An evaluation of the drug calculation skills of registered nurses

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ABSTRACT

Mathematical skill and proficiency underpin a number of nursing activities, with the most common application being in relation to drug dosage calculation and administration. Medication errors have been identified as the most common type of error affecting patient safety and the most common single preventable cause of adverse events and they can occur as a result of mathematical calculation error and or conceptual error. The purpose of this study was to evaluate the drug calculation skills of registered nurses ($n = 124$) on commencement of employment. The findings of this study indicate that there are inconsistencies in the amount of pharmacology content and drug calculation skills delivered within nursing curricula. The most frequent type of drug calculation errors are attributed to conceptual errors and participants identified ward based education on drug calculation as a pathway for improving the drug calculation skills of registered nurses. The study recommends that medication education, encompassing mathematical and conceptual drug calculation skills should be identified as a distinct competency in nursing curricula and continuing education programme.

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Introduction

Medication errors occur in approximately one in every five doses in a typical hospital (Barker et al., 2002) and have been identified as the most common type of error affecting patient safety and the most common single preventable cause of adverse events (National Medicines Information Centre, 2001). Carlton and Blegen (2006) argue that medication errors occur due to active failures and latent conditions, with active failures including dosage calculation. Mathematical errors have been associated with 11–14% of medication errors (Segatore et al., 1994; Wirtz et al., 2003). Whilst drug administration is predominately a nursing responsibility, both doctors and nurses have been found to make errors when calculating medication doses (Wirtz et al., 2003; Calabrese et al., 2001). Mathematical skill and proficiency are prerequisites to accurate medication calculations as the preparation of some medications require a number of complex calculations (Beaney, 2010). Two mathematical skills are necessary to achieve accurate drug dosages; the ability to calculate mathematically and the ability to extract relevant information from available clinical information in order to formulate a mathematical calculation to be solved (Wright, 2004).

The inability to accurately calculate medication dosages has been deemed to considerably contribute to the possibility of making a medication error (Oldridge et al., 2004; Preston, 2004; Haigh, 2002; Segatore et al., 1994). It is also argued that there is insufficient evidence to suggest that nurses' calculation skills cause medication errors (Wright, 2010; Sherriff et al., 2011). Therefore, this study aimed to further develop the existing body of knowledge by evaluating the drug calculation skills of registered nurses on commencement of employment.

Literature review

Poor drug calculation skills have been demonstrated amongst student and registered nurses (Gladstone, 1995; Hutton, 1998; Weeks et al. 2000; McMullan et al. 2010), even when assessed directly prior to graduation (Dilles et al. 2011). Adverse outcomes have occurred as a result of miscalculations (Calabrese et al., 2001) with calculation errors being identified in 12% of intravenous medications where a calculation was required (Wirtz et al., 2003).

It has been identified that student nurses recognise the importance of mathematics in patient safety, and the seriousness that errors may mean for patients (Walsh, 2008). However, the drug calculation skills of nursing students have been found to be inadequate with regard to mathematical calculation deficiencies, mathematical skill and conceptual and measurement inabilities (Gladstone, 1995; Jukes and Gilchrist, 2006). Misplacement of decimal point is identified as one of the most frequent

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mathematical errors (Kapborg, 1995; Grandell-Niemi et al., 2003). Student difficulties predominantly relate to fractions, ratios and interpreting information pertaining to drug calculations (Wright, 2005). Findings amongst students who have been assessed have varied. Wright (2005) identified average test scores of 53%, with 37.5% of students unable to answer half of the questions. Dilles et al. (2011) assessed students directly prior to graduation from 29 participating schools, found mean scores of 66% in a calculation test. Grandell-Niemi et al. (2005) explored the calculation skills of Finnish nurses and nursing students. They found that 50% of students attained a score of 67%, and 57% of nurses attained a score of 79%, with registered nurses having better scores than students. Polifroni et al. (2003) investigating how mathematical competence is validated for nursing practice in academic and acute care facilities found that validation procedures prior to medication administration were in place for 98% of nursing programs and 100% for acute health care facilities, and 87% of programs had policies with regard to mathematical skills. They questioned how a pass mark of 70% can be acceptable when even one error is unacceptable in clinical practice. However, Wright (2010) argues that there is insufficient evidence to suggest that poor results in calculation tests translate into medication errors in practice.

