Research

A comparison of handwritten and computer-assisted prescriptions in an intensive care unit

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Abstract

Background: We conducted a prospective comparative study to evaluate the potential benefit of computer-assisted prescribing (CAP). We compared the accuracy, completeness and time use of CAP with that of conventional handwritten prescribing at the intensive care unit (ICU) of the John Radcliffe Hospital, Oxford, UK.
Results: Twenty-five clinicians and 2409 drug entries were evaluated for accuracy, completeness, legibility and time spent prescribing. One hundred and twenty-eight handwritten and 110 CAP charts were monitored. One hundred percent of CAP charts were complete compared to 47% of handwritten charts.
Drug prescriptions were divided into three categories: intravenous fluids, intravenous infusions and intermittent drugs. Percentage of correct entries in each category were 64%, 47.5% and 90% for handwritten, compared to 48%, 32% and 90% for CAP charts, respectively.The mean time taken to prescribe was 20 s for hand written prescribing and 55 s for CAP.
Conclusions: Computer-assisted prescriptions were more complete, signed and dated than handwritten prescriptions. Errors in prescribing, including failure to discontinue a drug were not reduced by CAP. Handwritten prescribing was quicker than CAP. Simple enhancements of the computer software could be introduced which might overcome these deficiencies. CAP was successfully integrated into clinical practice in the ICU.

Keywords: computerised prescribing, critical care, intensive care

Introduction

Computerised prescribing is widely used in the United Kingdom for repeat prescriptions in general practice [1]. There is evidence that it has improved legibility and clarity, saved time for both medical and clerical staff, and reduced the time spent clarifying prescriptions with the dispensing pharmacist [2,3]. Its principal use in hospital practice has been for outpatient or inpatient discharge prescriptions, although some hospitals use fully integrated computerised prescribing systems. This is likely to expand in the next decade. Computer-assisted decision support in the hospital setting has already been shown to improve the use of antibiotics peri-operatively, reduce the costs of prescribing and influence clinical parameters such as limiting the emergence of antibiotic resistance [4].

Computer-assisted prescribing (CAP) for inpatients was introduced to the intensive care unit (ICU) of the John Radcliffe Hospital in May 1996 as part of the Hewlett Packard CareVue® patient information system (Hewlett Packard Ltd, Andover, USA). This study evaluated the computerised prescribing system by comparing the accuracy and completeness of prescriptions, and time spent prescribing before and after the introduction of CAP.

Methods

CareVue® is a proprietary ICU computer information system providing automatic charting of physiological and laboratory data. In our ICU, it has been directly interfaced with the patients' mechanical ventilators and arterial blood gas analysers, and hematology and biochemistry laboratories. In May 1996, a prescribing module of the system software was activated and introduced clinically after a period of modification and reconfiguration. CareVue® is supported by mirrored primary and secondary Hewlett Packard 9000 series/700 servers, supporting up to 4 bedside Hewlett Packard 712 series diskless workstation clients running HPUX 9.03 system software. A work station is sited at each patient's bedside.

The study was undertaken in two phases. The first phase consisted of a 3-week period during which handwritten prescriptions were evaluated. The second 3-week phase was conducted 1 month after the introduction and implementation of the CAP component of CareVue®. All medical and nursing staff received training at the bedside from the ward pharmacist and the CareVue® nurse specialist. All prescribing doctors monitored were unaware that their practice was being assessed.

Handwritten prescribing

Prescription charts were rewritten daily. Each prescription chart was required to be dated and a hospital sticker attached with the patient's address, date of birth and hospital number. The prescriber was then required to write, in the appropriate section, the drug name, the dose or amount to be diluted (with iv infusions), rate of administration (for infusions), volume of specified diluents required, route and frequency of administration. The prescription was then signed at the bottom with a single signature covering all drug entries.

Computer-assisted prescribing

In the second phase of the study, CAP was implemented following the introduction of the medication administration record (MAR) prescribing module of Hewlett Packard CareVue® (Fig 1). It is divided into the following three sections: the `scheduled' section contains drugs given at regular intervals; the `PRN' section contains drugs given as required and also iv fluids, infusions and enteral or parenteral feeds, and the `STAT' section contains any single dose drugs or fluids.

