

Utilizing Healthcare Failure Mode and Effect Analysis to Optimize the Management of Automated Dispensing Cabinet Workflow

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BACKGROUND

A retrospective analysis of patient safety incident reports from 2017 to 2019 identified drug-related events as a top concern, particularly medication and dosage errors. To address these issues, Automated Dispensing Cabinets (ADCs) were integrated into workflows, with a focus on proactive risk management to reduce inpatient medication errors and enhance patient safety.

AIM

The study aims to improve patient safety by using Healthcare Failure Mode and Effects Analysis (HFMEA) to enhance a closed-loop ADC(Automated Dispensing Cabinet) system, focusing on reducing inpatient medication errors through proactive risk management and targeted improvements in pharmacy dispensing.

METHOD

This study focuses on the 7th Zone Intensive Care Unit of a medical center hospital. In January 2020, a cross-disciplinary quality control circle team was established, including personnel from the pharmacy department, nursing department, quality center, and information department. The team first created a flowchart for the operation of the smart medication cabinet system. Following the HFMEA (Health Failure Modes and Effects Analysis) steps outlined by the VHA National Center for Patient Safety, which include process hazard index assessment and decision tree analysis, the team reviewed potential failure causes.

- Data CollectionData were collected from the patient safety reporting system and internal pharmacy reports from January 2020 to December 2023. HFMEA methods were used to guide improvements and policy development.
- For processes with high hazard indices (≥ 8) and lacking effective control mechanisms, corresponding improvement strategies were devised.
- The ADC workflow which include five main processes(physician prescribes medication,pharmacist prescription review, nurse routine retrieval medication as order, nurse mandatory retrieval medication as order, pharmacist medication replenishment) and 23 sub-processes of the ADC. (Table 1)

Table 1. Five Main Processes and 23 Sub-Processes

1. Physician prescribes medications	2. Pharmacist Prescription Review	3. Nurse Routine Medication Retrieval	4. Nurse Mandatory Medication Retrieval	5. Pharmacist Replenishes Medication
•1-1 Physician evaluates the patient's condition and issues medical orders.	•2-1 Information System Verification •2-2 Patient Cloud Data Inquiry •2-3 Prescription Evaluation	•3-1 Log into the ADC System •3-2 Select Patient •3-3 Choose Medication List •3-4 Retrieve Medications from the Drawer as per Medical Orders •3-5 Retrieve Medications from the Tower Cabinet as per Medical Orders	•4-1 Select Patient and Medication •4-2 Input the Medication Quantity •4-3 double check •4-4 Retrieve Medications	•5-1 Print Replenishment Report •5-2 Print Medication Labels •5-3 Prepare Medication •5-4 Enter Medication Name •5-5 Scan the Medication Bottle Barcode •5-6 Open the Medication Drawer •5-7 Check Medication Inventory •5-8 Confirm Medication and Expiry Date •5-9 Replenish Medication Drawer •5-10 Replenish Tower Cabinet Medication

RESULTS

The analysis identified 56 potential causes of workflow failures across five main processes and 23 sub-processes of the ADC workflow. Six high-risk potential failure modes were determined through decision tree analysis, including medication dispensing errors, lack of double-check mechanisms, absence of barcodes on medication bottles, incorrect retrieval of medications by nurses, inaccurate quantities retrieved by nurses, non-standardized medication labeling. (Table 2)

Table 2. Hazard Analysis (Excerpt items that corrective action)

Failure Mode			Risk Score		Decision Tree Analysis						Identify Action		
Potential Failure Causes		Potential Effects	Severity	probability	Hazard Index	Harm ?	Weakness ?	Single Point Measure ?	Existing Control Measure ?	Detectable?	Preced?	Action Type Control, Accept, Eliminate, Mitigate	Action
3.4.1.1	Pharmacist's refill error	Nurse get the wrong medicine	4	2	8	Y	N	N	N	Y	Control	1.Establish ADC drug subcontracting SOP 2.Standardization of drug refilling process in ADC	
3.4.2.1	The system cannot detect the quantity	Nurse get the wrong quantity	3	3	9	Y	N	N	N	Y	Mitigate		Education
3.5.1.1	Pharmacist's refill errors	Nurse get the wrong medicine	4	2	8	Y	N	N	N	Y	Control	Establish drug shelving process in tower cabinets 1.Establishing principles for labeling drug barcodes in tower cabinet drug storage locations 2.Adjust drug storage	
3.5.2.2	Medication bottle without barcode	Nurse get the wrong medicine	4	3	12	Y	N	N	N	Y	Control		
3.5.3.1	Medications without barcode for identification	Nurse get the wrong quantity	3	3	9	Y	N	N	N	Y	Mitigate		
5.8.1.1	Pharmacist failed to implement double review	Pharmacist's refill wrong medicine	4	2	8	Y	N	N	N	Y	Mitigate	Establish a double-check checklist and implement it	

