Genomic Nursing-A scoping Review

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Abstract

The accomplishments and difficulties in incorporating genetics into nursing education and practice are highlighted by the subject of nursing genetics. Although nursing has set criteria and competences for the practice of genetics, there is still variation in the genetics curriculum across educational programs. Although efforts have been made to expand nursing education and provide genetics instruction, progress is hampered by faculty ignorance and regulatory obstacles. Nonetheless, nurses—including APRNs and RNs—are in a good position to support the delivery of genomic care. In genetics services, APRNs in particular can be quite helpful in reducing the workload for clinical geneticists. To improve genetics education, facilitate ongoing education, and incorporate genetics into nursing practice, cooperative efforts are required. In the rapidly changing field of genomic healthcare, utilizing the experience of nurses can enhance patient outcomes and increase access to genomic services.

Keywords: Nursing, Genetics, Education, Genetic sciences.
Introduction

Customizing patient care based on a person's genetic or other omics, clinical, physiological, lifestyle, behavioral, and environmental traits is known as precision health, and it is currently moving toward clinical utility validation and deployment in healthcare settings. Even though there are currently geographical differences, there are many examples that may eventually become standard procedures. These include screening at-risk individuals for common hereditary cancer syndromes like BRCA1/2 (associated with breast and ovarian cancer) and Lynch Syndrome (linked to gastrointestinal, ovarian, brain, urinary tract, and sebaceous skin tumors; Buchanan et al., 2018; Williams et al., 2016). Additionally, integrating three-generation family history into electronic health records (EHRs) has been proposed. Additional uses include the diagnosis of solid organ transplant rejection and noninvasive prenatal screening of cell-free DNA for genetic alterations during maternal healthcare visits. Based on the molecular markers of cancer cells, oncology uses tailored diagnosis and therapies for tumors. In addition, a patient's genetic variation is considered when choosing prescription drugs and how much of them to take (Volpi et al., 2018). A paradigm shift in clinical practice has resulted from these advances, which are the result of significant scientific investments in large-scale genomic research initiatives, computational science methodologies, and partnerships between governmental and academic institutions [1-2].

Precision health agendas are constantly being pushed forward by large-scale population research programs. Notable examples in the United States (U.S.) are the Veteran's Administration (VA) Million Veteran Program and the All of Us initiative at the National Institutes of Health (NIH). According to a recent review (Fu et al., 2020), nursing perspectives on precision health are presented, and nurse scientists and clinical leaders are encouraged to actively participate in this endeavor by using All of Us data to conduct novel genomic research on social determinants of health, environmental and lifestyle choices, and biological contributors for various health conditions [3]. The advancement of precision health patient care models and genomics has been greatly aided by the nursing profession. This includes creating theoretical models to direct curriculum, educating, and training the nursing workforce, and incorporating genomics into routine clinical nursing practice in a variety of patient care contexts, including pharmacogenetics, hereditary cancer screening, and neonatal screening (Calzone et al., 2014; Rogers et al., 2017). Nurses are in a leadership position to integrate precision health into standard patient care because of their holistic worldview and evidence-based practice style. The aforementioned tasks encompass a range of activities, including the prescription and administration of pharmacogenetic-based treatments, family history assessments, genetic specialist referrals, interpretation of genetic laboratory tests, and patient, family, and community counseling and education [4-5].

Tools for performance evaluation and quality improvement are crucial for incorporating new clinical developments and procedures into standard healthcare delivery procedures. These technologies, which are connected to value-based financial reimbursement, allow for the objective assessment of whether healthcare teams, organizations, or systems are putting positive changes into practice that result in better healthcare delivery processes and
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outcomes (Institute for Healthcare Improvement, 2020a). Policy emphasis on health quality performance measurement and quality improvement infrastructure is crucial as genomic science moves from government-academic collaborations to ordinary healthcare operations [6].

A scoping examination and analysis of policy goals were carried out by experts serving on the Genomic Nursing and Healthcare Expert Panel (EP) of the American Academy of Nursing (AAN) between January and July 2019. Using healthcare quality measurements and benchmarking standards for genomic outcomes, the goals were to: provide an overview of the current state of U.S. genomic nursing healthcare policy; identify gaps in the application of precision health in clinical practice; identify opportunities for greater impact in genomic nursing; and encourage creative solutions for promoting broader implementation of precision health by issuing calls to action for the fields of nursing practice, workforce, education, research, and healthcare policy [7].

