Review

Educational strategies aimed at improving student nurse's medication calculation skills: A review of the research literature

Snezana Stolic*

QUT, School of Nursing, Victoria Park Rd, Kelvin Grove, Brisbane, Qld 4059, Australia

Ke ords:
Student nurse

studies that re ect the past and current state of knowledge pertaining to a particular subject (Whitmore and Kna , 2005). The review is conducted to make a more substantial contribution to nursing literature and nursing knowledge (Beyea and Nichll, 1998). This review is conducted to make a meaningful contribution related to strategies to improve medication calculations skills for student nurses.

Literature review

For the purpose of this review we have de ned medication error as ´a preventable event that may cause or lead to inappropriate medication use (Department of Health (DoH), 2004, para. 1). The ability to calculate and understand the administration of medications underpins the safe practice for RNs (Elliot and Joyce, 2005; Green eld, 2007; Harne-Britner et al., 2006; Pentin and Smith, 2006; Sung et al., 2008). The RN must not only understand all aspects of medication administration they must, more speci cally ensure correct medication calculations and dosage for the safety of patients (Andrew et al., 2009; Nursing and Midwifery Board of Australia, 2006; Rainboth and DeMasi, 2006; Wright, 2005). Mathematical skills are imperative for nurses in calculating medication dosages, liquid solutions, strengths, as well as intake and output computations (Kapborg and Rosander, 2001)). Previous studies investigating the numeracy skills of undergraduate nurses have identi ed serious de ciencies with 8.1—10.6% able to obtain 90% pass mark (Blais and Bath, 1992; Jukes and Gilchrist, 2006) and 55% able to obtain 100% (Gillham and Chu, 1995). Poor drug calculation skills can result in incorrect medication administration to the patient (Harne-Britner et al., 2006; Kapborg and Rosander, 2001; Wright, 2005). Some studies have suggested between 7.5% and 27% of all adverse events are due to drug errors (Berga Culleré et al., 2009; Fahimi et al., 2008; Fanikos et al., 2007; Gurwitz et al., 2005; Manias, 2007; Røykenes and Larsen, 2010; Runciman et al., 2003). In Australia reported medication errors due to wrong medication dosages range from 1% (Coombes et al., 2001; Runciman et al., 2003) to 20% of errors (Dawson et al., 1993; Eastwood et al., 2009). Improper dose or quantity errors occurred for 17% of administration errors made by student nurses in the USA (Wolf et al., 2006). No studies were detected that reported the incidence of medication calculation errors by student nurses in Australia. Inaccurate drug calculations can lead to drug errors and potential harm to patients (Department of Health, 2000; O'Shea, 1999; Wolf et al., 2006). Any medication error is unacceptable.

Methods

Inclusion and e clusion criteria

In order to complete a critical integrative review, articles were considered for inclusion if they met the following criteria;

- Related to student nurse or nursing student
- Related to medication or drug calculation or dosage or numeracy
- Published between 1990 and 2012
- Hypothesis tested
- Included educational strategies and
- Written in English

Exclusion criteria were as follows:

- Not abstract and
- Not repeated

Search for relevant studies

An extensive and systematic literature search using the documented criteria was undertaken. The studies in this analysis were retrieved through an electronic search of ve health care databases (Cummulative Index to Nursing and Allied Health Literature, Medline, Pubmed, Proquest and Sciencedirect). Search words used were: ‘39(Pubmed98(s)-2)-6751.9(x)-.7(ect)Tj/F13(e.0605-291.4(as)-29h)-2ie)

Table 1
A summary of 20 studies found to meet the review inclusion criteria on medication calculation education strategies for student nurses.

