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Nursing students' genomics literacy: Basis for genomics nursing education course development

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ABSTRACT

This study aimed to investigate the genomics literacy of Finnish and Filipino nursing students as a basis for developing a genomics nursing education course. This is a cross-sectional online survey using the 31-item Genomic Nursing Concept Inventory, IBM SPSS version 27, and item-analysis. A total of 245 nursing students participated in the study; 75% reported that they had not completed any genetics-genomics courses. The GNCI scores ranged from 2 to 31 total correct answers out of a total possible score of 31. The GNCI mean score of the Finnish cohort (9.53; SD = 3.48; 36% correct) was significantly lower compared to the Filipino cohort (16.21; SD = 9.74, 58% correct). These results show that the genomics literacy of nursing students in Finland and the Philippines is weak, particularly in human genome homogeneity and genotype-phenotype association concepts. We recommend designing effective genetic and genomic educational programs and updating the nursing curricula.

Background

The advancing science of genetics and genomics is remarkably transforming the way nurses deliver care (Beery et al., 2018; Bhavnani et al., 2017; Finnish Institute for Health and Welfare, 2019; World Health Organization, 2020). Genomics as a discipline is becoming mainstream in this genomic era and nurses needs to be aware of it; hence upgrading the current nursing curriculum is essential (Anderson et al., 2015; Campion et al., 2019). The paradigm shift of precision healthcare requires nurses to be prepared to provide genomics-informed nursing care (Aiello, 2017; Dumo et al., 2020). This transformation in global nursing knowledge to increase literacy in genomics is required to advance nursing's role in the genomics discipline (Buaki-Sogo & Percival, 2022; Bueser et al., 2022; Calzone et al., 2018). The need to maintain competent practice standards with the changes in science is essential, and thus knowledge of genetics-genomics is also essential. A primary reason for implementing genetics-genomics into a nursing curriculum is that new discoveries in genetics-genomics are revolutionizing medical approaches to the diagnosis, management, and treatment of disease (Calzone et al., 2018; Finnish Institute for Health and Welfare, 2019; Majstorović et al., 2021; Tonkin et al., 2020; World Health Organization, 2020).

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Validating the genetics/genomics literacy of students is important to ensure that appropriate genomic content is added to curricular integration (Abad & Sur, 2022; Dewell et al., 2020). Internationally, numerous studies have assessed the genomics literacy of nurses (Dagan et al., 2021; McCabe et al., 2016; Wright et al., 2019), nursing students (Dewell et al., 2020; Ward et al., 2016), and nursing faculty (Dewell et al., 2020; Read & Ward, 2016); however, the literacy of Finnish and Filipino nursing students has not been investigated to date. The identification of knowledge gaps by regions indicates a need to improve knowledge. In addition, an understanding of where genetics content exists in the curriculum is also necessary.

No one must be left behind in advancing genomics knowledge, regardless of whether a country's economic profile is highly developed or still developing. The International Society of Nurses in Genetics 2021 World Congress highlighted the importance of promoting diversity, inclusion, and health equity in genomic nursing (ISONG, 2022). Assessing the genetics and genomics literacy of nursing students across the world is important to strengthen genomics nursing education, practice, and research internationally (Calzone et al., 2018). Understanding the literacy in genetics and genomics between a developed country, such as Finland, and a developing country, such as the Philippines, is a stepping-stone in promoting diversity, inclusion, and health equity in genomic nursing worldwide.

Genomics in Finland and the Philippines

Finland is promoting the incorporation of genomic data to provide a distinctive opportunity for contemporary personalized health care (Finnish Institute for Health and Welfare, 2019; Ministry of Social Affairs and Health, 2022). The Finnish health care system has prepared for this by acknowledging that the clinical application and sharing of genetic information involves risk so a national genome strategy to safeguard genomic data has been developed so that it can be effectively and safely utilized in health promotion and well-being (Ministry of Social Affairs and Health, 2022). This judicious application of genomic data will provide more effective targeted screening, more accurate diagnoses, personalized treatment, and increased economic benefits (Finnish Institute for Health and Welfare, 2019). Moreover, limited genetics and genomics services are now offered by the Philippine government and private institutions (Abad & Sur, 2022). Recently, the Philippines has established the Philippine Genome Center (PGC) in 2019 as a national strategy to facilitate genomics application to public health promotion (Padilla & Cutiongco-de la Paz, 2016). The nursing educational systems in Finland and the Philippines are presented in Supplementary Material Table 1.

