Trends in Healthcare and Laboratory Medicine: A Forward Look into 2025

Damien Gruson[1,2,3], Tuğba Kemaloğlu Öz[4,5]

[1]Department of Laboratory Medicine, Cliniques Universitaires St-Luc and Université Catholique de Louvain, Brussels, Belgium

[2]Pôle de recherche en Endocrinologie, Diabète et Nutrition, Institut de Recherche Expérimentale et Clinique, Cliniques Universitaires St-Luc and Université Catholique de Louvain, Brussels, Belgium

[3]División de Tecnologías Emergentes de la Federación Internacional de Medicina de Laboratorio (IFCC), Milán, Italia

[4]Clinic of Cardiology, Alice Spring Hospital, Alice Spring, Australia

[5]School of Medicine, Flinders University - Adelaide, Adelaide, Australia

The landscape of healthcare and laboratory medicine is undergoing rapid transformation, driven by groundbreaking technological advancements, global health challenges, and a deeper understanding of the intricate connections among genetic factors, environmental factors, and diseases.[1,2] From the observations to date, it is evident that emerging technologies, the exposome, and the focused cardiovascular prevention strategies will define the next frontier in improving health outcomes and sustainability.

Emerging technologies, coupled with a focus on the exposome and targeted cardiovascular and other prevention strategies for chronic diseases, are defining the future of health outcomes and sustainable practices.[1] From generative artificial intelligence (AI) to advanced diagnostics, these innovations are now redefining the delivery of care. Hyperautomation and AI are set to enhance operational efficiency, minimize errors, and streamline workflows in laboratories. AI-driven tools, such as machine-learning algorithms, are becoming integral in predicting disease risks and optimizing diagnostic accuracy, particularly in complex conditions like cardiovascular diseases (CVD). Advancements in point-of-care testing and wearable health technologies also promise greater accessibility, especially in underserved regions.[3,4]

Investigating the complex interplay of external environmental factors with genetic predispositions offers critical insights into the mechanisms underlying multifactorial diseases. Such advancements are expected to not only enhance the ability to predict a patient's risk of disease but also pave the way for personalized therapeutic approaches that align with individual genetic and environmental contexts.

Moreover, the potential of the metaverse to augment medical training and virtual consultations is fast becoming a reality. AI technologies are now being utilized for generating synthetic patient cases, enhancing diagnostic training, and creating immersive learning environments. These technologies collectively underscore the importance of interdisciplinary collaboration and ethical frameworks to ensure equitable and secure implementation.

The exposome concept, which encompasses all life-long external and internal exposures, has emerged as a pivotal focus in the domain of laboratory medicine.[2] Environmental factors, including pollution, dietary patterns, and socioeconomic status, significantly impact our overall health. Integrating exposome data with omics technologies (such as genomics, proteomics, and metabolomics) is expected to provide a comprehensive view of the ways in which environmental and genetic factors interact to influence diseases, especially CVD. Advanced metabolomic techniques, supported by AI, are uncovering biomarkers that link environmental exposures to early metabolic changes, thereby facilitating personalized prevention strategies.

For example, past research has shown that air pollution and excessive dietary salt intake contribute to increased CVD risk by inducing subtle biochemical alterations. Advancements made in the field of laboratory medicine, with its capacity to detect and interpret these changes, position it as a cornerstone in proactive public health strategies.[2] Global collaborations have also begun to develop exposome-based policies so as to mitigate urban environmental risks such as pollution and inadequate access to nutritious food. A global emphasis on developing robust exposome analytics platforms will bridge the critical gaps encountered when integrating environmental data into routine clinical care.

Corresponding author: Damien Gruson, Department of Laboratory Medicine, Cliniques Universitaires St-Luc and Université Catholique de Louvain, Brussels, Belgium

e-mail: damien.gruson@uclouvain.be

Received: January 02, 2025 **Accepted:** January 28, 2025 **Available Online Date:** xxxxxx • **DOI:** 10.4274/balkanmedj.galenos.2025.2024-12-133

Available at www.balkanmedicaljournal.org

ORCID iDs of the authors: D.G. 0000-0001-5987-4376; T.K.Ö. 0000-0003-1168-8237.

