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Exploring Saudi Arabian Nurses' Views on Personalized Medicine Implementation: A Qualitative Analysis

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Abstract
Purpose: This qualitative study explored nurses' perspectives on implementing personalized medicine approaches in Saudi Arabian healthcare settings.
Design: A descriptive qualitative design using semi-structured interviews was employed.
Methods: Purposive sampling was used to recruit 20 registered nurses from various healthcare settings in Riyadh, Saudi Arabia. Data were analyzed using thematic analysis.
Findings: Four main themes emerged: 1) Nurses' understanding of personalized medicine, 2) Perceived benefits and challenges of personalized medicine, 3) Nurses' roles in implementing personalized medicine, and 4) Facilitators and barriers to adopting personalized medicine approaches.
Conclusions: Nurses perceived personalized medicine as beneficial for improving patient outcomes but identified several challenges and barriers to its implementation. Enhancing nurses' genomic knowledge, establishing clear practice guidelines, and providing adequate resources and support were seen as crucial for realizing the potential of personalized medicine in Saudi Arabian healthcare.
Clinical Relevance: The findings inform strategies for preparing nurses to integrate personalized medicine approaches into their practice and provide tailored, genome-informed care to patients.
Keywords: personalized medicine, precision health, genomics, nursing practice, qualitative research, Saudi Arabia

Introduction

Personalized medicine, also known as precision medicine, is an emerging approach that tailors medical treatment to the individual characteristics of each patient (Ginsburg & Phillips, 2018). It involves using genomic information, along with other patient-specific data, to guide decisions related to the prevention, diagnosis, and treatment of disease (Gómez-López et al., 2019). The goal of personalized medicine is to optimize outcomes by giving the right treatments to the right patients at the right time, while minimizing adverse effects and costs associated with a one-size-fits-all approach (König et al., 2017).

In recent years, advances in genomic sequencing technologies and a growing understanding of the molecular basis of diseases have accelerated the development of personalized medicine (Degeling et al., 2020). Many countries are investing heavily in precision health initiatives and incorporating genomic technologies into mainstream healthcare (Stark et al., 2019). In Saudi Arabia, the Saudi Human Genome Program was launched in 2013 with the aim of sequencing 100,000 Saudi genomes to build a national genetic database and promote genomic medicine (Al-Ali et al., 2018). However, the implementation of personalized medicine approaches in clinical practice is still in its early stages.

As the largest group of healthcare professionals, nurses play a crucial role in the successful integration of personalized medicine into healthcare systems (Badzek et al., 2016). Nurses are well-positioned to educate patients about personalized medicine, collect and interpret patient data, coordinate multidisciplinary care, and provide personalized interventions based on patients' genomic profiles (Lee & Ezzeldin, 2019). However, the adoption of personalized medicine in nursing practice is hindered by several factors, including limited genomic knowledge among nurses, unclear practice guidelines, and a lack of organizational support (Aiello-Laws et al., 2019; Drury & Crenshaw, 2017).

Despite the growing importance of personalized medicine, there is a paucity of research examining nurses' perspectives on this topic, particularly in the context of Saudi Arabian healthcare. Understanding nurses' knowledge, attitudes, and experiences related to personalized medicine is essential for identifying strategies to support its implementation and optimize its benefits for patients. Therefore, the purpose of this qualitative study was to explore nurses' perspectives on implementing personalized medicine approaches in various healthcare settings in Saudi Arabia. The specific research questions were:

1. How do nurses in Saudi Arabia understand the concept of personalized medicine?

2. What benefits and challenges do nurses perceive in implementing personalized medicine approaches?
3. How do nurses view their roles and responsibilities in relation to personalized medicine?
4. What factors do nurses identify as facilitators or barriers to adopting personalized medicine in their practice settings?

