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Research Article

AI Integration in green labs to achieve the third SDG goal: Literature review on good health and well being

Ahmad Fauzi [a,1,*], Diani Fatmawati [b,2]
[a] Department of Biology Education, Faculty of Teacher and Training Education, Universitas Muhammadiyah Malang, Jl. Tlogomas No. 246Malang, East Java, 65144, Indonesia
[b] Student of Graduate School of Biotechnology, College of Life Sciences, Kyung Hee University, 26 Kyungheedae-ro, Dongdaemun-gu, Seoul, South Korea
[1] ahmad_fauzi@umm.ac.id; [2] diani@umm.ac.id
* Corresponding

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ABSTRACT

Background: In today's era, artificial intelligence (AI) is increasingly being used in various fields, including healthcare and sustainability. While the use of AI can increase efficiency and have positive impacts, it also raises several critical concerns that require attention.
Objectives: This review aims to synthesize and evaluate green laboratory practices along with the use of AI in the Sustainable Development Goals (SDGs), especially the third SDG (good health and well-being).
Methods: A systematic analysis was conducted on 206 recent studies involving AI in biomedical research. The reviewed articles focused on empirical papers.
Results: The thematic synthesis revealed that AI applications in biomedical research were predominantly concentrated in diagnostic pathology, infectious disease management, oncology, and clinical decision support, with deep learning–based models.
Conclusion: Overall, this review suggests that while AI has demonstrated substantial potential to improve medical laboratory practices and health outcomes aligned with SDG 3. Future research should place greater emphasis on ethical governance, real-world clinical integration, and sustainability to ensure responsible and impactful implementation.

Keywords: artificial intelligence; good health; SDGs

SDGs Relevance: This literature review supports SDG 3 (good health and well-being)
Laboratory Affiliation: This study uses literature review method.

INTRODUCTION

The Sustainable Development Goals (SDGs) are a global agenda expected to address various human and environmental issues across a wide range of sectors. One of the 17 goals in the SDGs is achieving sustainable health and well-being (SDG 3). Achieving these SDGs presents numerous challenges, including the emergence of new diseases, the demand for healthcare, limited and under-distributed diagnostic capacity, and the use of environmentally friendly laboratories. The emergence of various outbreaks and pandemics also underscores the importance of building sustainable laboratory capacity (Ndjomou et al., 2021). In healthcare practice, laboratories contribute significantly to environmental burdens. Various clinical laboratories have reportedly adopted sustainable practices, such as reducing energy and water consumption, minimizing waste, and implementing green purchasing policies (Lopez & Badrick, 2012; Ongaro et al., 2022). Some laboratories have also successfully reduced carbon dioxide emissions and plastic waste, such as a clinical laboratory in a Malaysian hospital (Yeoh et al., 2024). Such sustainable practices play a crucial role in reducing environmental impacts and thus supporting the achievement of sustainable development (Bayrau et al., 2025), although these efforts must be undertaken through a holistic approach (Dye, 2018).

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Green laboratory practices are an important strategy for addressing health issues while also addressing environmental sustainability. In general, these laboratories integrate energy-efficient design, resource conservation, and waste reduction to minimize their environmental impact (Bhattacharya, 2024). Green laboratory practices need to be implemented not only in healthcare practices in hospitals but also in the biomedical research sector. Since then, reducing the carbon footprint has become a necessary effort (Welburn, 2024). Green laboratory practices can also reduce waste management costs and reduce energy and water consumption in medical laboratories. Furthermore, educational initiatives and the use of the latest technology are also alternative solutions for integrating sustainable principles in mitigating the environmental impact of the healthcare sector (Rai, 2024).

One of the latest technologies that has the potential to help improve the efficiency and precision of health diagnostics is artificial intelligence (AI). The use of AI can improve diagnostic accuracy and operational efficiency by reducing the rate of human error and optimizing resource allocation (Ashraf et al., 2025; Khwaji et al., 2024). AI's ability to quickly process complex data allows for the rapid identification of trends and abnormalities in test results (Wickramasekera & Gonapaladeniya, 2024). Furthermore, this technology can also improve biosafety management by providing real-time monitoring in addition to predictive maintenance (Qi et al., 2025). Furthermore, the use of AI is also said to be able to improve healthcare outcomes, equity, and effectiveness globally (Thomas & Leon, 2025).

While attention to the use of AI in the sustainable health sector is increasing, AI also has several shortcomings that have the potential to negatively impact the sustainable health sector. Some of the challenges of using AI include potential privacy issues, lack of data transparency, and algorithmic bias (Aknouch et al., 2025; Islam et al., 2025; Sanjaya & Kumar, 2025). Furthermore, AI technology is also reported to consume large amounts of energy, thereby increasing carbon emissions (Dhiman et al., 2024; Richie, 2022). Data centers operating AI also consume large amounts of electricity and fresh water (Sidorkin, 2025). Furthermore, the increased use of AI also leads to increased e-waste, which can lead to environmental pollution (Zhuk, 2023). Therefore, while AI has the potential to optimize the achievement of SDG 3, it also has the potential to negatively impact environmental sustainability.

