increase to morbidity or mortality. Implementing a specialist trauma nurse can reduce hospital LOS and missed injury. Introducing specialist trauma nurse services does not impact service costs (once the reduction in resident hours is accounted for).	LOS is often related to resource use and the financial impact on the health system. However, nonclinical factors such as discharge destination and age can contribute to patient LOS. Variations in job role make the evaluation of the impact difficult.	Measures of proportion and process were missing.	TNPs can benefit patients and the health service through their ability to perform advanced skills.	Further examination of the TNP role is needed to develop an adaptable and consistent model of care and ascertain evidence of the benefit of the role. International observational study to identify and compare specific trauma nurse roles for educational requirements/ role guidelines.
Team Composition	Khangura, 2012 (19)	To examine the effect of employing GPs in ED to manage patients	Introducing primary care (i.e., GPs) into ED.	Time based (i.e., time to assessment and treatment); Proportion based (i.e., rate of	GPs ordered fewer diagnostic blood tests than regular emergency physicians. One study reported	Rated as very low according to GRADE – the true effect is likely to be substantially	For example, time from waiting room to clinical assessment, LOS, clinical	There is evidence that employing GPs may use fewer resources to treat non-urgent patients in ED	Examination of whether the reduction in resource use by GPs translates into improved clinical

		triages as non-urgent.		diagnostic test, subsequent primary care use/ ED reattendance, patient education for self-management/ appropriate service use); Process based (i.e., admission to hospital, consultations/ referrals to hospital based on specialists, arrangement of follow up care); Cost based (i.e., cost of diagnostic tests/ treatment/ referrals); Clinical outcomes based (i.e., mortality, adverse event after discharge, treatments given).	GPs ordered more x rays, while the other 2 report GPs ordered fewer x-rays than regular emergency physicians. GPs tend to prescribe more (one study reported no difference), admit fewer non-urgent patients and make fewer referrals to hospital specialists or consultants than Emergency Physicians (one reported no difference for admissions and the opposite direction for referrals). Employing GPs resulted in savings in health care costs.	different from the estimate of the effect. None of the studies were random control trials. Study designs included were classified as observational studies. The studies were large and pragmatically designed to reduce risk of bias, however, there was no randomization due to a cross over in physicians in one study, and the predictable allocation of patients to emergency physicians or GPs in the other 2.	outcomes, details about cost calculation. Measures of provider characteristics (age, experience, level of expertise), patient characteristics (for all groups), hospital characteristics (catchment size, type [teaching or community] location), proportion of ED attenders classified as non-urgent to allow comparisons across studies.	than emergency physicians, thus may provide cost saving to EDs. Due to the few studies included and the variation in ED structures and health care systems, the applicability of the study findings are limited.	outcomes. Examination of evidence of resource and cost savings, whether GPs in ED generates more demand and increases use of ED for non-urgent problems. Methodologically: more practitioners (to reduce individual practitioner effects) and concealed randomization. 'Primary care-suitable problems' definition is needed.
Team Composition	Tai, 2011 (23)	To examine whether the presence of a trauma team in the ED affects patient outcomes.	The inclusion of a trauma team in a trauma system.	Proportion based (i.e., trauma team activation rate); Clinical outcomes based (i.e., mortality).	Trauma team involvement does not make a difference for patients with very high or low probability of survival. The trauma team has the most impact on patients with a	It is not ethical to design a random control trial comparing the presence or absence of a trauma team. The level of evidence is not high enough to	Morbidity needs to be investigated. Time, process and cost measures are missing.	The inclusion of a trauma team is now standard practice and the best available evidence suggests that trauma teams make the most difference for patients with moderate	Examining the impact on morbidity.

