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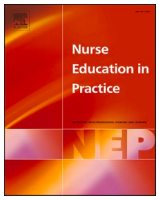

Nurse education leaders' perspectives on the teaching of numeracy to undergraduate nursing students: A qualitative research study

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ABSTRACT

Aim: The aim of this study was to explore the perspectives of nurse education leaders of Australian undergraduate nursing degrees on the teaching of nursing numeracy and how the Australian Nursing & Midwifery Accreditation Standards influence curriculum development.

Background: Nurses' numeracy skills are reportedly deficient worldwide, posing a significant threat to patient safety. This is an issue for the education of undergraduate nurses and thus for the nursing profession. The international literature reveals a heterogeneous blend of learning approaches, but it is unclear which approaches are best suited to improve the numerical calculation ability of nurses. In the Australian context, there are no accreditation standards referring to numeracy, therefore, it is important to discover how nurse education leaders' design and implement the teaching of numeracy.

Design: A qualitative approach using thematic analysis was employed. The setting was Australian universities that delivered an accredited undergraduate nursing degree leading to nursing registration.

Methods: Purposive sampling was used to recruit 17 nurse education leaders of Australian undergraduate nursing degrees. Individual, semi-structured virtual interviews were conducted between November 2022 and January 2023. Interview data were analysed using Braun and Clarke's (2006) six phases of thematic analysis.

Findings: Five themes emerged from the analysis: (i) indistinct accreditation standards, (ii) teaching basic maths for clinical applications, (iii) a range of bespoke teaching approaches (iv) we're nurses, not numeracy educators and (v) assumptions about an unprepared cohort.

Conclusion: The leaders of undergraduate nursing degrees assumed that nursing students would have proficiency in numeracy skills on entering university. However, this was not the case, hence numeracy was an essential skill that needed to be taught to the undergraduate nursing students. Lack of direction from the accreditation council led to the existence of various curricula and an array of approaches to teaching numeracy and medication calculations, which challenged nursing academics who did not consider themselves numeracy educators. This study makes a novel contribution to knowledge, teaching and practice in undergraduate nursing numeracy curricula.

1. Introduction

Nursing students and Registered Nurses (RNs) must be proficient in medication calculations to alleviate potential threats to patient safety. Unfortunately, the international literature is unequivocal that both undergraduate nurses' and RNs' numeracy skills are lacking, which has serious implications for the education of undergraduate nursing students, likewise the nursing profession (Minty-Walker et al., 2021).

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Depending on the area of practice, the proportion of working time spent administering medications is between 29% and 40% (Thomson et al., 2009). As a core nursing skill, it is paramount that undergraduate nursing programs prepare students with the knowledge and skills, to administer medications (Pegram and Bloomfield, 2015).

1.1. Background

It is often assumed that students are numerically competent when entering university and are able to perform basic calculations (Jukes and Gilchrist, 2006). Yet, evidence suggests the opposite is often the case, that is, there are serious deficiencies in undergraduate nursing students' abilities to pass a numerical or medication calculation test (Eastwood et al., 2011; McMullan et al., 2010; Wennberg-Capellades et al., 2022). This is a serious concern for students who are frightened that their lack of mathematical proficiency may result in "killing the patient" (Ramjan, 2011, p. e19). This deficiency remains evident prior to graduation, where nursing students' numeracy skills are still limited (Dilles et al., 2011). Of most concern is that these errors persist among practising RNs who have been unable to pass a medication test during their orientation (Fleming et al., 2014). Furthermore, in the clinical context, errors of the wrong dose were prevalent among RNs (Brabcová et al., 2023; Cavell and Mandaliya, 2021; Cheragi et al., 2013).

What happens in the undergraduate classroom warrants attention, specifically how the nursing curriculum is developed and delivered. A review by Minty-Walker et al., (in press), highlighted that a variety of learning approaches underpin nursing numeracy education. One approach is e-learning programs that have improved students' results on medication calculation assessments in several separate studies, (Aydin and Dinç, 2017; Mosca, 2017; Weeks et al., 2013a). Another is a more hands-on contextualised approach, that students preferred, as this more realistically represented the clinical practice environment (Ramjan et al., 2014). Other studies have shown a range of learning improvements and outcomes using simulated learning contexts (Dubovi et al., 2018; Hurley, 2017; Latimer et al., 2017; Mills, 2016; Pettigrew et al., 2020). A structured blended learning approach improved performance with medication calculations (O'Reilly et al., 2020). Finally, a didactic, or teacher-centred lecturing approach, was reported to significantly improve medication calculation skills by Van Lancker et al. (2016).

