Impact of emerging technologies on medication errors and adverse drug events
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CRD summary
This review assessed the effects of computerised physician order entry, automated dispensing machines, bar coding and computerised medication administration records on the likelihood of medication errors and adverse drug events. The authors' conclusion, that there was limited evidence in support of these technologies, is likely to be reliable.

Authors' objectives
To assess the effect of computerised physician order entry (CPOE), automated dispensing machines (ADMs), bar coding and computerised medication administration records (CMARs) on medication errors and adverse drug events (ADEs).

Searching
PubMed was searched from 1982 to March 2002 for studies published in peer-reviewed journals; the MeSH terms were stated. The reference lists in identified studies and previous reviews were also checked. Only studies that were published in full were included. Guidelines for implementation, reviews and user-satisfaction surveys were excluded.

Study selection
Study designs of evaluations included in the review
Controlled studies were eligible for inclusion. The included studies were prospective controlled studies (including time-and-motion studies and crossover studies), prospective time series with historical control, prospective and retrospective before-and-after studies, and retrospective time series.

Specific interventions included in the review
Studies of CPOEs, ADMs, bar coding and CMARs were eligible for inclusion if they were conducted in the USA. Studies of clinical decision support systems were excluded.

Most of the included studies of CPOE were conducted in institutions and, in all studies, CPOE systems were developed internally.

Participants included in the review
The inclusion criteria were not specified in terms of participants.

Outcomes assessed in the review
Studies that assessed medication errors and ADEs (the primary outcomes in the review) or other outcomes were eligible for inclusion. In the review, medication errors were defined as 'any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient or consumer'. ADEs were defined as 'any response to a drug which is noxious, unintended, and which occurs at doses normally used in humans for the prophylaxis, diagnosis or therapy of disease'. Some studies in the review reported results for different categories of ADEs (preventable and potential) and medication errors (errors in dosage, missed doses, non-missed doses and wrong time).

The review also assessed the appropriateness of the use of these interventions, where appropriateness was defined as the 'degree to which the technology was used as intended'. Other outcomes included the use of specific drugs, the time required to carry out various tasks, the number of drugs prescribed, hospital stay and the duration of therapy.

How were decisions on the relevance of primary studies made?
The authors did not state how the papers were selected for the review, or how many reviewers performed the selection.
Assessment of study quality
The authors did not state that they assessed validity.

Data extraction
The authors did not state how the data were extracted for the review, or how many reviewers performed the data extraction. The extracted data included study design, definition of ADE and results.

Methods of synthesis
How were the studies combined?
The studies were grouped according to the intervention and a narrative synthesis was undertaken.

How were differences between studies investigated?
Differences between the studies were not discussed in the review.

Results of the review
Four controlled studies (including two time-and-motion studies), one prospective study with a historical control, five before-and-after studies (4 prospective and 1 retrospective) and one retrospective time series evaluated CPOE. One controlled study and six before-and-after studies (5 prospective and 1 retrospective) evaluated ADEs. Three controlled studies and four before-and-after studies (all prospective) evaluated bar coding. The total number of participants was unclear.

Only results for the major outcomes of medication errors and ADEs and the appropriateness of use are reported in this abstract; other outcomes were reported in the review.

CPOE.
Medication errors and ADEs (3 studies): few controlled studies evaluated CPOEs. One prospective before-and-after study found that CPOE reduced preventable and potential ADEs; non-intercepted errors decreased by 55% (P=0.01) and preventable ADEs were reduced by 17% (P=0.37). One retrospective time series found that CPOE reduced 'all major categories' of medication errors: non missed dose errors by 81% (P<0.0001), non-intercepted serious errors by 86% (P<0.0003), and all medication errors by 83%. The ADE rate fell from 14.7 to 9.6 per 1,000 patient days towards the end of the study period, (P<0.09). One prospective before-and-after study (number of patients was not reported) found that CPOE reduced ADEs due to antibiotics from 28 to 4 (P=0.018).

Appropriateness of use (1 prospective before-and-after study): the study found that physicians overrode the CPOE system about 50% of the time. Overriding the system increased the number of drugs prescribed (from 1.5 to 2.7), the duration of therapy (from 103 to 330 hours) and the number of doses (from 11.4 to 27.6).

ADMs.
Medication errors and ADEs (5 studies): all five studies found that ADMs reduced medication errors. One prospective before-and-after study found that ADMs reduced the number of medication errors (10.4% versus 16.9%, P<0.001). Most errors were wrong-time errors. Other studies found that ADMs reduced dispensing errors compared with manually filled prescriptions (0.65% versus 0.84%); reduced error rates compared with the use of traditional cassettes (0.61% versus 0.89%); reduced errors on the cardiovascular surgery unit (from 0.0075 to 0.0058 errors per day, P>0.05), although they increased errors on the cardiovascular intensive care unit (from 0.0051 to 0.0090, P>0.05); and reduced errors compared with a decentralised unit dosing system (10.6% versus 15.9%, P<0.05).

No studies assessed appropriateness of use.

Bar coding.
Medication errors and ADEs (5 studies): the studies found that the error rate was reduced following implementation of
bar coding (1 study, 0.2% versus 1.0%); the accuracy of the medical supplies inventory was improved following implementation of bar coding (1 study, P<0.001); and the error rate in data entry was reduced compared with manual entry (3 studies: 0.79% versus 1.53%, P=0.0167; 1.7% versus 5.8%; and 2.63 errors versus 4.48 errors, P<0.0001).

No studies assessed appropriateness of use.

CMARs.

One study was identified but the authors were unable to obtain the publication.

**Cost information**

One before-and-after study found that CPOE reduced costs for antibiotic agents by an average of $81 per course. One controlled study found that CPOE decreased vancomycin use with projected savings of $22,500 to $90,000 per year. One before-and-after study found that costs for levofloxacin decreased from $231,416 to $87,972 for intravenous preparations and from $50,042 to $33,003 for oral preparations. One controlled time and motion study found that CPOE reduced hospital costs by 13.1%. One prospective before-and-after study found that when physicians overrode the CPOE system, the mean costs increased from $102 to $427. One study (1995) estimated the costs of implementing AMDs to be $1.28 million over 5 years for 10 acute care and 4 critical care units. One crossover study found that bar coding increased the cost by $35.85 per pharmacist per year. One study estimated the costs of implementing bar coding to be $119,516 annually.

**Authors’ conclusions**

There were few controlled studies with results that could be generalised that evaluated CPOE, ADMs, bar coding and CMARs. The authors also stated that there was limited evidence on the appropriateness of the use of these technologies.

**CRD commentary**

The review question was clear in terms of the study design, intervention and outcomes. Only one database was searched and this might have resulted in the omission of other relevant studies. Studies published only as abstracts were excluded and no attempt was made to locate unpublished studies, thus raising the possibility of publication bias. The methods used to select the studies and extract the data were not described; hence, any efforts made to reduce errors and bias cannot be judged. Validity was not formally assessed and the methodological limitations of the included studies were not adequately discussed.

There was limited information on the included studies: in particular, details of the number of participants, and the intervention were not consistently reported. A narrative synthesis was appropriate given the variety of study designs and outcomes assessed, but attention was not drawn to better quality studies. The statistical significance of differences between the intervention groups was not reported for all results. As the authors correctly stated, there was limited evidence pertaining to these technologies.

**Implications of the review for practice and research**

The authors did not state any implications for practice or further research.

**Bibliographic details**


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MeSH
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This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.