Figure 2 illustrates the prescribing process. The prescribing doctor is required to complete all sections of the prescription marked with an asterisk, other sections being optional. By clicking a trackball directed pointer on the medication box a pick-list of 236 commonly prescribed medications, fluids and feeds is displayed.

Depending upon the drug selected, appropriate routes of administration become available in another pick-list (eg po, iv, subcutaneous, etc). A preparation not included on the drug pick list may still be prescribed, but the computer cannot `advise' on the route of administration or dose. Specific doses or dose ranges are entered by typing the values into the dose box. Doses outside recommended ranges are flagged by a red warning box and denied entry.

The time for the drug administration to commence is added in the schedule box.

Free text entry of instructions (either from the prescribing clinicians or nurse) allows diluents, dilutions and infusion rates to be specified. By adding and storing the order at this point (mandatory and requiring entry of a unique six digit alpha/numeric password) the clinician's name and initials are appended to the prescription. Once a prescription is entered onto the system and stored, the drug, route, dose and frequency of administration cannot be changed. If such a change is required the prescription must be discontinued and completely rewritten. Any new entry, alteration, modification or discontinuation requires confirmation by entry of the physician's unique password.

Two levels of password are available. A prescribing clinician has access to entry, storage, alteration and discontinuation of all prescriptions as well as being able to log the administration of drugs. Nursing staff may also enter and discontinue prescriptions, but these are highlighted on the MAR as requiring confirmation by a clinician, with no drugs administration against these prescriptions being possible until this has occurred. A prescription is not active until it has been `signed' or authorised by a clinician, using their password.

Each prescription is transferred from the MAR to the drug flowsheet. The flowsheet is used to record the hourly rate of iv infusions and also the time of administration of scheduled `as required' drugs (Fig 3).

Additional features include automatic discontinuation of drugs following the entry of a stop date on to the prescription, or the ability to highlight prescriptions which should be reviewed on a certain day.

Criteria for evaluation

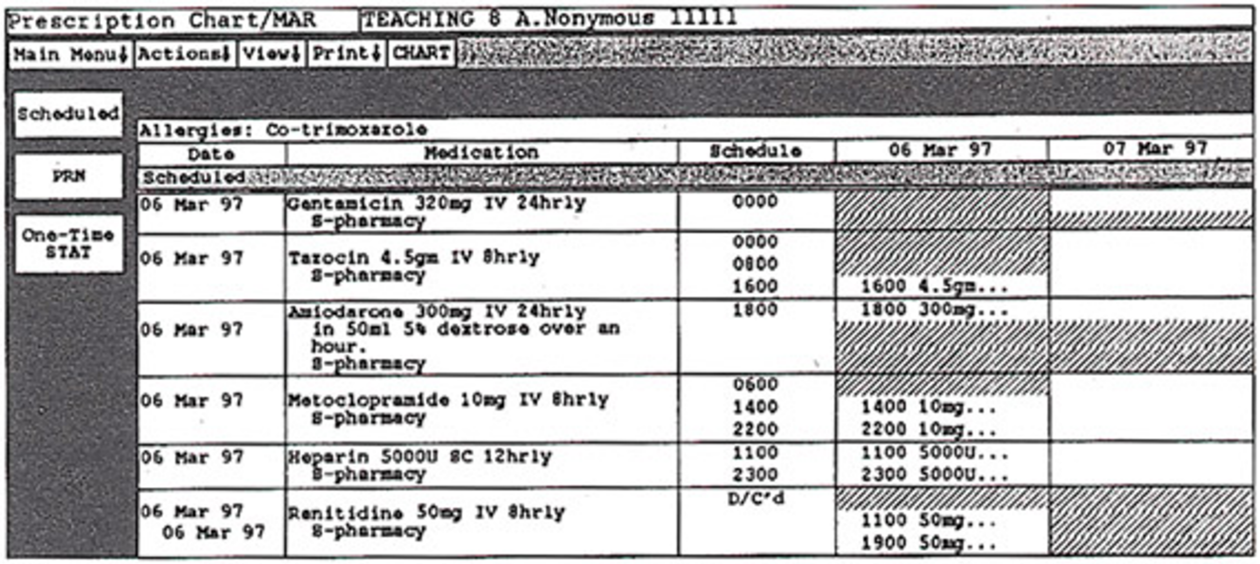
Each individual drug entry for both the handwritten prescribing and CAP was evaluated by the ICU pharmacist according to 19 predetermined criteria (Table 1) over two 3-week time periods.