- Summary of Improvement Measures:
 - System Level: Standardize ADC replenishment, medication packaging, and tower cabinet shelving procedures.
 - Management Level: Revise medication storage labeling, Implement dual-redundancy checklists and monitoring, Enhance education on prescription review and the "three checks, five rights" procedure for nurses.
 - Equipment Level: Integrate automatic drug recognition for blister-packed medications, Implement an information system for medication returns.
- Implementation of Improvement Measures:
 - Quality control circle monitoring period (January-December 2020):
 - (1)Packaging Error Rate: Reduced from 0.198% to 0%.
 - (2)Medication Administration Timeliness: The time from physician prescribing to medication administration was reduced by 80 minutes.
 - (3)Reduced Medication Returns: Medication returns in wards decreased by 60%, reducing handling and processing, and enhancing pharmaceutical care.
 - Administrative Efficiency: The number of urgent delivery requests decreased by 88%. Medication dispensing error rate: Reduced from 0.0304‰ before implementation (January to August 2020) to 0‰ after implementation in September 2020, maintaining a zero occurrence rate in 2021-2022. In the first and third quarters of 2023, the rates were 0.00325‰ and 0.0045‰, respectively. After additional measures, the fourth-quarter rate returned to 0‰.

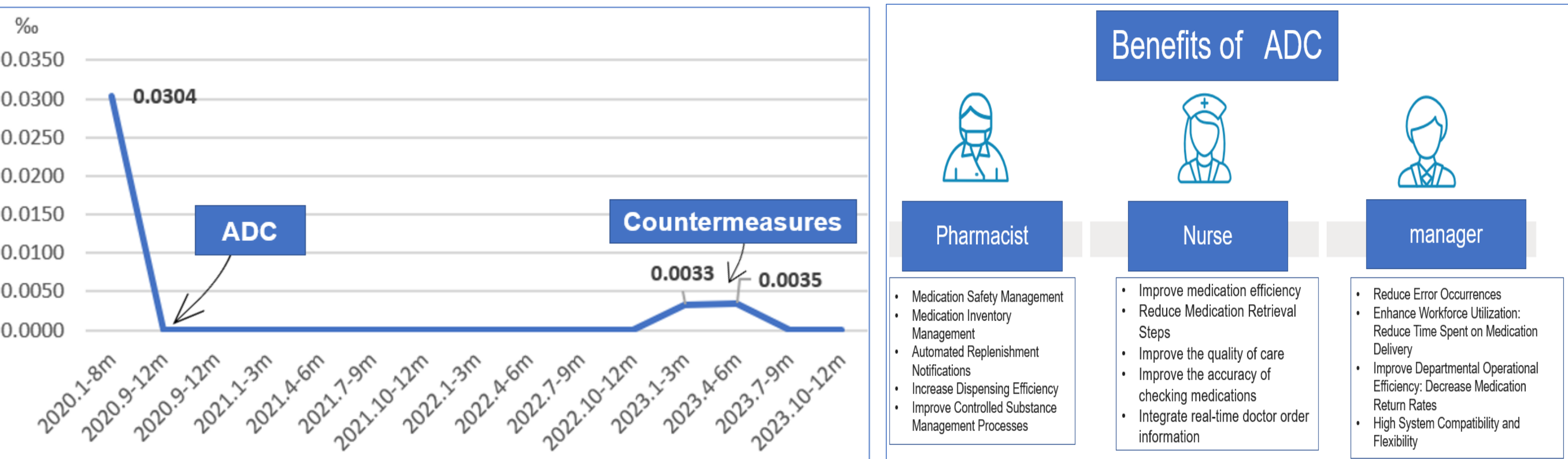


Figure 1. Pharmacist's Dispensing Error Rate

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Teamwork



CONCLUSIONS

- Through collaborative efforts, this study successfully implemented an ADC system and established a multidisciplinary medication management process based on HFMEA principles. The ADC system enhances automation, security, and accuracy, reducing medication errors and improving efficiency, especially in high-volume or high-risk settings. In the ICU, the ADC was tailored to meet the urgent medication needs, frequent prescription changes, and high-alert drugs associated with critical care.
- Remaining Issues:Medication Restrictions:
 - Future reviews and improvements are needed for managing commonly used medications with ADCs and the requirement for nurses to retrieve medications in non-emergency situations.
 - Quantity Detection: The ADC currently cannot detect incorrect quantities during medication retrieval.

