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Preventing Adverse Drug Events in Emergency Care through Interdisciplinary Collaboration and Digital Health Technologies

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ABSTRACT:

Background: Adverse drug events (ADEs) are an important source of preventable patient harm and healthcare utilization. Emergency departments (EDs) are particularly vulnerable to medication-related problems because treatment decisions must often be made rapidly, with incomplete medication histories and limited opportunities for verification. Although electronic prescribing, clinical decision support, and pharmacist-led interventions have improved selected medication safety processes, their effectiveness depends on how they are integrated into clinical workflows and interdisciplinary practice.

Objective: This narrative review explores how collaboration among emergency physicians, clinical pharmacists, nurses, and health informatics professionals can contribute to the prevention, identification, and management of ADEs in emergency care. It also examines the opportunities and limitations of digital health technologies in supporting safer medication use.

Methods: A narrative approach was adopted to synthesize established evidence and relevant guidance on medication safety in emergency settings. The discussion covers medication-related risks, interdisciplinary responsibilities, electronic health records, computerized provider order entry, clinical decision support, medication reconciliation,

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and emerging artificial intelligence applications. Emphasis was placed on the clinical interpretation of evidence and the practical challenges of implementing these interventions.

Results and Discussion: Medication-related harm in emergency care arises from multiple interacting factors, including incomplete clinical information, prescribing complexity, communication failures, interruptions, and fragmented information systems. Clinical pharmacists can improve medication histories and identify potentially inappropriate treatment, while emergency physicians and nurses provide essential diagnostic, therapeutic, and monitoring expertise. Digital technologies may reduce selected errors by improving access to information and providing targeted safety warnings. However, alert fatigue, inaccurate medication lists, poor usability, and insufficient interoperability can limit their effectiveness. The evidence suggests that combining professional collaboration with well-designed digital systems is promising, although direct evidence of additional benefit from fully integrated models remains limited.

Conclusion: Preventing ADEs in emergency departments requires an approach that connects professional expertise, reliable information systems, and organizational accountability. Future research should evaluate integrated interventions using clinically meaningful outcomes, including preventable patient harm, rather than relying exclusively on prescribing-error rates or process measures.

1. INTRODUCTION

Medication-related harm remains a persistent challenge in modern healthcare, despite improvements in prescribing systems, professional education, and patient safety practices. The consequences extend beyond temporary discomfort or the need to modify treatment. Serious adverse drug events can lead to organ injury, prolonged hospitalization, additional healthcare expenditure, and, in some circumstances, death. The World Health Organization has identified medication-related harm as a global patient safety priority through its Medication Without Harm initiative, which emphasizes the importance of safer practices in high-risk situations, polypharmacy, and transitions of care 1.

Emergency departments occupy a distinctive position within this problem. They function as the entry point for patients with acute illnesses, traumatic injuries, medication toxicity, and complications of chronic disease. Decisions frequently need to be made before a complete medical history is available. A patient presenting with chest pain, for example, may require immediate treatment while the clinical team is still determining whether the patient has recently taken anticoagulants, antiplatelet agents, or other medications that could influence treatment safety.

The emergency care environment also differs from other hospital settings in the intensity and unpredictability of its workflow. Clinicians manage multiple patients simultaneously, respond to sudden deterioration, and regularly experience interruptions. Medication orders may be initiated during resuscitation, modified following laboratory results, and transferred to another clinical team within a relatively short period. Each transition creates opportunities for information loss or misunderstanding.

It is therefore insufficient to view medication errors as isolated failures of individual attention. A prescribing error may originate from an inaccurate medication list, an unsuitable electronic default, a missed laboratory result, or a communication failure between professionals. In many cases, several weaknesses must occur together before a patient experiences harm.

Clinical pharmacists have become increasingly involved in emergency care, contributing expertise in medication selection, dosing, interactions, and reconciliation. At the same time, health informatics has changed the way medication information is collected, displayed, communicated, and used in clinical decisions. Electronic health records, computerized prescribing, and clinical decision support systems can help clinicians recognize risks that might otherwise remain unnoticed.

