Leapfrogging Health Services Delivery In Resource-Limited Settings With Artificial Intelligence

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Abstract

In this essay, we outline how Health Artificial Intelligence (HAI) might impact health services and systems in resource-limited settings: we see the impact of HAI in the quantity, quality, cost, and range of health services available. AI provides an opportunity for resource-limited settings to develop and deploy context appropriate tools, allowing them to leapfrog existing challenges in health services delivery. An immediate impact of AI-enabled technology in health services in resource-limited settings is likely through an increase in the quantity of health services, where it might bring advanced clinical decision-making capacity to places where such services do not exist. Where they do exist, Health AI may improve the quality of services. And since the marginal cost of production of most software-enabled services tends to be minimal, these services could be scaled up cost-effectively. Health AI technologies may also provide health services that were not available before, thereby increasing the range of available services. In this essay, we elaborate on the above, providing specific examples where appropriate. We conclude by acknowledging the transformative potential of Health AI in resource limited settings, but challenges remain, not least of which is for these regions to become producers, and not just consumers, of scientific knowledge and technologies in Health AI.

1. Introduction

Health Artificial Intelligence (HAI) offers unprecedented opportunities for resource-limited settings to leapfrog existing limitations in health services delivery—in fact, we posit that the relative impact of Health AI could be more profound in the developing world than in the developed world. We define Health Artificial Intelligence (HAI) as any technology that mimics human intelligence and aids in decision-making required to provide services or goods that improve human health. We use this definition to distinguish Health AI from other digital technologies that are used in healthcare but do not mimic human intelligence (such as simple electronic medical records). Consequently, in this essay, we will concentrate on the application of AI technologies with direct clinical or public health decision making applications as opposed to those that may have other (for example business, research) applications in health care.

An estimated 4·5 billion people around the world lack adequate access to essential health services, while 2 billion people face financial hardship while accessing health services.[1] The lack of adequate access to health services is largely attributable to resource limitations, i.e. the lack of the structural inputs of health services like health workers, finances and materials like diagnostic equipment and medicines. In resource-limited settings, Health AI could make a direct impact on all of these structural inputs of health services. We use the term resource-limited settings, and not a politico-economic or geographic epithet, because it allows us to elaborate on the mechanistic pathway by which Health AI can help improve health services—by improving upon their structural inputs. Also, politico-economic epithets like low-, middle-, or high-income countries are not necessarily reflective of the differences in access to health services prevalent within these countries.

There are reasons to believe that resource-limited settings are likely to leapfrog health service delivery through Health AI. Breakthrough technological innovations can dramatically reduce the cost of goods or services, making them available cheaply and easily. Such breakthrough technologies may allow resource-limited settings to take a vertiginous or an abbreviated path to development, enabling them to "leapfrog" traditional development paths.[2,3] Cellular telephony service is an illustrative example. Where telephony services were not freely available in the developing world, with the advent of cellular technology, much of the developing world was able to leapfrog terrestrial telephony services and move directly to widespread use of cellular phones.[4] A similar technology-led leapfrogging is expected to enable resource-limited settings to make rapid progress in many other sectors.[3,5] Resource-limited settings are well-poised to benefit from technological breakthroughs in AI because these technologies are increasingly being open-sourced, commoditised, and cheaper. Many of these countries also have an increasingly larger pool of technically proficient young people who can build Health AI applications to meet local needs, using their setting-specific data they already generate in their practice environments.

2. The Promise of Health AI

By 2030, the world is likely to see an estimated shortfall of 10 million health workers, most of it in resource-limited settings.[6] Not only do resource-limited settings have inadequate health workers, but also when health workers are available, these countries lack the fiscal resources to employ them and retain them. Many resource-limited settings already spend more than half their health budgets on health worker salaries.[7] Health Artificial Intelligence could help improve this substantial deficit of health workers.

The relative benefit of Health AI in resource-limited settings is likely high precisely because AI technology is able to reduce the need for a trained health workforce—a vital but costly input of health services—via its labour-displacing or labour-augmenting functions. Like most other cognitively demanding tasks, medical decision-making and the provision of health services entails a sequence of activities: information collection, processing and storage, followed by retrieval and synthesis of this information to make decisions to facilitate problem-solving. AI is promising in all of these domains, allowing accurate decision making cost-effectively. AI systems may be able to obviate the need for cognitively demanding, but repetitive and often tedious work, and allow health workers to focus on more meaningful aspects of care delivery.[8,9]

AI systems can reduce the need for a highly trained workforce through task-shifting, task-automating, task-replacing, or task-auditing. Although task-shifting of experts by non-experts has been used for long in health, this approach has a few challenges: there is an intrinsic gap in the service by non-expert compared to expert, and this intrinsic gap is hard to bridge; training of non-experts is usually done with reduced time and content, and there is no efficient mechanism to continually improve task-shifting performance. AI based task-shifting can overcome all of these challenges because these systems can be integrated with scalable task-auditing systems that can not only monitor task-shifting performance but also be used to continually improve the performance of AI-enabled task-shifting, task-automating or task-replacing systems.