Health care professionals with genetic and genomic knowledge are needed. Training nurses in genetics and genomics would enable them to provide these services in their care to patients and add to their skills in the assessment, management, and evaluation of care (Bhavnani et al., 2017; Buaki-Sogo & Percival, 2022; Bueser et al., 2022; Calzone et al., 2018). Appropriate genetic-genomic education will enhance nurses' collaborative work with multidisciplinary health care professionals, including genetic counselors, geneticists, physicians, clients, and families (National Academies of Sciences Engineering and Medicine, 2021; Tonkin et al., 2020). There is an urgent need to improve genetic and genomic nursing education worldwide by updating and upgrading the nursing curriculum to reflect advances in genetic and genomic technology (Calzone et al., 2018; Campion et al., 2019; Chair et al., 2019).

Learning Theories

The learning theories of cognitivism and constructivism guided this study. According to cognitivism, learning relies on both external and internal factors (Michela, 2018); the learner as an information-processor can acquire knowledge by undertaking cognitive operations, absorbing information, and storing it in memory. According to constructivism, the learners build meaning based on previous experiences, creating new knowledge through active engagement such as real-world problem solving (Tam, 2000). The need to measure deep understanding of foundational genetic-genomic knowledge is supported by both learning theories. Nurses who understand how genes influence health (i.e., understand foundational principles) are well positioned to deliver genomics-informed care (Abad & Sur, 2022; Aiello, 2017; Buaki-Sogo & Percival, 2022; Campion et al., 2019; Laaksonen et al., 2022; Majstorović et al., 2021; Ward et al., 2016; Zureigat et al., 2022). Genomics literacy is important to nurses so that they can deliver and explain precision healthcare across the care continuum, from assessment to evaluation of health outcomes. The Genomic Nursing Concept Inventory (GNCI) was designed to measure that foundational understanding that nurses are expected to recall and apply in practice.

Research Aim

This study aimed to investigate the genomics literacy of Finnish and Filipino nursing students as a basis for developing a genomics nursing education course. These findings can be used to inform nursing education, enable the design of evidence-based educational programs, and update nursing curricula.

The following research questions guided the study:

- What is the level of genomic literacy among Finnish and Filipino undergraduate nursing students?
- Are there any statistically significant differences in genomics literacy between Finnish and Filipino cohorts?

Method

Study Design

The study design was an online cross-sectional survey of Finnish and Filipino nursing students. The STROBE statement checklist of cross-sectional studies was used in reporting this study.

Samples and Setting

Baccalaureate nursing students (years 1-4) studying in a government-established educational institution were the target population of this study. Finland and Philippines were chosen as the study setting because both are comparably new to including genomics in their nursing education. A convenience sample was taken from one university in the Philippines and two universities of applied sciences (UAS) in Finland from 2020-2021. A total of 1,570 nursing students were invited from participating universities (n = 700 from the Philippines, and n = 870 from Finland), and 245 nursing students responded (n = 228 from the Philippines, and n = 17 from Finland), with an overall response rate of 16% (33% response rate from the Philippines, and 2% response rate from Finland). The main reason for the low response rate was that the data were collected during the COVID-19 pandemic time. Other reasons were lack of interest in the topic, lack of time, and student workloads.

Inclusion and Exclusion Criteria

Participants were included if they were (a) undergraduate nursing students of any year level; (b) studying in government institutions; and (c) willing to participate voluntarily. Participants were excluded

if they were (a) graduate nursing students; (b) studying in private institutes; or (c) employed and unemployed nurses.

Data Collection

The data were collected electronically using an electronic platform from Finnish and Filipino nursing students. The use of a convenience sample was appropriate in this study, as screening was first undertaken to identify whether the student had taken any genetics-genomics or biology courses.

The English version of the Genomic Nursing Concept Inventory (GNCI© 2017) was used in the Philippines, because English is used in teaching and represents the country's second official language. In Finland, both the English and Finnish versions of the GNCI were used to assist local and international students. Recruitment of undergraduate students was facilitated via email with the help of Finnish and Filipino department heads, deans and directors, and other individuals in leadership positions. Postings targeted to specific students were placed on their learning management system. The postings described the study and how to participate, and were placed there by the first author (A.P.). In Finland, both face-to-face and online recruitment were conducted. In the Philippines, a 30-minute online webinar was arranged to describe the study and recruit participants. The key people recontacted the students twice to increase the response rate. To facilitate the accuracy of the collected data, the students were instructed not to use any resources when answering the GNCI.