Authors/country	Sample	Design	Intervention	Test type	Pass score	Calculator/aids/ equivalency tables/formula	Pass rates/results	Comments
Pierce et al., 2008, UK	2 groups, 1st-3rd year SN, Total $n = 355$, Remedial Decimal group $n = 40$, control group $n = 56$	Quasi-experimental post test 12 weeks later	INSTRUCTIONAL 1 h lecture on understanding decimals and remedial + CD-Rom (optional)	30 question Diagnostic Decimal Comparison Exam (Steinle 2004)	100%	Not reported	Number of students who attained pass scores First year $n = 127$, 51.2% Second year $n = 110$, 47.3% Third year $n = 118$, 70.3% Decimal group Mean pre test 4.5 post test 5.6 Control group Mean pre test 4.9 Post 4.8	• Non randomised, all students included • No power • No validity and reliability reported • Small sample • Single site
Adams and Duf eld, 1991, Aust	1 group, 1st year SN, $n = 436$ pre test, 3rd year, $n = 106$ post test	Quasi-experimental pre test and 9 post tests (over 2 years)	INSTRUCTIONAL Lecture, tutorials and repeated worksheets	10 question drug calculation test	90%	Not reported	Marks improved over time, for rst semester post test (papers 1–5), mean scores 7.55 to 9.10 but not sustained, second or third year post test (papers 6–9) mean scores 7.52 to 8.85 Students results improved during second and third year to coincide with off campus clinical placement	• Non randomised, all students included • No power • No validity or reliability reported • Small sample • Single site • Valid and reliable • Several instructors
Koohestani and Baghecheghi, 2010, Iran	2 groups, 2nd year SN, DA group $n = 21$, control group $n = 21$	RCT Pre test and 3 months post test	INSTRUCTIONAL Lectures and workshops DA *Control group* Formula method	10 question IV calculation test (2 marks per question)	100%	No calculator No aids	Pre test range 0–8 both groups Post test(1) range 14–20 both groups DA group pre test mean score 3.9 Post test mean score (1) 17.04 Post test mean score (2) 16.76 Control group pre test mean score 4.48 Post test mean score (1) 17.42 Post test mean score (2) 14.28 Both groups improved over time Post test still poor only 7.3% achieved 100%	• Simple randomisation • Consensus method • Same instructor for both interventions • No power • Valid and reliable Cronbach's

Table 1 (*continued*)

Authors/country	Sample	Design	Intervention	Test type	Pass score	Calculator/aids/ equivalency tables/formula	Pass rates/results	Comments
							achieved <100% No difference between the 2 types of instruction	• Content validity reported • No reliability reported • Small sample • Single site
Rice and Bell, 2005,USA	2 groups, senior SN, DA group $n = 65$, control group $n = 42$	Quasi-experimental post test only 1 week later	INSTRUCTIONAL DA 1.5 h instructional and support for students	15 question medication calculation exam Self perceived con dence	Not reported	Yes for pre but not post (calculators)	DA group (mean% correct) Pre test 79%, post test 92% Control group	

