ORIGINAL ARTICLE IN HEALTH CARE RISK MANAGEMENT

Risk assessment of look–alike, sound–alike (LASA) medication errors in an Italian hospital pharmacy: A model based on the 'Failure Mode and Effect Analysis'

Nestor Ciociano[1], Lucilla Grisi[2], Lucia Bagnasco[3], Maria Giovanna Elberti[2], Marcello Mazzarella[4]

Affiliations:

[1] ASL TO4 Chivasso, Turin, Italy
[2] San Giovanni di Dio e Ruggi d'Aragona Hospital, Salerno, Italy
[3] ASL CN 1 Savigliano, Cuneo, Italy
[4] Faculty of Pharmacy, University of Salerno, Salerno, Italy

Corresponding author:

Dr. Maria Giovanna Elberti- San Giovanni di Dio e Ruggi d'Aragona Hospital, Salerno, Italy maria.elberti@sangiovannieruggi.it

Abstract

Introduction: Look alike/sound alike (LASA) drugs errors can take place in hospital wards, and they can place patients at risk for adverse events and death. This study was aimed to realize a risk assessment model for preventing LASA drugs distribution errors by the 'S.Giovanni di Dio e Ruggi d'Aragona' hospital pharmacy, in Salerno, Italy.
Methods: We used the 'Failure Mode and Effect Analysis' (FMEA) technique in combination with the Recommendations released by the Italian Ministry of Health in 2010. Our analysis led to the identification of the potential failure modes, together with their causes and effects, using the risk priority number (RPN) scoring system. A paired T test was used to compare means of RPN 1 and RPN 2, respectively before and after their application, in order to evaluate the effectiveness of corrective actions.
Results: In total, 6 phases, 16 steps, and 13 different potential failure modes were identified. The highest ranked failure modes, with an RPN score of 48 pertained to wrong drug dosage selection. Some of the critical failure modes in sample processing (phases n.1, 2, 3, and 4) were improved by 69.7% in the RPN by focusing on automated technology systems. T test showed that the difference between RPN 1 and RPN 2 was statistically significant for all corrective measures provided by our action plan.
Conclusions: Our study showed a lot of potential failure modes related to LASA drugs distribution system provided by the hospital pharmacy. Information technology solutions can be effective to reduce this risk, but the potential for error will remain unless these systems are carefully implemented.

KEY WORDS: risk management; risk assessment; LASA drugs; drug safety; FMEA; patient safety.

Riassunto

Introduzione: In ambito ospedaliero possono essere commessi errori nella distribuzione dei farmaci LASA (Look alike/sound alike) che possono mettere i pazienti a rischio di eventi avversi e di morte. Questo studio è stato realizzato per lo sviluppo di un modello di valutazione del rischio finalizzato a valutare gli errori nella fase di distribuzione dei farmaci LASA per l'Ospedale "S. Giovanni di Dio e Ruggi d'Aragona" di Salerno, in Italia.
Metodi: Abbiamo utilizzato la tecnica "Failure Mode and Effect Analysis" (FMEA) insieme alle Raccomandazioni pubblicate nel 2010 dal Ministero Italiano della Salute. La nostra analisi ha portato all'identificazione e valutazione di diverse potenziali tipologie di errore, insieme alle loro cause ed effetti, attraverso il sistema "Numero per la Priorità del Rischio" (RPN). E' stato utilizzato il T-test per dati appaiati per confrontare le medie di RPN 1 e di RPN 2, rispettivamente prima e dopo l'applicazione delle azioni correttive, al fine di valutarne l'efficacia.
Risultati: Nel complesso sono state identificate 6 fasi e 16 attività a rischio con 13 diverse potenziali tipologie di errore. La tipologia di errore più grave, con un punteggio di RPN pari a 48, è stata riscontrata in sede di scelta errata del dosaggio del farmaco richiesto alla farmacia. Alcune delle tipologie di errore evidenziate (fasi 1,2,3 e 4) sono state migliorate del 69,7% nel punteggio RPN, con l'introduzione di sistemi tecnologici automatici. Il T-test ha evidenziato una differenza tra RPN 1 e RPN 2 statisticamente significativa per le misure correttive previste dal nostro piano d'azione.
Discussione e Conclusioni: Il nostro studio ha evidenziato molti potenziali errori nel sistema di distribuzione dei farmaci LASA da parte della nostra farmacia ospedaliera. L'uso di soluzioni tecnologiche con un sistema informatico può ridurre notevolmente questo rischio, ma il potenziale di errore rimane a meno che tali sistemi non siano accuratamente implementati.

TAKE-HOME MESSAGE

Our risk assessment model for preventing LASA drugs distribution errors by the hospital pharmacy, based on the 'Failure Mode and Effect Analysis' (FMEA) technique in combination with the Recommendations released by the Italian Ministry of Health in 2010, showed that information technology solutions are very effective to reduce this risk.

Competing interests - none declared.

Cite this article as - Cite this article as: Ciociano N, Grisi L, Bagnasco L, Elberti MG, Mazzarella M. Risk assessment of look–alike, sound–alike (LASA) medication errors in an Italian hospital pharmacy: A model based on the 'Failure Mode and Effect Analysis'. J Health Soc Sci. 2017;2(1):47-64