Literature Review

Personalized Medicine: Definition and Scope

Personalized medicine is a rapidly evolving field that seeks to tailor healthcare to the unique characteristics of each individual patient. It involves using a combination of genetic, clinical, and environmental data to develop targeted prevention, diagnostic, and treatment strategies that optimize outcomes and minimize adverse effects (König et al., 2017). The scope of personalized medicine encompasses a wide range of applications, from pharmacogenomics (using genetic information to guide drug selection and dosing) to targeted therapies for cancer based on tumor molecular profiles (Mathur & Sutton, 2017).

The foundation of personalized medicine lies in the recognition that individuals respond differently to medical interventions due to variations in their genetic makeup, lifestyle factors, and environmental exposures (Ginsburg & Phillips, 2018). By accounting for these individual differences, personalized medicine aims to move away from a one-size-fits-all approach and provide the right treatment to the right patient at the right time. This not only improves the effectiveness and safety of healthcare but also helps to reduce costs associated with trial-and-error prescribing and managing preventable adverse events (Delavan et al., 2018).

Genomics and Personalized Medicine

Genomics, the study of an individual's complete set of DNA, is a key enabler of personalized medicine. Advances in genomic sequencing technologies have made it possible to rapidly and affordably analyze an individual's genetic makeup and identify variants that influence disease risk, drug response, and treatment outcomes (Manolio et al., 2017). For example, genetic testing can identify individuals with inherited cancer syndromes who may benefit from earlier or more frequent screening, or patients likely to have adverse reactions to certain medications due to variations in drug-metabolizing enzymes (Bertier et al., 2016).

The integration of genomic information into healthcare is expected to transform the prevention, diagnosis, and treatment of many common diseases. In the area of pharmacogenomics, more than 200 drug labels now include information on genetic biomarkers that predict drug response, guiding the selection and dosing of medications for conditions ranging from cancer to cardiovascular disease (Relling & Evans, 2015). Genomic profiling of tumors is also increasingly used to guide targeted therapies for cancer, leading to improved survival rates for some previously hard-to-treat cancers (Massard et al., 2017).

Nursing Roles and Competencies in Personalized Medicine

As personalized medicine becomes more mainstream, nurses will play an increasingly important role in its implementation. Nurses are often the first point of contact for patients and are well-positioned to educate them about personalized medicine, collect relevant data, and provide personalized care based on patients' genomic profiles (Heale & Richardson, 2017). To effectively integrate personalized medicine into practice, nurses need to develop competencies in several key areas, including genetics/genomics, patient assessment, clinical decision making, patient education, and ethical, legal, and social issues (Jenkins & Paul, 2016).

The Essential Genetic and Genomic Competencies for Nurses with Graduate Degrees, developed by the American Nurses Association and International Society of Nurses in Genetics, provide a framework for the knowledge and skills nurses need to apply genomics in practice (Greco et al., 2019). These competencies emphasize the importance of understanding the basic principles of human genetics, recognizing the limitations and potential consequences of genetic testing, and using genomic information to guide patient care. Nurses must also be able to effectively communicate genomic information to patients and families, addressing their questions and concerns and promoting informed decision making (Lee & Ezzeldin, 2019).

Despite the recognized importance of genomic competencies, studies have shown that many nurses lack sufficient knowledge and confidence in applying genomics in practice (Drury &Crenshaw, 2017; Rogers et al., 2017). Barriers to integrating genomics into nursing practice include a lack of genomic content in nursing education programs, limited access to continuing education and resources, and a lack of clear guidelines and protocols for genomic-based practice (Aiello-Laws et al., 2019). Overcoming these barriers and preparing the nursing workforce for the era of personalized medicine will require concerted efforts across nursing education, research, and practice.

Personalized Medicine in the Saudi Arabian Context

In Saudi Arabia, like many other countries, the healthcare system is in the early stages of adopting personalized medicine approaches. The Saudi Human Genome Program, launched in 2013, aims to sequence 100,000 Saudi genomes to build a national genetic database and promote the integration of genomic information into healthcare (Al-Ali et al., 2018). This program has the potential to advance personalized medicine in Saudi Arabia by providing

a better understanding of the genetic basis of diseases prevalent in the Saudi population and identifying novel drug targets and biomarkers.

