



Systematic review of interruptions in the emergency department work environment

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ABSTRACT

Objective: The purpose of this systematic review is to describe the operationalization of interruptions measurement and to synthesize the evidence on the causes and consequences of interruptions in the emergency department (ED) work environment.

Methods: This systematic review of studies explores the causes and consequences of interruptions in the ED. Of 2836 abstract/titles screened, 137 full-text articles were reviewed, and 44 articles met inclusion criteria of measuring ED interruptions.

Results: All articles reported primary data collection, and most were cohort studies ($n = 30$, 68%). Conceptual or operational definitions of interruptions were included in 27 articles. Direct observation was the most common approach. In half of the studies, quantitative measures of interruptions in the ED were descriptive only, without measurements of interruptions' consequences. Twenty-two studies evaluated consequences, including workload, delays, satisfaction, and errors. Overall, relationships between ED interruptions and their causes and consequences are primarily derived from direct observation within large academic hospitals using heterogeneous definitions. Collective strengths of interruptions research in the ED include structured methods of naturalistic observation and definitions of interruptions derived from concept analysis. Limitations are conflicting and complex evaluations of consequences attributed to interruptions, including the predominance of descriptive reports characterizing interruptions without direct measurements of consequences.

Conclusions: The use of standardized definitions and measurements in interruptions research could contribute to measuring the impact and influence of interruptions on clinicians' productivity and efficiency as well as patients' outcomes, and thus provide a basis for intervention research.

1. Introduction

Interruptions interfere with productivity and efficiency. Moreover, interruptions are linked to serious errors in complex work environments such as aviation, driving, and healthcare [1–4]. In healthcare, interruptions contribute to missed care or care delays with adverse consequences [3–4]. Acute care hospital work environments (e.g.,

emergency, acute care, intensive care, and operating rooms) exemplify the most demanding healthcare settings characterized by complex clinical and administrative activities requiring task switching with frequent interruptions [5–6]. Although some interruptions may mitigate errors and be essential in communicating task- or patient-related information, disruptive interruptions can also have negative consequences, such as failed or erroneous task resumption. Errors and missed

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care are unacceptable, including emergency departments (EDs) and intensive care units (ICUs) [2,5,7–8].

In hospitals and primary care facilities, interruptions occur disproportionately in EDs in comparison with non-ICUs [9–10]. The work environment in the ED is interruption-laden. Patient care is prioritized based on acuity, so if a clinician is caring for a low-acuity patient when a more critical patient arrives, care can be interrupted to care for the patient who requires urgent attention. An unstable trauma patient, for example, will be prioritized over a patient with low back pain. Although interruptions attributed to an unstable condition are reasonable, it is not uncommon for interrupted tasks to be delayed indefinitely or missed altogether [26,11].

It is crucial to evaluate the state of the science in ED interruptions research to determine what is known, what gaps remain, and where future studies should be directed. Current evidence on interruptions in the ED suggests that interactions among individuals, tasks, technology, and the work environment [12] cannot be fully explained by a linear structure-process-outcomes model [13]. The ED work environment includes task-switching or “multi-tasking” with distractions that are broadly linked to increased risk of cognitive errors; it must be viewed within a framework of *systems thinking* [14]. The causes and effects of interruptions in the ED merit inquiry to build on previous reviews and integrate critical appraisals from multiple disciplines. The recognition and classification of work environment features affect care delivery. To further advance interruption science to address interruptions prevention and/or management, conceptual and operational definitions as well as study designs are essential. This systematic review aims to describe the operationalization of interruptions measurement and synthesize the evidence on the causes and consequences of interruptions in the ED work environment.

2. Methods

2.1. Design

This systematic review of studies exploring causes and consequences of interruptions in the ED follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [15] standards and was conducted following best practice guidelines.

