Integrating genomics and precision health knowledge into practice: A guide for nurse practitioners

Trina Walker, DNP, APRN, FNP-C (Assistant Professor)[1], Anne L. Ersig, PhD, RN (Associate Professor)[2], Andrew A. Dwyer, PhD, FNP-BC, FNAP, FAAN (Associate Professor)[3], Rebecca Kronk, PhD, MSN, CRNP, FAAN CNE, ANEF (Professor)[4], Cynthia T. Snyder, DNP, ACGN, FNP-C, CBCN (Advanced Clinical Genomics Nurse Practitioner)[5], Karen Whitt, PhD, APRN, FNP-C, AGN-BC, FAANP (Associate Professor)[6], & Valerie Willis, PhD, RN, PPCNP-BC, PCNS-BC (Visiting Assistant Professor)[7]

ABSTRACT

Nurse practitioners (NPs) are the fastest growing group of health care providers, with an increase of 8.5% over the past year and anticipated growth of more than 40% by 2031. Improving NPs' knowledge of how genes influence health enables them to assess, diagnose, and manage patients in all states of health in a safe, efficient, and competent manner. Nurse practitioners may also care for patients who obtain direct-to-consumer (DTC) genetic tests without provider oversight and share their results; improved knowledge of genetics can provide NPs with the information and resources needed to interpret and understand DTC test results. The literature indicates that NPs have limited understanding of basic genetic concepts and guidelines for prescribing drugs affected by genomic variability. As a result, NPs report low confidence in their ability to accurately interpret and apply genetic test results, which inhibits genomics-informed precision health care. This article provides resources and clinical recommendations for using the 2021 American Association of Colleges of Nursing Essentials and the American Nurses Association Essentials of Genomic Nursing to facilitate the integration of genomics into NP curricula and practice. These resources will help future and practicing NPs integrate genomics into practice and improve precision health care.

Keywords: Clinical practice; competencies; education; essentials; genetics; genomics.

Journal of the American Association of Nurse Practitioners 36 (2024) 554–562, © 2024 American Association of Nurse Practitioners

DOI# 10.1097/JXX.0000000000001050

Introduction

In 2003, the landmark Human Genome Project (HGP) published the first nearly complete human DNA sequence, which catalyzed significant advances in using genomics to improve human health. Precision health care combines genomic data from the HGP with other factors contributing to health and risk for disease to improve prevention, diagnosis, and treatment of disease for patients, also referred to as clients, and populations (National Human Genome Research Institute [NHGRI], n.d.-a). The holistic nature of precision health care makes nurse practitioners (NPs) ideally positioned to use a precision health lens when providing care to patients and families across the lifespan and in all states of health and well-being. NPs practicing to the full extent of their education, license, and experience are essential to implement advances in genomics and make precision health care widely available supporting high-quality, equitable care (American Association of Colleges of Nursing [AACN], 2021; Institute of Medicine, 2011).

Precision health care

Precision health care incorporates genomics, patient and family history data, and information obtained from clinical assessment, patient behaviors, and the environments within which patients live, learn, work, play, pray, and age (Dewell et al., 2020; Juarez et al., 2014). Precision health care is relevant to both primary and specialty care. Although oncology is a frequently cited exemplar, genomics has broad implications for multiple populations, including children and adolescents, primary care patients, people with developmental delay, women with a history

[1]*Creighton University College of Nursing, Omaha, Nebraska* [2]*University of Wisconsin-Madison School of Nursing, Madison Wisconsin* [3]*Boston College William F. Connell School of Nursing, Chestnut Hill, Massachusetts* [4]*Duquesne University School of Nursing, Pittsburgh, Pennsylvania* [5]*Georgia Center for Oncology Research and Education, Atlanta, Georgia* [6]*George Washington University School of Nursing, Washington, District of Columbia* [7]*Clinical Division, Department of Medical and Molecular Genetics, Indiana University School of Medicine, Indianapolis, Indiana*

Correspondence: *Trina Walker, DNP, APRN, FNP-C; E-mail: trinawalker@creighton.edu*

Received: *28 March 2024; revised: 5 June 2024; accepted 12 June 2024*

of multiple miscarriages, older adults with polypharmacy, and others (NHGRI, n.d.-a). Genomics-informed care is no longer restricted to specialties such as genetics and oncology, and patients referred for specialty consultation will still need care provided by primary care providers, such as NPs. However, the promise of fully integrated, equitable, state-of-the-art precision health care remains elusive, largely due to the well-documented shortage of genetics specialists required to meet the growing demand for precision health services (Jenkins et al., 2021).

The purpose of this article is to provide NPs with a guide for integrating genomics and precision health knowledge into their practice. To do so, we linked *The Essentials: Core Competencies for Professional Nursing Education* (AACN, 2021) and *Essentials of Genomic Nursing: Competencies and Outcome Indicators* (3rd ed.; American Nurses Association [ANA], 2023), in order to provide specific recommendations for the use of genomics in clinical practice. Ultimately, we aim to improve competence and confidence for integrating genomics into advanced nursing practice to facilitate and enhance precision health care.

