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THE TRANSFORMATIVE IMPACT OF OPEN SCIENCE ON MEDICAL RESEARCH AND HEALTHCARE: A VIEW FROM UKRAINE

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Ключові слова: *відкрита наука, управління даними, великі дані, охорона здоров'я, медицина, стоматологія, цифрова медицина*

Abstract. The transformative impact of Open Science on medical research and healthcare: a view from Ukraine. Shevchuk O.O., Levkiv M.O., Berezko O.L., Boitsaniuk S.I., Kochan O.V., Shulhai A.H., Korda M.M. *Open science is focused on the free exchange of knowledge in all scientific fields and promotes closer cooperation between scientists and society. In the biomedical field, its importance is particularly great, because research results directly affect people's health, the functioning of healthcare systems and the formation of relevant policies. In the modern scientific environment, the principles of this concept are gaining special importance for the development of medical research and the improvement of clinical practice. Ukraine is actively adapting Open Science policies, which provides a number of strategic advantages. In particular, open research data contribute to the implementation of evidence-based medicine and reproducible research, a personalized approach to treatment, improving the practice of clinical research and the application of artificial intelligence in the field. All this contributes to improving the quality of medical services and supporting the health of the population as a whole. Relevant policies are being implemented in Ukraine through the adoption of relevant legislation, participation in Erasmus+, Horizon and other projects. Thanks to the projects of the European Union, including Erasmus+ KA2 Capacity Building in Higher Education, more stakeholders are involved, and not only the audience of scientists who implement the principles of Open Science. However, the openness of biomedical and dental data requires consistency between accessibility, ethics, security and legal regulation. There is a need to form common standards and form a new professional competence in the system of science and education – data stewardship, which has important features in the biomedical field. The study summarizes the main principles and practices of Open Science that relate to medicine and dentistry, as well as relevant practices and integration of Ukraine into the European research space. The literature search was carried out in electronic databases: MEDLINE (PubMed) and Google Scholar using the keywords "FAIR data", "open data", "big data", "medicine", "dentistry", "education", "deep learning". Works published from 2015 to 2025 were considered. It is necessary to further promote a national infrastructure, develop data management professions, and ensure the ethical use of medical information in the context of the digitalization of healthcare.*

Реферат. Трансформаційний вплив відкритої науки на медичні дослідження та охорону здоров'я: погляд з України. Шевчук О.О., Левків М.О., Березко О.Л., Бойцанюк С.І., Кочан О.В., Шульгай А.Г., Корда М.М. *Відкрита наука орієнтована на вільний обмін знаннями в усіх наукових галузях і сприяє тісній співпраці між вченими та суспільством. У біомедичній сфері її значення особливо велике, адже результати досліджень безпосередньо впливають на здоров'я людей, функціонування систем охорони здоров'я та формування відповідних політик. У сучасному науковому середовищі принципи відкритої науки набувають особливої ваги для розвитку медичних досліджень та удосконалення клінічної практики. Україна активно адаптує політики відкритої науки, що дає низку стратегічних переваг. Зокрема, відкриті дослідницькі дані сприяють імплементації доказової медицини та відтворюваних досліджень, персоналізованого підходу до лікування,*

вдосконаленню практики клінічних досліджень та застосуванню штучного інтелекту в галузі. Усе це сприяє покращенню якості надання медичних послуг та підтримці здоров'я населення загалом. В Україні впроваджуються відповідні політики через впровадження відповідного законодавства, участь у проєктах Erasmus+, Horizon та інших. Завдяки проєктам Євросоюзу, включно з Erasmus+ KA2 Capacity Building in Higher Education, залучається більше стейкхолдерів, а не лише аудиторії науковців, які впроваджують принципи відкритої науки. Однак відкритість біомедичних та стоматологічних даних вимагає узгодженості між доступністю, етикою, безпекою та правовим регулюванням. Постає необхідність у формуванні єдиних стандартів та формування нової професійної компетенції в системі науки й освіти – управління дослідницькими даними, яка має важливі особливості в біомедичній галузі. У дослідженні узагальнені основні принципи і практики відкритої науки, які стосуються медицини та стоматології, а також відповідних практик та інтеграції України до європейського дослідницького простору. Пошук літератури проводився в електронних базах даних: MEDLINE (PubMed) та Google Scholar за ключовими словами «FAIR data», «open data», «big data», «medicine», «dentistry», «education», «deep learning». Розглядалися роботи, опубліковані з 2015 року до 2025 року. Необхідним є подальше формування національної інфраструктури, розвиток професій з управління даними та забезпечення етичного використання медичної інформації в умовах цифровізації охорони здоров'я.

Open Science is an umbrella concept encompassing open access, open research data, reproducible research, open peer review, and other practices aimed at increasing the transparency and accessibility of science and expanding scientific collaboration and knowledge exchange for the benefit of science and society [1, 2]. This review paper explains that open data refers specifically to data that are made available for access and reuse under appropriate legal and licensing conditions. FAIR principles (Findable, Accessible, Interoperable, Reusable), in contrast, describe how research data should be managed to ensure their Findability, Accessibility, Interoperability, and Reusability. Importantly, FAIR data are not necessarily open, particularly in biomedical research, where access may need to be restricted to protect sensitive information. In recent years, global crises such as the coronavirus pandemic and climate change have only underscored the importance of Open Science as a means to overcome them [3, 4]. In the biomedical field, this concept is of particular importance because research results directly affect public health, the functioning of healthcare systems, and the development of evidence-based policy in this area [5, 6]. The relevance of this topic stems from Ukraine's active integration of Open Science principles into health research and healthcare practices as part of its European integration policy. This process is creating new opportunities for developing evidence-based medicine and personalized treatment approaches [7]. The use of open data can improve research reproducibility, support clinical trial procedures, and facilitate the application of artificial intelligence in diagnostics and therapy [8]. This directly contributes to a higher quality of medical services and an improved health level and well-being for the population. At the same time, the openness of medical data requires the establishment of reliable standards for ethical, legal, and secure information management. This, in turn, highlights the necessity of developing professional competencies in the field of research data management. In this context, open access to or sharing of research outputs is no longer limited to the academic community alone [9, 10]. To ensure the practical application of scientific discoveries, numerous public-private partnerships have been created [11]. These partnerships help ensure that research results do not remain confined to scientific publications but find real-world use – in the design of medical devices [12, 13], the creation of new medicines or new pharmaceutical forms of existing medicines [14], and the development of software for healthcare facilities [15]. Funding programs, such as the European Union's Horizon 2020 / Horizon Europe Research and Innovation Program, play an important role in this process [16]. Within the framework of the programs and its calls, collaboration between research institutions and businesses is supported, stimulating the transfer of knowledge and technologies to the commercial sector. Thanks to such initiatives, scientific achievements are more quickly transformed into innovative solutions that benefit society.