2.2. Search strategy

The findings of this systematic review can serve as an update to the review by Werner and Holden [12], which had a cut-off date of 2013. Inclusion and exclusion criteria were established *a priori*. Included studies were written in English, addressed ED interruptions, and were published from 2013 to 2020. Studies not reporting primary data (e.g., commentaries, reviews) were excluded. We selected databases and developed our search strategy in collaboration with a health sciences librarian (E.K.). We searched the following databases: Elsevier’s Embase and Compendex, IEEE Xplore, MEDLINE; CINAHL Plus with Full Text, Business Source Complete, PsycINFO, SocINDEX, ABI Inform, BIOSIS Previews, and the Cochrane Central Register of Controlled Trials. An updated search was performed on November 13, 2020. All searches included subject heading and keyword combinations representing work environment interruptions in the ED, using reproducible search strings (Appendix 1).

2.3. Literature appraisal

Initial searches yielded 5,136 results. Grey literature in the form of conference proceedings and abstracts from the Embase search were included to address publication bias. After the removal of duplicates, the titles and abstracts of the resulting 2836 sources were screened independently by two blinded reviewers (KJ and VD) using Rayyan [16]. Conflicts were resolved by a third reviewer (AK). A PRISMA flow

diagram is provided in Fig. 1. The full texts of 137 articles were included and then screened. Forty-four articles met inclusion criteria. Conceptual and operational definitions of interruptions were extracted. Each study was classified according to data collection methods (e.g., interviews, surveys, observations). Outcome categories associated with interruptions and consistent with the sociotechnical system of the Emergency Department work environment were drawn from the literature [12]. Classifications were double-verified by independent reviewers. Quality was appraised using Critical Appraisals Skills Programme (CASP) criteria (Table 2) [17].

3. Results

Article characteristics and major findings of the 44 articles on interruptions in the Emergency Department are summarized in Table 1. Thirty-six of the articles were published in 22 journals, and 8 were presentations at four conferences (Fig. 1). All articles reported primary data collection, and most were cohort studies (n = 30, 68%).

3.1. Definitions of interruption

Conceptual or operational definitions of interruptions were included in 27 articles. The most prevalent definition in these articles was a broad conceptualization of interruptions as breaks in attention and activity [18]. However, the conceptual definitions were heterogeneous, and within teams, definitions sometimes changed over time [4,19–21]. In the 17 other articles (39%), definitions were omitted. Of the 27 articles that specified a definition for interruptions, seven relied on Brixey et al. [18], and four applied structured observation tools.

3.2. Measurement of interruptions

Direct observation was the most common method of evaluating interruptions in the ED (38 articles, 86%). Researchers also employed interviews and surveys, but only 1 study included a chart review [22]. When direct observation was paired with interviews [8,23–26], it yielded primarily descriptive evidence. Observations paired with surveys [21–23,27–33] were more likely to be framed within the context of interruptions’ consequences.

3.3. Consequences of interruptions in the ED

The consequences of interruptions in the ED were classified as related to workload, delays, satisfaction and/or errors. In half of the studies, quantitative measures of interruptions in the ED were descriptive only, without measurements of interruptions’ consequences. The remaining 22 studies evaluated consequences, including workload, delays, satisfaction, and errors. The heterogeneity of studies’ effect sizes, outcomes, and measures did not permit data pooling, so we could not perform a *meta-analysis*.

Workload Although the abstracts of 15 articles mentioned the implications of interruptions on workload, only five articles mentioned the consequences of interruptions on workload [7,9–10,15,20]. Frequent interruptions and high-priority interruptions were described as increasing cognitive workload. Four of those articles quantified workload with the Workload Interruptions Tool. An increase in task time due to fatigue was found in self-reported physical and mental scores [50]. Generally, self-perceived measurements of workload were found to be higher at end-of-shift by physicians [30], residents [31], and nurses [39].

