# Medication Errors in the Emergency Department: Knowledge, Attitude, Behavior, and Training Needs of Nurses

Emanuele Di Simone[1], Noemi Giannetta[1], Flavia Auddino[2], Antonio Cicotto[2], Deborah Grilli[2], Marco Di Muzio[3]

[1]Department of Biomedicine and Prevention – University of Rome Tor Vergata, [2]Policlinico Umberto I of Rome, [3]Department of Public Health and Infectious Diseases, Sapienza University of Rome, Italy

## Abstract

**Aim:** The aim was to describe which elements of nurses' knowledge, training needs, behavior, and attitude can prevent Medication errors (Acronym MEs) in the emergency department during all steps of the administration of intravenous (IV) medications. **Methods:** An anonymous questionnaire made up of 43 items has been drafted and delivered to a sample of 103 nurses of a university hospital in Rome. The study has been supported by specific literature review. **Results:** Majority of the sample (94%) answered that topics related to the preparation and administration of IV medications were covered during the basic course while 63.2% only during the postbasic course. Only 15.6% of nurses judged excellent their level of knowledge about preparation and administration of IV medications while 89.3% considered that it is important to improve their knowledge; 85.6% said that the teaching about the use of IV medications should be increased during the degree course they attended; 30.3% agreed that specific postgraduate courses on the use of IV drugs should be designed. Moreover, only 22% of the sample believed that the coaching of new recruit nurses is critical to prevent errors. **Conclusion:** The sample showed appropriate knowledge, positive attitudes, and right behavior related to the preparation and administration of IV medications. The skills that nurses must have in pharmacology are still rising, both due to the safety of drug therapy and to the increasing number of drugs available; the result is that nurses have to update their knowledge regularly.

**Keywords:** Emergency department, intravenous infusion, knowledge, medication errors

## INTRODUCTION

Patients' safety is the main concern of all health-care systems around the world; this concern is shared and pointed out by WHO that, since 2001, requests health organizations to take urgent actions toward this aspect. Nurses, as directly responsible for assistance, play a central role for granting patients' safety.

In the report, *To Err is Human – Building a Safer Health System,* the Institute of Medicine (2000) claims that between 44,000 and 98,000 patients die each year because of errors during assistance supply and in Italy about 320,000 people per year suffer errors in health facilities.[1] According to National Coordinating council for Medication Error Reporting and Prevention (NCC MERP), a therapy error is defined as any adverse, undesirable, and fortuitous but predictable event that may cause an inadequate use of a drug or a danger for the patient. This episode could be due to an error of prescription, prescription's transmission, labeling, packaging or denomination, preparation, dispensation, administration, education, monitoring, or use of the drug. Particularly, the

intravenous (IV) administration of drugs seems to be the most frequent cause of MEs in Hospitals.[2] However, many errors are not adequately reported and consequently analyzed because of health workers' fear of disciplinary repercussions.

Medication errors occur with alarming frequency in hospital environments, particularly in critical care areas and emergency departments (EDs).[3,4] In ED, medication error risk is estimated to be from 4% to 14%.[5] ED turns out to be an environment in which the possibility of MEs that occurs is high for various reasons:[6]

- Each critical patient (ED patient) receives an average of 2.5 drugs per episode of care
- A high number of patients needing emergency cares increase the error risk

**Address for correspondence:** Dr. Emanuele Di Simone,
Department of Biomedicine and Prevention, University of Rome Tor Vergata,
Via Montpellier, 1-00133, Rome, Italy.
E-mail: emanuele.disimone@uniroma1.it

### Access this article online

**Quick Response Code:**

**Website:**
www.ijccm.org

**DOI:**
10.4103/ijccm.IJCCM_63_18

- Bearing in mind the increased prevalence of chronic diseases, the European population need a lot of medicine
- So the staff must know a large number of medicine for different patients' disease.