								• No power, however large sample • No reported validity and reliability • Descriptive statistics only
Rainboth and DeMasi, 2006, USA	2 groups, Sophomore diploma SN, RP $n = 54$, control group $n = 45$	Quasi-experimental pre test post test 4 weeks and 3 months later	INSTRUCTIONAL RP assignments and practice worksheets	14 question medication calculation exam pre test 10 question medication calculation test post test Student perception of medication calculations	Not reported	Yes calculator Yes equivalency tables for pre test but not post test	RP group (14 question) Pre test mean 11.35 Post test mean 13.09 RP group (10 question) Post test mean 9.3 Control group Post test mean 9.2 Intervention group scores statistically signi cant higher than control group	• Census method • One instructor • Convenience sample non randomisation cohort selected by semester enrolled in • Non power • Validity established • Reliability low (0.135–0.674) • Post test same as pre test • Reliability for student perception nstrument 0.768 • Same instructor for both groups • Small sample • Single site
Dilles et al., 2011, Belgium	2 groups, BN students $n = 404$, schools $n = 17$, DN students $n = 209$, schools $n = 12$	Quasi-experimental post test only 3–4 months prior to graduation	INSTRUCTIONAL Lecture textbook	Medication knowledge and 5 question medication calculation test Self rated readiness	Not reported	No calculator	Mean scores for diploma students knowledge = 52%, calculation 53% Means scores for bachelor students knowledge = 55%, calculation = 66% 7% attained >70% and 0% attained >85% Results of test did not correlate to readiness to graduate Only 15% rated ready to become RN	• Non randomised, all schools invited • No power however, large sample size • Validity established • No reported reliability • Many instructors
Harne-Britner et al., 2006, USA	2 groups, senior SN $n = 31$, RN $n = 22$, (years of experience 4–34 years)	Quasi-experimental, pre test, post test 4 weeks later	INSTRUCTIONAL All lecture + 4 different interventions 1. 30 min tutorial 2. Workbook, calculating drug dosage (de Castillo & Werner-McCullough 2002) 3. Self study 4. None	20 question IV medication calculation exam Medication calculation survey	90%	Yes calculator	SN 58.4% able to attain pass mark RN 45.2% able to attain pass mark Senior SN pre test mean 15.9, post test mean 17.4 $p = 0.003$ Practicing RN pre test mean 15.5, post test 18.6 $p < 0.001$ Statistical difference between pre and post but not between SN and RN or group	• Non randomised, convenience sample • No power reported • Valid and reliable KR20, 0.764 • Small sample • Single site

(continued on ne t page)

Wright, 2008, UK	2 groups, 2nd year SN, Blended learning group $n = 80$, control group $n = 92$	Quasi-experimental post test 12 months later	BLENDED LEARNING Lecture Tutorials Online and Face to Face

2006; Rice and Bell, 2005; Unver et al., 2013; Wright, 2007, 2008, 2012), one was undertaken at two sites (Harne-Britner et al., 2006), one study was undertaken at three to four sites (McMullen et al., 2011) and one was conducted at 29 nursing schools (Dilles et al., 2011). Nine studies were conducted in the Unites States of America (Adams and Duf eld, 1991; Costello, 2011; Craig and Seller, 1995; Green eld, 2007; Green eld et al., 2006; Jackson and De Carlo, 2011; Kohtz and Gowda, 2010; Rainboth and DeMasi, 2006; Rice and Bell, 2005), four in Britain (McMullan et al., 2011; Wright, 2007, 2008, 2012), three in Australia (Adams and Duf eld, 1991; Coyne et al., 2013; Glaister, 2007), and one each in Iran (Adams and Duf eld, 1991; Coyne et al., 2013; Glaister, 2007; Koohestani and Baghcheghi, 2010), Turkey (Unver et al., 2013) and Belgium (Dilles et al., 2011). One study had 2674 students (Jackson and De Carlo, 2011), two studies had between 613 and 229 participants (Dilles et al., 2011; McMullan et al., 2011), seven studies had between 96 and 172 participants (Adams and Duf eld, 1991; Coyne et al., 2013; Glaister, 2007; Pierce et al., 2008; Rainboth and DeMasi, 2006; Rice and Bell, 2005; Wright, 2008) and ten studies had between 26 and 87 participants (Costello, 2011; Craig and Seller, 1995; Green eld, 2007; Green eld et al., 2006; Harne-

differences were detected for one computer assisted learning study (McMullan et al., 2011). Two studies investigated computer and mathematical anxiety and resources identi ed by students required to demonstrate ‘real world’ nursing (Glaister, 2007; Wright, 2012).

Best practice research and clinical trials require sound measurement methods (Cook and Beckman, 2006). Of the 12 studies that reported differences detected, eight did not report validity or reliability (Adams and Duf

(Polit and Beck, 2014). In clinical research trials, using inadequate sample sizes is precarious and the likelihood of Type II error increases (Polit and Beck, 2014).