Because nursing is essential to the delivery of healthcare, genomics is transforming the nursing profession as a result of the revolutionary changes that genomics is bringing about in the field of healthcare (Calzone et al., 2010). Clinical practice is gaining traction from significant discoveries like the mapping of the human genome and the identification of genomic variants associated with health, disease, and possible treatments. These developments in genomics have an effect on all aspects of the healthcare system. As a result, the use of genomic data and technology is no longer limited to genetic experts but is now essential to the provision of non-specialized healthcare. Clinical uses include risk assessment, disease screening and diagnosis, prognosis clarification, and medication therapy optimization to maximize therapeutic benefit and reduce side effects. Therefore, in order to guarantee the delivery of safe, economical, and high-quality healthcare, nurses need to be proficient in genomics (Calzone et al., 2010) [8].

The foundation and supporting data for the practical application of genomics come from both basic and applied research. This corpus of scientific knowledge includes the identification and understanding of biological mechanisms and pathways that are essential for the development of later interventions, the characterization of genomic markers that identify people who are at risk of certain health conditions and outcomes, and the development and evaluation of interventions and treatments that are customized based on the genetic profile of an individual and their family [9].

In summary, precision health—which is defined by customized patient treatment based on a wide range of individual characteristics—is quickly moving toward clinical utility validation and system integration with healthcare delivery. Even with current geographic differences, a number of innovations—such as genetic testing for cancer syndromes with a family history, incorporating family medical histories into electronic health records, and using genomic data to tailor drug treatments—are about to become commonplace. These developments represent a paradigm change in clinical practice and are the product of significant investments in science and teamwork. Initiatives for large-scale population research, like the NIH All of Us project and the VA Million Veteran Program, are crucial in advancing the goals of precision health. As the backbone of healthcare delivery, nursing is essential to the advancement of patient care models for precision health. The development of theoretical frameworks and the incorporation of genomics into standard clinical practice are two ways that nurses contribute to the connection between patient care and genetic research.

It is impossible to overestimate the significance of performance evaluation and quality improvement as precision health is further included into healthcare delivery. To ensure that genetic developments are effectively implemented in ordinary clinical practice, policies that prioritize infrastructure for health quality evaluation and improvement are crucial. Additionally, in order for nurses to deliver safe, economical, and superior care, they must possess a thorough understanding of genetic science and its applications. To do this, one must be proficient in genomics, which can be obtained through both basic and applied research. This is because genetic discoveries are the basis for developing practical clinical interventions that are customized for each patient and their family. In order to facilitate the wider use of precision health, it will be necessary going forward for nursing practice, education, research, and healthcare policy to work together in a cooperative manner. In the
changing healthcare environment, nurses may continue to lead the way in providing individualized and efficient patient care by embracing the revolutionary potential of genomics.

**Required Genomic Training for Nursing:**

While there are many differences in how genetics and genomics are incorporated into nursing education and practice, Israel is the only nation that requires all nurses to complete a 28-hour course in order to guarantee that they have a baseline level of knowledge and proficiency in this area.

The majority of nations have sporadic and uneven approaches to integrating genetic and genomic knowledge into nursing education. Nonetheless, genetic/genomic skills have been defined in the US, UK, and Japan that are relevant to all nurses, irrespective of their specialization, degree of training, or clinical function. Building on the foundation created in the UK, European nations have also built interprofessional skills for genetic care. Even with these initiatives, only few nations reported having clear leadership promoting the use of genetics in nursing practice. To guarantee that nurses have the information and abilities needed to deliver high-quality care in the genomic era, more leadership and standards in nursing education and practice are required going forward [10].

**Specialists in Genomics:**

All 18 of the nations surveyed said they have access to specialized genetics services, which are usually found in centers of excellence. These services provide genetic testing and counseling, carried out by specialists with varying degrees of training or accreditation, depending on the nation. These experts could be doctors, genetic counselors, and, in certain situations, nurses. Of the eighteen countries, only five recognized the existence of a function for nurses with specialized training in genetics, known as a specialist genetics nursing role. Of these nations, four stated that they have established requirements for specialized genetics nurses. A few nations have also reported that some genetic counselors are also licensed nurses [11].

**Lifestyle Behaviors and Genomics:**

The World Health Organization (WHO) and the U.S. Department of Health and Human Services (DHHS) have released reports that emphasize the substantial impact of unhealthy behaviors on disease burden and premature death. These reports support the focus on promoting good health through lifestyle modifications for disease prevention. Because genomics sheds light on the relationship between genetic predisposition, environmental variables, and lifestyle choices and disease, particularly chronic illnesses, it holds promise for interdisciplinary study and public health. With an emphasis on chronic illnesses, research programs seek to comprehend how genetics, environment, and lifestyle interact to determine disease risk [12].

