Changes in medication administration error rates associated with the introduction of electronic medication systems in hospitals: a multisite controlled before and after study.

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Electronic medication systems (EMS) have been highly effective in reducing prescribing errors, but little research has investigated their effects on medication administration errors (MAEs).

To assess changes in MAE rates and types associated with EMS implementation.

This was a controlled before and after study (three intervention and three control wards) at two adult teaching hospitals. Intervention wards used an EMS with no bar-coding. Independent, trained observers shadowed nurses and recorded medications administered and compliance with 10 safety procedures. Observational data were compared against medication charts to identify errors (eg, wrong dose). Potential error severity was classified on a 5-point scale, with those scoring ≥3 identified as serious. Changes in MAE rates preintervention and postintervention by study group, accounting for differences at baseline, were calculated.

7451 administrations were observed (4176 pre-EMS and 3275 post-EMS). At baseline, 30.2% of administrations contained ≥1 MAE, with wrong intravenous rate, timing, volume and dose the most frequent. Post-EMS, MAEs decreased on intervention wards relative to control wards by 4.2 errors per 100 administrations (95% CI 0.2 to 8.3; p=0.04). Wrong timing errors alone decreased by 3.4 per 100 administrations (95% CI 0.01 to 6.7; p<0.05). EMS use was associated with an absolute decline in potentially serious MAEs by 2.4% (95% CI 0.8 to 3.9; p=0.003), a 56% reduction in the proportion of potentially serious MAEs. At baseline, 74.1% of administrations were non-compliant with ≥1 of 10 procedures and this rate did not significantly improve post-EMS.

Implementation of EMS was associated with a modest, but significant, reduction in overall MAE rate, but halved the proportion of MAEs rated as potentially serious.

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What is already known?

Medication errors are one of the leading causes of preventable patient harm in hospitals, and in response the WHO has nominated medication safety as the current 5-year global patient safety challenge.

Electronic medication systems (EMS) have been demonstrated to effectively reduce prescribing error rates, yet evidence of these systems improving medication administration error (MAE) rates or reducing associated harm is very limited.

No previous multisite or controlled studies evaluating the effects of EMS on MAE rates have been published.

What does this paper add?

We conducted a controlled before and after study at two major adult teaching hospitals to measure the effects of EMS on MAE rates.

Overall, 30.2% of all administrations observed had one or more clinical error and 3.3% of errors were rated as potentially serious and likely to cause permanent harm.

Implementation of EMS was associated with a significant but modest 14% overall reduction in MAE rate, with the greatest reduction observed in ‘wrong timing’ errors.

However, the intervention wards experienced a 56% reduction in medication administrations with a potentially serious MAE, suggesting that EMS are effective in reducing safety risks during medication

administration.

In 2017 the WHO announced medication safety as the next global patient safety challenge, reflecting continuing concerns regarding the high rates of medication errors and their impact on health outcomes and costs.

Evidence of effective interventions to reduce MAEs is also scant. A systematic review and meta-analysis of observational studies assessing the effectiveness of various training and technology-related interventions to reduce MAE rates found no significant effects.

The aim of this study was to conduct a controlled before and after study to investigate changes in MAE rates following the implementation of EMS at two large adult teaching hospitals.

Study design and intervention

A controlled before and after study was conducted at two major metropolitan adult teaching hospitals in Sydney, Australia. Hospital A is a 400-bed hospital and hospital B a 326-bed hospital. Each hospital was in the process of implementing a commercial EMS which included electronic prescribing and medication administration functionality. At hospital A data were collected from four general medical/surgical wards (two acute aged care, one renal/vascular/dermatology and one acute respiratory ward;

Study design. MAE, medication administration error.

Both EMS had limited decision support and medication administration was not supported with bar-code scanning. Nurses used the EMS to identify the medications to be administered to patients, with medications due for administration highlighted on screen.

