Decreasing medication errors in four intensive care units of a tertiary care teaching hospital in India using a sensitization programme

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ABSTRACT

Background. Medication errors have an adverse impact on the healthcare system by increasing patient morbidity and mortality. They are preventable, and educational or technology-based interventions are needed to reduce their prevalence and improve medication safety. We aimed to study the impact of a sensitization programme and a blame-free reporting tool for doctors and nurses on the prevalence and reporting of medication errors in the intensive care units (ICUs) of a tertiary care teaching hospital.

Methods. This prospective interventional study was conducted in the ICUs of cardiology, medicine, paediatrics and neonatology. Baseline medication errors were detected by prescription order review and direct observation of administration of medication for 30 days. A sensitization programme was conducted for doctors and nurses in these ICUs, the results were discussed, and a blame-free medication error reporting tool was introduced. Medication charts were modified to remove the transcription process in the cardiology and paediatrics ICUs. The follow-up study was conducted for 30 days in each ICU to monitor the impact of the sensitization programme.

Results. The prevalence of medication errors was found to be 334.1/1000 patient observation days. Prescription errors were the most common types of errors at 129.1/1000 patient observation days. The interventions significantly reduced the error rate in all four ICUs. The overall number of prescriptions with errors was reduced from 9.1% (177/1944) to 3.5% (48/1373) and no medication error was reported using the tool.

Conclusion. The sensitization programme on medication errors for doctors and nurses may be effective in improving medication safety. The impact was more pronounced in prescription errors. Reporting of medication errors did not improve in this study despite the introduction of a blame-free reporting tool.

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INTRODUCTION

The term 'medication error' is 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 healthcare professional, patient or consumer'.[1] Medication errors account for 28% of medical errors in general wards and 78% of medical errors in intensive care units (ICUs).[2] The prevalence of medication errors in the ICU ranges from 8.2 to 2344/1000 patient days.[3] Patients in the ICUs are especially vulnerable as they are critically ill, receive many medications by the parenteral route and have their medications changed frequently compared to those admitted to a hospital ward.[2] The type of patients, working environment and safety culture vary between ICUs and therefore, the error rates as well as the types of errors may also vary among ICUs of different specialties.[4]

Medication errors in ICUs of Indian hospitals have not been well studied. Jain *et al*. documented the error rate in a neonatology ICU as 0.7 errors per patient and 1.5 errors per patient in the paediatric emergency department in a teaching hospital.[5] The frequency of medication errors in the paediatrics and neonatal ICUs of a tertiary care hospital in India has been shown to be 41.7% and 76.6%, respectively,[6] and was found to be 51.6% in the paediatric wards of another tertiary care teaching hospital.[7] In India, medication errors go unreported as there is a fear of being reprimanded or sued.[8]

In many aspects, the ICU set up in India is different from that in developed countries, such as the low staff–patient ratio, the absence of standard operating procedures, irregular monitoring and review of patient safety and quality indicators. Only a few private hospitals involve clinical pharmacists in ICUs to improve medication safety. Since medication safety is not given much importance in many hospitals, we studied the prevalence and the common types of medication errors in four different ICUs (cardiology, medicine, paediatrics and neonatology) of a public tertiary care, teaching hospital. We also planned to study the impact of a sensitization programme for doctors and nurses on medication safety and reporting.

METHODS

This interventional study was conducted in four ICUs (medical

ICU, coronary care unit, paediatrics ICU and neonatology ICU) of a tertiary care, public teaching hospital in Puducherry, from January 2013 to July 2014. Data collection for both pre-intervention and post-intervention periods was done over a period of 30 days for each ICU. The 'direct' observation periods, i.e. when nurses were observed administering medicines, were divided into six time points: 6 a.m., 9 a.m., 2 p.m., 6 p.m., 9 p.m. and 1 a.m. These time points were designed to include different working conditions during various shift hours of the day to even out heterogeneity. The duration of direct observation for each day was 3 hours. All drugs administered during this period were observed by the first author and administration errors if any were noted and informed to the doctors and staff nurses for correction. These interceptions were done to stop the errors from reaching the patient or to prevent continuation of the error. The sequence and timing of ICU visits were randomized using Rando 1.2 software. The residents and staff nurses were not informed in advance of the day and time period of observation. During each visit to the ICUs, copies of the doctors' orders and nurses' transcription charts for the past 24 hours were scanned using a Canon LiDE110 scanner. The same methodology was used for the follow-up study after the intervention.

