



Evidence Briefings on Interventions
to Improve Medication Safety

Electronic medication administration records

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Electronic medication administration records

Policy question

Do electronic medication administration records reduce medication administration errors and improve efficiency?

Current evidence shows

There is some good quality evidence that electronic medication administration record systems in hospitals are associated with reduced medication administration errors (e.g. dose omissions, timing errors), improved quality indicators and enhanced medication documentation. Studies measuring efficiency of medication administration following electronic medication administration record implementation present mixed results. Electronic medication administration records are rarely implemented in the absence of other integrated health information technology, thus their effects should be considered in tandem with such technologies. Implementing electronic medication administration record systems requires significant workflow changes and ongoing monitoring to maximise system benefits and reduce unintended consequences, such as new medication errors associated with system use.

Background

Electronic medication administration records are electronic records of medications to be administered to patients. Perceived benefits of these systems include the ability to notify nurses of medications due for administration, track dose omissions, support policy adherence by enforcing the recording of reasons for dose omissions and the co-signing of medication administration, improved timing of administrations, and reduced risk of accidental medication discontinuities. Furthermore, there are potential improvements in the efficiency of the medication administration process, resulting in better medication management for patients. However, electronic medication administration record implementation is complex, can be costly, and may cause significant changes to workflow and introduce new errors unique to the system.

Electronic medication administration records

are populated with medication orders generally entered by doctors using an electronic prescribing system, but also in some instances by pharmacists, pharmacy technicians or nurses. In Australia, electronic medication administration records are usually implemented as a component of an electronic medication management (eMM) system which includes electronic prescribing capability.¹ Electronic medication administration records can also be integrated with scanning technology.² These combinations can improve workflow and increase the potential for significant safety gains.³

To administer a medication using an electronic medication administration record, the nurse signs onto the system and selects the medications to be given. Nurses may select a reason for not administering the medication, such as the patient being absent, or confirm administration of each dose. An electronic signature is stamped against the medication administered, recording the time of administration. Some systems trigger alerts when medications are due or overdue. Documentation of reasons for medication omission are often mandatory using these systems.

In 2013, the Australian Commission on Safety and Quality in Health Care published an evidence brief on electronic medication administration records.⁴ The current evidence brief aims to update the 2013 brief with contemporary evidence on the impact of electronic medication administration records on errors and efficiency.

Methods

A search of PubMed, Embase and Web of Science using the search terms *electronic medication administration record* OR *e-MAR* OR *electronic medication management* OR *eMM* to identify literature on the effects of electronic medication administration record use on patient safety and work efficiency within hospital settings. Grey literature was searched via Google Scholar and references of included papers hand-searched for articles not captured using the other methods. The search was limited to papers published between January 2003 and May 2021. Letters, conference abstracts, and dissertations were excluded. Studies where the sole source of medication administration error data was limited to methods likely to underreport error rates, such as by voluntary reporting,⁵ were

excluded. After the initial review of search results, 116 potentially relevant full-text articles were retrieved. Twenty-five articles were included in this review, 23 were studies in a hospital setting, and two were surveys of healthcare workers from multiple organisations.^{6,7} Seven were Australian studies,⁸⁻¹⁴ two from Canada,^{6,15} two were from the UK,^{16,17} two from Spain,^{18,19} one from Taiwan,²⁰ one from Iran,²¹ one from Finland,²² one from Singapore,²³ and the remaining seven were from the US.^{7,24-29}

Results

Most of the included studies used before-and-after study designs to assess indicators of the effects of an electronic medication administration record. Only two studies included a control group.^{9,10} Outcome indicators reported included medication administration, quality of care, timeliness and efficiency of administration, and staff perceptions. Most studies used audits of the electronic medication administration record or incorporated qualitative methods to provide contextual understanding and information in some instances. Descriptions of the electronic medication administration record functionality or vendor, changes in workflow or implementation processes were lacking in most studies.

Medication administration errors (MAEs)

The medication administration error (MAE) rate was examined in one study and three further studies evaluated technology impact on dose omissions.^{8,9,16,19} Three of the four studies reported a reduction in errors.^{9,16,19} In all studies, the electronic medication administration record was integrated with another system, such as an electronic prescribing system, though the electronic medication administration record was evaluated separately.

One Australian study showed a decrease in medication administration errors after electronic medication administration implementation at two hospitals.

Of three studies examining dose omission errors, two showed a reduction.

Two studies were from Australia, one evaluating the impact of an electronic medication administration record system on MAE rates and one on dose omissions.^{8,9} The largest was a controlled before and after study that assessed the impact of introducing an electronic medication administration record integrated with electronic prescribing on the MAE rate across two adult teaching hospitals.⁹ In total, 7451

medication administrations were directly observed and compared with information recorded in medication charts. A significant decrease in MAE on intervention wards compared to control wards by 4.2 errors per 100 administrations was found, with a decline in the proportion of potentially serious MAEs of 56%. The second Australian study compared the rate of dose omissions pre- and post-implementation of an electronic medication administration record system in an adult hospital.⁸ That study assessed omitted doses using data generated by the electronic medication administration record during February 2011, one to six years post implementation depending on the ward. These data were then compared with data from a previous study that conducted a chart review across five days in 2001 at the same hospital, four to nine years prior to implementation.³⁰ There was no significant overall reduction in dose omission rate (approximately 7.6% in 2001 and 7.5% in 2011) pre and post system introduction. The study found that post the electronic medication administration record a greater proportion of dose omissions contained documented reasons for omissions (26% before implementation versus 4.4% after implementation).

