

Advancing Safe Medication Practices with Automated Dispensing Cabinets in Operating Room And Anesthesia Settings: A Systematic Literature Review

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Monica Telinoiu, MS, MBA;¹ Ari Varon, Student;² Craig Greszler, PharmD, MBA;¹ Shannon Johnson, PharmD, MBA;¹ Amanda Hays, PharmD, MHA;¹ Julia Lucaci, PharmD, MS¹

1. Becton, Dickinson and Company; 2. Tarbut V'Torah Community Day School

BACKGROUND

- Medication management in operating rooms (OR) and anesthesia settings (AS) present unique patient safety challenges due to the high-level nature of care, time-critical decision-making, frequent workflow interruptions, and routine use of high-risk and controlled medications.
- Unlike inpatient wards, perioperative environments often require rapid medication access during procedures, increasing reliance on workarounds such as overrides, manual documentation, or delayed reconciliation.
- These practices can bypass established safety barriers, including pharmacist verification and standardized inventory controls, thereby increasing the potential for medication errors, documentation discrepancies, and regulatory non-compliance.
- Automated dispensing cabinets (ADCs) have been widely implemented across hospital settings to improve medication security, streamline access, and support safer medication-use processes.
- While substantial evidence exist for ADC effectiveness in inpatient units, their role in perioperative and anesthesia settings is more complex. The physical layout of ORs, anesthetic workflows, and shared responsibilities among multidisciplinary teams introduce distinct operational and safety considerations. As a result, the impact of the ADCs on medication errors, workflow-related safety risks, and staff behavior in these settings remains less clearly characterized.

