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# Medication calculation skills of graduating nursing students within European context

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## Abstract

**Aim:** The aim of this study is to evaluate the medication calculation skills of graduating nursing students in six European countries and analyse the associated factors.

**Background:** Medication calculation skills are fundamental to medication safety, which is a substantial part of patient safety. Previous studies have raised concerns about the medication calculation skills of nurses and nursing students.

**Design:** As part of a broader research project, this study applies a multinational cross-sectional survey design with three populations: graduating nursing students, nurse managers and patients.

**Methods:** The students performed two calculations (tablet and fluid) testing medication calculation skills requiring different levels of conceptual understanding and arithmetic. The managers and patients answered one question about the students' medication kills. In total, 1,796 students, 538 managers and 1,327 patients participated the study. The data were analysed statistically. The STROBE guideline for cross-sectional studies was applied.

**Results:** Almost all (99%) of the students performed the tablet calculation correctly, and the majority (71%) answered the fluid calculation correctly. Older age, a previous degree in health care and satisfaction with their current degree programme was positively associated with correct fluid calculations. The patients evaluated the students' medication skills higher than the nurse managers did and the evaluations were not systematically aligned with the calculation skills tested.

**Conclusions:** Nursing students have the skills to perform simple medication calculations, but a significant number of students have difficulties with calculations involving multiple operations and a higher level of conceptual understanding. Due to the variation in students' medication calculation skills and the unalignment between the

managers' and patients' evaluations and the calculation tests, further research is needed.

**Relevance to clinical practice:** Graduating nursing students enter clinical field as qualified professionals, but there is still room for improvement in their medication calculation skills. This calls for attention in the fields of clinical nursing, education and research.

**KEYWORDS**

drug dosage calculations, graduating nursing students, medication calculation skills, nurse managers, patients

## 1 | INTRODUCTION

Nurses' medication calculation skills are at the heart of medication safety (Goedecke et al., 2016; Slawomirski et al., 2017; World Health Organization, 2017) because nurses play a central role in administering medication (Rohde & Domm, 2018; Sulosaari et al., 2010). However, numerous studies have shown that medication calculation skills are either poor or varied among nursing staff (Fleming et al., 2014; McMullan et al., 2010; Ridling et al., 2016) and undergraduate nursing students (Bagnasco et al., 2016; Caboral-Stevens et al., 2020; Goodwin et al., 2019; McMullan et al., 2010; Sulosaari et al., 2012). This is worrying, as a significant proportion of errors in administering medication is reported to result from mistakes in medication calculations (Gorgich et al., 2016; Keers et al., 2013; Salami et al., 2019). As well as having serious consequences for individual patients, medication errors are considered to be major adverse events; thus, they are costly for healthcare systems (Goedecke et al., 2016; Slawomirski et al., 2017; Vaismoradi et al., 2016; World Health Organization, 2017). Medication errors can put patients' health and even their lives at risk, so it is essential that nurses have the numerical skills and abilities needed to perform the associated calculations (Caboral-Stevens et al., 2020; McMullan et al., 2010).

Medication calculation skills are acquired during nursing education and refined during the first few years of practice (Caboral-Stevens et al., 2020; Sulosaari et al., 2015). Although European nursing education is regulated by directives (2005/36/EC, 2013/55/EU), the sought-after unification has not yet been accomplished (Aiken et al., 2013; Humar & Sansoni, 2017; Lahtinen et al., 2014). Consequently, medication education in general varies within Europe (Kirwan et al., 2019; Sulosaari et al., 2014). Given the mobility of the nursing workforce in the European Union (Marć et al., 2019), the impact of medication calculation errors on patient care (Goedecke et al., 2016; McMullan et al., 2010; Slawomirski et al., 2017) and nursing students frequent high risk of error in medication calculations (Caboral-Stevens et al., 2020; Simonsen et al., 2014), there is a need for research on the medication calculation skills of graduating nursing students (hereafter GNSs) on the European level.

It is also worth considering different actors' perspectives on strengthening nurses' medication calculation skills. The role of leadership and management cannot be ignored (Murray et al., 2018;

> **What does this paper contribute to the wider global clinical community?**
> - Graduating nursing students can currently enter their working life with inadequate medication calculation skills, compromising medication safety in patient care.
> - The medication calculation skills of graduating nursing students seem to vary among countries, raising concerns about the mobility of early career nurses in Europe.
> - Nurse managers' and patients' positive evaluations of graduating nursing students' overall medication skills are a constructive foundation upon which to build on their medication calculation skills.

Richmond et al., 2009), as nurse managers (hereafter managers) are, for instance, in the position of recruiting and hiring new staff (Aiken et al., 2013; Richmond et al., 2009). Hence, their perception of nurses' skills is important for ensuring an appropriate level of competence in the units they are supervising (Kukkonen et al., 2020). As for patients, they need to be confident in the skills of the nurses attending them in order for a trusting relationship to exist (Dinç & Gastmans, 2013). Patients rely on nurses' medication skills, but it is also important to consider patients' own involvement in the measures taken for their safety (Bishop & Macdonald, 2017; World Health Organization, 2017); that is, by considering their perceptions of the medication care they receive.