In addition to a range of learning approaches implemented for nursing numeracy, different methods of calculation have also been reported: the traditional formula method, the proportional reasoning method and dimensional analysis, which have variously been reported to be effective with different cohorts (Gillies, 2004; Koharchik et al., 2014; Maley and Garofalo, 2017; Rainboth and DeMasi, 2006). The traditional formula method was used in the following studies, but for many reasons not favoured (Hurley, 2017; Koohestani and Baghcheghi, 2010; Maley and Garofalo, 2017; Newton et al., 2013). Crucially, the heterogeneous mix of learning approaches and methods of calculation that are used internationally means it remains unclear which learning approach, or indeed which combination, is most suited to students' different styles of learning.

Despite the widespread knowledge of poor numeracy skills and the variation in nursing numeracy education, it remains a challenge to ensure undergraduate nursing students are supported to develop their numeracy (Mackie and Bruce, 2016). Notably, in an Australian context, this knowledge has not influenced the regulation of nursing education degrees. Minty-Walker et al. (2021) identified that the latest Australian RN Accreditation Standards have no numeracy standards (Australian Nursing & Midwifery Accreditation Council, [ANMAC] 2019). That is, there is no requirement for graduates to demonstrate a minimum level of numeracy proficiency and no recommendations for undergraduate numeracy content or assessment (Minty-Walker et al., 2021). In the absence of an evidence-based approach to identifying minimum standards, it is logical to assume that each school designs its own nursing degree program. What these programs look like, how they are developed, the extent to which they align with any evidence about how to teach nursing numeracy and how they are evaluated, if at all, is not reported.

This issue of poor numeracy skills is significant on multiple levels including the impact on patients, relatives, RNs and the healthcare system. With RNs at the forefront of patient care, mathematical skills are vital to prevent an adverse event. This issue is significant for patients as it can result in increased length of hospital stay, life-threatening illness, disability, or death (Garrouste-Orgeas et al., 2012). The impact on the patient's relatives is often difficult to measure, with potential loss of income and psychological distress. In addition, medication errors affect the RN both mentally and emotionally, with feelings of burnout, depression, or suicidal ideation (Roberton & Long, 2017). Furthermore, the healthcare system is directly affected as poor medication management costs the healthcare system $1.2 billion annually in Australia (Westbrook and Baysari, 2019). Considering there are 42 higher education institutions across Australia that offer undergraduate nursing degrees with approximately 60,000 undergraduate nurses across the three years (Australian Government Department of Education, 2017), the potential for error is vast.

Therefore, it is crucial to investigate what happens from a teaching perspective at a school-based level to inform better strategies to solve this entrenched problem. More research is needed on how to improve numeracy skills, rather than research simply describing the nurses' lack of proficiency. This research provides a first-hand insight from the nurse education leaders of undergraduate nursing degrees across Australia into how nursing numeracy is implemented in the tertiary education setting.

1.2. Aim

The aim of this study was to explore the perspectives of nurse education leaders of Australian undergraduate nursing degrees on the teaching of nursing numeracy and how the Australian Nursing & Midwifery Accreditation Standards influence curriculum development.

2. Methods

2.1. Design and setting

A qualitative approach using thematic analysis was the appropriate method for this study. The setting for this research was Australian universities that delivered an accredited undergraduate nursing degree leading to registration with the Australian Health Practitioner Regulation Agency. Some Australian universities have multiple campuses in different regions and different states and thus the delivery of undergraduate content in Australia is usually via a combination of online and /or face to face teaching.

