

**PERSONALIZED MEDICINE AND LABORATORY TESTING: THE EXPANDING ROLE
OF NURSING IN TAILORED PATIENT CARE**

*Abdulrhman Ali Almazam, Ali Khalil Hassan Khader, Ali Jamal Alanazi, Nawal Hayef Bejad Almutairi,
Meshal Abdullah Alanazi

Ministry of National Guard Health Affairs.

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*Corresponding Author: Abdulrhman Ali Almazam

Ministry of National Guard Health Affairs.

<https://shorturl.at/as87p>

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ABSTRACT

Background: Personalized medicine represents a transformative approach to healthcare, tailoring treatment strategies based on individual patient characteristics, such as genetics, environment, and lifestyle. Laboratory testing plays a pivotal role in identifying biomarkers, genetic variations, and other critical data essential for the development of personalized care plans. Nursing professionals, with their patient-centered focus and role in care coordination, are increasingly integral to implementing personalized medicine in clinical settings. Despite its potential, the integration of personalized medicine faces challenges, including ethical considerations, disparities in access, and the need for interdisciplinary collaboration. **Aim:** This paper aims to explore the expanding role of nursing in personalized medicine, particularly in the context of laboratory testing and tailored patient care. It investigates how laboratory innovations support personalized medicine, examines nursing's responsibilities in this evolving paradigm, and highlights the impact of tailored interventions on patient outcomes. **Methods:** A comprehensive literature review was conducted, analyzing peer-reviewed articles, case studies, and clinical guidelines from 2000 to 2023. Key databases such as Pub Med, Scopus, and Web of Science were utilized. Thematic synthesis was employed to identify the intersections between laboratory testing, personalized medicine, and nursing practices. Additionally, case studies were reviewed to illustrate real-world applications of nursing roles in personalized care. **Results:** Advances in laboratory testing, including genomic and proteomic profiling, have significantly enhanced the development of personalized medicine. Biomarker-based diagnostics and pharmacogenomic testing enable precise treatment strategies, reducing adverse drug reactions and improving therapeutic efficacy. Nurses play a critical role in translating laboratory findings into actionable care plans, educating patients on tailored treatments, and monitoring adherence and outcomes. Case studies demonstrate that nursing interventions improve patient satisfaction, treatment adherence, and overall health outcomes in personalized care models. **Conclusion:** The integration of laboratory testing and personalized medicine is reshaping patient care, with nursing professionals playing a vital role in bridging the gap between technological advances and patient-centered care. By leveraging their expertise in communication, education, and care coordination, nurses ensure the effective implementation of tailored interventions. To fully realize the potential of personalized medicine, interdisciplinary collaboration, policy support, and enhanced nursing education are essential. This paper underscores the critical need to empower nursing professionals through training and resources to meet the demands of personalized care.

KEYWORDS: Personalized medicine, laboratory testing, nursing interventions, tailored patient care, genomic medicine, biomarkers.

INTRODUCTION

Personalized medicine represents a significant leap forward in modern healthcare, focusing on enhancing patient outcomes by customizing treatment approaches based on each individual's unique genetic makeup, environmental influences, and lifestyle choices. This approach contrasts sharply with traditional models of healthcare, which often rely on generalized protocols that

may not account for the diversity of patient populations. At the heart of personalized medicine lies laboratory testing, which plays a vital role in identifying genetic markers, biomarkers, and various diagnostic indicators that are essential for tailoring treatment plans to individual patients. Nurses are essential in bringing personalized care to life, serving as the vital link that connects clinical innovations with practices focused on

the needs of patients. Nursing professionals play a crucial role in the success of personalized medicine by interpreting laboratory results, educating patients, and coordinating multidisciplinary care plans.

The integration of personalized medicine into healthcare frameworks holds transformative potential, addressing longstanding challenges such as variability in treatment efficacy and adverse drug reactions. Theories such as precision health and genomic medicine lay the groundwork for personalized approaches, highlighting the significance of tailored diagnostics and interventions.^[1,2] Furthermore, the role of nursing is closely aligned with the principles of patient-centered care, highlighting its significance in the context of personalized treatment approaches. This alignment not only improves the delivery of care but also signifies the increasing acknowledgment of nursing as an essential part of the interdisciplinary healthcare team.