DOI 10.19204/2017/rsks4

Received: 25/09/2016 Accepted: 20/02/2017 Published: 15/03/2017

INTRODUCTION

Medication errors are common causes of patient morbidity and mortality, and adds financial burden to the institution as well. One of the most common causes of medication errors worldwide is produced by the confusion of similar drug names [1]. With thousands of drugs on market, no drug name is without problems. But look-alike, sound-a-like (LASA) drugs increase the possibility of medication errors. Medical errors due to LASA medication names are responsible for thousands of deaths and millions of dollars in cost every year [2]. Confusing similarities in the brand name and packaging of drugs represent one of the most common reasons for medication errors and are of concern worldwide. Indeed, many medical errors are attributed to similar features of the packages or to ambiguous names of medicines. LASA medication errors occur when a patient receives an incorrect medication because its name is spelled or sounds like another medication. The first alert was launched 40 years ago in literature. In 1973, Teplitsky published a list of LASA medicines to highlight the importance of considering the interpretation of the doctor's writing in the prescription of the drugs, which can lead to errors by the pharmacist. He suggested that clinicians should follow a sort of relaxing exercise when they write or communicate via phone LASA medicines to their patients [3]. In 2005, the World Health Organization (WHO) launched the World Alliance for Patient Safety and identified six action areas which LASA medication names is one of the inaugural patient safety solutions [1]. A system approach and a blame-free environment, aimed at better organizational performances, lead to much better results than focusing on individuals, which can be blamed for forgetfulness, carelessness or moral weakness. Furthermore, use of technology, information accessibility, communication, patient collaboration and multi-professional team-work are successful strategies to reach the goal of patient safety within healthcare organizations [4, 5]. However, today the problem is still underestimated due to the lack of proper procedures and sufficient awareness of this issue among health care workers. There are no sufficient data about the LASA medication errors [6]. In literature some studies investigated this phenomenon, but they did not offer a global framework on this issue. For instance, according to Berman, LASA drug errors are most common in the USA, causing millions of deaths. He showed that errors can be attributed to the confusion generated by similar names or similar labels and packages (25% and 33% of cases, respectively) [7]. Several studies have examined this issue within specific healthcare areas; for instance, Basco showed that LASA drugs errors were less frequent among pediatric patients than adults [8], and Kovacic and Chambers found that medication errors with oncology drugs can place cancer patients at risk for adverse events or death [9]. According to Galanter et al., drug name confusions are a relatively common and persistent source of medication errors; moreover, even when the confusing pairs of names are well known, as they often are (e.g., hydroxyzine/hydralazine), errors have stubbornly resisted eradication. His study, however, showed that indication alerts can have 3 beneficial effects: improvement of the problem list, interception of wrong patient errors, and interception of drug name confusion errors [10]. According to Naunton et al. [11], pharmacists in particular should play an important role in the community in implementing and undertaking strategies, e.g. home medicine reviews, which can play an important role in medication safety to minimize adverse drug events, and to ensure quality use of medicines. In a literature review, Ostini et al. [6] showed that there are many existing medications that can potentially cause clinical issues due to mix-ups, because of similar sounding or looking medication names. This confusion can be lethal for some medication errors. They suggested a multifaceted, integrated approach involving all aspects of the medication use process, in order to minimize this issue for medication safety [2]. However, in Italy there is little interest in preventing LASA errors by enrolled pharmacists [12].

Ciociano et al. showed an alarming situation and supposed that it was probably necessary to implement a new Ministerial Intervention against LASA drug errors by Italian policy makers [12]. According to Ciociano and Bagnasco [13], the implementation of preventive measures of LASA drugs incidents has given rise to a fundamental rule in clinical risk management, but the problem is underestimated, endorsed by the absence or inadequate presence of specific uniform procedures. Their review has identified technology and management solutions that could effectively limit, or eliminate, LASA drugs errors in hospital wards, or outside the hospital where the risk is more uncontrollable. Because this issue lead to a disastrous effect on patient's health and the sustainability of the health-care system, the Italian Ministry of Health passed a Recommendation in 2010 [14] for helping operators to reduce LASA errors, though special procedures of clinical management. Based on the significant experiences of surveys carried out by the Food and Drug Administration (FDA), the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), the English Institute for Safe Medication Practices (ISMP), the WHO Collaborating Centre for Patient Safety Solutions Guidelines (WHO), and the Canadian National Patient Safety Agency (NPSA) [15–19], which were released to indicate the best practices to avoid LASA drugs medication errors, the Italian guidelines were aimed to increase the awareness of the Italian health-care operators about the consequences arising from medical errors and, consequently, to inform them about actions that are necessary to prevent them. The aim of this study was to experiment a method for the risk evaluation of LASA drugs medication errors that can occur during the distribution phase of drugs and medical devices by the hospital pharmacy, according to the strategies and best practices suggested by Italian Regulations, and based on the Failure Mode and Effects Analysis (FMEA), in order to implement the most effective preventive measures of LASA drugs incidents.

METHODS

This study was carried out between July 2013 and September 2014 at the hospital drug room of the 'S. Giovanni di Dio e Ruggi d'Aragona' Hospital, in Salerno, Italy. This ward-based pharmacy supplies drugs and medical devices for its hospital and for other 220 cost centres in Campania, an Italian Region. Our hospital pharmacy is a 980 m^2 large room where 8 office workers work together with 4 hospital pharmacists. The hospital pharmacy is a department or service in a hospital, responsible for the supply of medications to hospital wards as well as ambulatory patients. In a preliminary stage of our research, a risk analysis was performed to define where and how the intervention was required. For this purpose, we used the best practices in risk assessment and LASA drugs risk management [15–19], through a procedure based on the Italian Regulations. Indeed, we chose to follow the 'Recommendation no. 1' released by the Italian Ministry of Health in 2010 [20] and the FMEA, in order to develop an effective risk assessment model for preventing LASA drugs medication errors risk. Objective of this study was to develop a model for the risk assessment of LASA drugs distribution process performed by our hospital pharmacy, in order to define the best control measures to eliminate or reduce to a minimum them. Firstly, we applied the actions suggested by the Italian Recommendations (Table 1).

Table 1. Some of the actions for preventing LASA drug errors in hospital setting (by Recommendations of Italian Ministry of Health, [14]).