## 2 | BACKGROUND

Medication calculations require numerical and conceptual calculation skills (Guneş et al., 2016; McMullan et al., 2010; Newton et al., 2009). Numerical skills refer to the basic functions and rules of calculations: the knowledge and ability to use formulas, perform mechanical calculations and follow the rules of rounding and conversion (Bagnasco et al., 2016; McMullan et al., 2010; Newton et al., 2009). Conceptual calculation skills refer to an understanding of the

numbers that are required for the task at hand, and which methods to apply to obtain the correct result (Fleming et al., 2014). Three main methods are used to perform medication calculations: dimensional analysis, ratio proportion and the formula method. In each of these methods, mere numerical calculation skills are not enough; conceptual skills are required to recognise the desired amount of medication and the strength of the supply in order to calculate the dose needed (Toney-Butler & Wilcox, 2020). That is, in clinical practice, a nursing student must first be able to understand what variables need to be used to be able to accurately perform a medication calculation based on medication orders (Newton et al., 2009, 2010).

Apart from slips and lapses (Keers et al., 2013), medication calculation errors occur because of either a lack of proficiency in basic mathematical skills and functions (Bagnasco et al., 2016; Baran et al., 2016; Newton et al., 2010; McMullan et al., 2010) or a lack of conceptual understanding of how to interpret clinical data in order to perform medication calculations (Bagnasco et al., 2016). Nursing students have mentioned difficulties in performing basic arithmetic operations without a calculator, but test results have also revealed difficulties in converting units of measurement and interpreting the information provided, in addition to a lack of conceptual understanding of the task at hand (Bagnasco et al., 2016). Nursing students make medication calculation errors in examinations (Baran et al., 2016) and in clinical practice (Gorgich et al., 2016).

Various factors have been identified as being associated with nursing students' medication calculation skills, but they are mostly single findings. The positively associated factors are success in previous studies, educational background, level of education, the amount of calculation study completed, phase of study and age.

Strong success in previous nursing studies and completing earlier nursing education has been noted as related to better medication calculation skills (Sulosaari et al., 2012). Likewise, there is a stronger link between higher medication skills and bachelor level studies than diploma level studies (Dilles et al., 2011). The provision of larger amounts of calculation education in both previous and current programmes has also been linked to better medication calculation skills among nursing students (Sulosaari et al., 2012). As for the phase of study, the findings are inconsistent. In general medication calculation tests, the performance of third-year nursing students has been weaker than that of first- and second-year nursing students (Dilles et al., 2011; Sulosaari et al., 2012), but second- and third-year nursing students have performed better in medication calculations than first- and fourth-year students (Sulosaari et al., 2012). The findings regarding age are also controversial, as younger nurses have demonstrated both less (McMullan et al., 2010) and more competence in performing basic numerical calculations (Sneck et al., 2016).

The factors that are negatively associated with medication calculation skills are test anxiety and lack of context in medication calculation exercises. Test anxiety has been reported in relation to mandatory medication calculation tests that have high stakes, such as when a flawless performance is required for a pass (Røykenes et al., 2014). Anxiety is also linked to poorer mathematical ability (McMullan et al., 2012). As for the lack of context, if calculations are not placed in an authentic context, it gives little training in

understanding which parameters should be selected for equations in a medication calculation, thus weakening nursing students' ability to solve the calculation (Newton et al., 2009; Stolic, 2014).

Nurses' risk of error in medication calculations varies by their career phase and the recurrence of medication calculations. Nursing students' risk of error is considered to be relatively high, as students show high levels of certainty about incorrect calculations (Caboral-Stevens et al., 2020). Correspondingly, the ability to perform medication calculations does not correlate with self-rated readiness to practise medication care, but readiness is deemed higher than calculation skills (Dilles et al., 2011). The more time that has elapsed since a nursing student's last medication management or pharmacology course, the higher their risk of error (Caboral-Stevens et al., 2020). After graduation, the risk of error seems to decrease during the first year of practice, in correlation with the frequency of performing medication administration tasks (Simonsen et al., 2014). Continuous education does not seem to fully solve nurses' problems with medication calculations, but being aware of one's own limitations reduces the risk of error (Simonsen et al., 2011).

This study is well founded as the awareness of the potential, limitations and need for further education of the GNSs regarding medication calculation skills may contribute to greater medication safety. This study provides unique results by combining the findings of objective medication calculations performed by GNSs with their patients' and managers' evaluations of their medication skills.