Delays were measured as a consequence of interruptions in six articles and included delays in care (i.e., assessment [34–35], treatment [36], information-sharing [37]). For example, the Triage Interruptions Assessment Tool [23,34,56] was developed to include discrete measures of delays in care/treatment as a negative patient outcome [23]. When delays were directly observed as a consequence of interruptions,

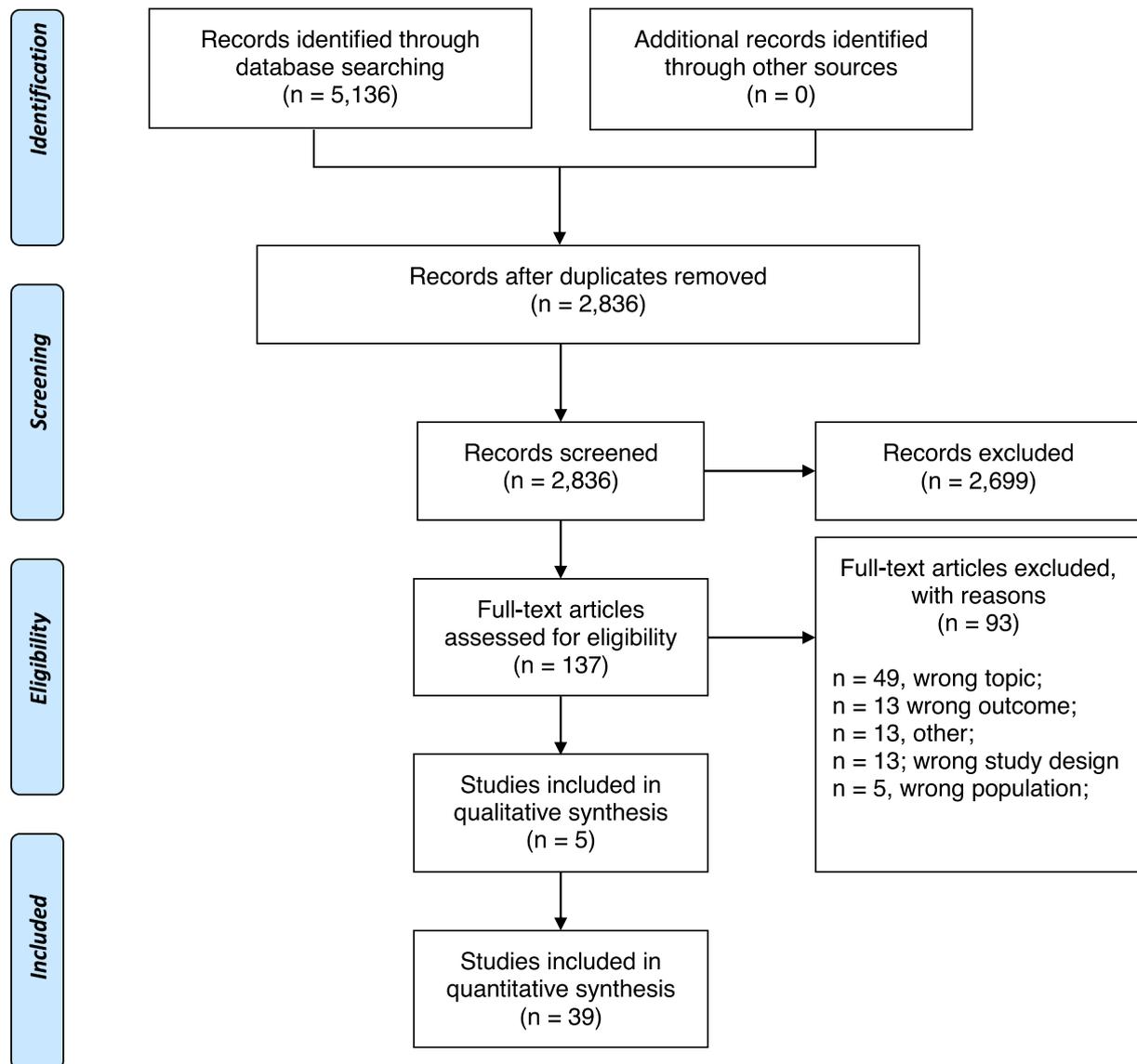


Fig. 1. PRISMA Diagram.

approximately 1 in 3 interruptions resulted in a distinct delay in care [34].