2.2. Participant recruitment, sampling and data collection

Purposive sampling was used to recruit nurse education leaders of undergraduate nursing degrees, based in any Australian tertiary institution offering an undergraduate nursing degree. Post graduate preregistration nursing degrees were excluded from the study as not all Australian universities offer this entrance pathway. The nurse education leaders are charged with overseeing the development and implementation of the curriculum at their university and usually lead the process for accreditation of the curriculum. The recruitment procedure was as follows: the chief researcher contacted every Australian School of Nursing ($n = 42$) to identify who held the role of nurse education leader, or equivalent, to establish a point of contact for each university. These points of contact were then directly emailed a participant information sheet and an invitation to participate in an interview. A total of 17 nurse education leaders, or equivalent, agreed to be interviewed. Reminder emails were sent two weeks later, with no further potential participants

expressing an interest to participate, therefore, interviewing ceased at 17 participants. Between November 2022 and January 2023, individual, semi-structured virtual interviews were conducted by the first author. Interviews lasted between 40 and 80 min and were audio recorded. A demographic data questionnaire and a semi-structured interview schedule (Table 1) were used to collect data. Interview recordings were transcribed verbatim using Panopto®. The first author diarised any reflections and impressions after each interview, to analyse the data contemporaneously.

2.3. Data analysis

Interview data were analysed using Braun and Clarke's (2006) six phases of thematic analysis. Analysis was a recursive process throughout six phases: familiarisation with the data by reading it several times, initial coding through the semantic and conceptual reading of the data, with NVivo® used to store and organise the analysis, searching for themes via grouping of codes, reviewing the themes at team meetings to check if a coherent representation of the data was revealed, giving an informative name to each theme and finally, writing up the analysis into a persuasive story.

2.4. Rigour and trustworthiness

The rigour and trustworthiness of this qualitative research was established using the evaluative criteria of credibility, transferability, dependability and confirmability (Nowell et al., 2017; Morse, 2015). The credibility and auditability of the study were established by the use of interview notes, recordings, verbatim transcripts and coding at the various stages of the analysis. Confirmability was maintained by a clear and logical audit trail of all data and its sources. Interview recordings were transcribed and then audited for accuracy by the first author and last author. The interviewer performed preliminary checking of some comments with the participants at the conclusion of the interview or via email post interview. A clear pathway disclosing how the team of researchers arrived at all themes was established, progressing from original transcripts to NVivo, then to Excel, as codes and themes developed. To further assist with the analytic process, regular team meetings were held to finalise the themes, with decisions clearly managed and documented at each stage. Verbatim quotes, linked to each participant's code, were presented in the findings, demonstrating authenticity of the data. Transferability of the data was enhanced by providing thick, detailed descriptions of the research context, setting and participants. While this study is unique to the Australian context, key findings may be transferable widely. Dependability was achieved by the consistency of the interview approach, using the same interview guide and ensuring the same questions were asked of all participants. To improve transparency, the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines (Tong et al., 2007) were used for reporting. The research team was aware of problems with personal bias and strove to minimise bias by employing reflexivity during the analysis (Nowell et al., 2017). The primary researcher is a female nurse academic with 13 years' experience teaching undergraduate nursing students, with the other four team members comprising two RNs and two mathematicians, bringing theoretical triangulation to the analysis. Furthermore, the RN academics represent diverse backgrounds in hospital and community-based models of nursing and the academic mathematicians have many years of experience providing mathematics support to students from many disciplines including nursing.

Table 1
Semi-structured interview schedule.

1. Tell me about your academic journey to become the director of your academic nursing program.
2. What can you tell me about the teaching of numeracy within your undergraduate nursing program? Prompts – underpinning theoretical approach, content development, method, year/s taught, context, and aids used.
3. Have you been involved in the accreditation of your undergraduate nursing program? If yes, what can you tell me about that process with respect to numeracy?
4. Can you tell me about the methods of calculation taught to nursing students at your university, and the reason for this approach? Prompts formula method, proportional reasoning, dimensional analysis
5. How do you embed numeracy into your nursing curriculum, for example what years of study and what subjects?
6. Can you tell me about the learning environment where numeracy is taught, do you teach numeracy in the classroom/tutorial room/lecture theatre, or in the nursing laboratory and why?
7. What can you tell me about the lecturers/tutors who are responsible for the direct teaching of numeracy? Prompts - Skills/expertise, support/mentoring from math experts, problems raised by them.
8. How is numeracy assessed, and are numeracy aids allowed?
9. How would you assess the overall teaching of numeracy in your undergraduate program? Prompts – effective/ineffective, any barriers/facilitators to effective teaching.
10. Who designs the content and assessments for each subject, and what are their skills?
11. Is there access to mathematics support at your university? If yes, do you collaborate with the school of mathematics or mathematics support staff to assist with numeracy teaching and assessment?
12. Do you use e-learning to assist with the development of the undergraduate nursing numeracy skills? For e.g., CD/DVD, Web based program such as Med+Safe or smart phone App.
13. Do you have any personal interest in the teaching of numeracy? If yes, how did this develop?
14. If you could create a perfect framework for the teaching of numeracy to undergraduate nursing students, what would it look like? What gets in the way of something like this being realised?
15. Any other comments?

