Asia-Africa Journal of Education Research (AAJER) The Official Journal of the International Association for the Promotion of Asia-Africa Research, India Volume 4, Number 1, 2024 ISSN: 2814 – 3639

https://journals.iapaar.com/index.php/aajer

The Intersection of Artificial Intelligence in Public Health Education for Sustainable Development

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Abstract

Public health education faces numerous challenges, including disparities in access, curriculum relevance, integration of technology, cultural and language barriers, and misinformation. These challenges hinder the development of a well-equipped public health workforce capable of addressing global health issues effectively. The paper analyses how AI-driven solutions, such as adaptive learning platforms, data-driven curriculum development, virtual simulations, and AI-powered translation tools, are transforming public health education by making it more accessible, relevant, and responsive to the needs of diverse populations. Moreover, the paper investigates the intersection of AI and public health education, highlighting how this synergy supports the achievement of Sustainable Development Goals (SDGs) 3 (Good Health and Well-being) and 4 (Quality Education). Artificial Intelligence enhances the accessibility and quality of education (SDG 4) by providing inclusive and adaptive learning opportunities, particularly for underserved populations. Simultaneously, AI contributes to improving health outcomes (SDG 3) by equipping future public health professionals with the skills and knowledge needed to address current and emerging health challenges. The findings suggest that embracing AI in public health education is not only a necessity for keeping pace with technological advancements but also a critical step toward achieving the broader goals of sustainable development.

Keywords: SDGs, artificial intelligence, health, well-being, education

Introduction

Artificial Intelligence (AI) is the capacity of a digital computer or a computer-controlled robot to execute activities that are often associated with intelligent individuals, such as reasoning and problem solving (Sharma, 2024). In computer science, the phrase is widely used to refer to the endeavour of creating systems that are endowed with the cognitive processes that distinguish

humans, such as the capacity to reason, find meaning, generalise, or learn from previous experience.

There are numerous definitions of artificial intelligence, and each of those definitions has undergone revision over time. The majority of definitions for artificial intelligence (AI) today state that AI is capable of solving complex cognitive problems associated with human intelligence, or that AI is capable of helping as many people as possible through smartphones or healthcare, or even that AI is capable of recognising problems and developing solutions for the benefit of technology, people, and society. However, the central concept of artificial intelligence has always been to create machines that are capable of thinking in the same way that humans do (Qin et al., 2024).

Public health education is the cornerstone for maintaining and improving community health standards, preventing diseases, and promoting healthy lifestyles. Public health education typically relies on five fundamental and core disciplinary areas, including biostatistics, epidemiology, environmental health sciences, social and behavioural sciences, and health policy and management (Ghaffar et al, 2021). Historically, traditional teaching methods have dominated the field of education, heavily dependent on didactic teaching methods, face-to-face interaction, and standardised curricula (Wartman and Combs, 2018). Although these methods are foundational, they have limitations in scalability, accommodating diverse learning needs, and rapid dissemination of information, particularly in the context of global health crises such as the COVID-19 pandemic in recent years (Liu et al., 2020).

The World Health Organization cited in Kolachalama (2022) emphasised in its 2018 report that digital technologies and AI are poised to become key tools in achieving its global strategic goals: to increase the number of people benefiting from universal health coverage by one billion, to increase the number of people protected from health emergencies by one billion, and to improve the health and well-being of one billion people. Furthermore, the application of AI in public health education is extensive, ranging from automating administrative tasks to facilitating the resolution of complex problems and decision-making processes in public health scenarios (Wang and Li, 2024).

The United Nations in the Bruntland Commission Report cited in Sharma (2024) established sustainable development as an overarching concept, stating it as development that

fulfils the demands of the present without jeopardising the capacity of future generations to satisfy their own needs. Thus, in order for sustainable development to be achieved, four aspects must be considered: society, environment, culture, and economics. These dimensions are interconnected rather than distinct. In order to achieve a higher quality of life, sustainability is a paradigm for thinking about the future in which environmental, sociological, and economic issues are all considered in the pursuit of that goal.

In the light of the topic under study, development and sustainability would therefore mean the ability of Artificial Intelligence to advance the cause of universal health coverage without neglecting the cultural, environmental, sociological and economical dimensions of health, ensuring that no one is truly left behind and that health disparities is significantly reduced while maintaining the dignity of the human person.