Education, support and supervision in clinical practice are frequently identified as factors to promote safe administration of medications, of which drug calculation is an integral part (Beaney, 2010; Dickinson et al., 2010), with a variety of strategies being advocated including computerised assessment of medication calculations (Hutton et al., 2010). Studies with registered nurses identify that nurses perceived that they did not have enough pharmacological knowledge for practice, which included drug administration, nurse prescribing and patient and student nurse education (King, 2004; Manias and Bullock, 2002). Conversely, it is argued that the existing evidence base is insufficient to assert that nurses' poor calculation skills contribute to medication errors (Wright, 2010; Sherriff et al. 2011). Wright (2010) and Sherriff et al. (2011) conclude that more research is needed into calculation errors in practice.

Methodology

The aim of the study was to evaluate the drug calculation skills of registered nurses commencing employment in 5 major academic teaching hospitals in the Irish Republic.

The first objective was to evaluate both the numerical skills and cognitive processes used by nurses to calculate drug dosages and rates. The second objective was to gain insight into the nature of education and support that nurses may have experienced around safety in drug calculation. It is anticipated that the findings will inform the education and professional development of practising nurses.

Research design

A cross sectional survey design incorporating mixed methods was utilised to ensure confirmation and completeness of the data and to expand and achieve a fuller understanding of the phenomenon under review (Doyle et al., 2009).

Sample

Five study sites, all major academic teaching hospitals in the Irish Republic, were purposively selected to access a cohort of registered nurses undertaking orientation programmes. Accessing those commencing employment was deemed the most practical opportunity to access registered nurses in a setting conducive to

taking a drug calculation examination ($n = 228$). Over a six-month period registered nurses commencing employment were invited to participate in the study. Participation was voluntary and participants were notified of the examination before administrating the test. The sample size was confined by the number of new staff commencing employment in the study period. The conduct of the examination was facilitated during the orientation programme but was a voluntary endeavour, one hundred and twenty four nurses ($n = 124$; 54%) across the study sites took part.

Research instrument

The questionnaire was developed through pilot work and field-testing to establish validity and reliability. It comprised of two sections, Section 1 had 8 items seeking background information on the participants' gender, age, mathematical education prior to commencing nurse education, academic level of nurse education course and main work department. Two open ended qualitative questions were included to gain insight into the participant's personal experiences of drug calculation education within their nurse registration course and provided an opportunity for them to offer information on how drug calculation skills may be enhanced. Section 2, consisted of a 20-item drug calculation test adapted from the literature on drug calculation. These test questions related to the calculation of metric conversions, tablets and fluid dosages and infusion rates (Appendix 1). The majority were scenario-based questions contextual to registered general nurses areas of practice. Participants were allowed to use calculators as field testing revealed that in the reality of practice most nurses have access to and use calculators usually on mobile phones.

Through the instrument we endeavoured to encourage participants to extract the relevant information needed to solve the problem by using visual images of drug containers thus making the test more meaningful, and participants were requested to include their calculation method so that their drug calculation skills could be assessed. Due to the limitation of resources, images used were those readily available on the internet. The test was supervised by the researchers to ensure participants completed the test on their own.

Questionnaires were sent to the thirteen Higher Institutes of Education in the Republic of Ireland that provide the undergraduate four year degree in nursing asking them to identify the amount of time given to pharmacology and identify the teaching strategies utilized to teach drug calculation skills in all years of the course. Fully completed questionnaires were returned from seven institutes.

Pilot study

Exploratory work was undertaken with a sample of new nurse employees ($n = 27$) from two hospitals ($n = 2$ sites) and personnel from Nurse Practice Development and Centres of Nurse Education to determine the feasibility of the research instrument and procedures to be used in the study. A number of revisions and improvements were undertaken which included reducing the number of test items and adjusting some items to improve clarity.

Ethical considerations

University and hospital ethical approval was granted by the Faculty of Health Sciences Ethics Committee and from the Ethics Committees of the participating sites. Written information was provided to all participants outlining the study, aims, methods, and participants' right to full information, confidentiality, anonymity and the right to withdraw at any time without explanation. Consent to participate was implied through return of completed