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Patient Safety Incidents and Medical Errors in Prehospital emergency Medical Services: A Systematic Review

حوادث سلامة المرضى والأخطاء الطبية في خدمات الإسعاف والطوارئ قبل الوصول إلى المستشفى: مراجعة منهجية

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Abstract:

Background: Prehospital emergency medical services (EMS) operate in unpredictable, time-sensitive environments in which diagnostic uncertainty, communication breakdowns, medication errors, unsafe procedures and system constraints can threaten patient safety. The diversity of incident definitions and surveillance systems makes evidence synthesis difficult.
Objective: To synthesize original evidence on the types, measurement, consequences and contributing factors of patient safety incidents and medical errors in prehospital EMS, and to identify practical improvements and research priorities.
Methods: This structured systematic-review manuscript follows PRISMA 2020 reporting principles and summarizes 14 individually traceable empirical studies published from 2012 to September 2026. The author-supplied selection diagram contains 235 database records and 14 included studies; its provenance remains unverified. A design-sensitive narrative synthesis was undertaken across medication, diagnostic, airway, dispatch, non-conveyance, incident reporting and safety-culture domains. Preliminary study-level methodological concerns were documented using design-appropriate JBI concepts. Meta-analysis was not attempted because denominators, populations and outcomes were incompatible.
Results: Pediatric medication studies reported dosing deviations in 34.7% of 360 administrations and 35.2% of 1,078 administrations. A Qatari safety-register study detected medication adverse events in 150 of 3,475 records (4.32%). Among 750 hospital-confirmed stroke cases, 282 (38%) were missed as stroke in prehospital classification. In an English fatal-incident series, response delays accounted for 41 of 69 reports (59%). Prospective airway and national airway-data studies described complications in 14% of 1,915 intubations and physiologic adverse events in 27.5% of 11,525 selected airway cases, respectively. Patient/witness interviews found perceived incidents in 5.3% of 3,156 episodes. These figures measure different constructs and should not be pooled.
Conclusion: Reported prehospital safety problems span clinical and operational processes, with important roles for communication, decision-support, training, audit, and system design. Voluntary incident surveillance substantially limits prevalence inference, whereas clinical registries and systematic follow-up provide complementary information. No single overall EMS medical error rate can be inferred from the selected studies.

Keywords: Patient Safety; Medical Errors; Emergency Medical Services; Prehospital Care; Medication Errors; Adverse Events; Clinical Decision-Making; Risk of Bias; Systematic Review.

الملخص:

الخلفية :تعمل خدمات الإسعاف والطوارئ قبل الوصول إلى المستشفى (EMS)في بيئات غير متوقعة تتسم بالحاجة إلى اتخاذ القرارات في الوقت المناسب، حيث يمكن أن يؤدي عدم اليقين التشخيصي، وانقطاع التواصل، والأخطاء الدوائية، والإجراءات غير الآمنة، والقيود النظامية إلى تهديد سلامة المرضى .ويجعل تنوع تعريفات الحوادث وأنظمة رصدها عملية استخلاص الأدلة وتحليلها أمرًا صعبًا.

الهدف :استخلاص الأدلة الأصلية المتعلقة بأنواع حوادث سلامة المرضى والأخطاء الطبية في خدمات الإسعاف والطوارئ قبل الوصول إلى المستشفى، وطرق قياسها، وعواقبها، والعوامل المساهمة في حدوثها، وتحديد التحسينات العملية وأولويات البحث.

المنهجية :تتبع هذه المخطوطة، التي أُعدّت في إطار مراجعة منهجية منظمة، مبادئ إعداد التقارير وفق إرشادات PRISMA 2020، وتلخص 14دراسة تجريبية يمكن تتبع كل منها على حدة، نُشرت خلال الفترة من عام 2012حتى سبتمبر 2026. ويتضمن مخطط اختيار الدراسات الذي قدمه المؤلف 235سجلًا مستخرجًا من قواعد البيانات و14 دراسة أُدرجت في المراجعة، إلا أن مصدر هذه البيانات لم يُتحقق منه .وأُجري توليف سردي للأدلة يراعي الاختلافات بين تصاميم الدراسات، وشمل مجالات الأخطاء الدوائية، والأخطاء التشخيصية، وتأمين مجرى الهواء، وتوجيه فرق الإسعاف، وقرارات عدم نقل المرضى إلى المستشفى، والإبلاغ عن الحوادث، وثقافة السلامة .كما وُثقت ملاحظات منهجية أولية على مستوى الدراسات باستخدام مفاهيم من أدوات معهد

جوانا بريغز (JBI)الملائمة لكل تصميم بحثي .ولم يُجرَ تحليل تلوي بسبب عدم التوافق بين المقامات الإحصائية، والفئات السكانية، والنتائج المدروسة.

النتائج :أبلغت دراسات الأخطاء الدوائية لدى الأطفال عن انحرافات في الجرعات في 34.7%من أصل 360عملية إعطاء دواء، وفي 35.2%من أصل 1,078عملية إعطاء .وكشفت دراسة قطرية استندت إلى سجل للسلامة عن أحداث دوائية ضارة في 150 سجلًا من أصل 3,475سجلًا، بنسبة بلغت .4.32%ومن بين 750حالة سكتة دماغية مؤكدة في المستشفى، لم يُتعرف على 282 حالة، أي 38%منها، بوصفها حالات سكتة دماغية عند التصنيف قبل الوصول إلى المستشفى .وفي سلسلة إنجليزية لحوادث مميتة، شكّلت حالات التأخر في الاستجابة 41بلاغًا من أصل 69، بنسبة بلغت .59%وأظهرت دراسات مستقبلية حول مجرى الهواء، إلى جانب دراسات وطنية مستندة إلى بيانات مجرى الهواء، حدوث مضاعفات في 14%من أصل 1,915عملية تنبيب، ووقوع أحداث ضارة فسيولوجية في 27.5%من أصل 11,525حالة مختارة تتعلق بمجرى الهواء، على التوالي .كما كشفت مقابلات أُجريت مع المرضى والشهود عن حوادث متصوَّرة في 5.3%من أصل 3,156حالة .وتقيس هذه النسب مفاهيم مختلفة، ولذلك لا ينبغي دمجها إحصائيًا في تقدير موحد.