Each ICU was managed by an in-charge nurse; staffing by patient care nurses (the ratio of nurse to patients) were as follows: cardiology 1:4, medicine 1:4, paediatrics 1:3 to 1:4 and neonatology 1:4 to 1:6. Apart from the faculty in-charge, patient care was given by two doctors (postgraduate residents) every 12 hours in all ICUs except in cardiology, where patient care was provided by one doctor in a 24-hour shift. The residents were involved in patient care and writing of prescriptions. The nurses were involved in patient care, transcription of doctors' orders and administration of medications. The pharmacists were not involved in prescription of medications, administration or monitoring processes in the ICUs/wards in our hospital.

Parameters studied

The doctor's orders were analysed for prescription errors, and nurses' charts were scrutinized for transcription errors. Administration errors were noted from direct observation of drug administrations and from the nurses' charts. The following were considered as medication errors: errors in the dose of a medication, incorrect route of administration, prescription or administration of medication that is contraindicated for the patient, administration of drug to the wrong patient, incorrect timing of infusion, incorrect transcription of doctors' orders with respect to dose, route of administration, and continuing a medication even after it was stopped by the treating doctor. The illegible or incomplete prescriptions and illegible transcriptions were not considered as medication errors. Documentation errors were not considered as medication errors in this study. When the nurses were carrying out verbal orders from the clinicians and were unable to document them in the nurses' chart during our direct observation, these were not included as errors. However, some of the infusions received by the patients such as vasopressors, muscle relaxants and sedatives which were not written in the doctors' order chart for long periods of time (as much as 2 weeks) and which could result in dose discrepancy between what the doctor wanted and what the nurse had administered were considered as medication errors. This was decided as per the opinion of the clinicians during our sensitization programme. Any error noted during the drug administration process was intercepted and corrected, but this was also included as an administration error. There was no blinding applied to the data collection and intervention to the healthcare professionals.

The total number of medication errors in each ICU was calculated and expressed in 1000 patient observation days, i.e. the error rate when 1000 patients experience the healthcare facilities in a day. The number of errors per day and the number of errors per patient for all four ICUs were calculated. The outcomes of the errors were not studied.

Sensitization programme on medication errors

The intervention consisted of a sensitization programme for all stakeholders regarding medication errors. All doctors and nurses of each ICU were invited to attend a single contact programme, lasting for 60–75 minutes, in which details of the data collected from that particular ICU were shared. The problems in the medication process with examples of case scenarios from our observation were described. The baseline study results pertaining to that ICU were given as a handout to all the doctors and nurses. Six programmes for neonatology and paediatrics, two for medicine and one for cardiology ICUs were conducted to ensure that all doctors and nurses working in these ICUs were sensitized.

Elements covered in the programme

Basic information on medication errors. Medication error: definition, types, individual and system-based factors responsible for it, clinical implications, reporting and methods to improve medication safety.

Common types of errors observed. We discussed the commonly observed errors, i.e. writing loading doses as 'OD' and not mentioning the maintenance dose led to repeated administration of higher doses of medicines, wrong drug dosage calculation for infusions, failure to document verbal orders were some of the errors discussed.

Problems in the medication process and possible solutions. Case-based discussions were used to explain problems in the medication process in ICUs. The communication gap between doctors and nurses, i.e. changes in orders after morning rounds had not been updated in nurses' transcription, which resulted in continuation/omission of drugs even after the prescription was changed. Lack of awareness on medication errors and lack of proper training on medication safety were the other important problems.

We invited opinions from the doctors and nurses regarding the problems and difficulties they faced in carrying out the medication process. It was suggested to modify the medication chart in ICUs to eliminate transcription errors and to supervise prescription orders by senior residents or fellow residents. The medication charts were modified in paediatrics and cardiology ICUs in such a way that there was no separate nurses' chart (Appendix 1, available at *www.nmji.in*). This bridged the communication gap between doctors and nurses, thereby preventing transcription errors and associated administration errors. The medicine and neonatology ICUs continued to have old medica-3tion charts during the follow-up study. We suggested changes in the prescription writing policy, i.e. writing prescriptions in block letters, giving the complete dosage schedule with loading dose and maintenance dose wherever required.

Blame-free medication error reporting tool. We sensitzed doctors and nurses about the blame-free medication error reporting tool for continuous reporting of medication errors in

ICUs, and we encouraged doctors and nurses to report medication errors as it would help in planning appropriate strategies to tackle the problem. The process was linked with the monitoring services for adverse drug reaction in the hospital (Appendix 2; available at *www.nmji.in*).

Follow-up study. A follow-up study on the above lines was conducted after 3 months in all the four ICUs to assess the impact of the intervention, and the results were compared with the baseline results.