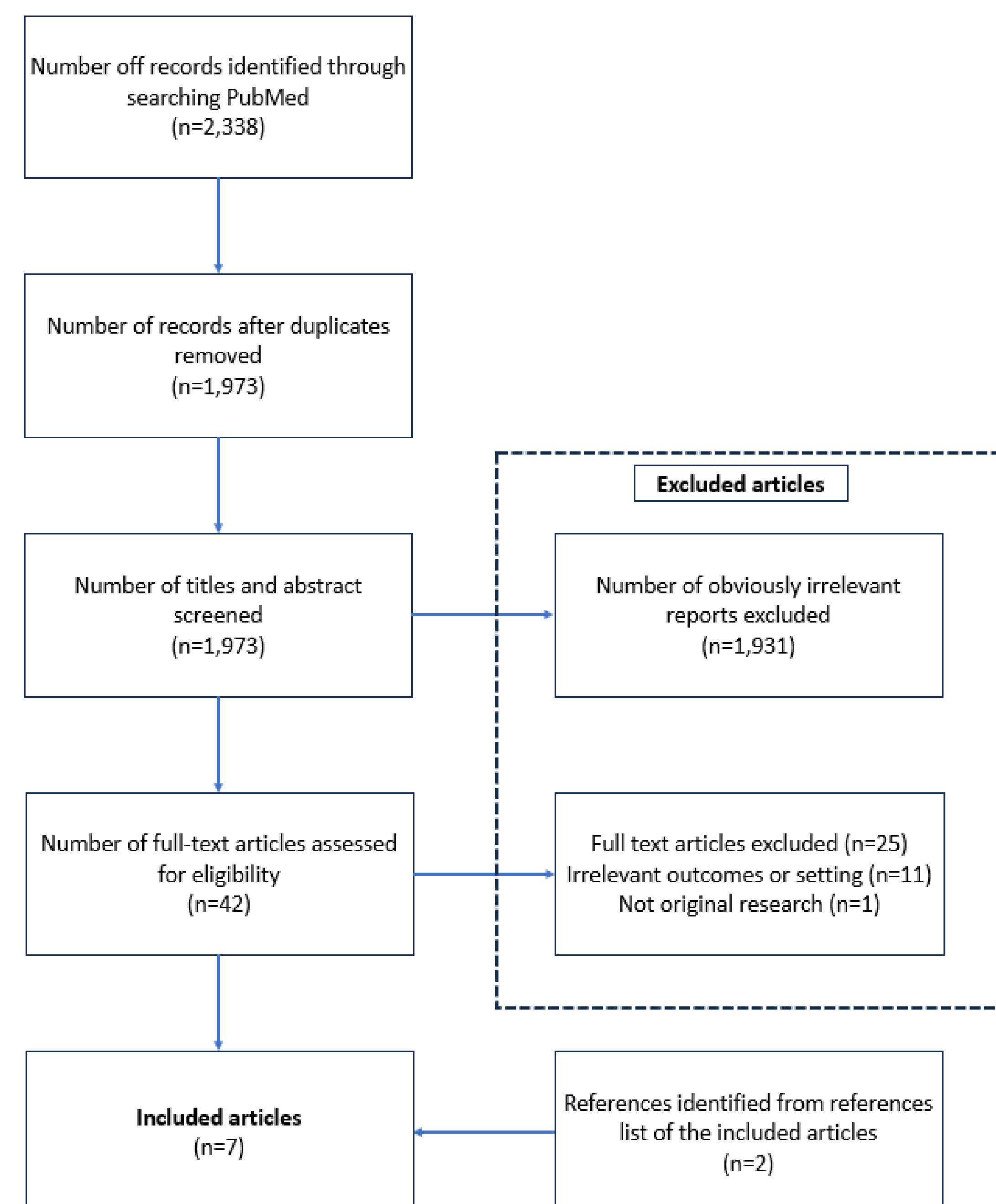
OBJECTIVE

- To evaluate the documented impact of ADCs on reducing medication errors in ORs and/or ASs from 2010 to 2025, including medication errors, unsafe access behavior, and patient safety outcomes.

METHODS

- A systematic literature review (SLR) was conducted in PubMed in June 2025 to identify empirical studies evaluating the use of ADCs in operating rooms and/or anesthesia settings
- The SLR was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and best practices.¹
- A review of citations was conducted for all full text reviews to identify studies that met our inclusion criteria but might have not been identified in our original search or were not indexed in PubMed.
- Original research studies reporting empirical data on ADC use in hospital operating rooms and/or anesthesia care environments were included if published in English within the past 15 years. Titles, abstracts, and full texts were independently screened by two reviewers, with conflicts resolved by a third reviewer. Data extraction was performed by one reviewer and verified by a second reviewer.

FIGURE 1: Flowchart of Studies Identified During Review



RESULTS

- The literature search identified 2,338 records; after screening and eligibility assessment, 7 studies were included in the final analysis (Fig.1). To support structured synthesis, outcomes were grouped into three predefined domains: medication error-specific outcomes, workflow-related safety risks, and staff perceptions and access control.
- Because individual studies reported outcomes across multiple domains, studies were not mutually exclusive and could contribute to more than one domain (Table 1)

Medication Error-specific Outcomes

- Five studies reported medication error-specific outcomes.^{2,3,4,5,6}
- A prospective randomized single-center trial in operating room anesthesia settings, China, found automated anesthesia carts significantly reduced total medication administration errors (7.3% vs 11.9%), driven primarily by fewer documentation/recording errors (4.0% vs 8.7%; $p < 0.01$), with no patient harm reported.²
- A before-after observational study in perioperative operating rooms, United States, demonstrated that near-real-time ADC-aims reconciliation significantly reduced controlled-substance discrepancy rates from 8.8% to 5.2% ($p < 10^{-6}$).³
- A pre-post study in an operating room/post-operation room (OR/POR) surgical unit, Taiwan, reported complete elimination of medication transporting and dispensing errors following ADC implementation (2 pre-ADC vs 0 post-ADC).⁴
- A pre-post study in a cancer-focused operating room setting, Italy, found implementation of an automated narcotic dispensing system eliminated load/unload registry errors (100% reduction; 90 to 0) and reduced registry corrections by 95% over an 8-month period.⁵
- A longitudinal before-after study conducted in an inpatient surgical ward, Taiwan, reported no significant reduction in medication error events following ADC implementation ($p = 0.78$).⁶

Workflow-related Safety Risks

- Six studies reported workflow-related safety risk outcomes.^{3,4,5,6,7,8}
- In a perianesthesia care unit, a quality-improvement intervention, United States, reduced ADC override rates from 17% at baseline to 8% after initial workflow changes and further to 4%, representing a 76% relative reduction, without increasing operating room delays.⁷
- In perioperative OR settings, United States, implementing near real-time AD-aims reconciliation achieved high system reliability, capturing 98.2% of ADC transactions within 5 minutes and reducing documentation latency to a median of ~60 seconds, supporting timely workflow correction during active cases.³
- In a surgical ward (Unit B), ADC implementation was associated with increased medication preparation time, with mean preparation time rising from 0.39 to 2.11 minutes per patient ($p < 0.001$), while urgent medication access time decreased, as medications were retrieved directly from the ADC within ~3 minutes, eliminating pharmacy delivery delays.⁶
- In an anesthesia and surgical unit (OR), Finland, ADC implementation reduced time spent on dispensing and preparing medications by 32 minutes per 8-hour shift (from 55 to 23 min) and decreased in-procedure exits to collect medications from outside the operating theatre from 64% of cases to 13%, reducing workflow interruptions during surgery.⁸
- In a surgical unit (OR/POR), Taiwan, ADC implementation significantly improved workflow timeliness, reducing medication delivery time for standing orders from ~40–45 minutes to ~3 minutes and for immediate/temporary orders from ~54–64 minutes to ~1.5–2 minutes ($p < 0.001$), mitigating delays in perioperative medication access.⁴
- In a surgical unit (OR), Italy, implementation of an automated dispensing system for narcotics reduced nursing time spent on dispensing and registry activities from 36 to 2 hours per month and pharmacist time from 9 to 1 hour per month over an 8-month period, substantially decreasing workflow burden related to medication handling.⁵