الخلاصة :تمتد مشكلات السلامة المبلغ عنها في خدمات الإسعاف والطوارئ قبل الوصول إلى المستشفى لتشمل العمليات السريرية والتشغيلية، مع أهمية دور التواصل، وأنظمة دعم القرار، والتدريب، والتدقيق، وتصميم الأنظمة .وتحد أنظمة الإبلاغ الطوعي عن الحوادث بدرجة كبيرة من إمكانية الاستدلال على معدلات الانتشار، في حين توفر السجلات السريرية والمتابعة المنهجية معلومات مكملة .ولا يمكن استنتاج معدل إجمالي موحد للأخطاء الطبية في خدمات الإسعاف والطوارئ استنادًا إلى الدراسات المختارة.

الكلمات المفتاحية :سلامة المرضى؛ الأخطاء الطبية؛ خدمات الإسعاف والطوارئ؛ الرعاية قبل الوصول إلى المستشفى؛ الأخطاء الدوائية؛ الأحداث الضارة؛ اتخاذ القرارات السريرية؛ مخاطر التحيز؛ المراجعة المنهجية.

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Introduction

Emergency medical services are the first clinical contact for many critically ill or injured patients. Teams must respond to incomplete information, uncontrolled environments, variable patient acuity and tight time constraints while coordinating with dispatchers, bystanders, receiving hospitals and other emergency responders. The safety of prehospital care therefore depends not only on individual clinical skill but also on reliable systems for recognition, treatment, communication, transport and follow-up. Failures at any point may cause unnecessary harm or allow deterioration to go unrecognized [15,16].

Patient safety incidents (PSIs) include reportable circumstances, near misses, events reaching patients without documented harm, and events producing harm. A medical error refers to a failure of a planned action or the use of an incorrect plan; the occurrence of an error, an adverse event and harm are not interchangeable. For example, a weight-based medication dose outside a recommended range may be

classified as an error without documented injury, whereas hypotension following an airway intervention may be an adverse event without evidence that a preventable error occurred. Distinguishing these concepts is indispensable when interpreting prehospital safety statistics [11,15].

Research has identified several high-risk processes in EMS. Pediatric medication administration requires accurate weight estimation, concentration selection and calculations under time pressure; retrospective studies from Michigan reported substantial rates of doses outside prespecified ranges [4,5]. Early diagnostic decisions can also be imperfect. In linked EMS and hospital records, Brandler et al. found that a substantial proportion of hospital-confirmed strokes were not identified as stroke in the field, particularly when presentation was atypical [7]. Airway procedures may involve clinically significant desaturation, aspiration or other complications, although procedure-related adverse physiology cannot automatically be described as preventable operator error [12,13].

The service system is an additional source of risk. National incident analysis has connected reported safety-related deaths with response delays, shortfalls in clinical care and injury during transport [3]. Qualitative research suggests that human performance is affected by the organization of work, technological systems, variable protocols, cognitive load and challenging mission conditions [8]. Non-conveyance decisions illustrate another important safety boundary: registry linkage enables assessment of subsequent reattendance and mortality, but these outcomes must be interpreted in light of illness severity and the absence of randomized allocation [9,10].

Earlier systematic reviews have demonstrated substantial variation in the identification and measurement of PSIs across prehospital settings. O'Connor et al. described higher recorded rates from chart review than from incident reporting, illustrating detection-method effects rather than necessarily true differences in patient risk [15]. A related systematic review of measurement strategies showed that past harm has been assessed more commonly than learning, prospective risk anticipation or resilience [16]. A focused synthesis bringing together incident mechanisms, reported clinical outcomes, and methodological vulnerabilities across recent and established empirical studies may therefore inform safer EMS systems.

The present review examines 14 identifiable original investigations across countries and study designs. It places special emphasis on a disciplined separation of errors, adverse events, incident reports and patient outcomes; evaluates the credibility and relevance of the evidence; and identifies practical risk-reduction priorities. The review is not limited to one EMS jurisdiction and is intended to identify transferable safety lessons while respecting differences between healthcare systems.

1.2. Research Problem and Rationale

Reliable estimates of prehospital patient harm are difficult to produce because reporting systems may capture only selected incidents and because clinical records often lack sufficient detail to judge causation or preventability. Staff may under-report near misses, differences in coding can obscure event types, and retrospective cohorts frequently lack a robust counterfactual. Medication-dose studies may provide precise measurements but focus on a restricted patient group, while incident reports may identify system weaknesses without providing a denominator. These design features prevent straightforward comparison of reported incident frequencies [1–6,15].

A second problem is the tendency to interpret operational or physiologic outcomes as evidence of medical error. Recontact after a non-conveyance decision may reflect appropriate uncertainty or evolving disease rather than a mistake; deterioration during advanced airway care may be attributable to baseline patient severity. Conversely, errors with no recorded harm may still identify high-priority

system vulnerabilities. The review therefore differentiates measurement of process deviations, incident occurrence, harms and outcomes, and explicitly evaluates the risk of selection, reporting, misclassification and confounding.