Yet the introduction of technology does not automatically make medication use safer. A poorly designed electronic system may produce excessive alerts, display outdated medication information, or encourage clinicians to rely on incomplete data. Similarly, placing a pharmacist in an emergency department may have limited impact if the pharmacist is excluded from clinical discussions or lacks timely access to relevant patient information.

These observations suggest that medication safety should be approached as an interdisciplinary and sociotechnical challenge. The effectiveness of any intervention depends not only on its technical or professional components, but also on how those components interact within the clinical environment.

This review examines the mechanisms of medication-related harm in emergency care, the contribution of different healthcare disciplines, and the role of digital technologies in preventing adverse drug events. It also considers implementation barriers, clinical applications, and priorities for future research.

2. NARRATIVE REVIEW METHODOLOGY

This article uses a narrative review framework to integrate clinical, technological, and organizational perspectives on adverse drug event prevention in emergency departments.

The review is informed by established patient safety literature, clinical studies, systematic reviews, and guidance from international healthcare organizations. The principal concepts include adverse drug events, medication errors, emergency department pharmacy services, medication reconciliation, electronic health records, computerized provider order entry, clinical decision support, interdisciplinary collaboration, and health informatics.

A thematic structure was selected because the research question extends beyond the effectiveness of a single intervention. It includes clinical decision-making, professional responsibilities, information management, and the interaction between technology and healthcare delivery.

The literature is discussed according to the following themes: sources of medication-related harm, interdisciplinary prevention strategies, digital medication safety tools, vulnerable patient populations, implementation challenges, and future developments.

Unlike a systematic review, this approach does not aim to identify every eligible study or produce pooled estimates of intervention effectiveness. The interpretation therefore emphasizes clinical relevance, consistency of findings, and practical implications rather than formal evidence grading.

A reproducible database search, including documented search dates, full search strings, and eligibility criteria, should be completed before submission to a journal. This distinction is important to avoid presenting a narrative synthesis as though it were a formally conducted systematic review.

3. UNDERSTANDING ADVERSE DRUG EVENTS IN EMERGENCY DEPARTMENTS

3.1 Definitions and clinical significance

The terms adverse drug event, adverse drug reaction, and medication error are related but should not be used interchangeably.

An adverse drug event refers broadly to injury associated with medication use. An adverse drug reaction is a harmful and unintended response to a medication, generally occurring under appropriate conditions of use. A medication error, in contrast, involves a preventable failure in the medication-use process, which may or may not result in patient injury 2,3.

This distinction has practical implications. A patient who develops gastrointestinal bleeding while taking an appropriately prescribed anticoagulant may experience an adverse drug event without a clearly identifiable prescribing error. Another patient who receives an incorrect insulin dose because of an electronic ordering mistake has experienced a medication error, whether or not hypoglycemia subsequently develops.

The prevention of medication-related harm therefore requires two complementary strategies: reducing errors in medication processes and identifying patients at increased risk of harm even when medications are used appropriately.

3.2 Why emergency departments are particularly vulnerable

Several features of emergency care increase medication safety risks.

First, clinical information is often incomplete. Patients may be unable to recall medication names, may obtain prescriptions from multiple healthcare providers, or may arrive without family members who can confirm their treatment history.

Second, the urgency of emergency treatment limits opportunities for prolonged verification. While medication review is desirable, it must be balanced against the consequences of delaying treatment for time-sensitive conditions.

Third, patients frequently move between care settings. A medication initiated by ambulance personnel may be continued in the emergency department, modified during admission, and changed again at discharge. Without reliable documentation, each transition introduces the possibility of duplication, omission, or inappropriate continuation.

Finally, emergency departments often treat patients with physiological instability. Acute kidney injury, shock, electrolyte disturbances, and changes in consciousness can alter medication requirements within hours.

A medication regimen that was appropriate before arrival may therefore become unsuitable during an acute illness.

3.3 Medication-related emergency presentations

Medication-related harm is not limited to events occurring after treatment begins in the emergency department. Adverse drug events are themselves an important reason for emergency attendance.

Common presentations include bleeding associated with antithrombotic treatment, hypoglycemia related to glucose-lowering medication, excessive sedation, drug-induced hypotension, and electrolyte disturbances.

