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Artificial Intelligence in Global Health

Recently, emerging technology such as the mobile health Pokemon Go trial designed for increasing physical activity or the Apple Heart Study for atrial fibrillation detection may help redefine the delivery of precision global health. In the era of big data, artificial intelligence (AI) has been described as 'the fourth industrial revolution', or 'industry 4.0', which could potentially allow for the development of the aforementioned precision global health. Since the beginning of the COVID-19 pandemic, the world has entered an era of digital evolution, as employees of virtually all business and global health-related systems started working remotely. This change served to further emphasize the important role that AI may play in the digital evolution of global health, echoing the changes seen with the introduction of public internet in the 1990s. By combining these powerful AI techniques with physical technologies, a new form of precision global health can emerge in this digital evolution era (*Figure 1*).

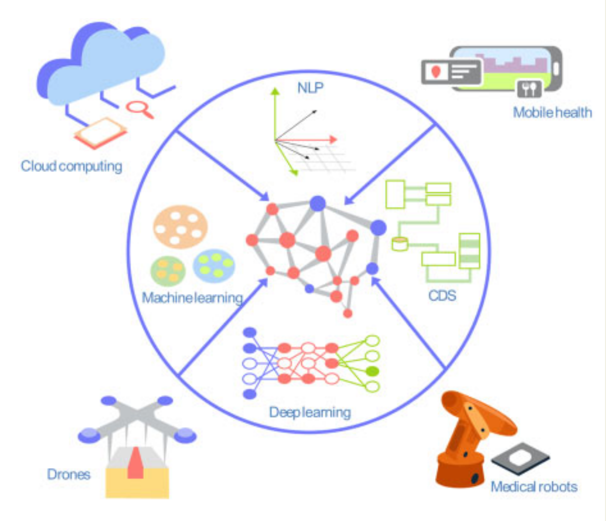

Figure 1 Within the field of medicine and global health, artificial intelligence can be classified into four categories; (1) machine learning models, (2) deep learning models; (3) natural language processing; (4) artificial intelligence-driven clinical decision support systems. By combining these powerful artificial intelligence techniques with physical technologies, such as cloud computing, drones, medical robots, and mobile health, a new form of precision global health can emerge in this digital evolution era.

Through our prior research efforts, we have described machine learning (ML) and deep learning (DL) through the utilization of big data and how these tools may be used to accurately predict outcomes. Recent advancement of the DL model, such as Generative Pre-trained Transformer 3 (GPT-3), can produce human-like text and potentially advance human communications. Although GPT-3 is far from being capable of performing clinically meaningful tasks (e.g. medical diagnosis, predicting outcomes of clinical trials), GPT-3 can assist physicians in repetitive tasks (e.g. scheduling, triage, public health intervention, billing codes, note writing for uncomplicated visits) and basic telehealth (e.g. PHQ-2 screening). Combining these models with augmented reality platforms or robotic agents in resource-poor areas, for example, can be utilized to increase vaccination rates (e.g. drone delivered COVID-19 vaccine), screen at-risk populations for parasitic infection, and promote age and region-appropriate annual screening (e.g. skin cancer surveillance using AI-assisted teledermatology). Several studies have shown that ML can also be used to predict the effect of weather patterns associated with heatwaves[2] and changes in air quality,[3] or identifying environmental patterns associated with dengue fever transmission. In addition, a combination of ML-blockchain and cloud computing can be used to help improve the global cardiovascular health epidemic (e.g. AI enable food selection to decrease obesity).[4]

