ORIGINAL ARTICLE

Genomic Medicine in Nursing Education: A Study of Genetic Literacy, Attitudes, and Perspectives among Undergraduate Nursing Students

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Abstract

Background and Aim: Pharmacogenomics is an emerging discipline in molecular genetics with significant potential to influence treatment and health outcomes. Therefore, this study aimed to evaluate the genetic literacy, attitudes, opinions, and perspectives of nursing students regarding genomic medicine. **Methods:** A cross-sectional design, utilizing an online questionnaire to collect data from nursing students enrolled in a university in the Riyadh region of Saudi Arabia. It was carried out over 4 months in 2025. The final questionnaire consisted of four sections: (1) Demographic information, (2) Knowledge of pharmacogenomics, (3) Attitudes toward genomics, and (4) Accessibility and availability of genetic testing. The collected data were analyzed using IBM the Statistical Package for the Social Sciences Version 26. **Results:** A total of 546 nursing students participated, with 45.8% males and 68.9% between 20 and 25 years old. The students demonstrated a good understanding of pharmacogenomics, with 60.8% correctly defining the term and 78% recognizing the role of genetic changes in adverse reactions. Notably, 93% understood that genetic modifications can impact drug efficacy. A substantial majority showed positive attitudes toward genetic testing, with 96.2% considering it for cancer treatment with fewer side effects and 87.4% for treatment with minimal adverse effects in the case of a family history of diabetes. **Conclusion:** Nursing students have a good understanding of pharmacogenomics, but knowledge gaps exist, particularly in basic genetics. Interest in genetic research and bio banking is low. The findings also highlight concerns about genetic testing accessibility and awareness of genetic discrimination protections. Targeted education and training are needed to address knowledge gaps and promote informed decision-making in genomic medicine.

Key words: Attitudes, genomic medicine, literacy, nursing education

INTRODUCTION

Pharmacogenomics is an emerging discipline in molecular genetics with significant potential to influence treatment and health outcomes.[1,2] As a branch of precision medicine, pharmacogenomics evaluates how a patient's genetic diversity affects how they respond to a medication or other treatment.[3,4] Pharmacogenetics testing is becoming more widely used in a world where health disparities exist in both developed and underdeveloped nations.[3] The role of pharmacogenomics has expanded from enhancing the drug effect to minimizing drug adverse reactions.[5] Globally, in 2022, the U.S. Food and Drug Administration's (FDA's) Adverse Event Reporting System received over 1.25 million adverse events, with approximately 175,000 deaths, suggesting a serious threat to the world's healthcare systems.[6-8] A novel idea called "precision medicine" has been developed in an effort to combat these adverse reactions and boost the therapeutic efficacy of medications. Its goals include optimizing patient outcomes and customizing

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treatment regimens.[9] Moreover, the majority of healthcare systems currently use pharmacogenomics (PGx) testing, and commercial firms provide a range of options, including direct-to-consumer testing. Leading the clinical implementation of PGx in a variety of practice contexts are healthcare professionals, including nurses and drug experts.[9,10]

Given their position following healthcare providers and their ability to prescribe and dispense medication to patients while also assisting with their education, nurses are widely regarded as the most qualified healthcare professionals.[11-15] On the other hand, in recent years, there has been a greater focus on the roles that nurses play in implementing genomic health practices. Nurses role in addition to providing healthcare, they are also involve patient counseling and education, therefore it is expected that nurses must be familiar with pharmacogenetics testing as the use and need of pharmacogenetics and genomics is increasing worldwide, and thereby demanding the nursing professionals significance in genomics.[16] As a result, it is important that nurses possess sufficient pharmacogenomics understanding. Previous research has shown that nurses and nursing students do not fully comprehend the various pharmacogenomics concepts. In addition, literature also revealed a lack or limited genomic literacy among nurses, students with notable heterogeneity.[4,16] For instance, research from across Canada showed that nurses lack the expertise to enable the use of pharmacogenetics testing in clinical settings. In spite of this, a large number of Canadian nurses expressed interest in learning about pharmacogenetics, especially through online seminars and courses.[16] Similarly, another study among medical and health science students revealed positive attitudes but lacked the knowledge.[17] Similarly, another recent study among Chinese nursing students revealed positive attitudes but limited levels of knowledge.[18] In Saudi Arabia, literature is lacking on this topic, particularly among nursing students; therefore, this study aimed to evaluate the genetic literacy, attitudes, opinions, and perspectives in genomic medicine among nursing students.