These presentations may resemble unrelated medical conditions. For example, medication-induced confusion in an older adult may initially be attributed to infection or neurological disease. Similarly, hypotension associated with multiple antihypertensive medications may be difficult to distinguish from dehydration or acute illness without a careful medication history.

Recognizing medication-related causes of emergency presentations is therefore an essential clinical skill.

The diagnostic process benefits from collaboration between emergency physicians, who assess the patient's acute condition, and pharmacists, who can identify pharmacological explanations for clinical findings.

4. INTERDISCIPLINARY COLLABORATION IN MEDICATION SAFETY

4.1 Clinical pharmacists as active members of emergency care teams

The traditional perception of pharmacists as professionals primarily responsible for medication dispensing does not adequately reflect their potential contribution to emergency care.

Clinical pharmacists can participate directly in treatment decisions, particularly when patients require complex or high-risk medications. Their responsibilities may include verifying medication histories, evaluating prescribed doses, identifying interactions, recommending therapeutic alternatives, and supporting medication monitoring.

Research has demonstrated the value of pharmacist involvement in emergency departments. Rothschild and colleagues described medication errors identified and recovered through emergency department pharmacist activities, illustrating the potential of pharmacists to intercept errors before they reach patients 4.

A later systematic review by Cohen and colleagues examined the contribution of clinical pharmacists to emergency department care and identified benefits across medication-related activities 5.

The significance of pharmacist participation extends beyond identifying incorrect prescriptions. Pharmacists can provide an additional perspective during clinical decision-making.

For instance, a patient with severe infection may require immediate antimicrobial treatment. The emergency physician determines the urgency and likely infectious source, while the pharmacist can assist with antimicrobial selection, renal dosing, compatibility, and subsequent adjustment as additional information becomes available.

Such collaboration is especially useful when clinical conditions change rapidly.

4.2 Emergency physicians and medication-related decision-making

Emergency physicians remain central to medication safety because prescribing decisions must be integrated with diagnostic reasoning and immediate treatment priorities.

The safest medication is not necessarily the one with the lowest theoretical risk. In emergency care, the consequences of withholding or delaying treatment must also be considered.

An anticoagulant may carry a risk of bleeding but provide substantial benefit in an appropriately selected patient. Likewise, a sedative may be necessary during a procedure despite the need for close respiratory monitoring.

Medication safety therefore requires balanced clinical judgment rather than an indiscriminate effort to minimize medication use.

Interdisciplinary collaboration strengthens this judgment by making pharmacological expertise available when treatment decisions involve uncertainty or competing risks.

4.3 Nursing responsibilities in medication administration and monitoring

Nurses are directly involved in medication preparation, administration, and monitoring, placing them in a position to detect errors that may not be apparent during prescribing.

Their contribution is particularly important for intravenous medications, continuous infusions, and treatments requiring frequent reassessment.

A medication order may be pharmacologically appropriate but still result in harm if it is administered at an incorrect rate or through an unsuitable route. Nursing verification and monitoring therefore represent essential components of the medication safety process.

Nurses may also be the first professionals to recognize an unexpected adverse response, such as hypotension, respiratory depression, or altered consciousness following medication administration.

Timely communication of these observations allows the clinical team to reassess treatment before further harm occurs.

4.4 The role of health informatics professionals

Health informatics professionals support medication safety by ensuring that clinical information is accurately represented, accessible, and usable.

Their responsibilities may include configuring electronic medication orders, developing clinical decision support rules, improving information exchange, and analyzing medication safety data.

Importantly, their work requires close collaboration with clinical professionals.

A technically accurate alert may still be ineffective if it appears at the wrong stage of care or interrupts a time-sensitive treatment process. Conversely, an alert designed with clinical input may provide the same information in a more useful and actionable form.

Health informatics should therefore be understood as a clinical enabling discipline rather than merely a technical support function.

5. DIGITAL HEALTH TECHNOLOGIES AND MEDICATION SAFETY

5.1 Electronic health records and access to medication information

Electronic health records (EHRs) have changed the way clinicians access medication histories, laboratory results, allergies, and previous treatment decisions. In emergency departments, where time and information are frequently limited, having these data available in one system can support safer prescribing.