Keywords:HFMEA, ADC, Patient safety

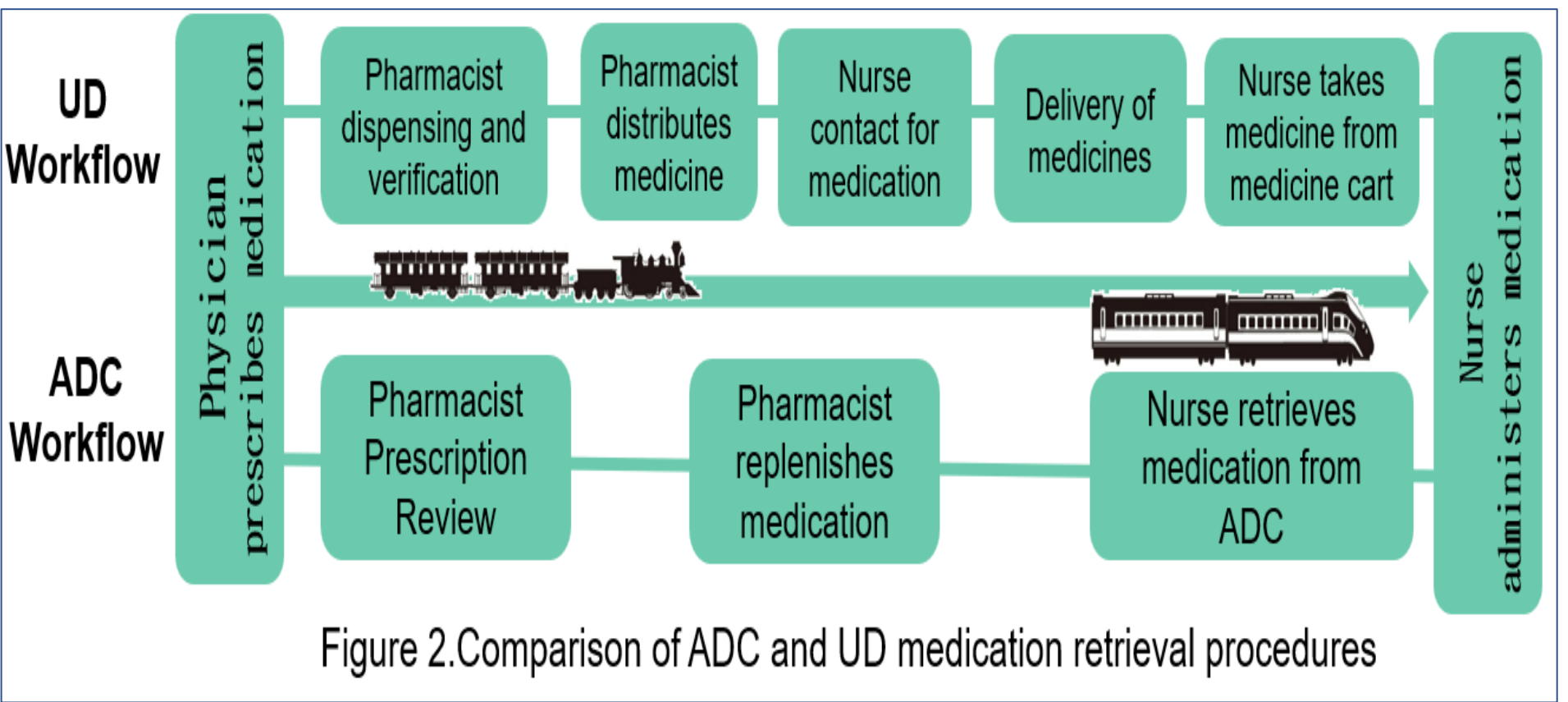


Figure 2.Comparison of ADC and UD medication retrieval procedures