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Reducing Medication Errors in Respiratory Care through Integrated Patient Registration and Pharmacy Verification Systems

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ABSTRACT: Medication errors remain a major challenge to patient safety and healthcare quality. Respiratory care is particularly vulnerable because patients frequently receive multiple inhaled, nebulized, oral, and intravenous medications, often during acute or rapidly changing clinical conditions. Errors involving patient identification, medication reconciliation, prescribing, dispensing, verification, administration, and monitoring can result in treatment failure, adverse drug events, prolonged hospitalization, and increased healthcare costs. Integrating patient registration systems with pharmacy verification and respiratory care workflows offers an opportunity to establish a closed-loop medication management process. This review examines the role of integrated patient registration, electronic health records (EHRs), computerized provider order entry (CPOE), clinical decision support systems (CDSS), pharmacist verification, electronic medication administration records (eMAR), and barcode medication administration (BCMA) in reducing medication errors associated with respiratory care. Particular attention is given to accurate patient identification, medication reconciliation, therapeutic duplication, allergy screening, dose and route verification, interdisciplinary communication, and bedside medication administration. The proposed integrated model connects registration personnel, physicians, pharmacists, nurses, and respiratory therapists through a shared electronic information environment. Successful implementation requires interoperability, standardized workflows, appropriate clinical alerts, professional training, human-factors engineering, and continuous quality monitoring. Integrating patient registration with pharmacy verification can establish multiple safety barriers throughout the medication-use process and potentially reduce preventable medication-related harm in respiratory care.

1. INTRODUCTION

Medication safety is one of the fundamental components of healthcare quality. Medication errors can occur during prescribing, transcription, dispensing, preparation, administration, and monitoring. The World Health Organization (WHO) has recognized medication-related harm as an important global patient-safety problem and has promoted system-level interventions through the Medication Without Harm initiative.

Medication errors are generally not attributable to a single healthcare professional. Instead, they frequently develop from weaknesses in interconnected healthcare processes. Inaccurate patient registration, incomplete medication histories, inappropriate prescribing, failure to recognize allergies or interactions, dispensing mistakes, communication failures, and incorrect medication administration may combine to produce preventable patient harm.

Respiratory care represents an important environment for medication-safety interventions. Patients with asthma, chronic obstructive pulmonary disease (COPD), pneumonia, acute respiratory failure, pulmonary infections, and other respiratory disorders may receive several medications simultaneously. These include short- and long-acting bronchodilators, inhaled corticosteroids, systemic corticosteroids, anticholinergic medications, antibiotics, mucolytics, and other supportive therapies.

Some respiratory medications are administered directly by respiratory therapists, whereas others are administered by nurses. Pharmacists review and dispense medications, while physicians and other authorized practitioners prescribe therapy. Consequently, respiratory medication management is inherently multidisciplinary.

An integrated information system connecting patient registration, prescribing, pharmacy verification, medication administration, and respiratory monitoring may provide multiple opportunities to identify errors before they reach the patient.

2. MEDICATION ERRORS IN RESPIRATORY CARE

Medication errors in respiratory care may involve the wrong patient, medication, dose, concentration, frequency, route, formulation, or administration time. They may also involve therapeutic duplication, drug interactions, allergy-related errors, inappropriate treatment duration, or failure to discontinue medications when they are no longer indicated.

Respiratory medications create additional challenges because the same active medication may be available in different formulations and delivery systems.

For example, bronchodilators can be delivered using metered-dose inhalers, dry-powder inhalers, soft-mist inhalers, or nebulizers. Combination inhalers may contain two or three pharmacologically active ingredients. Without careful medication reconciliation, clinicians may inadvertently prescribe another medication containing the same therapeutic component.

Patients admitted to hospitals may also be unable to accurately identify their outpatient inhalers. Some recognize medications by device appearance rather than medication name. This can contribute to incomplete medication histories and unintentional duplication.