## 3 | THE AIM

This sub-study is part of 'Professional Competence in Nursing' (PROCOMPNurse 2017–2021), a research project conducted in Finland, Germany, Iceland, Ireland, Lithuania and Spain. The aims of this sub-study are to test GNSs' medication calculation skills, to evaluate the factors that are associated with those skills, and to compare the results with patients' and managers' evaluations of GNSs' medication skills.

The research questions were as follows:

1. Can the GNSs provide correct answers to two calculations for oral medication?
2. Which GNS characteristics, if any, are associated with answering correctly?
3. Are the GNSs' correct medication calculations aligned with managers' and patients' evaluations of the GNSs' medication skills?

## 4 | METHODS

### 4.1 | Design

A multinational cross-sectional study design was used, and the reporting follows the corresponding STrengthening the Reporting of OBservational studies in Epidemiology (Supplementary file 1)

guideline (STROBE Statement, 2007). The participating countries were chosen on the basis of mutual research interests, yet relative geographical representativeness was achieved: Finland, Iceland, Ireland and Lithuania represented Northern Europe, Germany represented Central Europe and Spain represented Southern Europe (United Nations (UN), 2020). Convenience sampling was used for each of the populations (GNSs, managers and patients). The GNS data were collected from educational institutions between May 2018 and March 2019. The manager and patient data were collected during the same timeframe from hospitals accommodating the GNSs in their clinical training.

The inclusion criteria for GNSs were as follows: (i) they must be studying on a nursing degree or certificate programme leading to the initial qualification needed to practise as a registered nurse; (ii) the education or degree programme must be based on European Union Directives (2005/36/EC, 2013/55/EU); (iii) they must be participating in clinical training at the graduation stage; and (iv) they must be doing their clinical training in units treating adults (18 years old and over) to receive patient evaluation of the GNSs' medication skills.

The inclusion criteria for managers were as follows: (i) they must have a background in nursing; (ii) they must hold a management position at a hospital or unit level; (iii) they must have frequent contact with clinical nursing staff; and (iv) they must be responsible for, or participate in, the recruitment of nursing staff.

The inclusion criteria for patients were as follows: (i) they must be 18 years old or over; (ii) they must be able to give voluntary informed consent; (iii) they must be familiar with the language in which the survey was written; and (iv) they must have received nursing care from the participating GNS during his or her clinical training.

## 4.2 | Setting

Common competence requirements in European nursing education include pharmacology, but there is no minimum requirement for medication competence or medication calculation skills (2005/36/EC, 2013/55/EU). Furthermore, medication education practices vary within and among countries (Fleming et al., 2014; Sulosaari et al., 2014). Of the six participating countries, none have formal recommendations for medication education. Medication calculations may be integrated into pharmacology or other subjects. Three of the participating countries are currently using a standardised method to assess medication proficiency during nursing education. National regulations on medication competence tests are absent, but medication calculation tests are mandatory in the nursing programmes in each of the participating countries (Table 1).

Nursing education also grants different medication administration qualifications to graduate or registered nurses depending on the country in which they are studying. In all the participating countries, newly graduated nurses are qualified to administer medication through natural orifices independently. However, in Iceland, Lithuania and Spain, nursing education also qualifies nurses to administer medication through invasive routes without obtaining additional qualifications. Double-checking procedures are not mandatory in any of the countries (Table 2).

## 4.3 | Data collection

GNSs from Finland (*N* = 1,409), Germany (*N* = 556), Iceland (*N* = 117), Ireland (*N* = 456), Lithuania (*N* = 467) and Spain (*N* = 670) were

TABLE 1 Medication education during nursing education in the participating countries

| Medication education regulations and practices | Finland | Germany | Iceland | Ireland | Lithuania | Spain |
|---|---|---|---|---|---|---|
| Formal recommendation or regulation on medication education | No | No | No | No | No | No |
| Proportion of medication education | —[a] | 30 hr | 6 ECTS | —[a] | 3–5 ECTS | 3–9 ECTS |
| Pharmacology as independent subject | —[b] | Yes | Yes | —[b] | Yes | Yes |
| Medication education integrated to other subjects or pharmacology | Yes | Yes | Yes | Yes | Yes | Yes |
| Medication competence tests during education | | | | | | |
|    Theoretical | Yes | Yes | Yes | Yes | Yes | No |
|    Practical | Yes | Yes | Yes | No | No | Yes |
| Mandatory medication calculation tests during education | Yes | Yes | Yes | Yes | Yes | Yes |
| Use of medication passport or other standardised tool to assess and endorse medication competence during nursing studies | Yes | Yes | Yes | No | No[c] | No |

[a]Medication education is integrated to other subjects.
[b]Practices vary from educational institution to another.
[c]Currently introducing a standardised tool, but that was not in use at the time of the data collection.