The purpose of this study was to summarize the principles, practices, and main mechanisms of Open Science and innovation encountered by research teams in medicine and dentistry. It also aimed to outline national and international initiatives that facilitate Ukraine's integration into the European scientific space.

MATERIALS AND METHODS OF RESEARCH

This study was conducted as a narrative review with a structured literature search. The review aimed to provide a broad synthesis of scientific evidence, policy documents, and institutional initiatives related to Open Science, open data, FAIR data practices, and digital transformation in medicine, with particular attention to the Ukrainian context. Given the broad and heterogeneous nature of the research question and the inclusion of scientific publications, regulatory

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documents, and institutional materials, a narrative review design was considered appropriate.

The reporting and methodological transparency of the present review were checked against the principles of the SANRA scale for narrative review articles [17].

The primary research method used in this paper is the analysis of modern scientific literature and the regulatory framework regarding the impact of open science, open data, and modern electronic technologies on medicine. Based on the analysis, recommendations were synthesized for the development of regulatory support and institutional infrastructure of modern medical science in Ukraine.

The electronic literature search was conducted in MEDLINE (PubMed) and Google Scholar using predefined combinations of keywords. The PubMed search combined terms related to Open Science, open data, FAIR principles, research data management, medicine, dentistry, electronic health records, and artificial intelligence using the Boolean operators AND and OR. The following combinations were used: ("open science" OR "open data" OR "FAIR data") AND (medicine OR healthcare OR dentistry), and ("FAIR data" OR "open data") AND ("artificial intelligence" OR "deep learning") AND medicine. The following Google Scholar queries were used: "open science" medicine healthcare, "FAIR data" medicine, "research data management" medicine, and "open data" "artificial intelligence" medicine.

The search covered publications, policy and grey literature published from January 2015 to September 2025. The final database search was performed on September 15, 2025.

Grey literature and policy documents were considered separately from peer-reviewed publications. Targeted searches were conducted on the official websites of international organizations, European institutions, Ukrainian governmental bodies, public health institutions, and Open Science projects relevant to Ukraine. Eligible sources included legislation and policy documents, official strategies and action plans, institutional reports, project outputs, and official web resources directly addressing Open Science, research data governance, FAIR principles, digital health, or the implementation of these approaches in Ukraine. Sources were assessed according to the authority of the issuing organization, relevance to the review objectives, document status, currency, and direct applicability to the Ukrainian or European research context.

The inclusion criteria were:

I) full-text articles from journals written in English and Ukrainian;

II) books and book chapters written in English;

III) scientific papers, policy and grey literature published in 2015 and later.

The exclusion criteria were as follows:

I) case reports;

II) conference reports;

III) materials published before 2015;

IV) randomized controlled trials;

V) editorials, short communications, errata.

The current review included heterogeneous types of evidence and did not aim to estimate pooled treatment effects, therefore no formal risk-of-bias instrument was applied across all sources. Instead, publications were critically assessed for their direct relevance to the review question, methodological transparency, consistency of the reported evidence, recency, and the extent to which they directly supported the statement for which they were cited. Official and grey-literature sources were additionally evaluated according to the authority of the issuing organization, document status, and applicability to the Ukrainian context.

The selected information was synthesized narratively and organized into thematic domains: clinical trials and data sharing; electronic health records and real-world data; artificial intelligence and open medical data; FAIR data and metadata; and Open Science policies, infrastructure, and collaborative initiatives, with Ukrainian developments considered within each domain.

This study was based exclusively on previously published literature and publicly available documents and did not involve human participants, animals, or identifiable personal data; therefore, approval by an ethics committee was not required.

RESULTS AND DISCUSSION

Open Science is a crucial player that fundamentally changes biomedical research and healthcare practice. Its main goal is to make scientific results – including publications, datasets, software, and educational materials – more accessible to researchers, students, educators, and the general public.

This movement, recognized as a new scientific paradigm [2] and a global standard by organizations such as UNESCO [1], is crucial for advancing healthcare. Ensuring openness at all stages of the research cycle allows for a quicker response to global health challenges, promotes the development of evidence-based medicine, and fosters international collaboration in the field [18, 19]. The transparent exchange of information is at the core of the Open Science concept [4]. Open research data, in particular, ensures the reliability of published scientific information by promoting its free use, modification, and dissemination [19]. This directly supports the reproducibility and repeatability of experiments, thereby

increasing trust in scientists, their work, and the scientific system as a whole [20]. Furthermore, open data fosters collaboration among different scientific schools and teams, allows for the analysis of large volumes of information, and aids in the development of innovative solutions for global problems. In this context, data science in healthcare offers significant benefits and opportunities but also faces unique challenges due to the specific nature of the field, particularly the need to handle sensitive patient data [15].

Clinical trials and data sharing

A transparent system for conducting clinical trials of medicines is a central element of responsible scientific research. Open science practices in this area are aimed at improving reproducibility, scientific value, and strengthening the public's trust in trial results. In particular, the Peer Reviewers' Openness Initiative, as a foundational document, called on reviewers of scientific publications to accept for publication only those manuscripts whose authors commit to openly sharing their data and other related materials [19]. The initiative has shown a clear tendency to directly stimulate open science practices through the peer review process. Shared clinical trial data can support reanalysis, meta-analysis, and other secondary analyses, extending their scientific value beyond the objectives of the original trials [21]. These datasets enable secondary research that goes beyond the initial experiments. This was also confirmed in broader discussions on research reproducibility [20, 22]. These studies emphasize how open data can maximize the scientific utility of research. Open scientific data systematically leads to an increase in the number of citations, enhances the academic influence of researchers and their institutions, and provides wider opportunities for collaboration and attracting funding [23, 24]. It also encourages public involvement in scientific research ("citizen science"). State-funded research organizations are increasingly recognizing their moral obligation to promote data sharing, which further stimulates open science practices [5]. However, significant ethical challenges remain. Participants in clinical trials continue to be concerned about the possibility of data depersonalization, commercial exploitation of results, and other abuses [25-27]. These fears underscore the importance of transparent management of the clinical trial system, clear and understandable informed consent procedures for participants, and the application of robust technical measures to ensure information security. These issues have been consistently raised in discussions regarding the ethical aspects of using big data in healthcare [28]. Adherence to ethical norms, such as the Declaration of Helsinki, is paramount in achieving global health goals [29]. Registries play an important role in clinical research, quality improvement, benchmarking, and clinical decision support [25, 30]. These systems are crucial for connecting healthcare with science, education, and innovation [25].