The recent developments highlight the rapid progress being made in the fields of personalized medicine and laboratory testing. For example, progress in genomic sequencing technologies, such as next-generation sequencing, has revolutionized biomarker identification and risk stratification, allowing for more accurate predictions of disease susceptibility and treatment response.^[1] At the same time, progress in proteomics and metabolomics has broadened the horizons of laboratory diagnostics, providing a more profound understanding of intricate disease mechanisms.^[3] Additionally, the incorporation of artificial intelligence (AI) into laboratory processes has enhanced the efficiency and precision of data interpretation, supporting real-time decision-making in clinical settings.^[4] The trends observed in this field highlight a vibrant landscape that is transforming not only the diagnostic capabilities available but also the functions and responsibilities of healthcare providers.

This paper delves into the convergence of personalized medicine, laboratory testing, and nursing, emphasizing the essential function of nursing in the execution of customized patient care. The initial section explores the essential principles of personalized medicine and its dependence on advancements in laboratory technology. The second section examines laboratory testing technologies, highlighting their applications in clinical practice. The third section delves into the changing roles of nurses within this framework, highlighting the significant impact they have on patient outcomes. The paper wraps up with a thoughtful examination of the challenges and opportunities that lie ahead, along with recommendations for weaving personalized medicine into the fabric of mainstream healthcare. It highlights the crucial role that the nursing profession plays in this transformative process.

Foundations of Personalized Medicine

Historical Evolution From Generalized Treatments to Individual-Specific Approaches

The evolution of personalized medicine marks a significant shift from one-size-fits-all healthcare models to treatments tailored to the unique characteristics of each patient. Historically, medical practice relied heavily on generalized approaches, using population-based averages to inform treatment protocols. While effective for many, this method often failed to account for individual variations in genetics, environment, and lifestyle, leading to inconsistent outcomes and a significant burden of adverse drug reactions.^[5] The introduction of personalized medicine in the late 20th century signified a paradigm shift, fueled by advancements in molecular biology and the Human Genome Project, which culminated in the mapping of the human genome in 2003.^[6] This achievement laid the foundation for understanding genetic variations and their implications for disease susceptibility and treatment responses.

Milestones in Laboratory Testing Technology

Laboratory testing has played a pivotal role in the realization of personalized medicine. Early diagnostic tests were limited to basic biochemical assays, but the advent of high-throughput technologies revolutionized the field. Notably, polymerase chain reaction (PCR) technology, developed in the 1980s, enabled the amplification of specific DNA sequences, facilitating early genetic testing.^[7] This was followed by advancements in microarray technology and, more recently, next-generation sequencing (NGS), which have made comprehensive genomic analysis more accessible and affordable.^[8] These innovations have expanded the diagnostic capabilities of laboratories, enabling the identification of actionable genetic mutations and biomarkers with unprecedented precision. The progression from simple diagnostic assays to integrative multi-omic platforms underscores the transformative potential of laboratory testing in personalized medicine.

Role of Genomics and Biomarkers

Advances in Genetic Sequencing and Their Applications in Medicine

Genomic technologies, particularly NGS, have revolutionized personalized medicine by enabling comprehensive and efficient sequencing of the human genome. These advances have made it possible to identify single nucleotide polymorphisms (SNPs) and structural variants associated with diseases, such as cancer and cardiovascular disorders.^[9] For example, BRCA1 and BRCA2 gene mutations, identified through genomic sequencing, are now routinely used to guide breast and ovarian cancer prevention strategies.^[10] Additionally, pharmacogenomics—using genomic data to optimize drug therapies—has become a cornerstone of personalized medicine, allowing for the prediction of drug efficacy and the prevention of adverse reactions based on genetic profiles.^[11]