However, access to information should not be confused with information accuracy. An electronic medication list may contain discontinued prescriptions, duplicate entries, or medications that the patient has never taken. These problems are particularly relevant to patients receiving care from multiple hospitals or outpatient providers.

A practical example involves an older patient arriving with dizziness and hypotension. The electronic record lists several antihypertensive medications, but the patient has recently received a dose adjustment at another clinic. Unless the information is verified, the emergency team may base treatment decisions on an outdated regimen.

This illustrates why medication history verification remains a clinical responsibility even in highly digitalized hospitals.

Health informatics professionals can improve information reliability by supporting data exchange, identifying duplicate records, and designing interfaces that distinguish active, discontinued, and unverified medications.

5.2 Computerized provider order entry

Computerized provider order entry (CPOE) systems allow clinicians to prescribe medications electronically through standardized ordering interfaces.

Their benefits include improved order legibility, structured dose entry, reduced transcription requirements, and the opportunity to integrate medication safety checks into the prescribing process.

In a landmark hospital-based study, Bates and colleagues reported a 55% reduction in nonintercepted serious medication errors following implementation of computerized physician order entry. However, the observed reduction in preventable adverse drug events was not statistically significant, and the additional team intervention did not demonstrate a further benefit beyond CPOE in that study 6. PubMed +1

These findings demonstrate both the potential and the limitations of electronic prescribing. Reducing medication errors is an important achievement, but evidence of improved prescribing processes should not automatically be interpreted as evidence of reduced patient injury.

Furthermore, CPOE can introduce new types of errors. Clinicians may select an incorrect medication from a list of similarly named products, choose an unsuitable default dose, or unintentionally prescribe for the wrong patient.

The design of electronic prescribing systems should therefore be evaluated continuously, with particular attention to medication selection, dose defaults, patient identification, and high-risk orders.

5.3 Clinical decision support systems

Clinical decision support systems (CDSS) provide patient-specific recommendations or warnings intended to improve clinical decisions.

Medication-related decision support may include drug interaction screening, allergy alerts, renal dose adjustment recommendations, therapeutic duplication warnings, and monitoring reminders.

In emergency care, these functions can be especially valuable when prescribing decisions involve rapidly changing clinical information.

For example, a patient presenting with severe infection may require immediate antimicrobial therapy while laboratory results indicate impaired renal function. A decision support system can potentially identify the need for dose adjustment and present relevant information at the point of prescribing.

Nevertheless, the effectiveness of CDSS depends on its ability to distinguish clinically important warnings from low-priority information.

An excessive number of alerts can interrupt workflow and contribute to alert fatigue. Over time, clinicians may become accustomed to overriding warnings, including those that identify genuine risks.

The challenge is therefore not simply to increase the number of safety alerts, but to improve their clinical relevance.

Pharmacists and emergency physicians should participate in defining alert thresholds, while health informatics professionals should evaluate system performance, override patterns, and usability.

5.4 Medication reconciliation and care transitions

Medication reconciliation is one of the most important opportunities for preventing medication-related problems during emergency care.

The process involves establishing an accurate medication history, comparing it with current treatment orders, identifying discrepancies, and communicating intended medication changes.

Emergency departments face particular difficulties because patients may be admitted, transferred, or discharged before a complete medication history is obtained.

Kwan and colleagues examined medication reconciliation during transitions of care and found that pharmacist involvement was common among evaluated interventions. However, reconciliation alone did not consistently reduce subsequent hospital utilization, suggesting that it may be more effective when combined with broader transition-of-care strategies 7. PubMed

This finding is clinically relevant. Identifying a medication discrepancy is useful, but the benefit may be limited if the corrected information is not communicated to the next healthcare provider or understood by the patient.

The World Health Organization similarly emphasizes structured processes, workforce capability, information availability, patient participation, and measurement as important elements of safer medication transitions 8. منظمة الصحة العالمية

An integrated approach should therefore connect medication reconciliation with discharge counseling, updated medication lists, and communication with outpatient providers.

