Review Article

The Method of Checking Medications Prior To Administration: An Evidence Review

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Abstract

Background: Checking medications before their administration by nurses is a basic preventive action for medication errors. Due to the fact that nurses perform medication checking in the everyday clinical practice, either on their own (single) or with another nurse (double) and are responsible for what they administer to the patients, checking is directly related to nursing. Mostly the last years, queries around multiple issues about checking have been raised.
Aim: The present review was undertaken in order to collect and appraise research evidence about the method of medication checking (single and double) prior their administration.
Methodology: A literature search was undertaken to PUBMED, SCIENCE-DIRECT, BRITISH NURSING INDEX and CINAHL databases using specific keywords for relevant articles (of qualitative, quantitative, mixed methodology) published in English from January 1990 to March 2015. For the introduction of an article to the review, specific inclusion criteria were set. Additional data obtained through relevant reports from institutions and the articles' references. The selection process of the articles was based on the flowchart which was recommended in the PRISMA statement.
Results: Twenty primary research studies and three reviews were included in the review and their data was clustered according to the analysis of studies' findings: definition inconsistency, single-checking, double-checking, cases of checking application, benefits and drawbacks of checking, medication errors and promoting and supporting ways for checking method.
Conclusions: The present review gathers current evidence about medication checking prior their administration, either single or double. Yet data is limited and ambiguous, implying the need for additional research in the field, so that the subject would be investigated in depth with safer and accurate conclusions.

Keywords: nursing, medication preparation, medication administration, single checking, double checking, medication error.

Introduction

The procedures which are entailed in the management of patients' medication comprise fields of clinical practice where the risk of medication errors is high (Schelbred and Nord, 2007). The lack of checking habits is considered to be one of the contributing factors for medication errors and specifically those related to staff. Importantly, the implementation of double-checking method should be stressed at the undergraduate level of professionals' education (World Health Organization, 2011). In order to prevent medication errors' occurrence during medication preparation and administration a variety of specific methods and techniques is followed (Choo et al, 2010; Athanasakis, 2012).

Towards to the direction of safety insurance and care quality, the utmost measure that is adhered by nurses during medication administration is the appliance of the five rights: right patient, right medication, right dose, right route, right time, even though the last few years some researchers

tend to consider as vital more rights than the five mentioned above (Wilson et al, 2004; Elliot and Liu, 2010). Alongside with the five rights goes the measure of checking (single or double), which is used as a system-based strategy to address the combination of the health system complexity and the human factor that lead to errors. Strategies to prevent medication errors it's better to be applied 'concurrently with and never in isolation of other strategies' (Paparella, 2013, p. 632). The main objective of the above methods' appliance is to follow every step of the medication procedure effectively and minimise any potential harmful medication errors, particularly the medication administration errors.

Double-checking was evidenced as a mode to discover actual errors and near misses or prevent serious medication errors (e.g. route medication error: preparation of intravenous (IV) metronidazole instead of oral) (Manias et al, 2005; Sheu et al, 2009). In addition, medication checking was the third category of nurses' thinking during medication administration (Eisenhauer et al, 2007). Besides, the checking method is directly related with nurses, since they hold key-role in the medication procedures, thus it is possible to identify the error in time before the medication will be administered to the patient (Tran and Johnson, 2010).

Guidelines of professional bodies and policies

The British Nursing and Midwifery Council first published in 1986 a medication administration guideline. According to this, the second person should be involved in the medication administration with a first-level practitioner when 'that practitioner is instructing a learner or the patients' condition makes it necessary or in such other circumstances as are logically determined'. Also, it is recommended that that the second-level practitioner (i.e. the enrolled nurse) should have undertaken medication training and assessment in order to participate in the medication administration process (Nursing and Midwifery Council-NMC, 1986).

In 2010 in its report about safe medicine management, stated that prior medication administration every registrant (registered nurse, midwife, specialist community public health nurse) should check with another one about patients' allergies, inform patients and ask their consent, check the details of the prescription (substance, timing, strength, dose, frequency, route, date), check the way it is written (legible, clear, reasonable, authorized signature) and patients' identity (NMC, 2010).

Another published medication safety alert, coming from Canada and published over a decade ago by the Institute for Safe Medication Practices (ISMP Canada, 2003), discussing the virtues of independent double checks. Since then, various publications came out by the same institute and provided further insights to the subject, by expanding the knowledge of the independent double-checking definition, whilst providing steps about its performance, by providing examples of the clinical practice, relevant thoughts and nurses' perspectives (ISMP Canada, 2005; 2009; ISMP USA, 2008).

In the last concerning report of USA ISMP, independent double checks were characterized as 'undervalued' and 'misused'. However, it was suggested that the method 'can be part of a valuable defense' for the medication error prevention, considering its proper implementation, independent use, judiciously and has been standardized (ISMP USA, 2013). Beyond all these, the conduction of a cognitive review of the prescription and the medication preparation by the professionals-checkers is a factor which is interfered in the double-checking process (ISMP USA, 2014).

Furthermore, an investigation of an effective method for independent double-checking of high-risk clinical procedures published by the Canadian Patient Safety Institute (CPSI). The survey conducted at a post-anaesthetic care unit and a chemotherapy daycare centre in a teaching hospital in Toronto. The main conclusions of the investigation were the: acceptance of the method by the staff, double-checking was performed effectively, avoidance of certain types of medication errors (wrong drug in pump, wrong patient, documentation mismatch between order and label, clinically inappropriate order prescribed for a patient), detection of medication errors after bedside patient identification included as part of the independent double-checking procedure and necessity of modified

steps of double-checkings in different settings (Easty et al, 2008).

Two recently published Canadian guidelines are referring to the independent double-checking method, as well (College and Association of Registered Nurses of Alberta, 2014; College of Nurses of Ontario, 2014). It mentioned that the checking of medication should be independent, applied at high risk medications (insulin, heparin, chemotherapy), at each step (check prescription, perform calculations) and document all actions in patients' notes. In another chapter an alternate measure is proposed, that one of detecting the patient separately by nurses (College and Association of Registered Nurses of Alberta, 2014).