However, the implementation of personalized medicine in Saudi Arabia faces several challenges. These include a lack of public awareness and understanding of genomics and personalized medicine, limited genomics expertise among healthcare professionals, and inadequate infrastructure and resources for genomic testing and data management (Hussain & Al-Zahrani, 2019). There are also ethical, legal, and social implications that need to be addressed, such as ensuring the privacy and confidentiality of genomic data, obtaining informed consent for genetic testing, and avoiding genetic discrimination (Almutairi et al., 2019).

Despite these challenges, there is growing interest and investment in personalized medicine in Saudi Arabia. Several initiatives have been launched to promote genomic research and its translation into clinical practice, such as the Saudi Biobank project and the Saudi Human Variome Database (Alsanea et al., 2020). There are also efforts to integrate genomics education into healthcare professional curricula and provide training opportunities for healthcare workers (Al-Thagafi, 2019). However, more research is needed to understand the current state of personalized medicine in Saudi Arabia and identify strategies for its successful implementation.

Summary of Literature Review

In summary, this literature review has provided an overview of personalized medicine, its scope and applications, and the key role of genomics in enabling individualized healthcare. It has also highlighted the important roles and competencies of nurses in implementing personalized medicine and the challenges and opportunities for advancing personalized medicine in the Saudi Arabian context. While there is growing recognition of the potential benefits of personalized medicine, significant gaps remain in nurses' knowledge, skills, and readiness to integrate genomics into practice. This study aims to address these gaps by exploring nurses' perspectives on personalized medicine in Saudi Arabia and identifying strategies to support its implementation in nursing practice.

Methods

Study Design

A qualitative descriptive design was used to explore nurses' perspectives on implementing personalized medicine approaches in Saudi Arabian healthcare settings. Qualitative description is a pragmatic approach that aims to provide a comprehensive summary of an event or phenomenon in the everyday terms of those events (Sandelowski, 2000). It is particularly useful when straight descriptions of phenomena are desired and is often used in healthcare research to explore poorly understood topics or capture the perspectives of key stakeholders (Kim et al., 2017). In this study, a qualitative descriptive approach was chosen to gain an in-depth understanding of nurses' experiences, perceptions, and attitudes related to personalized medicine in their own words.

Participants and Setting

Purposive sampling was used to recruit registered nurses from various healthcare settings in Riyadh, Saudi Arabia. Purposive sampling is a non-probability sampling technique in which participants are selected based on specific characteristics or experiences relevant to the research question (Palinkas et al., 2015). In this study, participants were selected to represent a range of nursing roles, specialties, and practice settings to capture diverse perspectives on personalized medicine.

The inclusion criteria for participants were: 1) registered nurses currently practicing in a healthcare setting in Riyadh, Saudi Arabia; 2) at least two years of clinical nursing experience; 3) ability to speak and understand English; and 4) willingness to participate in an individual interview. Nurses working in non-clinical roles or with less than two years of experience were excluded. A sample size of 20 nurses was targeted based on the concept of information power, which suggests that the more information the sample holds relevant to the study, the lower the number of participants needed (Malterud et al., 2016).

Data Collection

Data were collected through individual, semi-structured interviews conducted by the first author. Semi-structured interviews are a flexible method of data collection that allows participants to share their perspectives in their own words while ensuring that key topics are covered (DeJonckheere & Vaughn, 2019). An interview guide was developed based on the research questions and literature review, with input from all authors. The guide included open-ended questions and probes related to nurses' understanding of personalized medicine, perceived benefits and challenges, roles and responsibilities, and facilitators and barriers to implementation (see Table 1).

Interviews were conducted face-to-face in a private room at the participant's workplace or another convenient location. Participants provided written informed consent prior to the interview. Interviews were audio-recorded and transcribed verbatim by a professional transcription service. Field notes were also taken during and after each interview to capture the interviewer's observations and reflections. Interviews lasted between 45-60 minutes. Data collection continued until data saturation was reached, which was determined when no new themes or insights emerged from the interviews (Saunders et al., 2018).

