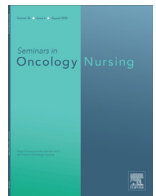




Contents lists available at ScienceDirect

## Seminars in Oncology Nursing

journal homepage: <https://www.journals.elsevier.com/seminars-in-oncology-nursing>

## Achieving Comprehensive, Patient-Centered Cancer Services: Optimizing the Role of Advanced Practice Nurses at the Core of Precision Health

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## ARTICLE INFO

## Key Words:

Advanced practice nurses  
Precision health  
Oncology  
Symptom science

## ABSTRACT

**Objectives:** The field of oncology has been revolutionized by precision medicine, driven by advancements in molecular and genomic profiling. High-throughput genomic sequencing and non-invasive diagnostic methods have deepened our understanding of cancer biology, leading to personalized treatment approaches. Precision health expands on precision medicine, emphasizing holistic healthcare, integrating molecular profiling and genomics, physiology, behavioral, and social and environmental factors. Precision health encompasses traditional and emerging data, including electronic health records, patient-generated health data, and artificial intelligence-based health technologies. This article aims to explore the opportunities and challenges faced by advanced practice nurses (APNs) within the precision health paradigm.

**Methods:** We searched for peer-reviewed and professional relevant studies and articles on advanced practice nursing, oncology, precision medicine and precision health, and symptom science.

**Results:** APNs' roles and competencies align with the core principles of precision health, allowing for personalized interventions based on comprehensive patient characteristics. We identified educational needs and policy gaps as limitations faced by APNs in fully embracing precision health.

**Conclusion:** APNs, including nurse practitioners and clinical nurse specialists, are ideally positioned to advance precision health. Nevertheless, it is imperative to overcome a series of barriers to fully leverage APNs' potential in this context.

**Implications for Nursing Practice:** APNs can significantly contribute to precision health through their competencies in predictive, preventive, and health promotion strategies, personalized and collaborative care plans, ethical considerations, and interdisciplinary collaboration. However, there is a need to foster education in genetics and genomics, encourage continuous professional development, and enhance understanding of artificial intelligence-related technologies and digital health. Furthermore, APNs' scope of practice needs to be reflected in policy making and legislation to enable effective contribution of APNs to precision health.

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### Introduction

Propelled by scientific and technological advancements, oncology has transitioned into the era of precision medicine, marking a decisive shift from a generalized to a personalized diagnostic and treatment approach. At the heart of this transformation lie the discoveries in molecular and genomic profiling. Breakthroughs such as high-throughput genomic sequencing and noninvasive diagnostic

techniques, such as liquid biopsies, have enabled a deeper and comprehensive understanding of cancer biology. The identification of specific biomarkers and oncogenic drivers, ultimately led to targeted therapies and new therapeutic approaches that address the precise molecular mechanisms underlying cancer.<sup>1</sup> In addition, the collaborative exchange of knowledge on a global scale has also played a pivotal role in this transformation, as large-scale genomic studies and interdisciplinary molecular tumor boards have pooled expertise across multiple disciplines to optimize patient care.<sup>2</sup>

Precision Medicine is defined as “use of an individual's genetic profile to guide decisions made in regard to the prevention, diagnosis, and treatment of disease.”<sup>3</sup> This personalized approach considers genetics, environment, and lifestyle to tailor medical strategies for

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## Lay Abstract

### What We Investigated and Why

Modern technologies and advances in genetic research have transformed the landscape of cancer care. These breakthroughs in understanding cancer biology have paved the way for personalized treatments known as “precision medicine.” The concept of “precision health” takes this a step further by integrating biological data with other factors affecting a person’s health, such as behavior, social status or environment. We explored how advanced practice nurses (APNs) emerge as key players in precision health.

### How We Did Our Research

We searched for scientific and professional literature on advanced practice nursing, oncology, precision medicine and precision health, and symptom science.

### What We Have Found

APNs, including nurse practitioners and clinical nurse specialists, are uniquely positioned to advance precision health. Their roles and competencies align with the core principles of precision health, APNs can thus help develop personalized interventions based on a comprehensive understanding of each individual. However, fostering APNs’ education in genetics and genomics, encouraging continuous professional development, and enhancing familiarity with AI-related technologies and digital health are crucial needs.

### What It Means

The practice of APNs within precision health must be recognized in policy and legislation to enable their meaningful contribution to this evolving field. Empowering APNs holds the key to advancing precision health and ensuring tailored, effective care for persons affected by the complexities of a cancer disease.

genetic or omic data alongside social, economic, cultural, and environmental factors to guide individuals towards optimal well-being (Fig. 1).<sup>11,12</sup> These factors might not only serve as risk determinants but also hold potential for interventions or modification through lifestyle changes. However, this approach presupposes access to information regarding the individual’s environmental, socio-economic, and living conditions. Yet, this type of data is rarely or not systematically present in health records. Like precision medicine, precision health involves the aggregation and analysis of extensive multidimensional data to generate generalizable knowledge.<sup>9</sup> This type of analysis is essential for comparing individual data with that of large, diverse populations, facilitating the identification of subgroups.<sup>9</sup> Consequently, there is an imperative to explore effective approaches for collecting this type of information and developing risk models that incorporate the growing number of factors influencing disease susceptibility.<sup>10,13</sup>

Nursing stands as the largest and key workforce in healthcare, playing a central role in promoting and optimizing health for individuals, families, communities, and populations. More specifically, advanced practice nurses (APNs), can play a crucial role in advancing and addressing the core elements and fundamental principles inherent to precision health.

The aim of this article is to discuss the opportunities and challenges for optimizing the role APNs can play within the paradigm of precision health. Ways in which APNs can integrate their core competencies within precision health are identified.

