Wiadomości Lekarskie

Medical Advances

Official journal of the Polish Medical Association
Wiadomości Lekarskie has been published since 1928



Volume LXXVII, Issue 11, NOVEMBER 2024 ISSN 0043-5147 E-ISSN 2719-342X

Wiadomości Lekarskie

Medical Advances

Official journal of the Polish Medical Association
Wiadomości Lekarskie has been published since 1928

ALUNA Publishing

Volume LXXVII, Issue 11, NOVEMBER 2024



Memory of
dr Władysław
Biegański

Wiadomości Lekarskie Medical Advances is abstracted and indexed in:
PUBMED/MEDLINE, SCOPUS, EMBASE, INDEX COPERNICUS,
MINISTRY OF SCIENCE AND HIGHER EDUCATION, POLISH MEDICAL BIBLIOGRAPHY

Copyright: © ALUNA Publishing

Articles published on-line and available in open access are published under Creative Common Attribution-Non Commercial-No Derivatives 4.0 International (CC BY-NC-ND 4.0) allowing to download articles and share them with others as long as they credit the authors and the publisher, but without permission to change them in any way or use them commercially.

Distribution and Subscriptions:
Bartosz Guterman prenumerata@wydawnictwo-aluna.pl

Graphic design / production:
Grzegorz Sztank fajne.work

Publisher:
ALUNA Publishing
29 Przesmyckiego st.,
05-510 Konstancin – Jeziorna, Poland
www.wydawnictwo-aluna.pl
www.wiadomoscilekarskie.pl
www.wiadlek.pl

Wiadomości Lekarskie
Medical Advances

Official journal of the Polish Medical Association
Wiadomości Lekarskie has been published since 1928

Editorial Team

Editor in-Chief:
Prof. Paweł Kalinski – Buffalo, USA

Honorary Editor in-Chief:
Prof. Władysław Pierzchała – Katowice, Poland

Editors of the issue:
Prof. Dmytro Diachuk – Academician of the National Academy of Medical Sciences of Ukraine, Director of the State Institution of Science «Center of innovative healthcare technologies» State Administrative Department, Kyiv, Ukraine

Prof. Yurii Yashchenko – Deputy Director for Scientific Work, State Institution of Science « Center of innovative healthcare technologies» State Administrative Department, Kyiv, Ukraine

Deputy Editor in-Chief:
Prof. Waldemar Kostewicz – Warsaw, Poland
President Polish Medical Association

Statistical Editor:
Dr Lesia Rudenko – Konstancin-Jeziorna, Poland

Managing Editor:
Agnieszka Rosa – amarosa@wp.pl

International Editorial Office:
Nina Radchenko (editor) – n.radchenko@wydawnictwo-aluna.pl

International Editorial Board – in-Chief:

Marek Rudnicki — Chicago, USA

International Editorial Board – Members:

Stalbek M. Akhunbaev	Bishkek, Kyrgyzstan	Jerzy Robert Ładny	Bialystok, Poland
Kris Bankiewicz	San Francisco, USA	Stella Nowicki	Memphis, USA
Christopher Bara	Hannover, Germany	Alfred Patyk	Gottingen, Germany
Krzysztof Bielecki	Warsaw, Poland	Palmira Petrova	Yakutsk, Russia
Zana Bumbuliene	Vilnius, Lithuania	Waldemar Priebe	Houston, USA
Stanislav Czudek	Ostrava, Czech Republic	Maria Siemionow	Chicago, USA
Mowafaq Muhammad Ghareeb	Baghdad, Iraq	Aleksander Sieroń	Katowice, Poland
Nataliya Gutorova	Kharkiv, Ukraine	Vladyslav Smiianov	Sumy, Ukraine
Marek Hartleb	Katowice, Poland	Tomasz Szczepański	Katowice, Poland
Roman Jaeschke	Hamilton, Canada	Andrzej Witek	Katowice, Poland
Andrzej Jakubowiak	Chicago, USA	Jerzy Woy-Wojciechowski	Warsaw, Poland
Peter Konturek	Saalfeld, Germany	Zbigniew Wszolek	Jacksonville, USA
George Krol	New York, USA	Vyacheslav Zhdan	Poltava, Ukraine

REVIEW ARTICLE

CONTENTS

Medical genetics as a basis for personalized medicine in contemporary Ukraine

Lyudmila O. Turova, Tatiana A. Vezhnovets, Andrii I. Kurchenko
BOGOMOLETS NATIONAL MEDICAL UNIVERSITY, KYIV, UKRAINE

ABSTRACT

Aim: To systematize and comprehensively analyze scientific sources and research on integrating personalized medicine into the national healthcare system.

