International Journal of Infectious Diseases 143 (2024) 107011

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Editorial

Transformative potential of artificial intelligence on health care and research in Africa

Moses J. Bockarie[1,2,*], Rashid Ansumana[1,3], Shingai Grace Machingaidze[4], Dziedzom K. de Souza[5], Patrick Fatoma[1], Alimuddin Zumla[6], Shui-Shan Lee[2,7]

[1] College of Medical Sciences, Njala University, Bo, Sierra Leone
[2] International Society for Infectious Diseases, Brookline, MA, USA
[3] School of Public Health and Tropical Medicine, Tulane University, New Orleans, LA, USA
[4] Africa Centres for Disease Control and Prevention (Africa CDC), Addis Ababa, Ethiopia
[5] Department of Parasitology and Department of Clinical Pathology, Noguchi Memorial Institute for Medical Research, College of Health Sciences, University of Ghana, Accra, Ghana
[6] Department of Infection, Division of Infection and Immunity, University College London; NIHR Biomedical Research Centre, UCL Hospitals NHS Foundation Trust, London, UK
[7] S.H. Ho Research Centre for Infectious Diseases, The Chinese University of Hong Kong, Shatin, Hong Kong

ARTICLE INFO

Keywords:
Artificial intelligence
Infectious diseases
Public health
Health care
Health research

The rise of artificial intelligence (AI) stands out as a revolutionary technological force, surpassing the transformative impact observed during the transition to web and mobile technologies [1,2]. Advances in technology present opportunities for enhancing scientific discovery, accelerating human progress, and improving quality of life. AI, a broad term covering machine and deep learning algorithms emulating human intelligence, has led to the development of various algorithms aiding tasks in public health, from workflow optimization to diagnostics and forecasting. The media has been captivated by the application of AI in health care, especially after the introduction of large language models such as generative pre-trained transformer in late 2022 [3,4]. AI drives technologies, such as Open AI's Chat generative pre-trained Transformer for natural language processing, have dramatically enhanced the quality of documents, including grant proposals and manuscripts, developed by African scientists communicating in European languages.

Emerging AI tools, such as GPT4 and Generative AI, driven by generative modeling, can dramatically improve the supply chain management for health care interventions, analysis of big data, accuracy of human actions, and learn from public health outcomes, such as access to healthcare, infection rates, morbidity, and mortality [5]. Generative AI is now used by millions worldwide, enabling scientists to tackle more complex questions, use new tools for improved data analysis, and unravel protein structures [5]. The vast potential of AI extends to enhancing health care and medicine delivery, aiding countries in achieving universal health coverage as proposed by the World Health Organization (WHO) [6]. AI will accelerate advancements in diagnosis, clinical care, health research, drug development, and the implementation of various public health interventions, such as disease surveillance, outbreak response, and health systems management [3]. In this regard, the New England Journal of Medicine (NEJM) launched NEJM AI in December 2023, a new monthly journal from NEJM Group, that explores the cutting-edge applications of AI and machine learning in clinical medicine [7].

In Africa, AI holds the potential to drive pioneering innovations in public health, significantly boosting knowledge, learning, creativity, and productivity in low-resource settings [6,8]. In recent years, AI has optimized and accelerated several innovations in different aspects of health care across Africa [8]. In Kenya, a mobile-optimized AI system has been developed for gestational age and fetal malpresentation assessment [9]. The gestational age model is comparable to the clinical standard and the fetal malpresentation model has high sensitivity and specificity across operators and

* Corresponding author:
E-mail address: mbockarie@gmail.com (M.J. Bockarie).