The time taken to prescribe a single drug by hand and using the computer module was measured, and the time it took a nurse to record that the drug has been given was measured using the two prescribing modes.

Results

One hundred and twenty-eight handwritten and 110 computer-assisted patient prescription charts were monitored over the 6 weeks of the study, resulting in 1184 handwrit-

Figure 1



Prescription Chart/MAR | TEACHING 8 A.Nonymous 11111

Main Menu | Actions | View | Print | CHART

Scheduled | PRN | One-Time STAT

Allergies: Co-trimoxarole

Date	Medication	Schedule	06 Mar 97	07 Mar 97
Scheduled				
06 Mar 97	Gentamicin 320mg IV 24hrly S-pharmacy	0000		
06 Mar 97	Tazocin 4.5gm IV 8hrly S-pharmacy	0000 0800 1600	1600 4.5gm...	
06 Mar 97	Amiodarone 300mg IV 24hrly in 50ml 5% dextrose over an hour. S-pharmacy	1800	1800 300mg...	
06 Mar 97	Metoclopramide 10mg IV 8hrly S-pharmacy	0600 1400 2200	1400 10mg... 2200 10mg...	
06 Mar 97	Heparin 5000U SC 12hrly S-pharmacy	1100 2300	1100 5000U... 2300 5000U...	
06 Mar 97 06 Mar 97	Ranitidine 50mg IV 8hrly S-pharmacy	D/C'd	1100 50mg... 1900 50mg...	

The medication administration record (MAR) computerised prescription. Demographic patient data and known allergies are clearly indicated. The start date, prescription and administration times are shown. The cross hatched areas indicate a period before the prescription was written and/or after it has been discontinued. The times under the dated vertical columns show times of drugs already given, and the blank white blocks indicate schedule administration time. Stock drugs on the unit have been endorsed `S-pharmacy' for information.

ten and 1225 computer-assisted individual drug entries being studied. There was an average of 10 individual drugs prescribed per patient per day, consisting of iv fluids, intravenous infusions, entail or parenteral feeds, `regular' and `as required' drugs.

Legibility, completeness, and authorisation of prescriptions

One hundred percent of the computerised patient prescriptions were signed and dated in comparison with 95% of handwritten patient prescriptions. Note that with CAP all individual drug entries were authorised, whereas with handwritten prescriptions one signature covered the whole prescription. Only 47% of handwritten prescription charts had full patient identification (name, date of birth and unit number, or hospital sticker) whilst this information was available with all prescriptions on the computerised system.

The following three drug prescription categories were considered.

Intravenous fluids and entail/parenteral feeds

Entries monitored in this section included all feeds, blood, blood derivatives, colloids and crystalloids. One hundred and ninety-four individual handwritten and 255 individual computerised entries were analysed in this category (Fig 4).