The significance of family health history in illness prevention is emphasized by programs like the surgeon general's and the Centers for illness Control and Prevention's (CDC) family history initiatives. In
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light of the role that genomics plays in the etiology of chronic illness, recent papers have called for support for population-based research, the translation of genomic research into health promotion, and the establishment of public health infrastructure in the field of genomics. They have also emphasized the significance of risk assessment, early detection, and prevention strategies. In summary, by clarifying the intricate interactions between genetics, lifestyle, and environment, genomics presents potential to improve disease prevention efforts. This information may be used to inform initiatives that will improve health outcomes and lessen the toll that chronic diseases take on society and healthcare systems [12].

Biobanks, which hold biological samples and data from huge populations, are a great resource for genetic research, especially when looking into common but complex illnesses. These biobanks can be focused on diseases or populations, and because of their huge sample sizes, well-characterized phenotypes, and wealth of information on exposures, dietary habits, lifestyle, and environmental factors, they provide nursing scientists exceptional opportunity to investigate biobehavioral research problems. A disease-specific biobank's potential for focused study is demonstrated by the CONCOR biobank in the Netherlands, which focuses on congenital heart disease. When genes linked to chronic illness vulnerability are found in combination with environmental factors that may be changed, the fields of genomics, lifestyle modification, and disease prevention come together. Healthcare professionals can inform patients and families about their susceptibility, promote lifestyle changes, and adjust therapies by using genetic screening to identify at-risk individuals. The articles in this series show how prevention tactics for several chronic conditions, such diabetes and cardiovascular disease, are informed by genomics. Promising developments in the identification of susceptibility genes, including a DNA variant linked to an increased risk of type 2 diabetes, could revolutionize patient care and preventive approaches. Comprehending the genetic risk factors can help with tailored therapies and patient education, which could result in major advancements in the prevention and management of disease. Healthcare professionals will be able to use genomic data as this field of study develops to help people make better health decisions and lower their chance of developing chronic illnesses [13].

As nursing genomic science progresses, nurse scientists are increasingly urged to engage in research at all stages of the process, collaborating with interdisciplinary colleagues. This involvement spans from identifying susceptibility genes and environmental risk factors to designing effective genetic screening programs, evaluating preventive measures, assessing adherence to recommendations, and implementing health surveillance based on genetic susceptibility. Additionally, nurse scientists are encouraged to explore research areas related to access to genomic healthcare, ethical considerations such as informed consent, and effective strategies for communicating genetic information to patients [13].

Opportunities for research will also expand to include investigations into gene-environment interactions, gene-gene interactions, and genetic
variability associated with symptoms such as fatigue and pain in chronic illness. Such insights can inform strategies for symptom management, improving the quality of care for individuals affected by chronic conditions. By actively participating in genomic research across the spectrum, nurse scientists can contribute to advancing knowledge, promoting evidence-based practice, and ultimately enhancing patient outcomes in the genomic era [14].

**Health Disparities and Genomics:**

The topic of finding practical ways to lessen health disparities is essential, especially in light of differences in health outcomes linked to racial, ethnic, gender, and healthcare access disparities. Initiatives like Healthy People 2010 and the creation of centers by organizations like the National Institute of Nursing Research (NINR) and the National Institutes of Health (NIH) dedicated to health disparities research emphasize this point. The study of health disparities has long been a focus of nurse scientists, and more recent work has included biological and genetic elements in their conceptual frameworks. Given that various population segments may have differing frequencies of genetic variations connected to disease, genomic-based research has the potential to have a substantial impact on health disparities research. Furthermore, genetic diversity might affect how different populations respond to therapies, emphasizing the global effects of health inequalities [15].

There is a complicated relationship between genetics and health inequities. For example, genetic variation may explain for higher disease susceptibility in different population segments, even while environmental factors and genes linked to disease susceptibility may be found for a condition. This brings up difficult questions about who should receive tailored therapies and genetic screening. It is recommended that nurse scientists participate in multidisciplinary discussions and studies concerning genetics and racial and ethnic health inequalities. However, the use of self-identified race or ethnicity in determining disease risk factors is still up for dispute in the scientific community. While some say that these identifiers propagate false conceptions and hide more significant causes of disease, others counter that they are helpful stand-ins for significant health-related variables. In order to minimize potential societal disadvantages like stigmatization or the reinforcing of racial and ethnic stereotypes, nurse scientists are essential in ensuring that genomic-based research is carried out and disseminated appropriately [16].