National initiatives on precision health care

Federal agencies, including the National Institutes of Health (NIH) and Veterans Administration (VA), support precision health initiatives and the integration of precision health into health care nationwide. In addition, the NIH-sponsored *All of Us* Research Program (NIH, 2023) is recruiting a large sample representative of the US population, with the goal of obtaining clinical and genomic data to improve scientific knowledge. This data set, which is not focused on any particular disease or condition, will support efforts to identify those at risk for disease, develop new treatments for common health conditions, and provide resources that NPs and their patients can use to improve health. Finally, the VA is expanding its National Precision Oncology Program (NPOP) to increase access to genetic services for veterans receiving cancer care nationwide (Scheuner et al., 2020).

However, patients who are underserved, or who live in areas with limited health care resources, have more difficulty accessing adequate and up-to-date health care. Historically marginalized populations are at an increased risk of disease and could benefit from precision health care yet are frequently unable to access it. Nurse practitioners can provide a critical bridge by helping these patients obtain screening, genomic testing, and treatment that will promote optimal health. An example of this is the statewide family history screening program for hereditary cancer in Georgia. This genetic screening program is offered in public health districts serving ethnically diverse and medically underserved individuals and is coordinated by an NP (Veitinger et al., 2022).

Genomics in precision health care

Genomics is central to precision health, and NPs must know how to use genomics to provide the best care possible for their patients. When adequately trained, NPs are ideally positioned to identify genetic conditions that impact the health of patients and their family members (Scheuner et al., 2020). As knowledge of genomics expands, differential diagnoses will increasingly include those caused by genetic variants. Genetic evaluation is already part of current NP practice, including collecting and reviewing individual, family, and social history, completing a comprehensive physical assessment, and reviewing testing and imaging results. For example, NPs should fully evaluate family history data to identify potentially inherited conditions and increased disease risk as part of routine, quality, holistic care. In addition, clinical decision support tools that many NPs use, such as UpToDate (Up To Date, 2023), now contain sections on genetic counseling and risk assessment, which are useful for NPs providing genomics-informed care (Aleman et al., 2021).

In addition to clinician-driven genetic testing, patients can access direct-to-consumer (DTC) genetic testing without consulting their health care providers and may bring their results to NPs to help understanding the meaning of the results (Wysocki & Osier, 2019). Given the limited amount of information provided in DTC results, NPs will need to know how to accurately counsel, educate, and refer patients as appropriate (Wysocki & Osier, 2019). However, NPs have limited knowledge of genetic principles and interpreting genetic test results (Scheuner et al., 2020).

Rapid development and implementation of treatments based on genomic data will also affect NP practice, particularly as these advances expand to include more health conditions. For instance, patients aware of their status for familial hypercholesterolemia (FH) are more likely to take cholesterol-lowering medication, supporting cascade testing in families (Huijgen et al., 2010). Further advances include targeted treatments for specific genetic variations within tumors, as well as recently approved gene therapy treatments for sickle cell disease and beta-thalassemia (Federal Drug Administration, 2023; Thompson et al., 2018). Targeted treatments such as these will change the natural history of multiple conditions, requiring NPs to change how they provide care to patients receiving genomics-based treatments.

Finally, genomics can inform selection of medications (e.g., antidepressants, anticoagulant therapy, and opioids) to treat certain conditions. Although many resources are available for pharmacogenomics implementation, genetic testing to guide medication prescribing in primary care is not routine. Reasons cited by clinicians include lack of prospective, randomized, clinical trials showing improved outcomes for drug therapy

based on genotype, ethics, limited cost-effectiveness data, lack of guidelines for testing, limited education for providers and patients, and delays in therapy while waiting for results of testing (Tantisira & Weiss, 2023). To ameliorate these concerns, the Clinical Pharmacogenetics Implementation Consortium (CPIC) provides guidelines to increase clinicians' understanding of how genetic test results can be used to optimize prescribing (CPIC, 2024). It is important to note that unlike most laboratory tests (e.g., a basic metabolic panel) that provide a snapshot of an individual's health at a particular point in time, genetic testing, including pharmacogenomic tests, is a one-time test that can inform longitudinal medical management decisions for a patient's lifetime.

Current state

Nurse practitioners play a critical role in integrating genetics, genomics, and precision health initiatives across health care settings for all populations (Dewell et al., 2020). Yet, their educational preparation in genetics, genomics, and precision health is limited. Multiple researchers have identified a persistent genomics knowledge gap for practicing nurses and NPs (Connors & Wysocki, 2023; Thomas et al., 2023). Factors contributing to this gap include inadequate genomics education in prelicensure and graduate education and limited opportunities to access and complete genomics-focused continuing education (Connors & Wysocki, 2023; Tonkin et al., 2020). Although nursing faculty may recognize the importance of genomics for advanced practice nurses, many have a limited background in genetics and genomics and may lack confidence to teach genomics to their students (Calzone & Tonkin, 2022). As a result, advanced practice nursing students receive limited education on genetics and genomics (Calzone & Tonkin, 2022).