The issue of double-checking of medications has drawn the attention of Australian Commission on Safety and Quality in Health Care (2013), by providing evidence briefings supporting that double-checking strategy can be performed selectively, independently; however, increasing nurses' workload. In brief, across the world, the majority of the hospitals have established policies about medication administration to the patients, including the steps of double-checking. Most of them can be found at the official pages of the hospitals.

Concepts' clarification

Checking has been defined as the 'verification of the correctness and appropriateness of a component of the medication administration process' (Eisenhauer et al, 2007). Single-checking is a procedure of checking the steps of medication preparation by a single nurse. Whereas, double-checking or called otherwise as independent double-checking concerns the procedure of recheck/verification of the medication preparation steps, not from a single but from two nurses separately, before the administration phase begins. It is of lessen importance whether the first nurse is present or not in the performance of the procedure from the second one, provided that the two particular colleagues have not discuss about this subject before the completion of the procedure (ISMP Canada, 2005; Australian Commission on Safety and Quality in Health Care, 2013).

The New South Wales Therapeutic Advisory Group (NSW TAG) defined the independent double-checking precisely as 'a procedure in which two individuals, preferably two registered practitioners, separately check each component of the work process'. The Ministry of Health of Australia concretized the policy: 'a second person should check the drug, dose, calculation, IV fluid, and the patient's identity prior to administration' (Australian Commission on Safety and Quality in Health Care, 2013).

Worth mentioning that the point of the checking procedure is that nurses are expected to find similarities in the information they manage. In case that a nurse find different results, the resolving of the differences emerged should be done before the medication would be administered to the patient (ISMP Canada, 2005). In a report by the CPSI in the context of double-checking, researchers added one more subcategory. If this is the case, the second nurse who applies the verification step is informed about the data around the medical order (dependent double-checking) (Easty et al, 2008).

Aim

The present review was undertaken in order to collect and appraise research evidence about the method of medication checking (single and double) prior to their administration.

Methodology

A literature search was undertaken to PUBMED, SCIENCE-DIRECT, BRITISH NURSING INDEX and CINAHL databases for relevant articles published in English from January 1990 to March 2015, independently of the techniques the authors used to interpreted data (qualitative, quantitative, mixed). The following keywords were used: 'nursing', 'medication preparation', 'medication administration', 'single checking', 'double checking'. An additional key word: 'medication errors' was added because of the fact that previous studies investigated potential co-relation between any of the checking methods and medication errors.

The literature review included articles which analyzed single or double-checking as part of the investigation of other issues (e.g. medication administration process) or as the main subject

(e.g. examine factors that foster and/or impede double-checking). Similarly, reports by institutions and organizations which discussed patient safety and medication administration subjects have been taken into account to support the literature review.

Another inclusion feature was that one of the sample, to be consisted entirely or partly of registered nurses. However, the literature search revealed that there were studies in which their sample was based for example, on medication errors reports or medication administration cases. In this case, these studies were included provided that they investigated the method of checking in relation with the medication errors within the nursing context.

Moreover, the references of the articles which adhered the inclusion criteria were explored in order to retrieve any potential new studies that were not retrieved in the first stage of the search. The majority of the detected articles were suitable to enter the review in the stage of title and abstract screening. In case of the existence of articles with no provision of their abstract, then their full-text has been ordered with the help of librarians and assessed. The selection process of the articles was based on the flowchart which was recommended in the PRISMA statement (Moher et al, 2009). The flow of articles' inclusion and exclusion in the literature review is presented in Figure 1.

Figure 1. Flowchart of literature search strategy.

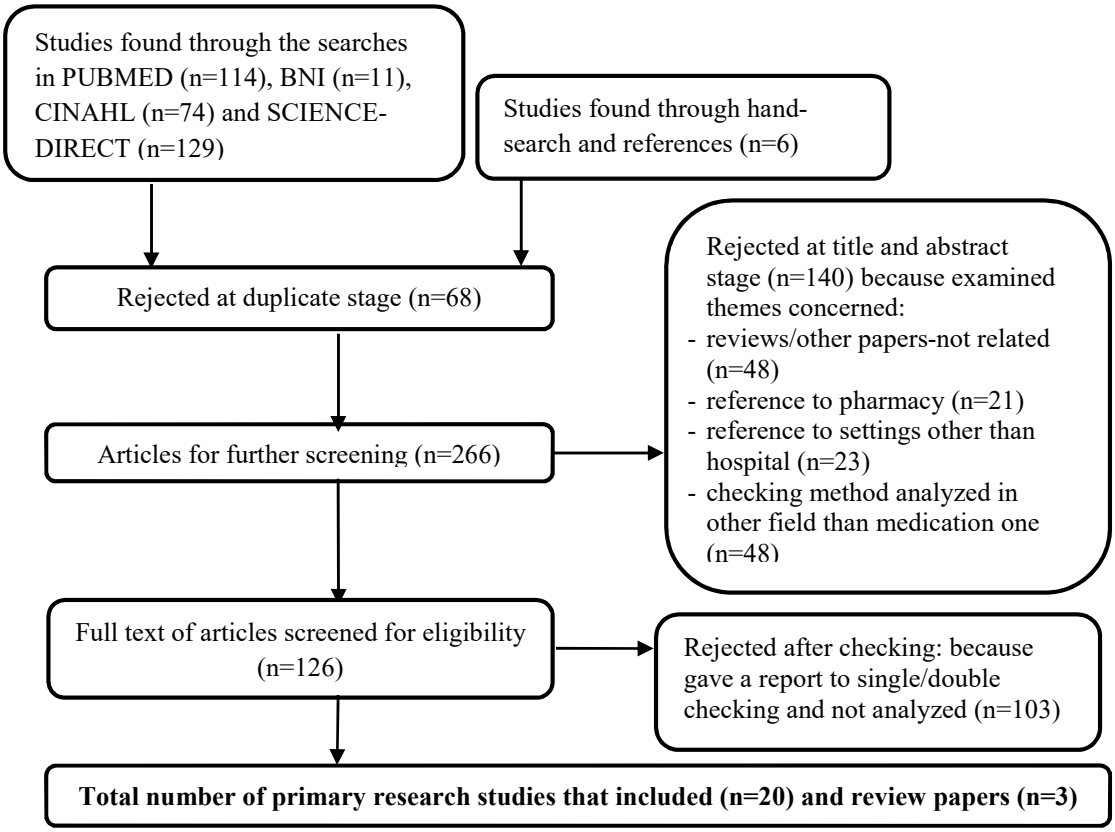

Table 1. Summary of key features of the research articles that were included in the present review.