Two further studies examined the effect of electronic medication administration record on MAEs, one was conducted in the UK,¹⁶ and one in Spain.¹⁹ The UK study, conducted in a paediatric intensive care unit, used three audits of medication administration charts (pre-implementation, one week post-implementation and six months after implementation) to identify dose omissions.¹⁶ A reduction in omitted medications was observed (8.1% of 528 doses pre versus 10.6% of 216 doses at one week post and 1.4% of 278 doses at 6 months post implementation). Reasons for dose omissions documented as 'other' or left blank were eliminated, while dose omissions documented as 'unavailable' were reduced, although these changes were not tested statistically.¹⁶ The study based in Spain was a before-after observational study conducted between 2012 and 2014.¹⁹ The hospital implemented an electronic medication administration record application (integrated with electronic prescribing and clinical decision support) and assessed dose omission errors, wrong dose errors, and cases where the paper chart or electronic medication administration record was lacking information on medication administration. The rate of MAEs significantly decreased from 48% of 1362 administrations to 37% of 967 administrations. The greatest reduction was observed in omitted dose errors, which halved.

Quality of care

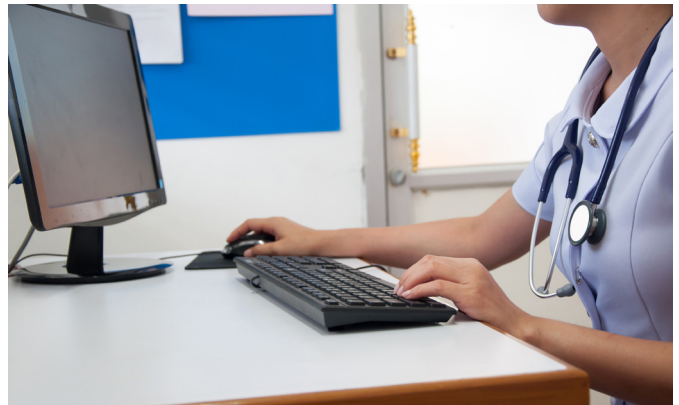
Only one study examined how the introduction of electronic medication administration record was associated with changes in a set of 11 quality of care indicators (e.g. patients with a diagnosis of heart attack prescribed aspirin at discharge).²⁴ This US study conducted a cross-sectional analysis drawing data from three national databases on 2,603 acute-care hospitals, including 986 with electronic medication administration record only, 115 with electronic prescribing only, 804 with both and 698 with none of this technology.²⁴ Hospitals using an electronic medication administration record, with or without electronic prescribing systems, had 14-29% higher odds of performing better on 10 of the 11 quality indicators as compared to hospitals that had not adopted any technology.²⁴

Timeliness, workflow and efficiency of medication administration

Four studies reported conflicting results in relation to changes in the timeliness, workflow or efficiency of medication administration after implementation of an electronic medication administration record,^{10,17,28,29} including one Australian study.¹⁰ Two studies reported no significant change in the time involved in medication administration after electronic medication administration record implementation,^{10,17} while another two studies reported an increase in administration efficiency.^{28,29} The Australian study was a controlled before-after time and motion study of doctors and nurses measuring the proportion of time spent on patient care and medication-related tasks pre and post electronic medication administration record (with electronic prescribing).¹⁰ Following 633 hours of observing nurses, no significant difference was found in the proportions of time spent on patient care or medication-related tasks between control and intervention wards in the post electronic medication administration record period, though nurses spent significantly less time with doctors on wards with an electronic medication administration record. Similarly, in one UK hospital, there was no statistically significant difference in the time taken to complete drug rounds immediately after implementation of an integrated electronic prescribing and electronic medication administration record system.¹⁷

Two studies examined administration efficiency using different metrics.^{28,29} A US before-after study assessed the rates of medication administrations per 100 patients (4 weeks pre and 24 weeks post implementation) in an emergency department.²⁸ The rate of medication administrations significantly increased, nearly doubling following electronic

medication administration record implementation. This increase was maintained across the study period and was attributed to the electronic medication administration record improving efficiency, particularly by new 'one-click' operation and electronic order sets. In a second US study, the hours worked per patient day by patient care technicians (staff taking on clerical duties and nursing tasks that do not require a nursing qualification) were assessed before and after the introduction of electronic medication administration record and electronic prescribing.²⁹ That study found a non-significant reduction in working hours following electronic medication administration record alone, though when combined with electronic prescribing a subsequent statistically significant reduction in working hours was reported and attributed to the integrated systems.