The International Committee of Medical Journal Editors (ICMJE) has introduced data-sharing requirements to improve transparency and reproducibility in clinical trials. The ICMJE requires manuscripts reporting clinical trials to include a data-sharing statement. Clinical trials that began enrolling participants on or after January 1, 2019, are also required to include a data-sharing plan in the trial registration [31]. Initiatives like ClinicalTrials.gov and the European Open Science Cloud (EOSC) underscore the need for open, traceable data pipelines.

In line with international trends, after joining the Horizon Europe and Euratom programs in 2021, Ukraine committed to promoting the adoption of Open Science practices in national programs, projects, and initiatives, in accordance with the requirements of these programs and current Ukrainian legislation [32]. Despite the challenges posed by the full-scale war, the adoption of the National Open Science Plan in October 2022 cemented these commitments, particularly regarding the deployment of best practices for research data management. Some Ukrainian medical journals align their editorial policies with international publishing standards, including ICMJE recommendations [33].

Electronic health records (EHRs) and real-world data (RWD) of clinical practice

Electronic health records (EHRs) are a rich but complex source of scientific evidence from real-world clinical practice [10]. They pose significant challenges for Open Science due to their heterogeneity and the sensitive nature of patient data. To address this issue, efforts are being made to convert raw medical data into digital assets that comply with FAIR principles, using systematic "FAIR-ification" processes [34] and automated metadata quality monitoring [35]. These approaches are vital for making sensitive medical data usable while preserving ethical standards. This is a known barrier in FAIR practices for biomedical data [36]. A crucial step in this area is the use of standardized metadata repositories, such as the Portal of Medical Data Models, which support interoperable formats [37]. These systems enable wider reuse, support reproducibility, and expand the possibilities for decentralized data integration, contributing to a better understanding of big data analytics in healthcare [38]. Data from EHRs are an important component of healthcare information systems and can support secondary analysis of clinical data [38]. Despite their immense potential, real-world EHR

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datasets require further harmonization and methodological innovation for their full use in evidence-based medicine [20, 22, 38]. The establishment of these systems is critical for advancing evidence-based decision-making [39] and overcoming information discontinuity in clinical practice [40]. Due to the heightened sensitivity of medical data concerning confidentiality, its processing requires adherence to strict information protection standards. This includes compliance with relevant data protection frameworks and careful consideration of ethical and legal requirements for sharing sensitive health information [41]. In addition, the use of open medical data requires a high level of cybersecurity, including data encryption, multi-layered protection, and regular audits to prevent the serious consequences of information leaks [42, 43].

In the context of digital reforms and adaptation to the challenges of war, Ukraine has significantly developed its digital healthcare infrastructure. The national e-Health system, launched in 2017, now includes electronic health records (EHRs), e-prescriptions, e-referrals, and integration with state registries. It plays a key role in ensuring the continuity of medical services, especially amid war and humanitarian crises. As a result of hostilities and mass displacement, the application of telemedicine solutions has become critically necessary. However, digital inequality, particularly in regions with weak communication infrastructure, hinders the effective use of EHRs and digital access to services. In addition to technical barriers, the insufficient level of digital literacy among medical staff also limits the potential of digital transformation [44]. Despite this, the e-Health system has made significant progress toward standardizing and reusing medical data, laying the foundation for compliance with FAIR principles and international practices [45, 46]. In 2025, the e-Health system also showed progress in data openness: the edata.e-health.gov.ua portal provides analytical monitoring of the financial reports of healthcare institutions, and the state platform data.gov.ua contains a significant number of open medical datasets. This facilitates the transparency and accountability of the healthcare system. Meanwhile, strategic documents emphasize the need to coordinate digital investments and develop a high-quality data infrastructure as a prerequisite for the effective transformation of the healthcare system during crisis and post-conflict recovery [47]. Thus, in the Ukrainian context, the further use of EHR-derived data for research will depend not only on digitalization itself but also on interoperability, standardized metadata, secure access mechanisms, and clear governance of secondary data use.

Artificial intelligence and open medical data

The integration of artificial intelligence (AI) into medicine has been largely made possible by open, multi-modal data. Open access to research outputs stimulates the development of AI and machine learning, which can significantly improve information analysis and the discovery of new patterns in various fields of science [48]. From advances in dental diagnostics [49, 50] to radiology [51], AI tools trained on open datasets show great potential in increasing the accuracy and speed of diagnostics. This is further confirmed by reviews on deep learning in medicine [52]. The availability of publicly accessible dental image datasets for AI training also contributes to this progress [53]. The effectiveness of applying artificial intelligence (AI) directly depends on the quality, balance, and transparency of the training data. Initiatives like federated learning enable the development of predictive models without the need for direct transfer of sensitive personal data. This ensures compliance with confidentiality requirements while promoting scientific collaboration between research organizations. Additionally, the integration of open bioinformatic workflows, such as the BioCompute Object (BCO, IEEE 2791-2020), enhances the reproducibility of AI by documenting each step of the analytical process in a machine-readable format [54]. This aligns with the principles of transparency and openness for data-driven research [55]. The use of open medical data makes it possible to train AI models on real clinical examples, which helps improve algorithms for disease diagnosis and prognosis. Specifically, neural networks trained on large datasets of medical images demonstrate high accuracy in detecting pathologies, such as malignant tumors at early stages [56]. In parallel, predictive algorithms successfully forecast the development of complications in patients with chronic diseases, particularly diabetes [57]. Studies have shown that AI can effectively recognize periapical lesions on panoramic radiographs, and with cone-beam computed tomography, it achieves a diagnostic accuracy of up to 93% [49]. Other studies show that deep learning models applied to various types of dental images provide a caries detection accuracy ranging from 74.5% to 98.7% [50, 58]. Taken together, these findings show the growing importance of data sharing for AI-based healthcare innovation, while highlighting the need to protect the privacy of medical data [41].

