AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

June 2017

Barcoding and other scanning technologies to improve medication safety in hospitals

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ISBN: 978-1-925224-83-2

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Bainbridge M, Askew D. Barcoding and other scanning technologies to improve medication safety in hospitals. Sydney: ACSQHC; 2017

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Preface

This preface was written by the Australian Commission on Safety and Quality in Health Care (the Commission) to provide context and background to the report which follows, *Barcoding and other scanning technologies to improve medication safety in hospitals.* The main report was prepared by ASE Health and Dr P Howard for the Commission.

Background

The Australian Commission on Safety and Quality in Health Care (the Commission) was established in 2006 by the Australian Government and state and territory governments to lead and coordinate national improvements in safety and quality in health care. The Commission has four strategic priorities that underpin its functions:

- Patient safety
- Partnering with patients, consumers and communities
- Quality, cost and value
- Supporting health professionals to provide safe and high-quality care.

The Commission's combined work plan 2016–2019 specifies development of a report on the use of scanning technologies in medication management, and how these technologies may be used to improve patient safety.

Scanning technologies are machine-readable codes with standard terminologies. Hospitals around the world have introduced scanning technologies in the medication management process to:

- Reduce medication errors and associated harm
- Improve the quality, safety and efficiency of health services.

Scanning technologies can be introduced at various stages in the medication management process.

The report focuses on the main types of scanning technologies used in hospitals: twodimensional barcodes and radio frequency identification. It summarises information and findings from two international literature reviews, and provides an overview of the use and implementation of scanning technologies in medication management processes in the Australian context.

Key findings

The review findings are linked to three main areas:

- Safety
- Scanning versus radio frequency technology
- Implementation in Australia.

Safety

Studies in the literature review indicate that the use of scanning technologies in hospital medication management processes can reduce errors, potential harm to patients and costs to the health system. Studies in the literature review found:

- The most significant medication safety gains occur when scanning technologies are employed at the point of administration, where the scanning technology verifies the patient's identity and the medicinal product being administered
- Scanning technologies require the support of electronic medication management systems before they can be employed at the point of administration
- Safe barcode implementations should employ two-dimensional barcoding
- Fewer adverse drug events led to a reduction in harm and fewer lives lost

Unit dose dispensing and administration has been shown to greatly improve patient safety and increase workflow efficiency. In Australia, however, not all medicines are packaged in unit doses by the manufacturer. To implement unit dose dispensing and administration, hospitals are required to invest heavily in technology and robotics to repackage medicines from the manufacturer into unit doses.

No studies indicated negative outcomes from introducing scanning technologies in medication dispensing or administration processes. However, in some instances where implementation of these new technologies or processes had been difficult, staff had created 'workaround' strategies in an effort to address them. As workaround strategies can reduce the benefits of scanning technologies and potentially introduce new risks and hazards, it is important for systems to be user-friendly and for staff to be provided with education on their use.

Scanning versus radio frequency technology

Scanning technologies are the most common form of auto-identification and data capture in hospitals. They are simple, universal and low cost. Radio frequency identification (RFID) tags hold more data compared to barcodes, and can be read automatically without the need for user intervention. RFID technology is expensive compared to barcode scanning technologies, and therefore the benefits are restricted to high-value medicines and devices.

Implementation in Australia

Examples of barcodes and scanning technology systems implemented in the medication management process in Australia are limited. The most common initiatives are the use of barcode scanning technologies in hospital pharmacy departments, where they are mainly employed for inventory management.

The most comprehensive implementations and use of scanning technologies in the medication management process in Australia are found at:

- St Stephen's Hospital, Hervey Bay, Queensland
- Royal Children's Hospital, Melbourne, Victoria.

Both hospitals have implemented electronic medication management systems which include barcode scanning dispensing and administration. Each hospital has received Stage 6 certification by the Healthcare Information Management Systems Society (HIMSS).

St Stephen's Hospital in Hervey Bay is a 96-bed hospital operated by UnitingCare that opened in October 2014 and was the first to achieve HIMSS Stage 6 certification. St Stephen's Hospital implemented unit dose dispensing, and administration was required to meet both federal and state manufacturing licensing rules to prepare unit dose packaging on site. As at March 2017, St Stephen's hospital was conducting a benefits realisation study evaluating the outcomes of their investment, however, final results are yet to be published. Preliminary data indicates a 22% reduction in medication administration errors compared to the pre-implementation baseline.

Conclusion

Introducing scanning technologies into hospital medication management processes represents a significant investment and change in work practices for health services. It also presents a major opportunity to improve the quality, safety and efficiency of patient care, and reduce costs to the health system.

There is limited published evidence detailing the safety and cost benefits of implementing scanning technologies at particular stages of the medication management process. However, there is sufficient evidence to encourage hospitals and health services to research, investigate and develop scanning technology implementations. Through this, hospitals could build towards a closed-loop medication management system to improve patient safety and reduce the risk of medication errors and adverse events.

Before implementing scanning technologies in hospital medication management processes, there are a range of issues which should be researched and investigated. To achieve optimal patient safety, workflow strategies and cost benefits, organisations should consider the following capabilities:

- Automated dispensing cabinets where the workflow includes scanning for restocking or selecting products
- An electronic medication management system for medication orders/prescriptions and administration, which involves mobile (bedside) computing
- Software and scanning equipment that enables patient verification from a barcode on a wristband and/or verification of the medicine from a barcode on a product pack
- Unit dose packaging.

Next steps

The Commission will use this report to inform the third edition of *Electronic medication* management systems: A guide to safe implementation, and the development of a self-assessment tool for electronic medication management systems.

Health services are encouraged to consider this report in the context of their local environment and seek up-to-date information from local reference sites when planning and developing business cases to implement scanning technologies in their medication management process. Appendices 1 and 2 in the report describe the costs and benefits of implementing scanning technologies in different systems.



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Glossary

Term	Definition
Auto-identification and data capture	The use of machine-readable codes such as barcodes and radio frequency identification tags using standard terminology. Can be used for items such as patient identification and medical record tracking.
Barcode medication administration (BCMA) system	A BCMA system consists of a barcode reader, usually with a portable computer with wireless connection, a computer server and software. Patients and medications are barcoded, and both barcodes must match before the medicine is administered. BCMA systems can also record medication events and timing and automatically upload this information to an electronic medication management system.
Closed-loop medication management system	Closed-loop medication management uses technology to minimise manual selection, input and transcription, to reduce human effort and some risks of human error. In this report, it means where all possible steps of the medication management process are supported electronically, from ordering through to administration.
Electronic medication management (EMM)	 Electronic medication management (EMM) is a broad term that incorporates any electronic clinical information system, tool or software application that is used to support the medicines management cycle. This includes: Prescribing systems Decision support systems Dispensing systems Ordering and supply solutions Administration records.
Radio frequency identification (RFID)	Transfer of data using radio frequency between a reader and a tag. The tag can be attached to a pallet of goods, high-value items or a patient wristband, or even inserted under the skin. The tag transmits a signal, and an antenna and transceiver read the signal and transmit it to a server. The RFID tag may be unpowered (passive) or contain a power source (active).
Unit dose medicine distribution	A pharmacy-coordinated method of dispensing and controlling medicines where medicines are contained in single unit packages, dispensed in a ready-to-administer form (as far as possible), and (for most medicines) provided in the patient care area with a maximum 24-hour supply. Unit dose systems differ depending on the specific needs of the organisation.

