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Evidence Briefings on Interventions to Improve Medication Safety

Automated dispensing systems

Policy question: Do automated dispensing systems reduce dispensing and administration errors and improve efficiency?

Current evidence shows: Automated dispensing systems (ADS) have the potential to reduce certain types of medication errors such as omitted doses, but are less effective in reducing other types of errors. There is some evidence to suggest that ADS assist with storage capacity and stock control, but the evidence is conflicting regarding time saved following installation of ADS. Cost savings are related to better stock control.

Background

The use of automated dispensing systems (ADS), also known as automated dispensing cabinets (ADC), unit-based cabinets (UBC), automated dispensing devices (ADD), automated distribution cabinets and automated dispensing machines (ADM), in hospitals is increasing. In 2011, 40% of US hospital pharmacies had a decentralised inpatient medication distribution system and 89% of those used ADS [1]. There are different types of ADS; ward-based ADS, pharmacy-based ADS and automated unit-dose dispensing systems (Table 1). Theoretical benefits of ADS are improved safety and efficiency, namely through reduced dispensing times, improved storage capacity and stock control, more appropriate allocation of staff to tasks and reduced dispensing errors [2].

Table 1. Description of the three different types of automated dispensing systems included in this review (modified from James [3])

Description	Examples of brands
Pharmacy-based ADS	
• Medications stored on designated shelves • Dispensing order entered, robotic arm or picking device selects medication from shelf and transfers to delivery station • Checked and labelled by pharmacy staff	Rowa Speedcase PackPicker® PillPick® consisting of PillPicker (packaging), DrugNest (storage) and PickRing (dispensing)
Ward-based ADS	
• Medications stored in electronically controlled cabinet linked to computer • To access medications, nurse enters password and patient details • Drawer containing selected medication opened • Nurse administers medication • System tracks who accessed the cabinet and for whom medications were selected	Pyxis MedStationTM MedSelect® McLaughlin
Automated unit-dose dispensing	
• Medications stored in calibrated canisters • When dispensing order entered, ADS ejects medication from the canister into strip-packing device which labels and seals the strip	Baxter ATC-212

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Methods

A literature search was undertaken to identify studies relating to automated dispensing systems in the hospital setting. Searches were performed in PubMed, Embase, and CINAHL. Google Scholar was used to identify grey literature. Conference abstracts, review articles, duplicates, commentaries and letters as well as articles describing implementation of ADS (e.g. guidelines for successful implementation) were excluded. The search was limited to English language articles published after 1980.

Results

The search yielded 981 potentially relevant published studies. Of the 28 articles that met the inclusion criteria, 17 were conducted in the US [4-20], nine in Europe [2 3 21-27], one in Saudi Arabia [28] and one was conducted in both the US and UK [29]. No Australian evaluation studies have been published.

Pharmacy-based ADS

Medication safety aspects

Observational studies following implementation of ADS in UK hospital pharmacies have shown significant decreases in dispensing errors post ADS (from 0.64% to 0.28% in one study [3]; and from 1.2% to 0.6% and from 2.7% to 1.0% in a multisite study [2]). Other studies have found non-significant reductions in dispensing errors following implementation of ADS [18 23] and one study found no reduction in dispensing errors [14].

Repacking system

Storage capacity

Compared to traditional storage, installing ADS in hospital pharmacies appears to result in less occupied space and increased storage capacity [2 23 25]. One study reported that storage capacity can be increased by 23% to 123% compared to traditional storage methods [2].

Time savings

Two studies [2 3] reported significant reductions in median time taken for the pharmacy-based ADS to 'pick' medications compared to staff picking medications off shelves. Other studies have reported non-significant reductions in time taken to fill first dose orders [18] and time taken to dispense medications [23].

Cost savings

One US study conducted in 2010 reported a net reduction of 2.0 technician full-time equivalents and a reduction of US$25,059 in inventory carrying cost following installation of an ADS [18]. A report from the King's College Hospital in the UK assessing the impact of ADS found that £534,000 was saved in reduced stock holdings (one-off saving) and £50,000 per year was saved in reduced expired medication expenditure [27].