**TABLE 2** Medication administration qualifications and procedures post-graduation

| Qualifications and procedures of medication administration | Country |
|---|---|
| Nursing education grants qualification to administer medication through natural orifices (po., pr., skin, ears, eyes[c]) | Finland, Germany, Iceland, Ireland, Lithuania, Spain |
| Nursing education grants qualification to administer medications through other than natural orifices (im., iv., io., sc.[c]) | Iceland, Lithuania, Spain, Germany[a] |
| Nationally or locally authorised medication administration permissions | Finland, Germany |
| Mandatory double checking of the medication administration | None |
| Newly graduated nurses administer medicines independently | Finland[b], Germany[b], Iceland, Ireland[b], Lithuania, Spain |

[a]io. and iv. excluded.

[b]With above-mentioned restrictions on iv.-, im.-, io.- and sc.-medications.

[c]per oral (po.), per rectum (pr.), intramuscular (im.), intravenous (iv.), intraosseus (io.), subcutaneous (sc.).

approached. The participants were recruited from 45 educational institutions: universities of applied sciences ($n = 12$) in Finland; nursing schools in universities ($n = 12$) and other hospitals ($n = 2$) in Germany; universities in Iceland ($n = 2$), Ireland ($n = 6$), Lithuania ($n = 1$) and Spain ($n = 5$); and colleges ($n = 5$) in Lithuania. The sample of educational institutions was formed on the basis of the educational infrastructure of the participating countries (Lahtinen et al., 2014). A total of 3,675 surveys were sent out, of which 1796 were returned, giving a response rate of 49% (country range 36%–88%).

To collect data from managers and patients, the sites were chosen according to the clinical placements of the GNSs participating in the study. Managers ($N = 853$) from 32 hospitals were invited to participate. The response rate was 66% (country range 38%–97%), and 538 responses were eligible for analysis. Patients ($N = 1,781$) from 34 university and other hospitals in addition to outpatient departments were invited to participate. The response rate was 74.5% (country range 54.0%–93.8%), and 1,327 responses were eligible for analysis.

The data collection in educational institutions and hospitals was organised in collaboration with the contact person at the site in question. The GNS surveys were delivered in both electronic and paper-and-pencil format. For the electronic surveys, REDCap electronic data capture tools hosted at the University of Turku (Harris et al., 2019) were applied. The paper-and-pencil format was used if the educational institution opted to do so. The manager and patient data were collected mainly in paper-and-pencil format, with participants returning their responses in sealed envelopes and either handing them direct to the researchers or contact person at the site or posting them to the national research teams.

## 4.4 | Measurements

Structured surveys were used for all three populations. The surveys were back-translated (Sousa & Rojjanasrirat, 2011) and piloted in each of the participating countries.

The GNSs' medication calculation skills were measured with two calculations which tested basic medication calculation skills, similar to those used in medication calculation education in all of the participating countries. The first, a tablet calculation, was about the duration of a tablet course, and the second, a fluid calculation, was about a single dose of a mixture. Both calculations required conceptual understanding and inference of the required parameters for the arithmetic operations. The tablet calculation needed to be performed by using a single arithmetic operation: dividing the package supply by the number of daily doses. The fluid calculation needed to be performed using multiple arithmetic operations, which made it more complex. The calculations were as follows:

Tablet calculation

'The tablet contains metronidazole 400 mg per tablet. How many days will the packet of 30 tablets last when the medicine has been prescribed 400 mg × 3 in a day? _____ days'

Fluid calculation

'The physician has prescribed erythromycin 40 mg/kg/day divided into three doses in a day to a child weighing 18 kg. Oral suspension contains erythromycin 80 mg/ml. How many millilitres do you give a child as a dose? _____ ml'

The GNSs' background factors of interest in this sub-study were as follows: (i) generic nurse competence derived from the Nurse Competence Scale (NCS; visual analogue scale [VAS] 0–100, 0 = very low level and 100 = very high level of competence) (Flinkman et al., 2017; Meretoja et al., 2004); (ii) satisfaction with current degree programme (1 = very unsatisfied and 4 = very satisfied); (iii) self-assessed level of achievement in studies (1 = very poor and 4 = excellent); (iv) level of previous education; (v) previous degree in health care; (vi) length of work experience; (vii) gender; and (viii) age.

The managers and patients evaluated the GNSs' medication skills with a single item using a VAS (0 = extremely poorly and 100 = extremely well). A 'Not applicable' option could be selected if a manager found that a statement did not apply to their unit or if a patient had not received any medication or related care from a GNS.

## 4.5 | Analyses

The continuous variables were summarised with means and standard deviation (SD) and the categorical variables with counts and percentages. The tablet calculation was calculated correctly by nearly all (close to 100%) GNSs in each of the countries, so further analysis of that item was not performed. To test the possible variables affecting the correctness of the fluid calculation, modelling was started with univariate binary logistic regression (country, age, previous degree, length of work experience as categorised, satisfaction with current degree programme, level of study achievement). The modelling was then continued by using multivariable modelling, where all significant factors from the univariate models were included. All pairwise comparisons between the countries were also estimated in the same model. While country effect was strongly dominant in the model, an additional model was executed without it. For the additional analysis, the total mean level of competence was compared between those who performed the fluid calculation correctly and those who did not, with one-way analysis of variance. In all the analysis, the missing responses were excluded.