It is essential to point out that pharmacological therapy's administration represents 40% of total nursing clinical activity in hospitals[7] and nurses are the last safeguards for patients from MEs.[8] Several works[9,10] underlined the shortage of researches conducted in ED.

The aim of this study is to describe knowledge, attitudes, behaviors, and training needs on IV pharmacological therapy's management from nursing staff of ED of Policlinico Umberto I of Rome, in order to prevent MEs.

## METHODS

Although many studies point out the importance of nursing staff's knowledge, behaviors, and role (risk protection activity and remedial strategy identification),[11,12] there are only few works that related nurses' knowledge, attitudes, behaviors, and training needs to IV drug's administration errors in DEA; in particular, it has not been found any document that proposed tools to evaluate if these variable may determine a pharmacological therapy's error.

Di Muzio *et al.*[13] through their multicentric work has processed a valid tool, with high feature of reliability and validation (Cronbach's alpha test: $r = 0.776$),[13] to relate knowledge, attitudes, behaviors, and training needs to pharmacological errors in resuscitation and intensive care. Hence, it has been necessary to perform this pilot survey before the adoption of this tool at a national level.

For this descriptive study, a sample size of convenience was used. The survey has been administrated to a sample of 103 nurses of ED between April and June 2016.

The survey is composed by an introduction where the test is described, contents are explained in details, and the objective of the research is shown and grants anonymity to respondents who decide to sign the informed consent. The test includes 43 items and 7 sections; these are structured as follow: the first section (Section A) focuses on the demographic feature (age and gender); the second section (Section B) investigates on professional characteristics (graduation's year, degree type, postbasic training, current professional activity, years of service, and city of current employment) and on the typology of received training about IV therapy (an item for base training and another for postbasic one); the third section (Section C) analyses the access mode to bibliographic upgrade; the fourth section (Section D) deals with the knowledge of widespread IV drugs in intensive care; the fifth section (Section E) studies the attitudes on IV drugs' use; the sixth section (Section F) investigates on behaviors adopted during IV drugs' administration; and the seventh section (Section G) focuses on identifying the training needs on IV drugs' use.

In order to collect data, we created a database. For statistical analysis, IBM SPSS (statistical package for the social science, statistics for Windows, version 22.0. armonk, NY:IBM Corp) for Windows, version 22.0, was used through a descriptive analysis of all test's variables using absolute frequencies and percentage.

### Ethics

In order to administrate this survey, we have required and obtained the authorization of health-care direction and the approbation of the Ethics Committee with Prot. 44/14 PT_ComEt CBM.

## RESULTS

The average age of participants was 43.9 years (standard deviation: ±17.1); 29.1% ($n = 30$) of the sample is represented by men and 70.9% ($n = 73$) by women.

About 53.5% ($n = 53$) admitted to have a less than mediocre English level although the test did not require any such specific knowledge.

### Statistical analysis

A descriptive analysis of all the variables of the questionnaire was carried out using absolute and percentage frequencies [Table 1], while for an univariate analysis, appropriate statistical tests were used (Chi-square test for categorical variables and Student's *t*-test and Mann–Whitney test for continuous variables).

Worth mentioning is the fact that nurses who achieved a university degree spend more time updating (>1 h per week) than those who did not graduate at the university ($P = 0.001$). Nurses who have a good knowledge of English (intermediate, good, and excellent) dedicate more than an hour per week to the bibliography update ($P < 0.001$).

This study shows also a statistically significant link between the university degree and the knowledge (intermediate, good, and excellent) of the English language ($P < 0.001$).

### Knowledge

In agreement with the literature,[14] the study shows that 77% ($n = 77$) of the sample considered drug dosage and calculation skills to be essential in order to reduce MEs during drug preparation.

Computerized prescription could reduce drug preparation errors according to 59.6% ($n = 59$) of the sample. Errors could also be reduced by the dispensation of a drug pack previously prepared by the pharmacy[15] and 62% ($n = 62$) of the sample agree with this ability.