Materials and Methods: A comprehensive literature review was conducted using PubMed, Google Scholar, and Scopus, focusing on data from the past 10 years (2014-2024). Articles in both English and Ukrainian were analyzed. Personalized approaches from the authors' own research were also included. The following methods were used: a systematic approach and bibliosemantic analysis.

Conclusions: However, for the implementation of personalized medicine in Ukraine, it is necessary to have awareness of the medical community about the possibilities of using molecular genetic profiling, competence to conduct risk assessment with the participation of several specialists, with the involvement of the patient in decision-making on treatment and diagnostic measures. The main tools for the widespread implementation of personalized medicine in Ukraine are qualified specialists, a wide network of molecular genetic diagnostics and pharmacogenetics laboratories, the development of competencies among healthcare providers and the development of personalized pharmacy. The expected result is the widespread implementation of diagnostic and treatment programs using personalized protocols based on the state of the individual patient's body at a specific time.

KEY WORDS: personalized medicine; omics technologies; health care

Wiad Lek. 2024;77(11):2340-2347. doi: 10.36740/WLek/197123 DOI

INTRODUCTION

Traditional approach to treatment design is based on the universal protocols chosen according to the diagnosed condition. For the reason that disease is an interplay of many variables characteristic of an individual and their environment, the one-fits-all paradigm does not always hold true [1]. The new means of biological data generation and the analysis schemes to derive clinically-relevant insights from the resulting data greatly contributed to precision medicine application in modern medicine. Precision medicine created an avenue for more detailed stratification of patients into the subgroups classified by the potential response to the treatment or a specific drug, which in most cases leads to better treatment outcomes, minimized side-effects and reduced waste of resources. But in practice, simplifying the unique patient case to a set of biological features may be suboptimal to the treatment outcomes. Modern medicine proposes a more comprehensive approach – personalized medicine (PM), which seeks to incorporate not only unique biological characteristics, but also social, psychological, environmental and individual preferences in personalizing the treatment.

Precision and personalized medicine are terms frequently used interchangeably [1]. The common aim of better optimizing clinical decisions for individual cases, along with the phonetic similarity of the terms, has led to confusion in the scientific literature. While precision medicine is data-driven and deeply-rooted in processing large volumes of biological data to obtain the protocols tailored to the specific biological profiles, personalized medicine utilizes a more holistic approach. Personalization attempts to individualize the treatment according to a fully unique case, as opposed to simply segregating patients into groups based on available biomarkers. Personalized schema involves a more interactive relationship between healthcare providers and patients, where treatment plans are co-created based on a combination of scientific evidence and individual circumstances [2].

AIM

The article is aimed at substantiating the implementation and prospects for the development of personalized medicine in Ukraine. Current trends in personalized medicine are outlined, focusing on the improvement of

public health monitoring systems, innovative methods of genetic diagnosis, and disease prevention. The widespread introduction of personalized medicine in Ukraine is supported by the formation of relevant competencies, the establishment of a wide network of molecular genetic diagnostics and pharmacogenetics laboratories, and the involvement of healthcare organizations, which are expected to significantly enhance specialized medical care. The purpose of the work is to systematize and comprehensively analyze scientific sources and research on the integration of the personalized medicine paradigm into the national healthcare system.

MATERIALS AND METHODS

The analysis of literature sources was conducted using the search engines for personalized medicine and biomedical research PubMed and Google Scholar, and the abstract database of scientific literature Scopus. Data for the last 10 years (2014–2024) were analyzed. We searched for articles in English and Ukrainian. Examples of our own research using personalized methods are provided. The following methods were used: systematic approach, bibliosemantic analysis.

REVIEW AND DISCUSSION

RELEVANCE OF PERSONALIZED MEDICINE IN THE WORLD AND IN UKRAINE

The utilization precision as one of the components comprising personalized medicine has long been proven effective [2–4]. Testing for biomarkers is increasingly recognized as a valuable tool, especially in chemotherapy prescription, when recognizing that only a fraction of patients will eventually benefit from a drug [5]. Testing shows means of narrowing the pool of candidate medications and helps avoid trial-and-error approach to the selection, which both improves the prognosis and reduces the costs. Given the rise of medical genetics and the testing.

In Ukraine, the relevance of PM is particularly pronounced given the slowed population growth, aging demographics [6], and the increasing burden of chronic diseases [7]—all of which contribute to escalating need in quality healthcare. The Personalized Prevention of Chronic Diseases (PRECeDI) consortium project underlines thet personalized prevention must be prioritized as a cost-effective measure to relieve the burden of chronic disease [8]. This is critical given the trend of increasing disability years in European countries. By adopting an individualized approach, PM could alleviate these burdens through targeted preventive measures and more effective treatments, thereby improving patient prognoses and reducing long-term healthcare costs.

