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Precision Nursing in the Era of Personalized Healthcare: Integrating Genomics, Biomarkers, Digital Health, and Data-Driven Interventions into Clinical Practice

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ABSTRACT
Precision nursing has emerged as an important extension of personalized healthcare, emphasizing the use of individual biological, clinical, behavioral, environmental, and social information to guide nursing assessment, decision-making, intervention, and outcome evaluation. This review examines the evolving role of precision nursing in contemporary clinical practice, with particular attention to the integration of genomics, biomarkers, pharmacogenomics, digital health technologies, artificial intelligence, predictive analytics, and patient-generated health data. It explores how these tools can support earlier risk identification, individualized care planning, medication safety, continuous monitoring, improved symptom management, and more responsive nursing interventions across oncology, cardiovascular care, critical care, diabetes management, mental health, maternal and child health, geriatrics, and community health. The review also evaluates the potential contribution of wearable devices, remote patient monitoring, electronic health records, and clinical decision-support systems to data-driven nursing practice. Despite these opportunities, implementation remains limited by inadequate genomic and digital literacy, fragmented health information systems, algorithmic bias, privacy and cybersecurity concerns, ethical uncertainty, unequal access to technology, and unclear professional accountability. Advancing precision nursing will therefore require competency-based education, continuing professional development, strong nursing leadership, interdisciplinary collaboration, ethical governance, and policies that promote equitable access and responsible data use. Future research should prioritize nursing-sensitive outcomes, implementation effectiveness, cost-effectiveness, patient acceptability, health equity, and the development of transparent and clinically relevant precision-care models. Precision nursing has the potential to strengthen patient-centered care by enabling nurses to deliver more predictive, preventive, personalized, and evidence-informed interventions while preserving professional judgment, therapeutic relationships, and patient preferences.
Keywords: precision nursing, personalized healthcare, genomics, biomarkers, pharmacogenomics, digital health, artificial intelligence, predictive analytics, nursing practice.

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Introduction

a) Transition from Standardized Care to Personalized Healthcare

Healthcare has undergone a profound transformation over the past two decades, shifting from a traditional "one-size-fits-all" model toward personalized approaches that recognize the unique biological, environmental, behavioral, and social characteristics of each individual. Conventional healthcare has largely relied on standardized clinical guidelines and generalized treatment protocols that, while effective for many patients, often fail to account for individual variability in disease susceptibility, therapeutic response, and health outcomes. As a result,

patients with similar diagnoses may experience markedly different responses to the same intervention, highlighting the limitations of uniform care models (Collins & Varmus, 2015; Ginsburg & Phillips, 2018).

The emergence of precision medicine represents a paradigm shift that seeks to tailor prevention, diagnosis, and treatment strategies according to an individual's genetic profile, biomarkers, lifestyle, environmental exposures, and clinical characteristics. Building upon this concept, precision health adopts a broader perspective by incorporating behavioral, psychosocial, and social determinants of health to promote disease prevention, health maintenance, and personalized care throughout the lifespan (Hickey et al., 2019). This expanded approach recognizes that optimal health outcomes depend not only on biological factors but also on socioeconomic conditions, health behaviors, and environmental influences that shape an individual's overall health trajectory (Fu et al., 2020)

Recent advances in genomic sequencing, biomarker discovery, digital health technologies, wearable sensors, electronic health records, and artificial intelligence have accelerated the transition toward data-driven healthcare. These innovations enable healthcare professionals to collect and analyze large volumes of patient-specific information, facilitating more accurate risk prediction, earlier disease detection, individualized therapeutic planning, and continuous health monitoring (Ielapi et al., 2020). Consequently, healthcare systems are increasingly moving toward predictive, preventive, personalized, and participatory models of care that improve clinical effectiveness while enhancing patient engagement and safety.

b) Emergence of Precision Nursing

As precision medicine continues to reshape healthcare delivery, nursing has evolved to embrace its principles through the development of precision nursing. Precision nursing extends personalized healthcare into nursing practice by integrating biological, clinical, behavioral, environmental, and patient-generated data to guide comprehensive nursing assessment, individualized care planning, symptom management, patient education, monitoring, and outcome evaluation (Fu et al., 2020). Rather than replacing the holistic philosophy of nursing, precision nursing strengthens it by combining scientific advances with person-centered care to address each patient's unique needs and preferences.

Precision nursing recognizes nurses as essential contributors to interdisciplinary healthcare teams because of their continuous interaction with patients across diverse care settings. Nurses play critical roles in collecting comprehensive health information, interpreting patient responses, coordinating care, educating patients and families, and translating complex scientific information into practical clinical interventions (Lopes-Júnior, 2021). Recent scholarship has further emphasized that precision nursing is becoming a defining direction for the profession, supported by advances in genomics, pharmacogenomics, biomarkers, digital technologies, and artificial intelligence that enhance clinical decision-making while preserving compassionate, evidence-based care (Harrington, 2021; Shun, 2023; Hammer et al., 2025).

c) Why Precision Nursing Is Important

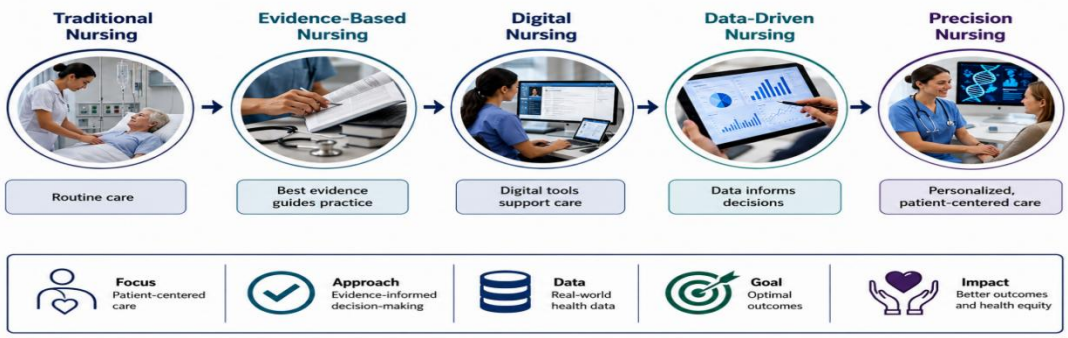
The importance of precision nursing continues to grow as healthcare systems confront increasingly complex patient populations, rising rates of chronic diseases, ageing societies, and widening health disparities. At the same time, unprecedented amounts of genomic, clinical, and digital health data are becoming available, creating new opportunities for earlier risk identification, individualized interventions, and proactive disease management (Hickey et al., 2019). However, realizing these benefits requires a nursing workforce capable of interpreting diverse data sources and integrating them into safe, ethical, and patient-centered practice.

Current evidence indicates that many nurses recognize the value of precision health but report gaps in genomic literacy, digital competencies, and confidence in applying precision-health principles within routine clinical care (Fangonil-Gagalang et al., 2025). Furthermore, ensuring equitable implementation remains a major priority, as unequal access to genomic services, digital technologies, and advanced healthcare resources may exacerbate existing health disparities if precision approaches are not implemented responsibly (Khoury et al., 2022; Lopes-Júnior, 2025).

d) Aim and Scope of the Review

This narrative review examines the evolving role of precision nursing within contemporary healthcare by critically synthesizing evidence on the integration of genomics, biomarkers, pharmacogenomics, digital health technologies, artificial intelligence, wearable devices, and data-driven interventions into clinical nursing practice. It further explores applications across multiple nursing specialties, identifies implementation challenges and ethical considerations, and discusses implications for nursing education, leadership, policy development, and future research. Figure 1 illustrates the evolution of nursing practice from standardized care toward predictive, preventive, personalized, and participatory precision nursing.

Figure 1. Evolution of Nursing Practice Toward Precision Nursing



Foundations of Precision Nursing

a) Definition and Scope of Precision Nursing

The rapid evolution of precision medicine has fundamentally reshaped healthcare by moving beyond standardized treatment approaches toward individualized care that accounts for the biological, environmental, behavioral, and social characteristics of each patient. Precision medicine is commonly defined as an approach to disease prevention, diagnosis, and treatment that considers individual genetic variability, environmental exposures, and lifestyle factors to optimize clinical outcomes (Collins & Varmus, 2015). Rather than treating patients solely on the basis of population averages, precision medicine seeks to deliver the right intervention to the right patient at the right time, thereby improving therapeutic effectiveness while minimizing unnecessary interventions and adverse outcomes.