Additionally, it is encouraged for nurse scientists to work in fields like pharmacogenomics, where there are a lot of potential for intervention due to the link between genomic medicine and health disparities. The introduction of racialized medications, like BiDil, to treat heart failure in African Americans has sparked debates regarding racialized customized medicine. While some see these advancements as positive, others urge researchers to go beyond using race as a simplistic proxy and instead push for a better knowledge of the genetic and environmental components impacting medication response. In conclusion, nurse scientists have a great
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opportunity to advance the field of genomics-health disparities research and policy creation, which will improve healthcare outcomes for all populations [17].

Technology and Genomics:

The contemporary panorama of genomic-based technologies, including genetic screening and genomic therapeutics, is encapsulated in the research theme of using modern technologies to satisfy human needs. The ability to characterize genetic material has come a long way, but there is still a significant "therapeutic gap" in putting these advances into practical clinical use, especially in cases like Huntington's disease where genetic risk can be determined but curative treatments are not available. For these kinds of disorders, nurse scientists are in a unique position to create and evaluate novel therapeutic interventions as well as help patients and their families recognize and manage their hereditary susceptibility. Conversely, gene-based treatments have the potential to enhance patient outcomes; yet there is a substantial danger associated with them, as demonstrated by instances such as gene therapy for X-linked severe combination immune deficiency (SCID). In addition to developing interventions and doing research to help patients and families understand risk information, nurse scientists can play a critical role in developing gene therapy protocols by helping patients and families deal with the uncertainty of novel gene-based treatments [18].

In order to close the knowledge gap between genomic technology and clinical application, research endeavors are required. Nurse scientists possessing expertise in genomic-based technologies, research methodologies, and behavioral interventions are well-positioned to tackle inquiries arising from novel genomic data. The amalgamation of biological and behavioral elements in investigations showcases the distinct input that nurses provide to the field of genomics research and establishes the framework for subsequent investigation by nurse scientists. Nurse scientists are encouraged to address important issues including implementation, test result disclosure, family communication, and decision-making processes related to genetic testing as genomic technologies continue to advance quickly. Understanding individual and family responses over time is crucial for improving testing procedures and developing policies that safeguard patients and families. Longitudinal studies provide this knowledge. Nurse scientists are in a unique position to address these issues and propel worldwide achievements in genetic research and clinical care because of their roles as educators, activists, and policy developers [19].

End of Life and Genomics:

Improving patients' and their families' end-of-life experience highlights the need for research focused on enhancing end-of-life care. The concern that people have of dying slowly and with technology, together with the worry of being abandoned and experiencing pain and suffering, are highlighted in reports from the Institute of Medicine (2003) and the NIH State of the Science Conference on Improving End-of-Life Care in 2005 (Grady, 2005). Coordinating research on palliative and end-of-life care is a major responsibility of the National Institute of Nursing Research (NINR), which also supports initiatives to assess present
practices and create plans for improvement. Working with the Office of Rare Diseases and the National Human Genome Research Institute at the National Institutes of Health, the NINR assembled a working group of scientists, physicians, and people with genetic disorders in 2001 to investigate the ways in which end-of-life concerns in this population differ from those in other populations and to suggest directions for future research in this area [20].

Although there is a dearth of research on end-of-life concerns in individuals with genetic disorders and no established model for end-of-life care or treatment discontinuation, the expert workshop's findings highlight unique difficulties faced by those with genetic conditions (Knebel & Hudgings, 2002a). Effective communication by healthcare providers, balancing the hopes for genomic advancements with the reality of genetic diagnoses, addressing feelings of guilt, fear, and regret among family members, pondering the implications of genetic testing, making difficult reproductive decisions, deciding how best to use rapidly evolving technological interventions, and addressing intergenerational care issues when multiple family members are affected by a genetic disease are just a few of the key areas of focus that nurse scientists are well-positioned to address (Knebel & Hudgings, 2002b). Nurse scientists can make a significant contribution to the development of customized interventions and support mechanisms that address the distinct needs and challenges faced by patients and families in these circumstances by exploring these subtle aspects of end-of-life care in the context of genetic disorders [21].