https://doi.org/10.1016/j.ijid.2024.107011

devices. In Nigeria, OnTime Consortium—an innovative collaboration that brings together researchers, policymakers, and big tech company to proffer solutions to the challenges faced by expectant mothers and their caregivers—has collaborated with Google in the development of an AI tool to assess geographic access to emergency obstetric care using its Directions API [10]. The aim of the obstetric care project is to identify limited access areas and enhance maternal health by informing decision-makers and public health stakeholders. The Rwanda Innovation Fund, in partnership with Viebeg Technologies, a Health Tech company backed by venture capital, is leveraging AI to enhance health care accessibility in Rwanda [11]. By facilitating real-time procurement of medical supplies, the initiative ensures health care facilities maintain accurate inventory levels, connecting providers directly with manufacturers. This innovative approach, funded, in part, by the African Development Bank, eliminates intermediaries, leading to cost savings of up to 40%. Viebeg Technologies is now extending its reach to other regions in East Africa, aiming to serve over 500 facilities and planning further expansion across the continent [11]. The prevention and control of infectious diseases is an important part of health systems in Africa. Addressing the public health challenge of antimicrobial resistance (AMR) in Africa requires extensive optimization of antimicrobial use and broader infection care. This optimization can be facilitated by thoughtfully designed AI models. A framework for the adaptive implementation and maintenance of such AI models has been created to enhance antimicrobial use and infection care as a learning system [12]. The implementation of AMR-targeted AI models should address factors such as AMR problem identification, legal and regulatory aspects, organizational support, and data processing [12].

In the area of diagnostics, numerous high-quality data sources are required to enhance machine learning algorithms for accurate diagnosis using tools such as ultrasound, magnetic resonance imaging, mammography, genomics, and computed tomography scan. Deep learning algorithms are used in rural South Africa to enhance the proficiency of health workers in diagnosing HIV through lateral flow tests [8,13]. A recent systematic review of the use of AI in disease diagnosis demonstrated favorable prediction rates based on accuracy, sensitivity, specificity, the area under curve precision, recall, and F1-score for different diagnostic methods [14]. In West Africa, where the number of pathologists per million people is less than 10, health facilities could benefit from AI in Cervical Cancer Screening and Diagnosis [15]. In Lesotho, where access to expert echocardiography is limited, focused echocardiography, combined with AI-supported analysis, has been shown to improve diagnosis and monitoring of heart function based on left ventricular hypertrophy [16].

The WHO Regional Office for Africa recognizes the significant potential of AI to revolutionize health care outcomes by enhancing access and strengthening health systems on the continent [17]. WHO Regional Office for Africa emphasizes the need for Africa to prepare for this inevitable transformation and showcases various AI technological innovations developed, deployed, and actively utilized to strengthen health systems throughout the African region on its website [17]. Africa Centers for Disease Control and Prevention, through its Digital Transformation Strategy, will support member states in harnessing the potential of AI to leapfrog some of the barriers affecting health care and public health. Utilizing its Digital Transformation Strategy, Africa Centers for Disease Control and Prevention aims to assist member states in leveraging the power of AI to overcome obstacles in health care and public health, facilitating significant advancements [18].

Although we recognize the potential of AI for health care in Africa, introducing the emerging AI health care initiatives in Africa poses challenges, including inadequate infrastructure, as well as understanding, trust, and acceptance of such applications [19]. Many regions lack the necessary electricity supply and internet access for the reliable implementation of large-scale AI projects. Moreover, access to high-quality locally generated data sets is required to improve on the available tools; however, most data sets are stored outside Africa, which limits their use in tackling health care issues specific for African people. Although Africa holds the highest genetic diversity of any continent, less than 2% of analyzed human genomes have focused on African individuals, even though Africa is the birthplace of humanity [20]. The use of AI in analyzing genomes from non-European people and detecting diseases [20,21] is constrained because 95% of the available data are from European genomes.

There have also been recent advances in the application of AI in basic health and biological sciences and partnership building to ensure resource limited countries in Africa benefit from the new platforms. DeepMind's AI system, AlphaFold [22,23], accurately predicts the three-dimensional structure of proteins from their amino acid sequences matching the precision of experimental models. Through a collaboration with European Molecular Biology Laboratory's European Bioinformatics Institute, the AlphaFold database has been established to offer free access to the global scientific community to three-dimensional protein structure predictions [22]. The latest database release has over 200 million entries that are available through individual downloads for the human proteome and for the proteomes of 47 other key organisms important in research and global health [24,25]. AlphaFold has recently been used by researchers to pinpoint hundreds of thousands of potential novel drug candidates at the molecular level [26]. This suggests that AlphaFold predictions, which are easily accessible, can be as valuable for drug discovery as experimentally determined protein structures, a process that often spans months or even years.