Building upon this concept, precision health extends beyond disease management to encompass health promotion, disease prevention, and long-term wellness throughout the lifespan. Precision health recognizes that health outcomes are influenced by the complex interaction of genomic, clinical, behavioral, environmental, and social determinants of health. Consequently, it emphasizes proactive risk assessment, continuous monitoring, early intervention, and patient engagement before disease develops or progresses (Ginsburg & Phillips, 2018; Hickey et al., 2019). This broader perspective shifts healthcare from a reactive model toward one that is predictive, preventive, personalized, and participatory.

Although often used interchangeably, personalized healthcare differs slightly from precision medicine and precision health. Personalized healthcare focuses on tailoring care to individual preferences, values, cultural backgrounds, and clinical circumstances while maintaining person-centered communication and shared decision-making. In contrast, precision medicine relies more heavily on scientific evidence derived from genomic, molecular, and biomarker information to guide clinical interventions (Fu et al., 2020). Together, these complementary approaches aim to improve patient outcomes through individualized, evidence-informed care.

Within this evolving healthcare landscape, precision nursing has emerged as a specialized nursing framework that integrates the principles of precision medicine and precision health into nursing practice. Precision nursing combines genomic information, biomarkers, pharmacogenomics, clinical data, digital health technologies, and patient-generated health information with holistic nursing assessment to develop individualized care plans that address each patient's unique biological, psychological, social, and environmental needs (Ielapi et al., 2020; Lopes-Júnior,

2021). Importantly, precision nursing does not replace traditional nursing values; rather, it strengthens person-centered care by incorporating scientific advances into comprehensive nursing practice.

The scope of precision nursing extends across the continuum of care, including health promotion, disease prevention, acute care, chronic disease management, rehabilitation, palliative care, and community health. More recently, the concept has expanded toward precision public health, which applies precision approaches at the population level by integrating epidemiological, genomic, environmental, and social data to reduce health disparities and improve health equity. In this context, nurses play a pivotal role in translating precision-health innovations into equitable clinical and community-based interventions (Lopes-Júnior, 2025).

b) Core Principles of Precision Nursing

Precision nursing is underpinned by several interrelated principles that guide individualized, evidence-based, and patient-centered care. Foremost among these is individualized assessment, whereby nurses integrate multiple sources of patient information including genetic characteristics, clinical history, lifestyle behaviors, psychosocial factors, and environmental exposures; to gain a comprehensive understanding of each patient's health status (Fu et al., 2020). Such comprehensive assessment enables nurses to identify individual risk profiles that may not be apparent through conventional assessment methods.

A second principle is risk prediction and preventive intervention. Advances in genomic science, biomarkers, predictive analytics, and artificial intelligence enable earlier identification of individuals at increased risk of disease or adverse clinical events. This predictive capability allows nurses to implement targeted preventive strategies, monitor vulnerable patients more closely, and intervene before complications occur, thereby improving patient safety and long-term health outcomes (Hickey et al., 2019).

Precision nursing also emphasizes patient participation and shared decision-making. Patients are no longer passive recipients of care but active partners who contribute personal health information, communicate preferences, and participate in selecting interventions aligned with their values and goals. Continuous patient engagement strengthens adherence, promotes self-management, and enhances satisfaction with care (Shun, 2023).

Another defining principle is continuous monitoring and data integration. Modern nursing increasingly relies on real-time information from wearable devices, remote patient-monitoring systems, electronic health records, and patient-reported outcomes to evaluate health status continuously rather than through episodic encounters alone. Integrating these diverse data streams supports timely clinical decision-making and facilitates proactive care planning (Hammer et al., 2025).

Finally, precision nursing remains firmly grounded in evidence-based practice and equity-focused care. While advanced technologies provide valuable decision-support tools, nursing interventions must continue to be guided by the best available evidence, clinical expertise, and patient preferences. At the same time, nurses must advocate for equitable access to precision-health technologies to ensure that innovations do not widen existing healthcare disparities but instead contribute to more inclusive and patient-centered healthcare systems (Fu et al., 2020; Shun, 2023).

c) Data Sources Used in Precision Nursing

Effective precision nursing depends on the integration of diverse and complementary data sources that collectively provide a comprehensive understanding of an individual's health. Genomic data and biomarkers

Table 1. Core Components of Precision Nursing

Component	Description	Typical Data Source	Nursing Relevance
Genomics	Genetic variation influencing health, disease susceptibility, and treatment response	Genomic testing, family history	Risk assessment, patient education, and genetic counselling
Biomarkers	Measurable indicators of normal or pathological biological processes	Blood tests, tissue samples, imaging	Early detection, diagnosis, prognosis, and monitoring
Pharmacogenomics	Genetic factors influencing medication efficacy and safety	Genetic testing	Personalized medication selection and adverse drug reaction prevention
Digital Health	Technology-enabled healthcare delivery and monitoring	Telehealth platforms, mobile applications, wearable devices	Continuous monitoring, patient engagement, and remote care
Artificial Intelligence	Computational tools for prediction, classification, and clinical decision support	Integrated clinical, genomic, and digital health datasets	Risk prediction, decision support, and personalized intervention planning
Social Determinants of Health	Social, economic, and environmental factors influencing health outcomes	Electronic health records, community databases, patient interviews	Equity-focused assessment, care planning, and population health management

provide insights into disease susceptibility, prognosis, and treatment response, while electronic health records offer longitudinal clinical information that supports continuity of care. Increasingly, wearable devices and remote-monitoring technologies generate continuous physiological data, enabling early detection of health changes and facilitating timely nursing interventions (Hickey et al., 2019).

In addition to biological and clinical information, patient-reported outcomes contribute valuable insights into symptoms, quality of life, treatment experiences, and functional status. Likewise, lifestyle and behavioral information, including physical activity, nutrition, sleep patterns, and medication adherence, provides important context for individualized care planning. Precision nursing also recognizes the significant influence of environmental exposures and social determinants of health, such as housing, education, income, employment, and healthcare access, on health outcomes. Integrating these multidimensional data sources through digital health platforms and advanced analytics enables nurses to deliver comprehensive, equitable, and personalized care that addresses both biological and social determinants of health (Ielapi et al., 2020; Topaz & Pruinelli, 2017; Roberts et al., 2024).

Genomics, Pharmacogenomics, and Biomarkers

a) Genomic Nursing

The integration of genomics into healthcare has transformed the understanding of disease susceptibility, diagnosis, treatment selection, and

Table 2. Applications of Genomics, Pharmacogenomics, and Biomarkers Across Nursing Specialties

Specialty	Precision Tool	Nursing Application	Expected Benefit
Oncology	Tumour genomic profiling	Treatment education, symptom monitoring, survivorship care	Individualized cancer care
Cardiology	Genetic risk scores and cardiac biomarkers	Risk surveillance and preventive interventions	Earlier identification of high-risk patients
Mental Health	Pharmacogenomic testing	Medication monitoring and treatment optimization	Reduced trial-and-error prescribing
Maternal Health	Prenatal genomic screening	Patient education, family counselling, care coordination	Early identification of hereditary risks
Critical Care	Organ-injury biomarkers	Early deterioration monitoring and rapid intervention	Faster clinical escalation and improved outcomes
Chronic Disease Management	Metabolic and inflammatory biomarkers	Individualized self-management and disease monitoring	Improved disease control and long-term outcomes

preventive care. Within nursing practice, genomic nursing refers to the application of genetic and genomic knowledge to support individualized assessment, patient education, clinical decision-making, and coordinated care across diverse healthcare settings. Unlike traditional approaches that primarily rely on observable clinical manifestations, genomic nursing incorporates inherited genetic variation to better understand individual disease risk, therapeutic response, and long-term health outcomes (Calzone et al., 2018)

One of the fundamental responsibilities of genomic nursing is the collection and interpretation of family health history, which remains one of the most valuable and cost-effective tools for identifying hereditary disease risk. Comprehensive pedigree assessment enables nurses to recognize patterns associated with inherited disorders, facilitating early referral for genetic evaluation and preventive interventions (Regan et al., 2019). As genomic technologies become increasingly accessible, nurses are expected to understand basic genomic concepts, explain genetic testing procedures, interpret genomic reports within their scope of practice, and communicate findings in language that patients and families can readily understand.