The research design for three of the 20 reviewed articles was reported as two or three group randomised control trials. This design is considered the gold standard or the most advance type of quantitative research design (Fewtrell, 2011). These studies are more likely able to show causal relationships between intervention and outcomes (Fewtrell, 2011). In this review for all 20 studies the variable being manipulated or independent variable was the education strategy/ies. For eighteen of the reviewed articles the dependent variable was medication calculation knowledge as measured by a researcher developed drug calculation test/exam (Adams and Duf eld, 1991; Costello, 2011; Coyne et al., 2013; Craig and Seller, 1995; Dilles et al., 2011; Green eld, 2007; Green eld et al., 2006; Harne-Britner et al., 2006; Jackson and De Carlo, 2011; Kohtz and Gowda, 2010; Koohestani and Baghcheghi, 2010; McMullan et al., 2011; Pierce et al., 2008; Rainboth and DeMasi, 2006; Rice and Bell, 2005; Unver et al., 2013; Wright, 2007, 2008). This raises concerns in regards to the validity and reliability of measuring medication calculation knowledge using a researcher developed drug calculation test, due to inconsistencies in developing the test.

Experimental designs are characterised by the use of the control group to which the intervention group is compared (Taylor et al., 2006). When studies compared two or more groups often the existence of a relationship between the control and intervention group is measured by comparing means or averages of the two groups for the required measured outcome (Polit, 2010). Six of the reviewed studies collected or reported data on the intervention groups only and all of these studies did report positive effects for the intervention group (Adams and Duf eld, 1991; Costello, 2011; Coyne et al., 2013; Jackson and De Carlo, 2011; Unver et al., 2013; Wright, 2007). The use of no control group research design is termed non experimental or quasiexperimental and the major disadvantage in this design is it's weakness in its ability to determine casual relationships (Polit and Beck, 2014).

This review has identi ed some concerns regarding the strategies used to teach medication calculation to student nurses. Studies focussing on traditional or conventional teaching had mixed results. Strategies addressing student nurses numeracy skills revealed improvements from pre test to post test using either remedial support (Pierce et al., 2008) or repeated worksheet drills (Adams and Duf eld, 1991). Pre test pass marks set between 75 and 100% for medication calculation exams, remain low, with 36% (McMullan et al., 2011) to 60% of students able to obtain this pass mark (Jackson and De Carlo, 2011). Solid foundation s in numeracy is essential to allow nurses to determine accurate medication dosage calculations (gx321.3;144).86.412(est5alcType)3(of347.1(t509-382.7(re8jo51)--46(mar)3e.2(est3-521 learning spaces enables learners to develop procedural knowledge promoting active learning (Ke and Xie, 2009; Noteborn et al., 2014). Active learning with the use of online resources and interactive software involving learner participation and engagement has proven effective across educational settings (DeGagne, 2011; Noteborn et al., 2014). Studies show that active involvement brings about greater understanding and knowledge retention while simulating deeper cognitive processes and critical thinking skills (Conrad and Donaldson, 2004; Mareno et al., 2010).

In summary, this article critically reviews research literature in regards to strategies aimed at improving medication calculation skills. These studies increase our understanding of the issues surrounding medication calculation for student nurses. This article provides vital information for academic teaching strategies in an attempt to increase student nurses understanding and retention of medication calculations for the improved safety of patients.

Implications for practice

Multiple interventions including interactive lectures, clinical case studies, clinical experience, workbooks, online software, calculators, technology aimed at different learning styles needs further investigating to prove bene cial for improving medication calculation skills and mathematics skills for student nurses. Further examination is required in the method of assessing the medication calculation abilities of student's nurses. Further research needs to be conducted in larger cohorts.