2.5. Ethical considerations

Ethics approval was received from Western Sydney University (Approval Number H15179). Prior to the interviews, all participants provided informed consent and were informed that participation was voluntary and they may withdraw at any time. To ensure confidentiality, potentially identifiable information was removed from the transcripts and each participant was assigned a code number. As there are only a limited number Australian Schools of Nursing ($n = 42$), the potential for identifiability of participants is high, hence the use of a code alongside quotes, rather than adding any detail about participants such as their gender or years of experience. The de-identified transcripts and audio recordings were securely saved in accordance with the university's research data management policy.

3. Findings

A total of 17 participants were interviewed for this study. As some Australian universities have multiple campuses in different regions, representation was from all Australian states: New South Wales ($n = 8$), Victoria ($n = 4$), Queensland ($n = 3$), South Australia ($n = 1$) and Tasmania ($n = 1$). Given the relatively small population of nurse education leaders ($n = 42$) and to preserve the identity of participants, aggregated, rather than individualised demographic data are presented in Table 2.

Five themes were generated from the data analysis: (i) indistinct accreditation standards; (ii) teaching basic maths for clinical applications; (iii) a range of bespoke teaching approaches; (iv) we're nurses, not numeracy educators; and (v) assumptions about an unprepared cohort.

3.1. Theme 1: Indistinct accreditation standards

With no accreditation standards in respect to nursing numeracy, the design and implementation of numeracy education were left to the discretion of the nurse education leaders, because: "*there was no major focus on what you do in relation to numeracy*" (P11) and "*I don't recall anything specific in the standards about numeracy* per se*, or how we teach it*" (P12).

Table 2
Participants demographic details.

Demographics		N = 17
Age	Median	51
	Range	37–66
Gender (*n*;%)	Female	14 (82%)
	Male	3 (18%)
Highest level of education (*n*;%)	Grad	1(6%)
	Dip	
	Masters	7(41%)
	PhD	9 (53%)
Years as a RN	Median	30
	Range	11–42
Years working in a tertiary education setting teaching undergraduate nurses	Median	15
	Range	3–32
Years of experience in current role	Median	2
	Range	1–12
Approximate size of entire undergraduate cohort*	Median	2000
	Range	631–5000
Involved in accreditation process	Yes	17 (100%)
Post graduate teaching qualification	Yes	10 (59%)
	No	7
If yes, did this qualification include content about teaching numeracy?	No	17 (100%)
Still working in the clinical environment	Yes	3 (18%)
	No	14 (82%)

* a Bachelor's degree in Nursing is 3 years in Australia

As there was: "*not a lot of specific direction in the ANMAC document about mathematics*" (P14), nurse leaders embedded numeracy in the curriculum differently: "*there's lots of different ways to do this* [embed numeracy] *because I'm well aware of other universities do it differently*" (P14). Numeracy was not a focus of the Australian accreditation council, with one participant voicing: "*it's an embedded concept that never, ever sees the light of day in that process, that's my perception*" (P16). Other participants made similar comments:

"*I don't actually remember them* [ANMAC] *asking me anything about numeracy … it wasn't something that they were flagging*" (P17). "*So, I would say that it's not high on their* [ANMAC] *list of priorities. That's not to say that you don't have to demonstrate that it's there*" (P13).