Authors, year and country	Objective	Methodology	Major findings
Winson (1991) UK	To examine nurses' attitudes towards single MA.	N=328 RNs and ENs from 6 specialities from 2 hospitals in one district health authority. Use of questionnaire (8 structured questions with qualitative data).	The majority of nurses considered themselves as able to administer medications alone. After the research, the MA policy received clarifications.
Kruse et al. (1992) Australia	To assess the implication and the cost of using 2 nurses administering non-restricted medications.	Cross-over study. 46 weeks study period. 3 wards of geriatric and rehabilitation unit of a hospital.	319 MEs found for 129.234 MA cases. ME rate when MA was done by a single nurse was: 2.98 (95% CI: 2.45-3.51) and 2.12 (95% CI: 1.69-2.55) by 2 nurses per 1000 MA cases. Additional nursing time of 17.1 h/1000 MA cases, when MA was done by 2 RNs. Statistically significant (29%) reduction in errors. Unclear advantages of double checking.
Ross et al. (2000) UK	To determine the incidence and type of ME and ascertain whether any ME prevention programmes had influenced their prevention.	Retrospective study of MEs documented for a 5 years period. Paediatric wards of a teaching hospital. Review of MEs reports.	195 MEs/5 years. Nurses were responsible for 59% of the MEs. The most common ME concerned the IV route (56%) and the most common drug involved were antibiotics (44%). Double-checking policy for all medications by pharmacy decreased MEs from 9.8 to 6 MEs/year. Change to less punitive reporting of MEs resulted in their increased reporting rate.
Jarman et al. (2002) Australia	The evaluation of the level of nurses' awareness of their responsibility following the introduction of single-checking of medications, their level of confidence in their checking technique and their level of satisfaction with the change.	Qualitative study, descriptive design. Use of a questionnaire and record of medication incident records. Implementation of a single-person checking protocol for 7 months. N=129 RNs who were working in multiple clinics of a hospital.	The application of a checking of medications by one nurse considered to be safe and contributed to the saving of time and enhances their responsibility. During the period of study 4 MA errors were reported, while the same period of the previous year happened 5 MA errors.
Manias et al. (2005) Australia	The assessment of the use of a MA protocol by graduate nurses in their medication management activities.	Descriptive prospective qualitative study. Use of in depth interviews, observations during MA and information from medication protocols. N=12 recently graduate nurses who were working in multiple clinics of a university hospital. For data analysis qualitative and quantitative techniques were used.	The MA protocol included the double checking. Nurses adhered to protocols if they perceived not to impede with other nursing activities. 97% of the sample double-checked the preparation of designated medications in 97% of situations, while they double-checked medications to the patient's bedside in

			80% of situations.
Gosbee (2006) Canada	To compare the effectiveness of 2 methods of independent double-checking.	Usability test. Use of 2 methods to perform double-checking: a flow sheet and the verbal read-back method. N=2 teams of 4 nurses. Checking of 12 PCA pump set-ups against 12 order forms, using each method for 6 checking times.	Both methods were effective. The ME detection rate was 88%.
Hospodar (2007) USA	To imply a creative time-saving project of improving documentation compliance for double-checking insulin administration.	Participated nurses from 2 inpatients nursing units in a 50-bed rehabilitation center. Use of posters and staff education. Recording of insulin administration times.	Pre-intervention: 187 administrations of insulin/65 double checks. Post-intervention: 230 administrations of insulin/167 double checks. Increase of the double checking compliance from 35 to 72% .
Conroy et al. (2007) UK	To identify MEs occurring and develop methods to reduce their recurrence risk.	Observational study which lasted over 6 weeks in a children's' hospital. 139 prescription and MA in 253 patients were checked. Over than 60 drug administration rounds.	63 interruptions were recorded. 9 actual errors and 141 violations of procedure. Failure to follow double checking in 16% of the patients it was not performing.
O'Connell et al. (2007) Australia	To examine nurses' perceptions towards the single-checking of medications, before and after its application.	Intervention study (prior and after the implementation of single-checking procedure). Two questionnaires used in two separated phases, approximately 18 months. N=124 nurses prior and n=122 after the implementation of this method, who were working in multiple clinics of a hospital with 16 years of experience on average. Data analyzed descriptively.	After the implementation of single-checking nurses' confidence (43%), accountability (44%), and drug awareness (33%) have been increased. 22% of nurses 'did not feel confident to their skills to check drugs independently'. Overall, nurses' perspectives about medication single-checking became positive, after their training relevant with the application of this method.
Armitage (2008) UK	The research of the double-checking procedure of medications using data from another larger study concerned MEs etiology and their report.	Mixed methodology. Study of 991 reports of MEs and 40 in depth interviews with health professionals from a university hospital.	Double-checking procedure should be applied selectively, when there is plenty of time and when the staff can comprehend the procedure. 4 themes emerged: deference to authority, reduction of responsibility, automatic processing and lack of time.
Davis et al. (2010) Australia	The evaluation of the importance of contextual and policy factors on nurses' judgment about MA practice.	Quantitative study. Questionnaire survey. Applied a number (6) of factorial vignettes. N=185 nurses, who were working in multiple clinics of a tertiary pediatric hospital (medical, emergency, surgical, intensive care) with >6 years of experience.	The double check of patients' identity, the medication and the verification of medical order were the factors that affect nurses' actions during MA.
Dickinson et al. (2010) New Zealand	To assess nurses' understanding and the practice of double-checking of medications, the factors that foster and impede the	Descriptive qualitative study. N=19 nurses who were working in wards of a pediatric hospital. Data collected via 3 focus groups and thematic analysis was used for their analysis.	The independent double-checking was deemed as a practice particularly essential in pediatric clinics. There were factors that affected its implementation during MA.