Instrument

We obtained permission from the author of the GNCI© to use the instrument in Finland and the Philippines. The GNCI© 2017 is a 31-item English-language scale with demonstrated validity and reliability (Cronbach's alpha values between 0.73 and 0.83) (Ward et al., 2014). The Finnish version of the GNCI demonstrated a Cronbach's alpha value of "good" ($\alpha = 0.816$; 95% confidence interval: 0.567-0.956) (Dumo et al., 2022). The GNCI was used to determine the participants' level of genetic-genomic knowledge. The GNCI items assess the understanding of genetic-genomic concepts relevant to nursing practice and identify specific targets for education (Ward et al., 2014). The following demographic data were also collected: age, sex, institution, year level, native language, and whether they have completed any genetic-genomics courses or any biology courses. The latter data point was important in data collection, as it will provide insight into the effectiveness of existing genetics and biology course content in the nursing curricula.

Data Analysis

IBM SPSS Statistics version 27 was used to calculate descriptive and inferential statistics. Kolmogorov–Smirnov and Shapiro-Wilk were used to test the normal distribution of the variables of age and total GNCI score. The Mann–Whitney U test—level of significance 0.05—was used to calculate the difference in the dependent variable (total GNCI scores) for independent groups: sex, country, and completion of a biology course. The independent samples Kruskal–Wallis test was used to compare total GNCI scores to participants' year level and whether respondents had completed a genetics–genomics course for academic credit. Fisher's exact test was used to determine if there were significant differences between the two participating countries and GNCI items. Item-analysis was used to analyze the student's responses on the 31-item GNCI and the relationship between them (Rezigalla, 2022).

Results

The Participants' Background

A total of 245 nursing students participated in the study (n = 17 from Finland, and n = 228 from the Philippines). The demographic data are presented in Supplementary Material Table 2. The age of the respondents ranged from 17 to 46 years; Filipino students' mean age was lower (20 years) than that in Finland (28 years). The majority of the respondents were female (88.24% in Finland, and 86.40% in the Philippines), and approximately half of the respondents were at the first-year level (47.06% in Finland, and 43.86% in the Philippines). Few of the respondents from the Philippines had completed any genetics or genomics courses for academic credit (25% in the Filipino cohort), while none of the respondents from Finland had completed any (0% in the Finnish cohort). Sixty percent of respondents from the Filipino cohort reported having completed a biology course, as did 53% of Finnish students.

Literacy in Genomics and Genetics

Overall, scores on the GNCI were low to high, ranging from 2 to 31 (out of a possible 31). In this study, scores among the Filipino cohort were higher compared to the Finnish cohort (58% mean score in the Filipino cohort, and 36% mean score in the Finnish cohort), with a mean score of 16.21 correct in the Filipino cohort and 9.53 correct in the Finnish cohort (95% confidence intervals). Supplementary Material Table 3 shows that the results of the Mann-Whitney U test reveals statistically significant differences between the nursing students from the Filipino cohort and the Finnish cohort (p-value = .023). Our study found statistically significant differences between male and female respondents in relation to their genomic knowledge (p-value = .022): females had better GNCI scores than their male counterparts.

There were no significant statistical differences between the genomics knowledge scores and completion of biology (p-value = .188) or genetics-genomics courses (p-value = .981). This means that regardless of whether students had completed a previous biology course or a previous genetics and genomics course, the GNCI scores were the same. In addition, the independent samples Kruskal–Wallis test showed no statistically significant differences between GNCI scores and students' year levels (p-value = .509). This means that regardless of whether students were in the first, second, third, or fourth year in their studies, the GNCI scores were the same. Our study results indicate an existing lack of genomics knowledge, and this implies that the current nursing curriculum requires reconstruction, which should include discussions with nursing leaders and national accrediting organizations that mandate essentials within the curriculum. In Finland, the national regulations derive from European Union directives (2013/55/EY), EU Council regulations (77/452/ETY, 2001/19/EY, 2005/36/EY), the Decree on Polytechnics 352/20023, and national Supervisory Authority for Welfare and Health (Valvira). In the Philippines, the Commission on Higher Education, the Philippine Nursing Act of 2002, RA 9173, and the Philippine Regulatory Commission determine the national regulations.