Staff Perceptions And Access Control

- Five studies reported staff perceptions and access control outcomes.^{2,4,6,7,8}
- In a perianesthesia care unit supporting operating room workflows, United States, a multidisciplinary nursing-pharmacy intervention was associated with improved adherence to ADC access controls, reflected by sustained reductions in override use (17% to 4%; 76% relative reduction), indicating a shift in staff practice toward verification-first medication access without perceived negative impact on perioperative throughput.⁷
- In a mixed-methods observational study in anesthesia/surgical and ICU settings, Finland, nurses reported high overall satisfaction with ADCs (84%), perceiving improved ease of work and safety; however, access-control compliance differed by unit, with frequent non-adherence in the OR (e.g., use under another user's login and inconsistent barcode scanning) compared with high compliance in the ICU, highlighting the role of staff training and culture in sustaining secure ADC use.⁸
- In a longitudinal before-after study in a surgical ward setting, Taiwan, nurses reported high overall satisfaction with ADC use (mean score 3.90), driven by improved medication availability and reduced pharmacy wait times, alongside moderate access-related burdens such as ADC queuing and increased preparation time due to repeated verification steps.⁶
- In a retrospective before-after study in an OR/post-operation room (OR/POR) surgical unit, Taiwan, ADC implementation was associated with significantly improved nursing satisfaction with perioperative medication access and delivery (overall score increase from 3.2 to 4.2; $p < 0.001$), supported by patient-specific, pharmacist-verified access controls without override functionality, indicating improved trust in access governance and reduced need for manual medication retrieval during time-critical surgical care.⁴
- A prospective randomized trial in operating room anesthesia settings, China, anesthesiologists reported greater satisfaction with automated anesthesia carts compared with conventional manual carts (297 vs 199 cases rated satisfactory; $p < 0.05$); however, compliance with access and documentation procedures was suboptimal, with full adherence observed in only 42% of cases, and all drug-recording errors attributable to incorrect cart use, indicating that usability and training significantly influenced access-control effectiveness.²

TABLE 1: Systematic Literature Review Included Study Information

First Author (Year)	Study Design	Clinical Setting	Country	Main Outcome Assessed
Wang, 2017 ²	Prospective randomized single-center trial	Operating room anesthesia	China	<ul style="list-style-type: none"> Medication administration errors; documentation/recording errors Anesthesiologist satisfaction; access/documentation compliance
Epstein, 2016 ³	Before-after observational study	Perioperative operating rooms	United States	<ul style="list-style-type: none"> Controlled-substance discrepancy rates ADC-aims transaction reliability; documentation latency
Liou, 2023 ⁴	Pre-post study	OR/Post-operation recovery unit	Taiwan	<ul style="list-style-type: none"> Medication transporting errors; dispensing errors Medication delivery time; perioperative access timeliness Nursing satisfaction; pharmacist-verified access controls
Portelli, 2019 ⁵	Pre-post observational study	Operating room	Italy	<ul style="list-style-type: none"> Narcotic load/unload registry errors; registry corrections Nursing and pharmacist time for narcotic handling
Wang, 2021 ⁶	Longitudinal before-after study	Inpatient surgical ward	Taiwan	<ul style="list-style-type: none"> Overall medication error events Medication preparation time; urgent access time Nurse satisfaction; perceived access burden
Franciscovich, 2024 ⁷	Quality-improvement intervention	Perianesthesia care unit	United States	<ul style="list-style-type: none"> ADC override rates; perioperative workflow impact Access-control adherence; override behavior
Metsämuuronen, 2020 ⁸	Mixed-methods observational study	Anesthesia/surgical unit (OR) and ICU	Finland	<ul style="list-style-type: none"> Dispensing/preparation time; in-procedure exits Staff satisfaction; access-control compliance behavior

CONCLUSION

- Automated dispensing cabinets were associated with improvements in medication safety and workflow across diverse international perioperative and anesthesia settings, including reductions in errors, overrides, and delays, along with improved access control and staff-reported experience. However, the available evidence was limited and heterogeneous, and the benefits observed appear to depend on appropriate implementation, staff training, and complementary safeguards.

KEY LIMITATIONS

- Only one database (PubMed) was searched, potentially limiting study capture; the search was limited to English-language publications and may have excluded relevant studies published in other languages.
- Publication bias is possible, as studies with negative or null findings may be less likely to be published.
- Only seven studies met the inclusion criteria, and the included studies were relatively small and heterogeneous, which may limit generalizability across institutions and geographic settings.

DISCLOSURE AND FUNDING

- Most authors (MT, CG, SJ, AH and JL) are employees of Becton, Dickinson and Company (BD). One author (AV) was a student intern affiliated with Yeshivat Heichal HaTorah-Tarbut V'Torah Community Day School.
- This work was conducted by employees of BD as part of their professional roles. Poster printing costs were funded by BD.

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