1.3. Study Objectives

1.3.1. General Objective

To systematically review empirical evidence on patient safety incidents, medical errors, associated harms, measurement approaches, and contributing factors in prehospital emergency medical services.

1.3.2. Specific Objectives

To classify common prehospital safety incident domains, including medication administration, diagnostic recognition, airway management, dispatch, transport and non-conveyance.

To summarize original study-specific incident frequencies, process deviations and patient outcomes without combining incompatible denominators.

To identify human, organizational, technological and communication factors associated with error or unsafe care.

To examine the strengths and weaknesses of incident reports, clinical records, administrative registries, prospective interviews and qualitative evidence.

To appraise methodological concerns and propose patient-safety interventions and research priorities.

1.3.3. Research Questions

What types of patient safety incidents and medical errors are most frequently reported in prehospital EMS research?

What are the study-specific frequencies and consequences of these events, and how do methods affect their measurement?

Which individual and system factors contribute to adverse events, error and near-miss risk?

How credible is the evidence, and which interventions should be prioritized by EMS leaders?

2. Methodology

2.1. Study Design

A structured review of original empirical literature was written to reflect PRISMA 2020 reporting domains [17]. The unit of synthesis was the primary study, not an isolated estimate or publication abstract. Given heterogeneous study designs and outcome definitions, the review employs narrative synthesis and explicit study-by-study tables rather than pooled prevalence estimates. This document distinguishes evidence that could be checked in accessible published records from numerical workflow counts provided in the supplied PRISMA image.

2.2. Search Strategy

The evidence-identification work for this manuscript used publicly accessible biomedical indexing and original publisher pages, focusing on prehospital patient safety, medical errors, incident reporting, medication administration, missed diagnoses, airway complications and non-conveyance. Records

were cross-checked by title, author, year, journal and DOI wherever available. Examples of core concepts were: "prehospital" OR "emergency medical services" OR "paramedic" AND "patient safety" OR "medical error" OR "adverse event" OR "medication error" OR "critical incident" OR "misdiagnosis." The identified studies span peer-reviewed research published from 2012 to September 2026.

The author supplied a PRISMA diagram stating 235 records from databases and 14 studies included. No original database export, date-stamped per-database results, duplicate-resolution log or list of full-text exclusion decisions was supplied. Consequently, the diagram is reproduced for continuity with the requested format but must not be interpreted as evidence that those 235 records were re-created or individually screened for this manuscript.

2.3. Eligibility Criteria

2.3.1. Inclusion Criteria

Original human research conducted in emergency medical services, ambulance care, prehospital emergency response or closely connected critical-care transport.

Quantitative, observational, diagnostic-accuracy, qualitative or mixed-methods designs with direct evidence on safety incidents, errors, adverse events, clinical decision quality or disclosure.

Study outcomes involving documented incidents, dose deviation, clinical safety events, diagnostic recognition, patient-related outcomes or contextual contributors to error.

Sufficient publicly traceable information about the source, design and major findings to allow conservative narrative synthesis.

2.3.2. Exclusion Criteria

Narrative reviews, systematic reviews, commentary, editorials or policy guidance as primary included studies (these were used for context where relevant).

Hospital-only studies without identifiable prehospital relevance.

Studies focusing exclusively on technical effectiveness with no interpretable safety or risk outcome.

Duplicate reports of the same analysis without substantively different questions or outcomes.

One pair of included papers [1,2] uses the same 845-report incident database to answer different questions; it is explicitly treated as overlapping evidence, not as two independent event populations.

2.4. Study Selection Process

The supplied selection figures were: 235 records identified; 115 removed before screening (70 duplicates, 30 automation-ineligible and 15 for other reasons); 120 screened; 40 excluded at title/abstract stage; 80 sought; 18 not retrieved; 62 evaluated for eligibility; 48 excluded by three user-labelled categories (20, 13 and 15); and 14 studies included. Each arithmetic step balances. The "reports of included studies" box in the image was labelled zero, which conflicts with 14 included studies; in the manuscript figure it is therefore corrected to 14 because the 14 listed studies each have an identifiable publication.

The exclusion categories remain named "Reason 1," "Reason 2" and "Reason 3," because the underlying individual exclusion decisions have not been supplied and should not be retrospectively

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invented. Accordingly, this flow is an author-specified representation requiring an audit trail before a claim of fully reproducible systematic screening can be made.

2.5. Data Extraction

For each original study, the following information was entered into a structured summary: authors, year, jurisdiction, study design, sample or event denominator, incident/safety domain, primary numerical findings when reported, and a key limitation. Percentages and confidence intervals are reproduced only where source reports provide them. Where denominators differ (e.g., patients, drug administrations, event reports or ambulance activations), they are kept separate. No new patient-level data were obtained.

2.6. Quality Assessment and Risk of Bias

JBI provides distinct critical appraisal instruments for prevalence studies, analytical cross-sectional studies, cohort studies, qualitative research and quasi-experimental studies [18]. These design-specific principles guided the appraisal. The review considered sampling frame, coverage, outcome validity, confounding, data completeness, response rate, transparent analytical methods and transferability. For interview studies, recruitment, reflexivity and participant representation were emphasized. For before–after training surveys, lack of matched participants and lack of a control group were considered important threats to causal inference.