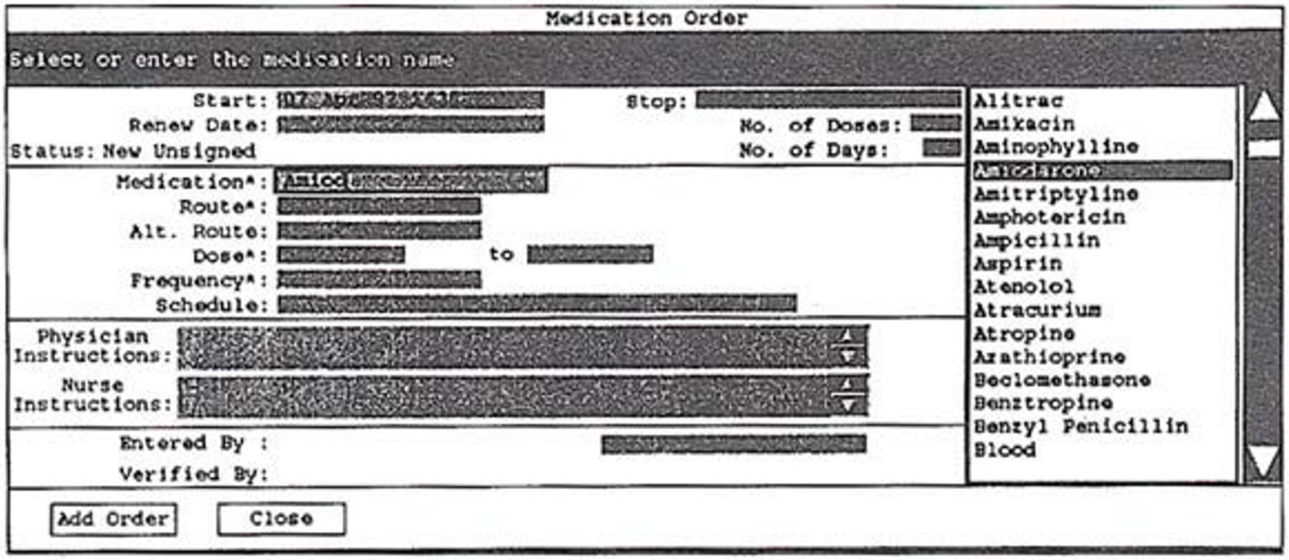
There was a decrease from 64% to 48% in the percentage of complete and correct individual entries (see Table 1 criteria) following the introduction of CAP (Fig 4). The percentage of entries with a missing rate of infusion increased from 18% to 28% (Fig 4). The number of drug entries remaining on the prescription chart despite having been removed from the treatment regimen more than 24 h previously also increased, from 1% to 17% (Fig 4).

Intravenous infusions

Prescriptions monitored in this section were those for sedatives, analgesics, inotropes, vasoactive agents, heparin and antiarrhythmics, administered by infusion. Two hundred and eighty-four handwritten and 247 computerised drug entries were assessed in this category. Major differences between handwritten prescribing and CAP are shown in Fig 5.

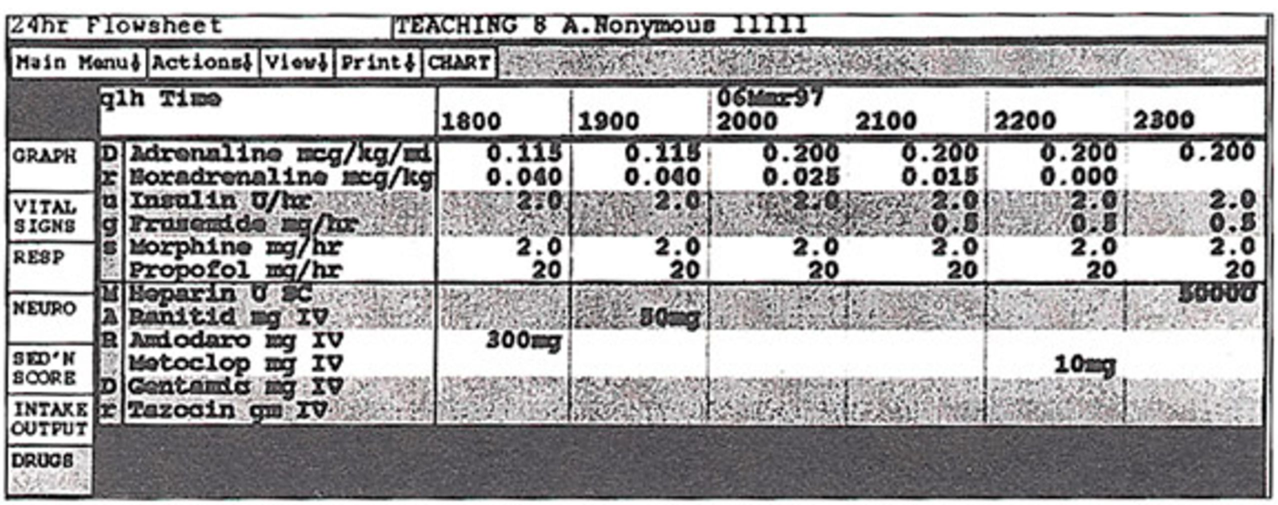
The percentage of correct entries for iv infusions decreased from 47.5% to 32% with CAP (Fig. 5). Thirty-one percent of CAP had no prescribed diluent and 27% had no prescribed diluent volume. The percentage of prescriptions with an incorrect rate of infusion was 16% with CAP and 1.4% with handwritten prescriptions.