	application of independent double-checking.		
White et al. (2010) Canada	To determine the elements of a list which contributed to the effective detection of MEs.	High fidelity simulation study. N=13 nurses, who were working in outpatient chemotherapy clinics.	The explicit determination of the steps of a nursing intervention is a preventive measure for specific error types, when nurses are required to perform a long series of mechanistic tasks under a high cognitive load.
Popescu et al. (2011) Australia	To explore the multifactorial influences on medication quality and safety in the context of single-checking policy for MA acute care.	Exploratory/descriptive study. Non participant observations. Follow-up semi-structured interviews. N=11 RNs. 30 medication episodes observed in a medical and surgical ward in a tertiary referral centre. Use of thematic and content analysis.	MA safety and quality were influenced by the therapeutic relationship, ward design and deviation from best practice guidelines. During medication rounds nurses experienced fewer interruptions and their overall duration was decreased.
Conroy et al. (2012) UK	To establish what policies there are in the UK children's units of checking medications and to discuss evidence on the different processes in use.	Survey of 105 questionnaires from 59 NHS Trusts with 69 hospitals. N=41 pharmacists and n=26 nurses from neonatal and children's units.	A role for single and double-checking depends on risk assessment. Double-checking was performed for certain medications.
Gill et al. (2012) Australia	The study of nurses' compliance with the adherence of a MA protocol and the reasons of non-compliance with it.	Mixed methodology design. N=72 RNs who answered the questionnaire and n=24 RNs that participated in focus groups, who were working in a NICU in a tertiary pediatric hospital.	Differences were found between the level of nurses' experience and their compliance with the protocol adherence. Nurses' non-compliance with the medication protocol observed more in the checking of patients' identity and the medications' double-checking.
Van Veen (2012) Canada	To implement independent double-checking in 2 different methods.	Pilot study in an outpatient oncology unit with oncology nurses as participants. 1st method of double checking: the resource nurse applied it for all chemotherapy medications, 2nd method: each nurse was responsible to performed it upon request.	Nurses were concerned about certain areas of the effectiveness of checking implementation. The 2nd method seemed to be more suitable. Modifications in patients flow and in the nursing schedule have done.
O'Connell et al. (2013) Australia	To examine the reliability and validity of the SCAMS.	Secondary analysis of data retrieved from longitudinal questionnaire on nurses' attitudes to single check MA by using a 13 item SCAMS. N=503 nurses with >5 years of experience from 38 wards of a large healthcare centre. Exploratory and confirmatory factor analysis.	Authors recommended SCAMS as a valid and reliable tool before and after the implementation of single-checking policy.
Alsulami et al. (2014) UK	To evaluate how closely double-checking policies are followed by nurses in paediatric areas and also to identify the types, frequency and rates of MA errors that occur despite the double-	Prospective, direct and undisguised observational study. Pediatric nurses had been observed for 4 months for the double-checking process for n=2000 MA cases at PICU, NICU, medical and surgical paediatric inpatients, total n=876.	The lowest (30%) double-check adherence rate concerned the 'dose calculation' step. A statistically significant difference found for double-checking medications in nine steps during weekends rather than weekdays. The MA error rate was 9.6% of

	checking process.		the total MA cases, with the most of the cases the MA by parents while the nurse was absent. Three limitations mentioned: study conducted in a single hospital, possible effect of the observer at nurses' performance and not all single administrations observed.
Bülbül et al. (2014) Turkey	To determine the levels of knowledge related with MA and MA errors of nurses.	Cross-sectional and descriptive design. Use of questionnaire and face to face interview. N=98 nurses from paediatric wards: <5 years 71% and >5 years 27% of the nurses.	Interruption/distraction rate during medication preparation was 92.9%. Checking adherence of high risk medications by 2 nurses was 64.3%. Undergraduate nurses were more able to calculate paediatric doses. Common errors: lack of calculation of set portion and errors related medication concentrations and dosage.

MA: *Medication Administration,* ***RN:*** *Registered Nurse,* ***EN:*** *Enrolled Nurse,* ***ME:*** *Medication Error,* ***PCA:*** *Patient-Controlled Analgesia,* ***SCAMS:*** *Single Checking Administration of Medication Scale,* ***PICU:*** *Pediatric Intensive Care Unit,* ***NICU:*** *Neonatal Intensive Care Unit.*

Table 2. Summary of key features of the non research papers (systematic/literature/policy review) that were included in the present review.

Authors, year and country	**Objective**	**Methodology**	**Major findings**
Alsulami et al. (2012) UK	To evaluate the evidence for double-checking the administration of medicines.	Literature search at 6 databases. 3 quantitative, 2 mixed methods, 9 qualitative methods, 2 systematic reviews were included.	There were major practical difficulties in double-checking. Need for further research and scientific evaluation of the double-checking method was expressed.
Australian Commission on Safety and Quality in Health Care (2013) Australia	Does double-checking by nurses reduce medication administration errors and improve safety?	Literature search at 5 databases. 17 studies included.	Double-checking was correlated with increased workload for nurses. Not enough evidence about the effectiveness of double-checking, but carried it out in certain situations.
Kellett & Gottwald (2015) UK	To provide evidence about double-checking high-risk medications and support nurse managers to their decision making on safe medication administration practice in clinical settings.	Critical literature review which was undertaken as part of an MSc. 11 primary research articles reviewed.	a) Evidence for double-checking, b) processes to support double-checking, c) human factors affect double-checking.