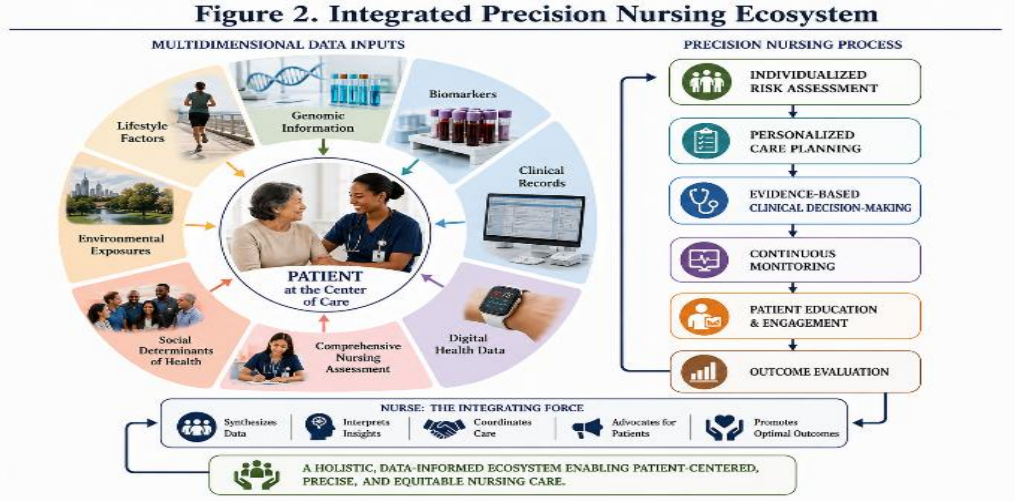
Equally important is the nurse's role in patient education and genetic counselling referral. Although nurses are not expected to replace certified genetic counsellors, they serve as essential intermediaries who prepare patients for genetic testing, clarify misconceptions, discuss potential benefits and limitations, and facilitate informed decision-making. Ethical communication is particularly important when discussing incidental findings, hereditary disease risk, privacy concerns, and the potential implications of genetic information for family members (Thomas et al., 2023). As emphasized by Dewell et al. (2025), integrating genomics into the nursing process strengthens individualized care while preserving the holistic principles that define professional nursing practice.

b) Genomic Competency in Nursing

Despite significant advances in genomic medicine, numerous studies indicate that genomic competency among nurses remains inconsistent across healthcare systems. Many practicing nurses acknowledge the growing importance of genomics in patient care but report limited confidence in interpreting genomic information, explaining genetic test results, or incorporating genomic evidence
into routine clinical practice (Zhao et al., 2022). These competency gaps may reduce nurses' ability to participate effectively in multidisciplinary precision-health initiatives.

Recent international reviews have identified deficiencies in genomic education within undergraduate nursing curricula, limited opportunities for continuing professional development, and inadequate institutional support for integrating genomics into clinical practice (Thomas et al., 2023; McLaughlin et al., 2024). Recognizing these challenges, professional organizations have updated essential genomic nursing competencies to guide curriculum development and lifelong learning. These competencies encompass genomic literacy, ethical and legal considerations, family-history assessment,

Figure 2. Integrated Precision Nursing Ecosystem



Technology	Main Function	Nursing Application	Key Limitation
Artificial Intelligence	Prediction, classification, and decision support	Risk stratification and personalized care planning	Algorithmic bias and limited explainability
Wearable Devices	Continuous physiological monitoring	Early detection of clinical changes	Device accuracy and patient adherence
Remote Patient Monitoring	Home-based health data collection	Chronic disease management and follow-up care	Digital inequality and internet access
Electronic Health Records	Integration of longitudinal patient data	Comprehensive assessment and care coordination	Interoperability challenges
Clinical Decision Support Systems	Evidence-based recommendations and alerts	Point-of-care clinical decision-making	Alert fatigue and user acceptance

interpretation of genomic information, communication skills, and interprofessional collaboration (Calzone et al., 2024).

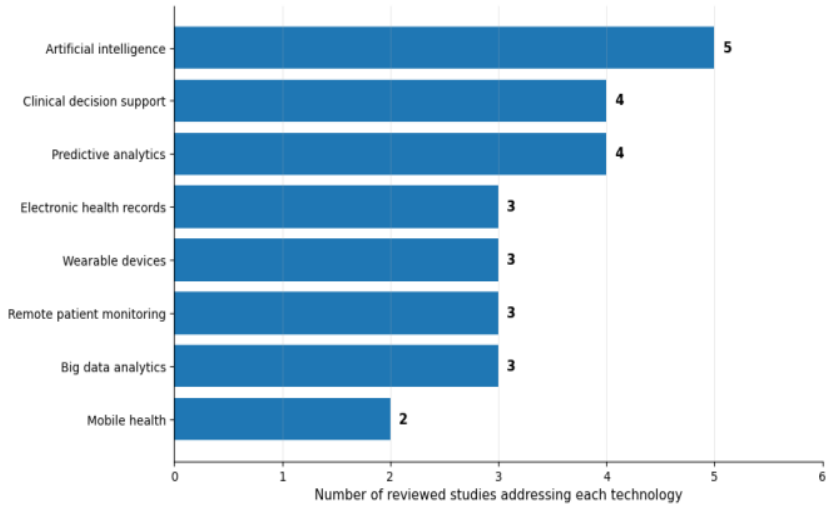
Furthermore, Dante et al. (2025) demonstrated that genomic literacy varies considerably across countries and clinical settings, highlighting the need for standardized educational frameworks that ensure consistent preparation of the nursing workforce. Similarly, Fangonil-Gagalang et al. (2025) reported that although nurses generally recognize the value of precision health, many perceive themselves as insufficiently prepared to implement genomic-based care. Strengthening genomic competency through competency-based education, simulation, continuing education, and interdisciplinary training will therefore be essential for the successful implementation of precision nursing.

c) Pharmacogenomics

Pharmacogenomics examines how genetic variation influences an individual's response to medications, including therapeutic effectiveness, optimal dosage requirements, and susceptibility to adverse drug reactions. As pharmacogenomic testing becomes increasingly integrated into clinical practice, nurses play an important role in translating pharmacogenomic information into safe, individualized medication management (Cheek et al., 2015).

Nursing responsibilities begin with comprehensive medication-history assessment, including previous treatment responses, adverse drug reactions, family history of medication sensitivity, and factors influencing medication adherence. Nurses also provide patient education regarding the purpose, benefits, and limitations of pharmacogenomic testing while addressing concerns related to confidentiality and informed consent. During treatment, continuous monitoring enables nurses to identify unexpected therapeutic responses or adverse effects that may indicate genetically mediated variations in drug metabolism or efficacy (Kabbani et al., 2023).

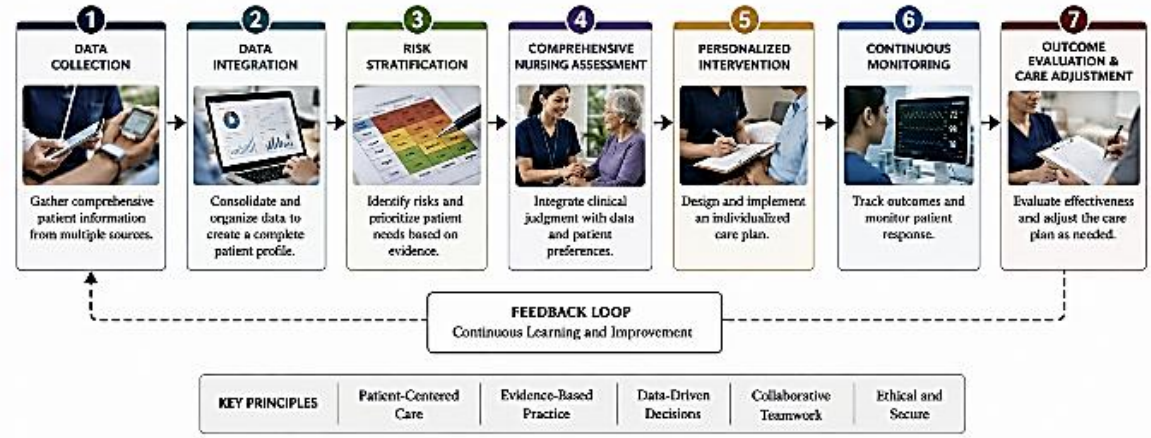
Chart 1. Distribution of Digital Technologies Discussed in the Reviewed Literature



Note. Frequencies are based on thematic coding of the digitally focused references in the approved bibliography. A study could be assigned to more than one category when its scope addressed multiple technologies.

Figure 4. Precision Nursing Clinical Decision-Making Pathway

A cyclical process that integrates data, nursing expertise, and patient preferences to deliver individualized, evidence-based care.