Nearly 66% ($n = 66$) of nurses is in favor of the availability of protocols and informative posters and brochures concerning the IV drug administration in wards, as suggested by several authors.[7]

On the possibility of a pharmacist's assistance during drug preparation, less than half of the sample (47.4%, $n = 47$) is

## Table 1: Demografic and professional characteristics

| Variables | *n* (%) |
|---|---|
| Total | 103 (100) |
| Age (97)[a] | |
| <30 | 20 (20.6) |
| 31-40 | 28 (28.9) |
| 41-50 | 31 (31.9) |
| >51 | 18 (18.5) |
| Gender (103)[a] | |
| Male | 30 (29.1) |
| Female | 73 (70.9) |
| Graduation degree (100)[a] | |
| University degree | 64 (64) |
| No university degree | 36 (36) |
| Postgraduation training (32)[a] | |
| Master | 27 (84.4) |
| Other | 5 (15.6) |
| Working years (101)[a] | |
| 1-5 | 22 (21.8) |
| 6-10 | 27 (26.7) |
| >10 | 52 (51.5) |
| IV drug preparation and administration topics studied in basic course (100)[a] | |
| No | 6 (6) |
| Yes | 94 (94) |
| IV drug preparation and administration topics studied in postbasic courses (69)[a] | |
| No | 26 (37.7) |
| Yes | 43 (62.3) |
| English level (99)[a] | |
| Low | 21 (21.2) |
| Middling | 32 (32.3) |
| Moderate | 30 (30.3) |
| Good | 14 (14.2) |
| Excellent | 2 (2) |
| Internet availability in workplace (98)[a] | |
| No | 3 (3.1) |
| Yes | 95 (96.9) |
| Library (also online) availability in workplace (93)[a] | |
| No | 34 (36.5) |
| Yes | 59 (63.5) |
| Hour per week dedicated to bibliographic upgrade (98)[a] | |
| <1 | 64 (65.3) |
| 1-5 | 31 (31.6) |
| 6-10 | 3 (3.1) |
| >10 | 0 |

[a]Number of nurses responding to the question. IV: Intravenous

in favor even if this is a strategy suggested in some work.[16] A relevant point concerns ward's alarms and emergencies that could produce inattention both in drug preparation and administration.[2,17] According to 90% (*n* = 90) of nurses, these alerts may actually cause MEs.

Finally, most of the participants, i.e., 98.9% (*n* = 98) considered MEs straightly related to workload (double shifts, overtime). The literature reports the fatigue due to shifts among the most frequent causes of errors[18] [Table 2].

### Attitude

Almost 95% (*n* = 95) of respondents considered a specific and systematic training extremely important in order to reduce error risk. The role of training on the prevention of errors is a key feature that several authors have focused;[7,16] specifically, Varndell *et al.*[10] highlights the lack of standardization in training programs.

About 89% (*n* = 89) add that MEs could also be reduced through a more deep awareness of error prevention, nurses' motivation, and through consultation of guidelines and available scientific evidences, and they considered protocols and procedures to be fundamental to influence operators' behavior. Nearly 91% (*n* = 91) of the sample deem necessary a systematic evaluation of IV therapy and safe administration skills; regarding this, Jones *et al.*[19] suggests the use of educational training based on teamwork that should improve the ED staff perception about safety.

A main aspect regards the importance of availment of errors' signaling systems:[20,21] only a small percentage of the sample (6.1%, *n* = 6) are in doubt about the possibility that they become an opportunity to improve care [Table 3].

### Behaviors

The majority of participants, i.e., 94% (*n* = 94) uphold the importance of handwashing before the therapy administration; drug's management is often related to the phenomenon of Healthcare-associated infections, a priority worldwide problem.