Emerging AI models can run on-device, without internet connectivity, and provide feedback scores to assist in upleveling the capabilities of middle-level technicians and operators in low-resource settings. Using AI technology, the Three Million African Genomes project is actively working to sequence the genomes of three million individuals in Africa [20]. This initiative has already unveiled previously unknown genetic variations within ethnolinguistic groups across the continent [20]. AI is being applied to the study of genomic sequences of viruses harbored in animals and will enable predicting their ability to potentially jump from their animal hosts into humans. As climate change alters and human populations are displaced into forests by conflicts and hunger, AI could serve to detect emergence of new zoonotic diseases and its integration into public health services will bolster rapid surveillance data sharing real-time before they start spilling over into humans [27].

AI language models, such as Chat generative pre-trained Transformer, hold potential for global health care; however, addressing language bias in Africa is a significant challenge. It is crucial to ensure robust training of these technologies, making them sensitive to diverse languages and cultures. Further research into AI's role in health care, especially in regions with limited resources, is warranted. Moreover, the substantial potential of integrating AI systems into health care requires a reassessment of ethical and legal frameworks [28]. The use of AI in health care in Africa and elsewhere in the world should be accompanied by oversight to address malfunctions, biases, or ethical breaches [6]. The key challenge lies in adapting traditional, cultural, and ethical liability concepts to the innovative and unpredictable nature of AI or exploring alternative approaches, such as reconciliation [29].

As we continue to embrace AI and its applications in health care in Africa, continued discussions, collaborations, and research are needed to navigate these complexities to find solutions that balance progress with protection.

Authors' contributions

The initial concept was conceived by the first author (MJB), while all co-authors made equal contributions to the development of the manuscript.