Recommendations for healthcare workers
1. Separate the storage of similar bottles at pharmacy and in ward; otherwise, highlight the similar features using methods and tools shared by pharmacy and wards.
2. Avoid verbal or via phone drug requests, unless in emergency –and when the doctor is absent. In these cases, it is requested that the healthcare workers, the doctor prescriber and the operator of the drug delivery system, repeat intelligibly the drug's name; the drug dosage should be also confirmed as soon as possible in written form. If the request depends on the supply of the hospital ward-based pharmacy, it is necessary that the request is both computerized and customized; and whether it is not possible, it is recommended using preprinted application forms and writing in a simple way, if possible in block capital.
3. Specify the meat of the prescription -which contains the medication and strength- the amount to be taken, the route by which it is to be taken and the frequency; in case of doubt, consult the prescriber doctor or the hospital pharmacist.
4. Avoid using abbreviations, especially if the drug prescriptions are hand-written or contain abbreviations.
5. Write legibly. Write preferably in block capital, especially if there is no availability of computerized medication chart.
6. Set a double control for the preparations of drugs that require warning and caution.
7. Discharge a patient from the hospital provided by sufficient information about the medical prescription, which should possibly be written in capital block.
Recommendations for healthcare administrators
1. Adopt a patient safety action plan including specific procedures for managing LASA medications.
2. Make all the necessary information available to the patients about the proper pharmaceutical drug use.
3. Find every indicator that can predict LASA drug errors in order to improve the patient safety.
4. Adopt only one therapeutic medication fact sheet.
5. Make sure the presence of a sufficient number of hospital pharmacists.
6. Introduce computer-based technologies for a correct drug management.
7. Adopt simple but effective process to centralize the anticancer drug distribution system provided by the hospital pharmacy.
8. Conduct a double checking during the dispensing and supply process.
9. Communicate to the wards 'alerts', extra symbols, colored codes, and a list of abbreviations and acronyms agreed between hospital pharmacy and wards.
10. Manage the patient-drug 'relationship' during the recovery and discharge process from hospital.
11. Communicate to all the wards and, periodically, update the LASA drugs list.
12. Organize a specific procedure with the hospital pharmacy for special and off-label drugs. In these cases, it is requested that special medical prescriptions and their supply must be in limited quantities, and guaranteed in short times.
13. Monitor and evaluate the drug management process periodically.
14. Organize a periodical training for healthcare workers.
15. Develop an effective system for the transmission of 'sentry' events.

Then, we used the 'FMEA' model to study the hospital distribution process, in order to individuate every specific failure modes and to estimate a risk index, before and after the application of some corrective actions. The drugs distribution process was divided in phases, which were further subdivided into steps; then, we identified in every single step all the potential failure modes. In our study, we followed the FMEA process suggested by McDermott et al. [21]. Therefore, the steps were the following: review process, brainstorm potential failure modes, list potential effects of each failure mode, assign severity, occurrence and detection rankings, calculate the Risk Priority Number (RPN) for each failure mode, prioritize the failures modes for action, take action to eliminate or reduce the high risk failure modes and calculate the resulting RPN as the failure modes are reduced. The relative risk of a failure and its effects are composed of three factors: 1) 'Probability of Occurrence' (O); 2) 'Severity' (S), and 3) 'Detection' (D). The 'Probability of occurrence' is the likelihood of a failure mode occurring. It can be studied looking at all the potential causes for a failure mode that have been documented for them in the past. The 'Severity' (S) describes the severity of the effect on the final process outcome resulting from the failure mode if it is not detected or corrected. The 'Detection' (D) is the ability to catch the error before causing patient harm. Power of detection is important for maintainability control (availability of the system) and it is especially important for multiple failure scenarios. A scoring rating scale from 1 to 5 was used for severity, occurrence and detection [22]. For every failure mode we calculated a risk priority number (RPN) as:

Risk priority number level (RPN) = (O x S) x (D). Since scores were 1–5, the resultant RPN scored 1–125. RPN was effectively used for the risk assessment of medication errors in other studies [23, 24]. We showed in Table 2 the parameters to calculate the RPN 1 [25]. In our study, we calculated the RPN to establish the priority of remedial measures. As a consequence, a corrective action plan was developed for resolution of identified high-risk failure modes, and a new RPN (RPN 2) was calculated. This second RPN was obtained by tests conducted and supervised according to the International standards. To evaluate effectiveness of the corrective actions, a paired T test was used to compare means of RPN 1 and RPN 2. Data analysis was performed by PSPP software. The statistical significance was set to $P < .05$. Finally, our model included a 'monitoring' phase to individuate further preventive measures for the system improvement.

Table 2. Rating scales used to assign values to the occurrence (O), severity (S), and detection (D) scores in the failure mode and effect analysis of the drug distribution process [25].

Occurrence (O)		Severity (S)		Detection (D)	
Score	**Failure mode probability**	**Score**	**Description of inury**	**Score**	**Likelihood of detection**
1	Remote: failure unlikely to occur (happening in 1 in 10000 episodes observed)	1	No injury or patient monitoring alone	1	Very high: detected 9/10 times
2	Low: relatively rare failure (happening in 1 in 1000 episodes observed)	2	Temporary injury needing additional intervention or treatment	2	High: detected 7/10 times
3	Moderate: occasional failure (happening in 200 episodes observed)	3	Temporary injury with longer hospital stay or increased level of care	3	Medium: detected 5/10 times
4	High: recurrent failure (happening in 1 in 100 episodes observed)	4	Permanent effects on body functions	4	Low: detected 2/10 times
5	Very high: common failure (happening in 1 in 20 episodes observed)	5	Death or permanent loss of major body functions	5	Remote: detected 0/10 times

RESULTS

The LASA drug distribution process provided by our hospital pharmacy was divided in 6 phases. Table 3 displays all its phases and individual steps.

Table 3. LASA drug distribution process: identification of phases and steps.