Figure 2



The drug entry page for the computerised prescription. The right hand box shows part of the pick-list of 236 drugs available to the physician. The first five letters `amiod' have been typed into the medication box, selecting amiodarone. By moving the trackball and clicking the centre key a drug is released on to the medication administration record (MAR). For further detail see main text.

Figure 3

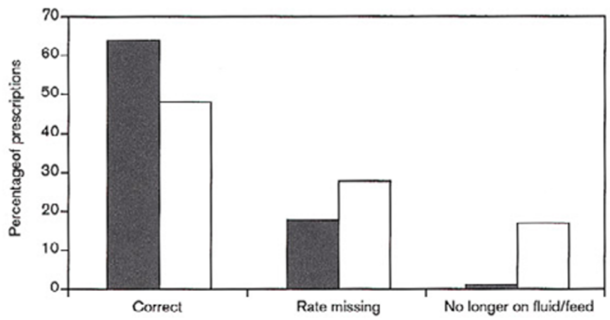


The 24 h flowsheet. Rates of iv infusions and times of administration for intermittent drugs are shown.

Intermittent drugs

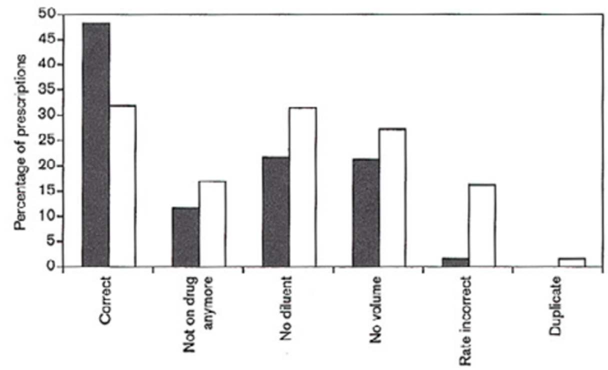
Prescriptions monitored in this category included antibiotics, H_2 antagonists, antihypertensives, potassium supplements and other agents. Seven hundred and six handwritten and 723 computer-assisted drug entries were analysed in this category. Ninety percent of entries for both handwritten and CAP groups complied with the specified criteria (dose, route, frequency). The results are expressed in Fig 6 as a percentage of the total number of erroneous prescriptions (approximately 10% of the total number of entries monitored).

Figure 4



The percentage of individual drug entries for iv fluids and enteral/ parenteral feeds in each category correctly prescribed, missing a rate or remaining on the prescription but not administered for over 24 h. ☐, Handwritten; ☐, computerised.

Figure 5



The percentage of iv infusions in each category correctly prescribed, those remaining on the prescription but not administered for over 24 h, without a specified diluent or volume, with an incorrect rate, or prescribed in duplicate. ▭, Handwritten; ☐, computerised.

Table 1

Criteria used to examine each prescription

Drug entry errors	
a	Complete and correct
b	Illegible
c	Spelling incorrect
d	Dose incorrect
e	No dose
f	Volume incorrect
g	No volume
h	No diluent
i	Diluent incorrect
j	No infusion rate
k	Rate of infusion incorrect
l	Frequency of administration incorrect
m	Route of administration incorrect
n	No frequency
o	No route
Drug administration errors	
q	Drug not administered within past 24 h*
r	Patient receiving a drug that is not prescribed
s	Patient never received drug†

*The prescription remained on chart despite not being needed or verbally discontinued. †The drug prescribed in anticipation of need, but never actually required.

