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PROSPECTS FOR THE DEVELOPMENT OF DIGITAL EPIDEMIOLOGY AND ANALYSIS OF INTERNATIONAL EXPERIENCE

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ABSTRACT. The article is devoted to the analysis of the formation, development stages, and international experiences of digital epidemiology. In modern healthcare systems, digital technologies — including artificial intelligence, big data analytics, geographic information systems (GIS), and mobile applications — play a crucial role in the early detection, monitoring, and forecasting of diseases. The study examines advanced practices in the implementation of digital epidemiology in the United States, Europe, and Asian countries, assessing their practical applicability within the context of Uzbekistan. Furthermore, the paper scientifically substantiates the key directions for developing digital epidemiology in Uzbekistan's healthcare system, including the establishment of a unified data platform, the development of analytical models, the expansion of international collaboration, and the enhancement of digital competencies among specialists.

In conclusion, the study emphasizes that digital epidemiology holds strategic significance for predicting the spread of diseases, improving the efficiency of healthcare systems, and reducing epidemiological risks in the future.

Keywords: Digital epidemiology; artificial intelligence (AI); big data analytics; geographic information systems (GIS technologies); digital health; biostatistical modeling; epidemiological monitoring and forecasting; infectious risk indicators; health information infrastructure; international digital health experience; data integration and interoperability.

ПЕРСПЕКТИВЫ РАЗВИТИЯ ЦИФРОВОЙ ЭПИДЕМИОЛОГИИ И АНАЛИЗ МЕЖДУНАРОДНОГО ОПЫТА

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АННОТАЦИЯ. Статья посвящена анализу процессов формирования, этапов развития и международного опыта в области цифровой эпидемиологии. В современной системе здравоохранения цифровые технологии — включая искусственный интеллект, анализ больших данных (Big Data), географические информационные системы (GIS) и мобильные приложения — играют ключевую роль в раннем выявлении, мониторинге и прогнозировании заболеваний. В исследовании рассмотрены передовые практики внедрения цифровой эпидемиологии в Соединённых Штатах

Америки, странах Европы и Азии, а также проведена оценка их практической применимости в контексте системы здравоохранения Узбекистана.

Кроме того, в работе научно обоснованы основные направления развития цифровой эпидемиологии в Узбекистане, включая формирование единой информационно-аналитической платформы данных, разработку аналитических моделей, расширение международного сотрудничества и повышение цифровых компетенций специалистов.

В заключение подчёркивается, что цифровая эпидемиология обладает стратегическим значением для прогнозирования распространения заболеваний, повышения эффективности системы здравоохранения и снижения эпидемиологических рисков в будущем.

Ключевые слова: Цифровая эпидемиология; искусственный интеллект (AI); аналитика больших данных (Big Data); географические информационные системы (технологии GIS); цифровое здравоохранение; биостатистическое моделирование; эпидемиологический мониторинг и прогнозирование; индикаторы инфекционных рисков; информационная инфраструктура здравоохранения; международный опыт цифрового здравоохранения; интеграция данных и интероперабельность.

Introduction. Formation and Evolution of Digital Epidemiology. Digital epidemiology is an innovative subfield of modern epidemiological science that focuses on gathering, managing, and analyzing health-related information through digital technologies. The conceptual and methodological basis of this discipline started to take shape in the early 2000s, in parallel with the global expansion of internet connectivity, mobile communication, and digital data infrastructures.

In its initial stage, the development of digital epidemiology was closely intertwined with the progress of electronic health (eHealth) and mobile health (mHealth) technologies. With the rise of Big Data analytics, artificial intelligence (AI), and biostatistical modeling during the 2010s, classical epidemiological approaches began transforming into interactive, data-driven analytical systems capable of real-time interpretation.

At present, digital epidemiology is characterized by the integration of data from multiple digital sources, the application of geographic information systems (GIS) for spatial mapping of diseases, and the use of real-time monitoring tools that can detect and predict epidemiological patterns with high precision. [1,2]

The Role of Digital Technologies in Healthcare Systems. In the digital era, technology has become a key component in improving the adaptability, efficiency, and accuracy of public health systems. AI-based analytical tools can automatically process and interpret massive volumes of epidemiological data, contributing to early outbreak detection and reliable modeling of transmission dynamics. [3]

Big Data analytics functions as the foundation of these systems, integrating data streams from clinical documentation, laboratory results, mobile applications, and social media platforms into a unified analytical ecosystem. This approach

makes it possible to identify determinants of risk and develop targeted intervention measures.