In the absence of a distinct accreditation standard relating to numeracy or medications, participants stated that they instead focused on numeracy through a lens of patient safety, aligning nursing numeracy with Standard 1: Safety of the public. One participant said: "*It* [numeracy] *was a subheading of, I suppose, or an implied heading under safety*" (P11) and another participant voiced: "*… it's about for me in ANMAC's standards in 2019, safety to the public. And I think that we have a responsibility, duty of care*" (P10).

3.2. Theme 2: Teaching basic numeracy for clinical applications

Basic numeracy teaching began in first year with numerical concepts a common feature. This progressed to clinical applications using the formula and proportional reasoning methods of calculation.

> Students: "work on conversions and understanding volume … and then each year that will build" (P4). "Covering fundamental foundational numeracy" (P8) was crucial "… they [the students] couldn't work a fraction … couldn't do simple conversions" (P13). A participant said: "the long division seems to stump a lot of students … they do find shifting decimal points quite difficult" (P6). To overcome this difficulty: "my philosophy is start with something simple that they can get a sense of achievement" (P11). However, one participant said: "we don't teach numeracy. They [students] bring numeracy into the program. They are taught how to operationalise drug calculations into the clinical space" (P17).
>
> The formula method was preferred: "the very basic calculation formula of strength required, over stock strength x volume over 1" (P13). A participant said: "I mean you've got your other maths concepts that come into play of course, but essentially, they do need to know their formulas" (P10).
>
> The formula method was taught for historical reasons: "I just think it's just what we've always known … that's the way that we continue to teach" (P4). Also, with a large teaching team across multiple campuses, the formula method: "is a way for us to remain consistent" (P14), "but they also have their own preference that they could identify to the students" (P15).

Proportional reasoning was reportedly added to develop students "*understanding of the context*" (P9). Participants said: "*we start with the formula … the most important part of this is you need to put the numbers in the right place*" (P11). Therefore:

> "We also introduced proportional reasoning … I can teach anybody to … remember a formula or use a formula. But if they don't have an understanding of the context and the reasoning behind it, they can still get it wrong and not realise that they got it wrong. So that's why we started using proportional reasoning. Somebody that can work out a figure in their head by using proportional reasoning is much more in tune to what the numbers actually mean and why they're there" (P9).

3.3. Theme 3: A range of bespoke teaching approaches

There were a diverse range of teaching and learning environments used to implement nursing numeracy with: "*online resources … that the students watch either pre-attending their simulation or their seminar*" (P12). This was consolidated with the "*theoretical part in online lectures and then … tutorial teaching and practice questions*" (P2). Additionally, "*… in tutorial seminars they* [student] *work through in small groups … develop a plan of care for a particular patient … and followed through into the simulation*" (P12). The application of the formula method of teaching was applied in practice: "*we will give them a medication chart and say, here's the stock strength, here's the dose that you're required to administer. Tell me how much you're actually going to give the patient*" (P11). This contextualised learning was supported with: "*a station set up that's just dedicated to numeracy where we will have a couple of practice maths tests for them to do, which is really good*" (P8). "*They also use the medication calculations in the skills labs with scenarios where they're drawing up medications*" (P2).

A crowded curriculum had an impact on the time spent teaching numeracy: "*I do an orientation at the beginning of the semester. … there seems to be so much stuff I have to talk about, that drug calcs are sort of shoved into a whole range of stuff within that two-hour period*" (P6). With limited time, self-directed learning was required: "*the majority* [basic maths] *is going to be done in the online space because obviously we cannot take up our really valuable workshop time with doing basic maths*" (P9). "*I would say in a whole semester it's likely to be in the league of two hours of directed teacher assistance*" (P16). Repetition was vital for student learning: "*at the start of every tutorial, we spend probably 15 min talking, thinking about maths. It's really important that we don't just do it once and never do it again*" (P8). Time was also valued in the practical environment: "*the labs vary between two and four hours … and a third of that in some way is doing some kind of numeracy*" (P8).

Participants described the online resources used to support students' learning of numeracy**:** "*we use Maths Success* [short videos] *for nurses which has been designed just specifically for a nursing cohort by this mathematician*" (P10). Another participant mentioned: "*we've got a really amazing template we use … H5P*® [collaborative framework]*"* (P4). The interactive online learning and assessment resource Med+Safe® was used to support student learning in numerous nursing degree programs: "*I like to introduce them to Med+Safe®. This is where you practice … and set guided sessions for them* [student] *to orientate them to the software and ensure that they're using it*" (P7).