PHASES		STEPS IN PROCESS	
1	Drug request from the ward.	A_1	The ward operator makes a request for LASA drugs to the hospital pharmacy via computer.
		B_1	The pharmacist evaluates the compliance of the request according to the procedures established by the hospital administration.
		C_1	The nurse sends a request for LASA drugs with drug distribution trolleys.
		D_1	The nurse sends a request for LASA drugs with drug distribution trolleys.
2	Life-saving drugs request from the ward.	A_2	The ward operator sends a request for LASA drugs to the hospital pharmacy via computer.
		B_2	The ward operator sends a hand-written request for LASA drugs to the hospital pharmacy.
		C_2	The pharmacist evaluates the compliance of the request with procedures established by the hospital administration.
		D_2	The nurse sends a request for LASA drugs with drug distribution trolleys.
		E_2	The nurse sends a request for LASA drugs with drug distribution trolleys.
3	Narcotic and controlled drugs request from the ward.	A_3	The medical doctor prepares a prescription on a special paper prescription form used by ward.
		B_3	The pharmacist evaluates the request received from the ward.
		C_3	The pharmacist prepares a prescription on a special paper prescription form used by the hospital pharmacy.
		D_3	The pharmacist manages drug-related data via computer.
4	Drug distribution from the pharmacy to each ward.	A_4	The operator delivers drugs from the hospital pharmacy to the ward with drug distribution trolleys.
5	Drug distribution from the pharmacy to the patients.	A_5	The pharmacist prepares a prescription on a special paper prescription form used by the hospital pharmacy.
		B_5	The pharmacist evaluates the hand-written prescription elaborated by a hospital prescribing centre.
		C_5	The pharmacist gives the medicine to the patient.
6	Drug request from the ward via phone.	A_6	The medical doctor send a request for LASA drugs to the pharmacist via phone.
		B_6	The pharmacist manages the LASA drug request.
		C_6	The ward operator distributes LASA drugs from the hospital pharmacy to the ward with drug distribution trolleys.

Table 4 shows the high-risk failure modes that our team identified during the LASA drugs distribution process. In total, 16 steps and 13 different potential failure modes were detected, which generally can result in several negative events, ranged from a simple alteration of the normal distribution flow to important damages for the safety patient. Our analysis revealed a high RPN before applying the corrective actions. The highest ranked failure modes, with an RPN score of 48 pertained to wrong drug dosage selection. After the implementation of 7 corrective measures as showed in Table 4, the RPN decreased for almost all of the failure modes (phase no. 1, 2, 3, 4, 6). Above all, the most effective correction actions were based on automated computerized systems (CA 4, CA 5, CA 6, and CA 7). Indeed, the critical failure modes in sample processing (phase no. 1, 2, 3, and 4) were improved by 69.7% in the RPN by focusing on automated technology systems. However, the automated technology system used by our hospital pharmacy did not totally eliminate the risk of errors in case of LASA drugs distribution; moreover, for 3 types of failure modes (phase no. 5; step no. 13, 14, 15) we did not find any preventive measure.

Table 4. Individuation of the failure modes and their scores during the hospital 'drugs distribution' process.

Phases (1-6)	**FAILURE MODES**		**P 1**	**S1**	**D 1**	**R P N 1**	**CORRECTIVE ACTIONS (CA)**	**P 2**	**S2**	**D 2**	**R P N 2**	**RPN1-RPN2 Difference for each failure mode (*n;* %)**	**RPN1-RPN2 Difference for phase *(n; %)***
Phase 1 Steps: A_1 A_2 A_3 D_1 E_2 D_3	no.1	Wrong drug selection (drug phonetically similar to another one).	1	4	3	12	Obligation to transmit the drug request via automated computer system (CA 1)	1	3	2	6	6 (50%)	23.3 (67.5%)
	no.2	Wrong drug dosage selection.	4	4	3	48		2	3	2	12	36 (75%)	
	no.3	Wrong drug selection (drug with the same name and package of another one).	4	3	3	36		2	2	2	8	28 (77.7%)	
Phase 2 Steps: B_1 C_2 A_3 B_5	no.4	Wrong drug selection (drug phonetically similar to another one).	1	2	1	2	Checking drug request and final validation via automated computer system (CA 2)	1	2	1	2	0 (0)	2.6 (44.6%)
	no.5	Wrong drug dosage selection.	2	3	1	6		1	2	1	2	4 (67%)	
	no.6	Wrong drug selection (drug with the same name and package of another)	2	3	1	6		1	2	1	2	4 (67%)	

Phase 3 **Steps:** **C_1** **D_2** **C_3** **C_5**	no.7	Wrong drug storage (drug phonetically similar to another one).	2	3	3	18	Automated centralized technology system (Buster System) provided by hospital pharmacy (CA 3) Storage of LASA drugs in rooms provided by shelves with separators (CA 4) Storage of high-supply LASA drugs in rooms provided by separated shelves (CA 5)	1	2	1	2	16 (89%)	20.5 (90.5%)
	no.8	Wrong drug storage (drug with a package graphically similar to another one).	3	4	2	24		1	2	1	2	22 (91%)	
	no. 9	Wrong drug dosage (drug with the same name and features of another one).	3	4	2	24		1	2	1	2	22 (91%)	
	no. 10	Wrong drug selection (drug with the same name and features of another one).	3	4	2	24		1	2	1	2	22 (91%)	
Phase 4 **Steps:** **B_2** **A_3** **A_5**	no. 11	Wrong drug dosage prescription.	3	3	2	18	LASA drug prescription via automated computer system (CA 6)	1	2	1	2	16 (89%)	10 (78%)
	no. 12	Wrong drug prescription (the drug is right, but the route of drug administration is wrong).	2	3	1	6		1	2	1	2	4 (67%)	
Phase 5 **Step:** **A_4**	no. 13	Transport in the same container of drugs with similar packages.	3	4	1	12	NONE	3	4	1	12	0 (0)	0 (0)
	no. 14	Transport in the same container of drugs with different dosage forms.	3	3	2	18		3	3	2	18	0 (0)	
	no. 15	Transport in the same container of drugs having different routes of administration.	3	4	1	12		3	4	1	12	0 (0)	
Phase 6 **Step:** **A_6**	no. 16	Verbal request of a drug that is phonetically similar to another one.	2	3	1	6	In case of emergency, recalling intelligibly LASA drug name and dosage form (CA 7)	1	2	1	2	4 (67%)	4 (67%)

For the corrective actions provided by our action plan, a paired T- test showed significant differences between before and after the risk-reduction strategy (Table 5). Indeed, T-test showed that the difference between RPN 1 and RPN 2 was statistically significant for all corrective measures provided by our action plan.