Figure 6 shows an increased frequency of failure to discontinue drugs that the patient was no longer receiving from 9.1% of errors with handwritten prescribing to 57% of errors with CAP. Although this increase appears large, this represented less than 6% of the total entries in this category.

Duplicate prescriptions also appeared in 11 cases in total with CAP. There were no duplicate prescriptions with handwritten prescriptions.

Time taken to prescribe

Time taken to prescribe one medication by computer and one medication by hand was measured. It took approximately 20 s to prescribe a single complete handwritten drug entry and 55 s to prescribe the same drug using CAP. To record that a drug had been given took 2 s on the handwritten chart and 21 s with CAP.

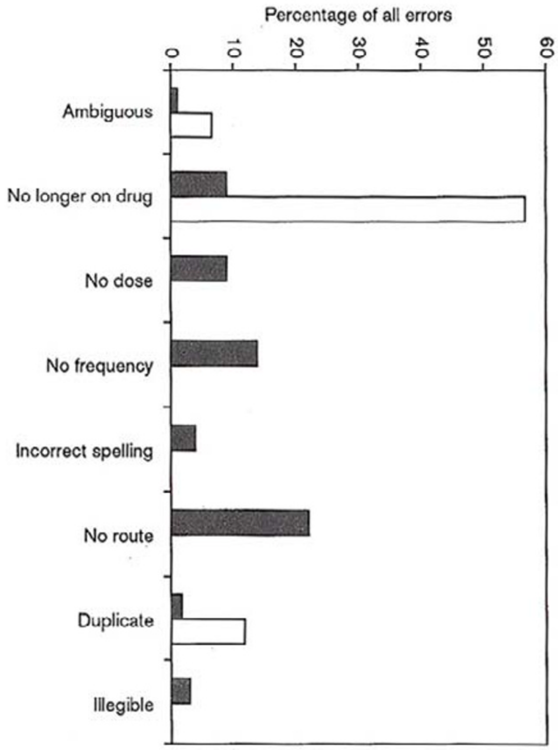
Discussion

This study was undertaken in order to assess the accuracy, completeness and time spent prescribing with CAP compared with handwritten prescriptions in a busy ICU in the UK. We were also interested in the other benefits it could offer to healthcare providers.

Accuracy, completeness and `signing' or authorisation

CAP provided a less accurate prescription for iv fluids and infusions, and prescriptions in all categories were more likely to remain on the chart despite having been discontinued from therapy, possibly due to a decrease in frequency of review of the chart. This problem needs to be highlighted in our training programme. There was also an uncommon problem of duplicate drug entries using CAP which did not occur with handwritten prescriptions. This was probably linked to the configuration of the system which segregated regularly scheduled drugs from `STAT' and `PRN' drugs. The three groups could not be displayed simultaneously on the bedside monitor making duplication more probable.

Figure 6



The percentage of errors in prescription for `regular' and `as required' drugs in both categories including drug with ambiguous instructions, those remaining on the prescription chart but not administered for over 24 h, without a dose, frequency or route, spelt incorrectly, duplicated, or illegible. ▭, Handwritten; □, computerised.

There was no facility with the current system to highlight this, but software enhancement could address this issue.

CAP offered benefits in terms of legibility since almost all the drug names were preconfigured within the system and there was no variation in quality to text. CAP were more complete than handwritten prescriptions in that each prescription chart uniquely and fully identified the patient (100% compared with 47%) and any allergies they may have, and every individual drug entry was authorised. With intermittent and scheduled therapy the mandatory fields of drug, dose, route and frequency meant that these categories were never missing from the prescription, in contrast with handwritten prescriptions. Our study confirmed previous work [5], that handwritten medication orders are subject to being incomplete, illegible and unsigned.