5.5 Barcode medication administration and smart infusion pumps

Barcode medication administration systems can provide an additional verification step by matching patient identification and medication information before administration.

In emergency departments, such systems may be particularly useful for high-risk medications and situations involving frequent medication administration.

However, barcode scanning does not eliminate the need for professional judgment. A correctly scanned medication may still be inappropriate for the patient's condition or prescribed at an unsuitable dose.

Similarly, smart infusion pumps can support safer intravenous medication administration through predefined drug libraries and dose limits.

Their effectiveness depends on appropriate configuration, regular library updates, staff training, and consistent use.

These technologies should be considered complementary safety mechanisms rather than substitutes for clinical assessment.

6. HIGH-RISK MEDICATION MANAGEMENT

High-risk medications deserve particular attention because errors involving them may produce serious harm even when the frequency of error is relatively low.

In emergency departments, anticoagulants, insulin, opioids, sedatives, concentrated electrolytes, and vasoactive medications commonly require additional safeguards.

6.1 Anticoagulants and antithrombotic therapy

Anticoagulants present a difficult balance between therapeutic benefit and bleeding risk.

Emergency clinicians may encounter patients who require anticoagulation for an acute condition, as well as patients presenting with bleeding complications related to existing treatment.

Accurate medication histories are essential because the type of anticoagulant, dose, timing of the last administration, kidney function, and concurrent medications may influence treatment decisions.

Clinical pharmacists can assist with identifying interactions, reviewing dose appropriateness, and supporting reversal strategies according to institutional protocols.

Digital systems can contribute by displaying relevant laboratory results and previous prescriptions, although missing or outdated information may reduce their reliability.

6.2 Insulin and glucose-lowering medications

Insulin-related errors can lead to significant hypoglycemia or hyperglycemia.

Emergency patients may have variable oral intake, acute kidney dysfunction, or rapidly changing glucose concentrations. These factors can make standard medication regimens inappropriate during acute illness.

Electronic prescribing templates may improve consistency, but inappropriate default doses can create risks if they are not adapted to the patient's condition.

Safe insulin use requires coordinated prescribing, pharmacy review when indicated, nursing verification, and appropriate glucose monitoring.

6.3 Opioids and sedatives

Opioids and sedatives are frequently used for pain control, procedural sedation, and management of agitation.

Their safe use requires careful consideration of respiratory status, previous medication exposure, age, and concurrent central nervous system depressants.

The involvement of multiple disciplines is particularly important during procedural sedation, when medication administration and physiological monitoring occur simultaneously.

Electronic documentation can improve the recording of administered doses and monitoring observations, but immediate clinical assessment remains essential.

7. MEDICATION SAFETY IN VULNERABLE POPULATIONS

7.1 Older adults and polypharmacy

Older adults frequently present with multiple chronic conditions and complex medication regimens.

Polypharmacy increases the possibility of drug interactions, therapeutic duplication, and medication-related symptoms that may be mistaken for new disease.

Age-related changes in kidney function, body composition, and pharmacodynamic sensitivity may further increase susceptibility to medication harm.

A collaborative approach can help identify medications contributing to acute presentations while ensuring that necessary treatments are not withheld unnecessarily.

Digital tools may assist by highlighting potentially inappropriate medications, but recommendations should be interpreted in relation to the patient's condition and treatment goals.

7.2 Patients with renal or hepatic impairment

Acute changes in organ function are common during emergency illness.

Medications that are normally well tolerated may accumulate when renal clearance decreases, while hepatic dysfunction may alter metabolism or increase sensitivity to certain drugs.

Clinical pharmacists can support individualized dose adjustment, particularly for renally eliminated antimicrobials and other medications requiring careful monitoring.

Decision support systems may improve the visibility of abnormal laboratory values, although automated recommendations should account for the limitations of estimated kidney function during rapidly changing acute illness.

7.3 Critically ill patients

Critically ill patients often receive multiple intravenous medications, continuous infusions, and rapidly changing treatment regimens.

In these situations, medication safety depends on accurate communication, standardized concentrations, appropriate infusion devices, and frequent reassessment.

The need for immediate treatment may limit the feasibility of conventional medication verification procedures.