Acronyms and abbreviations

Shortened	Explanation
term	
ACSQHC	Australian Commission on Safety and Quality in Health Care
ADC	automated dispensing cabinet
ADE	adverse drug event
BCMA	barcode medication administration
CPOE	computerised provider order entry
EMAR	electronic medication administration record
EMM	electronic medication management
RFID	radio frequency identification
SNOMED CT	Systematized Nomenclature of Medicine, Clinical Terms

Summary

Many hospitals around the world have introduced scanning technologies (machine-readable codes with standard terminologies) to reduce medication errors and associated harm, and to improve the quality, safety and efficiency of health services. To inform decision-making and local business cases, the Australian Commission on Safety and Quality in Health Care conducted two literature reviews on the use of scanning technologies (barcoding and radio frequency identification) in medication administration and pharmacy dispensing.

In Australia, the most common initiative has been to introduce barcode systems and processes in pharmacies. Scanning technology is only possible as an adjunct to electronic medication management and there are limited examples of barcoding and scanning system implementation. The most comprehensive examples of implementations in Australia are in St Stephen's Hospital, Hervey Bay, Queensland and the Royal Children's Hospital, Melbourne, Victoria. These hospitals have implemented electronic medication management, including barcode scanning dispensing and medicines administration.

Studies indicate that the use of scanning technology in medication management reduces errors, reduces potential harm to patients, and reduces costs to the health system.

No studies suggested that the use of barcode scanning in medication dispensing and administration had negative effects. However, there were examples of difficult implementations, and projects that had to change direction before they could be completed. The introduction of workarounds in some systems can bring new risks and potentially reduced the benefits of the system.

Introducing barcode scanning technology is cost-effective. A US study found that a barcode medication administration system for inpatient medication cost US\$2,000 per moderate or severe medication error prevented. This was less than the cost of additional hospital care resulting from preventable adverse drug events.

A study from the Netherlands provides a compelling example of the benefits, where fewer adverse drug events lead to a reduction in harm and fewer lives lost. Dutch hospitals use electronic prescribing through a computerised provider order entry system, so research in the Netherlands focuses on the implementation of barcode medication administration, including the costs of barcoding and repackaging medicines, and purchasing scanning hardware and software. This study found that implementing barcode verification reduces medication administration errors by 50%, with benefits to safety of health care services and a favourable cost–benefit ratio.

Unit dose dispensing using scanning technology is more expensive than pack-based dispensing, and currently requires a significant investment in technology and robotics within the hospital pharmacy. It is possible to implement unit dose dispensing as standalone technology. However, studies suggest that this approach will provide greater benefits if it is integrated into closed-loop medication management processes, which minimise the potential for human error throughout. Studies comparing unit dose distribution with ward stock systems show that unit doses are safer for the patient, and more efficient and economical for the organisation.

Radio frequency identification technology remains expensive in comparison to barcode scanning, and the benefits are therefore constrained to high-value items.

Benefits are achieved from introducing barcode medication management at the point of dispensing and barcoded medication administration. It is not possible to draw a firm conclusion on the incremental cost or benefit of adoption of a closed-loop medication management model. However, it seems likely there are safety benefits. Results of analysis from Australian integrated

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systems will help determine whether the additional investment required to implement fully closedloop medication management, including robotics, will result in additional safety improvements.

When developing business cases for scanning technology in medication management, health service organisations are encouraged to consider this report in the context of their local environment and seek up-to-date information from local reference sites.

1 Purpose and context

This report describes the current status of barcoding and other scanning technologies for medication management in the hospital sector, to inform decision-making and assist in the development of business cases. It outlines the current use of these technologies in Australia, and discusses evidence for the use of scanning technology in medication management in hospital. The highest quality studies have been conducted on barcode scanning in unit dose systems of medication administration.

The Australian Commission on Safety and Quality in Health Care (the Commission) work program includes developing safety assurance approaches in digital health systems in acute and primary care. This includes auditing the safety of the My Health Record system, and support for the safe implementation of electronic medication management systems in hospitals.

The Commission work plan specifies that a report will be provided to states and territories on the uses of scanning technologies and their capacity to improve patient safety throughout the medication management process. This report includes summarised information from two literature reviews on scanning technologies in medication management.

Appendices 1 and 2 in this report describe the costs and benefits of implementing scanning technologies in different systems. Health service organisations seeking to evaluate or introduce scanning technologies into the medication management process, including pharmacy dispensing and medication administration, can use these appendixes to help develop their business cases.

2 Introduction

Safe medication use involves several interdependent steps in the medication management process (Figure 1). Medication errors may occur at any stage in this process,¹ and may cause harm to patients (resulting in patient injury or death) and financial cost to the health system. Errors introduced at any step can be carried on to other steps in the process.

Figure 1: Medication management process



Source: APAC 2005²

2.1 Frequency of medication errors

In a study of the incidence of medication errors at various stages of the medication management process, errors resulting in preventable adverse drug events (ADEs) occurred most often at the stages of prescribing (56%) and administration (34%). Transcription errors (6%) and dispensing errors (4%) were less common. Errors were much more likely to be intercepted if they occurred earlier in the process: 48% of errors were intercepted at the ordering stage compared with zero at the administration stage.³

Of serious medication errors, about one-third occur at the ordering stage, one-third occur during the transcription and dispensing stages, and one-third occur during medication administration.⁴ One study identified 6.5 adverse events relating to medication use per 100 inpatient admissions; more than 25% of these events were the result of errors and were thought to be preventable.⁵

An Australian literature review in 2013⁶ reported the frequency of undesirable medication events based on several large studies in major teaching hospitals. In line with international studies, prescribing and administration errors were common, as were errors occurring on admission, discharge and post-discharge. Studies in specific populations also revealed high rates of

medication errors. For example, a four-year retrospective study in a major Australian children's hospital reported a rate of 6.58 medication errors per 1,000 bed days.⁷

Actions to reduce medication errors may include¹:

- Improving clinicans' training in clinical pharmacology therapeutics, including safety principles, to help them prescribe safely and effectively
- Educating consumers to ensure they understand how to take their medicines safely and effectively
- Conducting medication reviews and medication reconciliation, which can be performed by the doctor or pharmacist
- Implementing digital health interventions (including scanning technology such as barcoding) to support prescribing, dispensing and administration.

2.2 Using technology to reduce medication errors

Many hospitals around the world, and some in Australia, have introduced technology to improve the quality, safety and efficiency of health services. Technology has the potential to reduce medication errors.^{3,8} For example, computerised provider order entry can reduce the incidence of serious medication errors by 57% and the potential ADEs due to non-timing administration by 51%.⁸

Electronic medication management (EMM) can be more effective and less expensive than paperbased prescribing. In one hospital, the rate of ADEs decreased from 0.17 ADEs per admission to 0.05 ADEs per admission after EMM was implemented, equating to approximately 80 ADEs per year.⁹ The reduced costs associated with these ADEs were more than sufficient to offset the costs of the EMM.

In the medication management process, scanning technologies can be used from medication ordering to dispensing and administration, and can address the 'five rights' of medication safety:¹⁰

- 1. Right medicine
- 2. Right patient
- 3. Right time
- 4. Right dose
- 5. Right route of administration.

At the bedside, barcode technology may be used to verify a patient's identity before medicine administration. Bedside verification of medicines using barcodes generated by an electronic medication administration record (EMAR) system allows nurses to check and document the medication administration. If the EMAR imports medication orders electronically from either the physician's order entry or the pharmacy system, it may also reduce transcription errors.