Findings

The total number of retrieved studies from the literature search was 23. Specifically, 20 primary research articles and 3 review articles (including one systematic review) were detected. The key features of the research articles are presented in Table 1 and that of the reviews in Table 2.

From the total number of articles, the method of checking during medication preparation and/or administration was investigated as the main research topic in thirteen articles: single-checking was explored in five studies (Winson et al, 1991; Jarman et al, 2002; O' Connell et al, 2007; Popescu et al, 2011; O'Connell et al, 2013), double-checking in seven (Gosbee, 2006; Hospodar et al, 2007; Armitage, 2008; Dickinson et al, 2010; Van Veen, 2012; Alsulami et al, 2014; Kellett and Gottwald, 2015) and checking (in general) in one (Conroy et al, 2012). Whilst, in the rest research studies the checking method was analyzed in the context of another basic theme e.g. nurses' compliance with the implementation of a medication administration protocol (Manias et al, 2005).

The findings of the present review were clustered in the follow categories: definition inconsistency, single-checking, double-checking, cases of checking application, benefits and drawbacks of checking, medication errors and promoting and supporting ways for checking method.

Definition inconsistency

In the studies that included in the present review, the procedure of double-checking was firstly described by Dickinson et al. (2010) in four stages. Worth mentioning that there was a variety of interpretations of what the independent double-checking means exactly, but Dickinson et al. (2010) gave a clear step by step definition. A modified double-checking approach of these stages is presented in another reference, as well (Australian Commission on Safety and Quality in Health Care, 2013). Thus, underlying the fact that there was confusion as to the accuracy of the steps, their sequence has been described as follow:

- stage A: the application of the 5 rights from both nurses,
- stage B: calculation of medication dosology (independently-each nurse separately or simultaneously-doing the calculation together or the second nurse observes the first while doing the calculation or the first nurse shows the calculation result and the other checks if it right or not),
- stage C: medication preparation (medication is prepared by both nurses or by a single nurse whose actions are observed from the second one),
- stage D: medication administration (the medication is administered by the nurse with or without the presence of the second one) (Dickinson et al, 2010).

The process of double-checking has been described once more in a literature review paper. The authors outlined that the mechanism of double-checking should be developed within the 'systematic processes' context, thereby in their paper, the six steps of double-checking were described within the above context (Kellett and Gottwald, 2015).

Another crucial aspect of the double-checking is that one which concerned the professionals who were involved in it. Manias et al. (2005) supported that 'double-checking involved the process of having two nurses checking medications before administration' and according to the hospital protocol the two nurses had to check specified medications at the bedside. Despite this, other authors considered an approved trained enrolled nurse with a registered nurse (Winson et al, 1991) or a nursing student or sometimes a health care assistant and a nursery nurse as a second checker with a register children's nurse (Conroy et al, 2012). However, in a more recent paper it was stated that '...(double-checking) requires two qualified health professionals, usually nurses, checking the medication before administration to the patients' (Alsulami et al, 2014, p 1406). In this context, 'one nurse performs the task, the other one checks her/his work' and 'each nurse performs task independently and answers then compared' (Conroy et al, 2012), besides independently means without any input from the first practitioner (Baldwin and Walsh, 2014). The

principal reason of performing steps independently is to avoid any confirmation bias. In a study, double-checking was named as independent and the above factor of bias was investigated, without managing to found any difference before and after the intervention (White et al, 2010).

In four studies the elements that nurses took into account when they double checked medications were recorded. For instance, two studies that were conducting in paediatric settings gave detailed description of the factors that nurses were double checked: a) child's identity (applied in 90 out of 105 respondents), dose (89 out of 105), calculation (87 out of 105), prescription (86 out of 105), drug preparation (83 out of 105), child's weight (80 out of 105) and administration (72 out of 105) (Conroy et al, 2012) and b) drug due (92% adherence rate), correct drug (98% adherence rate), correct dosage formulation (90% adherence rate), dose calculation (30% adherence rate), measurement of dose (99% adherence rate), drug route (97% adherence rate), drug expiry date (95% adherence rate), allergy check (93% adherence rate), patient identity (96% adherence rate), administration to patient (83% adherence rate) and finishing with the documentation to medication record (99% adherence rate), plus more 4 steps for IV medication administration: drug diluents and volume (93% adherence rate), IV volume (92% adherence rate), rate of IV bolus (71% adherence rate), flush syringes labelled (67% adherence rate) (Alsulami et al, 2014).

In the other two studies, nurses' actions when administering medications included double-checking of patient's identity, medication and prescription's legality (Davis et al, 2010) and checking of route, dose, medication, (98.5%), time, time congruent, document administration (92-95%) and patients' identity (81.5%) (Gill et al, 2012). The experienced nurses were influencing the less experienced nurses concerning the double-checking patients' identity at the bedside (Gill et al, 2012).

Single-checking

One of the first studies which examined nurses' attitudes to single-checking policy showed increase of nurses' accountability, awareness and they considered that new policy as beneficial. A registered nurse's positive perspective was: 'a single person will be extra careful', while there were cases in which errors occurred even though medications have been checked by two people. Thirty seven per cent of the nurses both enrolled and registered were opposed to the new policy considered that the single-checking was unsafe and dangerous and that the double-checking should be mandatory. With regard to the question of allowance of enrolled nurses to administer medications alone, no considerable difference (48% versus 50%) found between those who agreed and disagreed. Checking should be performed by two nurses and at least one of them should be registered, commented a registered nurse who disagreed about the allowance of an enrolled nurse to administer medication alone (Winson et al, 1991).

