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Electronic prescribing systems and their impact on patient safety in hospitals

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Electronic prescribing systems and their impact on patient safety in hospitals

Policy question

Do electronic prescribing systems reduce medication errors and improve patient safety?

Current evidence shows

There has been a significant body of research assessing the impact of electronic prescribing in various hospital settings. Despite the volume of research there have been relatively few controlled studies and fewer randomised controlled trials. Differences across types of electronic prescribing systems also limit the generalisability of individual study results. Multiple meta-analyses of study findings provide confidence that electronic prescribing is associated with a reduction in prescribing errors. Evidence for improvements in other patient safety indicators (including medication errors resulting in harm or preventable adverse drug events, patient mortality and length of hospital stay) is mixed. Electronic prescribing systems are likely to introduce health information technology-specific errors that require careful monitoring.

Background

The landmark 1999 report by the Institute of Medicine, 'To Err is Human', increased awareness of the prevalence and impact of medication errors in hospital settings, and resulted in an increased focus on patient safety.[1] Since this time many different types of interventions have been trialled to improve medication safety, targeting neonatal,[2] paediatric,[3] and adult[4] patients; with electronic prescribing systems (ePS) consistently thought to have the greatest potential to reduce medication errors and improve medication management. In recognition of this potential, the Institute of Medicine has promoted the use of health information technology, primarily consisting of ePS with clinical decision support.

The benefits of ePS include improving access to health information, automated prompts and alerts to support clinical decision making, improvements to productivity and efficiency, and greater medication safety. The use of electronic prescribing is extensive in USA hospitals, with almost all reporting its use.[5] However, uptake of this technology has been slower in Europe and Australasia. This briefing aims to summarise the evidence on the use of ePS in hospitals and complements the *Interventions to Improve Medication Safety* series published by the Australian Commission on Safety and Quality in Health Care (ACSQH).[6-10]

Methods

A literature search was undertaken to identify studies relating to electronic prescribing in hospital settings. Searches were performed in PubMed, Embase, and CINAHL. Google Scholar was used to identify grey literature. Conference abstracts, review articles, duplicates, commentaries and letters as well as qualitative descriptions of existing systems were excluded. However, their reference lists were reviewed to identify any articles of relevance. The search was limited to English language articles published after 1980 and was run in June 2021.

Results

The search yielded 1700 potentially relevant published studies. During full text review it became apparent that many recent systematic reviews have been conducted on the impact of ePS in different hospital settings, including among paediatric and adult patients, as well as in intensive care units (ICU), and in oncology. As such, this briefing provides a summary of the findings from systematic reviews, reporting statistical summaries such as meta-analyses where available.

Evidence of the impact of ePS on prescribing errors, adverse drug events (ADE) and other patient outcomes

Current evidence indicates that ePS are effective in reducing prescribing errors. Two recent systematic reviews and meta-analyses examined this relationship.[11,12] The first, examining studies published between 2007-2018, included 11 studies in a meta-analysis and reported that across those studies. The introduction of ePS was associated with a 76% overall reduction in prescribing errors (RR 0.24; 95% CI: 0.13, 0.46), including an 83% reduction in dose errors (RR 0.17; 95% CI: 0.08-0.38).[11] The second review, searched for studies published between 2005-2019, and included 10 studies that examined the impact of ePS on prescribing error rates. Nine of those studies reported a statistically significant reduction in error rates.[12]

Results of the impact of ePS on adverse drug events (ADEs) and other patient outcomes, such as length of stay and mortality are less conclusive. Both systematic reviews and meta-analyses reported no evidence of a significant effect of ePS on preventable ADEs (Review 1 - relative risk (RR) 0.55;95% CI: 0.30-1.01; n=3 studies,[11] and Review 2 - RR 1.22 (95% CI: 0.18-8.38; n=5 studies).[12] Similarly, the reviews reported no evidence of a change in length of stay,[11,12] hypoglycaemia,[11] or mortality associated with ePS.[11,12] However, both reviews noted that the evidence was of low quality.

Included in these reviews was a large controlled Australian study conducted in two general adult teaching hospitals.[13] The impact of implementing ePS with basic decision support was assessed by prospective chart review and compared to hospital wards that did not receive the ePS. The implementation of ePS was associated with an approximately 60% decline ($p<0.0001$) in prescribing error rates on each intervention ward, driven mainly by a reduction in procedural errors such as unclear or incomplete orders. Furthermore, there was a 44% ($p=0.0002$) reduction in prescribing errors with the potential for moderate to serious harm in the intervention wards.