Errors involving respiratory medications can therefore originate before a prescription is written and continue throughout the medication-use pathway.

3. PATIENT REGISTRATION AND MEDICATION SAFETY

Patient registration represents the beginning of the electronic patient journey.

Although registration is often considered an administrative process, inaccurate registration can have significant clinical consequences. Incorrect patient selection, duplicate medical records, inaccurate demographic information, and mismatched patient identifiers can affect subsequent prescribing, laboratory testing, pharmacy verification, and medication administration.

Healthcare organizations should use standardized patient-identification procedures and unique patient identifiers.

Registration information should connect reliably with the electronic health record so that clinicians can access the correct patient's allergies, diagnoses, previous medication history, laboratory findings, previous encounters, and active prescriptions.

Accurate patient identification therefore represents the first safety barrier in an integrated medication management system.

4. MEDICATION RECONCILIATION

Medication reconciliation is a structured process for developing an accurate medication list and comparing it with medications ordered during admission, transfer, and discharge.

The process is particularly important in respiratory care.

A patient with COPD, for example, may already use a long-acting beta$_2$-agonist, long-acting muscarinic antagonist, inhaled corticosteroid, and short-acting rescue inhaler. If these medications are not accurately documented during registration and admission, additional prescriptions could result in therapeutic duplication.

An effective medication reconciliation process should capture medication name, strength, dose, frequency, route, indication when appropriate, and last known use. Allergies and clinically significant previous adverse drug reactions should also be documented.

Pharmacists can play an important role in verifying medication histories, particularly for patients receiving multiple medications or complex inhaled therapies.

The World Health Organization emphasizes medication reconciliation during transitions of care as an important strategy for preventing medication discrepancies and medication-related harm.

5. COMPUTERIZED PROVIDER ORDER ENTRY

Computerized provider order entry allows clinicians to enter medication orders directly into electronic healthcare systems.

Compared with handwritten prescriptions, CPOE can improve medication-order legibility, completeness, and standardization.

Respiratory medication orders should clearly identify:

- medication name;
- dose;
- concentration;
- formulation;
- route;
- frequency;
- indication when appropriate;
- duration when relevant; and
- specific respiratory delivery method.

Standardized respiratory order sets may further reduce variation in prescribing.

For example, an electronic COPD exacerbation order set could provide structured options for bronchodilators, corticosteroids, oxygen-related orders, and appropriate monitoring while still allowing clinicians to individualize treatment according to the patient's clinical condition.

However, electronic prescribing does not eliminate medication errors. Incorrect selections, inappropriate defaults, and duplicate orders can occur within computerized systems. Consequently, pharmacist review remains an important safety component.

6. CLINICAL DECISION SUPPORT SYSTEMS

Clinical decision support systems can automatically analyze medication orders against information stored in the patient's electronic record.

Potential CDSS functions include allergy checking, drug–drug interaction screening, therapeutic duplication detection, dose-range checking, contraindication identification, and laboratory-related alerts.

For respiratory patients, clinical decision support could identify situations such as simultaneous orders for medications containing overlapping bronchodilator components.

CDSS may also warn clinicians about a medication that conflicts with a documented allergy or important clinical condition.

Nevertheless, excessive low-value alerts can cause alert fatigue. Clinicians who receive numerous clinically insignificant warnings may override alerts without adequately reviewing them.

Healthcare organizations should therefore prioritize clinically meaningful alerts and continuously evaluate alert performance.

7. PHARMACY VERIFICATION

Pharmacy verification represents a central safety checkpoint between prescribing and medication administration.

After an electronic medication order is submitted, the pharmacist should evaluate the order together with relevant patient information.

The verification process may include assessment of:

Patient identity: confirmation that the medication is associated with the correct patient.

Medication appropriateness: evaluation of whether the medication is appropriate for the documented indication.

Dose: assessment of dose suitability according to patient-specific factors.

Route: confirmation that the prescribed delivery route is appropriate.

Frequency: evaluation of administration interval.