Jarman and colleagues (2002) investigated nurses' ability against the single-checking of medications. Medication checking by a single nurse reinforced nurses' autonomy and responsibility and there was high level of satisfaction with the change to single-person checking. Nurses also felt moderately to extremely aware of their level of awareness of responsibility and high confidence. Furthermore, there was a severe disadvantage: double-checking of medications was reasonably featured as time-consuming activity due to the additional amount of time spent by nurses to found colleagues or interrupt them to double check. After the implementation of single-checking medications, the overall time saving was 3 hours and 25 min, with 20 min as the average time saved when performed a routine medication round. Through nurses' statements it is supported that the saved time can be used to fulfill patients' needs. Overall, although some participants felt that single-checking might increase medication errors' potential, authors assumed that double-checking could be as effective as single-checking (Jarman et al, 2002).

In another subsequent research, nurses' attitudes before and after the implementation of the medication checking by a single nurse were explored. The findings of the study supported that through nurses' education and experience in the application of single-checking, their attitudes

became more positive towards its implementation. Almost half of the nurses (44%) participated to the research considered that they need 'increased education and support' to gain confidence to single check medications (O' Connell et al, 2007).

Other study in which single-checking policy for medication administration was examined, showed that Australian nurses protected medication administration quality and safety from multifactorial influences and deviations (e.g. interruptions, drug storage issues) through their behaviours (Popescu et al, 2011). Further, one of the last published researches was concerned the establishment of the psychometric properties of the Single Checking Administration of Medication Scale (SCAMS). The questionnaire was consisted of two factors: 'Attitudes towards single checking' and 'Advantages of single checking' with 10 and 3 items and with Cronbach's Alpha values of 0.85 and 0.87 respectively. The authors ended their research up by stressing the value of SCAMS for the health organizations that it can be used as an identification tool of nurses' educational needs about medication administration (O' Connell et al, 2013).

Double-checking

The double-checking procedure was perceived as impractical or unrealistic by nurses participated in focus groups, particularly when the hospital medication protocol does not describe the checking procedure explicitly. The authors concluded that the independent double-checking of medications may be a logical strategy to reduce error rates, if modifications of the applied protocol carried out (Gill et al, 2012). Likewise, double-checking was unlikely to be applied when nurses had to address other commitments (Manias et al, 2005).

White et al. (2010) conducted an evaluation of questionnaires/checklist for detecting pharmaceutical errors in a chemotherapy unit, but failed to demonstrate the effectiveness of double-checking in programming IV infusion pumps by nurses. The old checklist was consisted of 4 steps and after authors' observations the checklist was refined (White et al, 2010). A checklist was mentioned in a Canadian study, as well. The author examined double-checking in oncology settings and displayed a list of the responsibilities while performing checking. The first nurse, that one who checks every detail, is responsible for the patient and the second one, is responsible for the double check itself (Van Veen, 2012).

The adherence rate of double-checking was varied between the studies. At a neonate's unit the rate of double-checking for oral medications and IV was 67% and 76%, whereas for children's unit was 68% and 88%, respectively (Conroy et al, 2012). However, there were studies in which the adherence rate was higher. A study conducting at paediatric settings, double-checking two registered children's nurses needed to be involved in the procedure, according to the hospital policy. In the same study, 90% of the participants adhered the policy (Conroy et al, 2012). Nevertheless, double-checking might not be always performed by all nurses or failed to perform it always at the bedside (Ross et al, 2000; Manias et al, 2005; Conroy et al, 2007).

It was found that double-checking was adhered always/almost always by all nurses with 10-19 years of experience, while difference was identified for the adherence of checking between graduate nurses and the experienced ones. Nurses were not compliant to the medication administration protocol because they were influenced by factors, such as the familiarity with the patient, the medication and the ward culture (Gill et al, 2012). Furthermore, the rate of adherence of the double-checking steps was equal or greater than 90% for 11 out of the 15 total steps. According to the authors, the difference in the adherence rate of the double-checking may be attributed to 'disagreement between nurses or differences in their knowledge of the details of the double-checking process' (Alsulami et al, 2014).

Nurses were supporters of double-checking in paediatrics, primarily for patient safety, medication errors' prevention reasons, their own protection in case of error's occurrence and peer support and education provision to junior nurses. Attitudinal influences included factors like the complacency of the first nurse that the second one will detect any potential error, confidence,

experience and availability of the second nurse to double-check (Dickinson et al, 2010).

In some studies the double-checking procedure was not totally comprehensible. Double-checking was characterized as an 'inconsistent process' and 'multidisciplinary problem', therefore requires multidisciplinary solutions (Armitage, 2008). In other studies it was mentioned that the meaning of double-checking was unclear in the hospital protocol and the need of its revision was highlighted (Gill et al, 2012) or the nurses were confused by identifying lack of clarity concerning the steps they had to follow to double check a medication and in what kind of medications they had to perform it (IV fluids, IV medications, oral medications, controlled drugs) (Dickinson et al, 2010).

Four studies revealed specific elements when the double-checking procedure was explored. In the study of Dickinson et al. (2010) four themes were emerged: independent double-checking is best practice, variability in process of double-checking, environmental influences and attitudinal influences (Dickinson et al, 2010) and in the second study other four themes were emerged: deference to authority, reduction of responsibility, automatic processing and lack of time (Armitage, 2008). Also, the theme of 'Double-checking certain medications before administration' referred among other six themes (Manias et al, 2005). Finally, in the last paper, three themes detected: evidence for double-checking, human factors affect double-checking and processes to support double-checking (Kellett and Gottwald, 2015).

Cases of checking application

Single-checking was permitted in life-threatening situations (Conroy et al, 2012).