Barriers to genomics competency for practicing NPs, NP students, and nursing faculty persist despite the development of genomic competencies for all nurses, the *Essentials of Genomic Nursing: Competencies and Outcome Indicators* (third Edition; hereafter referred to as *The Genomic Competencies*; ANA, 2023; Connors & Wysocki, 2023; Thomas et al., 2023). In practice settings, support from nursing and facility leadership is essential for the assessment of NPs' genomic competency and implementation of continuing education activities (Calzone & Tonkin, 2022). Although initiatives to incorporate genomics education into practice settings have succeeded in research studies, implementation can be time consuming, and ensuring continued support remains challenging across practice settings (Thomas et al., 2023). Without continued support and a focus on genetics and genomics, practicing NPs will be unable to attain and maintain competency in genetics and genomics, given rapid advancements in technology (Dewell et al., 2020).

Despite these challenges, comprehensive education on genetics and genomics in prelicensure and graduate nursing education and support for genomics-informed nursing care are necessary to establish and maintain competency and integrate genomics into clinical nursing practice (Connors & Wysocki, 2023; Thomas et al., 2023). Ideally, education will integrate genomics with the information that nurses and NPs already use to inform their critical thinking, rather than addressing it as a separate topic. Doing so will help NPs consider genomics along with other information needed to diagnose patients and establish and execute care plans. To address the critical need for improved genomics education in nursing, nurse researchers and educators have developed educational programs to improve genomic literacy among doctorally prepared nurses. These programs include "Genomic Competencies for Nurses: An Online Course" (https://www.duq.edu/academics/colleges-and-schools/nursing/continuing-education-programs/genomic-competencies/index.php) and the "Translation and Integration of Genomics is Essential to Doctoral Nursing (TIGER)" program (https://nursing.vanderbilt.edu/tiger/). For NPs in clinical practice, continuing education activities and conference workshops and presentations (Box 1) can provide important information on integrating genomics into clinical care.

Integrating precision health care into advanced nursing practice requires addressing multiple gaps and barriers. These include the shortage of genetics specialists, limited educational preparation in genomics, limited knowledge of genomics and lack of confidence in teaching genomics content, lack of knowledge and confidence to integrate genomics into clinical practice, and limited support from nursing leadership for implementing genomics into practice. Additional gaps and barriers include the limited number of prospective, randomized, clinical trials showing improved outcomes for drug therapy based on genomic data, limited cost-effectiveness data on the use of genomics in primary care, and the lack of guidelines for genetic testing and limited scope of those that are available.

Definitions in the Key Terms box are from the following sources:

1. https://www.genome.gov/genetics-glossary;
2. https://www.cdc.gov/genomics/about/precision_med.htm;
3. https://www.google.com/url?q=https://www.genome.gov/For-Health-Professionals/Provider-Genomics-Education-Resources/Healthcare-Provider-Direct-to-Consumer-Genetic-Testing-FAQ;
4. https://www.cdc.gov/genomics/disease/cascade_testing/cascade_finding.htm;
5. https://www.cancer.gov/about-cancer/treatment/types/targeted-therapies.

Definition

Key terms

Genetics The branch of biology concerned with the study of inheritance, including the interplay of genes, DNA variation and their interactions with environmental factors. (1)
Genomics The field of biology focused on studying all the DNA of an organism—that is, its genome. Such work includes identifying and characterizing all the genes and functional elements in an organism's genome as well as how they interact. (1)
Precision health care A broad term referring to tailored, targeted, and/or personalized treatment for an individual. The term not only includes precision medicine ("personalized" medicine focusing on genetically informed management of disease) but also includes disease prevention and health promotion activities that may take place outside of a health care setting. (2)
Genetic testing A laboratory test to examine an individual's DNA. An individual's DNA and variations are unique and can be used in the context of medical care, ancestry studies, or forensics. Genetic test results of a genetic test can be used to confirm (or rule-out) a suspected genetic disease, determine the likelihood of parents passing on a genetic variant, or identify targeted cancer treatments. (1)
Direct to consumer testing Genetic tests sold directly to consumers to provide information about their genetic information (generally ancestry, some health traits and health risks) from a saliva sample. (3)
Pedigree A figure that depicts the relationships and health conditions of individuals in a family. A 3-generation pedigree provides important information about inheritance patterns of health conditions within families (i.e., cancer, cardiovascular disease, diabetes). (1)
Genetic counseling A process to help individuals and families understand genetic testing, possible results, and implications of findings. Genetic counselors are licensed professionals with expertise in genetics and counseling approaches. Counseling typically occurs both pretesting and posttesting. (1)
Pharmacogenomics Pharmacogenomics (also called pharmacogenetics) is a component of genomic medicine that involves using a patient's genomic information to tailor the selection of drugs used in their medical management. In this way, pharmacogenomics aims to provide a more individualized (or precise) approach to the use of available medication in treating patients. (1)
Cascade carrier screening The process of informing family members of a genetic condition within the family, followed by genetic testing of family members to determine genetic risk (i.e., carrier status). (4)
Targeted therapies Targeted therapy is a type of cancer treatment that targets proteins that control how cancer cells grow, divide, and spread. It is the foundation of precision medicine. As researchers learn more about the DNA changes and proteins that drive cancer, they are better able to design treatments that target these proteins. (5)