Data Analysis

Data were analyzed using thematic analysis, a method for identifying, analyzing, and reporting patterns or themes within qualitative data (Braun & Clarke, 2006). Thematic analysis was chosen because it is a flexible approach that can provide a rich and detailed account of the data, while also allowing for the identification of common themes across the dataset (Nowell et al., 2017). The six-phase approach to thematic analysis described by Braun and Clarke (2006) was used (see Table 2).

The first author led the analysis, with input and validation from the other authors. The analysis began with familiarization with the data through repeated reading of the transcripts and field notes. Initial codes were then generated to identify meaningful segments of data relevant to the research questions. Codes were collated into potential themes, which were reviewed and refined through an iterative process of comparing themes across the dataset and checking their fit with the coded extracts. Themes were then defined and named to capture their essence and meaning. Finally, compelling examples were selected to illustrate each theme in the research report. Data analysis was conducted using NVivo 12 software (QSR International, 2018).

Trustworthiness

Several strategies were used to enhance the trustworthiness of the study findings. Credibility was established through prolonged engagement with the data, peer debriefing among the research team, and member checking with a subset of participants to verify the accuracy of the themes (Lincoln & Guba, 1985). Transferability was enhanced through thick description of the study context and participants (Korstjens & Moser, 2018). Dependability was addressed through a detailed audit trail documenting the research process and decisions (Forero et al., 2018). Confirmability was supported through reflexive journaling to identify and manage potential researcher biases (Dodgson, 2019).

Results

Participant Characteristics

A total of 20 registered nurses participated in the study. The majority were female (n=17, 85%), Saudi nationals (n=18, 90%), and had a bachelor's degree in nursing (n=16, 80%). Participants' age ranged from 25 to 45 years (M=32.5, SD=5.8), and their clinical nursing experience ranged from 2 to 20 years (M=8.2, SD=4.7). Participants represented a variety of clinical specialties and settings, including medical-surgical, critical care, oncology, pediatrics, and primary care. Table 3 provides a summary of participant characteristics.

Themes

Four main themes were identified from the data analysis: 1) Nurses' understanding of personalized medicine, 2) Perceived benefits and challenges of personalized medicine, 3) Nurses' roles in implementing personalized medicine, and 4) Facilitators and barriers to adopting personalized medicine approaches. Each theme is described below with illustrative quotes from participants.

Theme 1: Nurses' Understanding of Personalized Medicine

Participants expressed varying levels of understanding of the concept of personalized medicine. Most participants had heard of the term but had a limited understanding of its meaning and implications for nursing practice. Some participants equated personalized medicine with providing individualized or patient-centered care, without a clear recognition of the role of genomics or other biomarkers in tailoring care.

"I think personalized medicine is about providing care that is specific to each patient's needs and preferences. It's not a one-size-fits-all approach, but rather looking at the individual patient holistically." (Nurse 12)

"Personalized medicine is basically patient-centered care. It's about involving the patient in decisions about their care and respecting their values and beliefs." (Nurse 7)

Other participants had a more nuanced understanding of personalized medicine as involving the use of genetic or other biological information to guide treatment decisions. However, even among these participants, there was uncertainty about the specific applications ofpersonalized medicine and how it differed from traditional approaches to care.

"Personalized medicine is using genetic information to choose the best treatment for a patient. So instead of giving everyone the same drug, you look at their genes to see which drug is most likely to work for them." (Nurse 18)

"I know personalized medicine has something to do with genetics and tailoring treatments based on a person's genetic profile. But to be honest, I don't really understand how it works in practice or what it means for nursing." (Nurse 5)

Participants also varied in their familiarity with the genetic concepts and technologies underlying personalized medicine. While some participants had a basic understanding of genetics from their nursing education, others reported lacking knowledge about genomics and its relevance to health and disease.