As advanced PM models become integrated into clinical practice, clinicians will increasingly rely on electronic health records to make informed, real-time decisions, minimizing the need for repeated testing and further optimizing resource utilization. Overall, personalized medicine not only aims to enhance individual health outcomes but also seeks to alleviate financial pressures on healthcare systems through preventive care and efficient resource management [2, 9].

The all-encompassing nature of personalized framework is partially reflected in earlier models. Predictive, preventive and personalised medicine (PPPM), brought forth by European Association for Predictive, Preventive and Personalised Medicine (EPMA) [1], lacks participatory component, included in the P4 public health model fostered by Leroy Hood since the beginning of millenia [10]. Personalization covers all above mentioned points but is not limited to them. Galdo et al. [11] identified three critical aspects missing in the P4 approach and formulated the extended 7P model of medicine, which acknowledges the importance of minimal disruption of patient's life rhythm, parsimonious approach to prescribing medical interventions of any kind as well as incorporation of scientific knowledge into clinical practice.

These aspects collectively (Fig. 1) enhance the personalization of treatment by integrating individual data and preferences into healthcare strategies, ultimately aiming for better health outcomes.

TRANSFORMATION OF 4-5P MEDICINE INTO 7P MEDICINE

The transition to personalized, prognostic, preventive and participatory medicine is driven by significant advances in basic science, digitalization and the development of information and communication technologies, providing a highly dynamic, adaptable and simultaneously personalized approach—anywhere and anytime [12–14].

However, changes in the healthcare system require natural actions and initiatives to improve legal regulations necessary to comply with the new legal environment, moral and ethical principles of a democratic state. [15].

One of the important components of the implementation of this system and the transformation of health care is the need to train modern specialists who are ready to work in the new conditions—both to participate in basic science research and to implement innovative methods in clinical practice, medical and social care, and the educational process [16]. It is the

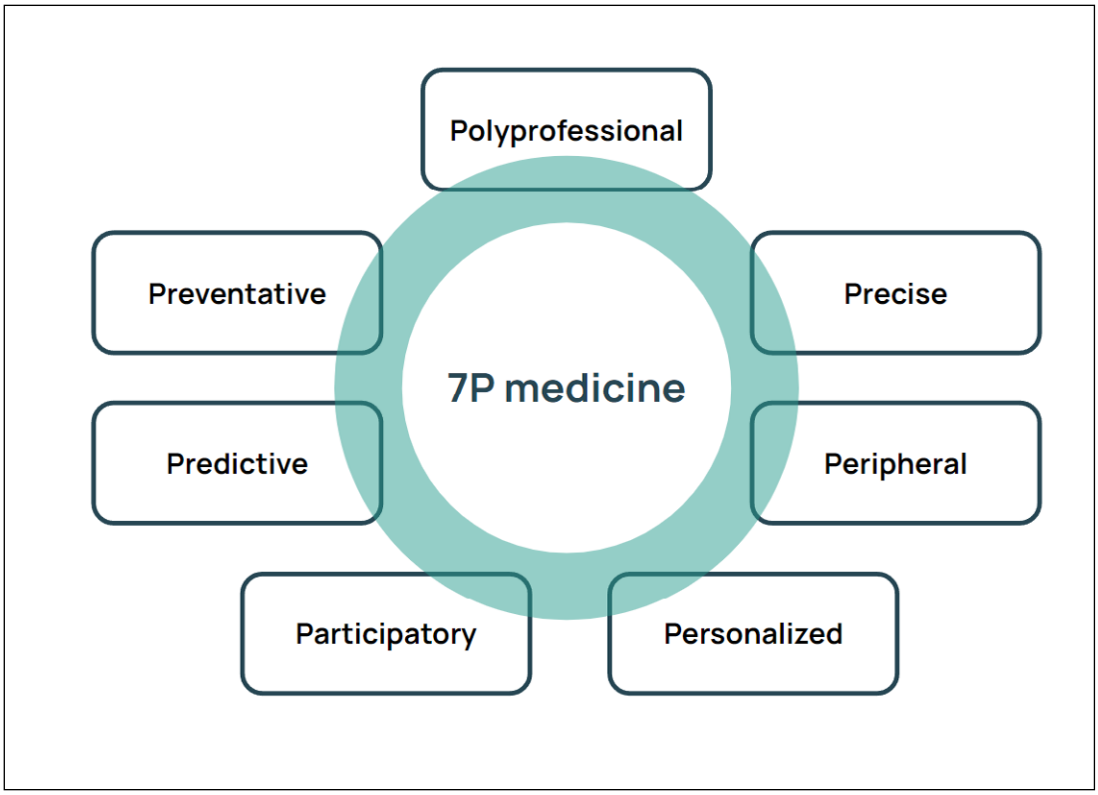


Fig. 1. The components of 7P medicine.

multidisciplinary team that is an absolutely necessary component in the implementation of consistent changes – improvement of the health care model.