METHODS

Study design

This study employed a cross-sectional design, utilizing an online questionnaire to collect data from nursing students enrolled in a public and a private university in the Riyadh region of Saudi Arabia. The data collection was carried out over 4 months from January to April 2025. The study population consisted of nursing students aged 20 years or more, currently pursuing their course in a university in the Riyadh region. The inclusion criteria were: (1) Being a nursing student in the second year or above, including interns, and (2) Being enrolled in a university in the Riyadh region. Students who did not meet these criteria were excluded from the study. The study was conducted by the principles of the Declaration of Helsinki. Participation in the study was voluntary, and informed consent was obtained from all participants. The confidentiality and anonymity of the participants were ensured throughout the study.

Sample size was calculated similar to previous studies[19-22] using an online calculator with a 5% margin of error, 95% confidence interval, and 50% expected response rate, assuming an unknown population.[23] The initial required sample size was 377 nursing students. To account for 10% attrition, we estimated a final sample size of at least 400 students. However, to enhance statistical power, minimize sampling bias, and allow for more accurate estimates, we approached 550 students, also considering their positive perspectives toward participating in the study.

Questionnaire development and validation

The questionnaire used in this study was adapted from previous studies with similar objectives.[17,24] The final questionnaire consisted of four sections: (1) Demographic information, (2) Knowledge of pharmacogenomics, (3) Attitudes toward genomics, and (4) Accessibility and availability of genetic testing. To ensure cultural relevance, the questionnaire was translated into Arabic and then back-translated into English using a forward and backward translation procedure. A pilot study was conducted among 20 randomly selected nursing students to test the questionnaire's validity and reliability. Data were collected using an online questionnaire distributed through Google Forms from June to August 2024. The questionnaire was randomly distributed among nursing students in the target population. Before data collection, the study protocol and questionnaire were reviewed and approved by the Ethical Committee at the King Saud University, Riyadh, Saudi Arabia. Informed consent was obtained from all participating students before they filled out the survey.

Data analysis

The collected data were reviewed and subsequently analyzed using IBM the Statistical Package for the Social Sciences (SPSS) Statistics software version 26 (SPSS Inc., Armonk, New York, USA). Descriptive statistics were used to estimate frequencies and percentages for categorical variables.

RESULTS

Five hundred and forty-six nursing students responded to the study, of which 250 (45.8%) were males, 376 (68.9% were between 20 and 25 years old, while the majority of the students belonged to a public university, 69.4% of them were Saudi nationals, 41.9% of them parents were working in a health care setting. The detailed description of the basic characteristics of the nursing students was given in Table 1.

Table 1: Demographic data of study participants

Variables	*n* (%)
Gender	
Male	250 (45.8)
Female	296 (54.2)
Age group	
20–25	376 (68.9)
26–30	170 (31.1)
Type of university	
Public	379 (69.4)
Private	167 (30.6)
Nationality	
Saudi	515 (94.3)
Non-Saudi	31 (5.7)
Parents work in a healthcare setting	
Yes	229 (41.9)
No	317 (58.1)
Coursework related to pharmacogenomics and pharmacogenetics	
Yes	252 (46.2)
No	294 (53.8)

Figure 1 illustrates the distribution of participants across study years by gender, showing representation of both males and females in all years with slight variation in proportions.

Figure 2 provides insight into the knowledge of nursing students regarding pharmacogenomics and genetic testing. The results show that while many students demonstrated a good understanding of key concepts, there were notable gaps in their knowledge. For instance, 60.8% were aware of pharmacogenomics, 78% recognized the link between genetic changes and adverse reactions, and 93% understood the impact of genetic changes on certain drugs. Furthermore, 71.2% knew about the FDA's recommendations on pharmacogenomics testing. However, a significant knowledge gap was evident in basic genetics, with only 7% of students correctly identifying the number of human chromosomes.

Table 2 the students' attitudes toward genetic testing and participation in genomic medicine and pharmacogenomics research were varied. While 48.9% were open to genetic testing to assess disease risk, a significant majority (96.2%) would consider testing when facing a cancer diagnosis to choose a treatment with fewer side effects. In addition, 53.8% expressed interest in knowing their susceptibility to diseases with available interventions. Most students (78.2%) believed that physicians should interpret their genome reports, and 53.1% thought pharmacists should also play a role. However, interest in participating in genetic research (28.8%) and bio banking (22%) was relatively low.