Health information technology errors

While ePS can reduce prescribing errors, they can also introduce new types of errors related to the use of health information technology (HIT). A recent systematic review identified five studies that had measured HIT-related errors and these studies reported that HIT related errors accounted for between 1.2% and 34.8% of all errors post ePS implementation.[12] Few studies have been undertaken to assess the rate of HIT-related errors in the medium- (2-5 years) and long-term (>5 years) after ePS roll-out.[14] A systematic review examining how reported HIT-related errors change over time found no studies comparing HIT-related errors associated with short, medium and long-term ePS use.[14] However, the authors concluded that the available evidence suggests that HIT-related errors persist over time, although possibly at a lower rate. Similar HIT-related errors have been described independent of time since ePS roll-out.[14] The main contributing factors for HIT related errors were construction errors with free text fields missing information and errors due to design flaws in the system function and build. Other common errors occur due to the gradual implementation of ePS where there is ongoing use of paper charts alongside ePS, i.e. hybrid electronic and paper systems.[14] To assist with the identification and remedying of HIT related errors associated with ePS, the ACSQHC has published guidance for Australian hospitals.[15]

Oncology settings

A systematic review of studies published between 1995 and 2016 assessed the impact of clinical decision support systems (stand alone and embedded in ePS) on cancer treatment, and supportive care.[16] The review identified 24 studies with a variety of outcomes of interest, though the quality of the studies was not assessed. The most common outcome of interest across the studies was prescribing error rates, and this was assessed in nine studies. All nine studies reported a statistically significant reduction in prescribing error rates following the integration of clinical decision support to existing ePS. The remaining outcomes were associated with adherence to guidelines, aspects of specialised treatment and workflow, and patient reported outcomes relating to symptoms.[17-19] Only one study in the review did not report an improvement in an outcome, and this was an increase in the time required by pharmacists to review orders with ePS compared to paper.[20]

A narrative review on the use of ePS for chemotherapy drugs supported the findings from the above review.[21] The narrative review highlighted the risk of introducing new error types where implementation of an ePS is not adequately modified to chemotherapy-specific processes, or where there is not strong engagement with all stakeholders.[21]

Hospital outpatient clinics

Three studies evaluated the use of ePS in hospital outpatient clinics.[22-25] Two assessed the effectiveness of ePS in USA hospital outpatient clinics on preventing paediatric dose errors, and both showed a reduction in error rates.[22,24] The first study compared paracetamol and promethazine doses calculated using the ePS

to those calculated manually, and found that use of the ePS reduced doses errors by half.[22] The second study, conducted in 2005, in a hospital outpatient clinic, six months pre and post ePS implementation, assessed prescriptions for paediatric acetaminophen or ibuprofen requiring weight-based dosing calculations.[24] The rate of patients experiencing an error significantly decreased from 32.6% (103 of 316 patients) to 20.5% (46 of 224 patients). The third study was conducted in a Canadian acute care hospital outpatient clinic.[25] During the study period of nine months, clinical decision support was implemented into an existing ePS. A random sample of 116 charts from the 17 weeks prior to the clinical decision support was implemented and 47 charts from the 22-week post implementation period were reviewed for potential ADEs. No statistically significant difference was reported in the number of events (10.3% or 12 of 116 charts were thought to result in an adverse event, compared to 4.3% or 2 of 47 charts; p=0.35).[25]

Paediatric inpatients

A systematic literature review investigated the effects of an ePS in paediatric hospital settings and identified 26 studies published between 2005-2011.[26] A total of four studies investigated the effects of ePS without clinical decision support compared to paper-based prescribing, and reported 44% to 88% reduction in prescribing error rates and 21% to 88% reduction in administration error rates. A total of five studies examined the effect of ePS with clinical decision support compared to paper-based prescribing and reported up to a 99% decrease in prescribing errors. A total of five studies compared ePS with and without clinical decision support and found a 36% to 87% reduction in prescribing errors when CDS was available.