**Genomic Nursing Data Science Exemplars**

The current landscape of genomic nursing data science is characterized by a focus on leveraging big omics data to deepen our understanding of disease biology. Nurse scientists are employing various omics approaches, including transcriptomics, epigenomics, and microbiomics, to probe into the biological underpinnings of diverse phenotypes. Here are some exemplary studies highlighting the breadth and depth of genomic nursing research:

1. Joseph et al. (2019) conducted a study analyzing gene expression patterns in whole-blood samples from healthy participants to identify associations with body mass index. Using weighted gene co-expression network analysis (WGCNA), they uncovered gene modules linked to catabolic and muscle system processes, shedding light on potential mechanisms underlying obesity [22].

2. Dorsey et al. (2019) characterized transcriptomes associated with chronic low back pain, delineating genetic differences between individuals with acute and chronic pain. Their findings corroborated previous research on the role of the major histocompatibility complex in pain symptomatology [23].

3. Flowers and team (2018) investigated gene expression perturbations in oncology patients experiencing evening fatigue during chemotherapy. By analyzing RNA transcripts from whole blood, they identified differential gene expression and perturbed biological pathways, shedding light on potential mechanisms of fatigue, including inflammation and energy metabolism [24].

4. Anderson et al. (2014) explored DNA methylation patterns in maternal peripheral blood cells and placental tissue associated with preeclampsia
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development. Utilizing genome-wide DNA methylation data, they identified differentially methylated CpG sites in maternal blood cells, providing insights into potential biomarkers of preeclampsia transmission from mother to offspring [25].

5. Wright et al. (2017) investigated the relationship between maternal parenting stress and epigenome-wide DNA methylation among African-ancestry motherchild dyads. Their study, utilizing saliva samples and epigenome-wide data collection, revealed associations between parenting stress levels and maternal DNA methylation patterns [26].

These exemplar studies demonstrate the diverse applications of genomic nursing data science, from unraveling the genetic basis of complex conditions like obesity and chronic pain to exploring epigenetic mechanisms underlying maternal health outcomes. By employing sophisticated analytical techniques and leveraging large-scale omics datasets, nurse scientists are at the forefront of advancing our knowledge of disease biology and paving the way for personalized approaches to healthcare.

Data Science Genomic Nursing Roles and Education

Indeed, genomic nursing data science requires a multidisciplinary approach, drawing on expertise from various fields such as biology, computer science, statistics, and nursing. Successful implementation relies on collaboration among individuals and laboratories with diverse skills and experiences. While nurse scientists on genomic nursing science teams may not always directly engage in data wrangling, preprocessing, and analysis, they play crucial roles throughout the data science lifecycle [27].

Non-data-intensive genomic nurses contribute to several key areas:

1. Patient Recruitment: They identify and recruit participants for genomic studies, ensuring diverse representation within the research cohort.

2. Biological Sample Collection: They oversee the collection of biological samples, ensuring proper handling and storage to maintain sample integrity.

3. Phenotype Collection: They gather detailed information on participants’ phenotypic traits, medical histories, and other relevant variables for comprehensive analysis.

4. Mechanistic Follow-Up: They conduct further investigations to elucidate the biological mechanisms underlying study findings, bridging the gap between genomic data and clinical outcomes.

5. Genomic Data Generation: They may be involved in generating genomic data through various techniques such as DNA sequencing, genotyping, or gene expression profiling.

6. Evaluation and Interpretation: They analyze and interpret study findings in the context of clinical relevance, considering implications for patient care and treatment strategies.

7. Translation to Clinical Practice: They play a pivotal role in translating research findings into actionable insights for clinical practice, informing healthcare providers and guiding patient management.
8. Influence on Data Policy and Governance: They contribute to discussions on data policy, governance, and ethical considerations, ensuring adherence to regulatory standards and protecting patient privacy and confidentiality.

By leveraging their expertise in nursing and genomics, nurse scientists contribute essential perspectives to interdisciplinary teams, enhancing the quality and impact of genomic nursing data science research.

**Genetic Counselors and Medical Genetics:**

Although the area of genetic counseling has grown significantly in the US over the last ten years, there is still a lack of genetic counselors providing direct patient treatment. Various groups have worked together to create plans to increase the number of genetic counselors in the workforce and enhance training initiatives in order to close this gap. The National Society of Genetic Counselors (NSGC), the Accreditation Council for Genetic Counseling (ACGC), and other professional organizations are members of the Genetic Counselor Workforce Working Group (GCWFWG), which was founded in 2013. The team determined what obstacles stood in the way of expanding the workforce and developed a strategy that included doable tactics. The training of genetic counselors, clinical supervision, and public awareness/value are the main objectives of this initiative. To keep up with the increased demand, the Association of Genetic Counseling Program Directors (AGCPD) is aggressively adding new training programs and growing the ones that already exist. They are also making sure that these programs continue to be rigorous and of high quality [28].