The common link between AI and Health Education hinges on their ability to complement each other's functionality. While Health Education deploys AI to enhance its reach, personalise learning, breakdown complex concepts, etcetera, Artificial Intelligence expresses its vastness by consuming substantial amounts of labelled data for training purposes (Manickam et al., 2022). They analyse this data to identify correlation patterns, which are then utilised to make predictions about future events or states. For instance, a chatbot trained on text examples can learn to generate realistic conversations with individuals, while an image recognition tool can learn to identify and describe objects in images by studying millions of examples (Muftić et al, 2023).

Assessing the interaction of Artificial Intelligence within Public Health Education, does not only highlight the potential to enhance the quality and effectiveness of education but also to innovate the tools and methods of imparting public health knowledge, ultimately equipping current and future public health professionals with the capabilities needed to meet the multifaceted health challenges of the 21st century.

This paper therefore explores the current challenges of public health education, how Artificial Intelligence addresses these challenges, and the intersection of Artificial Intelligence (AI) in Public Health Education, emphasising their role in achieving sustainable development relative to the United Nations Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being) and SDG 4 (Quality Education).

Current Challenges in Public Health Education

Contemporary public health education faces several challenges that impact its effectiveness. A one-size-fits-all approach often fails to consider the diverse demographic and socio-economic backgrounds of learners, leading to gaps in health literacy. Moreover, the static nature of traditional educational resources can result in out-dated information, restricting the responsiveness of public health education to emerging public health threats (Ghaffar et al., 2021). At the same time, there is a growing demand to enhance the practical skills of public health professionals, and traditional lecture-based methods fall short of efficiently addressing this issue.

Prior to and following the COVID-19 pandemic, significant changes occurred in the education of healthcare professionals. A decade of innovation, exemplified by massive open online courses, was disrupted by the COVID-19 pandemic, which unsettled educational systems worldwide (Frenk et al., 2022). This increased the utilisation of online technologies, led to substantial institutional reorganisations to accommodate a blended model of online and face-to-face teaching, and exposed pre-existing inequalities in access to educational resources both within and between nations (Yeoh, 2019, Tens, 2021, and Majumder et al., 2023).

The following are notable outlined challenges in Public Health Education globally;

1. **Disparities in Access to Education:** Access to quality public health education varies significantly across regions, particularly between high income and low-income countries. Factors such as poverty, lack of infrastructure, and political instability exacerbate these disparities, leaving many communities underserved (Frenk et al., 2019).
2. **Curriculum Relevance and Adaptation:** According to Beaglehole and Bonita cited in Jafar et al. (2024), Public Health Education curricula often struggle to keep pace with rapidly changing health needs and emerging global health threats. Additionally, many programmes are not tailored to address specific health issues of the communities they serve, leading to a gap between education and practical application.
3. **Integration of Technology in Education:** While technological advancements like e-learning platforms have the potential to enhance public health education, the digital divide remains a significant barrier. Many low and middle-income countries lack the necessary infrastructure, such as internet access and digital literacy, to fully benefit from these innovations (Bates et al. cited in Hemmat et al., 2019).

4. **Political and Economic Factors:** Global Public Health Education is heavily influenced by political and economic conditions. In many regions, health education initiatives are underfunded or deprioritized due to competing political interests. Economic instability can also limit resources available for education and training programmes (WHO, 2016).
5. **Cultural and Language Barriers:** Cultural and language differences present challenges in designing and delivering public health education programmes that are effective across diverse populations. Programmes that do not account for these differences risk being misunderstood or poorly received, reducing their impact (Napier et al., 2014).
6. **Workforce Shortages and Training:** The World Health Organization (WHO, 2020) noted that there is a global shortage of trained public health professionals, which affects the capacity to deliver quality education and health services. Moreover, existing professionals often lack opportunities for continuous development, which is critical in addressing evolving health challenges.
7. **Misinformation and Public Perception:** The spread of misinformation, particularly through social media, has become a significant challenge for public health education. Misinformation can undermine trust in public health initiatives and lead to harmful health behaviours. Educators must combat this by promoting health literacy and critical thinking skills.