Three articles examined patients' *satisfaction* with the overall quality of care, ED organization, and waiting times in relation to clinician interruptions [27]. Collectively, these studies suggest a moderate negative correlation between clinician interruptions and patient perceptions of care quality [21]. From the clinician's perspective, the relationship between job satisfaction and interruptions has not been quantified. Qualitative data suggest that interruptions and the necessity to "multitask" could be associated with job dissatisfaction in the ED [38].

Medical *errors* were associated with interruptions, including increased likelihood of prescribing errors by ED physicians [4] and triaging errors by ED nurses [34]. Pediatric ED nurses surveyed in Riyadh, Saudi Arabia, rated interruptions as the most important contributor to medication errors in the ED [29]. Among trauma physicians surveyed in the US, compromised patient care and information exchange at handoff were associated with daily interruptions [22].

4. Discussion/Implications

Research on ED interruptions published in the last decade endorses addressing interruptions is vital for ensuring high-quality care. Researchers and research teams are assessing relationships between ED interruptions and their causes and consequences, primarily through direct observation within large academic hospitals and using heterogeneous definitions and measurement tools. Differences in study results were consistent when the review was limited to higher quality articles using the CASP quality appraisal criteria. However, conceptual and operational definitions were more often included in higher-quality articles. Similarly, the study design of higher quality articles generally extended beyond descriptive reports to integrate assessments of workload, delays, satisfaction, and/or errors. Overall strengths of recent interruptions research in the ED include structured methods of naturalistic observation, including observations of instrument development [34,39], as well as definitions of interruptions derived from concept analysis [18]. Overall limitations in recent interruptions research in the ED

Table 1
Characteristics of papers describing the evaluation and consequences of interruptions in the Emergency Department.

Author	Sample	Setting	Interruption Definition	Evaluation Method				Consequences Evaluated				
				Interviews	Surveys	Observation	Chart review	Descriptive Only	Workload	Delays	Satisfaction	Errors
Eng et al., 2019 ⁴⁶	Physicians, n=49	Academic Medical Center	Type and frequency of overhead page	N	Y	Y	N	Y	N	N	N	N
Kim et al., 2019 ⁴⁷	Nurses, n=7	Academic Medical Center	An event that was initiated by other person(s)	N	N	Y	N	Y	N	N	N	N
Myers et al., 2019 ⁴⁸	Nurses, n=13	Academic Medical Center	Anything that takes the nurse's attention away from a task or communication activity already engaged in as part of their job	N	N	Y	N	Y	N	N	N	N
Schneider et al., 2019 ²⁷	Patients, n=1,418	Referral Center	An event that results in provider distraction from the task at hand thus causing discontinuation of the primary task, reallocation of attention or task switching to the interrupting event or secondary task	N	Y	Y	N	N	N	N	Y	N
Soares et al., 2019 ²⁸	Physicians, n=35	Simulation Lab	Activities that briefly disrupt a primary task	N	Y	N	N	N	N	N	N	Y
Al-Otaibi et al., 2018 ²⁹	Nurses, n=200	Referral Center, n=2	Not specified	N	Y	N	N	N	N	N	N	Y
Blocker et al., 2018 ⁴⁹	Nurses or Physicians, n=854 hours	Referral Center	Workflow Interruptions Tool (WIT)	N	N	Y	N	Y	N	N	N	N
Crane et al., 2018 ⁵⁰	Nurses, n=not specified	Referral Center	Not specified	N	N	Y	N	N	Y	N	N	N
Fong et al., 2018 ⁵¹	Physicians, N=18	Multi-center, n=3	Discontinuation of current task	N	N	Y	N	Y	N	N	N	N
Forsyth et al., 2018 ³⁹	Nurses, n=38	Referral Center	A break in the performance of an activity causing suspension of a task due to initiating the performance of an unplanned task with the assumption that the initial task will be resumed. ¹⁸	N	N	Y	N	N	Y	N	N	N
Forsyth et al., 2018 ⁵²	Physicians, n=23	Referral Center	Workflow Interruptions Tool (WIT)	N	N	Y	N	N	Y	N	N	N
Johnson et al., 2018 ³⁴	Nurses, n=8	Multi-center, n=2	Triage Interruptions Assessment Tool (TIAT)	N	N	Y	N	N	N	Y	N	Y
Thompson et al., 2018 ³³	Physicians, n=38	Referral Center	Not specified	N	Y	Y	N	Y	N	N	N	N
Westbrook et al., 2018 ⁴	Physicians, n=36	Referral Center	Discontinuation of current task	N	N	Y	N	N	N	N	N	Y
Blocker et al., 2017 ⁵³	Physicians, n=28	Referral Center	A break in the performance of an activity causing suspension of a task due to initiating the performance of an unplanned task with the assumption that the initial task will be resumed. ¹⁸	N	N	Y	N	Y	N	N	N	N
El-Sherif et al., 2017 ³⁰	Physicians, n=26	Referral Center	Attention shifted	N	Y	Y	N	N	Y	N	N	N
Fong et al., 2017 ⁴⁵	Physicians, n=18	Multi-center, n=3	Not specified	N	N	Y	N	Y	N	N	N	N