Hospitals should therefore establish emergency-specific safeguards that preserve treatment speed while reducing avoidable medication risks.

8. ARTIFICIAL INTELLIGENCE AND PREDICTIVE ANALYTICS

Artificial intelligence has introduced new possibilities for medication safety, particularly through predictive analytics and automated analysis of clinical data.

Potential applications include identifying patients at high risk of adverse drug events, detecting unusual prescribing patterns, prioritizing medication reviews, and supporting clinical surveillance.

For example, a predictive model could combine age, kidney function, medication burden, and previous adverse reactions to identify patients who may benefit from early pharmacist assessment.

Such an approach may be useful in emergency departments where pharmacist resources are limited and patient volumes are high.

However, the clinical value of AI depends on more than predictive accuracy.

A model may perform well in the population used for its development but become less reliable when applied to another hospital with different patients, prescribing practices, or electronic systems.

There are also concerns regarding transparency, data quality, algorithmic bias, and automation bias. Clinicians may place excessive confidence in computer-generated recommendations, particularly when those recommendations are presented without an explanation of uncertainty.

For these reasons, AI should be implemented as a supportive clinical tool, with clear professional oversight and prospective evaluation.

The strongest future applications may be those that integrate predictive information into existing interdisciplinary workflows rather than creating additional standalone alerts.

9. DEVELOPING AN INTEGRATED INTERDISCIPLINARY MEDICATION SAFETY MODEL

The preceding evidence suggests that medication safety interventions should not be implemented as independent activities. A pharmacist-led medication review, an electronic prescribing system, and a clinical decision support alert may each address specific risks. However, their effectiveness may be reduced when they operate without clear coordination.

An integrated model should connect clinical responsibilities with the flow of medication information throughout the emergency encounter.

9.1 Stage one: Initial medication risk assessment

Medication safety assessment should begin as early as clinically feasible, particularly for patients with complex medication histories or suspected medication-related presentations.

Emergency physicians and nurses can identify immediate clinical risks during triage and initial assessment. Electronic records may provide information about previous prescriptions, allergies, and recent healthcare encounters.

Patients at increased risk may be prioritized for pharmacist review. Examples include older adults with polypharmacy, patients receiving anticoagulants or insulin, individuals with renal impairment, and patients presenting with suspected adverse drug reactions.

This approach may help allocate limited pharmacist resources to patients most likely to benefit from additional assessment.

9.2 Stage two: Collaborative medication decision-making

Following initial assessment, medication decisions should incorporate the relevant expertise of the clinical team.

Emergency physicians determine treatment priorities and select appropriate therapeutic strategies. Clinical pharmacists assess medication-related risks, including dose appropriateness, interactions, and necessary monitoring.

Nurses contribute information about administration feasibility, patient response, and practical treatment considerations.

Digital systems support this process by making laboratory results, allergy information, medication histories, and relevant clinical warnings available at the point of care.

The objective is to create a coordinated decision-making process without introducing unnecessary delays.

9.3 Stage three: Medication administration and monitoring

Medication safety responsibilities continue after a prescription has been issued.

Nurses verify and administer medications, monitor clinical responses, and communicate unexpected findings. Pharmacists may provide additional guidance regarding infusion compatibility, administration rates, and medication monitoring.

Electronic medication administration records, barcode systems, and smart infusion pumps may strengthen these activities when implemented appropriately.

However, these tools must be supported by clear procedures for emergencies, equipment failure, and situations requiring immediate treatment.

9.4 Stage four: Medication reconciliation and discharge communication

Before discharge or transfer, the clinical team should ensure that medication changes are accurately documented and communicated.

This includes identifying medications that should be continued, discontinued, temporarily withheld, or modified.

Patients should receive understandable instructions about their medications, particularly when treatment changes are complex.

Electronic discharge documentation can support continuity of care, but the information must be accurate and accessible to subsequent healthcare providers.

9.5 Stage five: Continuous safety evaluation

Medication safety programs require ongoing evaluation rather than one-time implementation.

Quality teams, pharmacists, emergency clinicians, and health informatics specialists should periodically review medication-related incidents, system alerts, prescribing patterns, and patient outcomes.