American Nurses Association Essentials of Genomic Nursing: Competencies and Outcomes Indicators

The ANA, which plays a central role in defining the scope and standards of nursing practice (ANA, 2017), recognizes the importance of genetics and genomics in health care and established consensus genomics *Competencies and Curricula Guidelines* (1st ed.) in 2006 followed by *Outcome Indicators* for the identified competencies in 2008 (2nd ed). In 2023, the ANA updated the genomic competencies for nurses in the *Essentials of Genomic Nursing: Competencies and Outcome Indicators* (3rd ed.; hereafter referred to as *The Genomic Competencies*; **Table 1**; ANA, 2023), due to advances in technology and the increasing number of genomic applications in the clinical environment. *The Genomic Competencies* support the integration of genomic competencies into education and clinical practice for nurses in all academic programs and practice settings.

American Association of Colleges of Nursing Essentials

The Essentials: Core Competencies for Professional Nursing Education (hereafter referred to as *The Essentials*; **Appendix A**) were published by the AACN in 2021 to establish core competencies for individuals entering or advancing in the discipline of nursing. *The Essentials* are composed of 10 domains, which are subdivided into competencies and subcompetencies to align with the four spheres of care: (1) disease prevention/promotion of health and well-being, (2) chronic disease care, (3) regenerative or restorative care, and (4) hospice/palliative/supportive care. It is important that *The Essentials* support nursing education for competency-based practice, similar to *The Genomic Competencies* (3rd ed.; ANA, 2023).

Connecting *The Genomic Competencies* with *The Essentials*

The National Human Genome Research Institute supports the Inter-Society Coordinating Committee for Practitioner Education in Genomics (ISCC-PEG) to improve genomic literacy of health care providers, enhance the effective integration of genomics into health care, and improve health outcomes (NHGRI, n.d.-b). Members of ISCC-PEG come from various health care disciplines collaborate to identify educational needs, share best practices, and develop resources to support integration of genomics into health care practitioner education and practice. The following sections provide exemplars of how to align *The Genomic Competencies* (ANA, 2023) with *The Essentials* (AACN, 2021) and illustrate the use of genomic concepts in NP practice, which were developed by the ISCC-PEG Nursing Genomics Project Group (**Appendix B**).

Case examples: Clinical application of genomics

Pediatrics

A 10-year-old boy with normal BMI presents for a well-child examination. On examination, small clusters of xanthomas were discovered on both elbows. Family history revealed early coronary artery disease (CAD) in the patient's father, paternal uncle, and aunt. Based on patient presentation and family history, a lipid panel was

Table 1. The genomic competencies, number of subcompetencies for genomics-informed care, and their descriptions

Competency (Number of Sub-competencies)	Description
1. Nursing assessment: applying/ integrating genomic knowledge (4)	Conducts a complete genomics-informed history and physical (H&P), including the assessment of client knowledge and perceptions of genomics
2. Identification (4)	Uses genomics-informed H&P to identify, counsel, and provide resources to clients who may benefit from genomics services
3. Referral activities (1)	Identifies clients in need of specialized genomics referral
4. Provision of education, care, and support (8)	Develops a genomics-informed plan of care based on obtained H&P data to provide a more precise approach to prevention, diagnosis, and treatment of disease

obtained, which showed elevated total cholesterol (335 mg/dl; fasting reference range high-density lipoprotein <170 mg/dl), low-density lipoprotein-cholesterol (LDL-C) (145 mg/dl; fasting reference range <110), and triglyceride (150 mg/dl; fasting reference range <90 mg/dl for age 10 to 19 years) levels (Expert panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents and National Heart, Lung, and Blood Institute, 2011). Subsequent fasting samples confirmed hypercholesterolemia, consistent with primary hyperlipidemia. Given the family history and laboratory results, the patient was diagnosed with FH. The patient was referred to a specialist for further evaluation of CAD (Stewart et al., 2020), who recommended dietary modifications and initiation of a statin to reduce LDL-C and triglyceride levels.

At the follow-up appointment 1 month later, the NP discusses the implications of hereditary cardiovascular risk and elicits the family's concerns and questions. The family agrees to a genetic counseling referral to discuss testing and intrafamilial communication of risk to facilitate cascade carrier screening (i.e., testing other family members for FH), enabling blood relatives to understand their genetic risk and implement interventions to mitigate cardiovascular sequelae (Brown et al., 2020).