Double-checking was applied for:

- medication preparation cases which need compounding or characterized by complexity in their dosology calculation (Winson et al, 1991; Grissinger, 2006; Conroy et al, 2012),
- high risk medications (e.g. high toxicity drugs, such as chemotherapeutic agents, in cases of patient controlled analgesia, preparation for medication administration via pump). In high risk medications are included these that if particular measures not be taken, can cause major patient harm. Examples include certain categories of pharmaceutical substances with corresponding example: adrenergic (noradrenaline), anesthesia (propofol), anticoagulants (low molecular weight heparin), opioids (morphine), antidiabetics (insulin, sliding-scale), electrolytes (potassium) and others. It is worth noting the high risk medications should always be kept in a safe place (ISMP Canada, 2005; Conroy et al, 2012; ISMP USA, 2012; Baldwin and Walsh, 2014),
- the administration of controlled drugs and when drugs added to IV cannulas or infusion and epidural lines (Winson et al, 1991; Kellett and Gottwald, 2015),
- parenteral medications, opioid analgesics and certain oral medications (warfarin and digoxin) (Manias et al, 2005),
- medications which are new and administered for the first time, blockers of peripheral nerves or meshes/neuromuscular blockers, blood bags (and its derivatives) for transfusion (Jarman et al, 2002; Conroy et al, 2012),
- medications which are going to be administered intravenously, orally, unfamiliar medications (except multivitamins, ferrous fumarate and folic acid) or are addictive (Smith, 2004; Conroy et al, 2012; Kellett and Gottwald, 2015),
- all medications should be double checked before their administration (Alsulami et al, 2014), but there could be some exceptions (paracetamol, ibuprofen, oral antibiotics, inhalers) (Conroy et al, 2012),
- pump settings (White et al, 2010),
- high-risk populations: infants, children <12 years old, where the dose is weight related, elderly, pregnant women, patients with renal or liver impairment, congestive heart failure, (Winson et al, 1991; David, 2003; Grissinger, 2006; Conroy et al, 2012;

Australian Commission on Safety and Quality in Health Care, 2013).

Benefits and drawbacks of checking

The benefits of the use of medication checking method before their administration concern:

- the administration of the precise medication dosology, which reduces the possibility of occurrence of medication errors associated with inaccuracies in dosology,
- patient safety themes. In the research of Campbell and Facchinetti (1998), has been shown that when people control the work of others, at least 95% of possible errors are likely to be found. Based on these data, a report by the Institute for Safe Medication Practices (ISMP) Canada, says that if the frequency of errors is approximately 5% (1/20), then the application of dual control reduces the chances of error (5% × 5% = 0.25%) to 1/400 (ISMP Canada, 2005),
- the reduced frequency that a nurse is asked by a colleague to confirm the results of his/her work (Easty et al, 2008),
- the enhance of the nurses' critical thinking in relation to the management of pharmaceutical data (Jarman et al, 2002).

Except for the positive factors that support the use of double-checking of medications, its disadvantages are equally important to be reported:

- double-checking procedure of intravenously administered medication may not contribute to the error decrease, if not performed accurately. Besides, it is a time consuming procedure, which discourages nurses to assume responsibility for the medications issues (Torjesen, 2008),
- nurses get used to depend on others to identify potential errors (Grissinger, 2006),
- its application is not attainable when the staffing levels are not sufficient and when patients have high dependency from the nurses (Armitage, 2009),
- In the qualitative study of Dickinson et al. (2010), the level of understanding of the process of double-checking medications in pediatric nurses was investigated. Study's findings articulated that there was a difficulty in the implementation of checking when coexisted influence of environmental factors (interrupted/distracted when preparing medications, overcrowding in medication preparation room, other priorities, increased workload). Another disadvantage noted, related the non availability of written guidelines concerning medication, dosages and dilutions on the preparation room.

Medication errors

Five studies examined the likelihood of medication errors alongside the checking procedure (Kruse et al, 1992; Ross et al, 2000; Jarman et al, 2002; White et al, 2010; Alsulami et al, 2014; Bülbül et al, 2014). As it was illustrated by a British study, in contrast of caring out the double-checking, the medication error rate was about 67% with the majority (96%) of them were minor and 9.2% were errors that needed active intervention (Ross et al, 2000). Minor with no serious adverse consequences errors were observed among 319 medication errors in another study, as well (Kruse et al, 1992).

Regarding the category of medication error, the most common one was the medication administration by parents in their children (patients) while the nurse was absent during administration (Alsulami et al, 2014), pump-programming error, patient-identification error, clinical decision error, mismatch between drug label and other (White et al, 2010). Only in one study was reported that the most common type of medication involved in the error was antibiotics (Ross et al, 2000).

In a study coming from chemotherapy settings, the error detection rate varied from 0-90%, while it was ranged between 80-90% when checklist's items were specified in detail to perform checking. In brief, authors emphasized the fact that analytical checklists could represent an effective tool for the prevention of certain types of errors (White et al, 2010). A checklist was used by Gosbee in a usability laboratory (2006), when performing double checking. A series of

recommendations such as a list of variables to be checked and incorporated in the order form, designed in a way to decrease nurses' cognitive load and be in an explicit way (Gosbee, 2006).

In another recent Turkish study, the authors concluded that in their study group the possibility of medication administration error was highly potential. However, the medication errors that mentioned by nurses when answered an open-ended question were: a set portion calculation error, drug concentration and dosage error (Bülbül et al, 2014).

Promoting and supporting ways for checking method

Examples of ways to incorporate the method of checking in the nursing practice can contain policies development (applied in special cases), development of tools (redesign of order forms, reduce dependence on vigilance or memory), application of human factors engineering principles (ensure reliability, clarity and ease of learning of every above measure) and staff education (emphasize the double-checking's role-that is an assistant tool with the complexion of clinical practice) (ISMP Canada, 2005). For instance, nurses' perceptions against single-checking of medications can be achieved by using educational methods and medication strategies changes. In their study, O'Connell et al. (2007) utilized discussion sessions, medication administration policy revision and writing material. Clearer guidance and training programme for nurses proposed in a recently published study (Alsulami et al, 2014).

Some more strategies relevant to clinical practice to ensure safe medication administration in paediatric patients included the clarity of double-checking in the polices, training of staff about this method, creation of environment that supports checking, design of special rooms for safe medication preparation and have access to resources (Dickinson et al, 2010).