The purpose of evaluation should be to identify system weaknesses and opportunities for improvement rather than simply attributing errors to individual professionals.

10. PROPOSED FRAMEWORK FOR EMERGENCY DEPARTMENT MEDICATION SAFETY

The following framework is proposed as a practical synthesis of the evidence and concepts discussed in this review. It has not been independently validated as a clinical intervention.

Stage	Clinical pharmacy	Emergency medicine	Health informatics
Initial assessment	Identify medication-related risks	Establish diagnosis and treatment urgency	Provide medication and allergy information
Prescribing	Review doses, interactions, and contraindications	Select and authorize treatment	Support electronic prescribing and alerts
Administration	Advise on preparation and compatibility	Assess treatment response	Maintain electronic medication records

Stage	Clinical pharmacy	Emergency medicine	Health informatics
Monitoring	Evaluate drug-related complications	Manage clinical deterioration	Support laboratory and safety notifications
Discharge	Perform targeted medication reconciliation	Finalize treatment and follow-up	Support accurate discharge documentation
Quality improvement	Analyze medication-related incidents	Review clinical outcomes	Evaluate system performance and alert effectiveness

Nursing responsibilities extend across assessment, administration, monitoring, patient education, and transitions of care and should be incorporated into each operational stage.

The proposed framework emphasizes that medication safety is a continuous process rather than a single verification step.

11. IMPLEMENTATION CHALLENGES AND ORGANIZATIONAL CONSIDERATIONS

11.1 Staffing and resource limitations

The availability of clinical pharmacists varies considerably across emergency departments.

Some hospitals have dedicated emergency pharmacy services, while others rely on centralized pharmacy teams that provide support remotely or during limited hours.

Consequently, interventions that are effective in large academic hospitals may not be directly transferable to smaller institutions.

A practical approach may involve prioritizing high-risk patients and high-alert medications while gradually expanding pharmacist participation according to available resources.

11.2 Interoperability and information fragmentation

Medication information is frequently distributed across different healthcare organizations and electronic platforms.

A patient may receive prescriptions from primary care, specialist clinics, private hospitals, and community pharmacies. When these systems do not communicate effectively, emergency clinicians may be unable to obtain a complete treatment history.

Improving interoperability can support safer prescribing, but technical connectivity alone is insufficient. Medication records must also be accurate, appropriately standardized, and clearly identified as verified or unverified.

11.3 Alert fatigue

Clinical decision support systems may generate large numbers of warnings, many of which have limited clinical significance.

When alerts are excessively frequent, clinicians may begin to override them routinely. This creates the possibility that important warnings will receive insufficient attention.

Health informatics teams should work with pharmacists and emergency physicians to refine alert thresholds, reduce unnecessary interruptions, and evaluate whether alerts lead to meaningful changes in clinical practice.

11.4 Professional communication and organizational culture

Interdisciplinary collaboration depends on communication, mutual respect, and clearly defined responsibilities.

Medication safety may be compromised when professionals hesitate to question a prescribing decision or when concerns are not communicated promptly.

Hospitals should encourage a culture in which medication-related concerns can be raised constructively, regardless of professional hierarchy.

Regular case discussions and multidisciplinary review of medication incidents may help identify recurring problems and improve teamwork.

11.5 Technology-related unintended consequences

Digital systems may introduce new errors even while reducing traditional prescribing problems.

Examples include incorrect patient selection, inappropriate default doses, duplicate electronic orders, and incomplete transfer of medication information between systems.

These risks reinforce the importance of evaluating digital interventions under real clinical conditions.

Technology should support professional judgment and clinical workflow rather than create additional complexity.

12. MEASURING THE EFFECTIVENESS OF MEDICATION SAFETY INTERVENTIONS

A major challenge in medication safety research is the selection of appropriate outcomes.

Many studies evaluate medication discrepancies, pharmacist interventions, prescribing errors, or alert acceptance rates. Although these indicators are useful, they do not necessarily demonstrate that patients experience less harm.

For example, an increase in pharmacist interventions may indicate improved detection of medication-related problems rather than deterioration in prescribing quality.