Artificial Intelligence (AI) holds significant potential for improving the quality of medical care in Ukraine, especially during wartime when healthcare system resources are severely limited and the burden on medical professionals is increasing. The use of AI can contribute to more accurate diagnostics,

personalized treatment planning, continuous patient monitoring, and more effective allocation of available resources. Together, these factors can reduce medical errors and improve the quality of healthcare services. At the same time, the integration of such technologies requires a comprehensive approach that considers ethical, legal, and social challenges, including the protection of personal data and the prevention of algorithmic bias [59, 60]. It is important to note that Ukraine already has positive experience using AI in medicine, particularly for the automatic diagnosis of tuberculosis [61] and the monitoring of HIV infection prevalence [59]. For Ukraine, the expansion of AI-based healthcare therefore depends not only on access to algorithms but also on the availability of high-quality, interoperable and ethically governed medical data.

FAIR data and metadata

The FAIR principles are central to Open Science, and adherence to them is increasingly required by research funders and publishers. Implementing the FAIR principles is transforming approaches to datasets management, particularly regarding the creation, sharing, and reuse of data. A key aspect of FAIR use is ensuring the machine-readability of data, which is critical for effective long-term management [54]. FAIR compliance does not necessarily mean the data is open [36].

Numerous studies have highlighted the importance of international data-sharing communities in supporting AI research [48]. The promotion of FAIR principles involves using standard repositories, assigning a unique identifier such as a DOI to each dataset, and utilizing standardized metadata schemas [35]. This involves validating data formats and integrity, prioritizing open formats, and selecting an appropriate open license, such as Creative Commons Attribution 4.0 (CC BY 4.0), to facilitate accessibility, interoperability, and reuse of research outputs [62]. The availability of standardized datasets and supporting tools increases reproducibility, reduces redundant research, and accelerates cumulative scientific progress [10, 36, 62]. European research institutions are actively working on creating harmonized data-sharing mechanisms, with a particular focus on handling sensitive medical data [63]. Examples of such infrastructures include biomedical databases like GenBank (the US National DNA Sequence Database) and EMBL-EBI (the European Molecular Biology Laboratory – European Bioinformatics Institute) [64], as well as the Nightingale Open Science platform and dental datasets on the Kaggle platform, which provide access to open data to support health research and the development of clinical practice [55].

Implementing FAIR principles in the field of medical data is crucial for the development of modern medicine in Ukraine, especially in the context of the digital transformation of the healthcare system and integration with the European research space. The standardization of medical data is a prerequisite for ensuring its interoperability, improving the quality of clinical research, increasing the accuracy of artificial intelligence, and effective administration [65]. A promising example is the creation of a platform for anonymizing, harmonizing, and labeling medical datasets to support machine learning research [66]. Simultaneously, Ukraine is gradually developing an institutional infrastructure for implementing FAIR principles, including the creation of a roadmap for applying FAIR in scientific information management systems [67]. Additionally, the draft Strategy for the Development of Ukraine's Open Data Sphere for 2025-2027 includes a number of directions that directly correlate with the FAIR principles. Specifically, the document provides for improving data quality, interoperability, and expanding open data and metadata sets, which corresponds to the principles of findability and interoperability [68]. Meanwhile, in the context of the war in Ukraine, the FAIR system may be insufficient to ensure the protection of community rights and ethical responsibility. Instead, the CARE principles – Collective Benefit, Authority to Control, Responsibility, and Ethics – supplement FAIR by integrating moral foundations and focusing on the protection of vulnerable populations, particularly internally displaced persons and civilians under occupation [69]. Accordingly, the implementation of FAIR principles in Ukraine should be considered primarily as a research data governance challenge rather than simply as an expansion of open access to medical data.

Ecosystems of collaboration and policy changes

Implementing systemic changes in Open Science requires not only legal and regulatory support but also a developed institutional infrastructure and sustainable international partnerships. Cross-border initiatives, particularly the Observational Health Data Sciences and Informatics platform, as well as European research infrastructures, demonstrate the practical effectiveness of harmonized and decentralized approaches to scientific research in a global context [70]. In the field of research funding, the Horizon Europe program enshrines the principles of open access and data management in accordance with FAIR standards as key criteria for project evaluation [16], thereby creating institutional incentives for implementing open practices.

Parallel to this, grassroots initiatives are also becoming more active, changing the approaches to setting scientific priorities and participating in research. Examples of citizen science in healthcare [71] and the Indigenous data governance approaches

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[27], which are also applicable in the context of the war in Ukraine [69], illustrate the growing role of communities in the co-creation of knowledge. Such practices are increasingly being reflected in institutional strategies in both high-income and developing countries, where the integration of Open Science values into local research cultures is underway [72]. In developing countries, public-private partnerships can play an important role, but their implementation requires a balanced approach based on the principles of transparency, academic freedom, and long-term sustainability [11]. An important condition is the support of academic libraries as key centers for research data management and open access [73]. Overall, these processes indicate that Open Science is gradually transforming from a set of individual practices into a structural foundation for modern biomedical research – with a focus on open innovation [23] and prioritizing free access to research data [24].

Physician-scientists, who combine clinical practice with scientific activity [74], play a key role in translating research results into healthcare practice, particularly by working with open biomedical data repositories [75]. Engaging researchers in the analysis of thematically structured databases contributes to effective research process management and the development of interdisciplinary team collaboration [40]. The active participation of students in such projects shapes modern research education by providing practical experience in project management, data work, and analytics [76]. Another important aspect is, is that the use of open biomedical data supports the continuous professional development of healthcare professionals, giving them access to current scientific information and evidence-based clinical decisions [77, 78]. In this context, medical informatics serves as a strategic tool for responding to public health challenges and improving the quality of medical care [79].

Alongside considering international experience, Ukraine is actively forming its own initiatives for implementing Open Science principles. Specifically, the National Open Science Plan has been approved, as well as the Open Government Partnership Action Plan for 2023-2025. International educational programs, particularly Erasmus+ CBHE projects such as OPTIMA and Open4UA, play a vital role in this process by promoting the integration of Open Science into the higher education system. As a result of these projects, specific recommendations, methodological materials, and tools have been developed for implementing Open Science in universities [80, 81]. The National Research Foundation of Ukraine is actively supporting these approaches, adapting the terms of its competitions to the principles of the Coalition for Advancing Research Assessment. Additionally, the methodology for evaluating the effectiveness of scientific activities at research and higher education institutions during state attestation, which was updated by the Ministry of Education and Science in 2024, now includes qualitative indicators that promote fairer and more comprehensive institutional development. Parallel to this, the development of a professional standard for "Research Data Management Specialist" – data steward, is ongoing, and the Ukrainian Reproducibility Network (UARN) coordinates efforts to promote the principles of openness and reproducibility within the scientific community. Open medical data is becoming an increasingly powerful tool for improving the quality of medical services and advancing science [82].