Ward-based ADS

Medication safety aspects

Several observational studies have determined the impact of ward-based ADS on medication errors but results are inconsistent. Missed medication doses [4 5 15 28] and administration of the wrong dosage form rates [5 28] were reduced across different wards using different brands of ADS, while the administration of wrong doses was shown to increase [4 5]. Administration of unauthorised doses and wrong timing events decreased in one study [4] but increased in another [5].

Using the ADS to prompt clinicians to adhere to guidelines was examined in two studies. ADS was associated with improved compliance with pneumonia guidelines [20] and antimicrobial prophylaxis guidelines [6].

Time savings

One study reported that nurses spent significantly less time on medication-related activities, as well as charting or documenting, and significantly more time on patient interactions following ADS implementation.

Pharmacists spent significantly more time in floor-stock activities following implementation of this ADS [13]. In another study there was no change in time spent on nurse activities whereas pharmacists spent more time on clinical activities following ADS implementation [8].

Cost savings

Potential cost savings following implementation of ward-based ADS have been evaluated in the US [13] and Saudi Arabia [28]. These evaluations have limited relevance to Australia and are not discussed further in this briefing.

Automated unit-dose dispensing systems

A US study of the automated unit-dose dispensing system Baxter ATC-212 showed reduced time taken to fill a medication cart, which in 1994, was estimated to save a total of US$7,044 annually at one hospital [10]. This was despite the higher medication

acquisition costs for the automated system compared to the manual cart fill system. Another study found that using the Baxter ATC-212 computerised cart fill was more accurate (99.98%) than relying on manual filling (92.62% accurate) [12]. One study evaluated the frequency and severity of medication errors (defined as a dose of medication administered that deviated from the prescription) in one UK and two German hospitals. In the UK hospital, the wards had 80% of medications in ward stock with the remainder dispensed for individual patients and a pharmacist visited the ward twice daily. In Germany one hospital was using a traditional system i.e. large floor stock ordered twice weekly by nurses and twice yearly visits by a pharmacist, whereas the other German hospital was using the Baxter ATC-212 and was visited by a pharmacist twice daily. The study found that using the Baxter ATC-212 was associated with lower error rates (2.4%) compared to the traditional German system (5.1%) and the UK system (8.0%) [26]. Another study compared the number of medication errors (defined as a dose administered (or omitted) that deviated from the written medication order) that occurred on one ward in a US hospital using a unit-dose drug distribution system with one ward in a UK hospital using a ward-based supply system in combination with several visits per day by a pharmacist [29]. The study found a higher rate of medication errors in the US hospital compared to the UK hospital (6.9% vs. 3.0%).

Ward-based ADS

Staff opinions

A number of studies evaluating staff attitudes towards ADS have been published [2 3 7 13 21 22 30-34]. Reasons cited for using ADS were potential efficiency gains, whereas implementation costs and safety concerns were reasons cited for not implementing ADS [7].

Before-and-after studies show that staff attitudes tend to improve towards ADS after implementation [2 21 22]. An attitude difference between nurses and pharmacy technicians has been observed, with nurses having more positive perceptions about the ADS regarding their effects on time and medication availability. Pharmacy technicians reported negative perceptions of a ward-based ADS on the time to fill floor-stock items [13].

In addition to the papers summarised here on quality and safety aspects, a number of case studies [35-41], opinion pieces [42-53] and conference abstracts [54-65] have been published which may be of interest to some readers.

Conclusion

ADS are effective in reducing the number of omitted doses, but are less effective in reducing other types of errors. The evidence for improved patient outcomes with ADS is scarce. Compared to traditional storage of medications in pharmacies, installation of pharmacy-based ADS appears to increase storage capacity and reduce the time taken to fill prescriptions. Studies evaluating time savings following implementation of ward-based ADS report inconsistent findings. Whether these findings translate to the Australian setting, where individual patient dispensing is common, remains to be evaluated. Most studies were small observational studies evaluating one brand of ADS conducted at a single site without a control groups. These studies have limited generalisability. Qualitative studies evaluating staff attitudes before and after implementation of ADS show improved attitudes over time.

