

Safeguards for Using and Designing Automated Dispensing Cabinets

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Automated dispensing cabinets (ADCs) were introduced in hospitals in the late 1980s. These decentralized medication-distribution systems provide computer-controlled storage, dispensing, and tracking of drugs at the point of care in patient-care units. Although adoption of the technology started slowly, as of 2008, more than 80% of hospitals were using ADCs to replace manual floor stock systems or medication carts that had previously held a 24-hour supply of drugs in individual patient cassettes.¹

BENEFITS OF AUTOMATIC DISPENSING CABINETS

ADCs offer a variety of benefits to organizations and users:

- Nurses have increased access to drugs in patient-care areas and can facilitate administration in a timely way.
- The medications are locked up in patient-care units, and controlled substances and other drugs are electronically tracked.
- The stocking and distribution of medications are tracked to improve inventory control.
- When ADCs are interfaced with the pharmacy computer, they support the clinical review of medication orders by a pharmacist before administration.
- ADCs can be interfaced with other external databases, such as the facility's admission/discharge/transfer system and billing systems; as a result, the efficiency of drug dispensing and billing is enhanced.
- ADCs can be interfaced with barcode technology to automate the restocking process and to track dispensing of medications.

- If ADCs are linked to point-of-care bar-coding systems, an electronic match between the prescribed and selected medication is ensured.

WHAT THE RESEARCH SHOWS

On the basis of these benefits, ADCs have been recommended as a potential way to increase efficiency and reduce medication errors. A small body of evidence has been published regarding the impact of this technology on error rates. In 2003, Oren et al. published a meta-analysis that identified only seven controlled studies linking ADCs with medication-error rates or other secondary endpoints.² In general, after ADCs were implemented, these studies identified:

- lower rates of dispensing errors in filling ADCs compared with manual filling of traditional unit-dose cassettes.^{3,4}
- fewer errors in drug administration (mostly drugs given at the wrong time) and fewer missing doses.^{5,6}
- fewer drug-administration errors in a cardiovascular surgery unit but more errors in an intensive-care unit (ICU).⁷
- an increase in errors (by more than 30%) in six of seven nursing units evaluated.⁸

Except for wrong-time errors, these studies showed mixed results for reducing drug-administration errors with ADCs. Similar results were noted in a government-funded compilation of evidence related to ADCs.⁹ However, many of these studies had been conducted before important software and hardware enhancements were available, such as interfaces between ADCs and pharmacy computers and cabinets with individually lidded compartments. Although few studies clearly link the design and use of ADCs to the error rates, error-reporting programs have uncovered several factors that can affect the ability of ADCs to reduce medication errors.



FACTORS THAT INFLUENCE SAFETY

ADCs do not improve safety unless the cabinet's design and use are planned with attention to the following factors:

Patient profiling. If the ADC is linked to the pharmacy computer, a pharmacist can review each new medication order and screen it for safety before the drug can be removed from the cabinet. Without this feature, nurses might not be alerted to unsafe doses, potential allergic reactions, duplicate therapy, contraindications, drug interactions, or other important drug information. An example that was reported to the Institute for Safe Medication Practices (ISMP) Medication Errors Reporting Program (MERP) follows.

A patient died after receiving 10 mg of intravenous (IV) **colchicine**. The physician had prescribed "colchicine 1.0 mg IV now," but the decimal point was hardly visible. This flaw and the use of a trailing zero led the nurse to believe that the dose was "10 mg." If a pharmacist had prescreened the order, the nurse would have been instructed to remove 1 ampule of colchicine (1 mg) to administer the dose. However, the patient was affected by the error because the ADC was not profiled to the pharmacy computer and there was an excessive quantity of colchicine in storage (10 1-mg ampules). Thus, these conditions made it easy for the nurse to remove enough ampules to administer the fatal dose.

Overrides. Even when patient profiling is used, this feature is sometimes overridden to allow the removal of drugs in an emergency. However, the misuse of overrides has resulted in errors, as in the following example:¹⁰

A physician prescribed **Zosyn** (piperacillin/tazobactam) for a patient. The first dose was given in the emergency department, and a second dose was given on the medical unit. Both doses were retrieved from an ADC before the pharmacy review. However, when the pharmacy reviewed the order,

it was noted that the patient had a documented allergy to penicillin. Fortunately, the patient did not experience a serious allergic reaction.¹⁰

Overrides are not the only examples of work-arounds used to access medications from ADCs. Other types of work-arounds include the use of the “inventory” function (which is designed to determine the current number of doses of a particular medication on hand); gaining access to medications for patients before pharmacy screening; removing a larger quantity of drugs than that ordered for one patient; and removing medications for more than one patient while the cabinet is open.