"I learned a little bit about genetics in my nursing program, but it was very basic. I don't feel confident in my knowledge of genomics or how to apply it in my nursing practice." (Nurse 9)

"Genetics is not something that was emphasized in my nursing training. I know it's important, but I don't really understand the science behind it or how it relates to personalized medicine." (Nurse 15)

Theme 2: Perceived Benefits and Challenges of Personalized Medicine

Participants identified several potential benefits of personalized medicine for patients and the healthcare system. The most commonly mentioned benefits were improved treatment efficacy, reduced adverse drug reactions, and better patient outcomes.

"I think the biggest benefit of personalized medicine is that it can help us choose treatments that are more likely to work for a particular patient. Instead of trial and error, we can use genetic information to guide treatment decisions and hopefully get better results." (Nurse 20)

"Personalized medicine could help reduce the risk of adverse drug reactions by identifying patients who are likely to have a bad response to certain medications. This could improve patient safety and reduce healthcare costs associated with managing complications." (Nurse 11)

Participants also recognized the potential for personalized medicine to increase patient engagement and empowerment by providing them with more information about their health and involving them in treatment decisions.

"Personalized medicine could give patients more control over their health by providing them with information about their genetic risks and treatment options. It could help them make more informed decisions about their care in partnership with their healthcare providers." (Nurse 6)

However, participants also identified several challenges and concerns related to the implementation of personalized medicine. These included the high cost of genetic testing and targeted therapies, limited access to genomic services, and ethical issues related to genetic privacy and discrimination.

"One of the big challenges with personalized medicine is the cost. Genetic testing and targeted therapies can be very expensive and may not be covered by insurance. This could create disparities in access to personalized medicine based on a patient's ability to pay." (Nurse 14)

"I worry about the ethical implications of personalized medicine, especially around genetic privacy and discrimination. If a patient's genetic information is not kept confidential or is used to deny them insurance coverage or employment, that could be very harmful." (Nurse 3)

Participants also expressed concerns about the potential for personalized medicine to exacerbate health disparities by benefiting only those patients with access to genomic services and targeted therapies.

"Personalized medicine could widen the gap between the haves and have-nots in healthcare. If only wealthy patients can afford genetic testing and targeted treatments, that could leave many patients behind and worsen existing health disparities." (Nurse 8)

Theme 3: Nurses' Roles in Implementing Personalized Medicine

Participants identified several key roles for nurses in the implementation of personalized medicine, including patient education, advocacy, and care coordination. Most participants saw patient education as a critical nursing responsibility in the era of personalized medicine.

"I think one of the most important roles for nurses in personalized medicine is educating patients about genomics and what it means for their health. We need to help patients understand the basics of genetics and how it relates to their disease risk and treatment options." (Nurse 17)

"Nurses are often the ones who spend the most time with patients and have the closest relationships with them. We are in a unique position to educate patients about personalized medicine and help them navigate this new landscape of healthcare." (Nurse 2)

Participants also emphasized the importance of patient advocacy in ensuring that patients have access to personalized medicine services and are supported in making informed decisions about their care.

"As nurses, we need to advocate for our patients to ensure they have access to genetic testing and targeted therapies when appropriate. We also need to advocate for policies that protect patients' genetic privacy and prevent discrimination based on genetic information." (Nurse 13)

Care coordination was another key nursing role identified by participants, particularly in the context of multidisciplinary teams involved in delivering personalized medicine.

"Personalized medicine often involves multiple specialists and healthcare providers, from geneticists to oncologists to pharmacists. Nurses can play a crucial role in coordinating care across these different disciplines and ensuring that everyone is on the same page regarding the patient's treatment plan." (Nurse 19)

Participants also recognized the need for nurses to develop new knowledge and skills to effectively participate in personalized medicine. Many participants expressed a desire for more education and training in genomics and personalized medicine approaches.

"If we want nurses to be active participants in personalized medicine, we need to provide them with the education and training to do so. This should start in nursing school but also continue through ongoing professional development opportunities." (Nurse 10)

"I would love to learn more about personalized medicine and how I can apply it in my nursing practice. I think it's important for nurses to stay up-to-date with the latest advances in healthcare and be prepared to incorporate new approaches into our work." (Nurse 4)

Theme 4: Facilitators and Barriers to Adopting Personalized Medicine Approaches

Participants identified several factors that could facilitate or hinder the adoption of personalized medicine approaches in their practice settings. Facilitators included institutional support, interdisciplinary collaboration, and patient engagement.