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Table 1 (continued)

Author	Sample	Setting	Interruption Definition	Evaluation Method				Consequences Evaluated				
				Interviews	Surveys	Observation	Chart review	Descriptive Only	Workload	Delays	Satisfaction	Errors
Forsyth et al., 2017 ⁵⁴	Nurses or Physicians, n=14	Referral Center	Not specified	N	N	Y	N	Y	N	N	N	N
Heaton et al., 2017 ⁵⁵	Physicians, n=224 hours	Not specified	Not specified	N	N	Y	N	Y	N	N	N	N
Johnson, Alhaj-Ali, 2017 ⁵⁶	Nurses, n=9	Simulation Lab	Triage Interruptions Assessment Tool (TIAT)	N	N	Y	N	N	N	Y	N	Y
Jones et al., 2017 ³¹	Physicians, n=23	Referral Center	Not specified	N	Y	Y	N	N	Y	N	N	N
Ratwani et al., 2017 ⁵⁷	Physicians, n=18	Referral centers, n=3	External stimulus	N	N	Y	N	Y	N	N	N	N
Walter et al., 2017 ¹⁹	Physicians, n=36	Referral Center	External or internal stimulus	N	N	Y	N	Y	N	N	N	N
Weigl et al., 2017 ²⁰	Nurses, n=50; Physicians, n=30	Referral Center	Discontinuation of current task	N	Y	Y	N	Y	N	N	N	N
Berg et al., 2016 ⁵⁸	Nurses, n=10; Physicians, n=10	Multi-center, n=2	A break in the performance of an activity causing suspension of a task due to initiating the performance of an unplanned task with the assumption that the initial task will be resumed. ¹⁸	Y	N	N	N	Y	N	N	N	N
Berg et al., 2016 ⁵⁹	Nurses, n=10; Physicians, n=10	Multi-center, n=2	A break in the performance of an activity causing suspension of a task due to initiating the performance of an unplanned task with the assumption that the initial task will be resumed. ¹⁸	Y	N	N	N	Y	N	N	N	N
Cole et al., 2016 ³⁶	Nurses and assistants, n=111 hours	Referral Center	Not specified	N	N	Y	N	N	N	Y	N	N
Coplin et al., 2016 ³⁷	Physicians, n=52	Referral Center	Not specified	N	N	Y	N	N	N	Y	N	N
Johnson et al., 2016 ²³	Nurses, n=8	Referral Center	A break in the performance of an activity causing suspension of a task due to initiating the performance of an unplanned task with the assumption that the initial task will be resumed. ¹⁸	Y	Y	Y	N	N	N	Y	N	N
Kellogg et al., 2016 ⁶⁰	Physicians, n=6	Referral Center	Discontinuation of current task	N	N	Y	N	Y	N	N	N	N
Weigl et al., 2016 ²¹	Nurses or Physicians, n=6	Non-referral Center	Discontinuation of current task	N	Y	Y	N	N	N	N	Y	N
Forsberg et al., 2015 ³⁸	Nurses, n=9	Multi-center, n=2	Not specified	Y	N	N	N	N	N	N	Y	N
Itakura et al., 2015 ⁶¹	Patients, n=156	Referral Center	Not specified	N	N	Y	N	N	N	Y	N	N
Monteiro et al., 2015 ³²	Physicians, n=198	Multi-center, n=2	Not specified	N	Y	Y	N	N	N	N	N	N
Popovici et al., 2015 ²⁴	Nurses or Physicians, n=5	Multi-center, n=3	Not specified	Y	N	Y	N	N	N	N	N	N
Fong et al., 2014 ⁶²	Physicians, n=2	Referral Center	External stimulus	N	N	Y	N	Y	N	N	N	N