3 Scanning technologies in medication management

Scanning technology is the use of machine-readable codes with standard terminologies, and is also known as 'auto-identification and data capture'. Scanning technologies have been used extensively in non-health industries to improve accuracy and facilitate product identification, and their use in the health sector is increasing and evolving. Scanning technologies include barcodes, radio frequency identification (RFID) tags, patient smart cards, packaged software systems and biometric devices. As they are the only types of scanning technologies currently used in Australia, this report focuses on barcodes and RFID.

Scanning technologies can be used in a range of healthcare areas, including^{11,12}:

- Patient identification and profiling
- Patient movement and handover
- Diagnosis, including pathology and radiology
- Medication management
- Blood transfusion
- Surgical procedures
- Devices and implants
- Medical record tracking
- Sterile services
- Asset management.

3.1 Types of scanning technologies

The main types of scanning technologies in hospitals are barcodes and RFID.

Barcodes

A barcode is an optical machine-readable representation of data that relates to the object displaying the barcode. Originally, linear or one-dimensional barcodes represented data by varying the width and spacing of parallel lines. They required a special optical reader to scan the information. More recently, two-dimensional barcodes have been developed that use rectangles, dots, hexagons and other geometric patterns. Software is now available that can allow any device with a camera, such as a smartphone, to read a barcode.^{13,14}

Barcodes are simple, universal and low cost, which makes them the most common form of autoidentification and data capture.

Radio frequency identification

RFID uses radio frequency to transfer data between a tag or transponder, and a reader. The tag can be attached to a pallet of supplies, a clinical item, a patient wristband or even inserted under the skin. The tag transmits a signal, and an antenna and transceiver read the signal and transmit it to a server. RFID can be classified as active (where the tag has a power source) or passive (where the tag does not have a power source).¹¹ RFID tags can hold more data than barcodes, and can be read automatically without any user intervention.

The application of RFID technologies in hospitals is limited by high unit cost.¹⁵ Although RFID unit costs have decreased substantially over the past few years, they have not yet become sufficiently economical for health service organisations. RFID in health care is mostly used in asset management and supply chain applications.

3.2 Medication dispensing

Choosing the wrong product when dispensing medicines can cause serious patient harm. Patients can receive the wrong medicine, or an incorrect strength or formulation of the intended medicine. Barcode scanning identifies the majority of these errors, and allows them to be corrected before medicines are administered to patients.

Pharmacy dispensing software captures data entry from a prescription, and generates a number that identifies the medicine to be dispensed, the patient, and information about the medicine. This number can be presented as a barcode. When this barcode and the barcode on the manufacturer's packaging are scanned, the software compares the data recorded in the system with the product taken off the shelf to determine if the medicine is the same. Scanning the barcode at the final stage of dispensing, just before attaching the label, provides a final check to ensure the selected commercial pack matches the dispensing label (Figure 2).¹⁶



Figure 2: Barcode scanning in the dispensing process

Source: Clinical Excellence Commission (NSW)¹⁶

In hospitals, pharmacists regularly prepare compounded medicines such as intravenous solutions, parenteral nutrition and chemotherapy. Scanning of source ingredients during compounding, repackaging or labelling processes can ensure the labelled doses contain the appropriate ingredients.

In Australia, barcode scanning at the pack level for product selection is commonly used for dispensing in community pharmacies and in some hospitals. This practice is strongly recommended by professional bodies including the Pharmacy Board of Australia, the Society of Hospital Pharmacists of Australia and the Pharmaceutical Society of Australia.¹⁷ In 2014, NSW Health released an information bulletin that strongly recommended all public hospital pharmacy

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departments implement barcode verification in dispensing processes. The use of barcode scanning is also referenced in the National Safety and Quality Health Service Standards.; however, data on the uptake of barcode scanning in the Australian hospital sector is not readily available.¹⁸

3.3 Scanning technology regulation

In Australia, labelling of medicinal products is regulated by the Therapeutic Goods Administration (TGA) and covered by Therapeutic Goods Orders 91 and 92.¹⁹ TGA recommends all medicine labels include a machine readable code, such as a barcode. However this is only mandatory for prescription medicines, unless they are in starter packs. Moreover, where medicines are packaged with more than one label, then the most important information is on the main label and the machine readable code is not necessarily required on smaller units within the primary pack.

In the United States in 2006, the Food and Drug Administration mandated that barcodes be available for most pharmaceuticals and biologic products at the unit dose level, as a responsibility of medicine manufacturers, wholesalers and hospitals. This led to a rapid uptake of barcode systems in US hospitals, and the technology is now used throughout the medication management process, including pharmacy operations such as:

- Receipt of inventory from suppliers and stocking inventory locations from which patient medicines may be dispensed (e.g. stocking automated dispensing cabinets)
- Packaging of liquid medicines in ready-to-administer form
- Compounding of medicines
- Dispensing of patient-specific medicines for 24-hour medication carts and nurse server cabinets in patient rooms.

3.4 Medication administration

Barcode medication administration (BCMA) is a system comprising a barcode reader (usually with a portable computer with wireless connection to the server) and proprietary software. Both patients and medicines are barcoded, and these barcodes must match before the medicine is administered. BCMA systems also record the timing of medication events, allowing this information to be captured by the electronic medication management system.

At the bedside, different systems offer differing levels of sophistication. For example, some systems provide clinical decision support when specific medicines are scanned. Others automatically update the patient's medical record during scanning.

A 2013 survey by the American Society of Health-System Pharmacists reported that 80% of US hospitals had BCMA systems.²⁰ In 2014, barcode technology became a criterion for achieving Stage 2 of 'meaningful use' in hospitals under the 2009 American Recovery and Reinvestment Act.²¹ However, in Australia, there is limited use of barcode scanning of medicines in the acute sector at the point of care.

3.5 Unit dose medicine distribution systems

The unit dose system of medicine distribution is a pharmacy-coordinated method of dispensing and controlling medicines in healthcare settings. Details of the unit dose system may differ depending on the specific needs of the organisation, but the following elements are common to all systems:

- Medicines are contained in single-unit packages
- Medicines are dispensed in a ready-to-administer form, where possible

• For most medicines, a maximum 24-hour supply is delivered to or available in the patient care area at any time (see Figure 3).



Figure 3: Example of unit dose packaging with barcodes

Source: Wiegand²²

Unit dose dispensing of medicines was developed in the 1960s in the United States to support nurses in medication administration and reduce the waste of increasingly expensive medicines. Today, unit dose dispensing of medicines is a standard of practice in US hospitals. In Australia, few hospitals currently use a unit dose method of medicine distribution.

Studies generally compare unit dose dispensing with a ward stock system. In a ward stock system, nurses order commonly used medicines in bulk from the pharmacy, and the medicines are stored in a medication room on the ward. Nurses prepare medication cups for each patient during medication administration cycles. The correct number of pills must be taken out of the correct medicine container for each cycle and taken to the patient for administration. Liquids must be poured from the appropriate bottle and each dose carefully measured. Nurses are responsible for any necessary interim labelling.

Studies comparing unit dose distribution with ward stock systems generally show that unit dose systems are safer for the patient, more efficient and economical for the organisation, and a more effective method of organising professional resources.²³

Barcodes accurately identify medicines at the unit dose level by type, recommended dosage and frequency of administration. This provides nurses with a 'second check' and decision support tool during administration. Nurses can combine the information contained in the unit dose barcode with the patient wristband to ensure the 'five rights' of patient safety.