Statistical analysis

The prevalence of medication errors was expressed in 1000 patient observation days. The prescription error rate was also expressed in percentage (errors per 100 prescriptions). The effect of the sensitization programme on prescription errors was analysed using Fisher's exact test. Graphpad Instat version 3.0 was used to analyse the data. A p value of <0.05 was considered as statistically significant.

Ethical approval

This study was approved by the institute ethics committee (IEC) for human studies (approval certificate number IEC/SC/2012/5/197 dated 10 December 2012). The identity of the patients, doctors and nurses was kept confidential.

RESULTS

A total of 2735 patient observations in the four ICUs were made over the course of this study. In the baseline study, 1368 observations were made in the four ICUs (cardiology 186; medicine 435; paediatrics 164; and neonatology 583) and 457 errors were detected. Prescription errors were the most common type, which accounted for 38.7% of the total errors (177/457). The average number of total errors per day was 3.8. Transcription and administration errors accounted for 34.4% (157/457) and 26.9% (123/457), respectively, during the baseline study. The prevalence of medication errors was 334.1/1000 patient observation days. A total of 1944 prescriptions of 691 patients were analysed during the baseline study and the prescription error rate was found to be 9.1/100 prescriptions (177/1944). The proportion of prescriptions that had at least one error was 29/233 (12.5%) in cardiology, 38/586 (6.5%) in medicine, 36/309 (11.7%) in paediatrics and 40/816 (4.9%) in neonatology ICUs. Most of the prescription errors (126/177) and administration errors (65/123) were dose-related (Table I).

The total patient observations made during the follow-up study was 1367, and 173 errors were detected in the four ICUs (cardiology 177; medicine 436; paediatrics 282 and neonatology 472). The prevalence of medication errors reduced to 126.6/1000 patient observation days and the average number of total errors per day to 1.4. Transcription errors account for 41.7% of the total errors (72/173). Prescription errors and administration errors accounted for 27.7% (48/173) and 30.6% (53/173), respectively.

The follow-up study showed a reduction in the prevalence of medication errors in all four ICUs with cardiology showing the maximum reduction (89.1%) and neonatology having the lowest reduction rate (9.4%; Table II).

TABLE I. Categories of errors in prescription and administration process in the intensive care units (ICUs) (*n*=1368)

Category	Number of prescription errors		Number of administration errors	
	Infusion-related	Others	Infusion-related	Others
Wrong dose	50	76	4	61
Wrong route	–	1	–	3
Wrong formulation	–	–	–	1
Wrong patient	–	–	–	1
Wrong timing	4	2	–	10
Wrong rate	–	–	11	3
Wrong drug	2	2	–	26
Wrong diluent	–	–	3	–
No documentation	36	4	–	–

Total errors in the baseline study 457 Number of prescription errors 177 Number of administration errors 123
Number of transcription errors 157 Observation period 120 days (30 days each in medicine, neonatology, paediatrics and cardiology ICUs)

TABLE II. Effect of interventions on prevalence of medication errors in four intensive care units (ICUs)

Intensive care unit	Prevalence of medication errors (1000 patient observation days)											
	Prescription errors			Transcription errors			Administration errors			Total errors		
	Intervention		Change (%)	Intervention		Change (%)	Intervention		Change (%)	Intervention		Change (%)
	Before	After		Before	After		Before	After		Before	After	
Cardiology	204.3	28.2	–86.2	247.3	0*	–100	220.4	45.2	–79.5	672.0	73.4	–89.1
Medicine	114.9	29.8	–74.1	105.7	59.6	–43.6	48.3	22.9	–52.6	268.9	112.3	–58.2
Neonatology	75.5	36.0	–52.3	77.2	86.9	+12.6	60.0	69.9	+16.5	212.7	192.8	–9.4
Paediatrics	274.4	46.1	–83.2	122.0	17.7	–85.5	158.5	7.1	–95.5	554.9	70.9	–87.2

*There was no transcription at all in cardiology because of the implementation of a modified medication chart. Observation period 30 days in each ICU. Total patient observations at baseline 1368 (cardiology 186; medicine 435; paediatrics 164 and neonatology 583). Total patient observations after intervention 1367 (cardiology 177; medicine 436; neonatology 472 and paediatrics 282)

A total of 1373 prescriptions of 595 patients were analysed, and the prescription error rate was found to be 3.5/100 prescriptions (48/1373). In the cardiology ICU 5/173 (2.9%) prescriptions had at least one error, and in the medicine ICU, it was 11/443 (2.5%) prescriptions. The neonatology and paediatrics ICUs had 15/477 (3.2%) and 12/280 (4.3%) prescriptions with at least one error, respectively. The proportion of prescriptions with error significantly reduced in the cardiology, medicine and paediatrics ICUs ($p<0.05$). No statistically significant change was seen in the neonatology ICU ($p>0.05$; Table III).