The number of correct answers to the medication calculations was compared with the data from patients and managers in a descriptive fashion (i.e. no statistical method was used in this comparison). However, the evaluations (by Visual Analogue Scale) provided by the patients and the managers were examined using a two-way analysis of variance, including country and evaluator, in addition to the analysis of their interaction in the model. The interaction examined whether the difference of VAS evaluations between patients and managers differed between the participating countries.

The data were analysed using SAS 9.4 (SAS Institute Inc.). *p*-values of <.05 (two-tailed) were considered as statistically significant.

## 4.6 | Ethical considerations

The ethical board of the University of Turku granted approval for the whole research project (Statement 62/2017, 11.12.2017). Additional approvals were acquired locally where required. Research permission was granted by each of the participating hospitals and educational institutions. Permission to use the instruments was acquired from the copyright holders.

The research project was conducted according to the principles of research integrity, and the privacy of the participating organisations and individuals was protected at all phases. Informed consent to participate was required from all GNSs. The managers and patients signed an informed consent according to local legislation; where this was not required, returning the questionnaire was considered as an informed consent. In line with the GDPR (EC & European Commission, 2016 [Regulation EU 2016/679]), the participants were informed about the direct and indirect identification data and how it would be processed during and after the research. Participation was voluntary, and failure to participate had no consequences for a GNS's work or studies, a manager's work or a patient's care. In addition, the well-being of the participants was not jeopardised at any point (Declaration of Helsinki 2013).

## 5 | RESULTS

### 5.1 | Characteristics of the participants

Females (*n* = 1,563, 87%) prevailed in the GNS sample (*n* = 1,796), only 12% (*n* = 213) being male. Upper secondary level (*n* = 1,168, 65%) was the most frequently mentioned previous level of education. The majority (*n* = 1,429, 80%) of the participants had no previous degree in health care, but the rest (*n* = 349, 19%) had completed a degree in healthcare prior to starting their nursing education. Most of the GNSs (*n* = 1,375, 77%) had less than 25 months of work experience.

The GNSs' overall level of generic nursing competence (total NCS score) was 62.2 (SD 14.9), which showed a good level of competence. Most of the GNSs evaluated their own study achievements as good (*n* = 1,296, 72%) or excellent (*n* = 223, 12%). The vast majority of the GNSs were either satisfied (*n* = 1,055, 59%) or very satisfied (*n* = 190, 11%) with their current nursing programme.

### 5.2 | GNSs' medication calculation skills

The majority of the GNSs (*n* = 1,616, 99%) performed the tablet calculation correctly (correct result: 10 days). The non-response rate was 9% (*n* = 157). The incorrect answers (*n* = 23) varied between 0 and 133 days (Table 3).

Fewer GNSs (*n* = 1,064, 71%) performed the fluid calculation correctly (correct result: 3 ml). The non-response rate was 17% (*n* = 306). The incorrect answers (*n* = 426) varied between 0 and 4000 ml (Table 3). In practice, GNSs who answered the fluid calculation correctly had performed both calculations correctly.

There were statistically significant differences between countries in the number of correct answers to the fluid calculation (Table 3) apart from Finland and Iceland, where a significant difference was not found. Ireland, Germany and Spain had statistically corresponding results, but they all differed from those of Lithuania.

### 5.3 | GNS characteristics related to performing the fluid calculation correctly

Aside from country, three other GNS characteristics correlated with the correct answer to the fluid calculation. A statistically significant positive association was found with older age (*p* = .020), having a previous degree in health care (*p* < .001) and being satisfied with the nursing programme (*p* < .001). There was no statistically significant difference in gender, level of education, self-evaluated level of study achievement or total NCS score when compared with calculating the fluid calculation correctly (Table 4).

TABLE 3   Medication calculation results and country comparison of the fluid calculation