Data were collected on all six wards in both the pre-EMS and post-EMS implementation periods. A minimum of 10 weeks postsystem implementation elapsed before the postdata collection occurred (

Observation procedures

Nurses were recruited through information sessions and invited to participate by researchers on the study wards. In total 180 of nurses (constituting >90% of available participants) agreed to participate in the study and provided signed informed consent. Trained observers arrived on the study wards each day at the key medication administration times between the hours of 06:00 and 22:00 and randomly selected nurses to observe based on a list of consented nurses on that ward.

Observers shadowed nurses as they prepared and administered medications on the ward. Detailed information, including drug name, dose and route given, was recorded in real time using a handheld computer with specialised software (the Precise Observation System for the Safe Use of Medicines (POSSUM)).

Clinical and procedural medication administration error categories

Drug given was not equivalent to the drug prescribed.

Gentamicin prepared and administered instead of erythromycin.

Drug administered for which there was no documented order (if drug was given instead of a similar ordered drug, this was recorded as a ‘wrong drug’ error instead).

Heparin administered but no order for an anticoagulant.

Dose of drug given was not equivalent to the dose prescribed within a margin of 10%.

Digoxin 250 μg ordered but three 62.5 μg tablets prepared and administered.

Additional dose of an ordered medication was given.

Correct drug was given but was not equivalent to the formulation prescribed.

MS Contin 10 mg prescribed but two plain oxycodone 5 mg tablets given.

Route of administration not equivalent to the route ordered.

Injection given intramuscularly instead of intravenously.

Strength of drug given was not equivalent to the strength prescribed.

Entire content of ceftazidime 2 g vial prepared and administered when ceftazidime 1 g was ordered.

Drug prepared for or administered to the wrong patient.

Wrong solvent/diluent (injectables)

Solvent or diluent used not recommended for use with the drug based on Australian Injectable Drugs Handbook (AIDH) or manufacturer’s guidelines (MIMS Medicines Informations handbook).

Wrong solvent/diluent volume (injectables)

Solvent or diluent volume not appropriate according to AIDH or MIMS but without a dose error.

Wrong intravenous rate

Intravenous infusion or bolus rate not appropriate according to AIDH, MIMS or hospital guidelines (>15% faster than recommended).

Frusemide given at 8 mg/min (policy is frusemide to be given no faster than 4 mg/min

Incompatible drug (intravenous)

Drugs, diluents and solvents combined for intravenous infusion are not compatible according to AIDH/MIMS.

Cefotaxime and frusemide administered in combination.

Medication administered >60 min before or after the ordered time, or >30 min before or after a meal if medication ordered to be given with meals.

Read medication label

Nurse not observed reading the medication label.

Nurse observed storing the drug temporarily in a non-secure area.

Medication placed on patient locker.

Check patient identification

Nurse not observed to verify that the chart matches patient identification prior to administering medication/s.

Nurse did not read wristband or ask the patient’s name and date of birth prior to administration.

Record medication administration

Chart not signed to indicate medication administered (or not administered with reason documented).

Check pulse and/or blood pressure

Nurse did not check the apical pulse (with stethoscope) or measure blood pressure prior to administration of digoxin.

Use aseptic technique

Gross breach of aseptic technique.

Did not wash hands before medication preparation; touched tablets without gloves.

Check preparation: two nurses

Medication preparation not checked by two nurses for S4, S8 and all intravenous preparations.

Check infusion pump: two nurses

Infusion rate and settings not checked by two nurses for intravenous infusions.

Witness administration: two nurses

Medication administration not witnessed by two nurses (including the administering nurse) for S4, S8 and intravenous drugs.

Drugs of dependence register: two nurses

Drugs of dependence register not signed by two nurses.

Observers recorded medications without knowledge of what medications were documented on patients' medication charts. If observers noticed an error which had the potential to cause serious patient harm (eg, a tenfold dose of a medication), they were instructed to follow a 'serious error' protocol devised for the study which outlined the steps required to intervene.