By a recent estimate, in 46% of occupations, Large Language Models (LLM) and supporting software technologies alone could reduce-by-half the time required by a human to complete their jobs. And this impact could be the greatest in information processing activities like health services that require a long duration of training and are heavily regulated.[10] Labour displacing or augmenting functions of Health AI could generate substantial economic benefits: for example, a 2019 estimation

of the benefits of a wider adoption of AI in the United States estimated this benefit at 10% of overall healthcare costs.[11] Given recent advances are rapidly improving the capabilities of Health AI technologies in information processing and medical decision making functions,[12,13] newer estimates of economic benefit are likely to be higher.

The impact of Health AI is likely to be relatively higher in resource-limited settings also because the willingness to adopt a new technology is likely to be greater where there is an unmet need for services the technology provides. In advanced nations with entrenched regulatory regimes, rapidly changing technology can create a differential regulatory burden and dissuade developers of emergent technologies,[14] not least because strongly entrenched interest groups and incumbents may influence the regulatory regime in their own favor. However, since resource-limited settings have an unmet health services need, there could be greater stakeholder engagement and a willingness to work with innovators to create a robust but enabling regulatory environment for newer technologies. This necessity-driven willingness to create an enabling regulatory environment could be instrumental in allowing resource-limited settings to leapfrog health services delivery using Health AI.

In the discussion ahead, we elaborate further on how Health AI may impact the quantity, quality, cost, and range of health services available in resource-limited settings, giving specific examples.

3. Specific Examples

3.i. Quantity

Of the approximately 340,000 cervical cancers deaths that occur in the world each year, 90% occur in the developing world.[15] Cervical cancer is a disease that is preventable via cancer screening. Routine cervical cancer screening is usually done either by visually inspecting the cervix, by colposcopy, or by obtaining a tissue sample that is then laid onto a slide and visually inspected under a microscope by a pathologist. In much of the developed and resource-rich world, cervical cancer screening is routinely available for patients and is able to identify most precancerous or early cancer lesions. However, this screening service is not as accessible in resource-limited settings across the world. Even while cervical cancer screening using these methods is available across resource-limited settings, its provision is inadequate because this service requires physicians who are able to obtain the tissue sample, and pathologists who are able to prepare slides and screen them for cancerous lesions. An AI-based image recognition system is able to do this efficiently and at scale, often with a higher accuracy than cytopathologists.[16] AI enabled task-automating of visual inspection of the cervix and subsequent PAP smear based for those with higher risk is a strategy that can rapidly expand the quantity of cervical screening in resource-limited settings where expert gynaecologists and advanced equipment may not be readily available, by allowing health workers with minimal training to perform these services.[17] By thoughtfully integrating AI in clinical workflows, the quantity of cervical cancer screening services can be rapidly expanded.

3.ii. Quality

Image recognition systems are also able to rapidly increase the quality of health services provided. Microbiology services are often needed for the provision of health services, but often, they are either wholly not available, or where they are, the quality of services provided is poor. AI technology that already exists is able to work around this bottleneck. For example, an image recognition algorithm is able to detect parasites in a stool sample where there was no such expertise available

previously. Technologies like these can be deployed in many resource-limited settings, including rural primary health centers and district hospitals. One such technology developed in Thailand was shown to detect 34 intestinal parasites with upwards of 95% sensitivity and specificity.[18] AI technology developed in the Nepali setting was able to match accuracy of commercial microscopes in detecting Cryptosporidium and Giardia parasites.[19] In Uganda, researchers have developed AI based diagnostic tools to automate the reading of microscopic slides to diagnose diseases such as malaria, tuberculosis and intestinal parasites. Preliminary evaluation of these diagnostic tools show that a minimally trained health worker (a lab assistant with 18 months of broad based laboratory training), with the help of this AI technology, is able to provide diagnostic reading of the slide with a better quality than the existing standard of care, in real-time, and at minimal marginal cost.[20]

3.iii. Scope of Services

Advanced speciality services are a constant deficit in many resource-limited settings. For example, a survey done in Nepal showed that no primary health center or a district hospital in Nepal had access to epilepsy services from a neurologist. Few health facilities had access to Electroencephalogram (EEG) services required for the evaluation of patients with seizure disorders, and treatment gap for these patients was estimated to be in excess of 70%.[21] Although the lack of equipment is a bottleneck for a full range of of services required to provide adequate epilepsy care, an even greater bottleneck is due to the fact that there are very few specialist neurologists who can read these EEGs in resource-limited settings. AI-enabled automated reading of EEGs could be a satisfactory workaround around this.[22] This could greatly expand the range of neurological services that can be offered in a district hospital setting that have limited access to expert personnel. Orthopedic surgeons can use AI imaging models to generate 3D image reconstruction out of 2D plain films,

obviating the need for expensive CT or MRI images. This will allow surgeons to better plan surgical approaches in complex surgeries and provide such surgeries where they were not available before.[23]