## Opportunities for APNs in Precision Health

### *APNs’ Competencies: Integral to Advancing Precision Health*

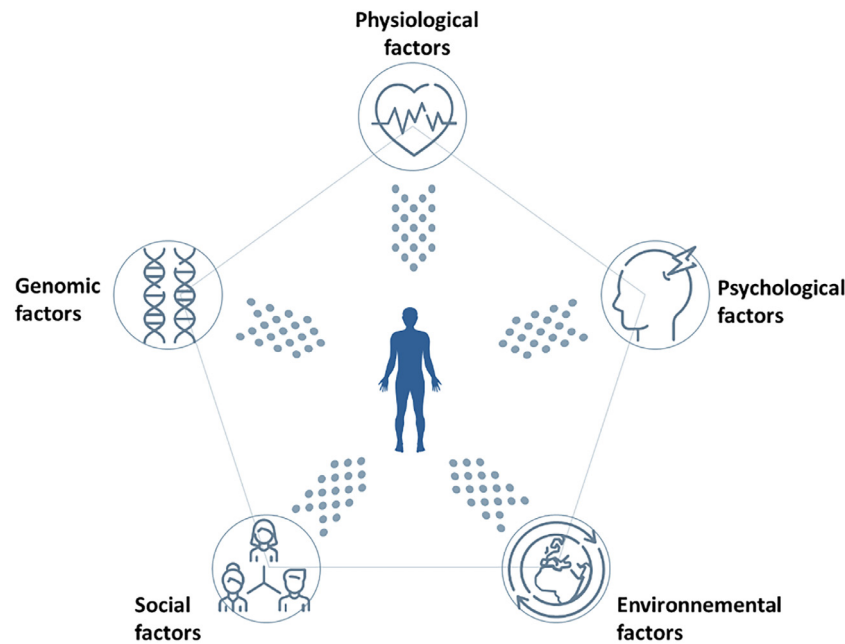
APNs are a diverse group of nurse professionals dedicated to delivering advanced and complex interventions. Based on Hamric’s and Hanson’s conceptual definition, advanced practice nursing is “the patient-focused application of an expanded range of competencies to improve health outcomes for patients and populations in a specialized clinical area of the larger discipline of nursing.”<sup>14</sup> These advanced roles require elevated levels of competency and capability beyond those of generalist nurses. Their practice adheres to defined competencies and standards, influenced by their authorized context and country, with some countries having established APNs roles, while others are still developing or establishing them.<sup>15</sup> APNs are nurses that have completed a master’s degree, and possess a comprehensive knowledge base, and clinical and decision-making competencies necessary for expanded nursing practice.<sup>16</sup> With multifaceted roles and competencies, APNs are uniquely positioned to enhance precision health by comprehensively addressing both common and complex diseases at the individual and population level.<sup>11,17</sup>

APNs conduct holistic evaluations that consider clinical characteristics, biological variability, environmental factors, and social determinants.<sup>9,11,18</sup> *Direct care* of patients and families, groups, communities, or populations, is the central competency of APNs with additional nonclinical responsibilities such as guidance and coaching, evidence-based practice, leadership, collaboration, and ethical practice.<sup>14</sup> While all APNs share the same core criteria and competencies, their clinical skill set varies depending on the population they are directed to. Globally, the nurse practitioner (NP) and the clinical nurse specialist (CNS) are widely recognized as the two primary roles of APNs. The primary distinctions between the NP and CNS lie in their areas of focus and involvement as well as their scope of practice. While the NP is primarily engaged in direct advanced nursing care activities, including diagnosing, prescribing, and treating various conditions or illnesses, the CNS typically has a greater involvement in nonclinical or indirect activities. This involves the development and implementation of nursing knowledge and evidence-based practices that support systems, education, and research.<sup>15,16,19</sup>

improved health outcomes.<sup>4</sup> The goal is to utilize these findings to provide the right treatment, for the right individual, at the right time, minimizing side effects and maximizing outcomes. As a result, patients’ responses and survival rates have seen remarkable improvement.<sup>5</sup>

Building upon the foundation of precision medicine, precision health represents a broader and more patient, family, and population-focused paradigm. The existing literature concerning precision medicine, emphasizes genetics, treatment, and illness prevention, making this concept somewhat restrictive. In recent years, the term “precision health” has progressively replaced “precision medicine,” adopting a more holistic approach. Its scope extends beyond traditional healthcare settings, underscoring the need to move beyond narrow considerations of cures and treatments. Instead, it highlights the importance of disease prevention, health promotion, and comprehensive care, recognizing their universal relevance to all individuals.<sup>6-8</sup> It actively encompasses the management and enhancement of health based on personalized information and timely actions and has the potential to empower individuals to take control of their own disease prevention.<sup>9,10</sup>

The integration of precision health into the evolving healthcare landscape complements the broader transformation driven by the proliferation of information through technology adoption and increased patient data collection. Precision health uses biological,



**Fig. 1.** Influential factors in precision health: genetic, physiological, psychological, environmental, and social determinants.

APNs guide and coach patients and their relatives in navigating the challenges of living with illness and treatments, ensuring the best possible quality of life, and engaging them in shared decision-making based on their education, goals, preferences, and abilities.<sup>20</sup> APNs contribute to the development of nursing knowledge and *evidence-based practice*, providing and translating best current evidence to clinical practice on an individual, unit-, service-, or health system-wide basis.<sup>21</sup> APNs provide *leadership* across multiple areas. In clinical leadership, they ensure the fulfillment of patient and family needs and goals, thereby achieving quality care. Their professional leadership involves occupying positions at the local and national levels to enhance visibility and credibility within the nursing and broader healthcare community. Additionally, they lead at the organizational or delivery system level, contributing to system-wide improvements.<sup>22</sup> Linked with the role of coaching and leadership, is fostering participatory care through active *collaboration with patients and other healthcare professionals* to develop personalized care plans. APNs facilitate cooperation and multidisciplinary approaches among various stakeholders, including researchers, clinicians, patients, and policymakers. Their ability to bridge different disciplines, positions APNs as catalysts for interdisciplinary collaboration, an indispensable element to any healthcare delivery system redesign, whether at the unit, service, organizational, or global level.<sup>23</sup> By assuming leadership roles and engaging in interprofessional collaborative efforts, APNs play a crucial role in addressing challenges and contributing to precision health objectives. This involves leading the coordination of care, delivering timely and appropriate treatments and interventions, developing primary, secondary, and tertiary preventive strategies, and identifying and categorizing individuals at higher risk while implementing interventions to reduce the incidence and severity of health-related outcomes.

With an awareness of the *ethical complexities* inherent in clinical practice, APNs are at the forefront of efforts to foster social justice and shape ethically responsive care environments, reflecting their commitment to both individual patient care and the advancement of ethical standards in healthcare.<sup>24</sup> Ethical considerations and patient advocacy are paramount in precision health, and APNs can ensure responsible and equitable implementation of precision health approaches. They safeguard patient autonomy, confidentiality, and the ethical use of genetic information in

clinical decision-making, maintaining the highest standards of patient care.

Table outlines tasks relevant to CNS and NP in response to the principles of precision health, based on their scope of practice and core competencies. An illustrative case is presented in [Box 1](#).

#### *APNs: Guiding Data From Collection to Integration in Precision Health*

Precision health involves harnessing a variety of data sources encompassing traditional data such as standardized surveys, health services data, electronic health records (EHRs), biological and biomedical results (laboratory tests or omic reports), imaging techniques, and physiological monitoring. In addition to these, there is an emerging integration of data coming directly from the patient. The entirety of these data comprises vast collections commonly known as “big data.” Big data, characterized by its high volume, velocity, and variety, is progressively assuming a pivotal role in the quest for optimal healthcare outcomes.<sup>25</sup>

EHRs hold a wealth of clinical information and can assist in the thoughtful selection and administration of medications, taking into consideration factors like drug interactions and genetic profiles. APNs can play a distinctive role in utilizing EHRs to produce decision support tools and reports, which, in turn, can facilitate the early detection of high-risk patients.<sup>26</sup> This empowers APNs to initiate targeted interventions swiftly for specific patient groups.