3.6 Automated dispensing cabinets

Automated dispensing cabinets (ADCs) are computerised medicine storage devices or cabinets that allow medicines to be stored and dispensed near the point of care, while controlling and

tracking medicine distribution. They are sometimes known as unit-based cabinets, automated dispensing devices, automated distribution cabinets or automated dispensing machines²⁴ (Figure 4).

Figure 4: An automated dispensing cabinet



Source: Pharmacy purchasing and products magazine²⁵

ADCs enable on-demand, ready access to unit dose medicines in a variety of patient care areas and with a high degree of built-in safeguards. They can provide nurses with near total access to the medicines needed in patient care areas, which can decrease the delivery time of medicines from the pharmacy to the patient care unit. ADCs can also ensure greater control over the capture of medication information, support security measures, and potentially reduce the medication error rate. More sophisticated versions of ADC software can provide additional clinician support to improve patient safety through:

- Machine-readable barcodes for restocking and selection of medicines
- Integration into automated refilling systems
- Provision of medication safety alerts and decision support when selecting medicines
- The capacity to link with telepharmacy operations for after-hours medication verification and distribution.

Many US healthcare organisations use ADCs as their primary method of medicine delivery. The change to the pharmacy distribution model associated with the implementation of scanning technologies has had broad workflow implications for pharmacists, pharmacy technicians and nurses, and the safety of associated practice.

ADCs can also be used to improve medication safety in the high-pressure environment of the emergency department. A recent study in a tertiary hospital emergency department in Victoria showed that ADCs could reduce errors in medication selection and preparation, and improve medication safety.²⁶

3.7 Closed-loop medication management

Closed-loop medication management uses technology (including scanning technologies) to minimise manual selection, input and transcription, which reduces human effort and the risk of human error.²⁷ In a hospital inpatient setting, it applies from when the clinician writes the

prescription to when the nurse or carer issues and administers the medicine. This means that the potential for human error is minimised at every step in the process. Closed-loop systems could be seen as the most 'mature state' of medication management.

The elements in Figure 5 interact to complete a closed-loop medication administration process. Barcoding technology cannot be effectively implemented without links to other systems. The closed-loop medication management process with barcoding is comprehensive and rated as Healthcare Information Management Systems Society (HIMSS) Stage 6 certification.



Figure 5: Closed-loop medication management process

Table 3.1 sets out three stages of introducing scanning technology, progressing towards closedloop medication management. It shows what is required to implement each scanning technology, and how the implementation of each new system can further reduce risk.

Table 3.1: Stepwise introduction of scanning technology in closed-loop medication management

Stage	Scanning	Elements required	Risk mitigated
1	Pharmacy stock control and dispensing	Barcode on package	Wrong medicine
2	Medication administration	 Barcode on package Patient ID on wristband Unit dose dispensing and administration 	Wrong medicineWrong patientWrong time
3	Closed-loop medication management (electronic ordering integrated with electronic medical record)	 Barcode on package Patient ID on wristband Unit dose dispensing and administration Robotic pack dispensing/ dispensing cupboard Underpinned by electronic ordering and fully linked to electronic medical record 	 Wrong medicine Wrong patient Wrong time Wrong dose

Table 3.2 describes how the introduction of particular aspects of auto-identification and data capture technology can mitigate risks and support the 'five rights' of medication safety.

 Table 3.2: Auto-identification and data capture

Scanning technology element	Risk mitigated through introduction of technology	Other benefits
Barcode on package	Wrong medicineWrong time	Reduces time to confirm patient and medicine identification
Patient ID on wristband (barcode or radio frequency identification)	Wrong patient	Potential for use in other nonmedication areas such as surgery procedure patient verification
Unit dose dispensing	Wrong doseWrong route	More efficient and economical method of organising professional resources. Possible mitigation of wrong route, depending on electronic medical record
Robotic pack dispensing/dispensing cupboard	Wrong medicineWrong patient	Possible mitigation of wrong route, depending on electronic medical record

4 Use of scanning technologies in health in Australia

In 2008, the Australian Commission on Safety and Quality in Health Care (the Commission) report *Technology Solutions to Patient Misidentification: Report of review*¹¹ described the situation in Australia regarding technology and the problem of patient misidentification as similar to that in many other developed countries. The report acknowledged that a strategic or system-wide approach to patient identification was not yet being taken.

The Commission developed specifications for a standard patient identification band in Australia, with standards for usability, content and colour.²⁸ These specifications were endorsed in 2008 by health ministers for use in public and private health services. In particular, they state that:

Patient identification bands should allow for the incorporation of new technologies that may be used to assist patient identification such as radiofrequency identification tags, barcode technologies or digital photos, whilst still fulfilling [other] requirements.²⁸

Since 2008, barcode technology has been deployed to tie items and documentation to a particular patient – for example, prescription and administration of medicines, ordering and reporting of tests, and provision of blood. Radio frequency identification tags are being deployed to track patients themselves, such as in neonatal and geriatric environments.

4.1 Electronic medication management in hospitals

Hospital electronic medication management (EMM) systems can improve the quality, safety and effectiveness of medication management. They support doctors, nurses and pharmacists to prescribe, order, verify, reconcile, dispense and record the administration of medicines, and provide access to patient information and clinical decision support in real time.

Paper prescribing involves risks and challenges, such as information that is missing, not matched or illegible.²⁹ EMM systems can improve patient safety by reducing medication errors and associated adverse events, increasing legibility of medication orders, and reducing variation in prescribing practice.

Uptake of EMM is low in Australian hospitals (Table 4.1), and most hospital medicines are still prescribed using the national inpatient medication chart, or other local and specialty charts. EMM has been implemented in health departments in the Northern Territory and the Australian Capital Territory, as well as some public and private hospitals. The New South Wales e-Medications Program supports Local Health Districts to implement and improve a range of processes and systems to deliver EMM within the state public health system.

Table 4.1: Use of technologies in	n Australia compared with	optimum closed-loop
medication management		

Step in the medication management process	Optimum electronic medication management system	Current state in Australian hospitals
Prescribing	Clinician chooses and electronically orders a medicine or regime for a patient	Some hospitals have electronic ordering and prescribing linked to the electronic medical record. Many hospitals use paper charts for medication administration. Medicine orders are collected by a pharmacist or faxed to the pharmacy.
Order review and verification	Medicines can be reviewed at the time of prescription and by the pharmacist using closed-loop electronic ordering and auto- identification and data capture technology	Pharmacists manually check the order in the pharmacy or on the ward. The order is manually entered into the pharmacy dispensing system. Electronic ordering and pharmacy systems are frequently incompatible, so that even with electronic ordering, the order must be transcribed between systems.
Medicine preparation	Medicines are prepared in the pharmacy with full supply-chain integration and audit trail	Supply and inventory systems do not integrate with medicine preparation in hospital pharmacies
Dispensing	Medicines are dispensed using integrated barcode validation, robotic dispensing and unit dose packaging	Medicines are dispensed using standalone barcode verification of the product that does not interfere with the EMM system
Distribution and supply to wards and units	Delivery and receipt of medicines are tracked electronically	Many hospitals do not track distribution and supply to the patient level
Administration and documentation	Medicines are administered and documented by confirming the patient's identity with the patient's wristband, and matching the product and unit dose using a barcode. Medicines administration is integrated with and recorded in the electronic medication management system.	Some hospitals use barcodes to confirm the patient's identity and the correct medicine to be administered

4.2 Case study: St Stephen's Hospital, Hervey Bay, Queensland

St Stephen's Hospital in Hervey Bay, Queensland, is a 96-bed hospital operated by UnitingCare Health that opened in October 2014. A digital health project was undertaken to provide a fully integrated electronic medical record in that hospital. It became the first hospital in Australia to achieve Stage 6 certification by the Healthcare Information Management Systems Society (HIMSS) for its advanced electronic medical record system.³⁰

Process and workflow

HIMSS Stage 6 certification requires closed-loop medication management. Moreover, it requires barcoding technology to be fully integrated with the clinical documentation system and computerised provider order entry to be effective.