Mental health

A 64-year-old woman presents with complaints of poorly controlled depression despite many years of taking antidepressant medication prescribed by a different provider. The patient reports adherence to prescribed medications, including trials of selective serotonin reuptake inhibitors, serotonin and norepinephrine reuptake inhibitors, bupropion, and benzodiazepines (as needed). She has been on the same treatment for the past 8 years yet continues to struggle with moderate to moderately severe symptoms of depression. Rather than continue with the trial-and-error approach, the NP orders a pharmacogenomic test to inform prescribing. Testing reveals a genetic variant indicating that the patient is a rapid metabolizer of the two medications she is currently taking. By working with the pharmacist and consulting CPIC guidelines (CPIC, 2024), the NP implemented a guideline-driven, evidence-based approach to management. Treatment was adjusted from multiple ineffective medications to a single maintenance medication that also decreased the patient's risk for dependence. At a follow up appointment, the patient reports a decrease in depression symptoms with concurrent improvement in her well-being and quality of life. She is now eager to return to her volunteer position at her church.

In this scenario, the NP uncovered chronically uncontrolled symptoms of depression despite multiple drug trials and recognized the risk of use of controlled substances in an older adult. The NP sought pharmacogenomic testing to improve management and reduce polypharmacy. On the return of test results, the NP sought all relevant information, including from the CPIC guidelines, to make evidence-based medication changes. This case highlights the NP's awareness of the applicability of pharmacogenomic testing and CPIC guidelines. Moreover, the NP's incorporation of genomic knowledge supported quality and safety in delivering person-centered genomic health care.

Box 1.

Nursing Genomics Resources

ISCC-PEG Nursing FAQ series (https://www.genome.gov/For-Health-Professionals/Provider-Genomics-Education-Resources/nursing-genomics-faq)
ISCC-PEG Direct to Consumer Genetic Testing (DTC-GT) FAQ (https://www.genome.gov/For-Health-Professionals/Provider-Genomics-Education-Resources/Healthcare-Provider-Direct-to-Consumer-Genetic-Testing-FAQ)
NHGRI GenomeEd (https://www.genome.gov/GenomeEd)
International Society Of Nurses in Genetics (ISONG) (https://isong.org/)
Global Genomics Nursing Alliance (G2NA) (https://www.g2na.org/)
CPIC Guidelines (https://cpicpgx.org/guidelines/)
LInking Nursing Knowledge And GEnomics (LINKAGE) (https://linkage.trubox.ca/)
American Association of Nurse Practitioners (AANP) Continuing Education course on Genetics (https://www.aanp.org/practice/clinical-resources-for-nps/clinical-resources-by-therapeutic-area/genetics)

Oncology

A 41-year-old woman presents for referral for a screening colonoscopy. The patient reports concerns about her recent DTC genetic testing results. Testing detected a variant in *MUTYH*, which has been associated with increased a risk for hereditary colorectal cancer. The patient reports no family history of colon polyps or colon cancer in parents, grandparents, siblings, or aunts and uncles. The DTC genetic test results show that the patient is a carrier of the variant in *MUTYH*, with one of the two gene copies affected. Using the National Comprehensive Cancer Network Guidelines for Genetic/Familial High-Risk Assessment: Colorectal, the provider notes that the patient should be managed per the general population screening guidelines (NCCN, 2023). The NP educates the patient and reassures her that she does not have an increased risk for colon cancer and should start screening colonoscopies at age 45 years.

Conclusions

Since the initial sequencing of the human genome in 2003, tremendous advances in knowledge of genomics have shifted its implementation from specialty clinics to primary care. The integration of genomics into clinical practice is crucial for advancing precision health care, in which nursing plays a critical role. Genomic nursing competencies for NPs will help fulfill the promise of genomics for improving outcomes and health of individuals, families, and communities. Genomics should inform critical thinking in all aspects of clinical care from assessment to management, evidence-based patient education, and advocacy. Links between *The Essentials* (AACN, 2021) and *The Genomic Competencies* (ANA, 2023) are intended to serve as a key resource for nurse educators and clinical

Appendix A. *The Essentials* domains, number of competencies and sub-competencies for Advanced-Level Education, and abbreviated descriptions

Domains (number of competencies; sub-competencies)	Description
Knowledge for Nursing Practice (3;11)	Integration, translation, and application of established and evolving disciplinary nursing knowledge and ways of knowing, as well as knowledge from other disciplines, including a foundation in liberal arts and natural and social sciences
Person-Centered Care (9;32)	Person-centered care focuses on the individual within multiple complicated contexts, including family and/or important others. Person-centered care is holistic, individualized, just, respectful, compassionate, coordinated, evidence-based, and developmentally appropriate. Person-centered care builds on a scientific body of knowledge that guides nursing practice regardless of specialty or functional area
Population Health (6;30)	Population health spans the healthcare delivery continuum from public health prevention to disease management of populations and describes collaborative activities with both traditional and non-traditional partnerships from affected communities, public health, industry, academia, healthcare, local government entities, and others for the improvement of equitable population health outcomes
Scholarship for the Nursing Discipline (3;17)	The generation, synthesis, translation, application, and dissemination of nursing knowledge to improve health and transform healthcare
Quality and Safety (3;15)	Quality and safety, as core values of nursing practice, enhance quality and minimize risk of harm to