Patient-generated health data (PGHD) such as patient-reported outcomes measures (PROMs), wearable technology, and passive monitoring systems play a significant role in precision health.<sup>27</sup> PGHD are health-related data and other information-created, recorded, gathered, or inferred by or from patients or their designees. They encompass a wide array of devices including electronic sensors that facilitate real-time monitoring of human behavior, biology, and environment. These devices can track physical activity, sleep patterns, falls, ambient light levels, body positioning, symptoms, or physiological markers such as glucose levels, respiratory rates, oxygenation, heart rate, or blood pressure, among others.<sup>28</sup> These data provide valuable information that APNs can integrate during their consultations as a basis for patient-oriented discussions on lifestyle modifications, physical activity, or medication adherence, enabling them to develop personalized care plans tailored to each patient's

**Table**  
Examples Illustrating How the Core Competencies of Clinical Nurse Specialists (CNS) and Nurse Practitioners (NP) Relate to the Principles of Precision Health and Patient-Centered Care

Core competencies*	Description
Direct clinical practice	<ul style="list-style-type: none"> <li>• Provides direct patient care, including comprehensive clinical assessment, and management considering not only the disease and its predisposing factors but also the patient's overall health status, comorbidities, psycho-social and environmental factors, recognizing that patients may have varying responses to treatment due to these individual differences (CNS/NP).</li> <li>• Assists in interpreting genomic/molecular testing results (NP).</li> <li>• In collaboration with oncologists, utilizes genetic/molecular profiling to guide diagnosis and treatment decisions (NP).</li> <li>• Identifies scenarios where preemptive testing (pharmacogenomics) holds relevance, contributing to decision-making processes (NP).</li> <li>• Contributes to the development of personalized intervention plans by collaborating with oncologists and other healthcare professionals (CNS/NP).</li> <li>• Identifies patients (individuals or groups) at risk/stratifies based on characteristics (CNS/NP).</li> <li>• Improves patient outcomes by delivering tailored care interventions (CNS/NP) and treatments (NP) that align with patients' supportive care needs.</li> </ul>
Guidance and coaching	<ul style="list-style-type: none"> <li>• Ensures that patients have a clear understanding of their diagnosis, treatment plan, and potential benefits and risks of precision health interventions (CNS/NP).</li> <li>• Provides education and self-management support as prevention to reduce risks: Public education, Behaviors/lifestyle changes (CNS/NP).</li> <li>• Informs, educates, and provides tailored and targeted self-management interventions to patients and families on precision oncology concepts, genetic testing, and personalized treatment options (CNS/NP).</li> <li>• Addresses the growing patient demand for online genetic tests, actively preventing potential scams from unreliable laboratories through targeted education and empowerment initiatives (CNS/NP).</li> </ul>
Evidence-based practice	<ul style="list-style-type: none"> <li>• Integrates research findings into clinical practice to promote evidence-based interventions and best practices in precision health (CNS/NP).</li> <li>• Keeps self-management materials and guidelines up to date (genetic/genomic tests, treatments, side effects, symptom management resources, etc.) (CNS/NP).</li> <li>• Proposes a strategy for the routine collection of a minimum set of clinical/biological data and precision health sensitive patient-reported outcome measures to foster nursing and symptom science research (CNS/NP).</li> <li>• Emphasizes value-based care, focusing on delivering the most effective and efficient precision health interventions to optimize patient outcomes and experiences and optimize healthcare resource utilization (CNS/NP).</li> </ul>
Leadership	<ul style="list-style-type: none"> <li>• Assumes precision health leadership roles in interdisciplinary and interprofessional teams and organizations (CNS/NP).</li> <li>• Provides expert advice and guidance to healthcare teams and colleagues (CNS).</li> <li>• Drives change by promoting and advocating for the adoption and integration of precision health principles in oncology clinical practice (CNS/NP).</li> <li>• Advocates for adequate resources to design and equip structure and process for successful implementation of precision health approaches (CNS).</li> <li>• Leads quality improvement initiatives, implement practice guidelines, and influence policy development to enhance precision health outcomes (CNS).</li> </ul>
Collaboration	<ul style="list-style-type: none"> <li>• Collaborates within an interprofessional and interdisciplinary team to uphold the principles of precision health integrating nursing knowledge in all aspect of precision health (CNS/NP).</li> <li>• Facilitates coordination among all specialties involved in precision health in oncology, assuming a key role in the process (CNS/NP).</li> </ul>
Ethical practice	<ul style="list-style-type: none"> <li>• Serves as a first contact counselor on risks and benefits of genetic testing (CNS/NP).</li> <li>• Ethical Decision-Making skills in counseling patients on the use of genetic data (CNS/NP).</li> <li>• Assures informed consent (CNS/NP).</li> </ul>

\* Based on Hamric's and Hanson's advanced practice nursing, 7<sup>th</sup> edition.<sup>14</sup>

unique experience, needs and circumstances. However, integration of PGHD into electronic records is still very limited.<sup>29</sup> APNs can play a leading role in defining the nature, collection, and utilization of PGHD, establishing a minimum data set to improve cancer care.

Furthermore, computational techniques have expanded the horizons for leveraging multifaceted data to impact patient care.<sup>30</sup> The adoption of artificial intelligence-based health technologies (AIHT) holds the promise of enhancing and refining healthcare practices. AIHT can enhance diagnostic accuracy, ensure consistency, and expedite the assessment of risk, as well as the interpretation of clinical data for prevention, surveillance, follow-up, and referral tasks. For instance, the use of natural language processing in clinician notes, along with machine learning prediction techniques, has proven valuable for predicting adverse outcomes and identifying comorbidities.<sup>31,32</sup> Notably, this impact extends to the implementation of clinical decision support algorithms (CDSAs), which enhance patient care through data-driven insights and can guide clinical decision-making and streamline patient evaluation processes, ultimately aiming to boost efficiency, reduce healthcare costs, and optimize patient flow.<sup>33</sup> CDSAs are designed to analyze patient data and provide recommendations or alerts to assist clinicians to provide objective and scientifically grounded information that serves as a foundation for the decisions regarding diagnosis, treatment, and other aspects of healthcare.<sup>34</sup> The development of algorithms will enable the identification of patients who possess disease risk factors (based on laboratory results) or those in need of recommended screenings guided by factors like age and family history, or aiding in the selection and administration of medications by taking into account the genetic profile of the patient (pharmacogenomics) or drug interactions.<sup>35</sup>

Currently, there are numerous artificial intelligence applications, including speech recognition, data mining, and the prediction of physical deterioration.<sup>36</sup> APNs are poised to lead the evolution of artificial intelligence in nursing due to their unique position as both potential users of AIHT and experts in professional care.<sup>37</sup> APNs share a collective responsibility to influence decisions pertaining to the incorporation of artificial intelligence into the healthcare system, ensuring that this transformation occurs in an ethical manner that aligns with fundamental nursing values.<sup>38</sup> These values include the access to care and equity. In the era of digitalization and artificial intelligence, digital literacy is a prerequisite that nurses have to promote in all patients, but in particular for vulnerable populations.