3.4. Theme 4: We're nurses, not numeracy educators

The teaching of numeracy to undergraduate nursing students was by a nurse academics, mathematics advisors, or nursing students as part of a peer support program. Many participants considered themselves: "*very good at clinical based education … and know the formulas*" (P9) but said we are: "*not maths teachers*" (P8), "*I don't think we've got the qualifications to teach the basic numeracy skills like a mathematician*" (P1). We used: "*that Med+Safe® program …. it is really good for our students in terms of helping them with those fundamental mathematical concepts … supplementing, I suppose what we are lacking*" (P8).

It was evident that nurse academics are good clinicians, they can teach to a formula: "*but teaching someone foundational mathematics who doesn't really understand the concepts can be very difficult for a registered nurse because … we're not taught it as nurses. We're taught how to calculate, but we're not taught how to teach others to calculate*" (P7). Participants said: "we *would still defer this part of nursing practice to somebody who has maths or numeracy in their title*" (P16).

Participants suggested that we need experts in mathematics or education to teach nursing numeracy: "*like a math teacher or something like that. I think we need to have experts teach that area. Like we've got biologists teaching our biology units*" (P1). Participants drew on mathematics support from in the university: "*if they* [students] *can't do it then they go out to the maths advisor*" (P10). Alternatively, participants said: "we *partner with an internal department* [for numeracy support] and *they are teachers … they have a more pedagogically sound education than we do … they can take them* [student] *right through the basics*" (P14).

In addition to maths advisors or educationalists: "*students helping each other, it's a really important learning strategy … so, I think working in class as a group to work through maths is really important*" (P8). Furthermore, students supporting other students was welcomed in.

"*Peer Assisted Study Support (PASS) classes within the university that are specifically around our units that we know students struggle with. and one of them is the medication unit*" (P12).

3.5. Theme 5: Assumptions about an unprepared cohort

It was assumed that undergraduate nurses would have proficiency in numeracy skills on entering university. One participant said:

> "I think we made assumptions about school leavers that they would have an adequate level of numeracy skills and I think we made assumptions about mature age students that they would bring with them some basic numeracy skills" (P13).

It was not only assumed, but it was also expressed as an expectation: "*I just find the idea of numeracy really difficult because at university we would expect students to come in with a level of numeracy and that we focus on the calculation*" (P17). There were contributing factors to why students may have a deficit in numeracy: "*some of our students have been out of school for a long, long time, so they haven't done any maths and haven't been trained in maths, you know, ten, 15 or 20 years. So, they require a lot of work in fundamental mathematical abilities*" (P8). Additionally: "*the demographic of our students who choose # university because we're an online university, rural and remote students, so first in family, a lot of people who identify as Aboriginal Torres Strait Islander, lots of international students … who may struggle with numeracy concepts*" (P14).

Not only were participants shocked that the students struggled with basic numeracy, but the students themselves were surprised: "*students who struggle often, they'll say to us, I cannot believe I'm struggling with this*" (P16). Participants noted students' difficulty in grasping: "*fundamental concept*[*s*]" that those with "*a successful completion in* [secondary school] *math subject should be able to just absorb*" (P16).

Considering this numerical deficit, participants conceded that: "*there is a moral obligation to make sure that students have … this knowledge before they go into second year*" (P13). It is important: "*… to support our students for success when they come … I don't like setting students up for failure. I like them to be best placed, best positioned and I think that's an ethical position to be in*" (P10).

4. Discussion

This study has, for the first time in the Australian context, described nurse education leaders' perspectives on the teaching of numeracy to undergraduate nursing students. Nursing degrees leading to registration in Australia are accredited by ANMAC, who do not have standards related to numeracy (Minty-Walker et al., 2021). This lack of regulatory guidance has led to nurse leaders applying their own standards and expectations when implementing numeracy education. Flexibility and diversity in developing and implementing numeracy education across institutions is expected, but considering recent research into nurses' inability to pass a numeracy or medication calculation test (Eastwood et al., 2011; Wennberg-Capellades et al., 2022), should a baseline numeracy standard be a requirement by ANMAC, similar to their requirement to demonstrate English language proficiency? (ANMAC, 2019).