(*continued*)

Appendix A. *The Essentials* domains, number of competencies and sub-competencies for Advanced-Level Education, and abbreviated descriptions, *continued*

Domains (number of competencies; sub-competencies)	Description
	patients and providers through both system effectiveness and individual performance
Interprofessional Partnerships (4;16)	Intentional collaboration across professions and with care team members, patients, families, communities, and other stakeholders to optimize care, enhance the healthcare experience, and strengthen outcomes
Systems-Based Practice (3;14)	Responding to and leading within complex systems of healthcare. Nurses effectively and proactively coordinate resources to provide safe, quality, and equitable care to diverse populations
Informatics and Healthcare Technologies (5;24)	Informatics processes and technologies are used to manage and improve the delivery of safe, high-quality, and efficient healthcare services in accordance with best practice and professional and regulatory standards
Professionalism (6;31)	Formation and cultivation of a sustainable professional identity, including accountability, perspective, collaborative disposition, and comportment, that reflects nursing's characteristics and values
Personal, Professional, and Leadership Development (3; 14)	Participation in activities and self-reflection that foster personal health, resilience, and well-being, contributes to lifelong learning, and supports the acquisition of nursing expertise and the assertion of leadership

Appendix B. Connecting *The Essentials, The Genomic Competencies*, and case examples

The Essentials: domains & sub-competencies	Performance indicator examples (*Genomic Competencies* in clinical vignettes)
Genomic Competency 1: Nursing assessment: Applying/ integrating genomic knowledge	
Domain 1: Knowledge for Nursing Practice • 1.2g: Apply a systematic defendable approach to nursing practice decisions • 1.3d: Integrate foundational and advanced specialty knowledge into clinical reasoning Domain 2: Person-Centered Care • 2.3h: Demonstrate that one's practice is informed by a comprehensive assessment appropriate to the functional area of advanced nursing practice	• Collect a client's personal and three-generation family health history to assess for genomic factors that impact the client's health. • Identify potentially significant information from the family health history. • Incorporate genomic health assessment data into routinely collected biopsychosocial and environmental assessments of health and illness parameters in the client, using culturally sensitive approaches. (Demonstrated in Vignettes 1 & 3)
Genomic Competency 2: Identification	
Domain 1: Knowledge for Nursing Practice • 1.3c: Synthesize current and emerging evidence to influence practice Domain 2: Person-Centered Care • 2.4f: Employ context driven, advanced reasoning to the diagnostic and decision making process • 2.4g: Integrate advanced scientific knowledge to guide decision making	• Describe the genomic factors that contribute to the variability of responses to pharmacologic agents. • Identify factors in the family health history that contribute to disease susceptibility, disease characteristics, treatment, and prognosis, or genomic condition. • Identify a client who may benefit from further evaluation of the identified disease susceptibility or genomic condition. (Demonstrated in Vignettes 1, 2 &3)
Genomic Competency 3: Referral activities	
Domain 2: Person-Centered Care • 2.9h: Guide the coordination of care across health systems Domain 6: Interprofessional Partnerships	• Identify a client who might benefit from referral to genetic specialists or information resources. • Facilitate appropriate referral to genetic specialists,

(*continued*)

Appendix B. Connecting *The Essentials, The Genomic Competencies*, and case examples, *continued*

The Essentials: domains & sub-competencies	Performance indicator examples (*Genomic Competencies* in clinical vignettes)
• 6.1k: Provide expert consultation for other members of the healthcare team in one's area of practice	accurately documenting and communicating relevant history and clinical data. • Develop a list of contacts for genomic referral resources within a client's community or respective healthcare setting. (Demonstrated in Vignettes 1 & 3)
Genomic Competency 4: Provision of education, care, & support	
Domain 1: Knowledge for Nursing Practice • 1.1e: Translate evidence from nursing as well as other sciences into practice Domain 2: Person-Centered Care • 2.2i: Apply individualized information, such as genetic/genomic, pharmacogenetic and environmental exposure information in the delivery of personalized healthcare • 2.2j: Facilitate difficult conversations and disclosure of sensitive information • 2.5i: Prioritize risk mitigation strategies to reduce adverse outcomes • 2.5j: Develop evidence-based interventions to improve outcomes & safety Domain 5: Quality & Safety • Design evidence-based interventions to mitigate risk	• Evaluate sources of evidence and clinical practice guidelines for a client whose care involves genomic healthcare. • Develop an interprofessional plan of care in collaboration with the client that incorporates genomics. • Use genomic indicators as rationale for a client who may benefit from further evaluation or other risk management interventions. • Develop a plan for follow-up of a client post-genomic referral. • Demonstrate the use of genomic technology and client data for clinical decision-making in providing safe client care. • Administer medications safely with consideration of pharmacogenomic test results if available. • Monitor the client's response to genomic-based interventions. (Demonstrated in Vignettes 1, 2 & 3)

preceptors as they embed genomics into NP education and practice to meet the burgeoning demand for precision health care. Resources are provided to improve genetic literacy among NP students, educators, and practicing clinicians and support implementation of genomics into advanced nursing practice.