					moderate severity of trauma and probability of survival.	draw a conclusion.		probability of survival. There is no evidence requiring the team to include specialties.	
Practices and Processes	Dexheimer, 2013 (21)	To examine the utilization of mobile devices in ED.	The introduction of technology into the healthcare system.	Time based (i.e., physician time spent accessing information); Process based (i.e., access time, user perception of speed, guideline accuracy, error reduction).	The effectiveness of hand-held devices as a triage support system, for use in the patient's room, for use in the consultation room, or for use wherever was most convenient was not reported.	The literature examined included 9 prospective studies (4 randomized studies) and 3 surveys (one had both a prospective and a study component).	Proportion, cost, and clinical outcomes measures are missing.	Hand-held devices have the potential to improve care quality and timeliness, however, there is little research evidence that supports the use of mobile devices in the ED.	Intervention design and implementation needs to ensure that the systems produce the desired effect. Human factors, accessibility, patient privacy are factors which need to be explored.
Practices and Processes	Fillmore, 2013 (8)	To examine the impact of clinical decision support systems on reducing costs.	The introduction of computerized clinical decision support.	Time based (i.e., LOS); Cost based (i.e., cost of care delivery, cost of process measures associated with adverse events, patient charges, resource utilization); Clinical outcomes based (i.e., adverse event after discharge).	Clinical decision support systems are often used in pharmacotherapy. There is evidence that clinical decision support systems reduce inpatient costs.	Studies include quasi-experimental trials (evaluation of intervention without randomization), controlled before-after study, and two randomized control trials.	Intervention implementation costs were not measured. Proxy measures of costs were often measured rather than direct measures – based on assumptions of an actual relationship. Proportion and process outcomes were missing.	Clinical decision support systems are promising interventions for widespread implementation and have been used extensively in pharmacotherapy. However, the cost/ benefit of clinical decision support systems is not well grounded in empirical evidence.	Concrete characterization of the benefits both clinical and financial, need to be established.
Practices and Processes	Ko, 2011 (18)	To examine whether the use of safety checklists	The use of safety checklists during care.	Time based (i.e., LOS); Proportion based (i.e., readmission rate); Process	Implementation of a post-endoscope checklist reduced LOS. Appropriate use of catheters	ED Studies were of low to moderate methodological quality (cohorts	Measures of cost and clinical outcomes were missing.	There is evidence that safety checklists improve protocol	Clinical trials comparing different checklist designs and content in the

		improves patient safety.		based (i.e., presence and documentation of disease indicators).	tended to increase following implementation of a safety checklist (not sig). Documentation of an indication for a catheter was unchanged, however, the presence of a physician increased significantly after the intervention.	with historical controls) – it is unclear whether appropriate allocation concealment and blinding occurred. One study reported a large difference in the observation periods between the control period (3 months) and the intervention period (4 weeks).		adherence and patient safety.	same setting to determine the most useful design and content of checklists. Health services piloting checklists should consider creating an evaluation plan on the use of the checklists and publish their findings.
Practices and Processes	Oredsson, 2011 (5)	To examine interventions designed to improve patient flow through ED.	The implementation of nurse requested x-ray.	Time based (i.e., wait time, LOS); Proportion based (i.e., rate of diagnostic test, LWBS); Process based (i.e., patient satisfaction).	No difference in LOS for patients needing an x-ray, LOS was reduced for patients that did not need an x-ray. Time to diagnosis was shorter in the nurse request group, however, physicians ordered an x-ray for nearly 8% of patients for whom the nurse did not. The quasi-randomized study reported no difference in LOS between nurses and physicians. Nurses ordered slightly more x-	Three studies examined nurse requested x-ray. Two were medium quality, one was low quality. All three were randomized, in one case, quasi-randomized.	Measures of cost and clinical outcomes were missing (e.g., mortality).	There is limited evidence that nurse requested x-rays can reduce wait time and LOS. This could possibly be affected by a greater emphasis on nurse education. The findings suggest that sorting patients that require no further investigation has the greatest impact on patient flow.	Nurse requested x-ray affects only part of the process/ ED system. Nurse requested x-rays may have other effects/ benefits not measured. Future research needs to examine the effect of nurse requested x-ray on a range of outcomes.