Importance of Artificial Intelligence (AI) in addressing these Challenges

1. AI-Driven Adaptive Learning Platforms: Artificial Intelligence helps overcome disparities in access to education by creating adaptive learning platforms that cater to different learning needs and environments. These platforms adjust content based on the learner's pace, background, and access level, ensuring that education is accessible even in resource-constrained settings. For example, AI platforms like Khan Academy's adaptive learning tools tailor content to individual students' needs, helping bridge educational gaps globally (Zawaki-Richter et al., 2019).
2. AI for Dynamic Curriculum Development: Artificial Intelligence continuously updates public health education curricula by analysing data on emerging health trends, ensuring that the content remains relevant. Artificial Intelligence can identify gaps in existing

curricula and suggest new modules or areas of study that align with current global health challenges (Hossain et al., 2020).

3. AI-driven curriculum tools according to Singh (2019) analyse epidemiological data to update public health courses with relevant information on new diseases or health trends.
4. AI-Supported E-learning and Simulation: AI enhances the integration of technology in public health education by providing realistic simulations and virtual labs. These tools allow students to practise public health interventions in a controlled virtual environment, enhancing their practical skills without needing physical resources (Li et al., 2022). AI powered simulation platforms like Simulab provide virtual training environments for public health scenarios, making education more immersive and hands-on.
5. AI for Resource Optimization: AI can optimise the allocation of limited educational resources, ensuring that funds are used efficiently to maximise impact. By analysing data on educational outcomes and economic conditions, AI helps public health institutions prioritise areas that need the most investment. AI algorithms help public health programmes allocate funding more effectively by predicting which interventions will yield the highest return on investment (Obermeyer and Emmanuel, 2016).
6. AI-Powered Translation and Localization**:** AI addresses cultural and language barriers by providing real-time translation and localization of educational content. AI tools can automatically translate course materials and adapt them to the cultural context of the learner, making public health education more accessible and relevant. AI-driven translation services like Google Translate, enhanced with natural language processing, allow real-time translation of educational materials into multiple languages (Turovsky, 2016).
7. AI for Continuous Learning and Professional Development: AI supports continuous professional development by providing personalised learning paths for public health professionals. AI-powered platforms offer tailored training programmes that update professionals on the latest public health developments, helping mitigate workforce shortages by enhancing skills and knowledge. Platforms like Coursera and Udemy use AI to recommend courses based on a professional's previous learning history, ensuring continuous development (Kaplan and Haenlein, 2019).

8. AI for Monitoring and Countering Misinformation**:** AI tools monitor social media and other digital platforms to detect and counteract misinformation in real-time. AI algorithms analyse content to identify false information and automatically generate accurate, evidence-based responses, helping to maintain public trust in health education. AI systems like those developed by IBM Watson Health scan the internet for health-related misinformation and provide authoritative, scientifically accurate counterpoints (Broniatowski et al., 2018).

The Intersection of Artificial Intelligence (AI) in Public Health Education for Sustainable Development

Artificial intelligence (AI) encompasses a broad collection of algorithms that increasingly affect public health both positively and negatively through applications in health promotion, health care, criminal justice, finance, social networks, employment, and other social determinants of health. Although fairness, accountability, transparency, and ethics (FATE) have been recognized in the AI research community as principles for evaluating algorithms, an intersectional approach is needed to ensure that negative impacts of AI on marginalised groups are understood and avoided and that AI reaches its full potential to support public health.

The potential for bias in AI algorithms is illustrated by high-profile examples, such as Microsoft's short-lived racist, antisemitic, and misogynistic chatbot Tay and the face depixelizer application that "reconstructed" a high-resolution facial image of a White Barack Obama (Bauer and Lizotte, 2021). When individuals and organisations in positions of power use AI applications for decision-making, they can directly affect social determinants of health for individuals subject to that power. For example, recidivism prediction systems are used to inform judicial decision-making on bail, parole, and sentencing, and Amazon's abandoned resume review system penalised applicants whose resumes contained the word 'women's' (Chouldechova, 2017).