References

1. Pedersen CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: dispensing and administration--2011. *Am J Health Syst Pharm* 2012;69(9):768-85.
2. Franklin BD, O'Grady K, Voncina L, et al. An evaluation of two automated dispensing machines in UK hospital pharmacy. *Int J Pharm Pract* 2008;16(1):47-53.
3. James KL, Barlow D, Bithell A, et al. The impact of automation on workload and dispensing errors in a hospital pharmacy. *Int J Pharm Pract* 2013;21(2):92-104.
4. Barker KN, Pearson RE, Hepler CD, et al. Effect of an automated bedside dispensing machine on medication errors. *Am J Hosp Pharm* 1984;41(7):1352-8.
5. Borel JM, Rascati KL. Effect of an automated, nursing unit-based drug-dispensing device on medication errors. *Am J Health Syst Pharm* 1995;52(17):1875-9.
6. Botwin KJ, Chan J, Jacobs R, et al. Restricted access to automated dispensing machines for surgical antimicrobial prophylaxis. *Am J Health Syst Pharm* 2001;58(9):797-9.
7. Fanikos J, Erickson A, Munz KE, et al. Observations on the use of ready-to-use and point-of-care activated parenteral products in automated dispensing cabinets in U.S. hospitals. *Am J Health Syst Pharm* 2007;64(19):2037-43.
8. Guerrero RM, Nickman NA, Jorgenson JA. Work activities before and after implementation of an automated dispensing system. *Am J Health Syst Pharm* 1996;53(5):548-54.
9. Helmons PJ, Dalton AJ, Daniels CE. Effects of a direct refill program for automated dispensing cabinets on medication-refill errors. *Am J Health Syst Pharm* 2012;69(19):1659-64.
10. Klein EG, Santora JA, Pascale PM, et al. Medication cart-filling time, accuracy, and cost with an automated dispensing system. *Am J Hosp Pharm* 1994;51(9):1193-6.
11. Klibanov OM, Eckel SF. Effects of automated dispensing on inventory control, billing, workload, and potential for medication errors. *Am J Health Syst Pharm* 2003;60(6):569-72.
12. Kratz K, Thygesen C. A comparison of the accuracy of unit dose cart fill with the Baxter ATC-212 computerized system and manual filling. *Hosp Pharm* 1992;27(1):19-20, 22.
13. Lee LW, Wellman GS, Birdwell SW, et al. Use of an automated