Cite this article as: Gruson D, Kemaloğlu Öz T. Trends in Healthcare and Laboratory Medicine: A Forward Look into 2025. Balkan Med J.;

CVD remains a leading global health challenge, with projections estimating a 73.4% increase in crude mortality by 2050 due to the rising aging populations and escalating risk factors such as hypertension and obesity.[5] However, efforts in primary prevention and early detection are bearing fruit, as evidenced by the declining age-standardized mortality rates. Laboratory medicine plays a crucial role in advancing these efforts through precision diagnostics and risk-stratification models. The Council of the European Union's recent emphasis on robust cardiovascular health initiatives aligns with the growing integration of digital health tools.[6] Tools such as remote monitoring devices and AI-powered risk-prediction models enable earlier detection, tailored interventions, and improved patient outcomes. Moreover, emerging research underscores the potential of integrating real-time biometric data with personalized AI algorithms to further refine risk predictions. This approach can not only optimize intervention strategies but also alleviate healthcare system burdens by reducing preventable complications. By focusing on such innovations, healthcare systems can address the dual challenges of an aging population and rising CVD risk factors while fostering a more proactive and cost-effective care paradigm.

Addressing sustainability in the healthcare domain is an urgent priority. Laboratories are increasingly adopting environmentally conscious practices, including reducing the consumption of plastic waste and optimizing energy. Notably, several institutions have implemented circular economy models for laboratory consumables, complemented by advanced recycling programs. Simultaneously, efforts to bridge health-equity gaps are accelerating, with a particular focus on women's health and underserved low-income communities. Targeted investments in health-equity initiatives thus have the potential to substantially improve global economic and health outcomes by 2040.

In conclusion, the convergence of cutting-edge technologies, exposome analytics, and cardiovascular prevention marks a pivotal moment in the evolution of healthcare and laboratory medicine (Figure 1). This integration refers not only to an incremental advancement but also a transformative leap toward precision medicine and holistic health strategies. To fully harness the potential of these innovations, it is essential to foster collaboration across all sectors-researchers, policymakers, healthcare providers, and technologists-thereby ensuring that every stakeholder can contribute to the collective vision. Embracing these advancements with a focus on sustainability, equity, and patient-centered care would propel laboratory medicine to new heights by catalyzing significant breakthroughs in disease prevention, diagnosis, and treatment. Moving forward, the dynamic synergy between these fields will serve as the foundation for a healthier, more equitable global future, where science and innovation work hand-in-hand to address the most pressing challenges in cardiovascular health.

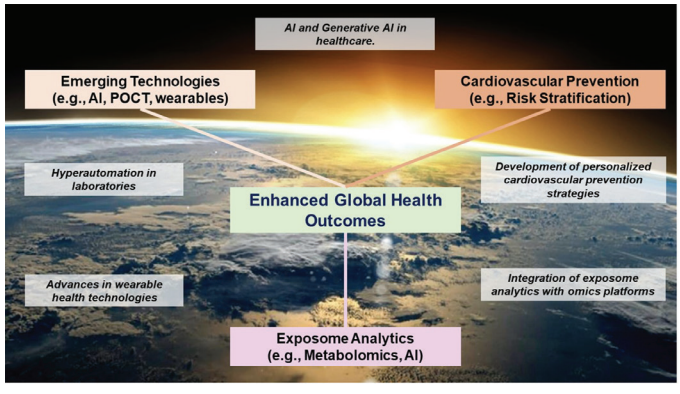

FIG. 1. Key technological and analytical drivers of healthcare innovation in 2025.

Authorship Contributions: Concept- D.G., T.K.Ö.; Design- D.G., T.K.Ö.; Literature Review- D.G., T.K.Ö.; Writing- D.G., T.K.Ö.; Critical Review- D.G., T.K.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

REFERENCES

1. Greaves RF, Gruson D. Six years of progress - highlights from the IFCC Emerging Technologies Division. *Clin Chem Lab Med.* 2024;62:1877-1879. [CrossRef]
2. Gruson D, Fux E, Kemaloğlu Öz T, et al. Contribution of laboratory medicine and emerging technologies to cardiovascular risk reduction via exposome analysis: an opinion of the IFCC Division on Emerging Technologies. *Clin Chem Lab Med.* 2025;63:521-524. [CrossRef]
3. Plebani M, Nichols JH, Luppa PB, et al. Point-of-care testing: state-of-the art and perspectives. *Clin Chem Lab Med.* 2025;63:35-51. [CrossRef]
4. Alanzi T, Ur Rehman S, Khan MA, Istepanian RSH. The evolution and mapping trends of mobile health (m-Health): a bibliometric analysis (1997-2023). Mhealth. 2024;10:23. [CrossRef]
5. Chong B, Jayabaskaran J, Jauhari SM, et al. Global burden of cardiovascular diseases: projections from 2025 to 2050. *Eur J Prev Cardiol.* 2024;zwae281. [CrossRef]
6. Cardiovascular health: council calls for more robust efforts to help prevent cardiovascular diseases - consilium [Internet]. [cited 2024 Dec 24]. [CrossRef]