#### *Precision Health and Symptom Science: Empowering APNs in Research and Clinics*

The fields of symptom science and precision health are integral components of a broader effort aimed at enhancing our understanding of diagnosing, treating, managing, and preventing patients' symptoms.<sup>39</sup> Symptom science, in particular, involves the study of symptoms at the molecular, physiological, and psychosocial levels as well as their occurrence, prediction, and management.<sup>40</sup> Over the last years, nursing has claimed symptom science as fundamental to its discipline and practice.<sup>40</sup>

The recently revised National Institutes of Health Symptom Science model (NIH-SSM) 2.0<sup>39</sup> provides a framework that aligns with precision health and the competencies of APNs, particularly emphasizing holistic nursing practice in caring for patients, families,

**Box 1. An Illustrative Case: NP and CNS Roles in Precision Health**

The rapidly evolving landscape of lung cancer demands a responsive and dynamic approach to patient care. With the emergence of new diagnostic and treatment approaches that require a comprehension of genomic profiles and molecular markers, the role of APNs becomes increasingly crucial. As clinical experts, APNs translate complex information for patients, support nursing staff education, and ensure smooth communication and collaboration among healthcare providers. The integration of evidence-based practices becomes essential, guiding nursing staff in delivering the most up-to-date and effective care based on current research and clinical guidelines. The case underlines the core principles of precision health with the competencies of APNs in orchestrating care strategies that align with the unique profile of the patient (Fig. 3).

Mrs. X, a 75-year-old nonsmoker with a history of chronic lower back pain and hypertension, was diagnosed 2 years ago with stage IVA adenocarcinoma of the right upper lobe of the lung. The cancer presented as cT4 (with ipsilateral nodules), cN2 (ipsilateral mediastinal lymph nodes), and cM1a (pleural metastases). Genetic testing revealed an activating mutation in exon 21 (p.L858R) of the EGFR gene.

She had been receiving treatment with erlotinib and bevacizumab for the past 2 years, but the disease has progressed, leading to the enlargement of mediastinal and hilar lymph nodes, as well as pleural nodules and lung metastases. A bronchoscopic biopsy was performed, revealing two alterations: the known mutation (p.L858R) and a new mutation (p.T790M) in exon 20 of the EGFR gene. The case was discussed at the tumor board and the decision involved a change towards Osimertinib, an oral targeted therapy, to bypass the T790M resistance mutation, pending insurance approval.

Mrs. X was experiencing Grade 1 fatigue, a recent loss of appetite, resulting in a 2kg weight loss, and had a BMI of 18. Her overall condition was rated as ECOG 1.

Mrs. X lives alone in a third-floor apartment without an elevator. Climbing the stairs, especially while carrying essentials, is challenging and leaves her breathless. With her sister 2 hours away and her brother in another country, Mrs. X manages daily life independently. She relies on friends for support, but it's her neighbor, Mrs. Y (60-year-old) who provide crucial and immediate assistance in navigating the daily life challenges she faces.

The nurse practitioner (NP) delivered the news of disease progression and conducted a comprehensive medical history and clinical examination. The NP coordinated the treatment plan, providing patient education, prescribing supportive medications, and scheduling regular follow-ups. Physiotherapy and dietitian consultations were prescribed to prevent weight and muscle loss.

Mrs. X expressed concerns about potential resistance to osimertinib in the future and the fear of a rapid decline in her health status. She explicitly communicated her wish to preserve her autonomy for as long as possible.

The clinical nurse specialist (CNS) extended the discussion to systematically assess the psychological impact, using the distress thermometer and problems list as a screening approach.

During the first month of osimertinib treatment, the CNS supported therapeutic education and adherence and symptom management through regular phone consultations with Mrs. X and her neighbor. These phone consultations were also utilized for monitoring side effects including symptoms, functional and psychological domains, specific needs and self-management abilities. The outcomes were systematically reported into the patient's electronic health record. This approach facilitated systematic and longitudinal monitoring to identify changes.

The CNS played a pivotal role in coordinating essential services and ensuring consistent information dissemination. Mrs. X remained independent in her daily activities and had established effective communication with the local health centers.

A 3-month radiological evaluation showed a partial response to the disease, and Mrs. X tolerated the treatment well.

The CNS identified a lack of patient education materials tailored for oral chemotherapy agents. Additionally, the information disseminated by colleagues lacked consistency and standardization on covering crucial aspects such as drug administration schedules, safety precautions, storage guidelines, potential side effects, and symptom management. Recognizing the need for standardized education, the CNS explored available guidelines and tools to assess the teaching requirements for oral agents. As a result, an oral teaching tool was introduced within the department, accompanied by training sessions for nurses to enhance their proficiency in educating patients about oral chemotherapy.

communities, and populations. This emphasis extends not only to treatment but also to prevention. The NIH-SSM 2.0 starts by acknowledging a complex symptom or cluster of symptoms. These can be more precisely classified based on phenotype using both biological and clinical data. The symptom phenotype can be influenced by genotype and environmental factors including the individual's social determinants of health (SDOH) and illness experience. Through the application of omics methods, physiological, and other laboratory data, biomarkers or targets can be delineated for the detection and monitoring of physical and behavioral symptoms. Clinical application relies on this knowledge for the development of personalized prevention approaches and targeted treatments. However, to accomplish its clinical translation and help inform broader applications of symptom science, policy and population health levers are required.

An essential contribution of advanced practice nursing to precision health lies in its emphasis on preventing and alleviating symptoms.<sup>27,41</sup> APNs play a pivotal role in recognizing and describing symptoms while tailoring strategies to ease their burden promote patients' self-management.<sup>27,42</sup> Through their expertise and the integration of current evidence-based approaches rooted in symptom science, APNs can incorporate this knowledge into their practice by:

Identification of Symptoms

Identify, evaluate, assess, and document symptoms experienced by patients using standardized and validated measurement tools, obtaining detailed patient histories, and conducting physical examinations, to gather comprehensive information about the nature, severity, and impact of symptoms on patients' lives. APNs can establish a minimum data set in routine data collection for both clinical practice and symptom research (eg, biomarkers, clinical data, PROMs).

Personalized Symptom Management Strategies and Evidence-Based Interventions

APNs develop tailored interventions to individual patients considering factors such as patients' genetic/genomic variability, SDOH, preferences, goals, and unique symptom experiences. These may include pharmacological interventions, nonpharmacological approaches (eg, behavioral strategies, complementary therapies), and patient symptom self-management support. APNs closely monitor treatment responses, adjust interventions as needed, and empower patients to actively participate in their symptom management.

**Understanding Symptom Patterns**

Management decisions can be guided by understanding the mechanisms underlying common symptoms, recognizing common patterns and associations among diverse symptoms, and identifying and effectively managing clusters of co-occurring symptoms.<sup>43</sup> By recognizing and addressing the full spectrum of symptoms that patients may encounter, APNs can facilitate the delivery of more precise and individualized evidence-based interventions and treatment approaches.

**Collaborative Approach**

Symptom science encompasses multidisciplinary research, incorporating aspects of physiology, psychology, sociology, and healthcare delivery. By working together with nurses, physicians, researchers, and other specialists, these professionals can contribute their expertise and perspectives to develop comprehensive approaches for symptom management and enhance patient care.