Barcoding systems implemented at St Stephen's are shown in Table 4.2.

Table 4.2: Clinical applications and scanning at St Stephen's Hospital, Hervey Bay

Clinical application	Element	Scanning
Computerised provider order entry (CPOE)	Medication order sentences and clinical decision support	Fully integrated with CPOE
Pharmacist verification	With product assignment	Pharmacy software automates clinical and departmental pharmacy processes
Electronic dispensing with unit dose packaging	Inpatient label tool	
Electronic medication administration record (EMAR)	The EMAR displays all active medicines for a specific patient, as well as the medicine, orders, tasks and administrations for the selected timeframe and selected order status	Fully integrated with EMAR
Automated dispensing cabinets (ADCs)	The cabinet connects to the patient's electronic medical record, and to a pharmacy stock database	Clinician administering medicine uses a scanner from the ADC to check that it is the right medicine, at the right dose, for the right patient, and whether the patient has any allergies, before opening the cabinet
Work stations on wheels	Computer screens on lightweight carts that access patient information anywhere in the hospital are used to securely transport the medicine from the ADC to the patient's room	
Point-of-care medication administration record	Barcoding technology to ensure safe administration of medicines at the bedside	Scanning automates the documentation of medication administration and tasks relating to specific physician/nursing orders at the point of care, and notifies the clinician when inconsistencies occur that could represent medication administration errors

Unit dose packaging

Barcode scanning is necessary to ensure compliance with all the steps in the closed-loop medication administration process. In Australia, medicines are normally packaged in blister packs

rather than in a single or unit dose package, but blister packs cannot be barcoded and scanned. Therefore, barcode medication administration requires unit dose packaging of medicines.

St Stephen's made a full evaluation of all distribution, clinical and administrative pathways to identify the organisational capability for unit dose packaging in the pharmacy. UnitingCare Health was required to meet both federal and state manufacturing licensing rules to prepare unit dose packaging on site at St Stephen's. Equipment was needed to implement unit dose packaging, including a de-blistering machine.

Not all commercially available medicines can be packaged in unit doses, and some may continue to be used in bulk multidose form, or in multidose sachets. UnitingCare Health suggested innovations to support unit dose packaging. Where bulk multidose forms of medicines are used, a roll of barcoded labels could be stored in the compartment next to the medicine, and the nurse could apply the label when the medicine is removed from ward imprest stock. Where multidose sachets are used, additional mechanisms to verify the medication administration dose could be built into the electronic medical record.

Evaluation

A benefits realisation study is evaluating the outcomes of the investment. One of the key measures in the study is 'reduced medication administration errors due to closed-loop electronic medication management'. If the closed-loop EMM reduces medication administration errors that have the potential to result in adverse drug events, this could provide a significant 'non-cashable' financial benefit.

Early analysis indicates that implementation of the system has resulted in a 22% reduction in medication administration errors. Clinical adoption and technical/build challenges could be key contributing factors. The final results of the study are yet to be published.

4.3 Case study: Royal Children's Hospital, Melbourne

The Royal Children's Hospital (RCH) in Melbourne, Victoria, introduced a hospital wide EMM and an electronic medical record in April 2016. In March 2017, the RCH achieved HIMSS Stage 6 certification.

Process and workflow

Barcoding systems implemented at Royal Children's Hospital include:

1. Pharmacy dispensing

To confirm that the pharmacy is supplying the correct product to the patient, the original manufacturer's pack is scanned at point of dispensing. Some manufacturer barcodes contain batch number and expiry date information, and this is automatically entered and recorded into the dispensing system. In all other cases, the batch number and expiry date is entered into the dispensing system manually. It is estimated this occurs for almost half the stocked products.

For a limited number of medications individual unit doses are prepared. A 2D barcode is applied to all pharmacy supplied doses.

2. Ward medicine preparation

Where a barcode exists on a drug product, this is scanned to identify the drug to be administered to the patient. As described above, this barcode scan be either from the manufacturer or applied by pharmacy. After the nurse has prepared the patient-specific dose, two nurses do an

independent check, and attach a label for that drug and dose to the prepared drug (medication cup, syringe, bag, etc.).

Labels can be made for any type of medication. The label is generated from the EMR and is patient, medication, dose and route specific The label contains a 2D barcode which contains this information^{*}.

The prepared drug is then taken to the patient's bedside. The patient's ID band is scanned and the medication is scanned to ensure correct medication to the correct patient.

3. Bedside scanning at medicine administration

The medicine label, either from pharmacy or ward prepared, is scanned at point of administration with a crosscheck to Medication Administration Record (MAR) and patient ID wristband. Scanning is by a device attached to computer on wheels (COW) or via a mobile hand-held device.

More details on this process can be found on the Commission's Labelling Standard Issues Register, at:

www.safetyandquality.gov.au/wp-content/uploads/2017/03/Standard-for-User-applied-Labelling-of-Injectable-Medicines-Fluids-and-Lines-Issues-Register-Jan-2017.pdf

Barcoding and other scanning technologies to improve medication safety in hospitals

5 Costs and benefits of barcode verification in hospital pharmacies and barcode medication administration

This section describes the literature review methods and discusses studies on the effect of barcode verification on medication errors, and the associated costs and benefits of barcode verification.

5.1 Literature review methods

The Australian Commission on Safety and Quality in Health Care conducted two literature reviews on the use of barcoding and other scanning technology for medication administration and in pharmacy dispensing. Databases searched were MEDLINE, EMBASE, CINAHL, the Joanna Briggs Institute Library of Systematic Reviews, the Cochrane Database of Systematic Reviews, and the Database of Abstracts of Reviews of Effects (DARE). Articles were limited to those published in English and where the study was conducted in Europe, the United States, Canada, the United Kingdom, New Zealand or Australia.

The first literature search looked at published studies from 2012 to January 2016 on barcode medication administration (BCMA) systems, with a focus on medication administration errors. Databases were searched using the search terms 'bar coding technology', 'bar coded medication administration', 'bar code point of care', and 'closed loop medication and medication errors'.

The second search looked at published studies from 2010 to July 2016 on barcode verification technology used in pharmacy dispensing and compounding. Databases were searched using the search terms 'barcode scanning technology', 'barcode technology in pharmacy dispensing', 'barcode verification', 'barcode scanning', 'barcode verification and dispensing of medications', 'barcode verification in drug preparation and dispensing', and 'barcode verification in pharmacy compounding'.

5.2 Literature review results

The majority of journal articles that examine scanning technology focus on barcode verification in the pharmacy during dispensing, and on the ward in medication administration, using unit dose dispensing.

5.3 Effect of barcode verification on errors

The literature generally supports the potential of BCMA to reduce medication administration errors up to one year after implementation, without increasing the time nurses spend on medication administration.³¹ However, the degree of implementation and the extent of user compliance with the system were not always reported, and these factors are critical to determining the effectiveness of the system.