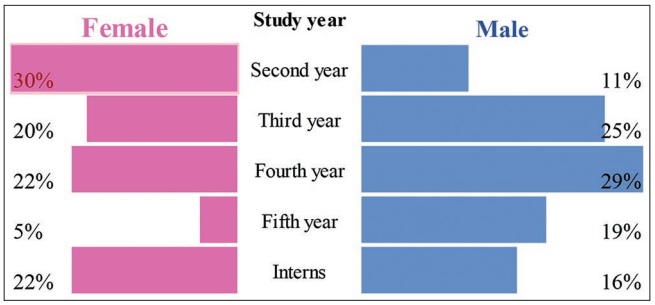

Figure 1: Distribution of study year by gender among participants

Table 3 highlights concerns and uncertainties about the accessibility and availability of genetic testing. Notably, only 19.2% of students were aware that insurance companies and employers are prohibited from genetic discrimination, with 50% expressing neutrality on this issue. Despite this, a majority (55.5%) recognized the benefits of genetic testing for individuals with a family history of serious genetic diseases. In addition, 49.3% agreed that online genetic testing has increased accessibility for individuals to explore their genetic health risks.

DISCUSSION

This study aimed to assess the knowledge, attitudes, and perceptions of nursing students in Saudi Arabia regarding pharmacogenomics and genetic testing. Our findings indicate that while nursing students demonstrated a good understanding of certain key concepts in pharmacogenomics, such as the impact of genetic changes on drug response and adverse reactions, there were notable gaps in their knowledge, particularly regarding the definition of pharmacogenomics and the role of genetic testing in healthcare. The study also revealed positive attitudes toward genetic testing and its potential applications in personalized medicine, although concerns about accessibility and the ethical implications of genetic testing were evident.

The findings of this study indicated that nursing students have a moderate level of knowledge about pharmacogenomics, which aligns with previous research conducted among healthcare professionals and students in other regions.[16,17,25,26] The results of our study suggested that two-thirds of the nursing students were familiar with the term pharmacogenomics, while a recent study carried out in Nigeria disclosed that 86.7% of nursing students were familiar with the concept of pharmacogenomics.[25] A comparative analysis of studies examining knowledge about human chromosomes reveals varying levels of understanding among different populations. Rahma *et al*. reported that 69.2% of medical and health sciences students correctly identified the incorrectness of the statement "Humans have 48 chromosomes."[17] In contrast, a study by Swadas *et al*. among nurses found that only 25% correctly answered this question.[16] Notably, our

Table 2: Attitudes, thoughts, and desire to participate in genomic medicine and PGX research

Items	Agree *n* (%)	Neutral *n* (%)	Disagree *n* (%)
I may consider undergoing genetic testing in the future to assess my risk for certain genetic diseases and inform my healthcare decisions.	267 (48.9)	269 (49.3)	10 (1.8)
I am only interested in knowing my susceptibility to diseases that have current interventions for protection	294 (53.8)	165 (30.2)	87 (15.9)
When facing a cancer diagnosis, I would consider genetic testing as a means to choose a cancer treatment with fewer side effects	525 (96.2)	4 (0.7)	17 (3.1)
If my family has a history of diabetes, I would consider having my genes analyzed so that I can choose a treatment with minimal adverse effects	477 (87.4)	64 (11.7)	5 (0.9)
My physician should explain my genome report to me	427 (78.2)	107 (19.6)	12 (2.2)
My pharmacist should explain my genome report to me	290 (53.1)	214 (39.2)	42 (7.7)
I am interested in attending a genetics (PGX) course or seminar	169 (31)	207 (37.9)	170 (31.3)
Interested in having my genetics collected by a biobank	120 (22)	62 (11.4)	364 (66.7)
I am interested in participating in genetic research	157 (28.8)	209 (38.3)	180 (33)

PGx: Pharmacogenomics

Table 3: Accessibility and availability of genetic testing

Items	Agree *n* (%)	Neutral *n* (%)	Disagree *n* (%)
Insurance companies and future employers are prohibited from conducting genetic tests	105 (19.2)	273 (50)	168 (30.8)
Individuals with a family history of serious genetic diseases may benefit from genetic testing, to determine the risk of developing these conditions.	303 (55.5)	242 (44.3)	01 (0.2)
The availability of online genetic testing has made it more accessible and convenient for individuals to explore their genetic health risks	269 (49.3)	273 (50)	04 (0.7)