Table 5. Paired mean difference statistics of Risk Priority Number (RPN) after corrective measures.

Mean (SD) RPN	Paired Differences			T	Df	Sig- (1-tailed)
	Mean (SD) RPN	95% CI of the Difference				
		Lower	Upper			
Pre- 17.000 (12.263)	11.500 (11.627)	5.304	17.695	3.956	15	0.001*
Post- 5.500 (5.2408)						

*P < .05

After analysis of the main failure modes resulting in every activity of distribution phase, and individuation of correction actions, we identified 19 further preventive measures for improving our action plan. For instance, in order to face failure modes no. 1–6, it will possible to insert in the automated, computerized system the font 'Tall Man', or different colors on monitors to highlight the slight differences between two similar drugs. This solution could be considered useful in case of similar dosage. Moreover, in order to deal with the failure modes no. 7–10 and no. 13–15, we could also apply a colored label with the following alerts: 'Drug easily-mistaken with LASA, be careful' and/or 'LASA drugs, pay attention!' on the LASA drug packages, and on shelves of the storage rooms. In order to face errors no. 11 and 12, the computerized system should contain all the format for rare prescriptions according to national and international regulations; then, a specific procedure with a dedicated list in case of abbreviations could be useful when medical doctors release hand-written prescriptions; in addition, in this case, they should write in block capital. As regard to failure mode no. 16, the healthcare management should create some dedicated LASA drugs registers where to indicate the patient's name associated with the drug's name and its dosage. All of these procedures should be also periodically monitored by trained pharmacists. A further measure of improvement, also called 'Safety Walkaround' consists of anonymous interviews conducted by a trained supervisor with healthcare operators to collect and examine useful information in order to identify further and unknown risks. These new activities aimed at improving our drug distribution system should be analyzed in depth in future research.

DISCUSSION

Medication error can be 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 health care professional, patient, or consumer' [26]. Look-alike/sound-alike medication names can often result in medication errors. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use [26]. Within healthcare facilities, pharmacists play a pivotal role in the prevention and review of medication-related adverse events. Examples of pharmacy services and programs that positively impact on

patient safety include direct patient care activities, use of formulary systems, standardized medication policies and guidelines, drug order review, implementation of safe drug distribution systems, application of computer technology, provision of drug information/ education to patients and health care workers, medication incident reporting and review systems [27]. As Cohen et al. stated, an effective and efficient drug distribution system through a systematic process redesign that includes both organizational and technological components can represent the best and most cost-effective way of preventing medication errors [28]. In our study, we developed a LASA drug errors risk assessment model for the improvement of drug distribution process within our hospital. This model was based on the 'Failure Mode and Effect Analysis' (FMEA) approach for identifying all possible failures in a system process and on the Recommendation released by the Italian Ministry of Health, which is a useful tool for helping Italian health-care operators. In literature, there are a lot of risk assessment methods, such as the Root Cause Analysis (RCA), the clinical audit, the Significant Event Audit (SEA), the Critical Incident Technique (CIT), the Confronting With Standard (CWS), the Failure Mode, Effects and Criticality Analysis (FMECA), and the Failure Mode and Effects Analysis (FMEA). We used the FMEA that has been advocated as a useful tool for proactive risk assessment by the Joint Commission on Accreditation of Healthcare Organizations [29]. This technique is a systematic process for identifying potential process failures before they occur, with the intent to eliminate them or minimize the risk associated with them [4]. FMEA is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service. 'Failure modes' means the ways, or modes, in which something might fail. 'Failures' are any errors or defects, especially ones that affect the customer, and can be potential or actual. 'Effects analysis' refers to studying the consequences of those failures. Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. The purpose of our FMEA-based process was to take actions to eliminate or reduce failures during the LASA drug distribution process, starting with the highest-priority ones. Failure modes and effects analysis can also document current knowledge and actions about the risks of failures, for use in continuous improvement [30]. The FMEA methodology is considered as a gold standard because of its validity. Indeed, when it is applied to the management of the clinical risk, the Failure Mode and Effect Analysis is able to identify negative events before they appear, introducing preventive safety measures, which can lead to a less frequency of negative events related to medical errors [31, 32]. Rodriguez-Gonzalez (2015) et al. also used effectively the FMEA method to evaluate the causes of preventable adverse drug events during the nurse medication administration process in inpatient units with computerized prescription order entry and profiled automated dispensing cabinets [33]. Lago et al. used the FMEA method to analyze the risk of errors in prescribing and administering drugs in paediatric wards studies [23]. Al Tehewy et al. applied this method for studying infusion therapy in a tertiary hospital intensive care unit in Egypt [24]. There a lot of studies indicating the FMEA analysis as an ongoing quality improvement process that can be carried out in healthcare organizations by a trained multidisciplinary team. However, to our knowledge, in Italy this method still has not been used to study the failure modes that can be generated during the LASA drugs distribution process provided by the hospital pharmacy. Our study followed the preventive actions suggested by the recent Recommendations of the Italian Ministry of Health. In Italy, after the publication of the Recommendations in 2010, the Ministry of Health has published a report on LASA drugs regarding the medication errors by LASA drugs occurred in the period 2011-2015 [34]. The Ministry of Health suggested that Italian Regions organize through Health