Acknowledgments: *All authors are members of the NHGRI's ISCC-PEG's Nursing Genomics Project Group. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health, U.S. Department of Health and Human Services, or the authors' affiliated institutions.*

Authors' contributions: *T. Walker and A.L. Ersig, cochairs of the Inter-Society Coordinating Committee for Practitioner Education in Genomics (ISCC-PEG) Nursing Genomics Project group, identified members who made major contributions to the development and writing of the manuscript and scheduled regular meetings for manuscript development. Furthermore, T. Walker and A.L. Ersig drafted a significant amount of content, made comprehensive revisions that were shared with other authors, formatted the manuscript, and completed all activities related to manuscript preparation and submission. A.A. Dwyer developed the first working draft, including figures and tables, and helped revise the manuscript, including input for case study development. R. Kronk identified key terms for the manuscript, provided insight and expertise on the manuscript topic, provided case study content, and contributed revisions to the initial draft. C.T. Snyder helped write and revise the Introduction and Current State sections of the manuscript, contributed case study ideas, and revised case study content. K. Whitt mapped the guiding competencies, created additional tables, and helped revise the manuscript. V. Willis helped draft the Introduction and Current state sections, provided supporting literature, helped edit the manuscript, and ensured that manuscript content was consistent with current knowledge and practice.*

Competing interests: *The authors report no conflicts of interest.*

References

Aleman, K. M., Chipman, M., Peck, J. L., Hughes, A. K., & Murphey, C. (2021). Direct to consumer genetic and genomic testing with associated implications for advanced nursing practice. *Journal of the American Association of Nurse Practitioners*, 34(2), 381–388. https://doi.org/10.1097/JXX.0000000000000624

American Association of Colleges of Nursing. (2021). *The Essentials: Core competencies for professional nursing education*. https://urldefense.com/v3/__https://www.aacnnursing.org/Portals/0/PDFs/Publications/Essentials-2021.pdf__;!!Mak6IKo!IxW_UkcZZq-PY87mPqsoO_jvDiuu0rogWaaUMjlX4NJ_vUBwzHrfLm0yX-Ea2lQaFh2EVvNB9Ih-t_xL7LS-dkgviO$

American Nurses Association. (2023). *Essentials of genomic nursing: Competencies and outcome indicators* (3rd ed.). American Nurses Association.

American Nurses Association. (2017). *Nursing scope of practice*. American Nurses Association. https://www.nursingworld.org/practice-policy/scope-of-practice/

Brown, E. E., Sturm, A. C., Cuchel, M., Braun, L. T., Duell, P. B., Underberg, J. A., Jacobson, T. A., & Hegele, R. A. (2020). Genetic testing in dyslipidemia: A scientific statement from the National Lipid

Association. *Journal of Clinical Lipidology*, 14(4), 398–413. https://doi.org/10.1016/j.jacl.2020.04.011

Calzone, K., & Tonkin, E. (2022). Genomic education and training resources for nursing. In *Genomic medicine skills and competencies* (D. Kumar, Ed., pp. 63–90). Elsevier.

Clinical Pharmacogenetics Implementation Consortium. (2024). *Guidelines—CPIC*. https://cpicpgx.org/guidelines/

Connors, L. M., & Wysocki, K. (2023). Genomics education for advance practice nurses: Staying cutting edge. *Journal of the American Association of Nurse Practitioners*, 35(12), 784–786. https://doi.org/10.1097/JXX.0000000000000958

Dewell, S., Benzies, K., & Ginn, C. (2020). Precision health and nursing: Seeing the familiar in the foreign. *Canadian Journal of Nursing Research*, 52(3), 199–208. https://doi.org/10.1177/0844562120945159

Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents, & National Heart, Lung, and Blood Institute. (2011). Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: Summary report. *Pediatrics*, 128(Suppl 5), S213–S256. https://doi.org/10.1542/peds.2009-2107C

Federal Drug Administration. (2023). *FDA approves first gene therapies to treat patients with sickle cell disease*. https://www.fda.gov/news-events/press-announcements/fda-approves-first-gene-therapies-treat-patients-sickle-cell-disease

Huijgen, R., Kindt, I., Verhoeven, S. B., Sijbrands, E. J., Vissers, M. N., Kastelein, J. J., & Hutten, B. A. (2010). Two years after molecular diagnosis of familial hypercholesterolemia: Majority on cholesterol-lowering treatment but a minority reaches treatment goal. *PLoS One*, 5(2), e9220. https://doi.org/10.1371/journal.pone.0009220

