Original research

Maths anxiety and medication dosage calculation errors: A scoping review

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A R T I C L E   I N F O

A B S T R A C T

A student's accuracy on drug calculation tests may be influenced by maths anxiety, which can impede one's ability to understand and complete mathematic problems. It is important for healthcare students to overcome this barrier when calculating drug dosages in order to avoid administering the incorrect dose to a patient when in the clinical setting. The aim of this study was to examine the effects of maths anxiety on healthcare students' ability to accurately calculate drug dosages by performing a scoping review of the existing literature. This review utilised a six-stage methodology using the following databases; CINAHL, Embase, Medline, Scopus, PsycINFO, Google Scholar, Trip database (http://www.tripdatabase.com/) and Grey Literature report (http://www.greylit.org/). After an initial title/abstract review of relevant papers, and then full text review of the remaining papers, six articles were selected for inclusion in this study. Of the six articles included, there were three experimental studies, two quantitative studies and one mixed method study. All studies addressed nursing students and the presence of maths anxiety. No relevant studies from other disciplines were identified in the existing literature. Three studies took place in the U.S, the remainder in Canada, Australia and United Kingdom. Upon analysis of these studies, four factors including maths anxiety were identified as having an influence on a student's drug dosage calculation abilities. Ultimately, the results from this review suggest more research is required in nursing and other relevant healthcare disciplines regarding the effects of maths anxiety on drug dosage calculations. This additional knowledge will be important to further inform development of strategies to decrease the potentially serious effects of errors in drug dosage calculation to patient safety.

1. Introduction

In the clinical setting, various healthcare workers are responsible for the correct administration of a prescribed drug (Polifroni et al., 2003). The United States Institute of Medicine report, "To Err is Human" stated that as many as 98,000 patients died as a result of medical errors that could have been prevented (Kohn et al., 2000). This report detailed different types of preventable medical mistakes, with the category "treatment errors" including errors in the administration and dosage of a drug. Barker et al. (2002) found that 19% of prescribed medications are given in error, with the administration of the wrong dose of drug being the third most common error at 17%, only after time (43%) and omission (30%).

Administering the incorrect dose of a drug can result from poor drug dosage calculation skills, and can lead to increased patient stay in hospital, adverse side effects, and death (Kohn et al., 2000).

Attaining proficiency and applying a systematic approach to drug dosage calculations is essential during undergraduate and formative studies, and is often a critical factor in passing clinical units of study and hence graduating into professional practice. However, obtaining proficiency or competency is often challenging for healthcare professionals and sometimes increases anxiety levels (Melius, 2012). For example, a review by Eastwood et al. (2009) found that paramedic students lacked the required mathematical proficiency necessary to safely calculate drug dosages in the clinical setting. Furthermore, a study by McMullan et al. (2010) revealed that 92% of nursing students and 89% of registered nurses were unable to pass a drug dosage calculation test. Similarly, Heaton et al. (2008) report that while 24% of medical students are confident with their drug dosage calculation skills, and only 15% of medical students are comfortable with preparing and administering

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medications in the clinical setting.

As many healthcare undergraduate programs have a basic level of maths as a pre-requisite, it is assumed that students entering a tertiary education degree possess a basic understanding of maths and the ability to undertake basic calculations (Jukes and Gilchrist, 2006). Healthcare workers encounter mathematical problems constantly from drug calculations, to measuring blood pressure, heart rate, weights and time (Wright, 2004). Whilst maths proficiency is essential in the healthcare setting, Tobias suggests that students enrol in nursing and other health sciences because they feared number manipulation (Tobias, 1978). Students who believe they are not able to master the concepts of basic mathematics are more likely to suffer with maths anxiety, according to Glaister (2007) and thus are more likely to avoid careers believed to have a large maths component (Beilock and Maloney, 2015). Furthermore, anxiety not only related to the performance of a maths activity, but also to learning or thinking about mathematics, can negatively affect performance (Ashcraft and Kirk, 2001; Beall et al., 2015).