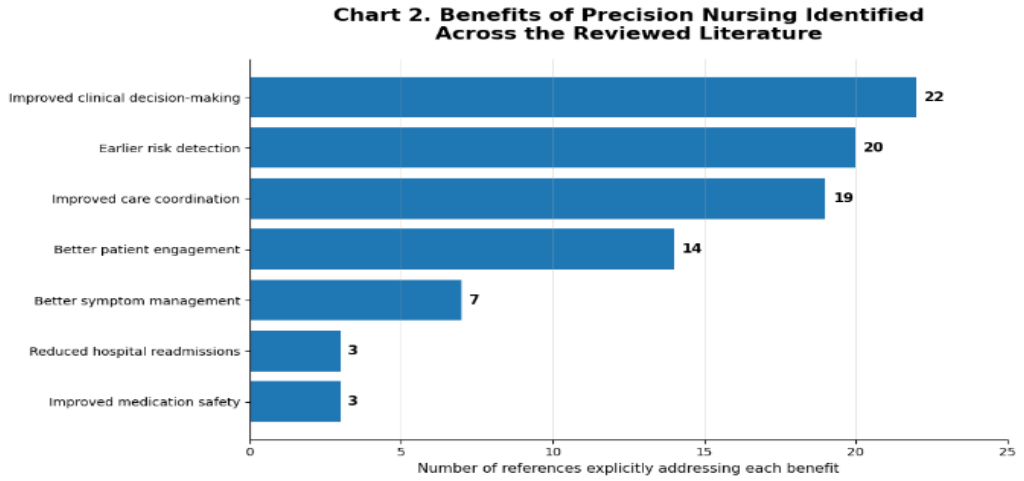


Advanced practice nurses are increasingly involved in interpreting pharmacogenomic reports, collaborating with pharmacists and physicians and supporting shared decision-making regarding medication selection and dosage adjustments. Fulton et al. (2024) emphasize that expanding pharmacogenomic competency among advanced practice nurses will improve medication safety, optimize therapeutic outcomes, and reduce avoidable adverse drug events.

Table 4. Clinical Applications of Precision Nursing Across Nursing Specialties

Specialty	Patient Population	Precision Technology / Data Source	Nursing Intervention	Expected Outcome	Implementation Consideration
Oncology	Patients with cancer	Tumour genomics, biomarkers	Symptom monitoring, treatment education	Individualized cancer care	Cost of genomic testing
Cardiovascular	Cardiac patients	Biomarkers, wearable monitors	Risk assessment, lifestyle counselling	Earlier intervention	Data integration
Critical Care	Critically ill patients	AI, predictive analytics, biomarkers	Early deterioration detection	Improved patient safety	Clinical validation
Diabetes & Metabolic Care	Patients with diabetes	Continuous glucose monitoring, mobile health	Self-management education	Better glycaemic control	Patient adherence
Mental Health	Patients with psychiatric disorders	Pharmacogenomics, digital monitoring	Medication optimization	Improved treatment response	Ethical considerations
Maternal & Child Health	Pregnant women and children	Prenatal genomics	Family education, care coordination	Early risk identification	Access to genetic services
Geriatric Nursing	Older adults	Wearables, remote monitoring	Fall prevention, medication review	Healthy ageing	Digital literacy
Community & Public Health	Populations and communities	Population health data, genomics	Risk stratification, prevention	Reduced health disparities	Health equity

d) Biomarkers in Precision Nursing



Note. Exact frequencies were calculated from binary thematic coding of the 40-reference bibliography. A reference was counted only when the benefit was explicitly discussed as an application, outcome, or implementation objective. Categories are not mutually exclusive; one reference may contribute to multiple benefits. Counts represent thematic coverage, not pooled effect sizes.

Biomarkers are measurable biological indicators that provide objective information regarding physiological processes, disease activity, therapeutic response, and prognosis. Within precision nursing, biomarkers support individualized assessment by enabling earlier diagnosis, risk stratification, disease monitoring, and evaluation of treatment effectiveness (Ielapi et al., 2020).

Several categories of biomarkers have direct relevance to nursing practice. Diagnostic biomarkers assist in confirming disease presence, whereas predictive biomarkers identify patients who are more likely to respond to specific therapies.

Prognostic biomarkers provide information regarding disease progression and expected clinical outcomes, while monitoring biomarkers allow clinicians to evaluate treatment effectiveness and detect disease recurrence over time. More recently, digital biomarkers, generated through wearable devices, smartphones, and remote-monitoring technologies, have expanded opportunities for continuous patient assessment outside traditional healthcare settings (Hickey et al., 2019). Integrating biomarker data with clinical assessment and patient-reported outcomes enables nurses to make more timely and individualized clinical decisions, reinforcing the principles of precision health (Hammer et al., 2025).

e) Nursing Applications of Genomics and Biomarkers

The integration of genomics and biomarkers has broad applications across nursing specialties. In oncology nursing, tumour genomic profiling supports individualized treatment selection, patient education, symptom monitoring, and survivorship planning (Dickman & Seven, 2025). In cardiovascular nursing, genetic risk scores and circulating biomarkers facilitate early identification of high-risk individuals and personalized prevention strategies. Mental health nursing increasingly benefits from pharmacogenomic testing to optimize psychotropic medication selection and reduce trial-and-error prescribing. Within maternal and child health, prenatal genomic screening and hereditary risk assessment enhance family education and coordinated care. In critical care, organ-specific biomarkers enable earlier recognition of patient deterioration and timely clinical intervention, while chronic disease management increasingly incorporates metabolic biomarkers to guide individualized self-management and long-term monitoring (Dewell et al., 2025; Limoges et al., 2024). Collectively, these applications demonstrate how genomics and biomarkers strengthen evidence-based, patient-centered nursing practice across the continuum of care.

Digital Health, Artificial Intelligence, and Data-Driven Care

a) Electronic Health Records and Big Data

The digital transformation of healthcare has significantly expanded the availability of patient information, creating new opportunities for precisionnursing through the use of electronic health records (EHRs) and big data analytics. EHRs provide comprehensive, longitudinal patient records that integrate demographic information, medical history, laboratory results, medications, diagnostic imaging, clinical notes, and treatment outcomes into a unified

Table 5. Challenges, Ethical Concerns, and Implementation Strategies

Challenge	Potential Consequence	Nursing Implication	Recommended Strategy
Data privacy and cybersecurity	Loss of patient trust and data breaches	Reduced confidence in digital health	Strong governance, encryption, and access control
Algorithmic bias	Unequal healthcare decisions	Unsafe or inequitable recommendations	Diverse datasets, transparent algorithms, and regular auditing
Limited precision nursing competence	Misinterpretation of genomic and digital information	Increased clinical risk	Education, competency frameworks, and continuing professional development
Poor interoperability	Fragmented patient information	Delayed or incomplete clinical decisions	Standardized health information systems and integrated digital platforms
Digital inequality	Unequal access to precision healthcare	Widening health disparities	Inclusive technology design, digital literacy programs, and equitable resource allocation
Unclear legal accountability	Professional uncertainty and liability	Reduced confidence in AI-supported practice	Clear governance policies, regulatory guidance, and defined professional responsibilities

digital platform. This integration enables nurses to access accurate and timely patient information, facilitating continuity of care across multiple healthcare settings while reducing fragmented documentation and communication errors (Topaz & Pruinelli, 2017).

Beyond supporting routine documentation, EHRs serve as a rich source of clinical data for identifying disease patterns, monitoring patient trajectories, and evaluating healthcare outcomes. When combined with big data analytics, EHRs enable healthcare organizations to identify high-risk populations, predict adverse events, evaluate intervention effectiveness, and support population-level quality improvement initiatives. Nurses increasingly rely on these data to perform individualized risk assessments, prioritize patient care, and coordinate multidisciplinary interventions that reflect each patient's unique clinical profile (Booth et al., 2021).