Institute of Medicine. (2011). *The future of nursing: Leading change, advancing health*. National Academies Press. https://doi.org/10.17226/12956

Jenkins, B. D., Fischer, C. G., Polito, C. A., Maiese, D. R., Keehn, A. S., Lyon, M., Edick, M. J., Taylor, M. R., Andersson, H. C., Bodurtha, J. N., Blitzer, M. G., Muenke, M., & Watson, M. S. (2021). The 2019 US medical genetics workforce: A focus on clinical genetics. *Genetics in Medicine*, 23(8), 1458–1464. https://doi.org/10.1038/s41436-021-01162-5

Juarez, P. D., Matthews-Juarez, P., Hood, D. B., Im, W., Levine, R. S., Kilbourne, B. J., Langston, M. A., Al-Hamdan, M. Z., Crosson, W. L., Estes, M. G., Estes, S. M., Agboto, V. K., Robinson, P., Wilson, S., & Lichtveld, M. Y. (2014). The public health exposome: A population-based, exposure science approach to health disparities research. *International Journal of Environmental Research and Public Health*, 11(12), 12866–12895. https://doi.org/10.3390/ijerph111212866

National Comprehensive Cancer Network (NCCN). (2023). *NCCN Guidelines Version 2.2023 genetic/familial high-risk assessment: Colorectal*. https://www.nccn.org/guidelines/guidelines-%09detail?category=2&id=1436

National Human Genome Research Institute (NHGRI). (n.d.-a). *Human genome project*. https://www.genome.gov/human-genome-project

National Human Genome Research Institute (NHGRI). (n.d.-b). *Inter-Society Coordinating Committee for Practitioner Education in Genomics (ISCC-PEG)*. https://www.genome.gov/ISCC-PEG

National Institutes of Health (NIH). (2023). *All of Us Research Program*. https://allofus.nih.gov/about/program-overview

Scheuner, M. T., Myrie, K., Peredo, J., Hoffman-Hogg, L., Lundquist, M., Guerra, S. L., & Ball, D. (2020). Integrating germline genetics into precision oncology practice in the Veterans Health Administration: Challenges and opportunities. *Federal Practitioner*, 37(Suppl 4), S82–S88. https://doi.org/10.12788/fp.0033

Stewart, J., McCallin, T., Martinez, J., Chacko, S., & Yusuf, S. (2020). Hyperlipidemia. *Pediatrics in Review*, 41(8), 393–402. https://doi.org/10.1542/pir.2019-0053

Tantisira, K., & Weiss, S. T. (2023). *Overview of pharmacogenomics*. https://www.uptodate.com/contents/overview-of-pharmacogenomics?csi=4804faa3-f5a5-4584-bf49-4e2165e51ce3%26source=contentShare#H3654040

Thomas, J., Keels, J., Calzone, K. A., Badzek, L., Dewell, S., Patch, C., Tonkin, E. T., & Dwyer, A. A. (2023). Current state of genomics in nursing: A scoping review of healthcare provider oriented (clinical and educational) outcomes (2012–2022). *Genes*, 14(11), 2013. https://doi.org/10.3390/genes14112013

Thompson, A. A., Walters, M. C., Kwiatkowski, J., Rasko, J. E., Ribeil, J.-A., Hongeng, S., Magrin, E., Schiller, G. J., Payen, E., Semeraro, M., Moshous, D., Lefrere, F., Puy, H., Bourget, P., Magnani, A., Caccavelli, L., Diana, J. S., Suarez, F., Monpoux, F.... Cavazzana, M. (2018). Gene therapy in patients with transfusion-dependent β-thalassemia. *The New England Journal of Medicine*, 378(16), 1479–1493. https://doi.org/10.1056/NEJMoa1705342

Tonkin, E., Calzone, K. A., Badzek, L., Benjamin, C., Middleton, A., Patch, C., & Kirk, M. (2020). A roadmap for global acceleration of genomics integration across nursing. *Journal of Nursing Scholarship*, 52(3), 329–338. https://doi.org/10.1111/jnu.12552

Up To Date. (2023). *Up to date*. https://www.wolterskluwer.com/en/solutions/uptodate

Veitinger, J. K., Kerber, A. S., Gabram-Mendola, S. G., Liu, Y., Durham, L. M., Durrence, D., Berzen, A. K., Shin, J. Y., Snyder, C., Bellcross, C. A., & Guan, Y. (2022). Screening for individuals at risk for hereditary breast and ovarian cancer: A statewide initiative, Georgia, 2012–2020. *American Journal of Public Health*, 112(9), 1249–1252. https://doi.org/10.2105/AJPH.2022.306932

Wysocki, K., & Osier, N. (2019). Direct to consumer versus clinical genetic testing. *Journal of the American Association of Nurse Practitioners*, 31(3), 152–155. https://doi.org/10.1097/JXX.0000000000000211

For more than 500 additional continuing education activities related to Advanced Practice Nursing topics, go to NursingCenter.com/CE.