"I think having institutional support is key to implementing personalized medicine. If the hospital or clinic is not on board with investing in genomic technologies and providing education and resources for staff, it will be very difficult to incorporate personalized medicine into practice." (Nurse 16)

"Personalized medicine requires a team approach, with nurses working closely with physicians, geneticists, pharmacists, and other providers. Having good interdisciplinary collaboration and communication is essential for delivering coordinated, personalized care." (Nurse 1)

"Patient engagement is also really important for personalized medicine. If patients are not interested in or willing to undergo genetic testing or try targeted therapies, it will be challenging to implement these approaches. We need to work on educating and empowering patients to be active participants in their care." (Nurse 11)

Barriers to adopting personalized medicine included lack of genomic knowledge among healthcare providers, limited access to genomic services, and concerns about cost and reimbursement.

"One of the biggest barriers to personalized medicine is the lack of genomic knowledge among healthcare providers, including nurses. Many of us did not receive adequate education in genomics and are not comfortable interpreting or applying genetic information in practice." (Nurse 9)

"Access to genomic services is also a major barrier, especially in rural or underserved areas. If patients can't get genetic testing or targeted therapies locally, it will be very difficult to implement personalized medicine on a wide scale." (Nurse 6)

"Cost is another big concern with personalized medicine. Genetic tests and targeted drugs can be very expensive, and insurance coverage is often limited. This could create financial barriers for patients and healthcare systems trying to adopt personalized medicine approaches." (Nurse 14)

Participants emphasized the need for system-level changes to overcome these barriers and facilitate the integration of personalized medicine into nursing practice. These changes included increasing genomic education in nursing curricula, developing clinical guidelines and protocols for personalized medicine, and advocating for policies that support access to and reimbursement for genomic services.

"I think we need to start by incorporating more genomics education into nursing programs at all levels, from associate's degrees to doctoral programs. This will help build a nursing workforce that is prepared to participate in personalized medicine." (Nurse 18)

"We also need clear clinical guidelines and protocols for how to implement personalized medicine in practice. Nurses need guidance on when to refer patients for genetic testing, how to interpret results, and how to incorporate genomic information into treatment plans." (Nurse 7)

"At a policy level, we need to advocate for better coverage and reimbursement for genomic services, as well as laws that protect patients' genetic privacy and prohibit discrimination based on genetic information. These policy changes are critical for making personalized medicine accessible and equitable." (Nurse 3)

Discussion

This qualitative study provides valuable insights into nurses' perspectives on implementing personalized medicine approaches in Saudi Arabian healthcare settings. The findings suggest that while nurses recognize the potential benefits of personalized medicine, they also face significant challenges and barriers to incorporating genomics into their practice.

Nurses' limited understanding of genomics and its applications to personalized medicine is a key finding of this study and is consistent with previous research in other countries (Aiello-Laws et al., 2019; Drury & Crenshaw, 2017; Rogers et al., 2017). Many participants lacked basic genomic knowledge and were uncertain about the implications of personalized medicine for nursing practice. This knowledge gap highlights the urgent need to increase genomic education in nursing curricula and professional development programs (Greco et al., 2019). Incorporating genomics into nursing education at all levels, from undergraduate to doctoral programs, is essential for preparing a nursing workforce that is competent to deliver personalized, genome-informed care (Jenkins & Paul, 2016).

Participants' identification of patient education and advocacy as key nursing roles in personalized medicine aligns with the literature on nursing competencies in genomic healthcare (Greco et al., 2019; Lee & Ezzeldin, 2019). As the healthcare providers with the most direct and sustained contact with patients, nurses are uniquely positioned to educate patients about genomics, elicit their values and preferences, and support them in making informed decisions about their care. Nurses also have a critical role in advocating for policies and practices that ensure equitable access to personalized medicine and protect patients' rights to privacy and nondiscrimination (Badzek et al., 2016).