Electronic prescribing in hospital intensive care units

The effectiveness of ePS in ICUs was assessed in a systematic review and meta-analysis including studies published between 2000 and 2016.[27] A total of 20 studies were reviewed and outcomes included impact on medication error rates, patient mortality, and length of hospital stay. Almost all studies used a before-after design, though one study included a comparison of ICUs with and without electronic prescribing.[28] Medication error rates prior to the implementation of an ePS ranged between 4.5% and 58.2% of orders, and post implementation the prevalence of error ranged between 0% and 8.2%. In summary, electronic prescribing systems were associated with an 85% reduction in prescribing errors (pooled RR: 0.15, 95% CI: 0.03–0.80, P = .03; n=9 studies). Subgroup analysis comparing paediatric with adult intensive care settings did not identify any significant difference in this result for adult ICU (pooled RR was 0.11, 95% CI: 0.00–3.41; n=4 studies) and paediatric ICU (pooled RR was 0.21, 95% CI: 0.02–2.65; n=5 studies). A total of seven studies assessed length of stay and only one study reported a statistically significant reduction following the implementation of an ePS.[27] That study reported a decrease from a mean of 7.44 days to 5.96 days after ePS introduction. Meta-analysis showed no overall significant effect of an ePS on ICU length of stay. A total of six studies assessed ICU mortality rates pre and post introduction of an ePS. In summary, electronic prescribing systems were found to be associated with an overall reduction in ICU mortality rates by 12% (pooled RR: 0.89, 95% CI, 0.78–0.99, P = 0.04). Subgroup analysis of four paediatric ICU studies did not find a significant difference in ICU mortality.[27]

Electronic prescribing in hospital emergency departments

One systematic review examined the effect of ePS on patient safety and clinical workflow in the emergency department (ED).[29] Studies published between 1990 and 2011 were reviewed and 22 studies were included, 20 of which were conducted in the USA. Most studies were pre-post intervention comparisons, and there were two randomised controlled trials.[30,31] A total of six studies examined the impact of ePS on patient safety, and twelve studies assessed workflow in terms of time spent by clinicians on duties and time spent by patients in the ED. Electronic prescribing systems were associated with significant improvements in patient safety, with significant decreases in prescribing errors (ranging from 17 to 201 errors per 100 orders), potential adverse drug events (decreased by 0.9 per 100 orders[32]), and prescribing of excessive dosages (31% decrease for a targeted set of renal disease medications observed during a randomised controlled trial[31]). However, one direct observational study reported that the addition of a provision for nurses to enter verbal orders to an existing ePS was associated with an increase in time spent on computers by nurses of up to 16.2%, with no significant change in time spent on direct patient care.[33]

Conclusion

A great deal of research has evaluated the impact of electronic prescribing in hospital settings, with well over one hundred individual studies summarised in systematic literature reviews. Despite the significant number of studies, relatively few have included controls, with almost all studies using before-after

designs. The vast majority of studies have been conducted in the USA. Several reviews that have assessed study quality have consistently noted the poor quality of studies, highlighting that many studies fail to adequately describe their methods, and include small samples. In addition, given the significant resources required to assess actual patient harm from medication errors, few studies have included this outcome. Despite these limiations, the studies provide overall consistent evidence that the introduction of ePS is associated with reduced prescribing error rates in across the range of hospital settings.

Lessons learned from implementation

- There is evidence indicating that during ePS implementation when both hybrid paper and electronic systems are in place, there is an additional risk of medication errors occuring. Steps to reduce the period in which dual systems are operating should be considered.[12,34,35]
- Specialist ePS systems (e.g. for ICU, oncology) which do not interface with hospital ePS systems are likely to introduce additional risk of errors and should be considered carefully in implementation plans.[16,27]
- With ePS replacing paper medication charts at an increasing rate in hospitals, the focus is shifting from implementation strategies to optimising ePS to deliver improved patient outcomes and ensuring the system is appropriately used.[36] Medication safety self assessment tools are available to assist with identifying opportunities for optimisation,[37] as well as guiding principals to ensure the sustainable governance of ePS.[38]
- The implementation of ePS can introduce new types of errors, i.e. technology-related errors. There is evidence that these errors persist in the medium- to longer-term after ePS implementation.[14] Monitoring these errors and their causes is important for initiating improvements to ePS design in order to improve patient safety.
- As system improvements and changes are likely to occur, and staff turnaround is inevitable, it is important to ensure access to technology support, staff training, and ongoing communicaton of major changes to functionality and appearance.[39]
- Care must be taken when implementing decision support with interruptive alerts so as to avoid alert fatigue due to a preponderance of clincially irrelevant alerts, which will reduce decision support effectiveness.[40]

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