Discussion

Safe medication management is a critical point for patient safety. The effectiveness of single and double-checking has been questioned in recent years. Double-checking has been incorporated in the everyday clinical nursing practice and has been acknowledged as a 'standard nursing procedure' by many healthcare organizations, particularly in the United Kingdom (Alsulami et al, 2012). Yet, from the results of the present review no clearly comprehensive data can be drawn.

Three review papers were detected and included in the present review. Their key features are presented in Table 2. The integration or not of the technique of double-checking medications before their administration, has not been proved adequately in a recently published systematic review of sixteen studies by Alsulami et al. (2012). In the second review paper the authors concluded that double-checking was carried out in certain situations: high-risk situations, patient populations and with high-alert medications (Australian Commission on Safety and Quality in Health Care, 2013). The last review paper summarizes data about double-checking when administer high-risk medications. In that paper, basic evidence for nurse managers are provided. The main conclusion was that double-checking for high-risk medications could be an effective strategy to improve patient safety (Kellett and Gottwald, 2015).

Human factors principles for patient safety: design for standardization and simplicity, know your users, participative design, design in safety, understanding when and why things may go wrong, make it easy for staff to do the right thing, procedure for safety, understand teamwork, think about how it all fits together, manage change) have been described by Norris (2009). Especially in nursing, there are tools (root case analysis, incident decision tree, foresight, team working, safety culture measurement, procuring medical devices and equipment) available for nurses to improve patient safety. The value of the above principles and tools in the healthcare field can be assessed when patient safety and health system issues are under examination.

A further facet of the subject is that independent double-checking of medications by pharmacists can limit medication errors. The reason of why is the concrete method applied is more likely to catch medication errors of endogenous ('errors arise within the mind of the individual'), rather exogenous ('errors arise from characteristics of

the task or a poor display of numbers and decimal places') originality. In the second case, there is high risk of occurrence of the psychological phenomenon factor called 'confirmation bias' (David, 2003). Thereby, double-checking should be independent in order to reduce possible bias (Alsulami et al, 2012).

Many studies used paediatric nurses as sample. This direction of conducting the studies in paediatric settings was probably correlated with the fact that double-checking of medications was especially for paediatric patients, a group of patients which the medication administration to them requires double-checking (Davies et al, 2010; Dickinson et al, 2010; Conroy et al, 2012; Gill et al, 2012; Alsulami et al, 2014).

In their everyday practice nurses undertake medication rounds and they are always vigilant to ensure safety during the entire process. Neglect of one of the steps of the 5 rights validation is more likely to happen when nurses are interrupted and this may result to medication error/s: wrong drug, wrong patient, wrong dose, wrong time and wrong route (Tang et al, 2007). Another aspect of the medication administration is the place of checking i.e. patients' bedside or not. According to an Australian hospital protocol, nurses were guided to check specified medications to the patient's bedside with the 80% of them adhered this practice (Manias et al, 2005).

When analyzing issues about the method of checking medications prior to their administration, a core theme is time. Single-checking facilitates the medication administration as to the concept of administer medications in time (O' Connell et al, 2013). Especially, that is the time saving that has been discussed in previous papers (Kruse et al, 1992; Jarman et al, 2002; Conroy et al, 2012; Alsulami et al, 2012; Australian Commission on Safety and Quality in Health Care, 2013). The fact of finding another nurse to perform the medication checking is usually a time-consuming process which is rendered hard in busy wards. Double-checking of controlled medications, like morphine oral solution has been questioned by author, underlying the possibility of staff shortage in addition to the waiting time for the second checker to perform checking, so that the patient will receive analgesia in a reasonable time (Mallard, 2003). After all, the additional time could be focused on patient-centre care provision (Jarman et al, 2002).

The establishment of protocols among hospitals remains a necessary policy. Double and single-checking process should be described, clearly clarified in the medication administration protocol and standardized (Popescu et al, 2011). One hospital's standard about double-checking was: 'All parts of the drug administration process should be checked from start to finish'. However, in some cases checking protocols may not be adhered by nurses (Conroy et al, 2007). Also, it is of practical relevance themes like: drug board designing (the drug boards to have boxes for double signature for every medication dose and space for clear medication prescribing) and the establishment of protected times for nurses in order to be able to perform the medication preparation and administration with as few as possible interruptions (Conroy et al, 2007).

An upside of the review was the provision of research evidence about the method of checking medications prior to administration by nurses. The present paper can be useful to investigate patient safety, medication errors and hospital policies relevant themes and a useful source of knowledge for professionals who are engaged in the clinical practice like registered nurses and nursing managers. However, there are some limitations that have to be mentioned: all stages of the review performed by one author and the data which assessed was published in English and in specific databases.

Conclusion

Single and double-checking are methods that matter to patient safety and nursing at the same time. The application of the method of double-checking is a measure that contributes to safe medication preparation and administration to patients, without implying that errors in these procedures can be reduced to great extent. Double-checking of medications should be recognized as a routine clinical procedure, rather than as an independent and individual action. For the incorporation of checking method in the clinical nursing practice, it is necessary to recognize and address both the factors that hinder

its performance by nurses, but also those ones which facilitate its effectiveness. However, due to existence of limited evidence-based knowledge on this subject, it is difficult to draw accurate and clear conclusions.

Future research

Armitage (2008) proposed that psychological research may pervade the subject about the aspect of the susceptibility of professionals' abilities on double-checking. Report to aviation industry and a skills list and structure plan for error management that can be transferred to the healthcare services, as well. As the Australian Commission on Safety and Quality in Health Care (2013) demonstrated through examples there are endpoints around the subject that need further investigation, such as lack of resources, individual responsibility, practically, hierarchy, environmental and lack of active processing.

It is necessary to conduct further research for the refinement of the whole checking procedure (e.g. its relation with the law), research studies (clinical trials) to explore issues related to the efficacy of either single or double-checking of medications during their preparation and administration by nurses and their importance in reducing medication errors (Alsulami et al, 2012), education campaign for the nurses to comply with hospital protocol (Gill et al, 2012) and ways of elimination of human verification bias (White et al, 2010).

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