Local Authorities specific training courses for healthcare operators based on that publication. In the period 2011–2015, the report showed 1,971 cases of medication errors occurred by LASA drugs. These cases were noticed by Health Care Local Authorities (*n* = 946; 48%), community pharmacists (*n* = 453; 23%), general practitioners, (*n* = 355; 18%), and family pediatricians (*n* = 217; 11%). Moreover, in Italy there is poor attention to medication errors management, in comparison with the global context [35]. Indeed, an exact valuation of the negative consequences related to medication errors still does not exist. According to some retrospective analysis of clinical records, which calculate the percentage of all admissions to Italian hospitals every year, medication errors occur between 2.9% and 16.6% of all admissions to hospital, and a percentage between the 37% and 51% of medication errors could be attributed to avoidable, or predictable negative events [25]. Moreover, a survey estimated that in Italy the number of the negative events by LASA drugs trebled in the 1994–2008 years, even though the number decreased from 2000 until now by 23.7% [25]. However, in literature LASA medication errors are not supported by reliable statistics [13] and, without an infrastructure to capture and assess all medication errors and near misses, the real number is not known. Therefore, despite numerous research findings, we cannot estimate the actual rates because they vary by site, organization, and clinician; because not all medication errors are detected; and because not all detected errors are reported [36]. Generally, medication errors occur in all settings [37], and may or may not cause an adverse drug event (ADE). Medications with complex dosing regimens and those given in specialty areas (e.g., intensive care units, emergency departments, and diagnostic and interventional areas) are associated with an increased risk of ADEs [38]. Phillips et al. found that deaths (the most severe ADE) associated with medication errors involved central nervous system agents, anti-neoplastics, and cardiovascular drugs [39]. Most of the common types of errors resulting in patient death involved the wrong dose (40.9%), the wrong drug (16%), and the wrong route of administration (9.5%). The causes of these deaths were categorized as oral and written miscommunication, name confusion (e.g., names that look or sound alike), similar or misleading container labeling, performance or knowledge deficits, and inappropriate packaging or device design. In our study, We showed all the above-mentioned failure modes. Consistent with the literature, or risk assessment model showed that similar name and/or package (e.g., Hydroxyzine/Hydralazine), using abbreviations, misunderstanding between physicians, nurses, pharmacists and other healthcare professionals can be some of the most important causal factors of medication errors. Our study was consistent with the most important international reports. According to the National Coordinating Council for Medication Error Reporting and Prevention [26], risk factors associated with LASA drugs errors include the drugs with similar names or similar packaging, medications that are not commonly used or prescribed, commonly used medications to which many patients are allergic (e.g., antibiotics, opiates, and nonsteroidal anti-inflammatory drugs) and medications that require testing to ensure proper (i.e., nontoxic) therapeutic levels are maintained (e.g., lithium, warfarin, theophylline, and digoxin). For instance, according to the Guidelines published by the Malaysian Ministry of Health [40] the most common risk factors associated with LASA drugs errors include illegible handwriting, incomplete knowledge of drug names, newly available products, similar packaging or labelling, similar strengths, dosage forms, frequency of administration, and similar clinical use. Finally, other causal factors could be environmental annoyance, and work-related stress. However, the most common mistake is probably misreading medication names that look similar, leading to errors associated with verbal prescriptions [36]. In our model, the most important corrective actions consisted of automated computerized distribution systems.

In our hospital, the BUSTER system is a robotized wardrobe for the management of the drugs. It is based on two main components: an electromechanical arm, which put in order the drugs into a dispenser, and a barcode reader that allows the system to identify every single package. In addition, computerized wardrobes can automate the drugs management process and allow sharing and exchanging information between two operators. The automated system is able to process the request on time and withdraw directly the order. In our hospital, healthcare management has introduced a computerized system to reduce the risk of drug error management through the elimination of 'physical contact' between drug and user. Indeed, user can interact with the system through dedicated touch-screen monitors. However, the risk cannot be totally eliminated. Our corrective actions were not sufficient to eliminate the risk during the LASA drug distribution process. In agreement with Battles and Keyes, automation holds substantial promise, for improved safety, but error experts caution that all technology introduces the potential for new and different errors [41]. Furthermore, in our model other corrective actions were also effective, such as storing LASA medications in separate locations on dedicated shelves, or in automated dispensing devices. In addition, we used techniques such as boldface and colour differences to reduce the confusion associated with the use of LASA names on labels, storage bins and shelves, computer screens, automated dispensing devices, and medication administration records. However, to increase patient safety, one of the major advances, in recent years, has been computerization. Above all, our model was based on the information technology systems. Agrawal reviewed the most important technological systems in preventing medication errors [42], and he showed that a variety of systems, such as drug-dispensing robots and automated dispensing cabinets, reduce dispensing errors by packaging, dispensing, and recognizing medications using bar codes. For instance, in a recent evaluation of the impact of bar-coding drugs in pharmacy and checking them before they are sent to patient care units, the dispensing error rate fell by 31% after bar-code implementation in pharmacy, and the potential rate of adverse events fell by 63% [43]. As showed by the Agrawal's review, bar-coded medication administration (BMCA) systems are much useful. They require that the nurse who administers the medication at the bedside should scan the patient's identification bracelet and the unit dose of the medication being administered. The system alerts the nurse to any mismatch of patient identity or of the name, dose, or route of administration: the right patient, drug, dose, route, and time. Schulmeister showed some risk reduction strategies such as, for instance, being aware of medications which look or sound like other drugs, installing pop-up alerts in computer system, prescribing medications both by their generic and trade names, placing eye-catching labels and warning stickers on storage bins, storing medication in nonadjacent areas, and advising patients to be alert for potential mix-ups with look-alike, sound-alike medications [44, 45]. Moreover, Morriss et al. studied the effectiveness of a barcode medication administration system on reducing medication errors in a neonatal intensive care unit using a prospective cohort design. After controlling for the number of daily medication doses per subject, the barcode system was associated with a 47% reduced risk of preventable adverse drug events [46]. Generally, applications of technology in medicine such as order entry systems, especially computerized prescribing, bar-coding for medications, blood, devices and patients, electronic systems to communicate key pieces of asynchronous data are very useful [47]. However, technological methods of clinical risk management could be less effective if the national and international best practices don't support these technological solutions. Another limitation is that effectiveness of the model depends also on the quality of the team effectiveness assessment. Computerized systems, pharmacy automation and barcoding can tackle the problem of look-a-like and sound-alike drugs. Such systems