The value of EHRs within precision nursing extends beyond data storage to intelligent knowledge generation. Large-scale integration of clinical, genomic, behavioral, and patient-generated health data allows nurses to recognize subtle changes in patient status that may not be apparent through traditional assessment alone. Consequently, digital information systems provide the foundation upon which many

Table 6. Core Competencies for Precision Nursing Practice

Competency Domain	Required Knowledge and Skills	Clinical Application	Educational Strategy	Expected Outcome
Genomic and Biomarker Literacy	Genetics, genomics, biomarker interpretation	Risk assessment and individualized care planning	Undergraduate and graduate education	Improved precision assessment
Pharmacogenomics	Genetic influence on medication response	Personalized medication management	Case-based learning and continuing education	Improved medication safety
Digital and Data Literacy	Electronic health records, health informatics, data interpretation	Data-driven clinical decision-making	Digital health training and simulation	Improved clinical efficiency
Artificial Intelligence Competence	AI principles, predictive analytics, clinical decision support	AI-assisted nursing practice	AI-focused professional development	Enhanced decision-making
Clinical Integration	Multidimensional patient assessment and care coordination	Personalized interventions	Interprofessional clinical education	Improved patient outcomes
Ethical and Legal Competence	Privacy, informed consent, governance, accountability	Ethical implementation of precision nursing	Ethics education and policy training	Safe and responsible practice
Communication, Leadership, and Collaboration	Patient education, shared decision-making, teamwork, leadership	Workforce preparation and organizational implementation	Leadership development programmes	Sustainable precision nursing implementation

precision health technologies, including artificial intelligence, predictive analytics, and clinical decision support systems, are built (Ronquillo et al., 2021).

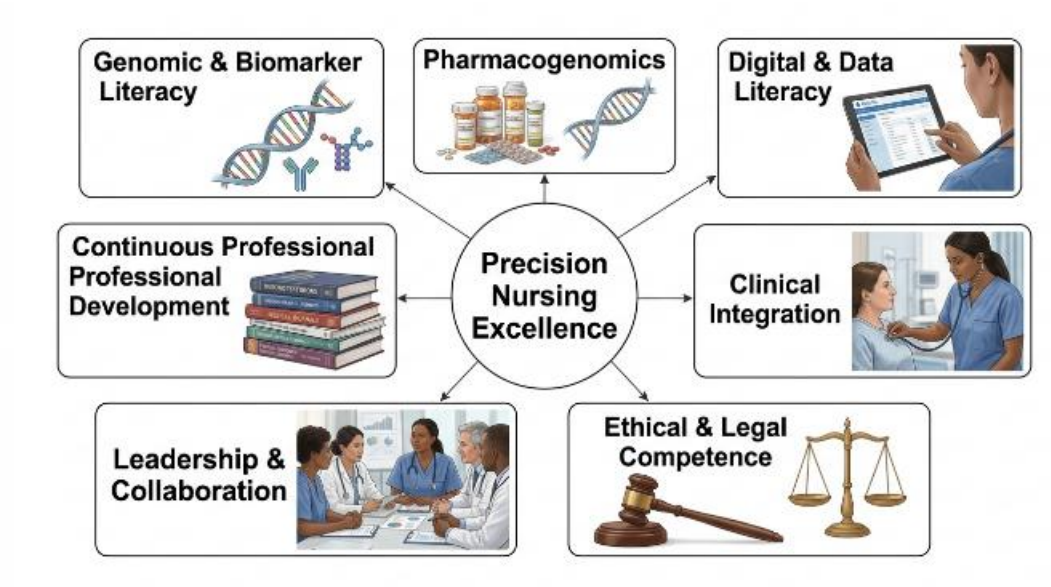
b) Artificial Intelligence and Machine Learning

Artificial intelligence (AI) has emerged as one of the most transformative technologies supporting precision nursing by enabling healthcare professionals to analyse complex datasets, recognize hidden clinical patterns, and generate evidence-informed recommendations that enhance patient care. Unlike conventional computer systems that rely on predefined programming, AI systems continuously learn from large volumes of structured and unstructured healthcare data, improving predictive accuracy and supporting increasingly sophisticated clinical decision-making (Ronquillo et al., 2021).

Machine learning, a major branch of AI, has demonstrated considerable value across diverse nursing applications. Algorithms can analyse combinations of physiological measurements, laboratory findings, medication records, imaging results, and nursing documentation to predict patient deterioration, identify individuals at risk for complications, and recommend timely interventions before adverse events occur. Such capabilities strengthen nurses' ability to provide proactive rather than reactive care, supporting the core principles of precision nursing.

AI also enhances clinical decision support by assisting nurses in interpreting complex clinical information and identifying evidence-based interventions tailored to individual patient characteristics. Rather than replacing professional judgement, AI functions as an intelligent support system that complements nurses' clinical expertise by reducing information overload, improving diagnostic accuracy, and facilitating rapid access to relevant evidence (Hassanein et al., 2025). In addition, natural language processing technologies increasingly automate routine documentation, extract clinically relevant information from narrative nursing notes, and reduce administrative workload. These improvements allow nurses to devote more time to direct patient care.

Another emerging application involves workload management and resource allocation. AI models can predict patient acuity, estimate staffing requirements, and optimise nursing assignments according to patient complexity, thereby improving workforce efficiency and patient safety. Furthermore, personalized intervention recommendations generated through AI integrate genomic information, biomarkers, clinical history, and patient-generated health data to support individualized care planning while preserving the nurse's central role in shared decision-making and compassionate patient care (El Arab et al., 2025). Nevertheless, successful implementation requires



transparent algorithms, rigorous validation, continuous human oversight, and careful attention to ethical concerns such as algorithmic bias, accountability, data privacy, and equitable access to AI-enabled healthcare technologies (Park et al., 2025).

c) Predictive Analytics

Predictive analytics represents another essential component of precision nursing by transforming historical and real-time patient data into actionable clinical insights that support early intervention and individualized care. Using advanced statistical models and machine-learning algorithms, predictive analytics estimates the likelihood of future clinical events based on combinations of demographic, physiological, laboratory, behavioral, and environmental information. These predictive capabilities allow nurses to anticipate complications before they become clinically apparent, facilitating timely preventive interventions and improving patient outcomes (Ronquillo et al., 2021).

Current applications of predictive analytics include the early identification of patient deterioration, sepsis detection, fall-risk assessment, pressure-injury prevention, hospital readmission prediction, and medication-related risk identification. For example, predictive algorithms integrated within electronic health records can continuously analyse changes in vital signs, laboratory values, and nursing assessments to identify patients at risk of rapid clinical decline. This capability enables earlier escalation of care and reduces preventable adverse events (Hassanein et al., 2025). Similarly, predictive models support discharge planning by identifying individuals at increased risk of readmission, allowing nurses to implement targeted education, follow-up monitoring, and care coordination strategies before discharge.

Importantly, predictive analytics should be viewed as an adjunct to, rather than a replacement for, professional nursing judgement. Although predictive models provide valuable estimates of clinical risk, nurses remain responsible for interpreting algorithm-generated information within the broader context of patient preferences, clinical presentation, psychosocial circumstances, and ethical considerations. Maintaining this balance between technological innovation and human-centred care is fundamental to ensuring that predictive analytics strengthens rather than diminishes the therapeutic relationship between nurses and patients (Park et al., 2025).

d) Wearable and Sensor Technologies

Wearable and sensor technologies have become integral components of precision nursing by enabling continuous, real-time monitoring of physiological and behavioral parameters beyond traditional healthcare settings. Unlike intermittent clinical assessments, wearable devices generate longitudinal patient data that provide nurses with a more comprehensive understanding of individual health trajectories and facilitate earlier detection of clinically significant changes. Advances in digital health have led to the widespread adoption of smart watches, continuous glucose monitors, cardiac rhythm monitors, activity trackers, sleep-monitoring devices, and fall-detection systems across both acute and community care settings (Mattison et al., 2022).

These technologies enhance nursing practice by supporting individualized assessment, promoting patient engagement, and improving chronic disease management. For example, continuous glucose monitoring enables nurses to evaluate glycaemic trends and tailor diabetes education more effectively, while wearable cardiac monitors facilitate early detection of arrhythmias and other cardiovascular abnormalities. Similarly, activity trackers and sleep-monitoring devices provide valuable insights into lifestyle behaviors that influence recovery, rehabilitation, and long-term disease prevention (Kallas et al., 2023). Nevertheless, successful implementation requires consideration of device accuracy, patient adherence, data security, interoperability, and equitable access to digital technologies. Nurses therefore play a crucial role in interpreting wearable-generated data, educating patients on appropriate device use, and integrating digital information into holistic, person-centred care plans (Smuck et al., 2021).

e) Remote Patient Monitoring and Mobile Health

Remote patient monitoring (RPM) and mobile health (mHealth) technologies have expanded the reach of nursing care by allowing patients to be monitored safely outside conventional healthcare facilities. These technologies support continuous communication

between patients and healthcare professionals through connected medical devices, smartphone applications, telehealth platforms, and cloud-based monitoring systems. By transmitting physiological measurements and patient-reported information in real time, RPM enables nurses to detect early clinical deterioration, evaluate treatment effectiveness, and intervene promptly when abnormal findings are identified (Farias et al., 2020).