**An Integrative Model for APNs in Precision Health**

Fig. 2 illustrates a comprehensive illustration of precision health for advanced practice nursing, integrating individual health factors (genetic, physiological, psychological/behavioral, social, environmental) and the social ecological model. This ecological perspective acknowledges that individuals exist within broader social systems and elucidate the interactive dynamics between individuals and their environments, which contribute to health outcomes.<sup>44</sup> It depicts the individual's unique beliefs and knowledge embedded into the microsystem, representing direct interactions with family and peers. It also connects with the mesosystem, encompassing societal and organizational structures. The exosystem delves into cultural elements, while the macrosystem includes laws and policies related to health. The chronosystem overlays a temporal dimension, acknowledging the impact of changes over a lifetime and historical events on an individual's health journey. In this systemic approach, APNs navigate a spectrum of competencies to deliver holistic and patient-centered care. The NP role in precision health involves the identification of individuals through molecular profiling, demographic considerations, clinical history and evaluation, and PGHD, such as patient-reported outcomes

or data derived from wearables. Harnessing the power of big data and machine learning, clinical decision support systems enable personalized patient categorization and facilitate the NP to tailor treatment strategies. Drawing on similar factors across the different ecological and healthcare levels (from individuals/populations to healthcare system), the CNS will identify and implement evidence-based interventions that address the unique needs of diverse patient groups.

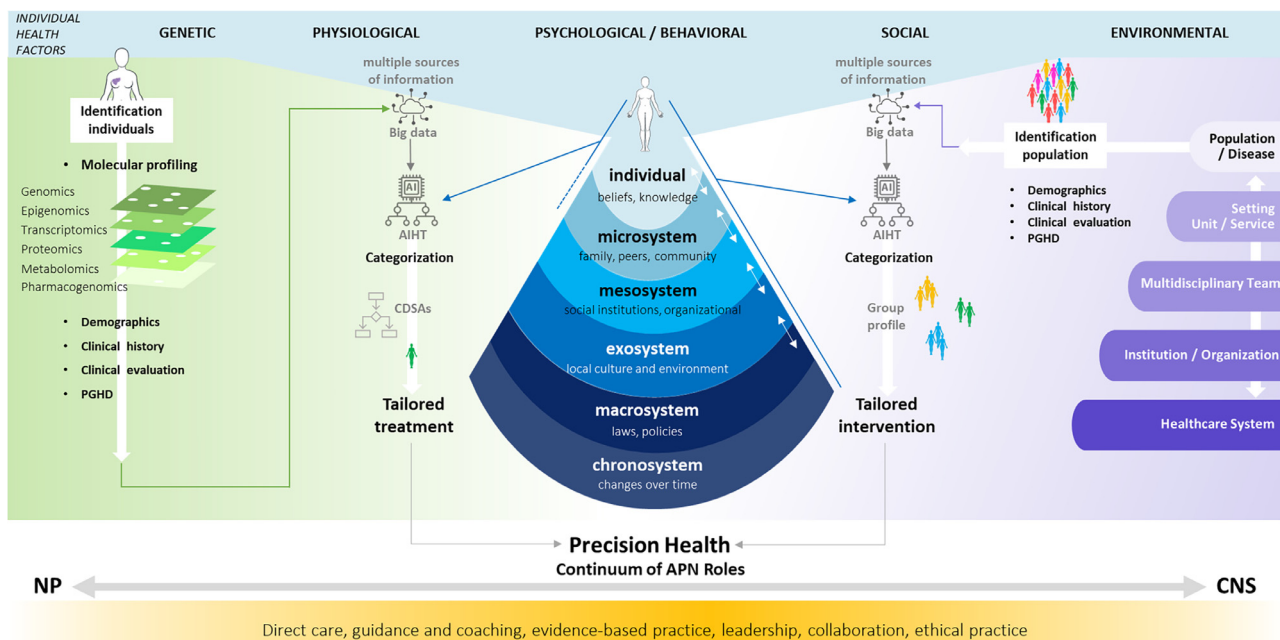
**Challenges Faced by APNs in Precision Health**

*Need for Policies Supporting APNs Roles and Interprofessional Collaboration*

Achieving optimal patient outcomes relies on continuous collaboration among nurses, physicians, data scientists, and other healthcare professionals. To facilitate this collaboration, there is a critical need for well-defined policies that support teamwork. These policies should not only acknowledge the distinct contributions of each professional group but also establish clear pathways for interdisciplinary collaboration. By breaking down traditional silos, such policies can pave the way for a unified approach to patient care, where insights from diverse perspectives synergize for improved health outcomes. Enabling factors include development of appropriate legislative and regulatory mechanisms at regional or national level, and the provision of high-quality education.<sup>45</sup>

*Need for Adequate Resources and Infrastructure*

While collaboration and education are foundational, their success is contingent upon the availability of adequate resources and infrastructure. Precision health in advanced nursing practice necessitates sophisticated tools, technologies, and supportive environments.<sup>46</sup> Investments in cutting-edge technologies for data collection and analytics, secure information-sharing platforms, and continuous professional development opportunities are essential.<sup>47</sup> Furthermore, healthcare institutions must ensure that APNs have access to continuous training to stay updated on advancements.



**Fig. 2.** The role of advanced practice nurses (nurse practitioners and clinical nurse specialists) at the core of precision health. PGHD, patient-generated health data (eg, patient-reported outcome measures, wearables); AIHT, artificial intelligence-based health technologies; CDSAs, clinical decision support algorithms.