One study found that error rates in order transcription and medication administration were substantially reduced in units using barcode electronic medication administration record (EMAR) technology compared with units that had not implemented it.⁸ The barcode EMAR reduced the potential for adverse drug events (ADEs), although it did not completely eliminate such errors.

Implementation of barcode EMAR in two US hospitals was associated with significant increases in total medication accuracy rates in most study units, and did not introduce new types of error into the medication administration process.³² Accuracy rates further improved when 'wrong time' errors were excluded from analysis. The frequency of errors that are preventable by barcode EMAR decreased significantly in both hospitals after implementation.

5.4 Costs and benefits of barcode verification

Most of the information about the costs and potential benefits from the introduction of barcode technologies are from three studies. $^{33,\;34,\;35}$

Return on investment

Maviglia et al.³³ assessed the costs and benefits of implementing a barcode system in a large, not-for-profit tertiary care hospital pharmacy in the United States, and determined the return on investment at the institutional level. The study found a positive financial return on investment for the hospital – the net benefit after five years was US\$3.49 million, and the break-even point occurred within one year of the system becoming fully operational.

Costs avoided by reducing deaths

In the Netherlands, Reijers and van Wely³⁴ discussed the introduction of BCMA, including the costs of barcoding and repackaging medicines, purchasing scanning hardware and software, and providing training to hospital staff. All hospitals in the Netherlands use computerised provider order entry systems, which improve safety and reduce costs. The addition of barcode verification during medication administration reduced errors in this area, such as administering the medicine at the wrong time, or the wrong medicine at the right time, by 50 percentage points. The authors concluded that barcode verification during medication administration is 'essential', and is most safely used alongside a standardised administration process.

The same study also considered the cost-benefit position based on implementing scanning technology for medication administration and unit dose barcoding. In 2004, 150 patients died in hospitals in the Netherlands as a result of preventable medication errors. If barcode verification reduces the number of medication administration errors by 50 percentage points, the authors conclude that there would be a corresponding reduction in lives lost (i.e. 75 deaths, rather than 150). Citing a human life as worth €2.6 million (approximately AU\$3.7 million), the authors calculate an annual saving of €195 million.

Barcode verification may have other benefits. The Hospital Admissions Related to Medication (HARM) report from 2006³⁶ sought to identify the number of medication-related hospital admissions in the Netherlands and the cost of preventable medication-related hospitalisation. This research found a reduction in medication-related hospital admissions, which at the time cost €4,500 per patient. The HARM research was on medication errors that occur outside the hospital, corresponding to medication-related hospitalisation. Reijers and van Wely³⁴ claim that this research is usable because costs would also be incurred if the error was made in hospital.

Additional costs are likely to be associated with an adverse event as a result of a medication error in hospital, including additional length of stay, additional medicines, corrective procedures or treatment. The impact of barcode verification on these aspects can only be estimated, and Reijers and van Wely do not include quantitative analysis of the potential savings in hospitals from hospital-attributable avoidable harm.

Costs associated with implementing unit dose dispensing

Costs associated with barcoding and packaging medicines at the unit dose level depend on whether this is done by the hospital, the wholesaler or the manufacturer (Table 5.1).³⁴ It is inefficient for individual hospitals to do this, and wholesalers or manufacturers could better undertake this to ensure quality and safety. However, although demand from hospitals for unit dose barcoding of medicines is likely to increase, manufacturers are unlikely to take on unit dose packaging and barcoding in the near future because the benefits do not yet outweigh the costs of changing manufacturing processes.³⁴

Table 5.1: Estimated costs for unit dose packaging and barcoding

Scenario	Annual costs
Hospitals repackage all medicines in Dutch hospitals	€29 million
Wholesalers repackage all medicines in Dutch hospitals	€15 million
Manufacturers (with or without an intermediary) apply barcoding at the unit dose level	Less than for wholesalers or hospitals, but significant upfront costs for manufacturers

Source: Reijers A, van Wely ³⁴

Appendix 1 sets out the costs and benefits identified by Reijers and van Wely³⁴ for the introduction of barcoding during medication administration, including the costs of barcoding and repackaging medicines (by wholesaler at the unit dose level each year), purchasing scanning hardware and software, and providing training to hospital staff. All hospitals in the Netherlands already used computerised provider order entry systems.

Cost per adverse drug event

In the United States, Sakowski and Ketchel³⁵ found that BCMA can be an effective and potentially cost-saving tool for preventing medication errors in the community hospital setting. They examined the costs and benefits of implementing a new electronic pharmacy management system, in which new medication orders were written on paper forms and hand-delivered or faxed to the pharmacy, and pharmacy staff reviewed orders and transcribed the information into the electronic pharmacy management system. The dispensed medicines included a barcode on the label, to be scanned during medication administration.

Over a five-year operating period, the BCMA system for inpatient medication administrations cost US\$2,000 per moderate or severe medication error prevented (range US\$1,800 to US\$2,600, and up to US\$5,600 in a conservative sensitivity analysis). The costs of additional hospital care resulting from these preventable ADEs would be US\$3,100 to US\$7,400 per ADE, indicating potential cost savings.

These costs included implementation of the new electronic pharmacy management system, and where such a system is already in place, the cost per ADE would reduce. However, part of the benefit realised in the hospital studied may have been through the introduction of the electronic pharmacy system itself. Care needs to be taken to separate the benefits from implementation of the pharmacy system and of additional systems. All sites maintained their existing paper-based, non-electronic prescribing procedures. Study sites deployed computers on wheels or handheld devices rather than installing individual computers in the patient rooms.

The study concluded that cost-effectiveness depends on how the system is used and how effective it is at preventing medication errors. The opportunity to prevent errors depends on the number and type of medication doses administered, and the potential for harm if an error does occur. The BCMA system evaluated in this study was used as a standalone application. The evaluation of the cost-effectiveness of BCMA as part of a comprehensive medication management system that includes computerised provider order entry and automated dispensing, or as a module within a comprehensive electronic medical record system, was not considered or costed in this paper, and warrants further study. Hospitals could use network resources for implementation and to support ongoing BCMA operations.

The costs and benefits identified by Sakowski and Ketchel are summarised in Appendix 2.³⁵ These include implementing and operating a commercial BCMA system, medication dose repackaging and an electronic pharmacy management system in a community hospital setting for five years. It also includes estimated costs if a new electronic pharmacy management system is not required, or where a new electronic pharmacy management system is not needed and minimal hardware is replaced.

6 Considerations for implementing scanning technologies

A range of issues need to be considered before implementing scanning technology in a hospital to reduce the risk of medication errors and adverse events.

6.1 One-dimensional or two-dimensional barcodes

Barcode technology can decrease transcription errors, but barcode-related errors can also occur. Patient misidentification is possible as a result of barcode errors. In the worst case, results could be transmitted to the incorrect patient medical record. Snyder et al.³⁷ examined the sources of barcode errors that generated incorrect patient identifiers when one-dimensional barcodes were scanned for point-of-care glucose testing. Error rates were determined for several barcode– scanner pairs. As many as three incorrect patient identifiers were generated from a single barcode. These patient mismatches were the result of minor barcode imperfections, failure to control for barcode scanner resolution requirements, and suboptimal printed barcode orientation. Snyder et al. recommended that healthcare device manufacturers adopt more robust and higher-fidelity alternatives than simple linear barcodes, such as two-dimensional barcodes or radio frequency identification.