Importance of Laboratory Tests in Identifying Actionable Biomarkers

The identification and validation of biomarkers are critical to the success of personalized medicine. Laboratory tests are instrumental in translating genomic discoveries into clinical applications by identifying biomarkers indicative of disease states, treatment responses, or prognostic outcomes. Biomarkers such as HER2 in breast cancer and EGFR mutations in lung cancer have transformed therapeutic strategies, enabling targeted interventions that improve efficacy and reduce toxicity.^[12] Furthermore, laboratory tests that integrate genomic, proteomic, and metabolomic data provide a comprehensive understanding of disease mechanisms, paving the way for holistic and personalized approaches to patient care.^[13]

Challenges in Implementation

Cost and Accessibility Issues

Despite its potential, personalized medicine faces significant implementation barriers, particularly in terms of cost and accessibility. Genomic sequencing and advanced biomarker testing, while increasingly affordable, remain expensive relative to traditional diagnostic methods, limiting their adoption in resource-constrained settings.^[14] Additionally, the infrastructure required for personalized medicine—such as bioinformatics tools and trained personnel—poses challenges for healthcare systems in low- and middle-income countries.^[15] Addressing these disparities is critical to ensuring that the benefits of personalized medicine are equitably distributed.

Ethical Concerns, Including Data Privacy

Ethical considerations represent another significant challenge in the implementation of personalized medicine. The use of genomic data raises concerns about patient privacy and the potential for genetic discrimination. Ensuring the confidentiality of genetic information is paramount, yet the increasing complexity of data-sharing networks poses significant risks.^[16] Ethical debates also surround the issue of informed consent, particularly in cases where genetic testing reveals incidental findings that may have implications beyond the immediate scope of care.^[17] Establishing robust ethical frameworks and regulatory policies is essential to addressing these concerns while fostering public trust in personalized medicine.

Laboratory Testing as the Backbone of Personalized Medicine

Laboratory testing is a cornerstone of personalized medicine, providing the essential data needed to tailor medical interventions to individual patients. The integration of genomic, proteomic, and pharmacogenomic analyses into routine clinical practice has transformed traditional approaches to diagnosis, treatment, and disease prevention. By facilitating the identification of biomarkers, risk factors, and pharmacological profiles, laboratory testing enables

precision in medical decision-making, improving outcomes and minimizing adverse events.

Types of Laboratory Testing

Genomic and Proteomic Analysis

Genomic analysis, particularly through next-generation sequencing (NGS), has revolutionized personalized medicine by enabling comprehensive interrogation of the human genome. This technique identifies genetic variations, such as single nucleotide polymorphisms (SNPs) and structural variants, that influence disease susceptibility and treatment responses.^[18] Proteomic analysis complements genomic studies by evaluating protein expression profiles, elucidating molecular mechanisms of disease, and identifying potential therapeutic targets.^[19] Together, these methods provide a holistic understanding of the biological underpinnings of health and disease, paving the way for more effective interventions.

Companion Diagnostics

Companion diagnostics are laboratory tests designed to identify biomarkers that predict the efficacy and safety of specific therapies. These tests are integral to personalized medicine, ensuring that treatments are only administered to patients most likely to benefit from them. For instance, tests for HER2 overexpression in breast cancer guide the use of trastuzumab, while EGFR mutation testing informs the use of tyrosine kinase inhibitors in lung cancer.^[20] By stratifying patients based on molecular profiles, companion diagnostics enhance therapeutic precision and reduce unnecessary exposure to ineffective treatments.

Pharmacogenomic Testing

Pharmacogenomic testing examines the relationship between genetic variations and drug metabolism, efficacy, and toxicity. This type of testing identifies polymorphisms in genes encoding drug-metabolizing enzymes, transporters, and targets, enabling the customization of drug regimens to individual genetic profiles. For example, testing for CYP2C19 polymorphisms can guide the use of clopidogrel, a common antiplatelet medication, to avoid reduced efficacy in poor metabolizers.^[21] Similarly, pharmacogenomic tests for thiopurine methyltransferase (TPMT) activity inform the dosing of thiopurine drugs to prevent severe toxicity in patients with low enzyme activity.^[22]

Impact on Treatment Decisions

Personalized Drug Dosing

Laboratory testing facilitates personalized drug dosing by identifying patient-specific factors that influence drug pharmacokinetics and pharmacodynamics. Genetic testing for variants in the CYP450 enzyme family is widely used to optimize dosing for drugs such as warfarin, antidepressants, and antipsychotics.^[23] This approach minimizes the risk of adverse drug reactions

and enhances therapeutic efficacy by tailoring doses to the patient's metabolic capacity.