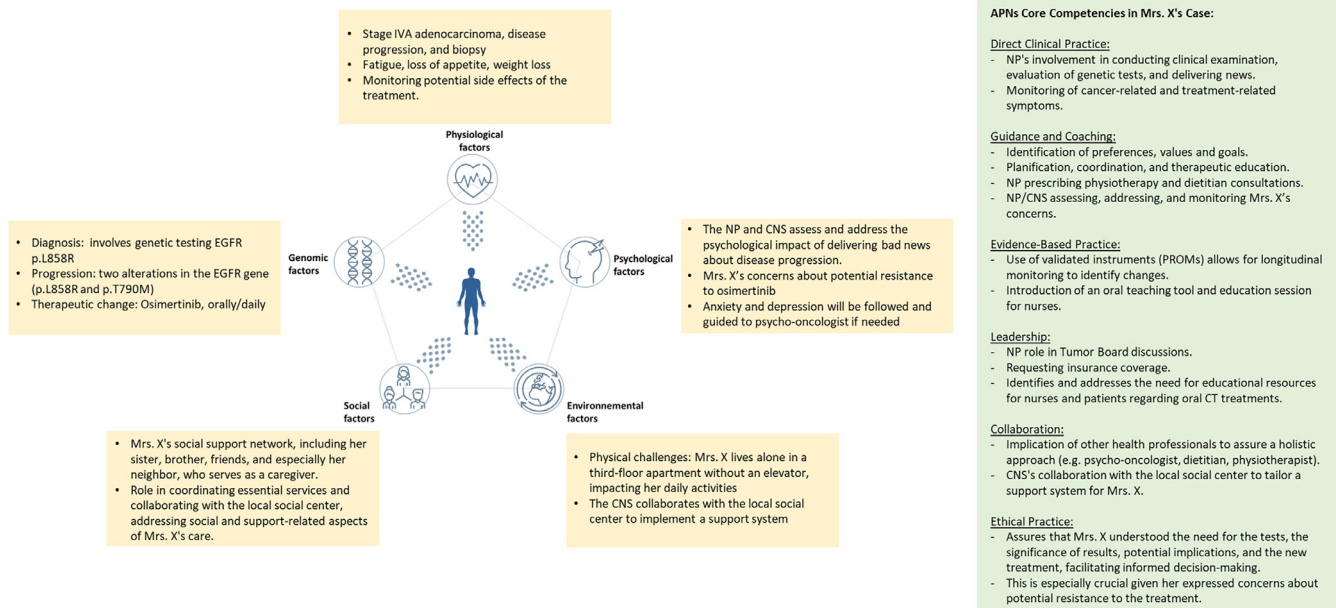


Fig. 3. Illustration of Mrs. X's case based on the core principles of precision health and APNs' competencies.

### Need of Curriculum Adjustments

Realizing the potential of nurses in the precision health landscape requires a proactive approach to education. Tailoring curricula to the demands of the evolving healthcare system paradigm can play a transformative role in preparing nurses for the opportunities and challenges. This includes integrating modules that emphasize interdisciplinary communication, omics integration, data interpretation, and technological proficiency.<sup>48</sup>

The rapidly evolving landscape in oncology presents ongoing challenges for APNs. With increased public knowledge, oncology APNs must be prepared to engage in meaningful discussions with patients about genetic testing, personalized treatment options, and potential hereditary factors in cancer risk.<sup>49</sup> As clinical experts and leaders in healthcare, APNs play a decisive role in advancing genomics practice. Their specialized knowledge bridges the gap between precision medicine and precision health, ensuring that the latest advancements in genetics and genomics are effectively integrated into clinical practice.<sup>50</sup> APNs need to be equipped with the skills to effectively communicate complex genomic information in a patient-centered manner. It is imperative that APNs stay updated with the latest advancements in the field to ensure that patients are well-informed, empowered to make informed decisions, and supported throughout their cancer journey.<sup>51</sup>

One of the most significant challenges in this effort is the lack of comprehensive genetics and genomics education tailored to the specific needs of APNs.<sup>35,52</sup> While they may have acquired basic knowledge from general nursing education, a firm grasp of genetics and genomics is required to understand the ethical and legal implications of genetic testing, mechanisms of action at molecular and cellular levels, and the side effects of various treatments (eg, targeted therapies, immunotherapy, biotherapy, cellular products). Understanding gene-environment interactions, medication-genome relationships, and the impact of genetic variations on disease development and treatment response is essential for oncology APNs navigating the model of precision health.<sup>11,25,53,54</sup>

Furthermore, the utilization of clinical tools and technology is crucial for APNs in categorizing patients into meaningful subgroups to tailor interventions effectively. The capacity to categorize patients is crucial for extrapolating targeted interventions from individuals to a

broader patient population based on similarity, for instance patients at higher risk or with poor prognosis.<sup>55</sup>

Technologies offer a multitude of advantages, from aiding clinical decision support and disease management to enhancing patient engagement and operational efficiency. However, this paradigm shift toward artificial intelligence in healthcare necessitates a significant transformation in the skills and knowledge of healthcare staff.<sup>56</sup> To effectively harness the potential of artificial intelligence, APNs must acquire a foundational understanding of AIHT and their applications in patient care.<sup>57</sup> Furthermore, they should actively engage in all stages of artificial intelligence development and implementation, thus contributing to the global advancement of healthcare through technology.<sup>33</sup> The imperative to integrate basic artificial intelligence knowledge into nursing education and promote the involvement of nurses throughout the technology research and development process is paramount for fostering innovation and ensuring that the vast potential of artificial intelligence in healthcare is fully realized.<sup>58</sup>

### Implications

#### The Role of APNs in Precision Health

APNs play a crucial role in precision health as their roles and competencies align with its core principles. APNs are essential in implementing and advancing precision health by personalizing interventions and treatments based on various patient characteristics, including individual molecular profiling, clinical data, lifestyle, environment, and social determinants.

#### Precision Health, Patient-Centered Care and Tailored Interventions

APNs can effectively utilize precision health principles to identify individuals or groups at higher risk and provide timely interventions and tailored treatment plans. APNs collaborate closely with patients and their relatives to develop personalized care plans, engaging in shared decision-making and considering patients' preferences, values, and goals. NP and CNS have distinct, complementary, and synergistic roles in the context of precision health and represent a

continuum in the development from tailored individual treatments and care plans to population-based interventions.

#### *Data Integration and Technology Challenges in Precision Health*

APNs contribute to data integration in precision health by analyzing diverse data sources, identifying patterns, trends, and individual variations to inform personalized healthcare decisions. APNs can lead in defining a minimum data-set to be collected, the nature of this data, and its integration into EHRs for daily practice and research. However, the challenge remains in developing information technology systems that have the capacity to integrate and analyze big data for healthcare providers and patients through automated data visualization or algorithm development. APNs should help to shape the future of AIHT in the healthcare system as users and care experts.

#### *Policy Transformation to Foster Precision Health*

The scope of practice for APNs is sensitive to the country's context and healthcare settings in which they operate. To fully harness their potential, healthcare policies need to facilitate the seamless integration of APNs into the precision health paradigm. Comprehensive reforms in regulation, funding, education, and healthcare policies are necessary to empower APNs, enabling them to play a pivotal role in taking part of and leading interprofessional teams and fostering precision health, especially in areas with a rapid development like cancer care.

#### **Conclusion**

With their advanced education, comprehensive knowledge base, and specialized competencies, APNs are well-positioned to take a lead position in establishing the principles of precision health. Precision health offers a framework wherein APNs can fully leverage their potential as change agents in healthcare systems. APNs will find their scope of practice in disease prediction, prevention, treatment and management as well as in health promotion activities. By considering each individual or population within the broader context of their genetic, clinical, behavioral, social and environmental influences, APNs can deliver tailored and holistic care. Through multiple data sources screening, APNs identify high-risk individuals or populations, implement preventive strategies, tailor interventions and treatments, collaborate with patients in shared decision-making. However, there is an urgent need for additional training and resources to ensure that APNs are equipped to integrate these concepts into their practice effectively. To overcome this challenge, policies defining and supporting the role of APNs, adjusted curricula, continuous professional development and access to up-to-date resources are essential to ensure high-quality oncology nursing care.

#### **Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### **CRedit authorship contribution statement**

**Sara Colomer-Lahiguera:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Conceptualization. **Jenny Gentizon:** Writing – review & editing, Writing – original draft, Conceptualization. **Melissa Christofis:** Writing – review & editing, Writing – original draft, Conceptualization. **Célia Darnac:** Writing – original draft, Conceptualization. **Andrea Serena:** Writing – original draft, Conceptualization. **Manuela Eicher:** Writing – review & editing, Writing – original draft, Conceptualization.