Organisations that are adopting a one-dimensional barcode identification system for medication administration should consider:

- Qualities of available wristbands, and whether they match the requirements for highquality barcode printing and maintain the integrity of the printed barcode
- Availability of high-quality printing to meet barcode scanner resolution requirements
- Implementing quality assurance processes during printing
- The need for periodic renewal of barcoded wristbands.

6.2 Patient wristband design

The standards for wristband design and implementation set out in the *Specification for a Standard Patient Identification Band*²⁸ should be considered and which state 'patient identification bands should allow for the incorporation of new technologies that may be used to assist patient identification such as radiofrequency identification tags, barcode technologies or digital photos, whilst still fulfilling [other] requirements'.

6.3 Workflow implications and implementation

Based on findings from industry experience in the implementation of technological solutions for patient identification, the Australian Commission on Safety and Quality in Health Care¹¹ highlighted the following issues:

- Diligent execution of appropriate process and workflow remains the key aspect of patient identification technology is an enabler, not a sole solution
- To be successful in the long term, implementation implies ubiquitous deployment of the technology throughout the patient journey
- The importance of formally developed corporate implementation strategies, planning and process scoping should not be underestimated.

Voshall et al.³⁸ state that, although barcode medication administration (BCMA) systems can improve the safety of the medication administration process, nursing workaround strategies may reduce the effectiveness and even introduce new hazards. Therefore, systems need to be user-friendly and staff educated on the system.

Koppel et al.³⁹ state that performance measurement and analysis of the core processes can avoid as much as 23% of all BCMA workarounds. The authors recommend several best practices for ensuring effectiveness:

- Collaborating with the multidisciplinary team (especially nursing), analysing results and taking steps to improve
- Monitoring the percentage of medicines scanned weekly as a performance measure
- Tracking the reasons why nurses opt out of scanning, such as medicines not scanning
- Revisiting BCMA processes every year or two, to review changes in medication use and prescribing patterns.

Nanji et al.⁴⁰ report on a case study of a 750-bed hospital in Boston in the United States, where the hospital pharmacy converted to a barcode-assisted medication dispensing process. The authors state that pharmacy barcode scanning technology offers a new strategy to address medication errors in the hospital setting, citing an 85% reduction in dispensing errors. They also claim a positive effect on nursing workflow. A range of interrelated issues are outlined below, including the solutions that were identified to contribute to successful implementation.

Training

There is a need to initiate training early. Options to ensure comprehensive understanding included a 'super user' model, one-on-one training for individuals with language and computer literacy barriers, and time for practical 'scanning sessions'.

Process flow

As in all large projects, unexpected challenges had to be overcome. These included impacts on process, such as dispensing sufficient medication for three days of patient care. These challenges were overcome by allowing the technicians to optimise their own workflow.

Technology

Several hardware and software problems affected system implementation, but vendors were available for additional training and customisation.

Staff resistance

Resistance to barcode scanning implementation was a prominent barrier driven by communication issues, staff feeling overwhelmed and negative perceptions about the technology. Users eventually discovered that the new system offered information that was previously lacking, including tracking, dosing frequencies, and preventing medication errors. This increased information led to empowerment, collaboration and teamwork, which served as a catalyst for system adoption.

6.4 Unit dose packaging

Dispensing medicines on a unit dose basis would require investment in repackaging in the pharmacy or elsewhere. In Australia, not all commercially available medicines can be packaged in unit doses. Some may continue to be supplied in bulk multidose form or in multidose sachets.

To implement unit dose packaging, St. Stephen's Hospital in Queensland invested in several types of equipment, including a de-blistering machine (see Section 4.2). In the Netherlands, Reijers and van Wely³⁴ found that it was more cost-effective for wholesalers to repackage medicines in unit doses than individual hospitals. Regardless of who undertakes the unit dose repackaging, the costs are higher than for using scanning technology on the patient wristband and the medicine packet only.

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6.5 Clinician engagement

Implementing BCMA often disrupts nurses' workflow. Taliercio et al.⁴¹ conducted a qualitative study on nurses' expectations of BCMA, and considered workflow, implementation and adoption issues and the key role of clinicians. Nurses were asked about changes they thought would occur while administering medicines using the barcoding system, and reported:

- BCMA could interfere in relationships with patients and as a result, create discomfort for patients or nurses
- BCMA could raise technical issues, such as the use of wired devices
- Reservations about the introduction of new technology, such as lack of knowledge about using the system and the need for training
- Training alongside someone who was familiar with the system should occur during the first months of its implementation
- The new system could give them peace of mind and security.

The authors suggested that system acceptance by nurses is one of the most important factors for successful implementation.

6.6 Supporting the effectiveness of barcode scanning

In their operational recommendations for barcode scanning, McKesson Health Systems⁴² focus on the physical movement of medicine products in the medication management process. They make recommendations to optimise barcode scanning at each of five stages: purchasing, receiving, repackaging, dispensing and administering (see Appendix 3).

6.7 Hardware and software

The hardware required for the chosen model of scanning technology and medication management includes:

- The scanning technology itself, such as barcode scanners and automated dispensing cabinets
- The supporting hardware, such as computers that links to the scanners to upload and check the data.

Medication scanning and associated technologies are continually advancing. Many sites may introduce barcoding technology using a computer on wheels to record administration and dispensing of medicines. Future models may include 'bring your own device', where clinicians use their own smartphones or other mobile devices.

Scanning technology and accompanying electronic medication management (EMM) software needs to be interoperable with the hospital software. Hospitals implementing EMM need to consider software integration with other systems, including electronic medical records.

A more favourable cost to benefit ratio may be achieved by purchasing hardware and software in bulk. However, studies on implementing scanning technology at scale, across multiple hospital sites and services, were not located for this report.

6.9 Wireless networks

Hospital wireless networks must be suitable, secure and reliable to support the implemented scanning technology. The use of mobile devices such as smartphones and tablets may require changes to the network infrastructure and security to support this requirement.

6.10 Terminology

A global collaboration has been established between GS1 and the International Health Terminology Standards Development Organisation (IHTSDO) to support interoperability. GS1 global trade item numbers (GTIN) are standards for automatic product identification through barcodes that are used for patient safety and traceability.⁴³ GS1 and IHTSDO are developing guidance and principles for linking SNOMED CT and GTINs at national and local level. Linking patient information with accurate medicines information in all electronic health records is likely to improve patient safety.

The Australian Medicines Terminology (AMT) is the national terminology used to deliver unique codes to unambiguously identify originator and generic brands of medicines commonly used in Australia. It also provides standard naming conventions and terminology to accurately describe medications. AMT can also be implemented in clinical information systems to support electronic medication management activities.⁴⁴

7 Conclusion

The introduction of scanning technology in the hospital medication management process represents a significant investment for health services. It also presents a major opportunity to improve the quality, safety and efficiency of patient care. Organisations need to consider the following capabilities to achieve optimal workflows and benefits:

- Automated dispensing cabinets where the workflow includes scanning for restocking or selecting products
- An electronic medication management system for medication orders/prescriptions and administration, which involves mobile (bedside) computing
- Software and scanning equipment that enables patient verification from a barcode on a wristband and/or verification of the medicine from a barcode on a product pack
- Unit dose packaging.

All studies identified in these literature reviews point to benefits. The Netherlands study³³ reported an economic benefit of adding unit dose barcoding administration to electronic prescribing, even when costs included the repackaging costs. However, it was not possible to draw a firm conclusion on the incremental cost or benefit of each phase of adoption from the available literature and reference information, although it seems likely there are safety benefits.