| Items | Country | Finland N = 514 | Germany N = 304 | Iceland N = 64 | Ireland N = 399 | Lithuania N = 272 | Spain N = 243 | Total N = 1,796 |
|---|---|---|---|---|---|---|---|---|
| Tablet calculation | Correct n (%) | 485 (99) | 292 (99) | 49 (**100**) | 371 (99) | 251 (98) | 168 (**95**) | 1616 (99) |
| | Incorrect n (%) | 3 (1) | 4 (1) | **0 (0)** | 3 (1) | 5 (2) | **8 (5)** | **23 (1)** |
| | Missing n[a] | 26 | 8 | 15 | 25 | 16 | 67 | 157 |
| Fluid calculation | Correct n (%) | 419 (**87**) | 172 (67) | 40 (85) | 206 (66) | 109 (**48**) | 118 (72) | 1064 (71) |
| | Incorrect n (%) | 61 (13) | 84 (33) | 7 (15) | 107 (34) | **120 (52)** | 47 (28) | 426 (29) |
| | Missing n[a] | 34 | 48 | 17 | 86 | 43 | 78 | 306 |
| Fluid calculation: country comparison | Finland | — | **<0.001** | 0.6895 | **<0.0001** | **<0.0001** | **0.0001** | |
| | Germany | **<0.0001** | — | **0.0016** | 0.7296 | **<0.0001** | 0.3423 | |
| | Iceland | 0.6895 | **0.0016** | — | **0.0005** | **<0.0001** | **0.0264** | |
| | Ireland | **<0.0001** | 0.7296 | **0.0005** | — | **<0.0001** | 0.1931 | |
| | Lithuania | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | — | **<0.0001** | |
| | Spain | **0.0001** | 0.3423 | **0.0264** | 0.1931 | **<0.0001** | — | |

Bold is used to highlight the lowest percentage of correct answers. Bold with underlinging indicates the highest percentage of correct calculations. The statistically significant *p*-values are also bolded.

[a]Missing responses were excluded from the analysis, and percentage of correct/incorrect is calculated from the given responses.

TABLE 4   GNSs' characteristics associated with correctness of fluid calculation

| Characteristic | Fluid calculation Correct n (%) | Fluid calculation Incorrect n (%) | p-value |
|---|---|---|---|
| Gender | | | |
| Female | 916 (71) | 369 (29) | 0.97 |
| Male | 138 (71) | 56 (29) | |
| Age, mean (SD) | 26.0 (7.0) | 24.8 (6.1) | **0.020** |
| Level of prior education | | | |
| Upper secondary level | 717 (68) | 269 (65) | 0.3132 |
| College level | 267 (25) | 120 (29) | |
| Higher education level | 71 (7) | 24 (7) | |
| Previous degree in health care | | | |
| Yes | 249 (82) | 56 (18) | **<.0001** |
| No | 810 (69) | 366 (31) | |
| Satisfaction with current programme | | | |
| Very unsatisfied | 24 (2) | 17 (4) | **<.001** |
| Unsatisfied | 190 (18) | 79 (19) | |
| Satisfied | 710 (68) | 255 (63) | |
| Very satisfied | 113 (11) | 56 (14) | |
| Level of study achievement | | | |
| Very poor/poor | 63 (69) | 28 (31) | .2624 |
| Good | 854 (82) | 320 (79) | |
| Excellent | 121 (12) | 59 (15) | |
| Work experience (years) | | | |
| 0–2 | 806 (77) | 338 (82) | .0989 |
| 2–5 | 161 (15) | 50 (12) | |
| >5 | 84 (8) | 25 (6) | |
| Total NCS score, mean (SD) | 62.4 (14.55) | 61.4 (14.89) | .2627 |

## 5.4 | Evaluations by managers and patients

The patients (*n* = 1,057) evaluated GNSs' medication skills to be 81.5 (SD 17.7, scale 0–100), and the variation between countries was 76.3–86.9 (Table 5). The managers (*n* = 483) assessed GNSs' medication skills at 58.22 (SD 21.4) and the variation between countries was 51.5–77.6. In every country, the patients evaluated the GNSs' medication skills more positively than the managers did.

The managers' and patients' evaluations were aligned with the proportion of correct medication calculations in more than one country, but in different ways (Table 5). In Iceland, the GNSs performed the calculations with a relatively high level of accuracy, and the evaluation of their medication skills was the highest among the managers (VAS 77.6) and one of the highest among the patients (VAS 84.2) in all countries. In Lithuania, the GNSs performed the calculations, especially the second one, with a low level of accuracy, and the evaluation of their medication skills was the lowest among the managers (VAS 51.5). Finnish GNSs showed a very high level of accuracy in performing the medication calculations, but this was not aligned with the relatively low evaluations of their skills by managers (VAS 56.3) and patients (VAS 76.5). Irish patients gave the highest evaluation of GNSs' medication skills (VAS 86.9), whereas German patients gave the lowest estimate (VAS 76.3). In Lithuania, the difference between managers' (VAS 51.5) and patients' (VAS 83.2) evaluations was the largest (Table 5).

## 6 | DISCUSSION

The aim of this study was to test European GNSs' medication calculation skills, evaluate the factors associated with the test results, and compare the results with patients' and managers' evaluations of the GNSs' medication skills. Multifaceted and multinational scrutiny was regarded as necessary, firstly, to take into account the views of the key stakeholders—that is, employers and care receivers—and secondly, because of the lack of coherence in medication education for nursing students in Europe (Fleming et al., 2014; Sulosaari et al.,

2014), which is worrying given the mobility of the nursing workforce within the EU (Marć et al., 2019).