#### **Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

#### **References**

- Hanahan D. Hallmarks of cancer: new dimensions. *Cancer Discov.* 2022;12(1):31–46. <https://doi.org/10.1158/2159-8290.Cd-21-1059>.
- Rao S, Pitel B, Wagner AH, et al. Collaborative, multidisciplinary evaluation of cancer variants through virtual molecular tumor boards informs local clinical practices. *JCO Clin Cancer Inform.* 2020;4:602–613. <https://doi.org/10.1200/CCI.19.00169>.
- National Human Genome Research Institute. Personalized Medicine. 2023. <https://www.genome.gov/genetics-glossary/Personalized-Medicine>. Accessed 28 August 2023.
- Schleiden S, Klingler C, Bertram T, Rogowski WH, Marckmann G. What is personalized medicine: sharpening a vague term based on a systematic literature review. *BMC Med Ethics.* 2013;14(1):55. <https://doi.org/10.1186/1472-6939-14-55>.
- Lassen UN, Makaroff LE, Stenzinger A, et al. Precision oncology: a clinical and patient perspective. *Future Oncol.* 2021;17(30):3995–4009. <https://doi.org/10.2217/fo-2021-0688>.
- Khoury MJ, Iademaro MF, Riley WT. Precision public health for the era of precision medicine. *Am J Prev Med.* 2016;50(3):398–401. <https://doi.org/10.1016/j.amepre.2015.08.031>.
- Minor L. We Don't just need precision medicine, we need precision health. *Forbes.* 2016. <https://www.forbes.com/sites/valleyvoices/2016/01/06/we-dont-just-need-precision-medicine-we-need-precision-health/?sh=3925022a6a92> Accessed 19 August 2023.
- Centers for Disease Control and Prevention. Precision health: improving health for each of us and all of us. Accessed 4 December 2023. [https://www.cdc.gov/genomics/about/precision\\_med.htm](https://www.cdc.gov/genomics/about/precision_med.htm).
- Khoury MJ, Evans JP. A public health perspective on a national precision medicine cohort: balancing long-term knowledge generation with early health benefit. *JAMA.* 2015;313(21):2117–2118. <https://doi.org/10.1001/jama.2015.3382>.
- Khoury MJ, Galea S. Will precision medicine improve population health? *JAMA.* 2016;316(13):1357–1358. <https://doi.org/10.1001/jama.2016.12260>.
- Fu MR, Kurnat-Thoma E, Starkweather A, et al. Precision health: a nursing perspective. *Int J Nurs Sci.* 2020;7(1):5–12. <https://doi.org/10.1016/j.ijnss.2019.12.008>.
- Hacker ED, McCarthy AM, DeVon H. Precision health: emerging science for nursing research. *Nurs Outlook.* 2019;67(4):287–289. <https://doi.org/10.1016/j.outlook.2019.06.008>.
- Chatterjee N, Shi J, García-Closas M. Developing and evaluating polygenic risk prediction models for stratified disease prevention. *Nat Rev Genet.* 2016;17(7):392–406. <https://doi.org/10.1038/nrg.2016.27>.
- Tracy MF. A definition of advanced practice nursing. In: Tracy MF, O'Grady ET, Phillips SJ, eds. *Advanced Practice Nursing: An Integrative Approach.* 7th ed. St. Louis, Missouri: Elsevier; 2023:74–97.
- Bryant-Lukosius D, Wong FKY. International development of advanced practice nursing. In: Tracy MF, O'Grady ET, Phillips SJ, eds. *Advanced Practice Nursing: An Integrative Approach.* 7th ed. Elsevier; 2023:137–165.
- International Council of Nurses. Guidelines on Advanced Practice Nursing 2020. Geneva, Switzerland: ICN – International Council of Nurses. 2020. [https://www.icn.ch/system/files/documents/2020-04/ICN\\_APN%20Report\\_EN\\_WEB.pdf](https://www.icn.ch/system/files/documents/2020-04/ICN_APN%20Report_EN_WEB.pdf).
- Williams JK, Katapodi MC, Starkweather A, et al. Advanced nursing practice and research contributions to precision medicine. *Nurs Outlook.* 2016;64(2):117–123. <https://doi.org/10.1016/j.outlook.2015.11.009>.
- Grady PA. Investigating the determinants of health: the role of nursing science. *Nurs Outlook.* 2017;65(5):489–491. <https://doi.org/10.1016/j.outlook.2017.04.010>.
- Fulton JS, Mayo A, Walker J, Urden LD. Description of work processes used by clinical nurse specialists to improve patient outcomes. *Nurs Outlook.* 2019;67(5):511–522. <https://doi.org/10.1016/j.outlook.2019.03.001>.
- O'Grady ET, Johnson JE. Guidance and coaching. In: Tracy MF, O'Grady ET, Phillips SJ, eds. *Advanced Practice Nursing: An Integrative Approach.* 7th ed. St. Louis, Missouri: Elsevier; 2023:212–242.
- Gray M, Terran WS. Evidence-based practice. In: Tracy MF, O'Grady ET, Phillips SJ, eds. *Advanced Practice Nursing: An Integrative Approach.* 7th ed. St. Louis, Missouri: Elsevier; 2023:243–278.
- Reed L, Carter M. Leadership. In: Tracy MF, O'Grady ET, Phillips SJ, eds. *Advanced Practice Nursing: An Integrative Approach.* 7th ed. St. Louis, Missouri: Elsevier; 2023:279–314.
- Dabney C, Carter M. Collaboration. In: Tracy MF, O'Grady ET, Phillips SJ, eds. *Advanced Practice Nursing: An Integrative Approach.* 7th ed. St. Louis, Missouri: Elsevier; 2023:315–340.
- Wocial LD, Robinson EM. Ethical practice. In: Tracy MF, O'Grady ET, Phillips SJ, eds. *Advanced Practice Nursing: An Integrative Approach.* 7th ed. St. Louis, Missouri: Elsevier; 2023:341–381.
- Harris CS, Pozzar RA, Conley Y, et al. Big data in oncology nursing research: state of the science. *Semin Oncol Nurs.* 2023;39(3): 151428. <https://doi.org/10.1016/j.soncn.2023.151428>.
- Whitman N, Purvis S. Improving outcomes for high-risk patients: creating timely reports from the electronic health record. *Clin Nurse Spec.* 2015;29(5):283–289. <https://doi.org/10.1097/nur.0000000000000154>.