The greatest benefits of RPM are observed in the management of chronic diseases such as diabetes, hypertension, heart failure, chronic obstructive pulmonary disease, and other long-term conditions requiring continuous follow-up. Home-based monitoring reduces unnecessary hospital admissions, improves medication adherence, strengthens patient self-management, and facilitates timely clinical intervention before complications become severe. Likewise, mobile health applications provide personalized education, medication reminders, symptom tracking, and behavioral support, empowering patients to participate actively in their own care (Wang et al., 2020).

Remote monitoring also improves healthcare accessibility for individuals living in rural and underserved communities where access to specialist services may be limited. Telehealth-supported nursing consultations enable ongoing assessment, education, counselling, and follow-up while reducing travel burdens and healthcare costs. Despite these advantages, successful implementation depends on reliable digital infrastructure, patient digital literacy, data privacy protection, and equitable access to internet-enabled technologies. Nurses therefore remain central to ensuring that remote monitoring complements, rather than replaces, therapeutic communication and person-centred care (Kallas et al., 2023).

f) Clinical Decision Support Systems

Clinical decision support systems (CDSSs) represent one of the most important applications of digital health within precision nursing. These systems integrate information from electronic health records, genomic testing, biomarkers, laboratory investigations, wearable devices, and patient-generated health data to generate evidence-based recommendations that support clinical decision-making at the point of care. Rather than functioning as autonomous decision-makers, CDSSs provide nurses with timely alerts, risk assessments, diagnostic support, and intervention recommendations that enhance clinical reasoning while preserving professional judgement (Ronquillo et al., 2021).

Within precision nursing, CDSSs facilitate individualized care by synthesizing diverse sources of patient information into meaningful clinical insights. For example, integrated systems can identify patients at increased risk of sepsis, recommend personalized medication adjustments based on pharmacogenomic results, or generate reminders for preventive interventions according to individual risk profiles. These capabilities improve consistency of care, reduce preventable errors, and strengthen adherence to evidence-based clinical guidelines (Hassanein et al., 2025).

Despite their considerable potential, CDSSs should complement rather than replace nursing expertise. Nurses remain responsible for interpreting system-generated recommendations within the broader clinical context, incorporating patient preferences, ethical considerations, psychosocial circumstances, and professional experience into final care decisions. Maintaining meaningful human oversight is essential to prevent overreliance on automated recommendations, minimise alert fatigue, and ensure that technology continues to support compassionate, patient-centred nursing practice (Booth et al., 2021).

Clinical Applications Across Nursing Specialties

Precision nursing is transforming healthcare by integrating genomic information, biomarkers, pharmacogenomics, artificial intelligence (AI), digital health technologies, and patient-generated data into individualized nursing care. Although the underlying principles remain consistent across healthcare settings, their clinical application varies according to patient populations, disease characteristics, and specialty-specific priorities. Across nursing specialties, precision nursing supports earlier disease detection, personalized interventions, improved treatment monitoring, and enhanced patient engagement, thereby promoting safer and more effective care.

a) Oncology Nursing

Oncology has become one of the leading specialties adopting precision nursing because cancer treatment increasingly relies on genomic profiling and

biomarker-guided therapies. Nurses play a central role in interpreting genomic information within their scope of practice, educating patients about precision therapies, monitoring treatment-related toxicities, coordinating multidisciplinary care, and supporting survivorship planning. Tumour genomic profiling enables individualized treatment selection while biomarker monitoring assists in evaluating therapeutic response and detecting disease progression. Precision nursing also strengthens symptom management by allowing interventions to be tailored according to each patient's biological characteristics and treatment response (Dickman & Seven, 2025; Hammer et al., 2025; Ielapi et al., 2020).

b) Cardiovascular Nursing

In cardiovascular nursing, precision approaches combine genetic-risk assessment, circulating biomarkers, wearable monitoring devices, and lifestyle data to improve prevention and disease management. Biomarkers such as cardiac troponins and natriuretic peptides support early diagnosis and risk stratification, while remote cardiac monitoring enables continuous observation of patients outside hospital settings. Nurses use these data to provide individualized education, optimize lifestyle interventions, promote medication adherence, and identify patients requiring early clinical review. These strategies contribute to improved cardiovascular outcomes and reduced hospitalization (Hickey et al., 2019; Kallas et al., 2023; Smuck et al., 2021).

c) Critical Care Nursing

Precision nursing has become increasingly important in critical care, where rapid clinical deterioration requires timely assessment and intervention. AI-supported predictive models, biomarker monitoring, and continuous physiological surveillance enable nurses to identify patients at increased risk of sepsis, organ dysfunction, and other life-threatening complications before obvious clinical deterioration occurs. Integrating predictive analytics with comprehensive nursing assessment supports earlier escalation of care, improves patient safety, and facilitates more individualized treatment decisions within intensive care environments (Harrington, 2021; Hassanein et al., 2025; Park et al., 2025).

d) Diabetes and Metabolic Care

The management of diabetes and metabolic disorders increasingly incorporates precision nursing through continuous glucose monitoring, wearable technologies, mobile health applications, and personalized lifestyle interventions. Continuous monitoring allows nurses to evaluate glycaemic trends in real time, identify early metabolic instability, and tailor patient education according to individual needs. Mobile applications further enhance self-management by supporting medication adherence, dietary monitoring, physical activity tracking, and communication between patients and healthcare providers. Together, these technologies promote improved glycaemic control and reduce long-term complications (Mattison et al., 2022; Wang et al., 2020; Kallas et al., 2023).

e) Mental Health Nursing

Precision nursing is also reshaping mental healthcare through pharmacogenomics, digital symptom monitoring, and individualized medication management. Pharmacogenomic testing assists clinicians in selecting psychotropic medications that are more likely to be effective while reducing adverse drug reactions and unnecessary treatment changes. Digital platforms and mobile applications facilitate continuous monitoring of mood, sleep patterns, medication adherence, and behavioural changes, enabling earlier intervention when clinical deterioration is detected. Nurses remain essential in educating patients about pharmacogenomic testing, monitoring treatment response, and supporting shared decision-making throughout the recovery process (Cheek et al., 2015; Hickey et al., 2019; Kabbani et al., 2023).

f) Maternal and Child Health Nursing

Within maternal and child health, precision nursing emphasizes hereditary-risk assessment, prenatal genomic screening, maternal monitoring, and family-centred education. Nurses support informed decision-making by explaining genomic testing procedures, discussing hereditary disease risk, coordinating referrals for genetic counselling, and promoting healthy pregnancy outcomes. Genomic information also supports earlier identification of congenital disorders and inherited conditions, enabling individualized prenatal care and timely intervention. As genomic medicine continues to evolve, nurses remain central to integrating scientific advances with compassionate, family-focused care (Calzone et al., 2018; Calzone et al., 2024; Thomas et al., 2023).

g) Geriatric Nursing

Older adults frequently present with multimorbidity, frailty, cognitive impairment, and polypharmacy, making geriatric nursing particularly suitable for precision approaches. Wearable devices, remote monitoring technologies, and predictive analytics support early identification of falls, functional decline, medication-related complications, and cognitive changes. Nurses use these technologies to develop individualized care plans that promote independence, improve medication safety, and facilitate home-based monitoring. Precision nursing also supports healthy ageing by enabling proactive management of complex health needs while reducing avoidable hospital admissions (Farias et al., 2020; Mattison et al., 2022; Smuck et al., 2021).

h) Community and Public Health Nursing

Precision nursing extends beyond individual patient care to population health through the integration of genomic information, environmental exposures, social determinants of health, and community-level data. Population-risk stratification enables nurses to identify vulnerable groups, target preventive interventions, and allocate healthcare resources more effectively. Precision prevention strategies combine epidemiological evidence with digital technologies to address chronic disease risk while reducing health disparities across diverse communities. Community nurses also play an important role in promoting equitable access to genomic services, digital health technologies, and personalized preventive care, ensuring that advances in precision health benefit all populations rather than widening existing healthcare inequalities (Dankwa-Mullan, 2024; Khoury et al., 2022; Lopes-Júnior, 2025; Roberts et al., 2024).

Benefits and Measurable Outcomes

The integration of genomics, biomarkers, pharmacogenomics, artificial intelligence (AI), digital health technologies, and patient-generated health data has enabled precision nursing to improve clinical decision-making across diverse healthcare settings. By tailoring nursing interventions to the unique biological, clinical, behavioral, and environmental characteristics of each patient, precision nursing supports more proactive, individualized, and evidence-based care. The resulting benefits extend beyond individual patients to nursing practice and healthcare systems, while measurable outcomes provide objective evidence for evaluating implementation success.

a) Patient-Level Benefits

At the patient level, precision nursing facilitates earlier disease detection, individualized interventions, improved medication safety, enhanced symptom control, increased patient engagement, and better quality of life. Integrating genomic information with clinical assessment enables nurses to identify hereditary disease risks and implement preventive strategies before disease progression. Similarly, biomarker monitoring supports earlier diagnosis and continuous evaluation of treatment response, allowing timely modifications to individualized care plans (Fu et al., 2020).