Maths anxiety refers to "a feeling of tension, apprehension, or fear that interferes with math performance" (Ashcraft, 2002) or "negative affective responses to mathematics" (Hoorfar and Taleb, 2015). Maths cognition occurs through working memory, a sequence of thought processes involving storage and tracking of a maths calculation (Ashcraft, 2002). Maths anxiety directly interferes with maths cognition when the student experiences intrusive thoughts when attempting maths calculations (Ashcraft and Kirk, 2001). This interference leads to an increase in mathematical errors (Bull, 2009). For example, in an experimental study Glaister (2007) found that maths anxiety was apparent in 20% of second year student nurses, and Bull (2009) reported a prevalence of 45% in first year nursing students. As maths anxiety increases, so too does the rate of medication calculation errors. Maths anxiety has a statistically significant influence on the accuracy of nurses' drug dosage calculation accuracies according to Melius (2012).

Preis and Biggs described what they called a Maths Anxiety Cycle (Preis and Biggs, 2001). The Cycle is a perpetual continuum during which negative math experiences lead to math avoidance, which in turn causes poor preparation and ultimately poor performance (Preis and Biggs, 2001). Poor maths performance in the clinical setting can lead to incorrect dosages of a prescribed drug to a patient, which can have serious consequences on a patient's well-being. Maths anxiety can impact students at all stages of this cycle, however the poor performance factor in the clinical setting for healthcare students can have extremely serious effects on patients such as adverse side effects, increased stay in hospital and potential fatalities (Kohn et al., 2000).

Ashcraft and Faust assert that maths anxiety originates from a history of failure, embarrassment and denigration when faced with maths problems (Ashcraft and Faust, 1994). However, previous mathematical learning experiences are not the only factor that may influence healthcare student's level of maths anxiety. Self-efficacy, gender, age, ethnicity and teaching methods also influence nursing student's drug dosage calculation abilities (Fulton and O'Neill, 1989, Glaister, 2007; Hodge, 1999, 2002; McMullan et al., 2012; Walsh, 2008).

This study utilised a scoping review approach to investigate the impact of maths anxiety on the accuracy of healthcare students' drug dosage calculations. It is anticipated findings will inform educational providers and researchers with other questions for further research and to highlight the importance of solid mathematical skills in undergraduate healthcare students. A six-stage process was used to identify and analyse the existing literature describing drug dosage calculation errors and maths anxiety in healthcare students.

2. Method

Scoping reviews aim to identify, map and review existing literature on a selected topic (Levac et al., 2010; Davis et al., 2009). Scoping reviews allow the extent of literature available on a research area to be identified, and will assess the value of venturing into a full systematic review. A scoping review was chosen for this study as it was an option that was faster and less costly than a systematic review (Arksey and O'Malley, 2005), and due to the specific nature of the research question, a scoping review allowed a broader body of literature to be investigated. The search is inclusive of both peer-reviewed research and grey literature (i.e. non peer-reviewed material and material that lacks sufficient basic bibliographical information such as author, publishing date and publishing body) in order to obtain a broad overview and to then guide more focussed research. This scoping review used the six stage methodology developed by Arksey and O'Malley (2005). These six stages are:

1. Identify the research question
2. Identify relevant studies
3. Study selection
4. Charting the data
5. Collating, summarising and reporting the results
6. Consultation (optional)

The consultation stage is considered optional, however in order to gain the most available information on this topic, experts in the topic area were contacted.

2.1. Identify the research question

The research question that guided this scoping review was: Does maths anxiety increase the incidence of drug calculation errors in healthcare students? As suggested by scoping review methodology (Levac et al., 2010) the question was formulated to be broad, and as such, encompass all disciplines of healthcare students to allow for a wide cross-sectional summary of available literature.

2.2. Identify relevant studies

A comprehensive search of multiple databases was undertaken using the search strategy outlined in Table 1. This search strategy was chosen to enable the research question to be answered by encompassing an extensive range of literature while maintaining feasibility in terms of staff and resources. The following databases were searched: CINAHL, Embase, Medline, Scopus, PsycINFO, Google Scholar, Trip database (http://www.tripdatabase.com/) and Grey Literature report (http://www.greylit.org/). The grey literature sites and Trip database were searched in order to identify non-peer reviewed papers.

There was no date limits placed on these searches. The initial search yielded 417 articles. A title and abstract review resulted in 24 articles remaining. Full text review left six articles selected for the scoping review study (Fig. 1). A search term strategy was established and was undertaken by both authors and verified with a specialist librarian. Table 1 outlines the MeSH terms and keywords used in each database for this search strategy.

2.3. Study selection

Studies were selected if all of the following three inclusion criteria were met:

1. The article addressed the construct of maths anxiety