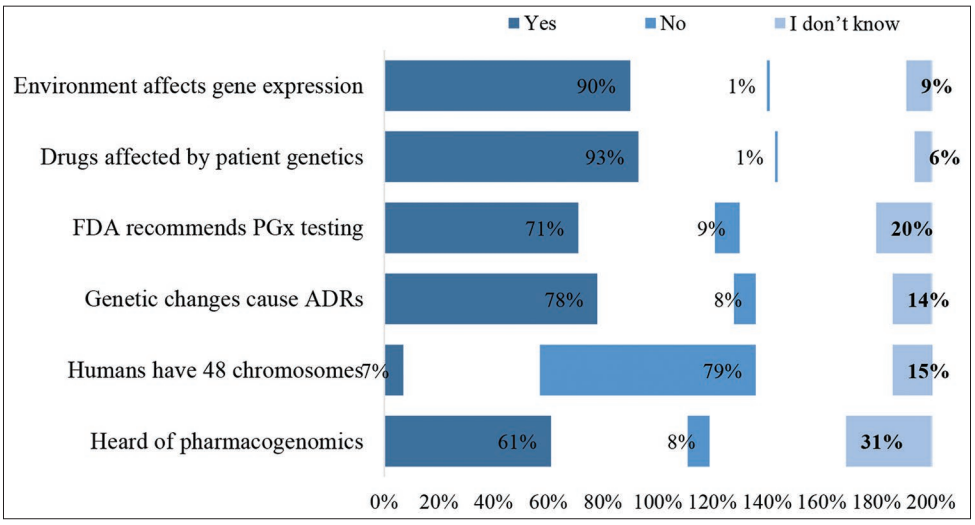

Figure 2: Knowledge of pharmacogenomics among nursing students

study demonstrated a higher percentage of correct responses, with 78.6% of participants accurately disagreeing with the statement that humans have 48 chromosomes. The perception that pharmacogenomics can influence adverse drug reactions (ADRs) varies among healthcare students and professionals. According to Agrawal *et al*., 46% of medical students believed that knowledge of pharmacogenomics is likely to decrease the number of ADRs.[26] In contrast, studies examining the relationship between genetic changes and adverse reactions reported higher percentages of agreement among nursing students and medical and health science students. In Nigeria, 85.5% of nursing students recognized that genetic changes can cause adverse reactions,[25] while 84.2% of medical and health science students in the UAE shared this view.[17] Our study found that 78% of nursing students agreed that genetic changes can cause adverse

reactions. The justification for these findings could be the importance of enhancing pharmacogenomics education in nursing programs to better prepare future healthcare professionals for the practical applications of genetic testing. Our study demonstrated a strong understanding of pharmacogenomics principles among nursing students, with 93% recognizing that certain drugs can be affected by genetic changes in patients. Our study's findings align with existing literature, showing healthcare students are increasingly aware of pharmacogenomics principles. This is consistent with Talwar *et al*.'s systematic review[27] and a UAE study where 90% of medical students recognized genetic changes' impact on drug responses.[17] Our study demonstrated that 48.9% of nursing students were interested in undergoing genetic testing for disease risk assessment, whereas a significantly higher proportion (96.2%) would consider genetic testing to inform cancer treatment decisions. These findings are consistent with previous research. For instance, a study among pharmacy students in Saudi Arabia reported a slightly higher interest in genetic testing for hereditary disease risk (58.3%).[1] In addition, a study among medical students found that 85% believed genetic information would be valuable for personalized medicine, a perspective that aligns with our respondents' strong support for genetic testing in cancer treatment decisions.[2]

Further research is needed to explore these attitudes in more depth and to understand how educational interventions might influence them. This study has several strengths, including its focus on a specific and relevant population (nursing students) and its exploration of both knowledge and attitudes toward pharmacogenomics. However, limitations include the reliance on a single region in Saudi Arabia, which may limit the generalizability of the findings to other areas. In addition, the cross-sectional design provides a snapshot of knowledge and attitudes at one point in time, without insight into how these might evolve with further education or clinical experience. The findings of this study have important implications for nursing education and healthcare practice. Given the increasing relevance of pharmacogenomics in patient care, nursing programs should prioritize the integration of comprehensive pharmacogenomics education to ensure that future nurses are equipped to support and implement personalized treatment plans. Moreover, addressing the ethical and accessibility concerns raised by students will be crucial for the successful implementation of genetic testing in clinical settings. By enhancing education and addressing these concerns, healthcare systems can better harness the potential of pharmacogenomics to improve patient outcomes.

CONCLUSION

This study reveals that nursing students have a good understanding of pharmacogenomics, but notable knowledge gaps exist, particularly in basic genetics. While students are open to genetic testing for specific purposes, their interest in participating in genetic research and bio banking is relatively low. The findings also highlight concerns about genetic testing accessibility and awareness of genetic discrimination protections. These results underscore the need for targeted education and training to address knowledge gaps and promote informed decision-making in genomic medicine.

DATA AVAILABILITY

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

CONSENT FOR PUBLICATION

Not applicable.

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