A large proportion of the GNSs in this study performed both medication calculations correctly; thus, it seems that they managed slightly better than the GNSs in earlier studies (Bagnasco et al., 2016; McMullan et al., 2010). However, the comparison is problematic. Those previous studies included a higher number of calculations, and they were more complex than the ones in this study. Importantly, the findings support the fact that although nursing students tend to find oral medication calculations easier, some still have difficulties with them (McMullan et al., 2010). The number of incorrect answers and non-responses was also substantial. It remains unclear whether the failure to provide an answer was due to an inability to perform the medication calculations or some other reason, such as questionnaire fatigue. The questionnaire fatigue seems like a plausible explanation, as students who did not respond to second medication calculation discontinued answering the questionnaire altogether and were not just skipping over the medication calculations. Nevertheless, the results are alarming. Whether the dose of medication provided is significantly smaller or larger than intended, it may have grave consequences for the patient.

Both medication calculations were relevant to nursing practice, but one was more complex than the other. This leads to a discussion about the GNSs' ability to solve calculations that are more demanding, such as the fluid one. The vast range of incorrect responses may indicate that GNSs are not able to perform complex calculations because of some inadequacy in either their mathematical skills or their conceptual understanding, both of which are required to reach the correct answer (Bagnasco et al., 2016). That is, the GNSs might not have known which numbers to use for which purpose in order to achieve the intended result. However, in this study these root causes of incorrect answers were not investigated; thus, further research is warranted.

Self-reflection with respect to medication calculations during the transition from a student to a qualified nurse is another aspect that needs more attention in future research. Regardless of the source of the calculation error, an incorrect dose poses a serious risk for a patient (Caboral-Stevens et al., 2020; McMullan et al., 2010). It is known that students are more prone to risky behaviour because

TABLE 5 Medication skills of the GNSs

| Items | Country | Finland | Germany | Iceland | Ireland | Lithuania | Spain | Total |
|---|---|---|---|---|---|---|---|---|
| Tablet calculation | *n* | 488 | 296 | 49 | 374 | 256 | 176 | 1639 |
| | % of correct | 99 | 99 | **100** | 99 | 98 | **95** | 99 |
| Fluid calculation | *n* | 480 | 256 | 47 | 313 | 229 | 165 | 1490 |
| | % of correct | **87** | 67 | 85 | 66 | **48** | 72 | 71 |
| Managers' evaluation | *n* | 106 | 87 | 27 | 96 | 69 | 99 | 483 |
| | Mean | 56.3 | 57.0 | **77.6** | 55.8 | **51.5** | 63.1 | 58.2 |
| | SD | 17.9 | 20,0 | 15.5 | 22.9 | 23.9 | 20.6 | 21.4 |
| Patients' evaluation | N | 202 | 111 | 86 | 266 | 205 | 187 | 1057 |
| | Mean | 76.5 | **76.3** | 84.2 | **86.9** | 83.2 | 78.9 | 81.5 |
| | SD | 17.5 | 18.3 | 17.9 | 15.9 | 17.5 | 17.9 | 17.7 |

Bold is used to highlight the lowest percentage of correct answers. Bold with underlining indicates the highest percentage of correct calculations.

they are overconfident about uncertain knowledge (Caboral-Stevens et al., 2020; Simonsen et al., 2014). This overconfidence seems to reduce following clinical experience, as nurses are more likely to seek assistance in case of uncertainty (Simonsen et al., 2011). Developing strategies, in both clinical practice and nursing education, for enhancing performance in medication calculations and critically reflecting on one's own abilities during the transition phase may increase medication safety.

There were differences between the countries in the number of correct answers and the number of unanswered calculations. The reasons behind these differences warrants detailed inspection, as the medication calculations in this study were based on the medication education and practices in the participating countries. They were also typical calculations that are learned during study and performed in clinical practice. Nationally, however, the findings of this study can be used to promote medication safety. High proficiency in medication calculation skills is a necessity in countries like Iceland, Lithuania and Spain, where newly graduated nurses are qualified, based on their education, to perform independently higher-risk medication management, including intravenous injections and infusions. The administration and preparation phases of providing these medications include calculations and are prone to involving errors (Kuitunen et al., 2020). Therefore, it may be beneficial to scrutinise the results of this study on the national level for a wide variety of tasks and in alignment with the clinical responsibilities of newly graduated nurses to ensure that they receive the support they need to maintain medication safety.

As for the associated factors, this study supports the findings that a previous degree in health care (Sulosaari et al., 2012) and increase in age are linked to better medication calculation skills (McMullan et al., 2010; Sulosaari et al., 2012). Practice with administering medication may be one reason that these factors seem to be aligned with better medication calculation skills (Sulosaari et al., 2012). Contrary to an earlier study (Sulosaari et al., 2012), in this sample self-evaluated success in one's studies was not a statistically significant indicator of medication calculation skills, but satisfaction with one's current degree programme was linked to better performance in medication calculations. This may be because satisfaction is increased through better instruction, which in turn results in better medication calculation skills, or it could be because the students who performed better in the medication calculations were generally more positive about their studies.