Risk Stratification and Disease Prevention

Biomarker testing plays a critical role in risk stratification and disease prevention. For instance, genetic testing for BRCA1 and BRCA2 mutations identifies individuals at high risk for breast and ovarian cancers, allowing for targeted preventive measures such as prophylactic surgery or enhanced surveillance.^[24] Similarly, lipidomic and metabolomic profiling are used to stratify cardiovascular risk, guiding interventions to prevent disease progression.^[25] These applications demonstrate the potential of laboratory testing to transform preventive care through early risk identification and targeted action.

Case Studies

Successful Applications of Laboratory-Guided Personalized Treatments

The efficacy of laboratory-guided personalized treatments is exemplified by several high-impact case studies. In oncology, the use of PD-L1 expression testing to guide immunotherapy with checkpoint inhibitors such as pembrolizumab has significantly improved outcomes for patients with advanced cancers.^[26] Another notable example is the management of chronic myeloid leukemia (CML) using BCR-ABL1 testing, which informs the use of tyrosine kinase inhibitors like imatinib, achieving remarkable survival rates.^[27] Beyond oncology, pharmacogenomic testing for HLA-B*5701 in HIV patients has enabled the safe use of abacavir by identifying individuals at risk for hypersensitivity reactions.^[28] These cases underscore the transformative impact of laboratory testing in enabling precise, effective, and safe patient care.

Expanding Role of Nursing in Personalized Medicine

Nursing professionals play a critical role in the implementation of personalized medicine, bridging the gap between advanced laboratory testing and patient-centered care. Their responsibilities extend from interpreting complex diagnostic information to coordinating care plans tailored to individual patient needs. As personalized medicine continues to evolve, the nursing profession must adapt to new challenges and opportunities, emphasizing collaboration, advocacy, and education to maximize its contributions to patient outcomes.

Nursing Responsibilities in Personalized Care

Interpretation and Communication of Lab Results

Nurses serve as vital intermediaries between the technical findings of laboratory tests and their practical application in patient care. By interpreting lab results, nurses ensure that patients and their families understand the implications of these findings. This is especially important in personalized medicine, where results often involve complex genetic or biomarker data that may be unfamiliar to patients.^[29] For example, explaining the

significance of BRCA1/BRCA2 genetic testing to a patient considering preventive measures for breast cancer requires not only technical knowledge but also the ability to communicate sensitively and effectively.^[30] Nurses thus play a key role in translating scientific findings into actionable healthcare strategies.

Development of Patient-Specific Care Plans

Personalized medicine demands care plans that are tailored to the unique genetic, environmental, and lifestyle factors of each patient. Nurses are instrumental in developing these plans, integrating laboratory findings with clinical observations and patient preferences. For instance, a nurse managing a patient with pharmacogenomic testing results may adjust medication regimens to account for genetic factors influencing drug metabolism.^[31] By combining clinical expertise with personalized data, nurses ensure that care plans are not only evidence-based but also aligned with the patient's goals and values.

Nursing in Multidisciplinary Teams

Collaboration with Physicians, Lab Technicians, and Pharmacists

The implementation of personalized medicine necessitates seamless collaboration among various healthcare professionals. Nurses act as coordinators within these multidisciplinary teams, facilitating communication and ensuring that laboratory findings are effectively integrated into clinical decision-making.^[32] For example, in oncology, a nurse may work closely with a physician to adjust a treatment plan based on tumor biomarker results, while collaborating with pharmacists to ensure the appropriate use of targeted therapies.^[33] This collaborative approach enhances the precision and efficacy of patient care, reflecting the holistic goals of personalized medicine.