In light of the background and issues presented, to date, a comprehensive review discussing how AI supports green laboratories in achieving good health outcomes and sustainable laboratory operations within the SDG 3 framework has yet to be widely conducted. Therefore, the purpose of this review is to map, evaluate, and synthesize various empirical papers integrating AI in the healthcare sector and analyze its impact on the environmental sector.

METHODS

Search strategy

A comprehensive literature search was conducted in the Scopus database to identify empirical studies involving the application of artificial intelligence in medical laboratory settings. The search strategy employed a Boolean query combining terminology related to artificial intelligence and medical laboratory domains: ("artificial intelligence" OR "machine learning" OR "deep learning" OR "AI" OR "neural network*" OR "computer vision") AND ("medical laborator*" OR "clinical laborator*" OR "diagnostic laborator*" OR "pathology laborator*" OR "biomedical laborator*" OR "microbiology laborator*" OR "hematology laborator*" OR "biochemistry laborator*" OR "molecular laborator*") AND (empirical OR experiment* OR evaluation OR "case study" OR implementation OR "real-world" OR "clinical validation"). The search was limited to publications indexed as journal articles, published in English, classified as final publication stage, and appearing between 2021 and 2025. Open-access status was unrestricted. The initial search yielded 219 records.

Inclusion and Exclusion Criteria and Literature Screening

Titles and abstracts were screened to exclude studies that were not directly related to human health, did not involve laboratory practices, or did not constitute empirical research. After applying these criteria, 211 articles remained for full-text assessment.

Retrieving PDF

Of the eligible articles, 206 full-text PDF files were successfully retrieved for detailed review and data extraction.

Data Extraction

A structured extraction procedure was applied to all included studies. Five key components were extracted from each article: (1) title, (2) research objective, (3) type of artificial intelligence applied and its specific application, and (4) main findings.

RESULTS

This review paper examined and extracted 206 articles involving research on the use of AI in biomedicine. The results of the thematic analysis based on the titles and research objectives of these articles are presented in Table 1. Based on Table 1, several papers can be grouped into several main thematic domains. The largest group relates to laboratory pathology and diagnostics, encompassing studies in pathology, laboratory medicine, genetics, and genomics, with a primary focus on laboratory analysis and AI-assisted diagnostic decision-making. A significant number of studies also address oncology and chronic diseases, including cancer, cardiovascular disorders, and metabolic diseases. Based on the titles and research objectives of these papers, AI is often applied to diagnosis, prognosis, and disease monitoring.

Table 1. Thematic synthesis of AI integration in health research

Thematic Cluster	Primary Medical Domain	Primary Focus
Laboratory & Diagnostic Pathology	Pathology & Laboratory, Genetics & Genomics	Laboratory analysis, pathology, and genetic diagnostics using AI
Infectious Diseases and Epidemiology	Infectious Diseases, Respiratory Diseases	Detection, prediction, and management of infectious diseases
Medical Specialties	Orthopaedics, Gastroenterology, Kidney & Urinary, Dermatology	AI applications across medical specialties
Special Populations	Neurological Disorders, Paediatric Care, Maternal & Reproduction	Care for special populations (paediatrics, maternal, neurology)
Oncology & Chronic Diseases	Cancer & Oncology, Cardiovascular Diseases, Diabetes & Metabolism	Diagnosis and prognosis of cancer and chronic diseases
Medical Imaging & Radiology	Medical Imaging	Medical image analysis for diagnosis and detection
Emergency & Critical Care	Emergency & Critical Care	Decision support for emergency and critical care

Next, a thematic analysis was conducted on various AI applications studied or utilized in the reviewed papers. The results of the thematic analysis are presented in Table 2. The extraction results demonstrate the diversity of AI approaches applied in healthcare research. Deep learning and CNNs are among the most frequently used methods. These applications are often found in image-intensive domains such as pathology and radiology. Supervised machine learning techniques are also frequently applied to structured clinical and laboratory datasets.

Table 2. Thematic analysis of AI types in health research

No	AI Types
1	Generative AI
2	Natural Language Processing
3	Transformer & Attention
4	Deep Learning
5	Machine Learning (Supervised)
6	Convolutional Neural Networks (CNN)
7	AutoML & Neural Architecture Search
8	Explainable AI
9	Recurrent Neural Networks (RNN)
10	Radiomics & Medical Imaging AI

The final thematic analysis was conducted based on the extracted findings from the various reviewed papers. The results of this thematic analysis are summarized in Table 3. The most frequently encountered findings were model and algorithm performance. For example, findings related to improved predictive accuracy and robustness. Closely related to this category are findings regarding performance metrics, such as accuracy, sensitivity, specificity, and area under the curve (AUC). These are commonly used to evaluate AI systems. Furthermore, diagnostic accuracy, prognostic capabilities, and treatment decision support, as well as comparative analyses comparing AI models with baseline methods or traditional clinical approaches, were also among the research findings reported in several reviewed papers. Furthermore, several studies reported findings related to cost, efficiency, and time, particularly in relation to workflow optimization and diagnostic turnaround time.