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Table 1 (continued)

Author	Sample	Setting	Interruption Definition	Evaluation Method				Consequences Evaluated					
				Interviews	Surveys	Observation	Chart review	Descriptive Only	Workload	Delays	Satisfaction	Errors	
Johnson et al., 2014 ²⁵	Nurses, n=3	Referral Center	Not specified	Y	N	Y	N	Y	N	N	N	N	N
Khandelwal et al., 2014 ²²	Patients, n=1,654	Referral Center	Not specified	N	Y	N	Y	N	N	N	N	N	Y
Nguyen et al., 2014 ⁶³	Nurses, N=5; Physicians, n=11	Referral Center	Discontinuation of current task	N	N	Y	N	Y	N	N	N	N	N
Peterson et al., 2014 ⁶⁴	Physicians, n=25	Referral Center	Not specified	N	N	Y	N	Y	N	N	N	N	N
Berg et al., 2013 ⁸	Nurses or Physicians, n=18	Referral Center	A break in the performance of an activity causing suspension of a task due to initiating the performance of an unplanned task with the assumption that the initial task will be resumed. ¹⁸	Y	N	Y	N	Y	N	N	N	N	N
Blocker et al., 2013 ³⁵	Patients, n=181	Referral Center	Task sequence changed	N	N	Y	N	N	N	Y	N	N	N
Ernst et al., 2013 ⁶⁵	Physicians, n=9	Referral Center	External stimulus	N	N	Y	N	Y	N	N	N	N	N
Hunte et al., 2013 ²⁶	Nurses or Physicians, n=16	Referral Center	Not specified	Y	N	Y	N	Y	N	N	N	N	N

Abbreviations/Notes: N = no, Y= yes

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highlight conflicting and complex evaluations of consequences attributed to interruptions, including the predominance of solely descriptive reports of naturalistic observations. Intervention research on the mitigation of ED interruptions' negative consequences is important to address these gaps.

In the studies in this review, naturalistic observations predominantly took place in large academic medical centers with trauma services. Although approximately 535 EDs in the US offer trauma services verified by the American College of Surgeons [40], another 4,700 EDs are also operating without a trauma designation [41]. The selection bias of interruptions science data collected disproportionately from large healthcare settings is persistent in related systematic reviews [2,5,7]. Balanced data to represent the diversity of ED care delivery are needed to improve the generalizability of descriptive reports of interruptions, as well as evaluations of consequences.

Naturalistic observations research can contribute to elucidating both the causes and consequences of interruptions. However, despite new investigations over the last decade, the linkages between interruptions and workload, delays, errors, and satisfaction were not well-defined in the reviewed studies. For example, associations between interruptions and satisfaction and stress were divergent. Some studies suggested links between interruptions and stress and dissatisfaction [20,25], whereas others framed interruptions as unavoidable and not stressful [38]. This discordance may be explained by differentiating interruptions as "disturbing" or "benign" [42].

In addition, five studies connected nursing interruptions with clinical errors, with two of them presenting anecdotal linkage without discrete evidence of the relationship. The other three studies offered evidence suggesting an impact of interruptions on prescribing and triaging tasks. These new observations align with syntheses of literature on acute care ICU work environments, which suggests negative effects of interruptions

on task resumption [43–44]. Although studies in controlled clinical environments are rare, 1 study demonstrated the negative effects of interruptions on task resumption (i.e., longer resumption lag, reduced resumption accuracy) [45]. Although resumption issues may result in patient harm [3,6], studies documenting the evidence of interruptions linked to errors are mostly absent.