PERSONALIZED MEDICINE IN CLINICAL PRACTICE WORLDWIDE

The Personalized Medicine Coalition (PMC) publishes an annual report summarizing the drugs approved by the U.S. Food and Drug Administration (FDA) that are classified as personalized. According to PMC [17], "those therapeutic products for which the label includes reference to specific biological markers identified by diagnostic tools" can be considered personalized. The 2023 report discussed 5 newly approved gene or cell-based therapies reverting rare genetic conditions, 6 new molecular entities found effective in cancer treatment, with some targeting rare forms, personalized therapy for the treatment of Alzheimer's disease and many more, including novel individualized diagnostics and drug combinations. Overall, the 2023 report states that personalized medicines have accounted for at least one-quarter of all new medicines approved for almost the entire decade, making personalization an increasingly sound approach that offers more and more options to those in need.

The diagnostic component of drug prescription personalization is achieved through the means of pharmacogenetic testing. Pharmacogenetics refers to the field of study focusing on the interaction between the individual genetic makeup and a response to a medication, aiming at precise drug selection for the maximization of treatment efficacy and the minimization of adverse reaction probability. For example, individuals with poor metabolizer status for irinotecan derive significant benefit from a genotype-guided dosage strategy, with a reduction in the risk of life-threatening neutropenia and severe diarrhea [18]. Warfarin is another drug with strongly genotype-dependent dosage, varying from 1 to 10 mg a day. The implementation of pharmacogenetic testing has been demonstrated to reduce the dosage adjustment period and to result in a notable decrease in the risk of bleeding or thromboembolism associated with the titration of warfarin.

Acknowledging the role of genetic variation in clinical decision-making, FDA keeps and regularly updates a table titled "Pharmacogenomic Biomarkers in Drug Labeling" [19], listing the personalized drugs and their corresponding biomarkers. Yet another resource called "Table of Pharmacogenetic Associations" [20], also maintained by FDA, keeps the record of drugs for which the evidence of gene-drug interaction is substantial and suggests the optimized approach accordingly. Application of pharmacogenetic testing still remains complicated by the translation of the findings from the lab to clinic. To further aid in the adoption of pharmacogenetics testing, Clinical Pharmacogenetics Implementation Consortium (CPIC) [21] offers standardized,

evidence-based and peer-reviewed drug-gene guidelines. The PharmGKB Genotype Selection Interface (GSI) [22] provides a convenient means of accessing genotype-tailored and up-to-date recommendations, aggregating CPIC and Dutch Pharmacogenetics Working Group (DPWG) guidelines with FDA's approved drug labels and Table of Pharmacogenetic Associations.

Evidence suggests that the application of pharmacogenetic testing can not only enhance treatment outcomes but also offer cost-effective and cost-saving solutions.

Genetic testing may not only guide medication selection, but also offer insight into predisposition to certain conditions and confirm or help establish the diagnosis early [23]. Preconception screening is available on demand and allows assessing the risk of conveying a recessive disorder to the offspring, identifying not manifested variants in otherwise healthy carriers. A more popular option, non-invasive prenatal testing (NIPT), aims to detect chromosomal abnormalities through sequencing cell-free foetal DNA in maternal blood and is available almost worldwide. The application of prenatal screening fulfills supportive function in reproductive autonomy, allowing informed reproductive decisions during pregnancy. With an expanding panel of identifiable conditions NIPT has a potential to inform preventative and therapeutic measures even before birth [9, 23].

Newborn screening allows for the early identification of metabolic and genetic disorders, which can lead to timely interventions. Improved screening processes contribute to better health outcomes and reduced healthcare costs by preventing severe complications from undiagnosed conditions. The Recommended Uniform Screening Panel accepted in the USA covers only a small fraction of genetic disorders, namely 35 out of more than 7500 conditions with therapy options available. For rapid and cost-effective diagnosis, rapid whole-genome sequencing may be a viable option for critically-ill newborns, as explored in Project Baby Bear [24].