The World Health Organization (2009) global standards for programme admission require "nursing or midwifery schools to admit students with backgrounds in basic science and mathematics" (p. 29). In theme 5, participants expected students to enter university with basic numeracy and were shocked this did not occur, hence work in fundamental mathematics was required. An added factor in the Australian context is that only 11% of universities list secondary school level mathematics as a prerequisite for entry to nursing degrees and 30% list secondary school mathematics as recommended studies or assumed knowledge (Minty-Walker et al., 2021). In a survey by Ralph et al. (2019), 89.9% of academics agreed that prerequisite subject areas are important for preparing nursing students for entry to university. This may not be seen as favourable by universities, who would lose income; additionally, there maybe resistance from governments considering the predicted nursing workforce shortage (Doleman et al., 2022). However, Dray et al. (2010) described a successful intensive 20-hour numeracy pre-entry programme that was delivered to prospective undergraduate nursing students who failed to demonstrate competence in a numeracy entrance test. The results demonstrated short and medium success, with most of students successfully passing the second attempt at the entrance test.

Regulatory baselines exist in nursing internationally. In the United Kingdom, the Nursing & Midwifery Council Standards for pre-registration require education providers to "confirm on entry to the programme that students have the capability to develop numeracy skills required to meet programme outcomes" (Nursing and Midwifery Council, 2023, p. 9). Additionally, the Nursing and Midwifery Council (2023) requires education institutions to "ensure that all programmes include a health numeracy assessment related to nursing proficiencies and calculations of medicines which must be passed with a score of 100%" (p. 14). Furthermore, in China and the United States (US) since 1995 and 1987 respectively, undergraduate nursing students are required to pass a national exam prior to registration - in China, the National Nursing Licensure Examination and in the US, the National Council Licensure Examination for RN [NCLEX-RN] (Hou et al., 2019). Curriculum is therefore consistent in its expectations of impending graduates. Of note is that regulatory baselines exist in other professions. For instance, Australian school teachers are required to demonstrate literacy and numeracy skills equivalent to the top 30% of the general population, by undertaking the Literacy And Numeracy Test for Initial Teacher Education [LANTITE] (Australian Council for Educational Research, 2023). As assessment is an important area of nursing numeracy, it requires further exploration in future studies.

With no regulatory standards, no baseline, no minimum entry requirements to most Australian nursing degrees and mathematics as assumed knowledge on entry to university, a cohort of undergraduate nursing students enter university unprepared, through no fault of their

own, to meet the expectations required with respect to numeracy. What seemingly exacerbates this problem, are nurse educators who view themselves as clinicians, not numeracy teachers, focussing on teaching medication calculations via the formula method, which is in their comfort zone. The result, as discussed by participants, was that basic numeracy education was delivered as self-directed learning through programs such as Med+Safe® with any remedial numeracy teaching referred to mathematics experts. Ultimately, safe medication administration is reliant on an individual's computational and arithmetical performance (Weeks et al., 2013b).

Who is best placed to teach nursing numeracy? Perhaps nurses and mathematics educators could work together to ensure the context of nursing numeracy alongside basic numeracy is taught and understood. Mackie and Bruce (2016) suggested that such cross-discipline collaborations could work in practice. Although this remains a contentious issue that requires further exploration, in this study, no participants self-declared any specific skills or qualifications in mathematics or numeracy teaching. This issue has also not been widely unpacked in the literature, other than a study by Dray et al. (2010) who mentioned that the delivery of a pre-entrance nursing numeracy program required "a teacher with the specific skills in numeracy teaching" (p. 94) and a study by van de Mortel et al. (2014) who employed a specialist to teach nursing numeracy.

