Cost-effectiveness of an electronic medication ordering and administration system in reducing adverse drug events

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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The study examined an electronic medication order entry system (MOE) versus the standard paper ordering system. MOE was designed to reduce adverse drug events (ADEs) that might cause significant morbidity and mortality. With MOE, doctors were provided with a menu of medications from the formulary and typical doses. An electronic medication administration record (MAR) completed by nurses was also added to the MOE system. Computerisation ensures that the dosage, route and frequency are always entered and are legible. Transcription has been eliminated for electronic medication orders. MOE/MAR also included drug-allergy checking, drug-drug interaction checking and duplicate drug checking.

Type of intervention
Treatment.

Economic study type
Cost-effectiveness analysis.

Study population
The study population comprised patients admitted to the medical centre and receiving a drug prescription.

Setting
The setting was a hospital. The economic study was carried out in Canada.

Dates to which data relate
The effectiveness data were derived from studies published between 1993 and 2004. No dates for resource use were explicitly stated. The price year was 2004.

Source of effectiveness data
The clinical data used in the economic evaluation were the rates of ADEs, rates of preventable ADEs and the effectiveness of MOE/MAR. The latter (effectiveness) was defined as the proportion of ADEs actually prevented by the system. A preventable ADE was defined as an ADE caused by an error or preventable by currently available means such as systems or information. ADEs were excluded from the study if an error was made but the ADE was judged to have minimal potential for injury.

Sources searched to identify primary studies
Clinical data were derived both from published studies and from the database of the UHN. ADEs and rates of preventable ADEs were obtained from several studies mainly conducted in Canada and the USA. The sample size, setting and results of each of these studies were given, although little information was provided on study design.
(probably case series). The effectiveness of MOE/MAR in reducing preventable ADEs was obtained from two published time series.

**Methods used to judge relevance and validity, and for extracting data**
A systematic review of the literature was undertaken to identify the clinical estimates. MEDLINE was searched. Inclusion and exclusion criteria were reported in detail. However, there was limited information on the design and other characteristics of the majority of studies included in the review. It is likely that most of the studies were time series. Data from the primary studies were combined by calculating weighted averages (weighting by sample size).

**Measure of benefits used in the economic analysis**
The summary benefit measure used was the number of ADEs averted per year with MOE/MAR in comparison with the standard system. A discount rate of 5% was used for future health benefits.

**Direct costs**
The cost analysis included costs relevant from the institution's perspective, such as system costs and workload costs. Cost-savings arising from decreased inappropriate drug use were not considered since they were not easy to quantify. The unit costs were not presented separately from the resource quantities. The cost of the system came from the UHN for implementation of the new electronic system (including purchase of the new software modules, project management, clinical team involvement) and additional training costs. Workload included time spent by nurses and pharmacists. Doctors' time was not included in the baseline evaluation of costs. Doctors were paid on a fee-for-service basis by the provincial health ministry. Thus, the increase in time spent in order entry by doctors was not relevant from the institution's perspective (but was included in a sensitivity analysis). The time horizon of the model was 10 years, which corresponded to the lifespan of the system, thus discounting was relevant. An annual discount rate of 5% was used. The price year was 2004.

**Statistical analysis of costs**
The costs were treated deterministically.

**Indirect Costs**
Productivity costs were not considered given the adopted perspective of the institution.

**Currency**
US dollars ($). The costs were initially expressed in Canadian dollars (CAD), but were converted to US dollars at the March 2004 rate of CAD 1 = $1.3821.

**Sensitivity analysis**
A series of univariate sensitivity analyses was carried out to assess the robustness of the cost-effectiveness ratios to variations in underlying clinical and economic assumptions. For example, the effectiveness of the system at reducing preventable ADEs, the ADE rate, the lifetime of the system, the cost of the system and additional doctor costs. Published ranges of values were used.

**Estimated benefits used in the economic analysis**
The number of ADEs averted per year with MOE/MAR (per 100 admissions) in comparison with the standard system was 32.2.

Over a 10-year time horizon, the discounted number of ADEs prevented by MOE/MAR would be 261.
Cost results
The additional costs incurred with MOE/MAR over the conventional system, over a 10-year time horizon, were $3,322,000.

Synthesis of costs and benefits
An incremental cost-effectiveness ratio was calculated in order to combine the costs and benefits of the alternative strategies.

The incremental cost per ADE averted with MOE in comparison with the standard system was $12,700.

The results of the sensitivity analysis showed that the cost-effectiveness ratio was highly sensitive to changes in the ADE rate, system effectiveness, system costs and additional doctor costs, whilst it was not sensitive to changes in the lifespan of the system. The incremental cost per ADE averted rose dramatically as the ADE rate dropped below 1.0 ADEs per 100 admissions (1.4 in the base-case). If system costs were $8 million initially and $1.35 million annually (as in published studies), it would result in an incremental cost-effectiveness of $73,000 per ADE averted. If the doctors’ workload increased by 5% owing to the system, it would result in an increase to $75,000 per ADE averted.

Authors’ conclusions
An electronic medication order entry (MOE) and administration system improved care by reducing adverse drug events (ADEs) at a cost of $12,700 per ADE averted in comparison with the standard system. However, data on the effectiveness of the new system were limited and changes in the estimates had a dramatic effect on the cost-effectiveness results.

CRD COMMENTARY - Selection of comparators
The choice of the comparators was clear in that the conventional system was compared with the new computerised approach. A detailed description of the new system was given. You should decide whether they are valid comparators in your own setting.

Validity of estimate of measure of effectiveness
The effectiveness data came from a review of the literature, the methods and conduct of which were described in detail. The database searched and the inclusion criteria were reported. Similarly, the approach used to combine the primary estimates was stated. Details of the sample size and results of the selected studies were provided. However, since there was limited information on the design and other characteristics of the primary studies, it was difficult to make an objective assessment of the validity of the primary sources. The issue of uncertainty surrounding the clinical estimates was investigated in the univariate sensitivity analysis.

Validity of estimate of measure of benefit
The summary benefit measure was specific to the intervention considered in the study. It would be difficult to compare with the benefits of other health care interventions. The impact of the new system on patients’ quality of life was not considered. The number of ADEs averted is an intermediate outcome that may be difficult to interpret.

Validity of estimate of costs
The categories of costs included in the analysis were consistent with the perspective adopted. A justification for the exclusion of some cost items was given. Further, the inclusion of doctors’ costs was investigated in the sensitivity analysis. However, the unit costs and the quantities of resources used were not presented separately, and some costs were given as macro-categories. The sources of the costs were reported. Statistical analyses of the costs were not performed, but the impact of variations in some cost items was considered. Discounting was performed. The price year was reported, which will aid reflation exercises in other time periods.
Other issues
Comparisons with findings from other studies were not made. The authors stated that, to their knowledge, there were no other published economic evaluations of MOE/MAR. In terms of the issue of the generalisability of the study results to other settings, the authors stated that the current study referred to tertiary care institutions, which might not be representative of other hospitals given differences in system/vendor costs, doctor reimbursement and workflow. The authors acknowledged that the main issue of the analysis related to the high uncertainty found around base-case estimates and the difficulty in interpreting the base-case results. Finally, the exclusion of cost-savings due to a reduction in ADEs might have led to an underestimation of the economic benefit of the new system.

Implications of the study
The study results suggest that MOE/MAR could be a cost-effective alternative to the conventional paper ordering system. Further research is required to determine more precise estimates of the potential benefits of this technology.

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