Allergies: assessment of documented allergies and previous reactions.

Interactions: identification of clinically important drug–drug or drug–disease interactions.

Therapeutic duplication: identification of overlapping medications.

Monitoring requirements: assessment of relevant clinical or laboratory parameters.

If the pharmacist identifies a potential problem, the medication order can be temporarily held while clarification is obtained from the prescriber.

This provides an important opportunity to intercept medication errors before medication preparation or administration.

8. INTEGRATION BETWEEN REGISTRATION AND PHARMACY SYSTEMS

The greatest potential benefit occurs when registration and pharmacy systems operate as components of the same information environment rather than as isolated systems.

Patient information entered during registration should automatically become available within the pharmacy information system.

Similarly, allergies, medication histories, diagnoses, laboratory results, and active medication orders should be accessible to pharmacists when clinically relevant.

This integration reduces repeated manual data entry and decreases opportunities for transcription errors.

The ideal workflow can be represented as:

Patient Registration → Patient Identification → Medication Reconciliation → Electronic Prescribing → Clinical Decision Support → Pharmacy Verification → Medication Dispensing → Respiratory/Nursing Administration → Monitoring → Electronic Documentation.

Each stage provides an additional opportunity to prevent an error from reaching the patient.

9. ROLE OF RESPIRATORY THERAPISTS

Respiratory therapists occupy an important position in medication safety because they frequently administer inhaled and nebulized medications.

Before medication administration, the respiratory therapist should verify the patient, medication, dose, route, frequency, and timing against the verified electronic order.

Respiratory therapists also provide a clinical assessment immediately before and after therapy.

Depending on the medication and clinical situation, monitoring may include respiratory rate, breath sounds, oxygen saturation, heart rate, work of breathing, treatment response, and adverse reactions.

This information should be documented electronically so that pharmacists, physicians, and nurses can access the patient's response to therapy.

Respiratory therapists therefore serve not only as medication administrators but also as an important clinical safety checkpoint.

10. BARCODE MEDICATION ADMINISTRATION

Barcode medication administration provides another layer of protection at the point of care.

The healthcare professional scans the patient's identification wristband and medication barcode before administration. The system compares these identifiers with the active medication order.

BCMA can support verification of several fundamental medication-administration rights, particularly the correct patient, medication, dose, route, and time.

When integrated with an electronic medication administration record, administration can also be automatically documented.

Barcode technology is especially useful in environments where multiple medications are administered during a single respiratory treatment.

However, organizations should monitor barcode workarounds, unreadable labels, missing barcodes, and system downtime because these can weaken the intended safety benefits.

11. PROPOSED INTEGRATED SAFETY FRAMEWORK

The following framework summarizes the principal stages of an integrated medication-safety system for respiratory care.

Stage	Safety Intervention	Primary Error Addressed	Main Professional(s)	Suggested KPI
Patient registration	Unique patient identification and demographic verification	Wrong-patient and duplicate-record errors	Registration staff	Duplicate patient records
Medication reconciliation	Verified medication and allergy history	Omission and therapeutic duplication	Pharmacist, nurse, physician	Reconciliation completion rate
Electronic prescribing	Standardized CPOE respiratory orders	Incomplete or incorrect prescriptions	Prescriber	Prescribing errors/1,000 orders
Clinical decision support	Allergy, interaction, dose and duplication screening	Preventable prescribing errors	Prescriber/pharmacist	Clinically significant alerts resolved
Pharmacy verification	Clinical pharmacist review	Drug, dose, route, frequency and interaction errors	Pharmacist	Pharmacist interventions/1,000 orders

Dispensing	Barcode and standardized medication labeling	Selection and dispensing errors	Pharmacy personnel	Dispensing errors/1,000 doses
Administration	Barcode patient and medication verification	Wrong patient, drug, dose, route or time	Respiratory therapist/nurse	Barcode compliance rate
Monitoring	Electronic clinical response documentation	Unrecognized adverse effects or ineffective therapy	RT, nurse, pharmacist, physician	Medication-related adverse-event rate
Discharge	Final medication reconciliation	Duplication, omission and inappropriate continuation	Pharmacist/physician/nurse	Discharge reconciliation rate

12. INTERPROFESSIONAL COMMUNICATION

Medication safety requires effective communication among all professionals involved in respiratory care.