Open Science in Ukraine and its current progress and remaining challenges

Taken together, the reviewed evidence indicates that Ukraine has already established several important elements of an Open Science ecosystem, including the National Open Science Plan, participation in Horizon Europe, the development of digital health infrastructure, the expansion of open governmental data, and institutional initiatives aimed at research data management and reproducibility. International projects such as OPTIMA and Open4UA have additionally supported the transfer of European Open Science practices into Ukrainian higher education and research institutions.

At the same time, the Ukrainian context reveals several areas that require further development. In medicine and dentistry, the implementation of Open Science is closely linked to the governance of sensitive health data, interoperability of information systems, FAIR-compliant research data management, ethical and legal safeguards, and the development of professional competencies in data stewardship. These issues are particularly relevant under wartime conditions, when continuity of healthcare, cybersecurity, protection of vulnerable populations, and reliable digital infrastructure become especially important. Thus, for Ukraine, further integration into the European Research Area requires not only formal adoption of Open Science policies but also their practical implementation in biomedical research and healthcare institutions.

Research limitations

The study is a narrative review, and does not provide quantitative synthesis or meta-analysis. The concept of Open Science is highly dependent on legislative, infrastructural and communication aspects, as well as on the interactions between them. Thus, any changes in one of these components may have unpredictable impacts on other components of

the ecosystem. Legal aspects were interpreted according to current legislation and published legal analyses. The legal considerations presented in this review are intended to support the discussion of Open Science in medicine rather than provide a comprehensive legal interpretation. Some relevant studies may not have been retrieved because they were not indexed in Google Scholar or PubMed at the time of literature search.

Prospects for further research

Future research should focus on developing qualimetric indicators to assess the impact of the implementation of Open Science and digital transformation on medical research and the healthcare system in Ukraine.

CONCLUSIONS

1. Open Science provides a framework for improving transparency, reproducibility, data reuse, and collaboration in medical research. In biomedicine, however, greater accessibility must be balanced with confidentiality, data protection, informed consent, and other ethical requirements.
2. FAIR principles support the findability, accessibility, interoperability, and reuse of research data but should not be equated with open data. Their implementation in medicine requires standardized metadata, interoperable infrastructures, appropriate access conditions, and sustainable research data management.
3. Ukraine has taken important policy and institutional steps toward integrating Open Science into the European Research Area. Further progress requires stronger research data infrastructure, clear governance mechanisms for sensitive medical data, development of data stewardship competencies, and continued alignment of national practices with European standards.

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REFERENCES

1. UNESCO. Recommendation on Open Science [Internet]. Paris: UNESCO; 2021 [cited 2025 Sep 15]. doi: https://doi.org/10.54677/MNMH8546
2. Gong K. Open science: the science paradigm of the new era. Cultures of Science. 2022;5(1):3-9. doi: https://doi.org/10.1177/20966083221091867
3. Zhou C, Boyko T, Ruda M, Shybanova A, Dzhumelia E, Kochan O, et al. Stability indicator for defining environmental and protective requirements for landscape ecosystems. J Environ Eng Landsc Manag. 2024;32(1):57-71. doi: https://doi.org/10.3846/jeelm.2024.20608
4. Cole NL, Kormann E, Klebel T, Apartis S, Ross-Hellauer T. The societal impact of Open Science: a scoping review. R Soc Open Sci. 2024;11(6):240286. doi: https://doi.org/10.1098/rsos.240286
5. Wendelborn C, Anger M, Schickhardt C. Promoting data sharing: the moral obligations of public funding agencies. Sci Eng Ethics. 2024;30(4):35. doi: https://doi.org/10.1007/s11948-024-00491-3
6. Reichmann S, Wieser B. Open science at the science-policy interface: bringing in the evidence? Health Res Policy Syst. 2022;20(1):70. doi: https://doi.org/10.1186/s12961-022-00867-6
7. Denefil O, Chorniy S, Boitsaniuk S, Manashchuk N, Chornij N, Levkiv M, et al. Analysis of microbiocenosis of a gingival sulcus and periodontal pockets of patients with periodontal diseases associated with systemic pathology. Explor Med. 2023;4(6):942-55. doi: https://doi.org/10.37349/emed.2023.00186
8. Liu W, Zhao Z, Levkiv M. Automatic diagnosis of diabetic retinopathy based on EfficientNet. In: 2023 17th International Conference on the Experience of Designing and Application of CAD Systems (CADSM). 2023. p. 64-7. doi: https://doi.org/10.1109/CADSM58174.2023.10076511

На умовах ліцензії CC BY 4.0

9. Bajcsy P, Bhattiprolu S, Börner K, Cimini BA, Collinson L, Ellenberg J, et al. Enabling global image data sharing in the life sciences. Nat Methods. 2025;22(4):672-6. doi: https://doi.org/10.1038/s41592-024-02585-z

10. Pramanik PK, Pal S, Mukhopadhyay M. Healthcare big data: a comprehensive overview. In: Research anthology on big data analytics, architectures, and applications. Hershey (PA): IGI Global; 2022. p. 119-47. doi: https://doi.org/10.4018/978-1-6684-3662-2.ch006

11. Leigland J. Public-private partnerships in developing countries: the emerging evidence-based critique. World Bank Res Obs. 2018;33(1):103-34. doi: https://doi.org/10.1093/wbro/lkx008

12. Kobylianskyi R, Przystupa K, Lysko V, Vikhor L, Prybyla A, Havryliuk M, et al. Thermoelectric cooling devices for ophthalmology. In: 2025 15th International Conference on Measurement. 2025. p. 253-6. doi: https://doi.org/10.23919/MEASUREMENT66999.2025.11078697

13. Jun S, Kochan O, Levkiv M. Metrological software test for studying the method of thermocouple error determination during operation. In: 2017 11th International Conference on Measurement (Measurement 2017); 2017 May 29-31; Bratislava, Slovakia. 2017. p. 171-4. doi: https://doi.org/10.23919/MEASUREMENT.2017.7983563