With an emphasis on assisting an increasing number of programs, ACGC is always assessing best practices in assessment and accreditation. They are investigating competency-based evaluation criteria and modifying training requirements to align with modern practice. The American Board of Genetic Counseling (ABGC) is creating certification exam eligibility requirements and pathways for genetic counselors with overseas training. To educate students for expanding markets and alternative service delivery models, such as remote counseling, individual training programs are revising their curricula. They are implementing cutting-edge training techniques, such as interprofessional educational activities, remote training options, and standardized patients. NSGC supports federal recognition by the Centers for Medicare and Medicaid Services (CMS) to permit genetic counselors to bill for services, as well as state licensure for genetic counselors. In order to address workforce difficulties, collaboration with other clinical partners—such as nursing and physician organizations—is also growing. The overall goals of these cooperative initiatives are to raise the number of genetic counselors with training, enhance the quality of training programs, and promote the acceptance and payment of genetic counseling services [29].

Sufficient genetic services for patients with genetic problems are severely hampered by the lack of clinical geneticists. Barriers like geographic distance, lengthy wait periods, poor insurance coverage, and inefficient referral systems have hindered patient access to genetic knowledge, even in spite of the growing understanding of the significance of genetics in healthcare. The growing demand for genetic
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services cannot be met by the current number of board-certified geneticists in the United States. The incidence of unusual illnesses suggests that up to 3 million interactions annually may be required; however, the current workforce is only able to meet a small portion of this demand. New patient appointment wait times have been longer, and many practices are operating at or close to capacity. The number of training programs and jobs for geneticists is being increased, and in an attempt to draw in more trainees, combined residency programs are being investigated. But in spite of these initiatives, the volume of applications has fallen short of expectations. Geneticists need to complete more training than other specialists, which might lead to a lengthier training period and lower earning potential [30].

Recruiting more geneticists and growing the genetic services industry would be encouraged by changing billing and pay policies to enable geneticists to turn a profit or break even. In order to effectively advocate for improved coverage for genetic services and demonstrate their value in improving health outcomes, professional organizations like the National Society of Genetic Counselors (NSGC) and the American College of Medical Genetics and Genomics (ACMG) must work together. The study of genetics should be covered more in medical school and residency training programs, with an emphasis on how genetic medicine may improve patient outcomes. More medical students and residents may be drawn to the field of genetics through mentoring programs and campaigns that highlight the effects of genetic testing on treatment and results. The lack of clinical geneticists can be addressed in part by working with nongeneticists who are interested in genetics and by implementing telehealth initiatives to maximize efficiency. Enhancing care and relieving pressure on a restricted number of providers are two more benefits of incorporating management standards into electronic health records. To summarise, a comprehensive strategy is needed to tackle the scarcity of clinical geneticists. This strategy should involve stakeholder collaboration, advocating for enhanced coverage and reimbursement, increasing genetics exposure during medical education, and optimizing the efficiency of genetic service delivery [31].

Main Role of Nurses:

The education of registered nurses (RNs) and advanced practice registered nurses (APRNs) in genomics is crucial given their significant roles in patient care, education, and coordination. With over 2.8 million employed RNs and 270,000 APRNs in the United States, ensuring adequate genomics education is essential for providing high-quality care across diverse patient populations. RNs typically hold varying degrees, including associate, bachelor's, or diploma in nursing, while APRNs must have a graduate degree in nursing. Both RNs and APRNs play critical roles in patient education, care coordination, and administration of therapies. APRNs, in addition to these roles, have the authority to assess, diagnose, manage health problems, order tests, and prescribe medications [32].

Despite the importance of genomics in nursing practice, the inclusion of genetics/genomics content in nursing education programs is inconsistent. Some programs may have genetics content in their
curricula, but the amount and type of content vary widely. Efforts to integrate genetics education into nursing curricula have been ongoing since the 1960s, with recommendations and initiatives from organizations like the NIH and HRSA. However, national surveys indicate that genetics knowledge among nursing faculty remains limited, despite increases in genetics content in some schools. This highlights a gap where even if genetics and genomics content is included in science courses, nursing faculty may not be adequately prepared to integrate this knowledge into their teaching [33].