Observers were nurses independent from the study hospitals and underwent extensive training using scenarios and field testing. Inter-rater reliability scores were calculated during practice sessions by having two observers collect data from the same medication administration events and then comparing them for agreement. Data collection commenced once κ scores

Errors were classified as either clinical errors (13 types) or procedural errors (10 types) (see

Clinical errors included wrong timing errors, which were defined as a medication that was administered >60 min before or after the prescribed time, or >30 min before or after a meal time if the medication was ordered to be administered with or in advance of food. Procedural errors were medication administrations where the preparation, administration or documentation of the drug did not comply with the law, State Department of Health or hospital policy or guideline.

The potential severity of errors was rated using a 5-point severity scale based on the New South Wales Health Department state-wide hospital incident monitoring system (see

Clinical error severity rating scale

Rating of likely outcome

Incident is likely to have little or no effect on the patient.

Incident is likely to increase level of care, for example, review, investigations and referral to another clinician.

Incident is likely to lead to permanent reduction in bodily functioning, increased length of stay and surgery.

Incident is likely to lead to a major permanent loss of function.

Incident is likely to lead to death.

Errors with a score ≥3 were classed as potentially serious with potential for permanent harm.

The error rate for each clinical error category was calculated by dividing the number of errors by the total number of administrations where that error category was applicable. The overall MAE rate was presented for each study period (pre and post) and group (control and intervention wards). The difference in error rate changes post-EMS in the intervention group relative to control groups was defined as the differences of the error rates over time between control and intervention groups, expressed as:

The 95% CIs were obtained using the normal approximation method. The overall procedural error rate and rate change for each procedural error category were calculated using the same definition and procedure as for clinical error rates. The proportion of administrations with at least one clinical error and proportion of administrations with potentially serious errors, that is, severity score ≥3, were presented by study period and group. The z-tests for proportions were used to compare the changes over time between study groups, with the level of significance set at $p<0.05$. Data analysis was conducted using SAS V.9.3.

A total of 7451 medication administrations were observed during the study, of which 4176 were during the baseline/preintervention period (2463 on control wards, 1713 on intervention wards) and 3275 were during the postintervention period (1528 on control wards, 1747 on intervention wards).

Clinical and procedural MAE rates at baseline

Clinical medication administration errors at baseline

Baseline (preintervention) clinical error rate

Errors/applicable administrations (n)

Error rate per 100 administrations (95% CI)

Errors/applicable administrations (n)

Error rate per 100 administrations (95% CI)

Error rate per 100 administrations

Wrong intravenous rate

Wrong solvent/diluent volume (injectables)

Wrong solvent (injectables)

Intravenous with incompatible drug

Medication administrations with ≥1 clinical error

Potential severity score ≥3

Procedural medication administration errors at baseline

Baseline (preintervention) procedural error rate

Errors/applicable administrations (n)

Procedural rate per 100 administrations (95% CI)

Errors/applicable administrations (n)

Procedural error rate per 100 administrations (95% CI)

Procedural error rate per 100 administrations

Check infusion pump: two nurses

Check patient identification

Witness administration: two nurses

Check pulse and/or blood pressure

Use aseptic technique

Check preparation S4/S8*/injection: two nurses

Record/sign medication administration

Drugs of dependence register: two nurses

Read medication label

Administrations with ≥1 procedural errors

*S4 and S8 drugs are listed as controlled substances according to legislation and regulations. They include drugs of addiction such as opioids.

Changes in MAE post-EMS implementation

We measured the pre–post changes in MAEs on the control and intervention wards and then compared the magnitude of changes to determine whether the intervention wards experienced a greater change in MAE rates relative to any changes observed on the control wards.

Clinical medication administration errors rates post implementation of the EMS and change in error rates between baseline and post-EMS

Clinical error category

Citation

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