Limitations

Limitations inherent in the design of some of these studies do not permit an assessment that interventions aimed at improving medication calculation skills are bene cial (or not) in all circumstances. Most studies which focused on student nurses used single or two sites, small sample sizes or questionable assessments. Randomisation when performed used simple, cluster or by last name or tutorial group. Many studies used self selection of students with limited data on students who did not choose to participate. Often those who choose not to participate may require more support. No study stated how they deduced the sample size. It is therefore dif cult to generalise the ndings from many of the 20 reviewed studies.

Conclusion

This paper represents a critical integrative review of the literature on interventions aimed at improving student nurse's medication calculation abilities. Of the 266 papers retrieved 20 met the inclusion criteria, two studies had more than 600 students, none reported how the sample size was deduced, and ten presented validity and/or reliability. Twelve of the studies reported positive results, of those six used traditional pedagogy, two used technology, one used psychomotor skills and three used blended learning to improve nursing calculation skills. Three studies used the gold standard of randomised control trial design. There is insuf cient evidence to date to support the implementation of any particular strategy aimed at improving medication calculation skills for student nurses. The main outcome of this review is to establish that there are very few well designed and adequately powered studies speci cally focused on this area of undergraduate nursing education. There needs to be more quality research on teaching strategies and assessment for undergraduate student nurses on their ability to accurately calculate medication dosages.

References

Adams, A., Duf eld, C., 1991. The value of drills in developing and maintaining numeracy skills in an undergraduate nursing programme. Nurse Educ. Today 11 (3), 213–219. http://dx.doi.org/10.1016/0260-6917(91)90062-F.

Andrew, S., Salamonson, Y., Halcomb, E.J., 2009. Nursing students' con dence in medication calculations predict math exam performance. Nurse Educ. Today 29, 217–223.

Arkell, S., Rutter, P.M., 2012. Numeracy skills of undergraduate entry level nurse, midwife and pharmacy students. Nurse Educ. Pract. 12 (4), 198–203. http://dx.doi.org/10.1016/j.nepr.2012.01.004.

Berga Culleré, C., Gorgas Torner, M.Q., Altimiras Ruiz, J., Tuset Creus, M., Besalduch Martín, M., Capdevila Sunyer, M., Codina Jané, C., 2009. Detecting adverse drug events during the hospital stay. Farm. Hosp. Engl. Ed. 33 (6), 312–323. http://dx.doi.org/10.1016/S2173-5085(09)70095-4.

Beyea, S., Nichll, L.H., 1998. Writing an integrative review. Assoc. Perioper. Regis-

Green eld, S., Whelan, B., Cohn, E., 2006. Use of dimensional analysis to reduce medication errors. J. Nurs. Educ. 45 (2), 91–94.
Gurwitz, J.H., Field, T.S., Judge, J., Rochon, P., Harrold, L.R., Cadoret, C., Bates, D.W., 2005. The incidence of adverse drug events in two large academic long-term care facilities. Am. J. Med. 118 (3), 251–258. http://dx.doi.org/10.1016/j.amjmed.2004.09.018.
Harne-Britner, S., Kreamer, C.L., Frownfelter, P., Helmuth, A., Lutter, S., Schafer, D.J., Wilson, C., 2006. Improving medication calculation skills of practicing nurses and senior nursing students. J. Nurses Staff Dev. 22 (4), 190–195.
Harvey, S., Murphy, F., Lake, R., Jenkins, L., Cavanna, A., Tait, M., 2010. Diagnosing the problem: using a tool to identify pre-registration nursing students' mathematical ability. Nurse Educ. Pract. 10 (3), 119–125.
Hilton, D., 1999. Considering academic quali cation in mathematics as an entry requirement for a diploma in nursing programme. Nurse Educ. Today 19 (7), 543–547.
Holland, A., Smith, F., McCrossan, G., Adamson, E., Watt, S., Penny, K., 2013. Online video in clinical skills education of oral medication administration for undergraduate student nurses: a mixed methods, prospective cohort study. Nurse Educ. Today 33 (6), 663–670. http://dx.doi.org/10.1016/j.nedt.2012.01.006.