Similarly, a reduction in electronic alerts may reflect improved system configuration, but it could also result from disabling warnings that were clinically important.

A comprehensive evaluation should therefore include several outcome categories.

Outcome category	Suggested indicators
Medication process outcomes	Prescribing errors, reconciliation discrepancies, administration errors
Clinical outcomes	Preventable ADEs, medication-related deterioration, clinically significant hypoglycemia or bleeding
Technology performance	Alert acceptance, override rates, inappropriate alerts, system-related errors
Interdisciplinary performance	Timeliness of pharmacist review, intervention acceptance, communication completeness
Patient outcomes	Medication-related return visits, readmissions, patient understanding of discharge medications
Operational outcomes	Time to treatment, pharmacist workload, intervention costs

Indicators should be interpreted with appropriate adjustment for patient complexity, clinical workload, and changes in incident reporting.

Importantly, interventions intended to improve safety should also be assessed for unintended delays in urgent treatment.

13. FUTURE RESEARCH DIRECTIONS

Although considerable research has examined pharmacist interventions and digital medication safety systems, several important questions remain unanswered.

First, future studies should investigate the combined effect of interdisciplinary collaboration and digital technologies. Much of the existing evidence evaluates individual interventions, making it difficult to determine whether integrated approaches provide additional benefits.

Second, greater attention should be given to clinically meaningful outcomes. Reductions in medication errors are valuable, but studies should also assess preventable patient harm, treatment complications, and medication-related healthcare utilization.

Third, research should explore how medication safety programs can be implemented in hospitals with different staffing models and levels of digital maturity.

This is particularly relevant to healthcare systems undergoing digital transformation, where electronic records and decision support technologies may be introduced before multidisciplinary workflows are fully established.

Fourth, artificial intelligence applications require rigorous prospective evaluation. Predictive models should be assessed not only for accuracy but also for their influence on clinician behavior, patient outcomes, and healthcare equity.

Finally, future studies should examine the sustainability and economic implications of integrated medication safety programs. Demonstrating clinical benefit is essential, but healthcare organizations also need evidence regarding staffing requirements, implementation costs, and long-term effectiveness.

14. STRENGTHS AND LIMITATIONS OF THIS NARRATIVE REVIEW

This review brings together three perspectives that are often examined separately: emergency medicine, clinical pharmacy, and health informatics.

Its principal strength is the emphasis on how professional responsibilities and digital systems interact during the medication-use process. Rather than treating technology as an independent solution, the discussion considers the clinical and organizational conditions necessary for effective implementation.

However, several limitations should be acknowledged.

First, the narrative approach does not provide the exhaustive study identification or formal risk-of-bias assessment associated with systematic reviews. Selection bias in the literature discussed is therefore possible.

Second, the studies included in the discussion vary in design, patient populations, interventions, and measured outcomes. This heterogeneity limits direct comparisons.

Third, evidence from general inpatient settings may not be fully applicable to emergency departments, where clinical urgency and workflow differ substantially.

Fourth, some proposed strategies, particularly those involving artificial intelligence and integrated digital workflows, remain insufficiently evaluated in prospective clinical studies.

These limitations should be considered when interpreting the recommendations.

15. CONCLUSION

Adverse drug events remain an important challenge in emergency care because medication decisions are frequently made under conditions of urgency, uncertainty, and incomplete clinical information.

The available evidence indicates that clinical pharmacists can contribute to safer medication use through medication review, reconciliation, dose optimization, and identification of potentially harmful prescribing decisions. Emergency physicians and nurses provide essential diagnostic, therapeutic, administration, and monitoring expertise, while health informatics professionals support the availability and effective use of clinical information.

Digital technologies, including electronic health records, computerized provider order entry, and clinical decision support systems, offer opportunities to reduce selected medication errors. Nevertheless, their effectiveness depends on data quality, usability, clinical relevance, and integration into existing workflows.

The central implication of this review is that medication safety should be approached as a shared clinical and organizational responsibility. Professional collaboration and digital technologies are complementary, but neither should be considered sufficient in isolation.

Future efforts should focus on developing integrated medication safety programs, evaluating their impact on preventable patient harm, and adapting successful approaches to different emergency care environments.

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