Nurse at computer (photograph: Kamon Wongon, Adobe Stock)

Perceptions of electronic medication administration record systems

Thirteen studies used qualitative methods to assess usability and user perceptions of implemented electronic medication administration record systems.^{6,11,13-15,17,18,20-23,25,26} Concerns from users centred around integration of the electronic medication administration record with other systems and its impact on workflow (e.g., more time spent on tasks, and problems with system accessibility) and patient safety (e.g., the introduction of new errors, bad system design, poor accessibility). Generally, nurses were positive about the electronic medication administration record after implementation.^{11,13,14,17,20-23,25,26} Aspects of medication administration documentation such as accuracy²⁵, quality of information^{17,23} and incidence of error,¹¹ were believed to have improved following electronic medication administration record implementation.

Three staff survey studies reported an overall perceived improvement in teamwork and communication following the implementation of an electronic medication administration record system.^{14,25,26} However, one study stated that communication between nurses and pharmacists did not improve.²⁵ Another study found that perceived improvements in teamwork increased over time from initial implementation alongside system optimisation and staff familiarity with the system.²⁶

In summary, a perceived benefit in thoroughness and quality of care were balanced with concerns regarding efficiency with the system. This dichotomy of perceived benefits for patient safety alongside interruptions to workflow is consistent with reported views about eMM more broadly.³¹

Nurses were positive about the implementation of electronic medication administration records, though also shared concerns regarding issues such as poor system design and accessibility that would require optimisation.

Health-information technology (HIT) errors and workarounds

The risk of introducing HIT errors is associated with system design features and the fit between the new system and existing workflows, both of which require ongoing attention.^{32,33} Four studies warned that the implementation of electronic medication administration records can be associated with some serious unintended consequences.^{11,12,15,19} Four studies referred to new errors related to the electronic medication administration record and reported these errors as a proportion of total medication errors or incidents (1.2% of n=937;¹⁷ 35.6% of n=82712), or the proportion of staff who had generated such an error (56.0% of n=664;¹¹ 80.0% of n=25¹⁵). The reported underlying reasons for HIT errors included problems with hardware and software such as computer speed and accessibility, and poor system design where the system was unintuitive, failed, or otherwise did not work as intended.

In addition, the presence of HIT errors or problems in system design can lead to staff 'workarounds' or actions to circumvent or fix a system failure. This phenomenon is well known following the introduction of eMM systems,³⁴⁻³⁶ though study of 'workarounds' specific to electronic medication administration record systems was limited to a single study.²³ In that study, workarounds were most frequently described as activities to circumvent or augment the system to

save time (See Table 1 for examples). Such actions can have serious patient safety consequences and violate hospital guidelines.³⁷ Inconsistency between electronic medication orders and instructions entered separately into the electronic medication administration record system can also lead to MAEs.³⁸

Table 1. Workarounds performed by nurses (reproduced from Yang et al. 2012²³)

Workaround	Quote
Nurse picked next time slot to serve because current used	<i>There are a lot of times we get held back because the nurses will say that somebody accidentally signed on their dose or rather they missed their dosage then they sign on the next dose. So in the end we have to write a stat dose for them to sign.</i>
Nurse cleared omission for PRN medicine in batches	<i>..if the frequency is put as PRN, which is when necessary and the nurses never give an exception for that when the patient doesn't need it, it will keep showing as omission and overdue. I'm always the person who clears all these omissions and it's a very long list.</i>
Nurse co-signed for another nurse during serving	<i>There were cases where nurses pick a medication and they key in their colleague's password to co-sign the medicine. By doing so, integrity is compromised</i>

Conclusion

Overall, the literature presents some encouraging results with modest reductions in medication administration error rates, minor improvements in workflow, and general satisfaction by nursing staff following the implementation of electronic medication administration records. Major methodological weaknesses across studies prevents firmer conclusions. Almost all studies assessed an electronic medication administration record system in the context of an existing electronic system, typically including electronic prescribing and clinical decision support, making it difficult to isolate the effects of electronic medication administration record alone. Definitions of administration errors varied for each of the studies, making comparison of results for this indicator difficult across studies. Almost all studies lacked controls or comparison groups. Finally, many studies were small, collecting data over a very short period, on single wards or units, or involving a small number of staff. To date there has been only one multi-site, controlled study on the impact on MAEs. Notably, that study was from Australia and reported a significant reduction in overall MAE rate by 4.2 errors per 100 administrations compared to control following a minimum of 10 weeks operation in a hospital setting.⁹

Lessons learned from implementation

- The implementation of an electronic medication administration record system is complex and attention to integration into workflows is important to achieve reduced medication administration errors and enhanced work efficiency.³⁹⁻⁴¹
- As with all health information technologies, electronic medication administration records are also associated with the introduction of new HIT errors and potential workarounds that may threaten patient safety if not addressed.^{11,12,15,19}
- Disruptions to workflow, such as double password entry in order to perform a medication double-check using an electronic system,⁴² or needing to wait for slow processing, may explain mixed results on work efficiency.⁴³ Understanding and targeting the source of these disruptions are required to optimise system performance and outcomes.

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