14. Kochan O, Boitsaniuk S, Levkiv M, Przystupa K, Tsvyntarna I, Patskan L. Emergence of nano-dentistry as a reality of contemporary dentistry. Appl Sci. 2022;12(4):2008. doi: https://doi.org/10.3390/app12042008

15. Abedjan Z, Boujemaa N, Campbell S, Casla P, Lojo A, Chatterjea S, et al. Data science in healthcare: benefits, challenges and opportunities. In: Consoli S, Reforgiato Recupero D, Petković M, editors. Data science for healthcare: methodologies and applications. Cham: Springer; 2019. p. 3-38. doi: https://doi.org/10.1007/978-3-030-05249-2_1

16. Weber KM, Lamprecht K, Biegelbauer P. Shaping a new understanding of the impact of Horizon Europe: the roles of the European Commission and Member States. fteval J Res Technol Policy Eval. 2019;47:146-54. doi: https://doi.org/10.22163/fteval.2019.347

17. Baethge C, Goldbeck-Wood S, Mertens S. SANRA-a scale for the quality assessment of narrative review articles. Res Integr Peer Rev. 2019;4:5. doi: https://doi.org/10.1186/s41073-019-0064-8

18. Pastorino R, De Vito C, Migliara G, Glocker K, Binenbaum I, Ricciardi W, et al. Benefits and challenges of Big Data in healthcare: an overview of the European initiatives. Eur J Public Health. 2019;29(Suppl 3):23-7. doi: https://doi.org/10.1093/eurpub/ckz168

19. Morey RD, Chambers CD, Etchells PJ, Harris CR, Hoekstra R, Lakens D, et al. The Peer Reviewers' Openness Initiative: incentivizing open research practices through peer review. R Soc Open Sci. 2016;3:150547. doi: https://doi.org/10.1098/rsos.150547

20. Navale V, Ji M, Vovk O, Misquitta L, Gebremichael T, Garcia A, et al. Development of an informatics system for accelerating biomedical research. F1000Res. 2019;8:1430. doi: https://doi.org/10.12688/f1000research.19161.2

21. Hollis S, Fletcher C, Lynn F, Urban HJ, Branson J, Burger HU, et al. Best practice for analysis of shared clinical trial data. BMC Med Res Methodol. 2016;16(Suppl 1):76. doi: https://doi.org/10.1186/s12874-016-0170-y

22. Wallach JD, Boyack KW, Ioannidis JPA. Reproducible research practices, transparency, and open access data in the biomedical literature, 2015-2017. PLoS Biol. 2018;16(11):e2006930. doi: https://doi.org/10.1371/journal.pbio.2006930

23. Kankanhalli A, Zuiderwijk A, Tayi GK. Open innovation in the public sector: a research agenda. Gov Inf Q. 2017;34(1):84-9. doi: https://doi.org/10.1016/j.giq.2016.12.002

24. Yaroshenko T. [Open access, open science, open data: how it was and where we are going (to the 20th anniversary of the Budapest Open Access Initiative)]. Ukrainskyi zhurnal z bibliotekoznavstva ta informatsiinykh nauk. 2021;8:10-26. Ukrainian. doi: https://doi.org/10.31866/2616-7654.8.2021.247582

25. Posadas-Martinez ML, Vicens J, Dawidowski AR, Martinez Von Scheidt MA, Pagotto VL, Blugerman GA, et al. The role of registries in improving health and bridging healthcare, research, education, innovation and development: a research department perspective. J Int Med Res. 2024;52(3):03000605241233140. doi: https://doi.org/10.1177/03000605241233140

26. Knoppers BM, Thorogood AM. Ethics and big data in health. Curr Opin Syst Biol. 2017;4:53-7. doi: https://doi.org/10.1016/j.coisb.2017.07.001

27. Carroll SR, Herczog E, Hudson M, Russell K, Stall S. Operationalizing the CARE and FAIR Principles for Indigenous data futures. Sci Data. 2021;8(1):108. doi: https://doi.org/10.1038/s41597-021-00892-0

28. Favaretto M, Shaw D, De Clercq E, Joda T, Elger BS. Big data and digitalization in dentistry: a systematic review of the ethical issues. Int J Environ Res Public Health. 2020;17(7):2495. doi: https://doi.org/10.3390/ijerph17072495

29. Kurihara C, Kerpel-Fronius S, Becker S, Chan A, Nagaty Y, Naseem S, et al. Declaration of Helsinki: ethical norm in pursuit of common global goals. Front Med (Lausanne). 2024;11:1360653. doi: https://doi.org/10.3389/fmed.2024.1360653

30. Blumenthal S. The Use of Clinical Registries in the United States: A Landscape Survey. EGEMS (Wash DC). 2017 Dec 7;5(1):26. doi: https://doi.org/10.5334/egems.248

31. Taichman DB, Sahni P, Pinborg A, Peiperl L, Laine C, James A, et al. Data sharing statements for clinical trials: a requirement of the International Committee of Medical Journal Editors. Lancet. 2017;389(10086):e12-4. doi: https://doi.org/10.1016/S0140-6736(17)31282-5

32. European Union, European Atomic Energy Community, Ukraine. Agreement between the European Union and the European Atomic Energy Community of the one part and Ukraine of the other part, on the participation of Ukraine in Horizon Europe - the Framework Programme for Research and Innovation and the Research and Training Programme of the European Atomic Energy Community (2021-2025) complementing Horizon Europe. Off J Eur Union. 2022 Mar 23;L95:1-17. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX%3A22022A0323%2801%29

33. Shevchenko AS, Danylchenko SI. [Adherence to ethical norms in scientific research and publications:

generalization of editorial policies of journals of Kharkiv National Medical University]. Eksperymentalna i klinichna medytsyna. 2025;94(3):172-81. Ukrainian. doi: https://doi.org/10.35339/ekm.2025.94.3.shd

34. Sinaci AA, Núñez-Benjumea FJ, Gencturk M, Jauer ML, Deserno T, Chronaki C, et al. From raw data to FAIR data: the FAIRification workflow for health research. Methods Inf Med. 2020;59(S01):e21-32. doi: https://doi.org/10.1055/s-0040-1713684

35. Devaraju A, Huber R. An automated solution for measuring the progress toward FAIR research data. Patterns (N Y). 2021;2(11):100370. doi: https://doi.org/10.1016/j.patter.2021.100370