Genetic testing has become a cornerstone in the personalized treatment and diagnosis of epilepsy, significantly enhancing clinical outcomes [25]. The approach to genetic testing in neuropathology has evolved from single-gene tests best suited for monogenic disorders to gene panels and whole-exome sequencing, yielding the best diagnosis success rate in pediatric patients. Identifying the specific genetic variant an individual carries comprises a critical foundation for personalized gene therapy, for example in Dravet syndrome (DS), also known as severe myoclonic epilepsy of infancy [26].

The integration of person-centered medicine takes special notice in the education and training of the professionals who will manage the interpretation of the genetic testing and adjust the therapy course accordingly [8, 27]. Providing the clinicians, IT specialists and laboratory technicians with a broad understanding of personalization ensures productive collaboration and implementation of PM [28]. Two personalized multicenter initiatives Genomic Medicine Sweden (GMS) and the Centers for Personalized Medicine (ZPM) initiative in Germany arrange programs that provide exposure to the field of personalized medicine in a multidisciplinary setting [3].

EXAMPLES OF PERSONALIZED MEDICINE IMPLEMENTATION IN CLINICAL PRACTICE

Earlier, we developed, improved and implemented a model of a comprehensive, multidisciplinary, personalized approach to medical and genetic counseling of families to prevent the development of perinatal and congenital pathology in children [29]. Perinatology and pediatrics occupy a special place in the new healthcare model as the most important area of clinical medicine that studies the health of a child in the process of its development and growth. After analyzing all the factors that influence the formation of aspects of a child's health and taking into account the "molecular genetic portrait", we developed health programming paradigms and identified "windows of opportunity" for targeted intervention during these periods.

The principles of personalization were used to predict perinatal pathology based on immunogenetic predictors [30], in children born prematurely, which allowed us to determine the possibilities and potential of targeted stage rehabilitation. The introduction of personalized medicine in today's conditions to prevent a high incidence of perinatal pathology, especially in preterm infants, is of extremely high medical and social importance.

In our other works [30–35], the strategy of personalized medicine was implemented in practice both for children with different nosologies and for adult patients, and with the active participation of both the patient and his or her family in achieving disease control. We studied not only clinical phenotypes, but also molecular and biochemical phenotypes, which, with the help of modern neuroscience programming, allowed us to personalize diagnostic, therapeutic, preventive and rehabilitation measures of medical support.

The personalized and preventive concept of health maintenance and programming of intellectual disabilities based on genetic screening is described in [32, 34, 35]. The study demonstrates broad prospects for the application of molecular genetic screening of children with delayed psycho-neurological development in

clinical practice in order to predict the patient's rehabilitation potential and implement socially adapted development and health of the child, which is of particular importance in martial law conditions for both the health care system and the economic sector of the country.

In addition, in the context of a constant increase in the incidence of allergic diseases, algorithms for determining the molecular genetic profile of sensitization and manifestations of the multimorbid phenotype have been developed and put into practice both at the pre-dosage stage for personalization of preventive measures and for personalized therapy. The predictive role of identifying an individual allergy profile at the prenosological stage for the purpose of preventive measures, as well as the choice of measures for patients with a realized atopy phenotype with an optimal diagnostic algorithm, improving disease control, and programming the prognosis of the patient's further health status has been determined [31, 36].

In conclusion, a detailed and systematic clinical evaluation of big data (patient's metabolic phenotype, proteome, microbiome) is the basis for selecting a genetic test and further application of personalized medicine in practice. To diagnose a clinically heterogeneous phenotype, a multidisciplinary approach should be used, including a clinical geneticist, neurologist, cardiologist, family doctor, or pediatrician. Knowledge about the use of the latest methods of precision genetic diagnosis and interpretation of their results can help diagnose almost all pathological processes, but each patient requires a personalized approach based on a genetic map—a genome study [37].

Highlighting the progress of personalization, we conclude the current state and the examples of personalization by medical field.

ONCOLOGY AND CANCER TREATMENT

Individualized chemotherapeutic drugs containing a dose calculated for a particular patient enable the doctor to achieve the maximum therapeutic effect with minimal side effects in diagnosing tumors, monitoring the effectiveness of radiation and chemotherapy [38].

Orphan diseases. Today, the problem of orphan diseases in Ukraine and the world is extremely relevant. According to the European Committee of Experts for Rare Diseases (EUCERD), the total number of different orphan diseases reaches 8 thousand. Most of them require personalized treatment, which is the only way to save patients with orphan diseases [24, 34].