Registration personnel establish patient identity. Physicians establish therapeutic intent. Pharmacists evaluate pharmacotherapy. Respiratory therapists administer and monitor many respiratory medications. Nurses coordinate medication administration and clinical monitoring. Information technology specialists maintain electronic system connectivity.

When these professionals work within disconnected workflows, clinically important information may be delayed or lost.

Integrated electronic communication can allow a pharmacist intervention to be documented immediately and made visible to the prescriber and respiratory therapist.

Similarly, an adverse reaction documented by a respiratory therapist can be transmitted to other clinicians and incorporated into future medication decisions.

13. HUMAN FACTORS AND TECHNOLOGY-RELATED RISKS

Technology should not be considered a replacement for professional judgment.

Electronic systems can introduce new categories of errors. Examples include selecting the wrong medication from a drop-down menu, accepting an inappropriate default dose, selecting the wrong patient record, overlooking an important alert, or developing workarounds that bypass safety controls.

System design should therefore incorporate human-factors principles.

Frequently used information should be clearly displayed, medication names should be distinguishable, high-risk alerts should be prominent, and unnecessary steps should be minimized.

Healthcare professionals should also receive training before and after implementation.

Reporting technology-related errors should be encouraged so that the system can be continuously improved.

14. IMPLEMENTATION STRATEGY

Implementation should begin with mapping the current respiratory medication workflow.

Healthcare organizations should identify where medication errors currently occur and determine whether they originate during registration, reconciliation, prescribing, pharmacy verification, dispensing, administration, or monitoring.

The organization can then standardize workflows and establish clearly defined professional responsibilities.

Electronic integration should subsequently connect registration, EHR, CPOE, pharmacy, eMAR, and barcode systems.

Before full implementation, the system should undergo testing using realistic scenarios. Examples include patients with similar names, documented allergies, duplicate bronchodilator orders, incorrect doses, discontinued medications, and incorrect administration routes.

Staff competency should then be evaluated before independent use.

15. QUALITY AND PERFORMANCE INDICATORS

Continuous monitoring is essential for determining whether integration actually improves patient safety.

Potential indicators include:

- medication errors per 1,000 medication orders;
- respiratory medication errors per 1,000 administrations;
- wrong-patient medication events;
- pharmacy interventions per 1,000 medication orders;
- medication reconciliation completion rate;
- barcode scanning compliance;
- clinically significant allergy-alert overrides;
- therapeutic duplication events;
- dispensing errors;
- adverse drug events; and
- percentage of medications verified by pharmacy before administration.

These indicators should be reviewed periodically by pharmacy, respiratory care, patient safety, nursing, medical, and information technology representatives.

A multidisciplinary medication-safety committee can analyze trends and develop corrective actions.

16. EXPECTED IMPACT ON PATIENT SAFETY

An integrated system creates multiple barriers between an initial medication error and the patient.

Consider a patient with COPD who is accidentally prescribed a medication duplicating an active inhaler.

Medication reconciliation may identify the existing treatment.

If the duplication remains, clinical decision support may generate an alert.

If the prescriber proceeds, the pharmacist may identify the duplication during verification.

If the order reaches the bedside, the respiratory therapist can conduct another clinical review before administration.

Rather than relying on a single individual to prevent the error, the system establishes several independent and complementary safeguards.

This principle is fundamental to modern patient-safety engineering.

17. POTENTIAL ORGANIZATIONAL BENEFITS

The benefits of integration may extend beyond medication-error prevention.

Improved information sharing can decrease unnecessary communication delays between respiratory therapy and pharmacy.