Although the teaching of basic numeracy was viewed by participants as being outside clinicians' scope of dedicated practice, numeracy education was underpinned by a variety of teaching approaches. These included face to face traditional classroom teaching, e-learning and contextualised learning with simulated teaching in a practical laboratory. Of note is that there seemed to be no clear pedagogical rationale for adopting one approach over another, rather an ad-hoc approach that was centred on the pragmatic use of available resources. Previous studies on different teaching approaches have reported contrasting results, such as no statistical difference between groups, post-exam results when comparing classroom versus e-learning approaches (Valizadeh et al., 2016). In another study, classroom-based teaching in combination with blended e-learning improved nursing students' performance on medication calculation exams (Öztürk and Güneş, 2023) and e-learning approaches alone had positive results in other studies (Aydin and Dinç, 2017; Mackie and Bruce, 2016). Taking a different approach, Hutton (1998) recommended that mathematics should be practised in the clinical environment and that "only by 'doing' mathematics did the theory make sense" (p. 35). Significant learning gains have been shown in studies using naturalistic approaches, such as allowing students to physically use syringes, tablets and ampoules to calculate and prepare medications (Dubovi et al., 2018; Hurley, 2017; Mills, 2016; Pettigrew et al., 2020), especially for first-year students who have limited clinical experience (Latimer et al., 2017).

In our study, participants highlighted in theme 2 that the formula method was predominantly taught and Gillies (2004) revealed students favoured this method as they only had to put the numbers into the formula, requiring less cognitive ability, especially when mathematics was not their strength. This approach is consistent with Skemp's (1976) keystone theory of instrumental understanding, where students follow mathematical procedures and rules without understanding the reasoning. Tertiary education should foster critical thinking and lifelong learning (Collier-Sewell et al., 2023), not just remembering a formula. Weeks et al. (2013b) highlighted that the words used in the formula method such as: "what you want, over what you've got, times what it's in" are "divorced from the real world of practice … and represent a weak and impoverished method of supporting students' learning" (p. e26) further contributing to conceptual errors. Studies where the difference between medication calculation methods such as proportional reasoning or the formula method (Grugnetti et al., 2014; Hurley, 2017; Maley and Garofalo, 2017; Newton et al., 2013) concur with the lack of a single effective approach to numeracy.

5. Strengths and limitations

Strengths of this study included being the first in the Australian context to describe nurse education leaders' perspectives on the teaching of numeracy to undergraduate nursing students. Although the results may not reflect the views of every nurse education leader in Australia, having a sample size of 40% of the population was a major strength. A limitation of the study was that the nurse education leaders at each university had slightly different roles and were at different hierarchical levels, therefore, not aware of every facet of numeracy teaching in their nursing degree program. Also, the change in governance roles every 2–3 years meant some staff had only recently commenced their role, limiting their knowledge on numeracy in the curriculum.

6. Conclusion

This research has revealed that nurse education leaders design and deliver nursing degree programs in the absence of any overarching accreditation standards regarding numeracy. With mostly non-existent prerequisite university entry requirements, students arrive unprepared. This leaves the teaching of numeracy to nurse academics who do not consider themselves mathematics teachers and so revert to their comfort zone of teaching the formula method. However, basic numeracy teaching is required, and students are supported by mathematics advisors, or other students in a structured peer support program. A variety of numeracy teaching approaches and resources are delivered to the students as dictated by the institution. This situation results in a range of pedagogical compromises that impede students' learning and academic teaching. While the need for 'flexibility' might be desirable in accreditation standards, the absence of a numeracy baseline leads to an ad-hoc approach and nursing students are graduating without a deeper understanding that will help them across their entire nursing career. Future studies need to determine who is best placed to teach nursing numeracy; if it is a collaboration between nurse academics and mathematics educators, will universities have access to this combined approach? Consideration is required as to what a baseline standard may look like. With students entering university mathematically unprepared, a preregistration standard that mirrors the United Kingdom could be beneficial, as might a numeracy entrance test or numeracy development program prior to entry.

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CRediT authorship contribution statement

CMW: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Roles/Writing – original draft, Writing – review & editing. **JP:** Conceptualization, Formal analysis, Methodology, Supervision, Validation, Visualization, Roles/Writing – original draft, Writing – review & editing. **LH:** Conceptualization, Formal analysis, Methodology, Supervision, Validation, Visualization, Roles/Writing – original draft, Writing – review & editing. **LR:** Conceptualization, Formal analysis, Methodology, Supervision, Validation, Visualization, Roles/Writing – original draft, Writing – review & editing. **NJW:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision Validation, Visualization, Roles/Writing – original draft, Writing –

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Declaration of Competing Interest

none.

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