



Review

Systematic review and meta-analysis of educational interventions designed to improve medication administration skills and safety of registered nurses



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ABSTRACT

Objectives: The aim of this study is to evaluate the nature, quality and effectiveness of educational interventions designed to increase the medication administration skills and safety of registered nurses working in hospitals.

Design: A systematic review with meta-analysis.

Data Sources: Intervention studies designed to increase the medication administration skills and safety of nurses, indexed in one or more databases (CINAHL, PubMed, Scopus, Cochrane, PsycInfo, or Medic), and published in peer-reviewed journals between January 2000 and April 2015.

Review Methods: The nature of the interventions was evaluated by narrative analysis, the quality of studies was assessed using the Effective Public Health Practise Project Quality Assessment Tool and the effectiveness of the interventions was ascertained by calculating effect sizes and conducting a meta-analysis.

Results: A total of 755 studies were identified and 14 intervention studies were reviewed. Interventions differed by their nature, including traditional classroom training, simulation, e-learning, slide show presentations, interactive CD-ROM programme, and the use of posters and pamphlets. All interventions appeared to improve medication administration safety and skills based on original p-values. Only five studies reached strong ($n = 1$) or moderate ($n = 4$) quality ratings and one of them had to be omitted from the meta-analysis due unclear measures of dispersion. The meta-analysis favoured the interventions, the pooled effect size (Hedges' g) was large, 1.06. The most effective interventions were a blended learning programme including e-learning and a 60-min PowerPoint presentation. The least effective educational intervention, an interactive internet-based e-learning course, was reported in the study that achieved the only strong quality rating.

Conclusions: It is challenging to recommend any specific intervention, because all educational interventions seem to have a positive effect, although the size of the effect greatly varies. In the future, studies sharing similar contents and methods should be compared with each other.

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1. Background

Medication administration is an important responsibility of registered nurses (RNs) (Sung et al., 2008), but despite being one of the most common nursing interventions (Blank et al., 2011) it is a procedure that is prone to errors (Thomas and Panchagnula, 2008; Blank et al., 2011; McLeod et al., 2013). While other phases of the medication process are usually double-checked, the actual administration is usually only verified by the person administering the medication (Schneider et al., 2006). Consequently, medication administration errors (MAEs) are difficult to prevent before reaching the patient (Ford et al., 2010;

McLeod et al., 2013). MAEs can have adverse implications in terms of patient morbidity and mortality (Mansour et al., 2012). Based on a systematic review of 91 studies, the median MAE rate is almost 20% of total error (Keers et al., 2013). Therefore, preventing MAEs is vital for increasing patient safety.

MAEs have been defined, for example, as events involving deviations from the physicians' written prescription (Gunningberg et al., 2014), or as a deviation from medication administration policies, procedures or best practise (Drach-Zahavy and Pud, 2010). Commonly used definitions in studying medication errors have been recommended (McLeod et al., 2013). Therefore, we used the widely known definition of National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP, 2015), which defines a medication error as a preventable incident that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare

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professional, consumer, or patient. In this study, medication errors are limited to those occurring during medication administration activities. MAEs include an incorrect dose or medication given to a patient, administration via an incorrect route or technique, at an inappropriate rate, administered at an incorrect time; or the complete failure to administer a medication.

There are many strategies to improve safety in the medication administration process. Some strategies support changing the work design or using directed technology to reduce errors, including bar-code technology. These strategies can be expensive, slow and difficult to implement (Schneider et al., 2006) and require a substantial commitment by the organisation. In addition, many MAEs are result of circumstances that these technologies or system changes do not address (Ford et al., 2010).

Another strategy to improve medication safety is to affect the knowledge, skills and attitudes of health professionals' toward safe medication practices (Schneider et al., 2006). The basis for such strategies is to be found in the many studies that indicate a lack of (medication) knowledge, education, experience and knowledge deficits contribute to MAEs (Kopp et al., 2006; Brady et al., 2009; Kane-Gill et al., 2010; Westbrook et al., 2011; Härkänen, 2014). Moreover, previous studies have found significant improvements in MAE rates after investing in nurse education and training initiatives (Keers et al., 2014). Nonetheless, MAEs are thought to be product of a multitude of factors, including human error and system characteristics, such as resource availability, organisational policies and procedures (Xu et al., 2014), high anxiety, distractions and procedural complexity (Hohenhaus et al., 2008). Identify or separating the contribution of these factors to MAEs is difficult.