Hereditary genetic diseases, and congenital defects of the central nervous system, hereditary mental disorders, neurological diseases (epilepsy, migraine, Parkinson's disease, Alzheimer's disease, amyotrophic lateral sclerosis, etc.). A combination of non-pharmacological and pharmacological treatments makes up a personalized patient management scheme [39, 40].

Metabolic diseases of metabolism, cardiac diseases, diabetes mellitus, neurodegenerative diseases of the bone and joints, connective tissue diseases, lung diseases, and allergic diseases. A number of markers that help to identify the leading pathogenetic mechanism in each case become a guide to a personalized approach to patient treatment. Personalized medicine is already a reality for gastroenterology and cardiology. Allergen-specific immunotherapy (ASIT) is one of the first personalized treatments in allergology, the essence of which is the administration of allergens to the patient that cause allergic reactions in him [31, 39].

RESPONSE TO IMMUNOPROPHYLAXIS

To date, genetic loci associated with the maintenance of a vaccine-induced immune response have been studied [40].

Another important area of personalized intervention is anti-aging, nutritional genetics, stem cell treatment, regenerative and—another separate area—reproductive medicine. Targeted sequencing embodies the embodiment of the wildest dreams of prenatal medicine representatives: determining the extracellular DNA of the fetus circulating in the mother's blood allows diagnosing chromosomal rearrangements (Down, Edwards, Patau, Turner syndromes) and the likelihood of aneuploidy from the 5th week of pregnancy [29].

CONCLUSIONS

Personalized medicine using scientific and technological progress, achievements in the field of preventive and health-saving technologies, focused on programming and shaping the optimal health trajectory is the basis for preserving the health of the nation.

However, for the implementation of personalized medicine in Ukraine, it is necessary to have awareness of the medical community about the possibilities of using molecular genetic profiling, competence to conduct risk assessment with the participation of several specialists, with the involvement of the patient in decision-making on treatment and diagnostic measures. The main tools for the widespread implementation of personalized medicine in Ukraine are qualified specialists, a wide network of molecular genetic diagnostics and pharmacogenetics laboratories, the development of competencies among healthcare providers and the development of personalized pharmacy.

The expected result is the widespread implementation of diagnostic and treatment programs using personalized protocols based on the state of the individual patient's body at a specific time.

PROSPECTS FOR FURTHER RESEARCH

We are developing a mechanism for implementing personalized medicine for broad integration into healthcare. We are preparing recommendations and effective strategies to overcome the existing barriers and use the potential of personalized medicine to improve health outcomes. An important initiative is to engage all stakeholders, including a multidisciplinary team of healthcare professionals, researchers, scientists, policy makers, and patients, to actively participate in a transformative healthcare paradigm shift. This change will be more precise, predictable, patient-centered, and tailored to individual needs, ultimately leading to better health outcomes and quality of life for citizens.