Table 3. Thematic analysis of research main finding

No	Category	Description
1	Model & Algorithm Performance	Findings related to the performance of AI models and algorithms
2	Performance Metrics	Findings related to AI performance metrics (accuracy, AUC, sensitivity, etc.)
3	Cost & Efficiency	Findings related to cost, efficiency, and time
4	Data & Features	Findings related to data, features, and variables used
5	Comparative Analysis	Findings comparing AI methods with baselines/other methods
6	Safety & Ethics	Findings related to safety, ethics, bias, and fairness
7	Clinical Implementation	Findings related to the implementation of AI in clinical practice
8	Clinical Outcomes	Findings related to clinical outcomes (diagnosis, prognosis, treatment)
9	Validation & Reliability	Findings related to the validation and reliability of AI systems
10	Limitations & Challenges	Findings related to limitations and challenges
11	Other	Other findings not included in the main categories

DISCUSSION

A review of over 200 papers shows that artificial intelligence has been widely integrated into various medical laboratory fields. A wide range of domains have been explored through research involving AI, including diagnostic pathology, infectious disease detection, oncology, and clinical decision support. This diversity reflects AI's critical role in advancing health-related goals aligned with SDG 3.

Several factors are driving the integration of AI in health research due to this technology, for example, because it is expected to improve diagnostic accuracy, disease prediction, and early detection of health disorders. Improvements in the quality of medical care are also expected to increase because AI is considered to have driven a revolution in clinical laboratory diagnostics by automating routine tasks to support clinical decision-making (Krylov & Sheblaev, 2024; Xie et al., 2024). In oncology, AI can play a role in early cancer detection, prognosis prediction, and assisting patient stratification (Sharma et al., 2025). Similarly, in the field of infectious diseases, AI has microbial diagnostics that can be utilized to rapidly identify and characterize pathogens and antimicrobial resistance genes (Sharma et al., 2025). AI is also capable of processing and analyzing large, complex data sets. By using AI to deal with such data, researchers and healthcare practitioners can develop efficient diagnostic and predictive models (Xie et al., 2024).

Based on the results of the thematic analysis of the AI technologies used, deep learning, convolutional neural networks, and transformer-based architectures are among the AI technologies frequently used as methods in reviewed health studies. In relation to these findings, deep learning has become a foundation in medical imaging that greatly facilitates researchers and practitioners to classify images, segmentation, and object detection in disease diagnosis and prognosis (Das, 2024; Gobinath et al., 2025). The use of transformer-based architectures plays a role in processing and integrating medical imaging data as an effort to improve segmentation accuracy and boundary precision (Singh et al., 2025). In line with this, the shift in the use of microscopes from traditional to digital in pathology also increasingly facilitates the application of AI in the world of health (Mozumder et al., 2025).

Based on the analysis of the findings of various papers reviewed in this study, in general, the use of AI consistently plays a positive role in clinical matters. The use of automated machine learning in various clinical applications is able to exceed the accuracy and efficiency of conventional models (Thirunavukarasu et al., 2023, 2024). Furthermore, the use of AI also has a positive impact on handling big data that is important in various medical fields (Thirunavukarasu et al., 2024). However, the challenges of using AI in the medical world also need to be considered. Challenges such as algorithm interpretability and the need for high-quality data are persistent barriers that must be overcome to ensure the successful integration of AI into healthcare systems (Hamza et al., 2024; Ribeiro et al., 2025). Furthermore, validation and oversight are also necessary to improve the accuracy and efficiency of AI use.

CONCLUSION

This review synthesized 206 empirical studies examining the use of AI in medical research. Several healthcare domains were mapped, including diagnostic pathology, infectious disease management, oncology, and clinical decision support. The use of AI in these domains contributes to the advancement of health outcomes aligned with SDG 3. Thematic analysis of the extracted papers reviewed also revealed an emphasis on performance-oriented AI applications dominated by deep learning-based approaches. However, several issues also need to be addressed in the use of AI, such as ethical issues, real-world implementation, sustainability considerations, and standard evaluation frameworks in laboratory settings.

Author Contributions: Ahmad Fauzi conceptualized the study, designed the review framework, developed the search strategy, conducted data screening and thematic analysis, and drafted the manuscript. Diani Fatmawati contributed to data extraction and critical revision of the manuscript

Conflicts of Interest: The authors declare no conflicts of interest.

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