					rays than physicians.				
Practices and Processes	Oredsson, 2011 (5)	To examine interventions designed to improve patient flow through ED.	The implementation of streaming (e.g., fast track).	Time based (i.e., wait time, LOS); Proportion based (i.e., rate of diagnostic test, LWBS); Process based (i.e., patient satisfaction).	Wait time was significantly reduced with fast track. Patients triaged as levels 4 and 5 had reduced wait time and LOS. Fast track had no effect on triage levels 1-3 or patients who were eventually admitted. The number of LWBS dropped by 50%.	Total of 13 studies (9 were medium, 4 were low quality). Two of the studies were quasi-randomized, the rest were prospective studies with historical (retrospective) control groups.	Measures of cost and clinical outcomes were missing (e.g., mortality).	Fast track interventions have demonstrated benefits on patient wait times and LOS. The introduction of fast track does not have a negative impact on treatment and wait times for patients with more severe diseases and injuries.	Fast track influences the entire process. Fast track may have effects/ benefits not measured by the papers included in this review. Future research needs to examine the effect of fast track on a range of outcomes.
Practices and Processes	McCaughey, 2015 (6)	To examine approaches to capacity management in ED.	The implementation of fast track and mid track.	N/A	Incorporates greater use of NPs, PAs, and cross-trained nurses to care for nonemergent patients.	Retrospective.	N/A	N/A	N/A
Practices and Processes	McCaughey, 2015 (6)	To examine approaches to capacity management in ED.	The implementation of scheduling (i.e., triage).	N/A	Allows for the unpredictable demand of ED services within the trauma system.	N/A	N/A	N/A	N/A
Practices and Processes	Elder, 2015 (3)	To examine the effect of three different models of ED care on patient and systems outcomes.	The implementation of PAT.	Time based (e.g., wait time, LOS); Proportion based (e.g., number of patients to be seen, patient disposition/ characteristics); Process based	PAT can reduce the number of patients waiting to be seen, time to assessment and treatment, the time spent in ambulance diversion, and the number of LWBS.	Singles site studies, sample size disparity (control vs treatment). Short (e.g., 10 days, or 8 hours per day) intervention evaluation.	Confounding variables (i.e., comorbidities, patient vital signs) were not evaluated. Patient satisfaction, impact on radiology or	Emergency physicians working at triage can reduce ED congestion and improve patient flow.	Interventions effectiveness for outcomes such as re-presentation, re-admission rates, number of reported AE and the overall cost effectiveness. Potentially

				(e.g., patient registration times, mode of arrival); Clinical outcomes based (i.e., harm).		Potential Hawthorn effect as staff were aware of the study. Staff data entry and types of patients excluded may bias results.	pathology studies were not evaluated. Minimal measures of clinical outcomes. Cost outcomes were missing.		incorporating a meta-analysis.
Practices and Processes	Oredsson, 2011 (5)	To examine interventions designed to improve patient flow through ED.	The implementation of Team triage.	Time based (i.e., wait time, LOS); Proportion based (i.e., rate of diagnostic test, LWBS); Process based (i.e., patient satisfaction).	One study reported no reduction in the LOS, other studies report LOS was reduced by 11% and LWBS reduced by 20%. Wait time to see a physician and wait time to x-ray was also reduced.	Six articles examining team triage were reviewed (3 medium and 3 low quality). Two were quasi-randomized, the rest were prospective observational studies with retrospective controls.	Measures of cost and clinical outcomes were missing (e.g., mortality).	Team triage impacts patient flow as measured by wait time and LOS. Fewer patients leave without being seen by a physician, which is not surprising given a physician is part of the triage team, could benefit patient safety.	Team triage influences the entire process. Team triage may have effects/ benefits not measured by the papers included in this review. Future research needs to examine the effect of team triage on a range of outcomes.
Practices and Processes	Elder, 2015 (3)	To examine the effect of three different models of ED care on patient and systems outcomes.	The implementation of MAUs.	Time based (e.g., wait time, LOS); Proportion based (i.e., readmission rate); Process based (e.g., patient and provider satisfaction); Cost based (i.e., bed costing and utilization); Clinical outcomes based (i.e., mortality).	Over 3 years, MAUs reduced patient LOS. Providers (nursing and medical staff) and patients preferred MAU care. MAUs can reduce hospital admission days by 27%, and bed utilization.	Low response rates and data source (clinical lead of each department) impede generalizability and introduce bias. Non-peer reviewed data was included. Two single site studies.	ED LOS was not consistently measured across the studies.	MAUs can improve patient care while reducing cost of care delivery (bed costing and utilization).	Interventions effectiveness for outcomes such as re-presentation, re-admission rates, number of reported AE and the overall cost effectiveness. Potentially incorporating a meta-analysis.