REFERENCES

1. Zhu F, Cui L, Xu Y et al. A Survey of Personalized Medicine Recommendation. Int. J. Crowd Sci. 2024;8(2):77–82.doi: 10.26599/IJCS.2023.9100013. DOI
2. Di Paolo A, Sarkozy F, Ryll B, Siebert U. Personalized medicine in Europe: not yet personal enough? BMC Health Serv. Res. 2017;17(1):289. doi: 10.1186/s12913-017-2205-4. DOI
3. Stenzinger A et al. Trailblazing precision medicine in Europe: A joint view by Genomic Medicine Sweden and the Centers for Personalized Medicine, ZPM, in Germany. Semin. Cancer Biol. 2022;84:242–254. doi: 10.1016/j.semcancer.2021.05.026. DOI
4. Hofmarcher T, Malmberg C, Lindgren P. A global analysis of the value of precision medicine in oncology – The case of non-small cell lung cancer. Front. Med. 2023. doi: 10.3389/fmed.2023.1119506. DOI
5. Wang E, Cho WCS, Wong SCC, Liu S. Disease Biomarkers for Precision Medicine: Challenges and Future Opportunities. Genomics Proteomics Bioinformatics. 2017;15(2):57–58. doi: 10.1016/j.gpb.2017.04.001. DOI
6. Parchuk D. Demohrafichna sytuatsiya v Ukrayini v umovakh viys'kovoho konfliktu. [Demographic situation in Ukraine in the face of military conflict. Model]. Dev. Econ. 2024. doi: 10.31891/mdes/2024-11-35. (Ukrainan) DOI
7. Pandey A et al. Disease burden among Ukrainians forcibly displaced by the 2022 Russian invasion. Proc. Natl. Acad. Sci. 2023;120(8):e2215424120. doi: 10.1073/pnas.2215424120. DOI
8. Boccia S et al. How to Integrate Personalized Medicine into Prevention? Recommendations from the Personalized Prevention of Chronic Diseases (PRECeDI) Consortium. Public Health Genomics. 2019;22(5–6):208–214. doi: 10.1159/000504652. DOI
9. Cornel MC, van der Meij KRM, van El CG et al. Genetic Screening—Emerging Issues. Genes. 2024;15(5). doi: 10.3390/genes15050581. DOI
10. Flores M, Glusman G, Brogaard K et al. P4 medicine: how systems medicine will transform the healthcare sector and society. Pers. Med. 2013;10(6):565–576. doi: 10.2217/PME.13.57. DOI
11. Galdo B et al. Artificial intelligence in paediatrics: Current events and challenges. An. Pediatría Engl. Ed. 2024;100(3):195–201. doi: 10.1016/j.anpede.2024.02.009. DOI
12. Blobel B, Ruotsalainen P, Brochhausen M et al. Autonomous Systems and Artificial Intelligence in Healthcare Transformation to 5P Medicine - Ethical Challenges. Stud. Health Technol. Inform. 2020;270:1089–1093. doi: 10.3233/SHTI200330. DOI
13. Nazir S, Yasir A, Naeem U, García-Magariño I. Internet of Things for Healthcare Using Effects of Mobile Computing: A Systematic Literature Review. 2024. doi:10.1155/2019/5931315. DOI
14. IBM Watson Health's chief health officer talks healthcare challenges and AI. Healthcare IT News. 2019. https://www.healthcareitnews.com/news/ibm-watson-health%E2%80%99s-chief-health-officer-talks-healthcare-challenges-and-ai [Accessed 17 March 2024]
15. Rajkomar A, Dean J, Kohane I. Machine Learning in Medicine. N. Engl. J. Med. 2019;380(14):1347–1358. doi: 10.1056/NEJMra1814259.
16. Gardes J et al. Maxwell@: An Unsupervised Learning Approach for 5P Medicine. in MEDINFO 2019: Health and Wellbeing e-Networks for All, IOS Press. 2019, pp. 1464–1465. doi: 10.3233/SHTI190486. DOI
17. Personalized medicine at FDA: The Scope & Significance of Progress in 2023. Personalized Medicine Coalition. 2023. https://www.personalizedmedicinecoalition.org/wp-content/uploads/2024/02/report-3.pdf [Accessed 17 March 2024]
18. Luzum JA, Petry N, Taylor AK et al. "Moving Pharmacogenetics Into Practice: It's All About the Evidence!, Clin. Pharmacol. Ther. 2021;110(3):649–661. doi: 10.1002/cpt.2327.
19. C. for D. E. and Research. Table of Pharmacogenomic Biomarkers in Drug Labeling. FDA. 2024. https://www.fda.gov/drugs/science-and-research-drugs/table-pharmacogenomic-biomarkers-drug-labeling [Accessed 17 October 2024]
20. C. for D. and R. Health. Table of Pharmacogenetic Associations. FDA, Oct. 2022, https://www.fda.gov/medical-devices/precision-medicine/table-pharmacogenetic-associations [Accessed 17 October 2024]
21. What is CPIC? CPIC. https://cpicpgx.org/ [Accessed 17 October 2024]
22. GSI: Genotype Selection Interface. PharmGKB. https://www.pharmgkb.org/genotype [Accessed 17 October 2024]