To address this challenge, it is essential to provide faculty development opportunities focused on genetics and genomics education. Intensive continuing education programs can help faculty enhance their knowledge and skills in genetics, empowering them to effectively integrate this content into their courses. Additionally, there is a need for standardized and evidence-based guidelines for genetics/genomics education in nursing programs. Clear guidelines can help ensure consistency in the quality and depth of genetics education across different nursing schools. Furthermore, collaboration between nursing organizations, educational institutions, and genetics/genomics experts is essential to develop comprehensive strategies for integrating genetics/genomics education into nursing curricula. These strategies should address faculty development, curriculum development, and evaluation of educational outcomes. Overall, enhancing genetics/genomics education for RNs and APRNs is crucial for preparing nursing professionals to provide competent and patient-centered care in an increasingly genomic-driven healthcare landscape [34].

When it comes to defining roles, duties, and competences relating to genetics and genomics, nursing has led the way. Outlining the duties and obligations of registered nurses (RNs) and advanced practice registered nurses (APRNs) who specialize in genetics, the first Statement on the Scope and Standards of Genetics Nursing Practice was issued in 1997 and revised in 2016. A consensus-building approach involving leaders from university programs, federal agencies, nursing specialty groups, and the International Society of Nurses in Genetics (ISONG) resulted in the development of genetics and genomics skills for all nurses. After that, these competences were revised to incorporate outcome indicators, guaranteeing their continued relevance and practicality in nursing practice [35].

A number of these competencies were included to the Essentials for Graduate Education in Nursing and the Essentials for Baccalaureate Education in Nursing by the American Association of Colleges of Nursing (AACN) in recognition of their significance. The Commission on Collegiate Nursing Education (CCNE) created these documents as guidelines for accrediting standards for graduate and undergraduate nursing programs. Although the groundwork for genetics teaching in nursing programs has been laid, there are still substantial regulatory obstacles to overcome. The Accreditation Commission for Education in Nursing does not appear to have evaluated curricula for genetic material, despite the fact that CCNE evaluates master's and bachelor's degree nursing programs for the existence of genetics content during the accreditation process [36].
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Moreover, the National Council for State Boards of Nursing's 2014 knowledge assessment demonstrates that the RN licensure examination noticeably lacks genetics/genomics topics. This reveals a weakness in the standards for ensuring newly certified registered nurses have the fundamental genetics and genomics knowledge needed for secure and efficient practice. Attempts have been made to provide practicing nurses with genomics continuing education in order to close these gaps. Over 17,000 people have benefited from initiatives like the Genetics Education Program for Nurses (GEPN), which offers nurses, nursing educators, and nursing students a variety of continuing education opportunities. Furthermore, partnerships with groups such as the International Society of Nurses in Genetics and the National Council of State Boards of Nursing have made it easier to provide nurses with genetics continuing education [37].

In conclusion, even though there has been progress in incorporating genetics and genomics into nursing education and continuing education programs, more work is required to guarantee that all nurses are equipped with the knowledge and abilities needed to successfully apply genetics and genomics into their practice. This entails removing obstacles related to regulations, improving the genetic component of nursing courses, and offering practicing nurses ample opportunity for continuous education.

Patient care can be much improved and access to genomic services can be greatly increased by increasing the opportunity for genetics education and training for nurses, especially APRNs. If even 1% of nurses pursue appropriate genetics continuing education, that equates to about 30,000 individuals who can make a substantial contribution to the field. APRNs and RNs are well-positioned to play key roles in genetics practices as clinical genetics expands to include medication administration, care management, and patient education beyond diagnosis and counseling. With their extensive training and capacity to evaluate, diagnose, and treat patient health issues, advanced practice registered nurses (APRNs) in particular can significantly enhance genetics services [38].

The increasing employment of APRNs in a variety of specialized practices indicates their versatility and potential for success in a wide range of fields, even though their graduate coursework may not be specifically focused on genetics. Similar initiatives might be put in place to support APRNs in genetics. Residencies, fellowships, and mentorship programs have been designed to train APRNs for full scope of practice in specialty areas. While an ideal program and fellowship plan for APRNs in genetics would be nationally recognized, these resources are not available at this time. It might be necessary for clinical genetics offices to offer APRNs role-specific on-the-job education and training, with an emphasis on topics including the natural history, management, and treatment approaches for certain genetic diseases [39].

Clinical geneticists can focus on new patient visits and challenging situations when APRNs handle a caseload of genetics patients that need continuous drug management and follow-up. This can facilitate patient access to care for those with genetic problems and assist shorten wait times for clinical genetics appointments. All things considered, utilizing
the genetics knowledge and proficiency of APRNs can improve the provision of genomic services and improve patient outcomes.