36. Hughes LD, Tsueng G, DiGiovanna J, Horvath TD, Rasmussen LV, Savidge TC, et al. Addressing barriers in FAIR data practices for biomedical data. Sci Data. 2023;10(1):98. doi: https://doi.org/10.1038/s41597-023-01969-8

37. Dugas M, Neuhaus P, Meidt A, Doods J, Storck M, Bruland P, et al. Portal of medical data models: information infrastructure for medical research and healthcare. Database (Oxford). 2016;2016:bav121. doi: https://doi.org/10.1093/database/bav121

38. Mallappallil M, Sabu J, Gruessner A, Salifu M. A review of big data and medical research. SAGE Open Med. 2020;8:2050312120934839. doi: https://doi.org/10.1177/2050312120934839

39. Chanyalew MA, Yitayal M, Atnafu A, Tilahun B. Routine health information system utilization for evidence-based decision making in Amhara national regional state, northwest Ethiopia: a multi-level analysis. BMC Med Inform Decis Mak. 2021;21:28. doi: https://doi.org/10.1186/s12911-021-01400-5

40. Gowda NR, Kumar A, Arya SK, Vikas H. The information imperative: to study the impact of informational discontinuity on clinical decision making among doctors. BMC Med Inform Decis Mak. 2020;20:175. doi: https://doi.org/10.1186/s12911-020-01190-2

41. Yadav N, Pandey S, Gupta A, Dudani P, Gupta S, Rangarajan K. Data privacy in healthcare: in the era of artificial intelligence. Indian Dermatol Online J. 2023;14(6):788-92. doi: https://doi.org/10.4103/idoj.idoj_543_23

42. Lieneck C, McLauchlan M, Phillips S. Healthcare cybersecurity ethical concerns during the COVID-19 global pandemic: a rapid review. Healthcare (Basel). 2023;11(22):2983. doi: https://doi.org/10.3390/healthcare11222983

43. Cartwright AJ. The elephant in the room: cybersecurity in healthcare. J Clin Monit Comput. 2023;37(5):1123-32. doi: https://doi.org/10.1007/s10877-023-01013-5

44. Kriachkova LV, Simon KI. [Medico-social rationale for the development of digital personnel potential in healthcare]. Medicni Perspektivi. 2025;30(2):234-46. Ukr. doi: https://doi.org/10.26641/2307-0404.2025.2.333698

45. Malakhov KS. Insight into the digital health system of Ukraine (eHealth): trends, definitions, standards, and legislative revisions. Int J Telerehabil. 2023;15(2):e6599. doi: https://doi.org/10.5195/ijt.2023.6599

46. Myronova G. Digitalization of healthcare in Ukraine: legal support of public and private interests. Entrep Econ Law. 2022;3:40-7. doi: https://doi.org/10.32849/2663-5313/2022.3.05

47. World Health Organization Regional Office for Europe. Principles to guide health system recovery and transformation in Ukraine: consultation draft, May 2022 [Internet]. Copenhagen: WHO Regional Office for Europe; 2022 [cited 2025 Sep 15]. Available from: https://www.who.int/europe/publications/m/item/principles-to-guide-health-system-recovery-and-transformation-in-ukraine--consultation-draft--may-2022

48. Huerta EA, Blaiszik B, Brinson LC, Bouchard KE, Diaz D, Doglioni C, et al. FAIR for AI: an interdisciplinary and international community building perspective. Sci Data. 2023;10(1):487. doi: https://doi.org/10.1038/s41597-023-02298-6

49. Setzer FC, Shi KJ, Zhang Z, Yan H, Yoon H, Mupparapu M, et al. Artificial intelligence for the computer-aided detection of periapical lesions in cone-beam computed tomographic images. J Endod. 2020;46(7):987-93. doi: https://doi.org/10.1016/j.joen.2020.03.025

50. Kühnisch J, Meyer O, Hesenius M, Hickel R, Gruhn V. Caries detection on intraoral images using artificial intelligence. J Dent Res. 2022;101(2):158-65. doi: https://doi.org/10.1177/00220345211032524

51. Lee JG, Jun S, Cho YW, Lee H, Kim GB, Seo JB, et al. Deep learning in medical imaging: general overview. Korean J Radiol. 2017;18(4):570-84. doi: https://doi.org/10.3348/kjr.2017.18.4.570

52. Piccialli F, Di Somma V, Giampaolo F, Cuomo S, Fortino G. A survey on deep learning in medicine: why, how and when? Inf Fusion. 2021;66:111-37. doi: https://doi.org/10.1016/j.inffus.2020.09.006

53. Uribe SE, Issa J, Sohrabniya F, Denny A, Kim NN, Dayo AF, et al. Publicly available dental image datasets for artificial intelligence. J Dent Res. 2024;103(13):1365-74. doi: https://doi.org/10.1177/00220345241272052

54. Wilkinson MD, Dumontier M, Aalbersberg IJ, Appleton G, Axton M, Baak A, et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data. 2016;3:160018. doi: https://doi.org/10.1038/sdata.2016.18

55. Umbach G. Open Science and the impact of Open Access, Open Data, and FAIR publishing principles on data-driven academic research: towards ever more transparent, accessible, and reproducible academic output? Stat J IAOS. 2024;40(1):59-70. doi: https://doi.org/10.3233/SJI-240021

56. Debelee TG, Kebede SR, Schwenker F, Shewarega ZM. Deep learning in selected cancers' image analysis-a survey. J Imaging. 2020;6(11):121. doi: https://doi.org/10.3390/jimaging6110121

57. Maniruzzaman M, Rahman MJ, Ahammed B, Abedin MM. Classification and prediction of diabetes disease using machine learning paradigm. Health Inf Sci Syst. 2020;8(1):7. doi: https://doi.org/10.1007/s13755-019-0095-z

58. Reyes LT, Knorst JK, Ortiz FR, Ardenghi TM. Machine learning in the diagnosis and prognostic prediction of dental caries: a systematic review. Caries Res. 2022;56(3):161-70. doi: https://doi.org/10.1159/000524167

59. Holt E. AI-assisted HIV case finding in Ukraine. Lancet Microbe. 2024;5(7):631. doi: https://doi.org/10.1016/S2666-5247(24)00077-6

60. Kolomoiets S. Concepts of creating an intelligent medical diagnostic system to assist in the work and training

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of doctors based on artificial intelligence. Inf Technol Soc. 2023;5(11):28-33.
doi: https://doi.org/10.32689/maup.it.2023.5.4