The managers and patients evaluated the GNSs' medication skills well over the VAS midpoint, which suggests that their perceptions were very positive. However, the differences between patients' and managers' perceptions, in addition to the apparent misalignment with the medication calculation skills of the GNSs, warrants further study. This could indicate that in spite of the positive perception overall, the managers or the patients (or both) might not have been especially aware of the GNSs' medication calculation skills. However, information on staff know-how is thought to be essential for managers (Siirala et al., 2020). Hence, the discussion and development work that have taken place between managers and educators needs to be continued in order to raise general awareness of the potential pitfalls and medication calculation skills *per se* of future professionals.

As for the patients, the discrepancy between their perceptions and the GNSs' actual medication calculation results may be explained by the fact that patients only see the end result: a GNS performing medication tasks fluently. They are not necessarily aware of the support and supervision provided by qualified nurses behind the scenes to make sure that patient safety is not jeopardised. In addition, patients are seldom in the position to be able to evaluate the calculations that underlie the administration and preparation of medicines, which happen out of view. However, in a broader sense, patient involvement in clinical education is beneficial for students and patients (Suikkala et al., 2018) thus it should be encouraged.

## 6.1 | Strengths and limitations

There are some limitations in this study that need to be considered. Firstly, only two medication calculations were used to assess GNSs' medication calculation skills, which can be criticised for giving a limited view (Stolic, 2014). However, it was necessary to standardise the assessment across the six countries, so these two calculations were chosen because they were in alignment with the fact that in all the participating countries, newly graduated nurses are allowed to administer oral medications independently.

Secondly, the participants were not requested to record the arithmetical operations that provided them with their answers. Thus, it remains unclear whether their errors were due to mathematical inability or sloppiness: information that would have provided a deeper understanding of how to deal with the issue in nursing education.

Thirdly, convenience sampling was used for all the respondent groups, limiting the generalisability of the results. Moreover, the response rates varied between countries and respondent groups remaining modest in some of the countries. However, the overall number of respondents in each group was adequate for reliable statistical analyses.

## 7 | CONCLUSION

Most of the GNSs in this research performed both medication calculations correctly, but a clinically significant number of them failed to answer the fluid calculation correctly. Given that GNSs are about to enter the clinical field, the results of this study are worrying from the perspective of medication safety in patient care. Further studies are needed to unravel the reasons behind the difficulties in basic medication calculations. Managers and patients evaluated GNSs' overall medication skills positively, but the lack of alignment in some countries between the GNSs' calculation results and their managers' and patients' evaluations is a prompt for further studies on the underlying causes of these differences. The country-specific variation in the independent duties assigned to newly graduated nurses in relation to administering medication implies that there is a need for further research specific to the medication calculation skills requirements in the individual countries.

## 8 | RELEVANCE TO CLINICAL PRACTICE

In the healthcare organisations, it is important to recognise the possible inadequate medication calculation skills of GNSs entering the clinical practice as qualified nurses. Thus, nurses and nurse managers working closely with GNSs and newly qualified nurses need systematic methods to assess the medication calculation skills of early career nurses within Europe. In addition, nurse educators also need systematic methods of teaching and evaluating the medication calculation skills of the students. Patients' current positive view on the GNSs' medication skills is a solid base for patient participation in medication education but it is also a call to elevate the skills of the GNSs' to meet the expectations of the patients.

### CONFLICT OF INTEREST

The authors declare no conflict of interest regarding this study.

### AUTHOR CONTRIBUTIONS

**Conceptualisation**: I.E., L.S., I.B-A., P.F., P.K., H.L-K., E.L., B.N., J.S., M.S., H.T. and S.K; **Data curation**: S.K., H.L-K. and E.L.; **Formal analysis**: E.L.; **Funding acquisition**: H.L-K., S.K. and L.S.; **Investigation**: L.S., I.B-A., P.F., P.K., H.L-K., E.L., B.N., J.S., M.S., H.T. and S.K.; **Methodology**: S.K., H.L-K. and E.L; **Project administration** and **Supervision**: H.L-K lead and S.K; **Resources**: L.S., I.B-A., P.F., H.L-K., E.L., J.S., M.S., H.T. and S.K.; **Validation**: I.E., L.S., I.B-A., P.F., P.K., H.L-K., E.L., B.N., J.S., M.S., H.T. and S.K.; **Visualisation**: I.E., L.S., H.L-K. and S.K; **Writing—original draft**: I.E.; **Writing—review & editing**: I.E., L.S., I.B-A., P.F., P.K., H.L-K., E.L., B.N., J.S., M.S., H.T. and S.K.

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