Nearly 90% (*n* = 90) support the necessity of the vital signs' monitoring before and during vasoactive drug administration (in order to reduce complications) and 95% (*n* = 95) judge very important respect rate of IV solutions. About 94% (*n* = 94) considered the 6G role to be essential in reducing MEs.

As reported in the literature,[8,22] finally, 94% (*n* = 94) agreed to perform a double check to verify the correct correspondence between prescription, preparation, and administration of IV drugs [Table 4].

### Training needs

In relation to training needs, it has been asked to nurses how they judge their own skill level about preparation and administration of IV drugs; 17.9% (*n* = 17) judge as excellent their own level. Almost 85.4% (*n* = 88) approved the necessity of skills' improvement and implementation about preparation and administration of IV drugs. In this question, there were two possible answers, "Yes" and "No;" in case of affirmative answer, the respondent had the possibility to suggest the area (or the areas) where, according to him, these improvements should be done: knowledge 86.4% (*n* = 76); ability and skills 36.4% (*n* = 32); problem solving 45.5% (*n* = 40); and motivation and attention 36.4% (*n* = 32). In the section of training needs, respondents were asked to propose some changes in order to envelope basic

## Table 2: Nurses' knowledge

| Knowledge | Disagree | Little agree, n (%) | Quite agree, n (%) | Very agree, n (%) | Totally agree, n (%) |
|---|---|---|---|---|---|
| Dosage calculus of intravenous drugs reduces preparation errors (100)[a] | 1 (1) | 3 (3) | 19 (19) | 33 (33) | 44 (44) |
| Computerizing drugs' prescription (CPOE) (computerizing medical Entry system) (99)[a] | 0 | 7 (7.1) | 33 (33.3) | 29 (29.3) | 30 (30.3) |
| Prepackaged package dispensation by pharmacy reduces medication error risk (100)[a] | 1 (1) | 15 (15) | 22 (22) | 34 (34) | 28 (28) |
| Informative protocols, posters, and brochure in wards promote error risk decrease (100)[a] | 1 (1) | 7 (7) | 26 (26) | 45 (45) | 21 (21) |
| Pharmacist's assistance during drug preparation reduces error risk (99)[a] | 5 (5) | 25 (25.3) | 22 (22.2) | 23 (23.2) | 24 (24.2) |
| Alarms noises and ward emergencies may cause inattentions during drug preparation and administration (100)[a] | 2 (2) | 8 (8) | 26 (26) | 31 (31) | 33 (33) |
| Workload (double shifts, extra time) contribute to pharmacological therapy's errors (99)[a] | 0 | 1 (1) | 14 (14.1) | 30 (30.3) | 54 (54.5) |

[a]Number of nurses responding to the question. CPOE: Computerized physician order entry

## Table 3: Nurses' attitudes

| Attitudes | Agree, n (%) | Neutral, n (%) | Disagree, n (%) |
|---|---|---|---|
| Systematic and specific training on IV drugs safe management would reduce error risk (100)[a] | 95 (95) | 5 (5) | 0 |
| Error's prevention and clinical risk management awareness would reduce error risk during drugs preparation and administration (100)[a] | 89 (89) | 10 (10) | 1 (1) |
| Operator's motivation may improve professional performance during therapeutic process (100)[a] | 89 (89) | 9 (9) | 2 (2) |
| For a safe management of IV drugs is necessary to have authoritative guidelines drafted taking into account available scientific evidences (100)[a] | 89 (89) | 9 (9) | 2 (2) |
| Protocols/guidelines/procedures may influence professional behaviors granting a safe management of therapeutic prices (99)[a] | 89 (89) | 9 (9.1) | 1 (1) |
| Clinical skills on safe management of pharmacological therapy should be systematically evaluate (100)[a] | 91 (91) | 8 (8) | 1 (1) |
| Pharmacological therapy errors must be noted to became an improvement opportunity for assistance (98)[a] | 92 (93.9) | 6 (6.1) | 0 |