medication storage and distribution system. *Am J Hosp Pharm* 1992;49(4):851-5.
14. Oswald S, Caldwell R. Dispensing error rate after implementation of an automated pharmacy carousel system. *Am J Health Syst Pharm* 2007;64(13):1427-31.
15. Schwarz HO, Brodowy BA. Implementation and evaluation of an automated dispensing system. *Am J Health Syst Pharm* 1995;52(8):823-8.
16. Shirley KL. Effect of an automated dispensing system on medication administration time. *Am J Health Syst Pharm* 1999;56(15):1542-5.
17. Sutter TL, Wellman GS, Mott DA, et al. Discrepancies with automated drug storage and distribution cabinets. *Am J Health Syst Pharm* 1998;55(18):1924-6.
18. Temple J, Ludwig B. Implementation and evaluation of carousel dispensing technology in a university medical center pharmacy. *Am J Health Syst Pharm* 2010;67(10):821-9.
19. Ward MJ, Boyd JS, Harger NJ, et al. An automated dispensing system for improving medication timing in the emergency department. *World J Emerg Med* 2012;3(2):102-07.
20. Sikka R, Sweis R, Kaucky C, et al. Automated dispensing cabinet alert improves compliance with obtaining blood cultures before antibiotic administration for patients admitted with pneumonia. *Jt Comm J Qual Patient Saf* 2012;38(5):224-8.
21. Chapuis C, Roustit M, Bal G, et al. Automated drug dispensing system reduces medication errors in an intensive care setting. *Crit Care Med* 2010;38(12):2275-81.
22. Coleman B. Hospital pharmacy staff attitudes towards automated dispensing before and after implementation. *Hosp pharmacist* 2004;11(6):248-51.
23. Fitzpatrick R, Cooke P, Southall C, et al. Evaluation of an automated dispensing system in a hospital pharmacy dispensary. *Pharm J* 2005;274(7354):763-65.
24. Rodriguez-Gonzalez CG, Herranz-Alonso A, Martin-Barbero ML, et al. Prevalence of medication administration errors in two medical units with automated prescription and dispensing. *J Am Med Inform Assoc* 2012;19(1):72-8.
25. Slee A, Farrar K, Hughes D. Implementing an automated dispensing system. *Pharm J* 2002;268(7191):437-38.
26. Taxis K, Dean B, Barber N. Hospital drug distribution systems in the UK and Germany - a study of medication errors. *Pharm World Sci* 1999;21(1):25-31.
27. Brinklow N. A report assessing the impact of an Automated Dispensing System (ADS) at King's College Hospital NHS Trust.: Pharmacy Department, 2006.
28. Dib JG, Abdulmohsin SA, Farooki MU, et al. Effects of an automated drug dispensing system on medication adverse event occurrences and cost containment at SAMSO. *Hosp pharmacist* 2006;41(12):1180-4.
29. Dean BS, Allan EL, Barber ND, et al. Comparison of medication errors in an American and a British hospital. *Am J Health Syst Pharm* 1995;52(22):2543-9.
30. Crawford SY, Grussing PG, Clark TG, et al. Staff attitudes about the use of robots in pharmacy before implementation of a robotic dispensing system. *Am J Health Syst Pharm* 1998;55(18):1907-14.
31. James KL, Barlow D, Bithell A, et al. The impact of automation on pharmacy staff experience of workplace stressors. *Int J Pharm Pract* 2013;21(2):105-16.
32. Novek J, Bettess S, Burke K, et al. Nurses' perceptions of the reliability of an automated medication dispensing system. *J Nurs Care Qual* 2000;14(2):1-13.
33. Sirois P, Fournier H, Lebouthilier A, et al. Nurses' perceptions and attitudes towards new ADU technology and use. *Technol Health Care* 2013;21(1):41-7.
34. Benrimoj SI, Thornton PD, Langford JH. A review of drug distribution systems: Part 2 - Automated dispensing for unit dose systems. *Aust J Hosp Pharm* 1995;25(3):230-35.
35. Garrelts JC, Koehn L, Snyder V, et al. Automated medication distribution systems and compliance with Joint Commission standards. *Am J Health Syst Pharm* 2001;58(23):2267-72.
36. Gaunt MJ, Johnston J, Davis MM. Automated dispensing cabinets. Don't assume they're safe; correct design and use are crucial. *Am J Nurs* 2007;107(8):27-8.
37. Gordon JO, Hadsall RS, Schommer JC. Automated medication-dispensing system in two hospital emergency departments. *Am J Health Syst Pharm* 2005;62(18):1917-23.
38. Paparella S. Automated medication dispensing systems: not error free. *J Emerg Nurs* 2006;32(1):71-4.