Digital technologies further strengthen patient-centered care by promoting continuous monitoring and personalized self-management. Mobile health applications, wearable devices, and remote patient monitoring systems enable patients to participate actively in managing chronic conditions while providing nurses with real-time information that supports timely intervention. This collaborative approach improves treatment adherence, strengthens communication, and empowers patients to make informed healthcare decisions. Collectively, these innovations contribute to improved symptom management, greater patient satisfaction, and enhanced health-related quality of life (Hammer et al., 2025; Hickey et al., 2019; Wang et al., 2020).

b) Nursing Practice Benefits

Precision nursing enhances professional practice by improving clinical judgement, supporting evidence-based decision-making, and facilitating earlier intervention. Access to integrated clinical, genomic, and digital health information enables nurses to identify subtle changes in patient status that may not be apparent through conventional assessment alone. Predictive analytics and clinical decision support systems further assist nurses in prioritizing care, recognizing high-risk patients, and selecting individualized interventions while maintaining professional autonomy and clinical judgement (Harrington, 2021).

Precision nursing also improves continuity of care by

integrating patient information across multiple healthcare settings and supporting effective communication within multidisciplinary teams. Individualized patient education, supported by digital health technologies and precision data, enables nurses to provide more targeted counseling that reflects each patient's specific health risks, treatment needs, and personal preferences. These capabilities strengthen nursing efficiency while preserving compassionate, person-centered care (Shun, 2023; Hassanein et al., 2025).

c) Health-System Benefits

Healthcare systems also benefit from precision nursing through improved quality of care, greater operational efficiency, and more effective resource utilization. Earlier identification of clinical deterioration and individualized risk prediction reduce preventable adverse events and support timely intervention, thereby decreasing avoidable hospitalizations and improving patient safety. Precision approaches also facilitate chronic disease management by enabling proactive monitoring and coordinated follow-up across the continuum of care (Farias et al., 2020).

Furthermore, integrating precision health into healthcare delivery supports value-based care by improving clinical outcomes while potentially reducing unnecessary diagnostic procedures, ineffective treatments, and healthcare expenditures. Population-level data integration also enables healthcare organizations to identify trends, allocate resources more effectively, and develop targeted public health interventions that address health disparities and improve overall population health (Ginsburg & Phillips, 2018; Roberts et al., 2024).

d) Outcome Measurement

The successful implementation of precision nursing requires robust evaluation using standardized outcome measures that reflect patient, professional, and health-system performance. Common indicators include nursing-sensitive outcomes, disease-specific clinical measures, patient-reported outcome measures, healthcare utilization, cost-effectiveness, and health equity indicators. Examples include reduced hospital readmissions, shorter length of stay, medication safety, improved symptom control, enhanced patient satisfaction, and increased adherence to individualized care plans.

Continuous evaluation of these outcomes enables healthcare organizations to determine the effectiveness of precision nursing interventions, identify areas requiring improvement, and support evidence-based policy development. Establishing standardized outcome frameworks will also facilitate comparison across healthcare settings and strengthen future research examining the long-term impact of precision nursing on patient outcomes, nursing practice, and healthcare delivery.

Challenges, Ethics, Equity, and Implementation Barriers

Although precision nursing has considerable potential to improve individualized care, its successful implementation requires addressing multiple ethical, technical, organizational, and professional challenges. The integration of genomic information, artificial intelligence (AI), biomarkers, electronic health records, and digital health technologies introduces new responsibilities for nurses while raising important concerns regarding privacy, equity, clinical accountability, and infrastructure. Addressing these challenges is essential to ensure that precision nursing remains safe, equitable, evidence-based, and patient-centered.

a) Privacy and Cybersecurity

Precision nursing relies heavily on large volumes of sensitive health information, including genomic data, electronic health records, wearable-device data, and patient-generated health information. Protecting these data from unauthorized access, cyberattacks, and inappropriate secondary use is fundamental to maintaining patient trust and professional accountability. Genomic information is particularly sensitive because it contains lifelong biological information that may also have implications for family members. Consequently, healthcare organizations must implement robust cybersecurity measures, secure data storage systems, access controls, and regulatory compliance to protect patient confidentiality throughout the data lifecycle (Booth et al., 2021; Dankwa-Mullan, 2024; Ronquillo et al., 2021).

Nurses also play an important role in protecting digital health information by following institutional privacy policies, educating patients about data security, documenting accurately, and ensuring appropriate use of digital technologies during clinical practice.

b) Informed Consent and Genomic Ethics

Obtaining informed consent becomes increasingly complex when genomic testing and precision health technologies are incorporated into routine nursing practice. Patients must understand the purpose of genomic testing, potential benefits, possible limitations, incidental findings, future use of genetic information, and implications for biological relatives before consenting to testing. Nurses frequently serve as the primary healthcare professionals responsible for explaining these issues in language that patients can understand.

Ethical challenges also arise when genomic testing reveals unexpected findings unrelated to the original clinical indication or identifies hereditary conditions that may affect family members. These situations require careful communication, respect for patient autonomy, confidentiality, and appropriate referral to genetic counselling services. Nurses must balance patients' right to privacy with broader ethical responsibilities while ensuring that genomic information is communicated accurately and compassionately (Calzone et al., 2018; Limoges et al., 2024; Tonkin et al., 2020).

c) Algorithmic Bias and Health Equity

Artificial intelligence and predictive analytics are increasingly incorporated into precision nursing; however, algorithmic bias remains a significant concern. AI systems are developed using historical datasets that may underrepresent certain populations or reflect existing healthcare inequalities. When biased data are used to train predictive models, clinical recommendations may unintentionally disadvantage specific racial, ethnic, socioeconomic, or geographically underserved populations.

Such bias may lead to inaccurate risk prediction, unequal treatment recommendations, delayed diagnosis, or reduced access to healthcare services. Nurses should therefore critically evaluate AI-supported recommendations rather than accepting them uncritically. Transparent algorithm development, diverse training datasets, continuous validation, and regular bias auditing are essential to ensuring equitable implementation of precision nursing technologies (Dankwa-Mullan, 2024; Khoury et al., 2022; Obermeyer et al., 2019; Roberts et al., 2024).

d) Digital Inequality

Despite rapid advances in digital health, unequal access to technology continues to limit implementation of precision nursing. Many patients experience barriers related to internet connectivity, affordability of digital devices, limited digital literacy, language differences, disability, or geographic isolation. These disparities are particularly evident in rural communities, low-income populations, and older adults, who may have limited access to wearable devices, telehealth services, or mobile health applications.

Digital inequality can reduce patient engagement, restrict access to precision healthcare, and widen existing health disparities if not addressed through inclusive implementation strategies. Nurses are well positioned to identify patients at risk of digital exclusion, provide education regarding digital technologies, advocate for equitable access, and adapt care plans according to individual patient circumstances (Farias et al., 2020; Lopes-Júnior, 2025; Mattison et al., 2022).

e) Legal and Professional Accountability

As AI-supported decision-support systems become more common, questions regarding legal responsibility and professional accountability continue to emerge. Although digital technologies may provide evidence-based recommendations, final clinical decisions remain the responsibility of licensed healthcare professionals. Nurses must interpret technology-generated information within the broader clinical context while considering patient preferences, ethical principles, and professional standards of care.

Clear organizational policies defining professional responsibilities, documentation requirements, and governance structures are necessary to reduce legal uncertainty surrounding AI-assisted healthcare. Ongoing education will also ensure that nurses understand both the capabilities and limitations of emerging precision technologies while maintaining safe and accountable clinical practice (El Arab et al., 2025; Hassanein et al., 2025; Ronquillo et al., 2021).

f) Technology and Infrastructure Barriers

Implementation of precision nursing also depends on robust healthcare infrastructure capable of integrating multiple sources of clinical information. Many healthcare organizations continue to experience challenges related to poor interoperability between electronic health records, inconsistent data quality, fragmented digital systems, alert fatigue, workflow disruption, implementation costs, and insufficient

technical support. These barriers reduce the efficiency of digital technologies and may limit clinician acceptance.