Table 3 reports a preliminary study-level concerns assessment grounded in the accessible report information. It does not represent a formally completed, independently duplicated item-by-item JBI checklist. Some papers were accessible only in abstract form; therefore “not verifiable” is used where needed instead of inventing yes/no answers. The manuscript does not claim a quantitative JBI score or calibrated low/moderate/high overall risk-of-bias totals that cannot be substantiated from complete appraisal sheets. The review team must perform and archive two independent full-text assessments before journal submission.

2.7. Data Synthesis and Analysis

Findings were grouped into five prespecified interpretive areas: (1) incident detection and reporting; (2) medication safety; (3) diagnostic and clinical decisions; (4) procedural or physiologic harm; and (5) organizational, communication and disclosure factors. Due to substantial clinical and statistical heterogeneity, no meta-analysis, weighted average incidence or causal effect estimate was calculated. Quantitative data are interpreted with study-specific denominators, and qualitative results contribute explanatory rather than prevalence evidence. Reporting followed the principles of synthesis without meta-analysis (SWiM) [19].

2.8. Ethical Considerations

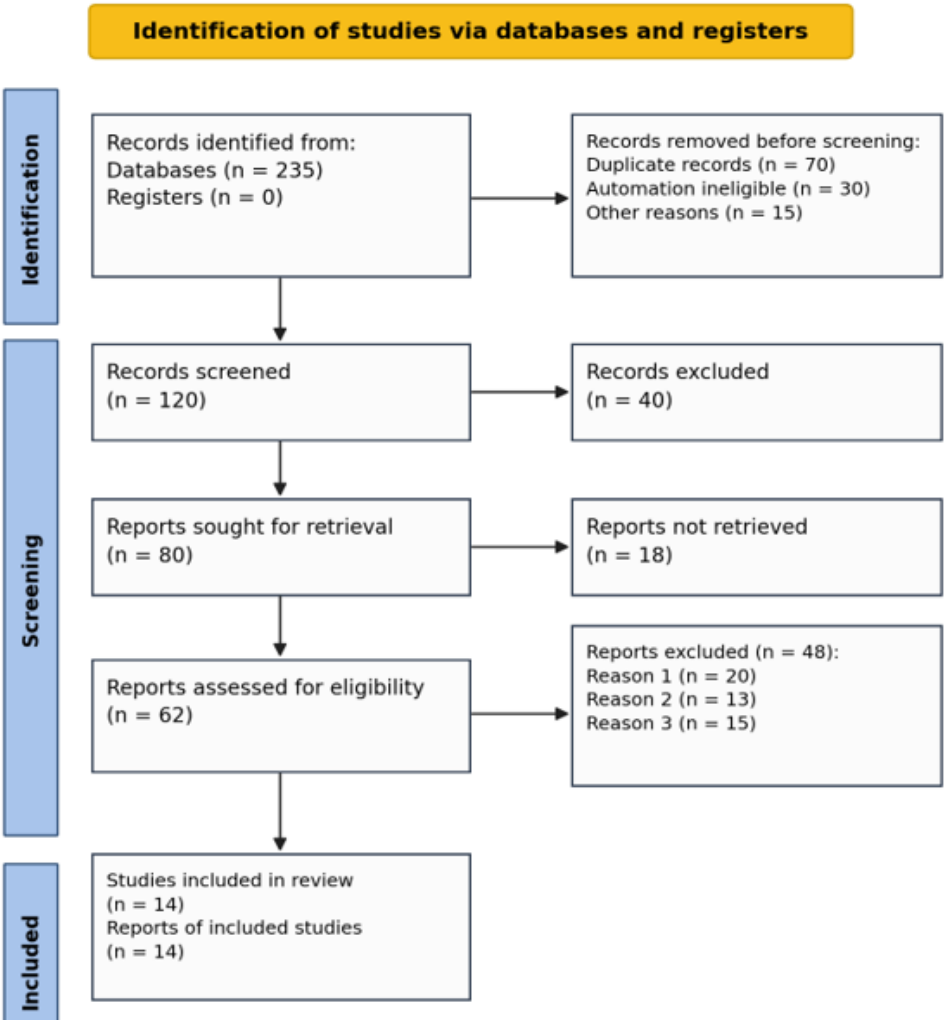
Only publicly available, previously published results were synthesized. No individual patient data were accessed, and no new participant recruitment occurred. Primary study ethical approvals remain the responsibility of the original authors. Protocol registration, if desired for a future prospective update, must occur before that new review begins; registration of this retrospective manuscript cannot be represented as prospective.

3. Results

3.1. Study Selection

The author-provided identification and screening sequence began with 235 database records and no registry records. After removal of 70 duplicates, 30 automatically marked ineligible records and 15 records removed for other reasons, 120 records remained for screening. Forty records were excluded, leaving 80 reports sought for retrieval. Eighteen reports were not retrieved, and 62 reports proceeded to eligibility assessment. Forty-eight were excluded using three numerical categories (20, 13 and 15). Fourteen studies were retained, with 14 corresponding reports (Figure 1).

The counts are internally arithmetically consistent but are not traceable to an original screening log. Thus, Figure 1 records the supplied selection totals rather than an independently audited search process.



- **3.2. Characteristics of Included Studies**

The 14 original publications cover Germany/Austria, England, the United States, Qatar, Finland, Denmark, Spain, France and Canada. Their designs include voluntary incident-database analysis, medication audits, diagnostic record linkage, prospective patient interviews, registry cohorts, prospective procedural studies, qualitative interviews, and training-related mixed methods. The study-specific evidence is summarized in Table 1, with caution about overlapping datasets and differences in denominators.