Insufficient number and wrong placement of ADCs. If the number of ADCs on the medical unit is insufficient, nurses might remove doses ahead of time because of limited access during busy drug-administration times. Placement of an ADC in areas with high traffic or low illumination can also lead to distractions and to the misreading of screens or labels.

Look-alike drug names on the screen. Choosing the wrong drug from an alphabetical list of choices may also contribute to errors arising from look-alike drug names. An example from the MERP follows:

One hospital reported several mixups between injectable **diazepam** (Valium) and **diltiazem** (Cardizem) when the drugs were removed from an ADC in the ICU. In each case, the nurse incorrectly chose diazepam on the screen, which was listed directly above the intended product, diltiazem. In one case, diazepam was given at the prescribed dose for diltiazem. In another case, the error was discovered before the patient was affected when a physician noticed the amber-colored vial and the product label was rechecked. The nurses in these cases thought that they had removed the correct product from the ADC. Thus, they failed to inspect the product label carefully, missing opportunities to catch the original selection error.

Excessive quantities of drugs. ADCs that contain a wide assortment of or an excessive quantity of medications can also increase the risk of errors, as in

the colchicine incident described earlier, especially if the ADCs are not profiled to the pharmacy computer. The following example from the MERP shows how a carefully limited stock in the ADC can offer a safety net:

After the pharmacy was closed, an order was written for “1 gram calcium gluconate IV.” Each 10-mL vial contains 1 g of calcium gluconate, which is equivalent to 93 mg of elemental calcium. The nurse misunderstood this information on the label and thought she needed about 10 or 11 vials to prepare the 1-g dose. Fortunately, the ADC contained only six vials. The 10-fold error was discovered and averted when the nurse contacted a pharmacist about the need for additional vials.

Stocking procedures. Stocking medications in ADCs is primarily a pharmacy function, although nurses sometimes return unused doses to the ADC. However, this is an error-prone practice that the ISMP does not endorse. Cabinets that do not have bar-coding technology rely on a double-check system before medications leave the pharmacy. This process is vulnerable to errors because rarely is any system used to verify that the correct drug has been placed in the correct drawer. Examples submitted to the ISMP and to the Pennsylvania Patient Safety Authority involved erroneous stocking of the following drugs or strengths, many with look-alike drug names or packaging:

- **NUBAIN** (nalbuphine) was placed in an adjacent drawer intended for **BUPRENEX** (buprenorphine)
- **FIORICET** (acetaminophen, butalbital, caffeine) was placed in a drawer intended for **FIORINAL** (aspirin, caffeine, butalbital)
- **HYDROMORPHONE** 4-mg syringes were placed in a drawer intended for morphine 4-mg syringes.
- **tIZANidine** (**ZANa**flex) was placed in the compartment intended for **tiGABine** (**GABITRIL**).
- A Carpuject syringe of digoxin was placed in a drawer intended for ketorolac (Toradol).

Storing medications with look-alike names or packaging next to each other in the same drawer or bin can also cause stocking and retrieval errors, particularly

during emergencies, when the patient profiling system is bypassed. An example of this type of error was reported to the Pennsylvania Patient Safety Authority:

During a cardiac catheterization, a nurse received a verbal order for IV **Lopressor** (metoprolol). She accidentally removed **Levophed** (norepinephrine) from the ADC, which was stored in a bin adjacent to Lopressor. The patient received the incorrect medication and needed treatment and observation during and after the procedure.¹⁰

SAFETY PRACTICE RECOMMENDATIONS

Before ADCs were available, technicians prepared doses, pharmacists checked their work, and the medications were dispensed to patient-care units in carts or were placed in nurse servers. Nurses then acted as a final independent check of the dispensed medications.

With ADCs, if medications are stocked and removed without bar coding, the same level of redundant checking systems no longer exists, even when the pharmacist verifies the medication order before the nurse can access the medication. Therefore, it is crucial to use ADC systems with minimal bypasses so that safety is on par with other methods of dispensing unit-dose medications, such as robotic dispensing or manual cart fills, which include several built-in redundancies.

In 2007, the ISMP convened a national forum of stakeholders to develop interdisciplinary guidelines for promoting safe practices for the use of ADC technology. The guidelines were finalized in March 2008.¹¹

The immediate implementation of all elements in the guidelines is an ambitious goal. Even now, many steps can be taken to improve safety associated with ADCs. The guidelines are meant to support organizations and vendors in making decisions about resource and strategic planning as well as in facilitating ongoing safety enhancements.

The ISMP also produced a self-assessment for ADC technology, which is available free to all health care providers.¹² The ISMP encourages all organizations that use ADCs to form interdisciplinary teams to review the guidelines and complete the self-assessment to maximize safety.

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