When developing local business cases for scanning technology in medication management, organisations are encouraged to consider this report in the context of their local environment and seek up-to-date information from local reference sites.

7.1 Further considerations

The investment required for unit dose dispensing and administration presents a challenge. However, Reijers and van Wely³³ reported that working with wholesalers to barcode at the unit dose level was more cost-effective than individual hospitals repackaging medicines by unit dose.

Continued evaluation of 'early adopter' sites will be useful to build an Australian evidence base and capture the lessons learned. The effects of changing and improving workflow should, as far as possible, be distinguished from the direct effects of introducing scanning technologies into the hospital medication management process. This will include evaluating the different costs, outcomes and returns on investment from sites with different models and workflows, such as:

- Sites that use pack-based barcode medication dispensing and barcode medication administration
- Sites that invest in unit dose barcode medication dispensing and administration
- Sites that invest in fully closed-loop medication management with robotics dispensing and integration with the electronic medical record.

The potential risks associated with one-dimensional barcodes, including misidentification of patients, suggest that safe implementation should use two-dimensional barcoding. In addition, human-readable demographic and identifying information should always be available.

Studies suggest that how the system is used and the effectiveness of the system in preventing medication errors could have a large effect on the cost-effectiveness estimate. The opportunity to prevent errors depends on the number and type of medication doses administered, and the potential for harm if an error does occur.

In addition, introducing barcoding technology is also likely to introduce workarounds, which can create new risks and fail to achieve the benefits of the original implementation. It is therefore

essential to review and assure the changes to clinician workflows and software usability when redesigning medication management services.

Implementation strategies should continue to appraise the use of handheld or mobile devices in scanning processes, as well as radio frequency identification technology.

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Appendix 1 Summary of costs and benefits: the Netherlands

Source: Reijers and van Wely³³

Costs

Repackaging items by wholesaler: €14.8 million minimum each year

Implementing in hospital: one-time investment of €240,000 per hospital; yearly investment of €128,000 per hospital

Implementing in all Netherlands hospitals (based on 83 hospitals, assuming none already have the technology): estimated one-time investment of €19.9 million; estimated yearly investment of €10.6 million.

Benefits

Lives saved: 75 per year (based on a reduction in medication errors of 50 percentage points)

Direct hospital costs saved: €195 million per year (based on a reduction in medication errors of 50 percentage points and 75 lives saved per year)

Associated hospital costs saved: based on a reduction in medication errors of 50 percentage points, which results in a reduction in avoidable harm, the costs associated with additional length of stay, additional medication, corrective procedures or treatment would be reduced. This was not quantified in this study, but is based on work that found that preventable medication-related hospitalisation cost €4,500 per patient.

Working with global standards throughout the supply chain: manufacturers save \in 69 million as a one-off saving and \in 11.5 million each year. Wholesalers save \in 12 million as a one-off saving and \in 1.2 million each year. Hospitals save \in 2 million as a one-off saving and \in 2.5 million each year.

Source: Sakowski and Ketchel³⁴

Implementing and operating a commercial barcode medication administration (BCMA) system, unit dose repackaging, and electronic pharmacy management system in a community hospital setting for five years

Costs (US\$): \$40,000 (range: \$35,600 to \$54,600) per BCMA-enabled bed. For a 100-bed facility, between \$3.6 million and \$5.5 million over five years.

Benefits (US\$): adverse drug events (ADEs) are reduced. Estimated cost of care associated with each error is between \$3,100 and \$7,400.

The cost of implementing and operating a hospital inpatient BCMA system over five years is \$2,000 (range for hospitals in study: \$1,800 to \$2,600) per moderate or severe event averted when both costs and errors are discounted at 3% per year. This is less than the estimated \$3,100 to \$7,400 cost of care associated with such errors.

Conservative cost per ADE averted (where BCMA only averts medication errors in 0.4% of administration attempts) from the sensitivity analysis increases to \$5,600, which is within the range of additional costs of care.

Implementing and operating a commercial BCMA system and unit dose repackaging in a community hospital setting for five years, where a new electronic pharmacy management system is not required

Costs (US\$): \$30,000 per BCMA-enabled bed, or \$3 million at a 100-bed facility.

Benefits: The cost per ADE averted should be lower than for the scenario above because the electronic pharmacy management system is already in place. However, in this study, part of the reduction in ADEs in the hospital may have been due to the introduction of the electronic pharmacy management system itself.

Implementing and operating a commercial BCMA system and unit dose repackaging in a community hospital setting for five years, where a new electronic pharmacy management system is not required and minimal hardware replacement is needed

Costs (US\$): \$20,000 per BCMA-enabled bed or \$2 million at a 100-bed facility.

Benefits: The cost per ADE averted should be lower than for the scenarios above because the electronic pharmacy management system is already in place, and minimal hardware replacement is needed. However, in this study, part of the reduction in ADEs in the hospital may have been due to the introduction of the electronic pharmacy management system itself.

Appendix 3 Operational recommendations to support barcode scanning effectiveness across the medication use system

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System	Recommendation
component	
Purchasing	 Before implementing a barcode scanning initiative, hospital pharmacists should evaluate their product procurement strategy and procedures. This may be a simple formulary review with reductions in similar products or a comprehensive review. Several steps are included, but the key one is working with suppliers and wholesalers to implement product barcoding wherever possible. It is important to know if medications are already barcoded or can be by the wholesaler using tools or programs to identify products available. Other important steps are deciding how to handle products without barcodes and identifying challenging products such as vials and ampoules of injectable medications.
Receiving	Integrating scanning with the receiving process will be important for when drugs arrive on site at the hospital. A number of considerations are included:
	 A resource intensive first task will be creating a database with all drugs on the formulary including barcode information, either as a freestanding database or integrating with the hospitals electronic health record Determining the best way to integrate successive checks into the receiving process so that products are scan tested, if appropriate, and only released to the Pharmacy unit when this has occured Implementing processes for updating the drug database, ideally both regularly and working with IT in real time Using the same scanners as nursing staff to ensure items will scan in the pharmacy and at the bedside if the pharmacy is already utilising barcode scanning, they will either need to replicate the system for administration or develop a new system for both.
Repackaging	 Linked to reviewing the purchasing strategy, there is a need to decide which repackaging approach best fits the organisation's needs. To support barcode scanning and BCMA, certain drugs that lack scannable barcodes, or are not manufactured in a unit dose barcoded form, will need to be repackaged or labelled. It may be financially attractive to purchase drugs in bulk and repackage them into unit dose at the pharmacy or it may make sense to liaise with wholesalers themselves. For repackaging there are two options: In-house with either a manual or automated system Outsourced to providers who should be adequately evaluated before contracting.
Dispensing	Evaluate different dispensing models
	 Improve accuracy for automated dispensing cabinets by using a scan and load approach; when using centralised dispensing, be aware of timing related issues to replenishment; consider using Lean principles to streamline processes; develop a feedback loop to reinforce desired employee behaviours.
Administering	Incorporate a 'feedback loop' into administration, including performance
	management as well as periodic analysis of core processes
	Collaborate with the multidisciplinary team, especially nursing
	 Monitor the percentage of medications scanned weekly

Track why nurses opt out of scanning and revisit BCMA processes every year or two	System component	Recommendation
two.		Track why nurses opt out of scanning and revisit BCMA processes every year or two.

Source: Adapted from McKesson Health Systems²

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