[a]Number of nurses responding to the question. IV: Intravenous

## Table 4: Nurses' behaviors

| Behaviors | Disagree, n (%) | Little agree, n (%) | Quite agree, n (%) | Very agree, n (%) | Totally agree, n (%) |
|---|---|---|---|---|---|
| Handwashing is necessary before preparation and administration (100)[a] | 0 | 0 | 6 (6) | 30 (30) | 64 (64) |
| A check of vital signs before and after vasoactive drug's administration (dopamina, dobutamina, and nitroglicerina) reduces compliances (100)[a] | 0 | 0 | 10 (10) | 30 (30) | 60 (60) |
| To respect infusion speed of administered solutions through IV (come chemioterapici, antibiotici, amine, eparina, etc.) reduces errors (100)[a] | 0 | 0 | 5 (5) | 28 (28) | 67 (67) |
| The 6R role following (right prescription, right drug, right patient, right dosage, right administration Route, etc.) reduces errors (100)[a] | 0 | 2 (2) | 4 (4) | 30 (30) | 64 (64) |
| Before administration is necessary to perform a double check to verify the right correspondence between prescription, preparation, and administration of the IV drug (100)[a] | 0 | 0 | 6 (6) | 32 (32) | 62 (62) |

[a]Number of nurses responding to the question. IV: Intravenous

and advance skills in preparing and administering IV drugs: 77.9% (*n* = 74) suggested a systematic attendance to training courses; 72.6% (*n* = 69) proposed the insertion of specific topics in basic and postbasic courses; 52.6% (*n* = 50) pointed out the importance of specific supporting tutoring for new hires, and 33.7% (*n* = 32) signaled the integration of audit activity with study and research activity.

## DISCUSSION

Both in our study and in previous ones, it emerges that nurses are aware that organizational changes could contribute to reduce MEs.[20] Almost all of the nurses sampled confirm that it is necessary to find new organizational strategies to reduce workload and considered to be the main element associated

to MEs.[4] Actually, in the EDs of Policlinico Umberto I of Rome, there is a complex situation related to the presence of a nursing staff hired in outsourcing mode. Despite these nurses are young and well qualified, the management system implies a systematic turnover that makes it hard to determine regular training and improvement needs from the perspective of the nursing coordinator. Moreover, the outsourcing nurse is often required to fill up ward staff shortage or absences due to disease, determining situations of possible risk.

Finally, the problematic of ED's overcrowding determines the impossibility to grant a constant nurse-patient ratio, which could contribute to errors arising, because nurses must often assist a too high number of patients, often, in critical clinical conditions.[5]

As far as pure knowledge is concerned, Wright[23] highlights the need to a good calculus' knowledge for drug dosage in order to reduce MEs; the dosage calculus can be split in two phases: at first, the operator must analyze the dosage provided by the pharmacy according to the prescription and then he/she must adopt the drug's dosage with respect to the specific patient;[24] youngest nurses have indeed shown to have less skills than older colleagues who, through personal experience inside wards, have developed better calculus' knowledge.[25] The relevance of this topic regards, especially those who focus on training, because the process of learning through trials and errors, although being an important aspect of workers' experience, could determine a dangerous increase in malpractice. A Finnish study contrasts this finding, revealing how the younger age groups are more prepared than their elders.[26]

Some authors highlight that some problems caused by erroneous management of drug therapy can be reduced using technologies such as computerized physician order entry. However, a technology designed without an understanding of the activity of intensive care nurses turns out to be damaging to workflows and must be revised or replaced; otherwise, it may compromise its beneficial use and lead to the introduction of new sources of error. For this reason, every new technology should be anticipated by a training period.[11]

In the Hung *et al.*'s work,[20] it emerges the necessity of implementing the use of errors' signaling systems; the signal of an emergency caused by a nursing error is a primary element to limit the recidivism and to grant patients' safety.[21] The relating survey confirms this point, showing that nurses considered important to note errors in order to improve care quality. Despite this, the availment of monitoring tools for errors is still low and unknown; this could be due to many reasons and maybe also to our culture, where the research of the error is still focused on the guilty person who was wrong.