GIS technologies are equally essential, providing spatial and temporal mapping of disease distribution, identifying high-risk regions, and modeling epidemic behavior. During the COVID-19 pandemic, GIS-based visualization and AI-assisted data analytics became crucial in supporting real-time decision-making and global surveillance efforts. [4]

Analysis of International Experience. The study of international experiences in digital epidemiology offers a valuable empirical and conceptual foundation for countries aiming to design effective, locally adapted models of digital public health governance. Over the last decade, leading nations such as the United States, European Union (EU) members, Japan, South Korea, and China have successfully integrated digital epidemiology as an essential element of health security policy.

The United States: Model of Integrated Digital Surveillance. In the U.S., the institutional structure of digital epidemiology is primarily shaped by the Centers for Disease Control and Prevention (CDC). Systems such as the National Syndromic Surveillance Program (NSSP) and Digital Disease Detection System collect and analyze vast amounts of clinical and laboratory data in real time. These systems utilize machine learning algorithms and Big Data analytics, which allow for faster, more precise detection of emerging outbreaks compared to conventional methods.

An important example is HealthMap, which applies AI-based data mining to synthesize open-source information from news, blogs, and social media. HealthMap was among the first systems to visualize the initial spread of COVID-19 globally. The interoperability between federal and local databases ensures rapid, coordinated information sharing across institutions. [5]

The European Union: Integrated Epidemiological Monitoring. Within the EU, the European Centre for Disease Prevention and Control (ECDC) serves as the principal institution overseeing digital epidemiology. Its EpiPulse system consolidates epidemiological data from all member states into a single, interactive database functioning as an early warning mechanism for cross-border infectious diseases.

EpiPulse employs GIS visualization, statistical forecasting models, and interactive dashboards that allow experts to analyze the spatial and sociodemographic characteristics of diseases. The European model is further strengthened by its robust legal and ethical framework, particularly through the General Data Protection Regulation (GDPR), which guarantees data security and transparency. Additionally, emphasis on public health literacy and open data participation promotes the principles of collaborative and participatory digital epidemiology. [6]

Asian Practices: AI-Driven Public Health Management. Asian countries—especially South Korea, Japan, and China—have demonstrated remarkable efficiency in implementing digital epidemiological systems during public health crises.

- In South Korea, the Smart Quarantine System, operated by the KCDC, merged data from telecommunication companies, financial institutions, and healthcare networks, enabling real-time contact tracing and outbreak containment using AI analytics.
- Japan's National Institute of Infectious Diseases (NIID) established the FETP-Digital platform, automating the collection and visualization of epidemiological data and generating predictive epidemic models through biostatistical computation.
- In China, the Artificial Intelligence for Public Health (AIPH) initiative employs large-scale predictive algorithms to process clinical and social data, allowing automatic recognition of infection risks and facilitating nationwide preventive strategies. [7]

Lessons from Global Practice. Comparative assessment indicates that successful digital epidemiology systems are based on three interdependent components:

1. Comprehensive data integration and interoperability, combining health, demographic, and social data within unified digital infrastructures;
2. AI- and Big Data–based predictive analytics, ensuring timely monitoring and risk forecasting;
3. Institutional and human capacity development, including skilled digital epidemiologists and data scientists.

Collectively, these elements demonstrate that digital epidemiology is not only a technological framework but also a strategic instrument for ensuring national health security, enhancing decision-making, and strengthening public resilience. [8]

Prospects for the Development of Digital Epidemiology in Uzbekistan. Uzbekistan has made significant progress in the digital transformation of its healthcare system over recent years. Initiatives such as the Electronic Healthcare Project, the MedData platform, and the implementation of electronic medical records (EMRs) have provided a solid base for adopting digital epidemiology.

To reinforce these achievements, several strategic priorities have been identified:

- Establishing a national digital epidemiological platform integrating all health-related data sources;
- Developing biostatistical and analytical models for disease simulation and forecasting;
- Expanding international cooperation to align national strategies with global best practices;
- Improving digital literacy and analytical competencies among healthcare and IT specialists to enable effective interdisciplinary collaboration.