Practices and Processes	Oredsson, 2011 (5)	To examine interventions designed to improve patient flow through ED.	The implementation of POCT.	Time based (i.e., wait time, LOS); Proportion based (i.e., rate of diagnostic test, LWBS); Process based (i.e., patient satisfaction).	Some studies report shorter LOS when laboratory analyses were performed in ED. Other studies report no effect on LOS or admission rates. One study reported shorter turnaround time and high provider satisfaction.	Six articles (4 were medium and 2 were low quality).	Measures of cost and clinical outcomes were missing (e.g., mortality).	The impact of POCT on patient flow (LOS/ admission rate) depends on the tests available in the POCT. If patients still need laboratory tests to complement the POCT, then POCT will not affect patients LOS.	As the range in tests available to POCT increases, research needs to examine the precision and reliability of the methods – low precision will impact patient safety and hamper patient flow.
Practices and Processes	McCaughey, 2015 (6)	To examine approaches to capacity management in ED.	The implementation of outsourcing services.	N/A	The effectiveness of a bed tracking system was not reported.	It is not clear how the data from bed tracking system was used within the study.	N/A	N/A	N/A
Patient Engagement	Flynn, 2012 (24)	To examine decision support interventions designed for use with acute patients in ED.	Decision supports for patients (paper-based information sheets on disease risk, risk/ benefit of treatment).	Time based (i.e., median length of hospital stay); Proportion based (e.g., readmission rate, patient treatment preference); Process based (e.g., patient satisfaction, patient involvement); Clinical outcomes based (i.e., adverse events after discharge, diagnosis)	Decision support information increased patient knowledge of test and treatment risks, patient satisfaction, patient engagement in decision making, and reduced patient exposure to negative imaging tests than those provided with usual care. Patients provided with decision supports were less likely to return within 7 days,	Two randomized control trials and three cross-sectional studies. The randomized control trials were low risk of bias. All three cross-sectional studies provided adequate descriptions of the presenting condition, including definitions of the exposure and collection of outcomes	Cost based measures were missing.	Decision support interventions are used for a small range of decisions and have a positive effect on patient knowledge, satisfaction, preferences for involvement, and degree of engagement. Decision support interventions can reduce healthcare utilization without evidence of harm or lack of feasibility.	User-centered design studies and efficacy studies to identify when and how shared decision making can happen in ED. Comparative studies for different shared decision making. Exploration of ethical justification of shared decision making in a broader range of preference sensitive decisions in ED. Establishing contextual barriers

			though there was no effect on median LOS or rates of adverse events after discharge.	(two were considered moderate risk from participant selection and non-response, one was considered low risk).	and facilitators of shared decision making and addressing key methodological issues and outcomes. The use of computer based/ interactive methods that enable presentation of outcome probabilities tailored to individual patients may enable better engagement and documentation.

Note: ED, Emergency Department; LWBS, left-without-being-seen; LOS, length of stay; MAU, Medical Assessment Unit; NP, Nurse Practitioner; PA, Physician Assistants; Physician Assisted Triage; POCT, Point-of-care Testing; TNP, Trauma Nurse Practitioner;