Declarations of competing interest

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

[1] Bill Gates *Gates notes: the blog of Bill Gates. The Age of AI has begun*; 2023. https://www.gatesnotes.com/The-Age-of-AI-Has-Begun. [accessed 01 March 2024].
[2] Wachter RM, Brynjolfsson E. Will generative artificial intelligence deliver on its promise in health care? *JAMA* 2024;**331**:65–9. doi:10.1001/jama.2023.25054.
[3] Beam AL, Drazen JM, Kohane IS, Leong TY, Manrai AK, Rubin EJ. Artificial intelligence in medicine. *N Engl J Med* 2023;**388**:1220–1. doi:10.1056/NEJMe2206291.
[4] Weeks WB, Taliesin B, Lavista JM. Using artificial intelligence to advance public health. *Int J Public Health* 2023;**68**:1606716. doi:10.3389/ijph.2023.1606716.
[5] Lee P, Bubeck S, Petro J. Benefits, limits, and risks of GPT-4 as an AI chatbot for medicine. *N Engl J Med* 2023;**388**:1233–9. doi:10.1056/NEJMsr2214184.
[6] World Health Organization *Ethics and Governance of Artificial Intelligence for Health - WHO guidance*. Geneva: World Health Organization; 2021.
[7] Kohane IS. Injecting artificial intelligence into medicine. *NEJM Ai* 2024;**1**:1–3. doi:10.1056/Ale2300197.
[8] Ngo HT, Akarapipad P, Lee PW, Park JS, Chen FE, Trick AY, et al. Rapid and portable quantification of HIV RNA via a smartphone-enabled digital CRISPR device and deep learning. *medRxiv* 16 May 2023 [accessed 01 March 2024]. doi:10.1101/2023.05.12.23289911.
[9] Gomes RG, Vwalika B, Lee C, Willis A, Sieniek M, Price JT, et al. A mobile-optimized artificial intelligence system for gestational age and fetal malpresentation assessment. *Commun Med (Lond)* 2022;**2**:128. doi:10.1038/s43856-022-00194-5.
[10] Banke-Thomas A, Macharia PM, Makanga PT, Beňová L, Wong KLM, Gwacham-Anisiobi U, et al. Leveraging big data for improving the estimation of close to reality travel time to obstetric emergency services in urban low- and middle-income settings. *Front Public Health* 2022;**10**:931401. doi:10.3389/fpubh.2022.931401.
[11] African Development Bank *How Rwanda is using Artificial Intelligence to improve healthcare*; 2022. https://www.afdb.org/en/success-stories/how-rwanda-using-artificial-intelligence-improve-healthcare-55309. [accessed 01 March 2024].
[12] Howard A, Aston S, Gerada A, Reza N, Bincalar J, Mwandumba H, et al. Antimicrobial learning systems: an implementation blueprint for artificial intelligence to tackle antimicrobial resistance. *Lancet Digit Health* 2024;**6**:e79–86. doi:10.1016/S2589-7500(23)00221-2.
[13] Turbé V, Herbst C, Mngomezulu T, Meshkinfamfard S, Dlamini N, Mhlongo T, et al. Deep learning of HIV field-based rapid tests. *Nat Med* 2021;**27**:1165–70. doi:10.1038/s41591-021-01384-9.
[14] Kumar Y, Koul A, Singla R, Ijaz MF. Artificial intelligence in disease diagnosis: a systematic literature review, synthesizing framework and future research agenda. *J Ambient Intell Humaniz Comput* 2023;**14**:8459–86. doi:10.1007/s12652-021-03612-z.
[15] Hou X, Shen G, Zhou L, Li Y, Wang T, Ma X. Artificial intelligence in cervical cancer screening and diagnosis. *Front Oncol* 2022;**12**:851367. doi:10.3389/fonc.2022.851367.
[16] Firima E, Gonzalez L, Manthabiseng M, Bane M, Lukau B, Leigh B, et al. Implementing focused echocardiography and AI-supported analysis in a population-based survey in Lesotho: implications for community-based cardiovascular disease care models. *Hypertens Res* 2024;**47**:708–13. doi:10.1038/s41440-023-01559-6.
[17] WHO Regional Office for Africa *AI driven Innovations*; 2024. https://innov.afro.who.int/global-innovation/ai-health-driven-innovations-3922. [accessed 01 March 2024].
[18] Africa Centres for Disease Control and Prevention *Digital transformation strategy*; 2023. https://africacdc.org/download/digital-transformation-strategy/. [accessed 01 March 2024].
[19] Erasmus R, Ondoa P. Taking the train of digital health and artificial intelligence to improve medical laboratory service in Africa: key considerations. *Afr J Lab Med* 2023;**12**:2329. doi:10.4102/ajlm.v12i1.2329.
[20] Wonkam A. Sequence three million genomes across Africa. *Nature* 2021;**590**:209–11. doi:10.1038/d41586-021-00313-7.
[21] EditorialAfrica's people must be able to write their own genomics agenda. *Nature* 2020;**586**:644. doi:10.1038/d41586-020-03028-3.
[22] Ohno S, Manabe N, Yamaguchi Y. Prediction of protein structure and AI. *J Hum Genet* 2024. doi:10.1038/s10038-023-01215-4.
[23] Jones RN, Miyauchi S, Roy S, Boutros N, Mayadev JS, Mell LK, et al. Computational and AI-driven 3D structural analysis of human papillomavirus (HPV) oncoproteins E5, E6, and E7 reveal significant divergence of HPV E5 between low-risk and high-risk genotypes. *Virology* 2024;**590**:109946. doi:10.1016/j.virol.2023.109946.
[24] European Molecular Biology Laboratory *EBI. AlphaFold Protein Structure Database*; 2024. https://alphafold.ebi.ac.uk/. [accessed 01 March 2024].
[25] Yang Z, Zeng X, Zhao Y, Chen R. AlphaFold2 and its applications in the fields of biology and medicine. *Signal Transduct Target Ther* 2023;**8**:115.
[26] Callaway E. AlphaFold found thousands of possible psychedelics. Will its predictions help drug discovery? *Nature* 2024;**626**:14–15. doi:10.1038/d41586-024-00130-8.
[27] Guitian J, Arnold M, Chang Y, Snary EL. Applications of machine learning in animal and veterinary public health surveillance. *Rev Sci Tech* 2023;**42**:230–41. doi:10.20506/rst.42.3366.
[28] Donnelly DL. First do no harm: legal principles regulating the future of artificial intelligence in health care in South Africa. *Potchefstroom Electron Law J* 2022;**25**. doi:10.17159/1727-3781/2022/v25ia11118.
[29] Bottomley D, Thaldar D. Liability for harm caused by AI in healthcare: an overview of the core legal concepts. *Front Pharmacol* 2023;**14**:1297353. doi:10.3389/fphar.2023.1297353.