No. / Study	Location / Design	Population / Outcome	Main finding
1. Hohenstein et al. (2014)	Germany / Austria; Retrospective analysis of voluntary critical-incident reports	845 reports; General patient safety / incident reporting	Staff-related problems accounted for 56% of reports; 82% involved life-threatening or potentially life-threatening situations.
2. Hohenstein et al. (2016)	Germany / Austria; Secondary thematic analysis of incident database	845 reports; 247 communication-related; Communication / medication processes	247 of 845 reports were related to communication failure; included medication and dispatcher communication problems.
3. Yardley & Donaldson (2016)	England; National incident-report database thematic analysis	69 death-associated reports; Dispatch / clinical care / transport	Response delays 41/69 (59%); shortfalls in care 24/69 (35%); transit injury 4/69 (6%).
4. Hoyle et al. (2012)	USA; Retrospective pediatric medication record review	360 administrations in 230 children; Pediatric medication dosing	125/360 administrations deviated by at least 20% from weight-based recommended dose (34.7%; 95% CI 30.0–39.8).
5. Kazi et al. (2024)	USA; Retrospective multicenter pediatric medication audit	1,078 doses in 727 children; Medication safety after dosing reference	380/1,078 doses outside defined dose range (35.2%); reference implementation did not eliminate error.
6. Howard et al. (2022)	Qatar; Retrospective analysis of safety register	3,475 records; Medication-related adverse events	150 records (4.32%) contained 161 medication AEs, of which 12 were classified harmful.
7. Brandler et al. (2015)	USA; Retrospective record linkage; diagnostic accuracy	72,984 transports; 750 confirmed stroke; Missed/incorrect recognition of stroke	EMS correctly identified 468/750 strokes (62%); 282 (38%) were not

			identified as stroke in field.
8. Poranen et al. (2024)	Finland; Qualitative semistructured interviews	15 EMS clinicians and supervisors; Contributors to human error	Themes: changing work environments, organization of work, and individual/cognitive factors.
9. Møller et al. (2025/2026)	Denmark; Registry-based non-conveyance cohort	17,402 non-conveyed patients; Non-conveyance and recontact	Within 48 h: EMS reassessment 4.70%; hospital admission 4.92%; 14 deaths (0.08%).
10. Jensen et al. (2025)	Denmark; Population register cohort	383,611 ambulance dispatches; Distance and non-conveyance decisions	16.6% non-conveyed; odds of non-conveyance for 40–50 km versus 0–10 km OR 1.82.
11. Péculo-Carrasco et al. (2026)	Spain; Prospective multicenter patient/witness interviews	3,156 EMS episodes; Patient-reported safety incidents and harm	166/3,156 incidents (5.3%; 95% CI 4.55–6.08); harm reported in 58/166 (34.9%).
12. Le Bastard et al. (2023)	France; Prospective multicenter intubation cohort	1,915 intubated patients; Airway procedural complications	267/1,915 (14%) experienced complications; difficult airway and operator changes were risk factors.
13. Spigner et al. (2026)	USA; National cross-sectional NEMSIS study	11,525 NMBA airway cases; Physiologic adverse events after airway drugs	27.5% had an adverse physiological event within 10 min; hypoxemia 25.0%, hypotension 15.0%.
14. Krugliak et al. (2024)	Canada; Before–after mixed-methods disclosure training surveys	54 pre; 69 post responses; Incident disclosure and safety culture	All participants supported disclosure; comfort with disclosure increased after training.

Table 1. Characteristics and key findings of 14 original studies included in the structured synthesis.

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3.3. Patient Safety Incident Detection and Reporting

Volunteer and administrative incident systems provide different views of harm. Hohenstein et al. analyzed 845 prehospital critical incident reports submitted through a German-language anonymous system. Staff-related factors contributed to 56% of incidents, and 82% involved patients in potentially life-threatening conditions; however, because the numerator represents voluntarily reported incidents without a complete population denominator, this finding cannot estimate the risk to an average EMS patient [1]. An analysis of the same database identified 247 communication-related reports among 845 incidents. These reports add detail about message acknowledgement, transfer of information, communication with dispatch, and medication-related misunderstandings, but they must not be treated as an independent 845-report sample [2].

Yardley and Donaldson identified 69 reports linked to death from an English ambulance incident system. Delayed response accounted for 41 incidents (59%), shortfalls in clinical care for 24 (35%), and transport injury for four (6%) [3]. These proportions describe the distribution within death-associated reported incidents, not the relative frequency of all preventable EMS deaths. The cases nevertheless indicate priority system interfaces for learning: dispatch escalation, rapid allocation, effective clinical decision-support, and safer patient transport.

Prospective patient or witness follow-up may identify events that are missing from staff incident systems. In a Spanish multicenter study, systematic interviews of 3,156 EMS episodes identified 166 self-reported incidents (5.3%, 95% CI 4.55–6.08); 58 of the 166 reports were associated with perceived harm [11]. The response rate was 40.4%, creating potential nonresponse bias. The value of the study lies in inclusion of non-harm events and an independent patient perspective, not definitive clinical adjudication of preventability.

3.4. Medication Errors and Medication-Related Adverse Events

Two Michigan pediatric studies found notably similar dose-deviation proportions in different study periods. Hoyle et al. assessed 360 selected prehospital medication administrations in children with recorded weights; 125 were outside a prespecified ±20% dose range (34.7%, 95% CI 30.0–39.8) [4]. Kazi et al. reviewed 1,078 medication administrations in 727 pediatric patients after a statewide dosing-reference initiative and reported 380 deviations (35.2%) [5]. The percentages cannot demonstrate a change over time because the studies differ in participating services, measurement details and medication mix. They consistently underscore the risks introduced by infrequent pediatric exposure, weight dependence, concentrations and dose-volume calculations.