Supplementary Material Table 4 shows the respondents' performance on the GNCI©. Respondents from the Filipino cohort performed better in their responses to the question about "Mutations and disease" (Question 21, 75% answered correctly), the concept "Autosomal dominant" (Question 30, 74% answered correctly), and the topical category "Genome basics" (Question 2, 73% answered correctly). Respondents from the Finnish cohort performed better in their responses to the question about "Genetic testing" (Question 14, 76% answered correctly), the concept "Genome basics" (Question 2, 65% answered correctly), and the concept "Family history" (Question 26, 65% answered correctly). In contrast, respondents from the

Filipino cohort performed least well in response to the question about genotype-phenotype association. As an example, this question asked students to distinguish genotype from phenotype. Students who answered (b) had them reversed; 46% of students knew that all cells contain the same genes, while 47% could correctly describe the function of a gene. Respondents from the Finnish cohort performed least well in response to the question about "Human genome homogeneity" (Question 3, 12% answered correctly), the concept "Genome composition and organization" (Questions 4 and 8, 12% answered correctly), and the concept "Autosomal inheritance" (Question 24, 18% answered correctly). For five items, the mean correct response percentage was < 50% among respondents from the Filipino cohort compared to 24 items with < 50% correct responses in the Finnish cohort. Fisher's exact test showed statistically significant differences on 12 items with a p-value (two-sided) lower than 0.05 level of significance. Respondents from the Filipino cohort performed higher in GNCI items specifically in gene function (Items 1 and 6, p-value = .048; .005 respectively), human genome homogeneity (Item 3, p-value < .001), genome organization (Items 4 and 8, p-value = .001; <.001 respectively), gene expression (Item 11, p-value = .040), germline/somatic mutations (Item 18, p-value = .043), cancer genotyping (Item 20, p-value = .042), family history/red flags (Item 23, p-value = .044), inheritance of autosomal mutations (Item 24, p-value = .004), pharmacogenomics (Item 27, p-value = .047), and heterozygosity in autosomal dominant conditions (Item 29, p-value = 0.002) compared to respondents from the Finnish cohort. The scale reliability measure showed a Cronbach's α of 0.949, indicating a high internal reliability of the whole GNCI.

Discussion

Our study evaluated the genetic and genomic literacy in Finnish and Filipino nursing students. Our findings demonstrate the need to bridge these students' knowledge gaps. Acquiring adequate levels of genetic and genomic literacy is important to achieve genomics competency in nursing practice (Majstorović et al., 2021). Genomics knowledge acquisition is important to accelerate genomics integration into healthcare and improve patient outcomes (Calzone et al., 2018). Our findings are consistent with those of other international studies demonstrating the lack of nurses' genomic literacy (Dewell et al., 2020; Majstorović et al., 2021; McCabe et al., 2016; Read & Ward, 2016; Ward et al., 2016; Wright et al., 2019). Finnish and Filipino nursing students' genomic literacy was weakest in basic genomic concepts, particularly in the areas of human genome homogeneity and genotype-phenotype association, similar to the results from Europe, Australia, Canada, and the USA. Majstorović et al. (2021) identified low genomic literacy in Croatian undergraduate students; Dewell et al. (2020) found low GNCI scores among nursing students and faculty in Canada; Wright et al. (2019) reported a low mean GNCI score in Australia among registered nurses and midwives; McCabe et al. (2016), Read and Ward (2016), and Ward et al. (2016) highlighted low genomic literacy among practicing nurses, nursing students, and nursing faculty in the USA. Our results are similar to those of a large cohort study by Dagan et al. (2021) among Israeli nurses. They found that, compared to male nurses, female nurses had more genomic knowledge and performed more genomic practices. In contrast, Dewell et al. (2020) found that male nurses achieve better GNCI scores in a Canadian cohort. This implies that it is important for nurse educators to conduct an initial genomics literacy assessment using a validated tool on the target population of learners to have an overview of existing knowledge gaps. This step is essential when developing and designing genomics nursing courses to facilitate efficient learning processes and evidenced-based teaching.