Regarding attitudes, 89% ($n = 89$) of the sample consider that awareness with respect to error prevention and clinical risk knowledge can reduce errors. Knowledge about MEs' prevention can be improved by specific training courses and through the increase of the time dedicated to the study of scientific literature.

Previous articles propose many strategies to reduce MEs;[5] among organizational intervention, they indicate the computerized prescription, the employment of unitary drug dosage packs by pharmacy, the use of protocols and informative posters and brochures regarding the drug's management, and the direct assistant of a pharmacist inside the ward.

Inadequate knowledge may result in inadequate skills and this could be the result of a system failure because it does not provide sufficient education regarding the drug administration. Studies report that there is a lack of education regarding the pharmacology teaching in the basic undergraduate program,[27] as also confirmed by the results of our study, especially in the field of knowledge. Training courses have been pointed out as being able to decrease error risk by 54%.[28] Strong motivation of nursing staff must of course also be integrated in this process. It is indeed important to underline that majority of the respondents (65.3%, $n = 64$) do not spent any time or less than an hour per week, in bibliographic update, although more than half of the sample (63.5%, $n = 59$) admitted that libraries and internet access are available to them in the workplace.

Data analysis shows as audible and visual alarm events represent a very important problem that induces inattention and interruptions during the process of management of IV therapy.

The most common events distracting nursing staff are as follows:[2]
- Recovering cart missing drugs
- Technical problems during administration
- Answering the phone
- Answering the rings and assisting patients
- Noisy rooms.

These data are particularly important in emergency rooms, where staff must be focused both on the management of critical patients, in stable conditions but unable to move, and on incoming red codes that need the assistance of the whole staff assigned to that unit.

About 85% of drug administration interruptions are causes of errors (e.g., wrong dosage or mode), procedural errors (e.g., missing identification of the patient or inadequate handwashing),[29] or both. New technologies, for instance, infusion pumps or patients' monitoring have been identified as interrupting sources during the drug administration process.[30]

Drug administration process requires clinical and professional evaluations, supervision, and critical thinking.

Since administration process is often performed in a chaotic state, nurses must be able to manage simultaneously many activities keeping clinical proficiency and granting patient's safety, even during the process.[2]

Indeed, the way nursing staff handle drug administration process interruptions, combined to the inevitability of these interruptions in clinical environment, is the key point to grant patients' safety.[17]

Although these data are not related to other sample parameters (age, experience's year, degree level, and employer), they could actually be affected by the cultural baggage of the professional in relation to the technological proposal.

Percentage of hour per week dedicated to training, indeed, could suggest that staff knowledge is sufficient to know about the existence of specific possible actions but not enough to allow them a critical judgment of their avail.

## Work's limits

Although sample size has no statistical significance, it points out many interesting aspects for further study and discussion. The descriptive analysis has restricted the possibility to compare obtained data with sample features; it should be desirable to study relations between some of the elements emerged in this work and the age, the experience, the degree level, and the workers' contractual conditions, in order to reach a more deep knowledge of the sample and consequently to be able to propose more efficient actions to improve efficiency, efficacy, appropriateness, and essential goals of the health-care system.

Furthermore, although each country is characterized by a different health-care system and therefore by a variety of drug event monitoring, the current survey has been performed in a unique western hospital and this constitutes a limitation of the phenomenon comprehension. Finally, it must be noticed that although some countries in the Asian region including India have established a pharmacovigilance company, in this study, it is not possible to demonstrate the applicability of the survey to other drug monitoring systems.[31]

## CONCLUSION

IV pharmacological administration represents one of the most relevant responsibilities for an ED nurse. It is a fundamental step intercepting errors made in previous phases of drug management, before they reach the patient,[11] actually playing an important role for the patients' protection and it provides an important source of indispensable data for development and identification of suitable remedial strategies. Implementation of strategies to fill up training needs could be useful because knowledge may direct behaviors on the basis of scientific evidence, reducing in this way the error risk of the clinical practice.[32-34]

Pilot studies results are encouraging in this respect. Experience and skills are fundamental to adopt the correct behaviors in order to prevent medication errors.