Since 100% of individual drug entries were authorised by password with computerised prescribing it was always possible to trace a member of staff prescribing or administering a medication. Start and stop dates and changes in dose were always recorded and identifiable in comparison with handwritten prescriptions where changes in doses were less likely to be dated and signed by the prescriber. The time of initiation or discontinuation of the prescription was virtually never recorded on the handwritten charts, and discontinued prescriptions were frequently unsigned.

Speed of prescribing

Computer-assisted prescriptions took more than twice as long to prescribe as handwritten prescriptions. Administration also took the nursing staff longer to record with CAP than on the handwritten charts. This was due, however, to the much greater detail entered with CAP which was not part of the handwritten record, and the extra time taken to move around the computer screen and store information. Our study focused on time spent prescribing drugs and logging that drugs had been given. Related secondary time issues such as drug stocktaking, ordering drugs from the central pharmacy and time taken to issue discharge prescriptions were not studied. A similar study describing parenteral nutrition (PN) ordering in a neonatal intensive care unit [6] looked at time spent on writing and ordering PN with manual and computer systems. Time was reduced by the computerised ordering, and improvements to nutritional composition were noted in the computerised group. Other investigators [7] have demonstrated that computerised prescriptions result in total time saving advantages even when time to enter the information takes 2-3 times longer with computerised systems. Indeed, our study focused on the task at the bedside workstation and, in this area, more time was spent with CAP compared to handwritten prescribing. It may be that secondary time costs will be reduced with this system, but it was not part of this study.

Suggested enhancements for future MAR systems

As a result of this evaluation we have identified several enhancements which would improve the performance of CAP. Originally there was no facility to prescribe infusions. This deficit was circumvented by free text entry of information. A purpose-designed infusion entry component would greatly reduce prescription errors for this category of drugs. Highlighting of duplicate prescriptions would prevent this error occurring, and if all sections of the prescription chart could be viewed simultaneously drug therapy could be more easily reviewed by all ICU staff. A facility to make authorised changes to a prescription without the need for it being completely rewritten would be useful. A higher level of enhancement of CAP could include decision support tools. These would allow preconfigured combinations or sets of drugs to be prescribed for specific clinical situations. Drug interactions and incompatibilities could be flagged, much improving the safety of drug therapy. Advice on cost of prescribing could be included, offering alternative cheaper options to the clinician.

Conclusions

The CareVue® MAR prescribing system has become well integrated into practice in our ICU. It produces a complete, fully legible and permanent prescription. It did not reduce errors in prescribing, and in fact increased such mistakes, but software enhancements to the system, and improved training of clinicians may reduce these. Prescribing and recording administration of medication at the bedside takes longer with CAP, but there may be secondary time savings with this system.

References

1. Gallup Poll: **.** *Computerisation in GP practices in England and Wales: 1993 survey. Leeds: NHS Management Executive* 1993.
2. Roland MO, Zander LI, Evans M, Morris R, Savage RA: **Evaluation of a computer assisted repeat prescribing programme in a general practice.** *BMJ* 1985, **291:**456-458.
3. Moss RL, Pounders JN: **Impact of computerisation on dispensing time in an ambulatory-care pharmacy.** *Am J Hosp Pharm* 1985, **42:**309-312.
4. Pestonik SL, Classen DC, Evans RS, Burke JP: **Implementing antibiotic practice guidelines through computer-assisted decision support: clinician and financial outcomes.** *Ann Intern Med* 1996, **124:**884-890.
5. Winslow EH, Nestor VA, Davidoff SK, Thompson PG, Borum JC: **Legibility and completeness of physicians' handwritten medication orders.** *Heart Lung* 1997, **26:**158-164.
6. Puangco MA, Nguyen HL, Sheriden MJ: **Computerised parenteral nutrition ordering optimises timely nutrition therapy in a neonatal intensive care unit.** *J Am Diet Assoc* 1997, **97:**258-261.
7. Ikeda M, Hayashi E, Yamauchi K: **Model analysis in time duration in a medication order entry system with attention to do-medication orders.** *Comput Biol Med* 1994, **24:**473-483.