Conclusion:
In conclusion, the discussion on nursing genetics highlights both the progress made and the challenges that persist in integrating genetics and genomics into nursing education and practice. While nursing has been a leader in delineating roles, responsibilities, and competencies related to genetics, there remains significant variability in the amount and type of genetics content covered in nursing education programs. Despite efforts to increase genetics education, regulatory barriers and limited genetics knowledge among nursing faculty continue to hinder progress in this area. However, there are promising initiatives aimed at addressing these challenges. The development of genetics and genomics competencies for all nurses, along with their incorporation into nursing education standards, represents a significant step forward. Additionally, efforts to provide genetics continuing education for practicing nurses, such as the Genetics Education Program for Nurses (GEPN), have reached thousands of professionals and have the potential to further enhance genetics literacy among the nursing workforces.

Moreover, the discussion emphasizes the critical role that nurses, both RNs and APRNs, can play in the delivery of genomic services. As clinical genetics expands to include care management and treatment options, nurses are well-positioned to contribute to various aspects of genomic care, including patient education, medication management, and coordination of services. APRNs, with their advanced training and scope of practice, can particularly make significant contributions to genetics services and help alleviate the burden on clinical geneticists. Despite the challenges, there is a clear opportunity to leverage the skills and expertise of nurses to improve access to genomic services and optimize patient outcomes. By enhancing genetics education, providing support for continuing education, and integrating genetics into nursing practice, nurses can play a vital role in advancing genomic healthcare and addressing the evolving needs of patients with genetic conditions. Moving forward, collaborative efforts among nursing organizations, educational institutions, and healthcare providers will be essential to further integrate genetics into nursing practice and ensure that nurses are equipped to meet the demands of genomic healthcare in the future.

References


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Appendix A
Questionnaire Statements

Dear participant,
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Thank you for participating in our survey on your experiences with nurse-patient communication in cancer treatment. Your opinion is crucial for us to assess the quality of care delivered by nurses and the influence of communication on your healthcare encounters.

This questionnaire seeks to collect your opinions on several facets of nurse-patient communication while interacting with healthcare personnel in cancer environments. Your candid feedback will provide significant insights on how nurses can enhance their assistance in helping you manage your health conditions and treatment.

Your feedback on the effectiveness of nurse listening, clarity of information, empathy shown by nurses, involvement in decision-making, support in symptom management, and overall satisfaction with care will help us identify areas for improvement and meet your needs effectively.

Your answers are kept secret, and your identity is ensured to remain anonymous. Answer each question deliberately and honestly based on your own experiences. Your opinion will help enhance the quality of care delivered by nurses in cancer settings, leading to better patient outcomes and satisfaction.

Thank you for your critical involvement and comments in this crucial research on nurse-patient communication in cancer treatment. We value your input.

1. I believe my nurse attentively listens to my concerns and inquiries throughout our conversations.
   - 1: Strongly Agree
   - 2: Agree
   - 3: Neutral
   - Disagree
   - Strongly Disagree

2. The information given by my nurse is clear and easily comprehensible.
   - 1: Strongly Agree
   - 2: Agree
   - 3: Neutral
   - Disagree
   - Strongly Disagree

3. I am at ease talking about my health concerns with my nurse.
   - 1: Strongly Agree
   - 2: Agree
   - 3: Neutral
   - Disagree
   - Strongly Disagree

4. My nurse demonstrates sensitivity and comprehension of my emotional needs.
   - 1: Strongly Agree
   - 2: Agree
   - 3: Neutral
5. I am content with the length of time my nurse allocates for me during appointments.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree

6. My nurse includes me in decision-making about my treatment plan.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree

7. I get assistance from my nurse in handling my symptoms and side effects.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree

8. My nurse gives me the essential information to make educated choices about my treatment.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree

9. I trust my nurse's competence in handling my healthcare requirements.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree

10. My nurse successfully connects with other healthcare team members.
    • 1: Strongly Agree
    • 2: Agree
    • 3: Neutral
    • Disagree
    • Strongly Disagree

11. I am satisfied with the general level of care given by my nurse.
    • 1: Strongly Agree
    • 2: Agree
    • 3: Neutral
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• Disagree
• Strongly Disagree

12. I believe my nurse respects and considers my ideas and preferences about my treatment.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree

13. My nurse motivates me to inquire and request explanation about my therapy.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree

14. I believe my nurse respects my privacy and confidentiality throughout our exchanges.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree

15. Overall, I am pleased with the communication and care offered by my nurse.
   • 1: Strongly Agree
   • 2: Agree
   • 3: Neutral
   • Disagree
   • Strongly Disagree