Scientific Analysis and Future Perspectives. The findings of this research indicate that digital epidemiology serves as a key catalyst for healthcare modernization. It supports the creation of early warning systems, promotes efficient resource distribution, and enables precise epidemic forecasting.

In the near future, Uzbekistan aims to establish a national AI-based surveillance infrastructure, integrate predictive models into policy-making, and employ GIS dashboards for real-time visualization of disease risks. These measures will significantly improve the country's capacity for epidemic prevention and public health management.

Conclusion. In summary, the study highlights that the integration of advanced technologies—such as AI, Big Data analytics, and GIS modeling—is revolutionizing global health surveillance paradigms. Digital epidemiology merges diverse datasets and computational modeling to create a new framework for understanding disease dynamics in real time.

Countries that have institutionalized digital epidemiology (the U.S., EU, Japan, South Korea, and China) exhibit superior levels of operational efficiency, predictive accuracy, and epidemiological resilience. The evolution of this field depends on three pillars: integrative data ecosystems, algorithmic intelligence, and skilled human capital.

For Uzbekistan, the creation of a unified digital health infrastructure, the development of locally adapted analytical tools, and capacity building among specialists are of strategic importance. Digital epidemiology should be viewed not merely as a technological innovation but as a methodological transformation—a foundation for evidence-based policymaking, efficient resource use, and preparedness for emerging health challenges.

REFERENCES

1. Salathé, M., Bengtsson, L., Bodnar, T. J., Brewer, D. D., Brownstein, J. S., Buckee, C. O., ... & Vespignani, A. (2012). Digital Epidemiology. PLOS Computational Biology, 8(7), e1002616.
2. Eysenbach, G. (2001). What is e-health? Journal of Medical Internet Research, 3(2), e20.
3. Choi, J., Cho, Y., & Shim, E. (2021). Big Data and Artificial Intelligence for Infectious Disease Surveillance: A Systematic Review. Journal of Medical Internet Research, 23(9), e34321.
4. Oliver, N., Lepri, B., Sterly, H., & Vinck, P. (2020). Mobile phone data for informing public health actions across the COVID-19 pandemic life cycle. Science Advances, 6(23), eabc0764.
5. Centers for Disease Control and Prevention (CDC). (2022). National Syndromic Surveillance Program (NSSP) Overview. Atlanta, USA. →
6. European Centre for Disease Prevention and Control (ECDC). (2023). EpiPulse: The European Surveillance Portal for Infectious Diseases. Stockholm: ECDC Publications.
7. Korea Disease Control and Prevention Agency (KDCA). (2021). Smart Quarantine System and Digital Contact Tracing in the Republic of Korea. Seoul.
8. Chinese Center for Disease Control and Prevention (China CDC). (2022). Artificial Intelligence for Public Health (AIPH) Report. Beijing.

ИСПОЛЬЗОВАННАЯ ЛИТЕРАТУРА:

1. Салате М., Бенгтссон Л., Боднар Т. Дж., Брюэр Д. Д., Браунштейн Дж. С., Бакки К. О., Vespignani, A. (2012). Цифровая эпидемиология. PLOS Вычислительная биология, 8 (7), e1002616.

2. Эйзенбах, Г. (2001). Что такое электронное здравоохранение? Journal of Medical Internet Research, 3 (2), e20.

Choi, J., Cho, Y., & Shim, E. (2021). Большие данные и искусственный интеллект для надзора за инфекционными заболеваниями: систематический обзор. Journal of Medical Internet Research, 23 (9), e34321.

4. Oliver, N., Lepri, B., Sterly, H., & Vinck, P. (2020). Данные мобильных телефонов для информирования общественности о действиях в рамках жизненного цикла пандемии COVID-19. Science Advances, 6 (23), eabc0764.

5. Центры по контролю и профилактике заболеваний (CDC). (2022). Обзор Национальной программы синдромного наблюдения (NSSP). Атланта, США. →

6. Европейский центр профилактики и борьбы с болезнями (ECDC). (2023). EpiPulse: Европейский портал наблюдения за инфекционными заболеваниями. Стокгольм: Издательство ECDC.

7. Корейское агентство по контролю и профилактике заболеваний (KDCA). (2021). Умная система карантина и цифровое отслеживание контактов в Республике Корея. Сеул.

8. Китайский центр по контролю и профилактике заболеваний (China CDC). (2022). Доклад "Искусственный интеллект для общественного здравоохранения." Пекин.