4.1. Limitations

First, while the heterogeneity of studies did not permit data pooling and a meta-analysis could not be performed, qualitative evaluations of the frequency and ranges of interruptions observed are reported. Second, although conference abstracts were included in the literature search, several were excluded because they lacked study findings. Several of the studies presented at conferences do not appear to be published beyond the abstract text.

5. Conclusion

This review synthesizes measures, causes, and consequences of interruptions specific to the ED work environment. Research on ED interruptions published in the last decade has primarily occurred through direct observation within large academic hospitals and using heterogeneous definitions and measurement tools. Collective limitations are weaknesses attributed to research design and measurement to more fully address causal inference between interruptions and negative outcomes. Optimal solutions to address interruptions are dependent on clearer linkages between cause and effect. Therefore, future prospective observational studies should explicitly examine relationships between interruptions and consequences, focusing on workload, delays, satisfaction, and errors.

Table 2
Quality appraisal of cohort studies.

Author (Year)	Clear aim	Acceptable recruitment	Exposure bias	Outcome bias	Identified factors	Adjusted for factors	Follow-up complete	Follow-up length	Results precise	Trust results	Applied locally	Fits other evidence
Eng 2019 [46]	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	Y
Kim 2019 [47]	Y	N	Y	Y	N	N	N	N/A	N/A	Y	Y	Y
Myers 2019 [48]	Y	N	Y	Y	N	Y	Y	N/A	Y	Y	Y	Y
Schneider 2019 [27]	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Y	Y
Soares 2019 [28]	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Y	Y
Al-Otaiba 2018 [29]	Y	Y	Y	N	N	N	N/A	N/A	N	Y	Y	Y
Blocker 2018 [49]	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Y	Y
Crane 2018 [50]	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	Y	Y	Y
Fong 2018 [51]	Y	N	Y	Y	N/A	N/A	N/A	N/A	Y	Y	Y	Y
Forsyth 2018a [39]	Y	Y	Y	Y	Y	Y	Y	N/A	N	Y	Y	Y
Forsyth 2018b [52]	Y	Y	N	N	N	N	N	N/A	N	Y	Y	Y
Johnson 2018 [34]	Y	N	Y	Y	N	N	Y	N/A	Y	Y	Y	Y
Thompson 2018 [33]	Y	N	Y	Y	Y	Y	N	N/A	N	Y	Y	Y
Westbrook 2018 [4]	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Y	Y
Blocker 2017 [53]	Y	N/A	Y	Y	N	N	Y	N/A	N	Y	Y	Y
El-Sherif 2017 [30]	Y	Y	Y	Y	Y	N	N/A	N/A	Y	Y	Y	Y
Fong 2017 [45]	Y	Y	Y	N	N	N	N/A	N/A	Y	Y	Y	Y
Forsyth 2017 [54]	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	Y
Heaton 2017 [55]	N	Y	N	N	N	N	N/A	N/A	N	Y	Y	Y
Johnson 2017 [56]	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Jones 2017 [31]	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Ratwani 2017 [57]	Y	Y	Y	N	N	N	N/A	N/A	Y	Y	Y	Y
Walter 2017 [19]	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Weigl 2017 [20]	Y	Y	Y	N	N	N	N/A	N/A	N	Y	Y	Y
Berg 2016a Florin [58]	Y	Y	N/A	N	N/A	N/A	N/A	N/A	N/A	Y	Y	Y
Berg 2016b [59]	Y	Y	N/A	N	N/A	N/A	N/A	N/A	N/A	Y	Y	Y
Cole 2016 [36]	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	Y	Y
Coplin 2016 [37]	Y	N	N	Y	N	N	N/A	N/A	N	Y	Y	N
Johnson 2016 [23]	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	Y	Y
Kellogg 2016 [60]	Y	Y	N	N	N	N	N/A	N/A	Y	Y	Y	Y
Weigl 2016 [21]	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	Y	Y
Itakura 2015 [61]	Y	Y	N	Y	N	N	N/A	N/A	Y	Y	Y	Y
Fong 2014 [62]	N	N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	Y	N/A
Johnson 2014 [25]	Y	Y	N	N	Y	N	N/A	N/A	N	Y	Y	Y
Khandelwal 2014 [22]	Y	N/A	Y	Y	Y	Y	N/A	N/A	Y	Y	Y	Y
Nguyen 2014 [63]	Y	N	N	N	Y	N	N/A	N/A	Y	Y	N	Y