We observed a reduction of 86.2% in prescription errors in the cardiology, 74.1% in medicine, 52.3% in neonatology and 83.2% in paediatrics ICUs (Table III). Transcription errors were decreased significantly in the medicine (43.6%) and paediatrics ICUs (85.5%), whereas the neonatology ICU showed an increase of 12.6% in transcription errors (Table III). There was no transcription of doctor's orders at all in the cardiology ICU due to implementation of the modified medication chart. The prevalence of errors in administration of drugs increased by 16.5% in the neonatology ICU, while there was a significant reduction in the cardiology (79.5%), medicine (52.6%) and paediatrics ICUs (95.5%; Table II).

Failure to document the inotropes, sedatives and muscle relaxants in the prescription charts resulted in 36 of 50 prescription errors in the medicine ICU in the baseline study. Most of these medications were given to patients on the verbal orders of doctors but were not documented in the prescription charts even after 24 hours. These medications were continued for many days unnecessarily as doctors and nurses failed to document it in their charts. When this problem was notified, we observed that there was a dose discrepancy between what the doctor had prescribed and what the nurses were actually administering. Hence, these were considered as errors in this study.

During the baseline study, we observed dosage errors due to error in microgram to milligram conversion. A child who underwent corrective surgery for congenital diaphragmatic hernia was prescribed morphine infusion with ten times the normal dose (28 mg instead of 2.8 mg). A 7-year-old child with cardiorespiratory arrest, who was on mechanical ventilation, was prescribed injection fentanyl 1.5 g as 50 ml infusion instead of 1500 µg. These orders were intercepted and the errors were prevented from reaching the patient. A patient in the medicine ICU who had snake bite with acute kidney injury and on haemodialysis was prescribed injection vancomycin 1 g '96h', but it was mistaken by the staff nurse as injection vancomycin 1 g 'q6h'. Unfortunately, the patient was given vancomycin every 6th hourly. A mistaken identity led to wrong drug administration (amphotericin B instead of fluconazole) to one of twin babies in the neonatology ICU. Prescribing proton pump inhibitors and H_2 blockers concomitantly and also failure to give proper instructions about administering proton pump inhibitors before food were important reasons for prescription errors in the cardiology ICU.

DISCUSSION

Main findings

The prevalence of medication errors in our study was 334.1/1000 patient observation days. Every third patient in the ICU got exposed to an error and one in ten patients experienced an administration error. This underscores the fact that medication errors are high in ICUs.[9–11] The ICU setup in our hospital is different from ICUs in developed countries. The nurses are not involved in daily patient rounds, which leads to a communication gap between doctors and nurses regarding changes in medications or doses. Pharmacists are not involved in ICU care, medication chart review and medication safety in most hospitals. Involving clinical pharmacists in medication review can reduce 66% of the medication errors in ICUs, but they are not available in most government hospitals.[12] Prescription errors were the most common types of errors in our study at 129.1/1000 patient observation days. This is due to the lack of awareness about medication errors, communication gap between doctors and nurses and lack of supervision of the medication process in the ICUs. Nearly two-thirds of administration errors were due to errors in transcription. The absence of standard treatment guidelines and effective mechanisms such as a barcode system for patient identification and lack of periodic training of nurses were other possible reasons for the high prevalence of errors in the ICUs.

The prevalence of medication errors in the follow-up study reduced to 126.6/1000 patient observation days. Our intervention programme may have raised awareness of healthcare professionals about medication safety and resulted in a reduction in the error rate. The sensitization programme along with implementation of a modified medication chart had a stronger impact on the medication process than the sensitization programme alone. It is also possible that because of continuous monitoring of the medication process doctors might have been more alert while prescribing and the nurses also may have been influenced by the continuous observation. This Hawthorne effect may also have contributed to the reduction in medication error rate in our study. Patients in the paediatrics ICU were given 12-hourly prescriptions during the baseline study, which was changed to a single prescription per day in the follow-up period. This was done to avoid discrepancy in the drug and doses between the two prescriptions. However, this also resulted in decrease in the number of prescriptions studied in the post-intervention period. The increase in transcription and

TABLE III. Effect of intervention on prescription errors in intensive care units (ICUs)

Intensive care unit	Proportion of prescriptions with error (%)		95% CI for intervention effect (*P*)
	Before intervention	After intervention	
Cardiology	29/233 (12.45)	5/173 (2.89)	1.701–10.901 (0.0005*)
Medicine	38/586 (6.48)	11/443 (2.48)	1.350–5.052 (0.0028*)
Neonatology	40/816 (4.90)	15/477 (3.15)	0.8704–2.792 (0.1535)
Paediatrics	36/309 (11.65)	12/280 (4.29)	1.443–5.120 (0.0013*)