23. Jayashankar SS et al. Non-Invasive Prenatal Testing (NIPT): Reliability, Challenges, and Future Directions. Diagnostics. 2023;13(15):2570. doi: 10.3390/diagnostics13152570. DOI
24. Therrell BL et al. Current Status of Newborn Bloodspot Screening Worldwide 2024: A Comprehensive Review of Recent Activities (2020–2023). Int. J. Neonatal Screen. 2024;10(2). doi: 10.3390/ijns10020038. DOI
25. Bayat A, Bayat M, Rubboli G, Møller RS. Epilepsy Syndromes in the First Year of Life and Usefulness of Genetic Testing for Precision Therapy. Genes. 2021;12(7). doi: 10.3390/genes12071051. DOI
26. Fan H-C, Yang M-T, Lin L-C et al. Clinical and Genetic Features of Dravet Syndrome: A Prime Example of the Role of Precision Medicine in Genetic Epilepsy. Int. J. Mol. Sci. 2024;25(1). doi: 10.3390/ijms25010031. DOI
27. Masucci M, Karlsson C, Blomqvist L, Ernberg I. Bridging the Divide: A Review on the Implementation of Personalized Cancer Medicine. J. Pers. Med. 2024;14(6). doi: 10.3390/jpm14060561. DOI
28. Cinti C, Trivella MG, Joulie M et al. The Roadmap toward Personalized Medicine: Challenges and Opportunities. J. Pers. Med. 2024;14(6):546. doi: 10.3390/jpm14060546. DOI
29. Turova L. Kurchenko A. Medical and genetic consulting in the clinical practice of an andrologist. Men's Health Gend. Psychosom. Med. 2020;1–2:39–49. doi: 10.37321/UJMH.2020.1-2-04. DOI
30. Turova L, Kurchenko A. Immunogenetic predictors of risk of miscarriage. Immunol. Allergol. Sci. Pract. 2020;3–4:79–87. doi: 10.37321/immunology.2020.3-4-09. DOI
31. Turova L, Naumenko O, Bobyr V. Immunogenetic Predictors of Allergic Rhinitis. Asthma Allergy. 2023;3:49–57. doi: 10.31655/2307-3373-2023-3-49-57. DOI
32. Turova L, Makovetska AM, Savelyeva mv. Synergy of influence of polymorphic variants of the genes of the system of the first and second phase of detoxification of xenobiotics and psycho-emotional stress on the reproductive health of a man: literature review and clinical case. Men's Health Gend. Psychosom. Med. 2023;1-2(14-15):83–99. doi: 10.37321/UJMH.2022.1-2-09. DOI
33. Turova L. The prognosis of intrauterine growth retardation of fetus at different terms of pregnancy in the case of microelementosis. Immunol. Allergol. Sci. Pract. 2023. doi: 10.37321/immunology.2023.1-2-06. DOI
34. Turova L, Rymarovych N. Influence of immunogenetic determinants on the rehabilitation potential and the possibility of surgical interventions in patients with congenital malformations. Immunol. Allergol. Sci. Pract. 2024;4:47–56. doi: 10.37321/immunology.2023.4-05. DOI
35. Shchubelka K et al. Genetic determinants of global developmental delay and intellectual disability in Ukrainian children. J. Neurodev. Disord. 2024;16(1):13. doi: 10.1186/s11689-024-09528-x. DOI
36. Zabolotna DD, Naumenko OM, Bobyr VV, Turova LO. Suchasnyy pohlyad na alerhen-spetsyfichnu imunoterapiyu [Modern view of allergen-specific immunotherapy]. Otorhinolaryngology. 2023;4(6). http://ir.librarynmu.com/handle/123456789/10386 [Accessed 17 October 2024] (Ukrainan)
37. Oleksyk TK. et al. Genome diversity in Ukraine. GigaScience, 2021;10(1):159. doi: 10.1093/gigascience/giaa159. DOI
38. Herasymenko OV. Personalized oncology as a global uniting aim of clinical experience, unified protocols and modern technologies on the way to the victory against neoplastic processes. Infus. Chemother. 2020:53–54. doi: 10.32902/2663-0338-2020-3.2-53-54. DOI
39. O'Connor D et al. Common Genetic Variations Associated with the Persistence of Immunity following Childhood Immunization. Cell Rep. 2019;27(11):3241-3253.e4. doi: 10.1016/j.celrep.2019.05.053. DOI
40. Kaploukh OM. Personalized program of medical and psychological rehabilitation of dementia patients. Exp. Clin. Med. 2021;90(3):70–75. doi: 10.35339/ekm.2021.90.3.kap. DOI

This article was performed in the framework of the scientific research works «Assessment of the state of regionalization of perinatal care in the regions in the context of perinatal risk management of newborns, routing of patients according to identified risks. Assessment of material and technical, organizational, analytical, methodical and educational capacity of perinatal centers» (2023–2024, No state registration 0123U103032) and «Study of immunogenetic aspects of diagnosis, treatment and prevention of allergic and other socially significant multifactorial diseases». (2023–2024, No state registration 0124U000023).

CONFLICT OF INTEREST

The Authors declare no conflict of interest

CORRESPONDING AUTHOR

Lyudmila O. Turova

Bogomolets National Medical University

13 Taras Shevchenko Blv., 01601 Kyiv, Ukraine

e-mail: dr.turova@gmail.com

ORCID AND CONTRIBUTIONSHIP
Lyudmila O. Turova 0000-0002-4481-3009 A B D F
Tatiana A. Vezhnovets 0000-0003-1156-8614 B E F
Andrii I. Kurchenko 0000-0001-6858-2025 B E

A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

RECEIVED: 21.06.2024
ACCEPTED: 27.10.2024

CREATIVE COMMONS 4.0