This survey, according to previous works,[34] has pointed out that majority of nursing staff consider positive skills, adequate knowledge, and proper behaviors to be important in order to reduce pharmacological therapy's errors; however, theoretical knowledge should be coupled to specific clinical trainings. In order to improve the health-care quality and to grant patients' safety, it is essential to invest on training programs for nurses and to promote an adequate knowledge and awareness of therapy's errors and specific tools of prevention.

## Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Banfi G, Magon G, Maniaci G, Vinci A. Methodology in nursing research and clinical risk. Fronte theory to prescrive. Presentation of a draft of nursing research. Padova: Piccin; 2007. p. 19-50.
2. Hayes C, Power T, Davidson PM, Daly J, Jackson D. Nurse interrupted: Development of a realistic medication administration simulation for undergraduate nurses. Nurse Educ Today 2015;35:981-6.
3. Storti M, Zucchi A, Buccoliero P. Risk analysis in the process of administering drugs in the emergency departments care: A multicenter observational study. Prof Inferm 2011;64:213-8.
4. Ehsani SR, Cheraghi MA, Nejati A, Salari A, Esmaeilpoor AH, Nejad EM, *et al.* Medication errors of nurses in the emergency department. J Med Ethics Hist Med 2013;6:11.
5. Weant KA, Bailey AM, Baker SN. Strategies for reducing medication errors in the emergency department. Open Access Emerg Med 2014;6:45-55.
6. Mitchell Scott B, Considine J, Botti M. Medication errors in ED: Do patient characteristics and the environment influence the nature and frequency of medication errors? Australas Emerg Nurs J 2014;17:167-75.
7. Dougherty L, Sque M, Crouch R. Decision-making processes used by nurses during intravenous drug preparation and administration. J Adv Nurs 2012;68:1302-11.
8. Lapkin S, Levett-Jones T, Chenoweth L, Johnson M. The effectiveness of interventions designed to reduce medication administration errors: A synthesis of findings from systematic reviews. J Nurs Manag 2016;24:845-58.
9. Flannery AH, Parli SE. Medication errors in cardiopulmonary arrest and code-related situations. Am J Crit Care 2016;25:12-20.
10. Varndell W, Elliott D, Fry M. Assessing, monitoring and managing continuous intravenous sedation for critically ill adult patients and implications for emergency nursing practice: A systematic literature review. Australas Emerg Nurs J 2015;18:59-67.
11. Donati D, Tartaglini D, Di Muzio M. Medication errors during intravenous drug administration in Intensive Care Units: State of the art and strategies. Scenario 2015;32:20-7.
12. Di Simone E, Giannetta N, Spada E, Bruno I, Dionisi S, Chiarini M, *et al.* Prevention of medication errors during intravenous drug administration in Intensive Care Units: A literature review. Recenti Prog Med 2018;109:103-7.
13. Di Muzio M, Tartaglini D, De Vito C, La Torre G. Validation of a questionnaire for ICU nurses to assess knowledge, attitudes and behaviours towards medication errors. Ann Ig 2016;28:113-21.
14. Phua LC, Tan SS. Practical knowledge of drug: How do nurses fare? Singapore Nurs J 2011;38:7-14.
15. Roman C, Poole S, Walker C, Smit de V, Dooley MJ. A 'time and motion' evaluation of automated dispensing machines in the emergency department. Australas Emerg Nurs J 2016;19:112-7.
16. Berdot S, Roudot M, Schramm C, Katsahian S, Durieux P, Sabatier B, *et al.* Interventions to reduce nurses' medication administration errors in inpatient settings: A systematic review and meta-analysis. Int J Nurs Stud 2016;53:342-50.
17. Flynn F, Evanish JQ, Fernald JM, Hutchinson DE, Lefaiver C. Progressive

care nurses improving patient safety by limiting interruptions during medication administration. Crit Care Nurse 2016;36:19-35.