61. [Artificial intelligence helps diagnose tuberculosis and other lung pathologies: results of using modern equipment in Ukraine]. [Internet]. 2025 Apr 2 [cited 2025 Sep 15]. Ukrainian. Available from: https://www.phc.org.ua/news/shtuchniy-intelekt-dopomagae-diagnostuvati-tuberkuloz-ta-inshi-patologii-u-legenyakh-rezultati

62. Research Data Sweden. Licences [Internet]. 2024 Dec 11 [cited 2025 Sep 15]. Available from: https://researchdata.se/en/manage-data/describe-share-and-preserve-data/what-should-i-share/licences

63. Attieh HA, Haber A, Wirth FN, Buchner B, Prasser F. Enabling open science in medicine through data sharing: an overview and assessment of common approaches from the European perspective. J Open Access Law. 2023;11(2):1-10.
doi: https://doi.org/10.63567/j7djwk68

64. Morales J, Pujar S, Loveland JE, Astashyn A, Bennett R, Berry A, et al. A joint NCBI and EMBL-EBI transcript set for clinical genomics and research. Nature. 2022;604(7905):310-5.
doi: https://doi.org/10.1038/s41586-022-04558-8

65. Kaduk D, Aleksandrova T, Talapova P, Agieieva I, Ved M, Trofymenko M, et al. Current state and prospects of implementation of data standardization in the health care system of Ukraine (literature review). Medicni Perspektivi. 2023;28(3):190-8.
doi: https://doi.org/10.26641/2307-0404.2023.3.289226

66. Andreychenko A, Korzhuk V, Kondratenko S, Cheraneva P. Platform for generating medical datasets for machine learning in public health [Preprint]. arXiv; 2023.
doi: https://doi.org/10.48550/arXiv.2310.08532

67. Hauschke C, Nazarovets S, Altemeier F, Kaliuzhna N. Roadmap to FAIR research information in open infrastructures. J Libr Metadata. 2021;21(1-2):45-61.
doi: https://doi.org/10.1080/19386389.2021.1999156

68. [Notice of the beginning of public discussion of the draft order of the Cabinet of Ministers of Ukraine ''On approval of the Strategy for the Development of Open Data in Ukraine for 2025-2027'']. [Internet]. 2024 Aug 14 [cited 2025 Sep 15]. Ukrainian. Available from: https://thedigital.gov.ua/regulations/povidomlennya-pro-pochatok-gromadskogo-obgovorennya-proyektu-rozporyadzhennya-kabinetu-ministriv-ukrayini-pro-zatverdzhennya-strategiyi-rozvitku-sferi-vidkritih-danih-ukrayini-na-20252027-roki

69. Suchikova Y, Nazarovets S. Extending the CARE Principles: managing data for vulnerable communities in wartime and humanitarian crises. Sci Data. 2025;12(1):420.
doi: https://doi.org/10.1038/s41597-025-04756-9

70. Lovestone S, EMIF Consortium. The European medical information framework: a novel ecosystem for sharing healthcare data across Europe. Learn Health Syst. 2020;4(2):e10214. doi: https://doi.org/10.1002/lrh2.10214

71. Ciasullo MV, Carli M, Lim WM, Palumbo R. An open innovation approach to co-produce scientific knowledge: an examination of citizen science in the healthcare ecosystem. Eur J Innov Manag. 2022;25(6):365-92.
doi: https://doi.org/10.1108/EJIM-02-2021-0109

72. Okafor IA, Mbagwu SI, Chia T, Hasim Z, Udokanma EE, Chandran K. Institutionalizing Open Science in Africa: limitations and prospects. Front Res Metr Anal. 2022;7:855198.
doi: https://doi.org/10.3389/frma.2022.855198

73. Rice R. Supporting research data management and open science in academic libraries: a data librarian's view. Mitteilungen der Vereinigung Österreichischer Bibliothekarinnen und Bibliothekare. 2019;72(2):263-73.
doi: https://doi.org/10.31263/voebm.v72i2.3303

74. Rosenblum ND, Kluijtmans M, Ten Cate O. Professional identity formation and the clinician-scientist: a paradigm for a clinical career combining two distinct disciplines. Acad Med. 2016;91(12):1612-7.
doi: https://doi.org/10.1097/ACM.0000000000001252

75. Lazem M, Sheikhtaheri A. Barriers and facilitators for disease registry systems: a mixed-method study. BMC Med Inform Decis Mak. 2022;22(1):97.
doi: https://doi.org/10.1186/s12911-022-01840-7

76. Ravikumar R, Kitana A, Taamneh A, Aburayya A, Shwedeh F, Salloum S, et al. The impact of big data quality analytics on knowledge management in healthcare institutions: lessons learned from big data's application within the healthcare sector. South East Eur J Public Health. 2022;2022(Special Issue 5):1-17.
doi: https://doi.org/10.11576/seejph-6194

77. Kerezoudis P, Devin CJ, Goncalves S, Alvi MA, Asher AL, Bydon M. The role of clinical registries in health care. In: Quality and safety in neurosurgery. Elsevier; 2018. p. 53-67.
doi: https://doi.org/10.1016/B978-0-12-812898-5.00005-9

78. Enticott J, Johnson A, Teede H. Learning health systems using data to drive healthcare improvement and impact: a systematic review. BMC Health Serv Res. 2021;21(1):200.
doi: https://doi.org/10.1186/s12913-021-06215-8

79. Geanta M, Cucos B, Boata A, Nuta AC, Nuta FM, Semenov VV. The Ukrainian war and the pandemic: the impact on public health and the need for new health digital tools and the next level of intelligence. Medicni Perspektivi. 2023;28(4):207-17.
doi: https://doi.org/10.26641/2307-0404.2023.4.294241

80. Dahle S, Berezko O. Recommendations for the Open Science and Research Assessment reforms in Ukraine (1.2.1). Zenodo; 2025.
doi: https://doi.org/10.5281/zenodo.15752905

81. Luchenko D, Karnaukh B, Filatova-Bilous N, Tsuvina T, Yevkov A, Shumilo I. Draft Law of Ukraine Amending Legislation on National Open Science Policy (2.1) [Internet]. Zenodo; 2025. 96 p.
doi: https://doi.org/10.5281/zenodo.15441719

82. Lee CH, Yoon HJ. Medical big data: promise and challenges. Kidney Res Clin Pract. 2017;36(1):3-11.
doi: https://doi.org/10.23876/j.krcp.2017.36.1.3

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