Howard et al. examined 3,475 entries in a Qatar ambulance-service patient safety register and identified 161 medication-related adverse events in 150 records (4.32% of records); 12 events were classified as harmful [6]. Failure to administer an indicated medication and administration outside guideline parameters were important identified categories. This result has a different denominator and case definition from pediatric dose-deviation studies; accordingly, comparing 4.32% directly with 34–35% would be misleading. Both datasets support medication reconciliation, dosing aids, closed-loop checks and systematic audit, but neither alone establishes a universal error prevalence across EMS.

3.5. Diagnostic Decision-Making and Non-Conveyance

Brandler et al. linked prehospital reports with a stroke registry for 72,984 transports. Among 750 confirmed stroke cases, EMS recognized 468 and missed 282 (38%) in the field; sensitivity was 62.4% [7]. This reflects the challenge of recognizing atypical presentations and potential shortcomings in

screening practice. A missed prehospital label is a diagnostic-process concern and may lead to delayed pathways, but the study does not mean each missed stroke was a preventable or negligent error.

Two Danish registry studies evaluated safety-relevant patient pathways rather than independently adjudicated error. Møller et al. followed 17,402 patients who were not conveyed after EMS assessment; within 48 hours 4.70% were reassessed by EMS, 4.92% were admitted, and 14 died (0.08%) [9]. Jensen et al. studied 383,611 ambulance dispatches and reported non-conveyance in 16.6%, with longer hospital distance associated with higher odds of non-conveyance (OR 1.82 for 40–50 km versus 0–10 km) [10]. These findings justify structured reassessment triggers, safety-net instructions and linkage of ambulance and hospital data; they do not establish that recontact or mortality was caused by an unsafe non-conveyance decision.

3.6. Airway-Related Safety Events

Airway intervention is high-risk because the clinical procedure may occur in hypoxic and hemodynamically unstable patients. Le Bastard et al. reported complications in 267 of 1,915 prospective prehospital intubations (14%). Complications were associated with difficult laryngoscopy, obesity and the requirement for additional operators, suggesting a role for airway planning, backup devices, physiologic optimization and skills maintenance [12]. The study was based on physician-staffed French mobile intensive care units; direct extrapolation to paramedic-only systems must be cautious.

Spigner et al. evaluated a United States national EMS data sample containing 11,525 neuromuscular-blockade assisted airway cases. At least one physiologic adverse event was recorded in 27.5% within 10 minutes; hypoxemia and hypotension occurred in 25.0% and 15.0%, respectively [13]. Baseline physiologic instability increased post-procedural event risk. Such temporal events are clinically important safety outcomes, but claims of direct causation or preventability require appropriate comparison groups and better adjustment for indication and underlying severity.

3.7. Organizational and Human Factors

In a qualitative Finnish study, Poranen et al. conducted 15 interviews with paramedics and supervisors. Contributors to human error were organized under three major domains: changes in the work environment, organization of work, and factors related to paramedics themselves [8]. These observations support a systems perspective in which workload, protocol clarity, communication, technology and individual cognitive capacity interact. The study provides contextual explanations rather than an estimate of incident frequency.

Safety culture includes how events are disclosed and learned from. In a Canadian before–after study of disclosure training in critical care transport, 54 paramedics responded before training and 69 afterward; perceptions of comfort with disclosure improved, and respondents consistently recognized their professional responsibility to communicate PSIs [14]. The study shows feasibility of training and positive perceptions, but low participation, nonpaired responses and lack of direct observation limit causal inference about actual disclosure behavior or reduction in patient harm.

3.8. Risk of Bias and Methodological Quality

Table 2 presents structured concerns derived from study design, sampling, outcome definition and the available reports. It deliberately avoids assigning an unsupported checklist score. Voluntary incident systems have high selection/ascertainment concerns, linkage cohorts generally have more complete capture but are vulnerable to confounding and proxy misclassification, and interview/survey designs

face nonresponse and recall bias. Prospective measurement of procedural complications can strengthen event capture while still leaving uncertainty about preventability or attribution.

Study	Primary concern / likely direction	Preliminary judgment	Appraisal instrument for full-text audit
Hohenstein et al. (2014)	Voluntary anonymous reports; no exposure denominator; severe-event reporting bias.	High ascertainment concern	JBI prevalence / cross-sectional or case series
Hohenstein et al. (2016)	Shares database with study 1; not an independent sample and cannot be pooled twice.	High ascertainment concern	JBI prevalence / cross-sectional or case series
Yardley & Donaldson (2016)	Death-associated, voluntarily reported incidents only; no population mortality incidence estimate.	High selection concern	JBI prevalence / cross-sectional or case series
Hoyle et al. (2012)	Only children with documented weight and selected medications; no direct measured clinical harm.	Moderate–high selection concern	JBI prevalence / cross-sectional or case series
Kazi et al. (2024)	Retrospective; definition >20% difference; comparison with earlier period not causal.	Moderate ascertainment concern	JBI prevalence / cross-sectional or case series
Howard et al. (2022)	Register capture and reporting completeness uncertain; not equivalent to total medication error incidence.	Moderate–high reporting concern	JBI prevalence / cross-sectional or case series
Brandler et al. (2015)	Hospital-linked stroke registry; alternative clinical classification and setting limits generalizability.	Moderate spectrum concern	JBI diagnostic accuracy