39. Wellman GS, Hammond RL, Talmage R. Computerized controlled-substance surveillance: application involving automated storage and distribution cabinets. *Am J Health Syst Pharm* 2001;58(19):1830-5.
40. Woehlck HJ, McQueen AM, Connolly LA. Off-hours unavailability of drugs during emergency situations with automated drug dispensing machines. *Can J Anaesth* 2007;54(5):403-4.
41. Jones DG, Crane VS, Trussell RG. Automated medication dispensing: the ATC 212 system. *Hosp Pharm* 1989;24(8):604, 06-10.
42. Automated decentralized pharmacy dispensing systems. *Health devices* 1996;25(12):452-73.
43. Equipment management guide. Improving the drug distribution process--do you need an automated decentralized pharmacy dispensing system? *Health devices* 1996;25(12):441-51.
44. Follow ISMP guidelines to safeguard the design and use of automated dispensing cabinets. *Alta RN* 2010;66(6):26-8.
45. Grissinger M. Safegurads for using and designing automated dispensing cabinets. *Pharm Ther* 2012;37(9):490-1; 530.
46. Karr A. Automated dispensing - Procuring automated picking and storage systems. *Hosp pharmacist* 2004;11(4):152-54.
47. Shah A. Automated dispensing - Practical tips on managing implementation. *Hosp pharmacist* 2004;11(5):198-200.
48. Shu W, Towne P, So A. Transition to new automated dispensing cabinets at two tertiary care hospitals. *Am J Health Syst Pharm* 2011;68(13):1200-2.
49. Tallon RW. Automated medication dispensing systems. *Nurs Manage* 1996;27(8):45-6.
50. Wong BJ, Rancourt MD, Clark ST. Choosing an automated dispensing machine. *Am J Health Syst Pharm* 1999;56(14):1398-9.
51. Do automated dispensing machines improve patient safety? *Can J Hosp Pharm* 2009;62(6):516-9.
52. Barker KN. Ensuring safety in the use of automated medication dispensing systems. *Am J Health Syst Pharm* 1995;52(21):2445-7.
53. Perini VJ, Vermeulen LC, Jr. Comparison of automated medication-management systems. *Am J Hosp Pharm* 1994;51(15):1883-91.
54. Breen M, Breton G, Lazzerini C, et al. Evaluation of medication dispensing errors within the Pharmacy of Longjumeau Hospital. *Int J Clin Pharm* 2012;34 (1):210.
55. Fayard C, Schweitzer M, Recoules C, et al. Management of automated dispensing systems in oncology and haematology units. *Int J Clin Pharm* 2012;34 (1):226.
56. Goodine C. Safety audit of automated dispensing cabinets. *Can J Hosp Pharm* 2010;63 (1):70-71.
57. James KL, Barlow D, Bithell A, et al. The impact of automation on workload and dispensing incidents in hospital pharmacy. *Int J Pharm Pract* 2011;19:89-90.
58. James L, Barlow D, Bithell A, et al. Role conflict: Occupational stressors versus patient safety. The effect of workload and pharmacy staff stressors on prevented dispensing incidents in hospitals with manual and automated dispensing systems. *Int J Pharm Pract* 2009;17 (S2):B2-B3.
59. Kynicos S, Lee P, Huh JH, et al. Revising automated dispensing cabinet inventory to improve efficiency. *Can J Hosp Pharm* 2011;64 (1):80-81.
60. Perez Serrano R, Negro Vega E, Molina Garcia T, et al. Allocating the cost of the medicines after implementing an automated dispensing system+. *Eur J Hops Pharm Sci Pract* 2012;19 (2):164-65.
61. Saez De La Fuente J, Izquierdo E, Esteban C, et al. Safe use of automated drug dispensing system to improve management of high risk medicines. *Eur J Hops Pharm Sci Pract* 2012;19 (2):128.
62. Sempere Serrano P, Cachafeiro Pin AI, Castellano Copa P, et al. Introduction of an automated drug dispensing system in an intensive care unit. *Eur J Hops Pharm Sci Pract* 2012;19 (2):141.
63. Thomsen LA, Herborg H, Rossing C. From machine to mouth: How can automated dose dispensing lead to safer and more effective patient medication? *Int J Clin Pharm* 2011;33 (4):715.
64. Viprey M, Burgos Leon-Djian C, Dode X, et al. Effect of unit dose drug dispensing system on medication administration errors. *Int J Clin Pharm* 2012;34 (1):174.
65. Walser L, Skinner J, Chisholm A. Early impact of a decentralized automated dispensing system in a small regional hospital. *Can J Hosp Pharm* 2011;64 (1):81.