enable an efficient medication usage process. Importantly, pharmacists can also review orders through the system which adds another safety check. A computer-based data entry system helps prevent many medication mix-ups since the software shows up all related medicines and drug strengths. These systems can also contain dosage guidance which appear if pharmacists are about to recommend an adult dose to a child. Hospital and pharmacies should invest in such systems to address the problems found in manual systems and thereby improve patient safety. However, there is still skepticism about the evidence regarding the impact of such systems on clinical outcomes [42]. Moreover, a second concern is raised by evidence of the potential negative consequences of information technology systems (IT) on patient safety, which can adversely affect clinical care by generating more work or new work for clinicians, causing workflow problems, or even generating new kind of errors [48]. In every case, as Agrawal stated, IT system itself is less important than its implementation. The main barriers to widespread adoption are the high costs of the systems, but we should also consider ethical issues of the human behavior that depends on the types of errors, which can be operative, applicable or psychological [7]. Generally, in cases of clinical errors, indeed, there is the tendency to reproach a single person as the responsible of all [5]. IT systems can be only one of solutions provided by a multifaceted strategy to prevent medication errors and improve patient safety. However, a complex strategy focused on the organization and IT systems might lead to a lack of effective solutions to the problems. In conclusion, we believe that the adoption of a risk assessment model based on FMEA by hospitals, probably, can improve the recognition and prevention of LASA drug errors. The drugs distribution process is one of the most critical stage, but we also need to consider all the stages that are prescribing, transcribing, dispensing, and administration drugs. Probably, our study could pave the way to further research in this area, which is often neglected by scholars. However, our study has some limitations. Indeed, it was based on a theoretical model and some of the most effective corrective actions for implementing this model should be checked in a future research, by a comparison with data provided by our hospital concerning adverse events by LASA drug errors occurred during the distribution process. However, information technology solutions hold great promise for reducing LASA medication errors in hospitals, even if the potential for error will remain unless these systems are carefully implemented.

CONCLUSION

Confusing drug names is a common system failure. Indeed, many drug names can look or sound like other drug names, which may lead to potentially harmful medication errors and to very serious consequences for patients. This study has proactively evaluated all possible negative events that can occur during the drugs LASA distribution process performed by our hospital pharmacy, with the subsequent corrective actions recognized through a risk assessment model based on the Recommendation of the Italian Ministry of Health (2010) and FMEA process. Our model could be useful in order to define the best corrective actions to reduce LASA drugs errors during the distribution process in other hospitals from industrialized countries. information technology solutions hold great promise. However, a consistent implementation of these automated systems is also required.

References

1. WHO patient safety curriculum guide: multi-professional edition. (NLM classification: WX 167). Geneva: World Health Organization; 2011.
2. Jeetu G, Girish T. Prescription Drug Labeling Medication Errors: A Big Deal for Pharmacists. J Young Pharm. 2010 Jan-Mar;2(1):107–111.
3. Teplitsky B. Hazards of sound-alike, look-alike drug names. Calif Med. 1973;119(5):62.
4. La Pietra L, Calligaris L, Molendini L, Quattrin R, Brusaferro S. Medical errors and clinical risk management: state of the art. Acta Otorhinolaryngol Ital. 2005 Dec;25(6):339–346.
5. Reason J. Human Error: models and management. British Med J. 2000;320:768–770.
6. Ostini R, Rougheadb E, Kirkpatricka C, Monteitha R, Tetta S. Quality Use of Medicines – medication safety issues in naming; look-alike, sound-alike medicine names. Int J Pharmacy Pract. 2012;20:349–357.
7. Berman A. Reducing medication errors through naming, labelling, and packaging. J Med Syst. 2004;28:9–29.
8. Basco WT Jr, Ebeling M, Hulsey TC, Simpson K. Using pharmacy data to screen for look-alike, sound-a-like substitution errors in paediatric prescriptions. Acad Pediatr. 2010;10:233–237.
9. Kovacic L, Chambers C. Look-alike, sound-alike drugs in oncology J Oncol Pharm Practice. 2011;17:104–118.
10. Galanter WL, Bryson ML, Falck S, Rosenfield R, Laragh M, Shrestha N, et al. Indication Alerts Intercept Drug Name Confusion Errors during Computerized Entry of Medication Orders. PLoS One. 2014;9(7):e101977.
11. Naunton M, Gardiner HR, Kyle G. Look-alike, sound-alike medication errors: a novel case concerning a Slow-Na, Slow-K prescribing error. Int Med Case Rep J. 2015;8:51–53.
12. Ciociano N, Saullo F, Pacillo M, Romano F, Bagnasco L. GRP-20 analysis of Italian hospital pharmacist activities to prevent LASA drug errors in treatment: first results. Eur J Hosp Pharm. 2013;20:A7–A8.
13. Ciociano N, Bagnasco L. Look alike/sound alike drug names. Int J Clin Pharm. 2014; 36(2):233–242.
14. Ministry of Health, Italy. Recommendation no.12 for preventing LASA drug errors. Rome, Italy: Ministry of Health; 2010. In Italian.
15. Word Health Organization. Word Alliance for Patient Safety: Patients for Patient Safety. Geneva: WHO;2010 [cited 2016 Dec 28]. Available from: www.who.int/patientsafety/patients_for_patient/en.
16. NPSA. Design for patient safety A guide to labelling and packaging of injectable medicines. First edition, 2008 [cited 2016 Dec 28]. Available from: https://www.nrls.npsa.nhs.uk/EasySiteWeb/getresource.
17. The Joint Commission. Look-alike/sound-alike drug list, 2011 [cited 2016 Dec 28]. Available from: https://www.jointcommission.org/lasa/.
18. Institute for Safe Medication Practice. ISMP' List Of Confused Drug Name [cited 2016 Dec 28]. Available from: http://www.ismp.org/.
19. NHS – NPSA. Design for patient safety. A guide to the graphic design of medication packaging. 2nd edition, London 2007 [cited 2016 Dec 28]. Available from: http://www.nrls.npsa.nhs.uk/resources/collections/design-for-patientsafety/?entryid45=63053.
20. Ministry of Health, Italy. Sicurezza dei pazienti e Gestione del rischio clinico: la qualità dell'assistenza farmaceutica. Rome: Ministry of Health; 2011. In Italian.
21. McDermott R, Mikulak RJ, Beauregard MR. The basics of FMEA (2nd edition). LLC USA: Taylor & Francis; 2009.
22. Institute For Safe Medication Practices. The virtues of independent double checks-they really area worth your time! ISMP Medication Safety Alert. 2003;8(5):1.
23. Lago P, Bizzarri G, Scalzotto F, Parpaiola A, Amigoni A, Putoto G, et al. Use of FMEA analysis to reduce risk of errors in prescribing and administering drugs in paediatric wards: a quality improvement report.