Poranen et al. (2024)	Small purposive qualitative sample; explanatory evidence, not error incidence.	Moderate transferability concern	JBI qualitative
Møller et al. (2025/2026)	Short follow-up; repeat contacts are proxy outcomes, not proof of decision error.	Low–moderate confounding concern	JBI cohort
Jensen et al. (2025)	Observational associations; confounding by severity and rurality, cannot infer error.	Moderate confounding concern	JBI cohort
Péculo-Carrasco et al. (2026)	40.4% interview response; recall and perception differences; not clinician-adjudicated.	Moderate nonresponse concern	JBI prevalence / cross-sectional or case series
Le Bastard et al. (2023)	Operator/workflow context physician-led MICUs; complications not necessarily preventable errors.	Moderate confounding concern	JBI cohort
Spigner et al. (2026)	Temporal association cannot establish preventability or direct medication-caused harm.	Moderate confounding concern	JBI prevalence / cross-sectional or case series
Krugliak et al. (2024)	Small nonpaired voluntary samples (25–30% participation); perception, not observed disclosure/harm.	High self-selection concern	JBI quasi-experimental + qualitative

Table 2. Evidence-grounded preliminary methodological concern for each included original study. Judgments are provisional, not final checklist outcomes.

The most important cross-study methodological concerns were: (i) absence of a known denominator in incident-report datasets; (ii) likely under-reporting and severity-dependent reporting; (iii) clinical heterogeneity and medication-specific dose definitions; (iv) imperfect measurement of error versus harm; (v) baseline case-severity confounding for airway and non-conveyance outcomes; (vi) qualitative

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transferability limits; and (vii) participant nonresponse in surveys. These weaknesses should reduce confidence in simple cross-study rankings and causal claims.

3.9. Narrative Synthesis of Findings

Across the 14 publications, the most consistent conclusion is that prehospital safety is shaped by interdependent clinical decisions, medications, procedural skills, information flow and organizational conditions. The evidence is stronger for identifying specific process vulnerabilities than for estimating the national burden of preventable harm. Pediatric medication audits show reproducible deviations from prescribing references, whereas survey and incident-report results capture a broader set of events. Registry cohorts offer useful follow-up outcomes but not direct proof of error. No single study in this set quantifies the full spectrum of prehospital PSIs, and the outcome definitions prevent meaningful pooled prevalence or mortality estimates.

4. Discussion

4.1. Principal Findings

This synthesis identifies several recurring safety domains in EMS: medication dosing and omission, recognition and triage of time-sensitive conditions, high-risk airway interventions, dispatch delays, non-conveyance, communication failures and incident disclosure. Although clinically distinct, these domains share reliance on rapid decisions under uncertainty, accurate data transfer, standard operating procedures and opportunities for learning. The evidence supports addressing the conditions that make safe performance difficult rather than reducing all errors to individual provider failure [1–14].

Rates are strongly influenced by how safety is defined and detected. A percentage of medication administrations outside a threshold, the proportion of fatal incident reports related to dispatch delay, and the prevalence of patient-perceived incidents are different estimands. Reports with no denominator cannot support patient-level incident prevalence. The earlier systematic review by O'Connor et al. found that chart review generally detected more events than reporting systems, which reinforces the need for multiple complementary surveillance methods [15].

4.2. Medication Safety and Decision Support

The two pediatric medication audits are particularly relevant for targeted improvements. However, a drug-dose deviation should not be equated with actual patient injury. Future programs should measure both calculation/documentation accuracy and clinical outcomes. Protocolized weight assessment, electronic dose calculators, concentration standardization, prefilled preparations, barcode verification where feasible, and two-person checks for high-risk medications are plausible quality-improvement approaches that deserve prospective evaluation. Implementations should avoid shifting cognitive burden into complex interfaces or increasing treatment delay.

4.3. Diagnosis, Non-Conveyance and Continuity of Care

Missed stroke recognition and clinical non-conveyance are distinct but related examples of complex EMS decisions. Field clinicians work with limited diagnostic tools and evolving signs, and uncertainty is unavoidable. Safer systems may include enhanced symptom screening, stroke-team pre-alert criteria, repeat vital signs, clinician consultation for borderline non-conveyance, explicit return precautions, and cross-system patient outcome feedback. Because subsequent admission is not in itself a medical error, audit programs should evaluate appropriateness of the original decision with blinded case review rather than simply counting repeat contacts [7,9,10].

4.4. Human Factors, Communication and Safety Culture

Human factors evidence suggests that risk controls should include team briefings, closed-loop communication, clearer role responsibilities, functional dispatch-to-field handoff, equipment readiness, fatigue-sensitive rostering and regular case reviews. Event reporting should be designed to promote learning and psychologically safe disclosure; it should record near misses as well as harm. Disclosure training may improve confidence but its effect on patient understanding, actual disclosure timeliness and trust needs outcome-based testing [2,8,14].

4.5. Interpretation of Study Quality

The included evidence is not uniformly weak or strong. Population registry linkage improves ascertainment of subsequent care, while prospective interviews add a missing patient perspective. However, neither substitutes for confidential clinical adjudication of preventability. Voluntary systems are useful for uncovering failure modes but cannot provide an unbiased incidence denominator. Qualitative evidence explains how safety threats arise but should not be converted into estimates of frequency. Therefore, confidence should be tied to the exact question each design can answer, not to a generic numerical quality score.

4.6. Implications for EMS Policy and Practice

An integrated EMS safety program should triangulate clinical record review, event reporting, dispatch metrics, pharmacy audits, procedural quality indicators, patient follow-up and hospital-linked outcomes. The system should distinguish avoidable error, unavoidable complication, delayed care and harm severity using reproducible definitions. Regular multidisciplinary review can identify modifiable risk controls, and audit findings should feed back into training, protocols, equipment checks and operational planning. Improvement projects should use run charts or controlled before–after analyses to assess whether safety changes translate into patient benefit.