*$p<0.05$, Fisher's exact test was used to analyse the proportion of prescriptions with errors before and after the sensitization programme. Total number of prescriptions at baseline 1944 (cardiology 233; medicine 586; neonatology 816 and paediatrics 309) Total number of prescriptions after intervention 1373 (cardiology 173, medicine 443, neonatology 477 and paediatrics 280)

administration errors in the neonatology ICU was perhaps due to frequent change of nurses. It is difficult for new nurses to adapt to the medication process quickly, especially in neonatology. There was not a single error reported using the blame-free reporting tool we introduced, despite the sensitization and encouragement offered. The possible reason for this is the perception of healthcare professionals that reported errors would be used as performance indicators.[13] The culture of spontaneous reporting of medication errors in our country is yet to develop. More awareness has to be created among healthcare professionals regarding the importance of reporting errors. The change to start reporting may take time as was the experience in other countries.[11,14]

Comparison with other studies

A systematic review in 2010 on medication errors reported that worldwide the prevalence varies between 8.2 and 2344/1000 patient days in different ICUs.[3] The prevalence in our hospital is more than that observed in a study by Capuzzo in 2005 (90.9/1000 patient days), but this is perhaps because the authors used the voluntary reporting method to estimate the prevalence.[15] The prescription error rate is higher than that observed in a general hospital in Israel.[16] However, our prevalence rate of administration errors is less than that observed in a multidisciplinary ICU, which was reported as 497.5/1000 patient days.[3] This may be due to a short period of observation of administration of medications we followed. A retrospective study in the department of paediatrics of a tertiary care hospital showed that implementation of a standard dosing table for antibiotics reduced the dosing errors from 34.3% to 5.06%.[17] Reference tools should be made available and easily accessible for prescribers in ICUs as this can help improve the quality of the medication process without much cost.[18–20]

Our results showed that an educational approach can decrease the prevalence of errors in ICUs but it is more effective when associated with system changes such as modification of a medication chart. We speculate that the effect of the awareness programme may fade in due course of time and suggest that there should be other system-based interventions such as implementation of standard treatment guidelines, computerized physician order entry and clinical decision support system to improve medication safety.[21–23] Regular medication audit should be done to assess medication safety and to strengthen the system. Clinical pharmacists should be involved in medication review and a regular audit process. Many studies have shown that participation of clinical pharmacists in ICUs can significantly reduce the prevalence of medication errors and patient harm due to these errors and it can also help clinicians to make informed decisions during ward rounds.[24–28] Unfortunately, services of clinical pharmacists are not available in public hospitals in India. Their involvement in the medication process may improve patient safety in general wards and ICUs.

Strengths and limitations of the study

Prescription order review and direct observation of medication administration add to the accuracy of medication error rate reported in this study. Once detected, all the errors were corrected and either prevented from reaching the patient or prevented from continuation. Hence, our intervention reduced a considerable amount of patient harm even though we did not study the outcome of the errors. A major limitation of this study was that our observation of medication administration was confined to only three hours each day. Hence, the administration errors in this study are underestimated. It also may have been more informative if the outcomes of the errors were studied and their severity explained.

Conclusion

The prevalence of medication errors in the ICUs was 334.1/1000 patient observation days. Prescription error was the most common type of error in the ICUs and most of the errors were dose-related. A sensitization programme on medication errors may reduce the prevalence of medication errors in ICUs—the effect is more pronounced on prescription errors. However, spontaneous reporting of medication errors did not improve.

As electronic prescription is still not affordable in most government hospitals in India, the sensitization programmes and modified medication charts used by us are simple methods to prevent medication errors. Modified medication charts are being used in all the four ICUs after our study. Doctors may be aware of common error-prone situations and more careful while prescribing medications. Our study resulted in a change in prescription writing policy in ICUs and development of standard treatment guidelines.

The combination of education of stakeholders regarding medication errors, awareness that it is being monitored and process redesign of error traps leads to sustainable reduction of medication errors in ICUs. A sensitization programme on medication safety can be included in the orientation programme of healthcare professionals who join a hospital to train them in all aspects of medication safety even before they start patient care activities. Moreover, periodic training and monitoring programmes should be done to review the process and to have a sustained effect on medication safety. Furthermore, involvement of a clinical pharmacist in the medication process may reduce medication errors and related adverse events.

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Conflicts of interest. None declared

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