According to Schneider et al. (2006), few attempts have been made to study educational interventions aimed at improving medication administration. Since then, however considerable improvement has occurred in the field of patient safety, such that we assume that the volume of educational interventions has increased along with other patient safety interventions. There is one earlier systematic review of the impact of interventions designed to reduce hospital MAEs (Keers et al., 2014). Keers et al. (2014) included only randomised controlled trials (RCTs) and controlled trials in their review, only three of which concerned nurse education and training. The present review and meta-analysis aims at studying the educational interventions offered to nurses and aimed at improving the medication administration in hospital settings. To the best of our knowledge, this is the first systematic review and meta-analysis regarding this topic.

2. Method

2.1. Aims

The aim of this study was to evaluate the nature, quality and effectiveness of educational interventions designed to increase the medication administration skills and safety of registered nurses working in hospitals.

The specific research questions were:

- What kind of educational interventions have been conducted to increase the medication administration skills and safety of registered nurses? (Narrative synthesis)
- What was the quality of these intervention studies? (Quality assessment)
- How effective have interventions been in reducing MAEs and/or increasing safety or skills? (Meta-analysis)

2.2. Search Strategy

The process of identifying studies was performed by (MH) and a librarian. Six databases were reviewed: CINAHL, Scopus, Cochrane, PubMed, PsycInfo, and Medic (Finnish). Only peer-reviewed studies

published in English or Finnish between 1st of January 2000 and 9th of April 2015 were included. In the Cochrane database, only clinical trials were chosen for review.

The PICO method (Participant = registered nurses in hospitals/inpatient settings; Intervention = educational intervention; Comparison = no intervention/other intervention; and Outcome = medication administration skills/safety of medication administration) was used to define the research question, inclusion and exclusion criteria, and search strategy. Search terms were chosen based on preliminary searches and included (in English): medication/drug; administration, safety/error/incident/near miss; skill/competence; nurse. Search terms were modified slightly depending of the database used and combined with Boolean operators. The modification was pre-tested and final form decided with the librarian. MH interrogated the databases on April 9, 2015. All search results were printed for later selection of the studies. Seven hundred fifty-five references were identified from the six databases. (Fig. 1.)

2.3. Selecting Studies and Extracting Data

Studies were independently selected by two reviewers (MH and ET) according to an inclusion and exclusion criteria decided beforehand.

The inclusion criteria for final analysis were as follows:

- 1) Intervention studies including RCTs, Controlled Clinical Trials (CCTs), Cohort analytic, Case-control, Cohort, and Interrupted time series studies (following Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies and its dictionary)
- 2) Studies reporting the administration of any medications by registered nurses
- 3) Studies performed in the hospital/inpatient settings, all wards including intensive care unit, emergency department, and operating rooms; both adult and paediatric patients
- 4) Peer-reviewed research articles published in English or in Finnish

The exclusion criteria were:

- 1) Studies reporting other than educational interventions
- 2) Studies reporting administration of medications by other health professionals or nurse students, or studies reporting e.g. prescribing or dispensing of medications
- 3) Studies performed in the outpatient settings, assisted living and nursing homes
- 4) Grey literature including theses and conference proceedings etc.

Of the original 755 references, 726 references were excluded based on a cursory examination of the article titles and/or abstracts, and study criteria. Based on a more comprehensive reading of the full text of the articles, an additional four studies were excluded. After removing duplicates ($n = 14$) and adding other relevant articles ($n = 3$) found during preliminary searches and reviewing reference lists of articles, 14 articles were accepted under review. (Fig. 1). Data extraction and narrative synthesis were performed by MH and ET.

2.4. Assessing the Quality of the Selected Studies

The quality of the 14 studies were assessed independently by two reviewers (MH and KV-J) using the EPHPP Quality Assessment Tool for Quantitative Studies and its dictionary (2015). The component ratings in this tool include evaluations of a) Selection bias, b) Study design, c) Confounders, d) Blinding, e) Data collection method, f) Withdrawals and Drop-outs, g) Intervention Integrity, and h) Analyses. A global rating of each study was made based on components A–F and using the following scale: 1) Strong (no weak ratings), 2) Moderate (one weak rating), and 3) Weak (two or more weak ratings). After independently assessing the quality of the studies, the reviewers compared the results of their assessment and discussed their findings to reach a consensus. (Table 1.)

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