Standardized electronic orders may reduce clarification calls.

Accurate medication reconciliation may reduce unnecessary duplicate medications.

Electronic documentation can provide data for quality-improvement projects and accreditation activities.

Integrated systems may also improve traceability because organizations can determine when a medication was prescribed, verified, dispensed, administered, and documented.

This information can support medication-use evaluations, incident investigations, and quality-improvement initiatives.

18. CHALLENGES AND LIMITATIONS

Several barriers can affect implementation.

Financial costs associated with EHR integration, barcode equipment, software licensing, maintenance, and training may be substantial.

Older information systems may have limited interoperability.

Healthcare professionals may resist changes that increase documentation requirements or initially slow workflow.

Alert fatigue may reduce the effectiveness of clinical decision support.

Incorrect information entered during registration can also propagate throughout the electronic system.

Furthermore, electronic verification cannot guarantee clinical appropriateness if essential clinical information is absent.

Healthcare organizations therefore need strong governance, standardized procedures, continuous training, and regular system evaluation.

Downtime procedures should also be established to maintain medication safety during temporary technology failures.

19. FUTURE DIRECTIONS

Artificial intelligence may provide additional opportunities to improve integrated medication safety.

Future systems could analyze patient characteristics, medication history, diagnoses, laboratory values, respiratory parameters, and previous medication responses to identify unusual or potentially unsafe medication orders.

AI-assisted systems could also prioritize medication orders requiring urgent pharmacist review.

Predictive models may identify patients at greater risk for medication-related adverse events.

Natural language processing may help extract medication histories from clinical documentation and compare them with active prescriptions.

However, AI should complement rather than replace pharmacist, physician, nurse, or respiratory therapist judgment. Algorithms require clinical validation, continuous monitoring, transparent governance, and human oversight.

Future studies should investigate whether integrated registration and pharmacy verification systems specifically reduce clinically significant respiratory medication errors, rather than focusing exclusively on general medication-error rates.

20. RECOMMENDATIONS

Healthcare institutions should consider establishing a closed-loop respiratory medication management model integrating patient registration, medication reconciliation, electronic prescribing, clinical decision support, pharmacist verification, barcode-assisted administration, and clinical monitoring.

Patient identifiers should be standardized across all clinical information systems.

Respiratory medication order sets should use standardized terminology for medication, formulation, concentration, route, frequency, and delivery device.

Pharmacy verification should occur before medication administration whenever clinically feasible.

Respiratory therapists should have real-time access to verified medication orders and should document treatment response electronically.

Medication reconciliation should be prioritized at admission, internal transfer, and discharge.

Organizations should monitor medication errors and near misses and use these data to continuously redesign workflows.

Finally, implementation should be accompanied by interdisciplinary education involving registration personnel, pharmacists, respiratory therapists, nurses, prescribers, quality personnel, and information technology specialists.

21. CONCLUSION

Reducing medication errors in respiratory care requires more than improving individual prescribing or administration practices. Medication safety depends on the integrity of the entire medication-use pathway, beginning with accurate patient registration and continuing through medication reconciliation, prescribing, pharmacy verification, dispensing, administration, monitoring, and discharge.

Integration of patient registration and pharmacy verification systems can create a reliable information pathway in which the correct patient's clinical and medication information is available at every stage of treatment.

When combined with CPOE, clinical decision support, medication reconciliation, barcode medication administration, and respiratory therapist monitoring, this approach creates multiple safety barriers capable of identifying errors before they reach patients.

The pharmacist and respiratory therapist have complementary roles within this framework. Pharmacists provide medication-focused clinical verification, while respiratory therapists provide bedside verification, administration, and assessment of respiratory response.

Ultimately, an integrated registration–pharmacy–respiratory care system represents a multidisciplinary approach to medication safety. Its effectiveness depends not only on technology but also on accurate data, appropriate workflow design, interprofessional communication, staff competency, continuous monitoring, and a strong organizational culture of patient safety.

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