Advocacy for Patient-Centered Approaches

Nurses have long been advocates for patient-centered care, a principle that aligns closely with the ethos of personalized medicine. By prioritizing the individual needs and preferences of patients, nurses ensure that personalized care plans are both scientifically sound and personally meaningful.^[34] Advocacy efforts often include addressing disparities in access to personalized medicine, particularly for underserved populations, and promoting equitable distribution of healthcare resources.^[35] This advocacy reinforces the ethical foundation of personalized medicine, emphasizing inclusivity and fairness.

Educational and Policy Implications

Need for Specialized Training in Genomics and Personalized Medicine

As the scope of personalized medicine expands, nursing education must adapt to equip professionals with the necessary skills and knowledge. Genomics, bioinformatics, and advanced laboratory techniques are now integral components of personalized care, requiring

specialized training for nurses.^[36] Continuing education programs and certifications in these areas can enhance nurses' ability to interpret genetic data and apply it in clinical practice. For example, programs focusing on pharmacogenomics enable nurses to guide medication decisions based on genetic testing results, improving patient safety and outcomes.^[37]

Recommendations for Incorporating Personalized Care in Nursing Curricula

To prepare future nurses for the challenges of personalized medicine, nursing curricula should integrate foundational and advanced concepts in genomics and individualized care. Core topics might include genetic counseling, ethical considerations in genetic testing, and the use of digital tools for personalized care planning.^[38] Policymakers and educational institutions must collaborate to standardize these curricula, ensuring consistency and quality across training programs. Additionally, initiatives to increase awareness of personalized medicine among practicing nurses can bridge the gap between theoretical knowledge and clinical application, fostering a workforce that is well-prepared to meet the demands of modern healthcare.^[39]

CONCLUSION

The rise of personalized medicine signifies a pivotal moment in the field of healthcare, offering the potential to improve patient outcomes by implementing customized therapeutic approaches. Personalized medicine fundamentally utilizes the latest developments in laboratory testing, genomics, and pharmacogenomics to provide treatments that are tailored to the unique genetic, environmental, and lifestyle characteristics of each individual. This method enhances the accuracy and effectiveness of medical treatments while also reducing the potential dangers linked to broad treatment strategies, including negative drug reactions and the ineffectiveness of therapies.

The foundation of personalized medicine lies in the essential role of laboratory testing, which serves as its core component for success. The advancements in genomic and proteomic analyses, along with companion diagnostics and pharmacogenomic testing, have significantly transformed the field of diagnostics. These innovations empower clinicians to pinpoint actionable biomarkers, thereby enhancing the precision of treatment decisions. The advancements in these technologies serve as a foundation for the predictive, preventive, and therapeutic possibilities inherent in personalized care, encouraging a more proactive strategy in managing health. Nonetheless, the significant expenses and difficulties in accessing these tests highlight the necessity for a fair allocation of resources, aiming to guarantee that the advantages of personalized medicine are accessible to all individuals.

Nursing plays a crucial role in personalized medicine, highlighting the profession's commitment to patient-

centered care and a comprehensive approach to health management. Nurses play a vital role in bridging the gap between intricate laboratory data and patient care. They interpret and communicate these complex insights, transforming them into personalized care plans that address the specific needs of each patient. Their partnership with diverse teams, which includes physicians, laboratory technicians, and pharmacists, facilitates the smooth incorporation of personalized medicine into clinical practice. Furthermore, nurses play a crucial role in advocating for fair access to individualized care, tackling inequalities and promoting inclusive practices within the healthcare system.

With the ongoing evolution of personalized medicine, it is essential that the educational and professional growth of nurses keeps pace with these advancements. It is crucial for nurses to receive specialized training in genomics, bioinformatics, and laboratory diagnostics in order to effectively navigate the complexities associated with personalized care. Incorporating these competencies into nursing curricula and fostering continuing education initiatives will empower nurses to fully engage in this paradigm shift. Furthermore, it will be essential to create policies and guidelines that promote the ethical application of personalized medicine. This approach is vital for protecting patient privacy and ensuring that data is used responsibly.