If bias can be mitigated, the potential for AI to improve public health is broad, with applications in outbreak identification, screening and diagnosis, health promotion, and management of chronic conditions. Many health-related AI applications involve supervised machine-learning techniques, which use data to learn the relationship between human-specified inputs (features or covariates) and outputs (labels or outcomes). These are analogous to techniques such as logistic regression but have the ability to accommodate complex inputs (e.g., images, voice

recordings, text data, medical histories) and to learn complex relationships between inputs and outputs. For example, such techniques were used to identify social media posts indicating suicide ability (O'Dea et al., 2015). Level of concern was hand coded for 2000 tweets; using this training set, AI algorithms were able to assess new tweets comparably to human coders. An AI application such as this has clear public health potential as a screening tool.

Public health epidemiologists know how to evaluate predictive performance using sensitivity and specificity, predictive values, agreement, and performance curves. These same criteria are used by the AI community to evaluate tools, and they represent important common ground that is ripe for the development of new validation standards. Intersectionality teaches that it is not safe to assume that something fair for multiple single axes individually will also be fair at specific social intersections, and this learning has much to offer the framing of fairness in AI. It is often mathematically impossible to simultaneously meet criteria for different fairness definitions, and a predictive algorithm can be fair by some criteria despite disparate impact (Chouldechova, 2017).

Intersectionality, heterogeneity, and public health ethics go hand in hand. However, both intersectionality and ethics require that we pay attention to the most marginalised to improve well-being or at least ensure we are not exacerbating marginalisation (Bowleg cited in Lehman et al., 2024). Thus, an intersectional approach to AI has the potential not only to add scientific rigour through a focus on heterogeneity but to promote ethical evaluation in performance and impact.

Conclusion

Greater implementation of AI, regardless of whether explicitly for public health purposes, requires the attention and expertise of public health ethicists, epidemiologists, and other public health professionals, including those across the full range of social intersections. Given the demonstrated risks of propagating societal biases and inequities, algorithmic bias should be assumed until demonstrated otherwise. Moreover, ensuring fairness is impossible without transparency, both to enable on-going evaluation and to build community trust and accountability. Fortunately, the surge in interest in FATE in the AI research community presents a timely opportunity for meaningful collaboration. Together, intersectionality and public health have the potential to bring new perspectives and processes to conceptualization, design, implementation, and evaluation of AI to ultimately harness its power to improve the public's health for those at all social intersections.

Furthermore, Artificial Intelligence (AI) offers unprecedented opportunities and challenges for humanity. If AI can be positioned and leveraged correctly, it can rapidly accelerate progress on achieving the United Nations' Sustainable Development Goals (SDGs), including SDG #3: 'Ensure healthy lives and promote wellbeing for all at all ages'. Achieving this goal could have a transformative impact on global health. An ethical, transparent and responsible approach to AI development will result in AI translating data into contextually relevant knowledge, conclusions, and impactful actions.

Recommendations

1. Expand AI-Driven Educational Tools: Public health institutions should invest in expanding AI-driven educational tools and platforms that provide adaptive and personalised learning experiences. This will ensure that public health education is tailored to the needs of diverse learners, particularly in underserved regions, aligning with the goals of SDG 4.
2. Incorporate AI into Public Health Curricula: Educational institutions must integrate AI technologies into their public health curricula to prepare students for a future where AI will play a central role in health care. This integration should include training on AI applications, data analysis, and the ethical implications of AI in health.
3. Promote Collaborative Research and Development: Collaboration between educational institutions, technology companies, and public health organisations is essential to advance AI applications in public health education. Joint research initiatives should be encouraged to explore innovative AI solutions that address emerging global health challenges, thus supporting both SDG 3 and SDG 4.
4. Focus on Equity and Inclusion**:** AI tools should be developed and implemented with a strong focus on equity and inclusion, ensuring that they are accessible to all learners, regardless of their socioeconomic status or geographic location. This approach will help bridge the educational gap and contribute to reducing health disparities, aligning with the objectives of SDG 10 (Reduced Inequalities).
5. Ensure Ethical Use of AI**:** It is crucial to establish clear ethical guidelines for the use of AI in public health education. These guidelines should address issues such as data privacy, algorithmic bias, and the potential for AI to reinforce existing inequalities. Institutions should prioritise ethical AI practices to ensure that AI's role in education supports social justice and sustainable development.
6. Enhance Continuous Professional Development**:** AI should be used to facilitate continuous professional development for public health professionals. By providing personalised learning paths and up-to-date content, AI can help professionals stay informed about the latest developments in global health, ensuring they are equipped to address both current and future challenges.

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