27. Hickey KT, Bakken S, Byrne MW, et al. Precision health: advancing symptom and self-management science. *Nurs Outlook*. 2019;67(4):462–475. <https://doi.org/10.1016/j.outlook.2019.01.003>.
28. Corwin E, Redeker NS, Richmond TS, Docherty SL, Pickler RH. Ways of knowing in precision health. *Nurs Outlook*. 2019;67(4):293–301. <https://doi.org/10.1016/j.outlook.2019.05.011>.
29. Demiris G, Iribarren SJ, Sward K, Lee S, Yang R. Patient generated health data use in clinical practice: a systematic review. *Nurs Outlook*. 2019;67(4):311–330. <https://doi.org/10.1016/j.outlook.2019.04.005>.
30. O'Brien RL, O'Brien MW. CE: nursing orientation to data science and machine learning. *Am J Nurs*. 2021;121(4):32–39.
31. Sim JA, Huang X, Horan MR, et al. Natural language processing with machine learning methods to analyze unstructured patient-reported outcomes derived from electronic health records: a systematic review. *Artif Intell Med*. 2023;146: 102701. <https://doi.org/10.1016/j.artmed.2023.102701>.
32. Reddy V, Nafees A, Raman S. Recent advances in artificial intelligence applications for supportive and palliative care in cancer patients. *Curr Opin Support Palliat Care*. 2023;17(2):125–134. <https://doi.org/10.1097/spc.0000000000000645>.
33. Raymond L, Castonguay A, Doyon O, Paré G. Nurse practitioners' involvement and experience with AI-based health technologies: a systematic review. *Appl Nurs Res*. 2022;66: 151604. <https://doi.org/10.1016/j.apnr.2022.151604>.
34. Weber S. A qualitative analysis of how advanced practice nurses use clinical decision support systems. *J Am Acad Nurse Pract*. 2007;19(12):652–667. <https://doi.org/10.1111/j.1745-7599.2007.00266.x>.
35. Cheek DJ, Bashore L, Brazeau DA. Pharmacogenomics and implications for nursing practice. *J Nurs Scholarsh*. 2015;47(6):496–504. <https://doi.org/10.1111/jnu.12168>.
36. Topaz M, Murga L, Gaddis KM, et al. Mining fall-related information in clinical notes: comparison of rule-based and novel word embedding-based machine learning approaches. *J Biomed Inform*. 2019;90: 103103. <https://doi.org/10.1016/j.jbi.2019.103103>.
37. Ronquillo CE, Peltonen LM, Pruinelli L, et al. Artificial intelligence in nursing: priorities and opportunities from an international invitational think-tank of the Nursing and Artificial Intelligence Leadership Collaborative. *J Adv Nurs*. 2021;77(9):3707–3717. <https://doi.org/10.1111/jan.14855>.
38. Buchanan C, Howitt ML, Wilson R, Booth RG, Risling T, Bamford M. Predicted influences of artificial intelligence on the domains of nursing: scoping review. *JMIR Nurs*. 2020;3(1):e23939. <https://doi.org/10.2196/23939>.
39. Kurnat-Thoma EL, Graves LY, Billones RR. A concept development for the symptom science model 2.0. *Nurs Res*. 2022;71(6):E48–E60.
40. Pickler RH. Advances and challenges in symptom science. *Nurs Res*. 2020;69(2):89–90.
41. Dorsey SG, Griffioen MA, Renn CL, et al. Working together to advance symptom science in the precision era. *Nurs Res*. 2019;68(2):86–90. <https://doi.org/10.1097/nnr.0000000000000339>.
42. Howell D, Mayer DK, Fielding R, et al. Management of cancer and health after the clinic visit: a call to action for self-management in cancer care. *J Natl Cancer Inst*. 2021;113(5):523–531. <https://doi.org/10.1093/jnci/djaa083>.
43. Kwekkeboom KL. Cancer symptom cluster management. *Semin Oncol Nurs*. 2016;32(4):373–382. <https://doi.org/10.1016/j.soncn.2016.08.004>.
44. Sallis JF, Owen N, Fisher EB. Ecological models of health behavior. *Health Behavior and Health Education: Theory, Research, and Practice*. 2008:465–485.
45. DiCenso A, Bryant-Lukosius D M-MR, Donald F, Abelson J, et al. Factors enabling advanced practice nursing role integration in Canada. *Nurs Leadersh*. 2010;23(Special Issue):211–238.
46. Harrington L. New health technologies advancing nursing practice. *AACN Adv Crit Care*. 2017;28(4):311–313. <https://doi.org/10.4037/aacnacc2017604>.
47. World Health Organization. Global strategy on digital health 2020–2025. Geneva, 2021. <https://iris.who.int/bitstream/handle/10665/344249/9789240020924-eng.pdf?sequence=1>. Accessed 19 August 2023.
48. Swenty CL, Titzer JL. A sense of urgency: integrating technology and informatics in advance practice nursing education. *J Nurse Pract*. 2014;10(10):e57–e67. <https://doi.org/10.1016/j.nurpra.2014.07.034>.
49. Little ID, Koehly LM, Gunter C. Understanding changes in genetic literacy over time and in genetic research participants. *Am J Hum Genet*. 2022;109(12):2141–2151. <https://doi.org/10.1016/j.ajhg.2022.11.005>.
50. Kelly P. The clinical nurse specialist and essential genomic competencies: charting the course. *Clin Nurse Spec*. 2009;23(3):145–150. <https://doi.org/10.1097/NUR.0b013e3181a42356>.
51. Flowers E, Martin M, Abid H, Binford S, Mackin L. Pairing pedagogical and genomic advances to prepare advanced practice nurses for the era of precision health. *BMC Med Educ*. 2019;19(1):112. <https://doi.org/10.1186/s12909-019-1542-x>.
52. Seibert DC. Genomics and nurse practitioner practice. *Nurse Pract*. 2014;39(10):18–28. <https://doi.org/10.1097/01.Npr.0000453641.13662.03.quiz28-9>.
53. Lopes-Júnior LC. Personalized nursing care in precision-medicine era. *SAGE Open Nurs*. 2021;7: 23779608211064713. <https://doi.org/10.1177/23779608211064713>.
54. Fulton CR, Swart M, De Luca T, et al. Pharmacogenetics and practice: tailoring prescribing for safety and effectiveness. *J Nurse Pract*. 2018;14(10):697–704.e1. <https://doi.org/10.1016/j.nurpra.2018.09.021>.
55. Parimbelli E, Marini S, Sacchi L, Bellazzi R. Patient similarity for precision medicine: a systematic review. *J Biomed Inform*. 2018;83:87–96. <https://doi.org/10.1016/j.jbi.2018.06.001>.
56. McGrow K. Artificial intelligence: essentials for nursing. *Nursing*. 2019;49(9):46–49. <https://doi.org/10.1097/01.NURSE.0000577716.57052.8d>.
57. Simmons D, Salyer P. Future technologies influencing APRN practice. In: Tracy MF, O'Grady ET, Phillips SJ, eds. *Advanced Practice Nursing: An Integrative Approach*. 7th ed. St. Louis, Missouri: Elsevier; 2023:709–743.
58. von Gerich H, Moen H, Block LJ, et al. Artificial Intelligence-based technologies in nursing: a scoping literature review of the evidence. *Int J Nurs Stud*. 2022;127: 104153. <https://doi.org/10.1016/j.ijnurstu.2021.104153>.