While personalized medicine holds remarkable promise for transforming healthcare, it encounters considerable obstacles that need to be overcome in order to fully harness its benefits. The ethical considerations surrounding data privacy and informed consent highlight the necessity for strong regulatory frameworks and the importance of interdisciplinary dialogue. Moreover, incorporating personalized medicine into healthcare systems requires significant investment in infrastructure, education, and research initiatives. Confronting these challenges necessitates a collaborative approach involving policymakers, healthcare professionals, and educational institutions.

To sum up, personalized medicine signifies a transformative change in the field of healthcare. It merges scientific advancements with a focus on the individual patient, aiming to reshape the benchmarks for diagnosis, treatment, and prevention. Nurses, as integral members of the healthcare team, play a pivotal role in translating the promise of personalized medicine into practical outcomes. Through the adoption of innovative laboratory testing methods, the promotion of collaboration across various disciplines, and a commitment to ethical and equitable practices, the nursing profession is poised to significantly influence the future of personalized care. The path forward lies in sustained investment, education, and collaboration, ensuring that personalized medicine becomes a cornerstone of global healthcare systems, accessible to

all and transformative for the health of future generations.

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"الطب الشخصي واختبارات المختبر: الدور المتوسع للمريض في رعاية المرضى المخصصة"

الملخص:

الخلفية:

يمثل الطب الشخصي نقلة نوعية في مجال الرعاية الصحية، حيث يتم تصميم العلاجات وفقاً للخصائص الفردية لكل مريض، بما في ذلك العوامل الوراثية والبيئية وأسلوب الحياة. تعتبر الاختبارات المخبرية، مثل التحليل الجيني وتحليل البروتينات، أدوات أساسية لدعم هذه النهج، حيث تساعد في الكشف عن المؤشرات الحيوية التي تعزز من دقة التشخيص والعلاج. ومع ذلك، يواجه تنفيذ الطب الشخصي تحديات تشمل التكاليف العالية والقضايا الأخلاقية مثل الخصوصية.

الهدف:

يهدف هذا المقال إلى استكشاف الدور الحيوي للمريض في الطب الشخصي، مع التركيز على تفسير نتائج الاختبارات المخبرية، تطوير خطط رعاية مخصصة، والعمل ضمن فرق متعددة التخصصات. كما يناقش أهمية تدريب الممرضين والممرضات على المهارات المتقدمة اللازمة لدعم تطبيق الطب الشخصي.

الطرق:

يعتمد المقال على مراجعة الأدبيات الحديثة المتعلقة بالطب الشخصي والاختبارات المخبرية ودور التمريض، مع تحليل أمثلة عملية لتطبيق الرعاية الصحية المخصصة.

النتائج:

تؤدي الاختبارات المخبرية دوراً أساسياً في تحسين القرارات العلاجية، مثل تحديد الجرعات الدوائية المثلى وتقليل المخاطر الجانبية. كما تبرز الممرضات كعنصر رئيسي في فرق الرعاية الصحية، حيث يعملن على تفسير النتائج المخبرية للمرضى، تطوير خطط علاجية تتماشى مع الاحتياجات الفردية، والتنسيق بين الفرق متعددة التخصصات. التدريب على علم الجينات واستخدام التكنولوجيا الطبية المتقدمة يعتبر أساسياً لتمكين الممرضات من دعم هذا النموذج العلاجي.

الخلاصة:

الطب الشخصي يقدم إمكانيات هائلة لتحسين نتائج الرعاية الصحية من خلال تقديم علاجات مخصصة للمرضى. يلعب التمريض دوراً حيوياً في تنفيذ هذا النهج، بدءاً من التفسير العلمي لنتائج الاختبارات وحتى العمل ضمن فرق طبية متعددة لضمان تطبيق الرعاية الفعالة. تعزيز التعليم التمريضي المتخصص ودعم السياسات الداعمة للطب الشخصي يساهمان في تحقيق التكامل بين العلم والممارسة.

الكلمات المفتاحية:

الطب الشخصي، التمريض، المؤشرات الحيوية، علم الجينات، الاختبارات المخبرية، الرعاية الصحية المخصص.