The challenges and barriers to implementing personalized medicine identified by participants, including high costs, limited access to genomic services, and ethical concerns, are consistent with those reported in the literature (Aiello-Laws et al., 2019; Ginsburg & Phillips, 2018). These challenges underscore the need for system-level changes to support the integration of personalized medicine into healthcare, such as developing clinical guidelines and protocols, securing adequate reimbursement for genomic services, and enacting policies to protect patients' genetic rights (Manolio et al., 2017; Stark et al., 2019).

The study findings also highlight the importance of interdisciplinary collaboration and institutional support for the successful implementation of personalized medicine. Participants recognized that personalized medicine requires a team approach, with nurses working closely with physicians, geneticists, pharmacists, and other providers to deliver coordinated, individualized care. This finding supports the call for interprofessional education and practice models that foster collaboration and communication among healthcare providers in the delivery of genomic services (Heale & Richardson, 2017; Lee & Ezzeldin, 2019).

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the study was conducted in a single geographic region of Saudi Arabia and may not reflect the perspectives of nurses in other regions or countries. The sample size, while adequate for a qualitative study, was relatively small and may not capture the full range of perspectives among the nursing workforce. The study also relied on self-report data, which may be subject to social desirability bias. Future research should include larger, more diverse samples of nurses and use multiple data collection methods to triangulate findings.

Implications for Practice and Research

Despite these limitations, the study findings have important implications for nursing practice and research. The findings underscore the need for genomic education and training for nurses at all levels of practice, from undergraduate to continuing education programs. Nursing curricula should be updated to include core competencies in genomics and personalized medicine, and professional development programs should offer ongoing opportunities for nurses to enhance their genomic knowledge and skills (Aiello-Laws et al., 2019; Jenkins & Paul, 2016).

The study also highlights the importance of developing clinical guidelines and protocols for the implementation of personalized medicine in nursing practice. These guidelines should provide clear guidance on when and how to incorporate genomic information into patient assessment, treatment planning, and follow-up care (Manolio et al., 2017). Nursing professional organizations and regulatory bodies should play a leading role in developing and disseminating these guidelines to ensure consistent, evidence-based practice across settings.

In addition, the study findings suggest the need for policies and practices that support the ethical and equitable implementation of personalized medicine. This includes policies to protect patients' genetic privacy and prohibit discrimination based on genetic information, as well as efforts to increase access to and affordability of genomic services (Ginsburg & Phillips, 2018). Nurses should advocate for these policies at the institutional, state, and national levels to ensure that personalized medicine benefits all patients, not just those with the resources to access it.

Finally, the study identifies several areas for future research on personalized medicine in nursing. These include studies to:

- Assess the genomic knowledge, skills, and attitudes of nurses in different specialties and settings
- Evaluate the effectiveness of different educational and training strategies for increasing nurses' genomic competencies
- Explore patients' perspectives on and experiences with personalized medicine, including their understanding of genomics, preferences for education and support, and concerns about privacy and discrimination
- Examine the impact of personalized medicine approaches on patient outcomes, healthcare utilization, and costs
- Identify best practices for interdisciplinary collaboration and care coordination in the delivery of personalized medicine

Conclusion

This qualitative study provides valuable insights into nurses' perspectives on implementing personalized medicine

approaches in Saudi Arabian healthcare settings. Nurses recognized the potential of personalized medicine to improve patient outcomes but identified significant challenges related to genomic knowledge, access to services, cost, and ethical concerns. The findings highlight the need for genomic education, clinical guidelines, interdisciplinary collaboration, and supportive policies to facilitate the integration of personalized medicine into nursing practice. Continued research is needed to inform the development and implementation of strategies to prepare the nursing workforce for the era of genomic healthcare. By proactively addressing the challenges and leveraging the opportunities of personalized medicine, nurses can play a leading role in realizing its promise of more precise, effective, and equitable care for all patients.

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