Natural language processing (NLP) stands at the intersection of AI and linguistics, allowing for the pre-processing of human language; breaking down grammar and transforming it into numerical data, vectors, and matrices that computers can understand. An example of the potential power of NLP within the healthcare field can be seen through its combination with DL methodology. These tools can be utilized to create an archive of conversations between clinicians and patients within primary care clinics to improve the patient's experience. This data can then be used as a training set for medical robots to facilitate the distribution of medical questionnaires in primary care clinics or personalized recommendations in telemental health for patients in areas of physician shortage. Natural language processing analysis of social media postings can be used to identify potential risk factors for medical conditions such as diabetes (e.g. tweeted/retweeted/liked pages regarding candy, high-sugar beverages) and gastric cancer (e.g. liked Facebook/Instagram pages related to tobacco products). Other potential uses include the detection and tracking of infectious disease outbreaks through social media postings or identifying high-risk groups for vaccine non-compliance based on social media activity. Natural language processing can also be applied for translating complex medication instructions (e.g. oral contraceptive pills for teenagers) to help educate patients with poor health literacy, particularly in remote areas or areas with scarce medical resources. Startup companies, such as Sensory TrulyNatural (Santa Clara, CA, USA), are currently using NLP for speech recognition on cloud-based devices that can be used in remote areas for a variety of global health interventions.

A concept termed 'computer vision' is defined as the ability of a machine to see, analyze, and interpret images or videos that mimics a human's natural visual process. Computer vision can be used for the remote diagnosis of various medical conditions using imaging data. For example using computer vision for the diagnosis of malaria based on the images of peripheral blood smears,[5] or the diagnosis of tuberculosis based on CXR findings.[6] Images obtained from remote villages can be transmitted via cloud-based mobile phones and sent to an AI analytic pool for interpretation. The original sender will then receive a response containing medical recommendations and triage. Global Good (Bellevue, Washington, DC, USA) applied DL to mobile phones for cervical cancer screening in Africa. Moreover, computer vision with enhanced computational power can be used for scanning food in restaurants or even on the street, and AI can then predict calorie content and provide recommendations on whether individuals should consume the item or not. This could prove useful in helping prevent the development of childhood metabolic syndrome or eating disorders in developed countries and decrease *Opisthorchis viverrini*-related cholangiocarcinoma in developing countries.

Another potential area where cutting edge technology and medicine intersect is through the utilization of medical robots (e.g. doc.ai) and programmed drones for the delivery of prescriptions or vaccines in resource-poor settings. Zipline (San Francisco, CA, USA), for example, uses AI-enabled drones to deliver medications, blood products, and vaccines in Ghana and Rwanda. Stanford Lab OceanOne, an AI-enabled robot, was utilized to explore the ocean and reduce global warming. DroneSense, from Austin, Texas, delivered vaccines to a small island in the remote South Pacific.[7] Medical robots and drones can be combined with the aforementioned computer vision to allow for several exciting potential areas of expansion. For example, employing computer vision for the remote diagnosis of parasitic infections or tuberculosis based on computer-analysed imaging findings, followed by operating drones for the delivery of the resultant anti-helminthic or anti-tuberculosis medications.

Finally, AI-enabled clinical decision-making has been implemented within the medical field for decades, and in recent times has been increasingly applied for the delivery of global health. Ada Health GmbH (Berlin, German), for example, is an AI-powered self-checkup application, which has integrated Swahili and Romanian languages in order to help people with scarce medical resources in East Africa and Romania. Artificial intelligence-enabled clinical decision-making, such as the virtual doctor, will become increasingly prevalent in remote areas.[8] One area of implementation has been the telemonitoring of heart failure patients, where remote monitoring of fluid balance allowed for the adjustment of diuretics without an in-person office visit, and in effect, decreased utilization of hospital resources. The potential applications of a program like this are boundless.

There remain three main challenges for the integration of AI in precision global health. Firstly, data variability, data incompleteness, and poor data quality control strain AI validation.[9] Second, algorithm limitations such as generalization to unknown data distributions, Blackbox mechanism, adversarial examples, overfitting, and a lack of reporting guidelines in ML studies remain as barriers. Finally, AI can lead to ethical issues such as patient confidentiality violations, health inequality, or misuse and bias from cultural prejudices.[10]

Artificial intelligence has tremendous potential for the facilitation of precision global health, particularly in resource-poor settings. Artificial intelligence-enabled physical technologies (e.g. cloud computing, mobile health, drones) can be used to prevent or treat infectious diseases in low-income country settings and reduce non-communicable, 'lifestyle-related' diseases in developed countries. However, several limitations must be addressed before applying AI principles to global health on a large scale.

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