5. Strengths, Limitations, and Recommendations

5.1. Strengths

The review covers multiple stages of the EMS pathway, includes peer-reviewed original investigations across several health systems, incorporates recent 2025–2026 evidence, separates errors from adverse events and outcomes, and explicitly records denominator differences and methodological vulnerabilities. The citation trail enables independent checking of each included publication.

5.2. Limitations

This evidence synthesis has major limitations. First, the author-provided PRISMA counts have not been reconstructed from primary database searches and selection logs, so the 235-to-14 flow should not be represented as an independently reproducible systematic search. Second, some original full texts were unavailable or only partially reviewed; an item-by-item dual-reviewer JBI assessment therefore remains incomplete. Third, one pair of reports [1,2] analyzes overlapping source data. Fourth, the selected studies span incompatible populations, time periods, health systems and outcome measures. Fifth, causal inference and direct assessment of preventability were uncommon; many events were surrogate outcomes or self-reported experiences. Sixth, the review is not a registered protocol and may be affected by selection choices made during manuscript development.

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5.3. Recommendations

Create common operational definitions for medical error, near miss, no-harm incident, adverse event, preventability and harm severity across EMS datasets.

Implement multimethod safety surveillance: incident reports plus random chart review, dispatch audit, prospective patient follow-up, medication audits and linkage to hospital outcomes.

Prioritize pediatric dose calculation safeguards and periodically audit high-risk medicines, concentrations, omitted medications and protocol compliance.

Standardize high-risk procedure safety checks and monitor both procedural complications and baseline patient physiology.

Strengthen clinical decision support, reassessment and safety-netting for atypical stroke presentations and non-conveyance decisions.

Use confidential multidisciplinary learning reviews that evaluate system contributors and communicate actionable changes to clinicians.

Evaluate interventions with prospective, preferably controlled designs and patient-important endpoints rather than relying only on staff confidence or documentation completeness.

5.4. Requirements Before Submission as a Completed Systematic Review

To convert this manuscript from an evidence-grounded structured draft into a fully reproducible publishable systematic review, the research team must (1) archive dated database search queries and exports showing the 235 unique source records; (2) supply deduplication, title/abstract decisions and the 62 full-text eligibility decisions with explicit exclusion reasons; (3) reconcile the 14 included citations with those full-text decisions; (4) confirm the 14 full texts and record all study-level extraction fields; (5) conduct two independent, design-specific JBI assessments with item-by-item yes/no/unclear judgments and a dispute-resolution process; (6) archive a reproducible synthesis table and protocol deviations; and (7) conduct a final PRISMA 2020 checklist audit. These are substantive verification activities, not merely wording changes.

6. Conclusion

Patient safety incidents and medical errors in prehospital emergency medical services arise across medication administration, diagnostic and transport decisions, complex airway procedures, dispatch and information transfer. Fourteen traceable original studies reveal significant variation in measurement and design, but collectively support a systems-based patient-safety agenda. Medication-dose deviations, missed condition recognition and physiologic procedural events warrant close measurement, while incident-report analyses show opportunities for organizational learning. Robust surveillance should integrate multiple sources and discriminate error from harm. The presented manuscript supplies a fully drafted narrative synthesis and transparent study-level evidence table; formal completion of the systematic review requires validation of author-supplied PRISMA counts and independent full-text appraisal.

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Appendix A. Study-by-Study Appraisal Evidence Log

ID / Source	Evidence supporting judgment	Information requiring confirmation
1. Hohenstein et al. (2014)	Voluntary anonymous reports; no exposure denominator; severe-event reporting bias.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
2. Hohenstein et al. (2016)	Shares database with study 1; not an independent sample and cannot be pooled twice.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
3. Yardley & Donaldson (2016)	Death-associated, voluntarily reported incidents only; no population mortality incidence estimate.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
4. Hoyle et al. (2012)	Only children with documented weight and selected medications; no direct measured clinical harm.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
5. Kazi et al. (2024)	Retrospective; definition >20% difference; comparison with earlier period not causal.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
6. Howard et al. (2022)	Register capture and reporting completeness uncertain; not equivalent to total medication error incidence.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
7. Brandler et al. (2015)	Hospital-linked stroke registry; alternative clinical classification and setting limits generalizability.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
8. Poranen et al. (2024)	Small purposive qualitative sample; explanatory evidence, not error incidence.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution,

		applicability and final inclusion decision.
9. Møller et al. (2025/2026)	Short follow-up; repeat contacts are proxy outcomes, not proof of decision error.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
10. Jensen et al. (2025)	Observational associations; confounding by severity and rurality, cannot infer error.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
11. Péculo-Carrasco et al. (2026)	40.4% interview response; recall and perception differences; not clinician-adjudicated.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
12. Le Bastard et al. (2023)	Operator/workflow context physician-led MICUs; complications not necessarily preventable errors.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
13. Spigner et al. (2026)	Temporal association cannot establish preventability or direct medication-caused harm.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.
14. Krugliak et al. (2024)	Small nonpaired voluntary samples (25–30% participation); perception, not observed disclosure/harm.	Check full text; record JBI item-level evidence, assessor 1 / assessor 2, conflict resolution, applicability and final inclusion decision.

Abbreviations: AE = adverse event; CI = confidence interval; EMS = emergency medical services; JBI = Joanna Briggs Institute; MICU = mobile intensive care unit; NMBA = neuromuscular blocking agent; OR = odds ratio; PSI = patient safety incident; PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.