A genomic literacy assessment must precede the curriculum development to overcome knowledge shortfalls. As an example of how measuring literacy can inform curricular development, using the GNCI tool, nurse educators can recognize where student knowledge is very weak, and this can help an educator in designing a course and creating learning activities to rectify the knowledge deficit in the curriculum. In our study, we found that students have misconceptions regarding a person's genotype; 49% answered incorrectly that genotype is the traits and characteristics determined by their genes. A nurse educator can then use this information to formulate appropriate genomics nursing courses and learning materials such as web-based courses, video clips, online resources, flipped learning approaches, and so on.

Low nursing genomic literacy is due to multifactorial educational barriers. These obstacles include deficient genomic knowledge among educators, crowded curricula, inadequate time, and lack of regulatory legislation requiring genomic competency (Calzone et al., 2018; Majstorović et al., 2021). Two factors are crucial, one of which is the lack of nursing leaders in designing curricula; the other is nurse trainers' reluctance to consider alternative approaches that facilitate integrating new knowledge and clinical advances (Calzone et al., 2018). Similarly, Abad and Sur (2022) reported various other issues that impede the expansion of nurses' roles in genetics and genomic competency in clinical practice.

Although, we cannot generalize the Finnish results with such a small sample and further research is needed using larger cohort groups. The value of our study is that our methodology and results can help nurse educators to design tailored genetics and genomics nursing education based on evidence. Our findings could inform the development of any educational interventions. We suggest that genomics nursing education be included in the nursing curriculum as a stand-alone or elective course to overcome curriculum implementation challenges. Our suggestion is supported by Fangonil-Gagalang and Schultz (2021); Fater (2014); the International Society of Nurses in Genetics (2022); and Zureigat et al. (2022). We suggest that nurse educators, especially those who are novices in genomics concepts, use the available genomics education resources repository published by the International Society of Nurses in Genetics (ISONG) global membership and education committees (Fater, 2014; International Society of Nurses in Genetics, 2022). Our results make an important scientific contribution by expanding our understanding of the magnitude of the knowledge problem of the lack of genetics and genomics literacy among nurses.

When incorporating genomics knowledge into nursing curricula, basic principles of genomics, omics, precision medicine, precision health, nurses' role, practical nursing applications, and the ethical, legal, and social implications of genetic-genomic concepts need to be addressed. Educational nursing preparation to integrate genomics empowers nurses to engage patients, families, and communities to promote healthier behaviors (Campion et al., 2019; Laaksonen et al., 2022; Majstorović et al., 2021; Saleh et al., 2019). For example, nurses who are knowledgeable about cancer genomics could provide better support in patient education and family counselling. Nurses who are knowledgeable about the genetics and genomics of Alzheimer's disease could provide a better understanding of the disease process, which can help in creating personalized nursing care. Nurses who are knowledgeable about pharmacogenomics and medication safety could better ensure patient safety. Nurses who are knowledgeable about the genomics of diabetes could provide better quality of nursing care. Ultimately, nurses who are educated and knowledgeable about genomics-informed nursing care can facilitate evidence-based practices to improve patient outcomes.

Limitations and Recommendations

The large difference between participants by country (n = 17 for Finland, n = 228 for the Philippines) makes comparisons inaccurate

and difficult. Results cannot be generalized. The results from Finland should be interpreted carefully because the research did not examine how much the nursing curriculum relies on biology taught in other courses.

In this study, researchers did not have control over the possibility of respondents using internet searches while answering the GNCI tool. The response rate was low and based on a convenience sample. The COVID-19 restrictions and other factors, such as students' workload, lack of interest in the topic, and lack of time to participate, explained the low response rate in general. Nonetheless, although the survey response rate was lower than expected, we still had enough responses to conduct some analyses, although there may be a selection bias. Our study findings provide a valuable snapshot of genomic literacy among undergraduate nursing students, and a solid starting point for the development of a nationally and internationally adapted curriculum.

Conclusion

The literacy in genetic and genomics knowledge and its application to the clinical situation in a cohort of nursing students from Finland and the Philippines is low to moderate. The understanding of genomic and genetic basic concepts was weakest particularly in the areas of the human genome homogeneity and genotype-phenotype associations. The study findings provide specific information about the concepts nursing students do and do not understand, which can be leveraged to inform evidence-based education. Designing effective and targeted educational programs and updating nursing curricula is necessary to ensure that the next generation of nurses are prepared in advanced genomics, as well as in personalized health care, in order for them to practice evidence-based clinical care.

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Declaration of Competing Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.teln.2022.11.013.

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