BMJ Open. 2012:2:e001249. Doi:10.1136/bmjopen-2012-001249.

24. Al Tehewy M, El Hosseini M, Habil I, Abdel Maaboud M, Abdel Rahman S. A proactive risk management using failure mode and effects analysis for infusion therapy in a tertiary hospital intensive care unit in Egypt. Acta Medica Mediterranea. 2015;31:195.
25. Bizzarri G, Farina M. Strategia e gestione del rischio clinico nelle organizzazioni sanitarie. Milano: Franco Angeli Editore; 2012.
26. National Coordinating Council for Medication Error Reporting and Prevention. What is a medication error? [cited 2016 Dec 28]. Available from: www. nccmerp.org/aboutMedErrors.html.
27. Canadian Society of Hospital Pharmacists La Société canadienne des pharmaciens d'hôpitaux. Impact of Hospital Pharmacists on Patient Safety. Background Paper. Dec 2003 [cited 2016 Dec 28]. Available from: http://www.cshp.ca/dms/dmsView/1_1_1_safety.pdf.
28. Colen HB, Neef C, Schuring RW. Identification and verification of critical performance dimensions. Phase 1 of the systematic process redesign of drug distribution. Pharm World Sci. 2003 Jun;25(3):118-25.
29. Joint Commission on Accreditation of healthcare organizations. An introduction to FMEA. Using failure mode and effects analysis to meet JCAHO's proactive risk assessment requirement. Failure Modes and effect Analysis. Health Devices 2002;31:223-226.
30. Failure Mode Effects Analysis (FMEA) [cited 2016 Dec 28]. Available from: http://asq.org/learn-about-quality/process-analysis-tools/overview/fmea.html.
31. McDermott RE, Mikulak RJ, Beauregard MR. The basics of FMEA. Portland, OR: Resources Engineering, Inc;1996.
32. McNally KM, Page MA, Sunderland VB. Failure mode and effects analysis in improving a drug distribution system. Am J Health Syst Pharm. 1997;54:171-177.
33. Rodriguez-Gonzalez CB, Martin-Barbero ML, Herranz-Alonso A, Durango-Limarquez MI, Hernandez-Sampelayo P, Sanjurjo-Saez M. Use of failure mode, effect and criticality analysis to improve safety in the medication administration process. J Eval Clin Pract. 2015;21(4):549-559.
34. Italian Ministry of Health. Report farmaci LASA 2011- 2015. Rome, Italy: Ministry of Health; 2016. In Italian.
35. Millauro A, Nante N. Il risk management: origini, evoluzioni, prospettive. Mondo Sanitario Volume. 2005;12;1-2. In Italian.
36. Hughes RG, Blegen MA. Medication Administration Safety in Patient Safety and Quality: An Evidence-Based Handbook for Nurses. Hughes RG, editor. Rockville (MD): Agency for Healthcare Research and Quality (US); 2008.
37. Pronovost P, Morlock L. ICU incident reporting systems. J Crit Care. 2006;17(2):86–94.
38. Henriksen K, Battles JB, Marks ES, Lewin DI. Advances in patient safety: from research to implementation. Rockville, MD: Agency for Healthcare Research and Quality; 2005.
39. Phillips J, Beam S, Brinker A, Houlguist C, Honig P, Lee LY, et al. Retrospective analysis of mortalities associated with medication errors. Am J Health Syst Pharm. 2001;58:1835–1841.
40. Pharmaceutical Services Division Ministry of Health Malaysia. Guide on handling look alike, sound alike medications. 2012 [cited 2016 Dec 28]. Available from: http://www.pharmacy.gov.my/v2/sites/default/files/document-upload/guide-handling-lasa.pdf.
41. Battles JB, Keyes MA. Technology and patient safety: a two-edged sword. Biomed Instrum Technol. 2002;36:84–88.
42. Agrawal A. Medication errors: prevention using information technology systems. Br J Clin Pharmacol. 2009 Jun;67(6):681–686.
43. Poon EG, Cina JL, Churchill W, Patel N, Featherstone E, Rothschild JM, et al. Medication dispensing errors and potential adverse drug events before and after implementing bar code technology in the pharmacy. Ann Intern Med. 2006;145:426–434.

44. Schulmeister L. Look-alike, sound-alike oncology medications. Clin J Oncol Nurs. 2006;10(1):35–41.

45. Chanakit T, Napaporn J, Chiempattanakajohn T, Sangkhawan S, Wichakot S. The survey of look alike/sound alike (LASA) drugs available in hospitals in Thailand. Afr J Pharmacy Pharmacology. 2013;7(6):227–239.

46. Morriss FH, Abramowitz PW, Nelson SP, Milavetz G, Michael SL, Gordon SN, et al. Effectiveness of a barcode medication administration system in reducing preventable adverse drug events in a neonatal intensive care unit: A Prospective cohort study. J Pediatr. 2009;154:363–368.

47. Bates DW, Cohen M, Leape LL, Overhage JM, Shabot MM, Sheridan T. Reducing the frequency of errors in medicine using information technology. J Am Med Inform Assoc. 2001;8:299–308.

48. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. J Am Med Inform Assoc. 2004;11:104–112.