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Table 2 (continued)

Author (Year)	Clear aim	Acceptable recruitment	Exposure bias	Outcome bias	Identified factors	Adjusted for factors	Follow-up complete	Follow-up length	Results precise	Trust results	Applied locally	Fits other evidence
Peterson 2014 [64]	Y	Y	N	N	N	N	N/A	N/A	N	N	N	Y
Berg 2013 [8]	Y	Y	N	N	Y	N	N/A	N/A	Y	Y	Y	Y
Blocker 2013 [35]	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	Y	Y	Y
Ernst 2013 [65]	Y	N/A	Y	N	Y	N	N/A	N/A	Y	Y	Y	Y
Hunte 2013 [26]	Y	Y	N	N	N	N	N/A	N/A	N	Y	N	Y

Abbreviations: Y = Yes; N = No; N/A = Unable to assess.

CRedit authorship contribution statement

Valerie Danesh: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Farzan Sasangohar:** Investigation, Writing – original draft, Writing – review & editing. **Ann-Sofie Kallberg:** Conceptualization, Data curation, Formal analysis, Investigation, Writing – review & editing. **Emily B. Kean:** Data curation, Investigation, Methodology, Visualization, Writing – review & editing. **Juliana J. Brixey:** Conceptualization, Data curation, Investigation, Writing – review & editing. **Kimberly D. Johnson:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Appendix 1

SDC Table 1. Search Strategy

Reproducible Search Strings for Elsevier Embase, Ovid MEDLINE, and EBSCOhost CINAHL Plus with Full Text

Embase	MEDLINE	CINAHL
1 ('emergency ward'/de OR 'emergency ward':ti,ab OR 'emergency department':ti,ab OR 'emergency room':ti,ab OR 'emergency service':ti,ab OR 'trauma center':ti,ab OR 'emergency health service':ti,ab)	Emergency Service, Hospital/ OR Trauma Centers/ OR emergency ward*.ti. or "emergency ward".ab. OR trauma center*.ti. or "trauma center".ab. OR emergency department*.ti. or "emergency department".ab. OR emergency room*.ti. or "emergency room".ab. OR emergency service*.ti. or "emergency service".ab. OR emergency health service*.ti. or "emergency health service".ab.	(MH "Emergency Service") OR (MH "Trauma Centers") OR TI ('emergency ward*' OR 'emergency department*' OR 'emergency room*' OR 'emergency service*' OR 'trauma center*' OR 'emergency health service*') OR AB ('emergency ward*' OR 'emergency department*' OR 'emergency room*' OR 'emergency service*' OR 'trauma center*' OR 'emergency health service*')
2 (interrupt*:ti,ab OR distract*:ti,ab OR disrupt*:ti,ab OR 'task switch':ti,ab OR 'multitasking' OR 'multi-task':ti,ab OR 'multitask':ti,ab)	Multitasking Behavior/ OR interrupt*.ti. or interrupt*.ab. OR distract*.ti. or distract*.ab. OR disrupt*.ti. or disrupt*.ab. OR task switch*.ti. or "task switch".ab. OR multi-task*.ti. or multi-task*.ab. OR multitask*.ti. or multitask*.ab.	(MH "Distraction (Iowa NIC)") OR (MH "Distraction") OR (MH "Multitasking Behavior") OR TI (interrupt* OR distract* OR disrupt* OR 'task switch*' OR 'multitasking' OR 'multi-task*' OR 'multitask*') OR AB (interrupt* OR distract* OR disrupt* OR 'task switch*' OR 'multitasking' OR 'multi-task*' OR 'multitask*')
3 1 AND 2	1 AND 2	1 AND 2

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