18. Baghaei R, Ghaderi C, Naderi J, Rahim F. The rate and type of medication errors made by nurses: A study from Northwestern Iran. Singapore Nurs J 2015;42:12-6.

19. Jones F, Podila P, Powers C. Creating a culture of safety in the emergency department: The value of teamwork training. J Nurs Adm 2013;43:194-200.

20. Hung CC, Lee BO, Liang HF, Chu TP. Factors influencing nurses' attitudes and intentions toward medication administration error reporting. Jpn J Nurs Sci 2016;13:345-54.

21. De Caro F, Pirozzi D, Boccia G, Cavallo P, Motta O, Palmieri L, *et al*. How to simplify and improve incident and near miss reporting in wards: I.R.G.E. (Incident Reporting with Gravity Effect) system. Ital J Public Health 2011;8:170-8.

22. Durham ML, Suhayda R, Normand P, Jankiewicz A, Fogg L. Reducing medication administration errors in acute and critical care: Multifaceted pilot program targeting RN awareness and behaviors. J Nurs Adm 2016;46:75-81.

23. Wright K. Medicines management: What nurses need to know. Nursing & Residential Care, Sep2015;17:507-11.

24. Benlahouès D. Comprendre les calculs de doses. Soins Pediatr Pueric 2016;290:21-5.

25. Athanasakis E. Mathematical knowledge and drug dosage calculation: Necessary clinical skills for the nurse. Vimatou Asklipiou 2013;12:5-25.

26. Sneck S, Saarnio R, Isola A, Boigu R. Medication competency of nurses according to theoretical and drug calculation online exams: A descriptive correlational study. Nurse Educ Today 2016;36:195-201.

27. Sulosaari V, Huupponen R, Hupli M, Puukka P, Torniainen K, Leino-Kilpi H, *et al.* Factors associated with nursing students' medication competence at the beginning and end of their education. BMC Med Educ 2015;15:223.

28. Hsaio GY, Chen IJ, Yu S, Wei IL, Fang YY, Tang FI, *et al.* Nurses' knowledge of high-alert medications: Instrument development and validation. J Adv Nurs 2010;66:177-90.

29. Di Muzio M, Cammilletti V, Petrelli E, Di Simone E. Hand hygiene in preventing nosocomial infections: A nursing research. Ann Ig 2015;27:485-91.

30. Relihan E, O'Brien V, O'Hara S, Silke B. The impact of a set of interventions to reduce interruptions and distractions to nurses during medication administration. Qual Saf Health Care 2010;19:e52.

31. Patel I, Balkrishnan R. Medication error management around the globe: An overview. Indian J Pharm Sci 2010;72:539-45.

32. Di Muzio M, Marzuillo C, De Vito C, La Torre G, Tartaglini D. Knowledge, attitudes, behaviour and training needs of ICU nurses on medication errors in the use of IV drugs: A pilot study. Signa Vitae J Intensive Care Emerg Med 2016;11:182-206.

33. Di Simone E, Tartaglini D, Fiorini S, Petriglieri S, Plocco C, Di Muzio M, *et al.* Medication errors in Intensive Care Units: Nurses' training needs. Emerg Nurse 2016;24:24-9.

34. Di Muzio M, De Vito C, Tartaglini D, Villari P. Knowledge, behaviours, training and attitudes of nurses during preparation and administration of intravenous medications in Intensive Care Units (ICU). A multicenter Italian study. Appl Nurs Res 2017;38:129-33.