Successful implementation requires investment in interoperable health information systems, standardized data formats, reliable digital infrastructure, workforce training, and multidisciplinary collaboration among clinicians, information technology specialists, healthcare administrators, and policymakers. Continuous evaluation of system performance and user experience is equally important to ensure that technology enhances rather than complicates nursing practice (Booth et al., 2021; Hassanein et al., 2025; Smuck et al., 2021).

Nursing Education, Leadership, and Policy

The successful integration of precision nursing into routine healthcare depends not only on technological advancement but also on a well-prepared nursing workforce, effective leadership, and supportive health policies. As genomics, biomarkers, pharmacogenomics, artificial intelligence (AI), and digital health technologies become increasingly embedded in clinical practice, nurses require new competencies that extend beyond traditional nursing education. Academic institutions, healthcare organizations, professional bodies, and policymakers must collaborate to ensure that nurses possess the knowledge, skills, and ethical competencies needed to deliver individualized, data-driven, and patient-centred care.

a) Required Precision Nursing Competencies

Precision nursing requires a multidisciplinary competency framework that combines scientific knowledge, digital literacy, and clinical decision-making skills. Core competencies include genomic literacy, biomarker interpretation, pharmacogenomics, data literacy, digital health competence, AI literacy, ethical reasoning, patient communication, and shared decision-making. Nurses must be able to understand genomic information, interpret biomarker results, evaluate AI-supported clinical recommendations, and integrate multiple sources of health data into individualized care planning while maintaining patient safety and professional accountability (Calzone et al., 2024; Dante et al., 2025; McLaughlin et al., 2024; Regan et al., 2019; Thomas et al., 2023).

Equally important are communication and critical-thinking skills. Nurses should be able to explain complex genomic concepts in language that patients and families can understand, support informed decision-making, and address ethical concerns related to genetic testing and digital health technologies. Continuous professional development will therefore remain essential as precision healthcare continues to evolve.

b) Curriculum Development

Preparing the future nursing workforce requires substantial changes to undergraduate, graduate, and continuing nursing education. Precision nursing concepts should be integrated throughout nursing curricula rather than taught as isolated topics. Educational programs should include genomics, pharmacogenomics, digital health technologies, artificial intelligence, health informatics, data interpretation, ethical decision-making, and interdisciplinary collaboration.

Simulation-based learning, virtual clinical environments, and case-based teaching can provide opportunities for students to apply precision nursing principles to realistic clinical scenarios. Continuing professional education is equally important for practicing nurses who must continually update their knowledge as emerging technologies become integrated into healthcare delivery. Interprofessional education involving medicine, pharmacy, genetics, bioinformatics, and information technology will further strengthen collaborative practice and improve implementation of precision healthcare (Calzone et al., 2024; Fulton et al., 2024; McLaughlin et al., 2024; Tonkin et al., 2020).

c) Nursing Leadership

Nurse leaders play a critical role in translating precision nursing from research into everyday clinical practice. Their responsibilities extend beyond technology adoption to include workforce preparation, strategic planning, ethical governance, quality improvement, and organizational change management. Effective leadership ensures that digital innovations are implemented safely, align with evidence-based practice, and support high-quality patient care.

Leaders must also promote interdisciplinary collaboration, advocate for adequate resources, establish competency development programmes, and

evaluate the impact of precision nursing initiatives on patient outcomes and workforce performance. By fostering a culture of continuous learning and innovation, nurse leaders can facilitate successful implementation while maintaining patient-centred values and professional standards (Booth et al., 2021; Fangonil-Gagalang et al., 2025; Ronquillo et al., 2021).

d) Policy and Regulation

The continued advancement of precision nursing requires comprehensive policies that support safe, ethical, and equitable implementation. Policy priorities include genomic data protection, AI governance, digital health standards, interoperability, equitable access to emerging technologies, professional accountability, and standardized competency requirements. Regulatory frameworks should provide clear guidance regarding data privacy, informed consent, algorithm transparency, and the responsible use of AI-supported clinical decision support systems.

National nursing organizations, healthcare regulators, and government agencies should collaborate to establish evidence-based standards that promote consistency across healthcare settings while protecting patients and healthcare professionals. Policies should also encourage equitable access to genomic services and digital health technologies to ensure that the benefits of precision nursing are available across diverse populations rather than limited to well-resourced healthcare systems. Continued investment in research, workforce development, and digital infrastructure will further support sustainable implementation of precision nursing worldwide (Dankwa-Mullan, 2024; Khoury et al., 2022; Roberts et al., 2024).

Future Directions and Research Priorities

Precision nursing is expected to evolve rapidly as advances in genomics, digital health, artificial intelligence (AI), and data science continue to reshape healthcare delivery. Future developments will extend beyond individualized treatment toward predictive, preventive, and continuously adaptive models of care that integrate multidimensional health information across clinical and community settings. Continued research is essential to strengthen the evidence base, improve implementation, and ensure that technological innovation translates into meaningful improvements in patient outcomes and health equity.

a) Multi-Omics Integration

Future precision nursing will increasingly incorporate multi-omics approaches that combine genomics, proteomics, metabolomics, epigenomics, and microbiomics to provide a more comprehensive understanding of disease mechanisms and individual health variation. Integrating these biological data with clinical assessment and digital health information will support more accurate risk prediction, earlier diagnosis, and highly personalized nursing interventions. Nurses will require additional education and interdisciplinary collaboration to interpret increasingly complex biological information and translate it into safe, patient-centred care (Hammer et al., 2025; Roberts et al., 2024).

b) Explainable and Responsible Artificial Intelligence

Although AI has demonstrated substantial potential within precision nursing, future research should prioritize the development of transparent, explainable, and ethically responsible AI systems. Improving algorithm interpretability, reducing bias, strengthening human oversight, and validating AI models across diverse patient populations will increase clinician confidence and promote safe clinical adoption. Research should also examine nurses' acceptance of AI technologies and identify strategies for integrating AI into routine clinical workflows without diminishing professional judgement (Dankwa-Mullan, 2024; Obermeyer et al., 2019; Ronquillo et al., 2021).

c) Precision Home and Community Care

Advances in wearable technologies, home sensors, remote patient monitoring, and virtual nursing are expected to expand precision nursing beyond hospitals into patients' homes and communities. Future care models will increasingly combine real-time monitoring, personalized prevention, and community-based risk assessment to improve chronic disease management while supporting ageing in place. These developments may reduce unnecessary hospital admissions and improve healthcare accessibility for geographically underserved populations (Farias et al., 2020; Lopes-Júnior, 2025; Mattison et al., 2022).

d) Priority Areas for Nursing Research

Future nursing research should focus on evaluating

nursing-sensitive precision outcomes, implementation strategies, clinical effectiveness, cost-effectiveness, patient acceptability, workforce preparedness, and health equity. Large multicentre studies, implementation science, and longitudinal evaluations are needed to determine how precision nursing influences patient outcomes across diverse healthcare settings. Continued collaboration among nurses, geneticists, clinicians, data scientists, engineers, and policymakers will accelerate evidence generation and support sustainable integration of precision nursing into healthcare systems worldwide (Fangonil-Gagalang et al., 2025; Hammer et al., 2025; Hickey et al., 2019).

Conclusion

Precision nursing represents a significant advancement in contemporary healthcare by integrating genomic, biomarker, pharmacogenomic, clinical, behavioral, environmental, and digital information to support individualized, evidence-based nursing care. Throughout this review, evidence demonstrates that precision nursing enhances risk assessment, strengthens clinical decision-making, improves symptom management, promotes patient engagement, and supports more effective coordination of care across multiple nursing specialties. The integration of artificial intelligence, predictive analytics, wearable technologies, remote patient monitoring, and electronic health records further expands nurses' ability to deliver proactive and personalized interventions while maintaining patient-centred practice.

Despite these opportunities, widespread implementation requires continued investment in workforce education, digital infrastructure, interoperability, ethical governance, and equitable access to precision health technologies. Nurses must develop competencies in genomics, digital health, data literacy, pharmacogenomics, and AI while preserving professional judgement, compassionate communication, and ethical responsibility. Healthcare leaders and policymakers also have essential roles in establishing supportive regulatory frameworks, promoting interdisciplinary collaboration, and reducing disparities in access to precision healthcare.

As healthcare continues to transition toward personalized and data-driven models of care, precision nursing is positioned to become a cornerstone of modern nursing practice. Continued research, innovation, and professional development will be critical to ensuring that precision nursing improves patient outcomes, strengthens healthcare systems, advances health equity, and prepares the nursing profession for the future of individualized healthcare.

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