3.iv. Cost

Throughout much of the developing world, the diagnosis of Tuberculosis (TB) is done via what is referred to as the passive case finding strategy where patients are tested if only they present to the health facility with symptoms suggestive of TB. But because much of the TB disease is among those who are asymptomatic (yet still can transmit the disease to others), the passive case finding approach often results in missed TB cases. Passive case finding approach has resulted in almost a million missed TB cases per year in South East Asia alone. In 2023, of the 10.8 million TB cases estimated globally, only 8.1 million were diagnosed, and 1.25 million died of the disease.[24] Dramatically reducing the burden of TB requires diagnosing these undiagnosed people—mostly asymptomatic—via an active case-finding approach.[25] Screening services, including high-quality x-rays are an important tool for diagnosing asymptomatic TB.[26] Although x-ray services are often available in resource-limited settings, doing them at scale can be prohibitively expensive. As a result, actively screening people for asymptomatic TB is more expensive than the passive approach because the yield (the likelihood of identifying a case per test) of the former approach is lower. Automated x-ray reading services may be able to significantly reduce the costs associated with x-rays required to diagnose this disease.[27,28] Studies of active case finding approached using AI automated chest x-ray show that not only is this approach able to diagnose more patients than the traditional symptom based passive approach, it also reduces costs by over 37% compared to an approach using newer screening approaches that use GenXpert, with comparable test sensitivity.[29–31]

4. Challenges

4.i. Realising the promise

While the opportunities to leapfrog health services delivery by use of AI-enabled technologies are substantial, challenges remain. While some challenges apply to all countries irrespective of their economic status, some challenges are unique to resource-limited settings. The first challenge that applies to everyone is whether AI technologies are able to meet their promise. Even with a breakthrough technology, implementation of the technology may not generate the outcomes that are initially expected. It has been more than a decade since predictions were made that AI replacement would replace the majority of doctors.[32] Today, although the promise remains, we are nowhere close to a point where machines and algorithms can have such dramatic clinical impact.

4.ii. Exercising agency

The second, and related challenge lies around who has agency over what technologies to develop and what problems to work on, and who makes the decisions to allocate resources: much like current drug-development research, large sums of money could be spent to develop AI-related technologies to address problems in the richest countries while leaving problems of the rest of the world unaddressed. This could exacerbate the already existing disparities in health-related research and development.[33] To prevent this resource-limited settings ought to exercise agency, own their problems, and define their own agenda for Health AI.

4.iii. Setting priorities

The third challenge is that the development of Health AI prioritises problems that are relevant to resource-limited settings. One of the major challenges of the current system of innovation in the pharmaceutical industry has been that resource allocation often does not match mortality and morbidity burden across the world.[34] We could see a similar disparity in the development of Health AI, thereby perpetuating already existing health inequities around the world.

4.iv. Building data systems

The fourth challenge before we realise the promise of Health AI in resource-limited settings countries is the availability of accurate and reliable data.[35] Because electronic medical records and data-capture systems aren't as prevalent across resource limited settings, these settings are likely to not have enough training data. Even when they do have data, data may not be standardised or reliable. As a result, these settings may not be able to develop Health AI models to address health problems that they suffer from, or may have to use tools that were developed using training data that is not reflective of their populations. This could raise concerns about the safety, trustworthiness and transparency of Health AI tools and technology.

4.vi. Appropriate regulatory and normative standards

Resource-limited settings often lack the right regulatory mechanisms to enable the development of Health AI technologies while ensuring patient safety. As these countries look to build regulatory mechanisms and institutions to regulate Health AI, they may do well to look beyond existing and legacy regulations that are prevalent in developed countries. Any proposed regulatory mechanism should balance the twin objectives of protecting patients and communities while also enabling these settings as producers of technologies. These should not be seen as competing priorities and objectives. These Authorities should not only prevent patient harm but also focus on creating an

enabling environment for the production of Health AI technology. The World Health Organization's new initiative in creating WHO Listed Authority (WLA) Framework offers the potential to modify regulatory authorities based on need and function, and could offer a model for resource-limited settings to scale up regulatory entities in Health AI that are appropriate for their contexts.[36]

4.v. Ensuring equity and fairness

The fifth, and related challenge is ensuring that AI-enabled health technologies are accessible and equitably distributed. Furthermore, while the regulatory landscape in the resource-limited settings could evolve to be accommodating of newer technologies, it could also mean that poor regulatory oversight could also result in the proliferation of substandard technologies, or data brokering, and jeopardize human health among some of the most vulnerable people in the world.

4.vi. Transforming consumers into producers

Sixth, a challenge that needs to be overcome before the transformative potential of Health AI can be realised begins with a change in mindset: reimagining resource-limited settings as producers instead of as mere consumers of scientific knowledge, tools and technology in Health AI. In fact, we argue that without resource-limited settings producing their own tools and technology, it may not be possible to ensure the benefits of Health AI to all people around the world. Such transformation from consumers to producers could be challenging. However, as the example of some countries that are making rapid technological progress show, by taking ownership and exercising agency, resource-limited settings can catalyse this transformation from mere consumers to producers of scientific knowledge, technology, and tools in Health AI.[37]

4.vii. Reimagining systems

Finally, as we pursue the transformative potential of Health AI, it may even necessitate resource-limited settings to re-imagine the organization of their health systems, the set-up of health facilities and the training and employment of health workers. In such a scenario, the greatest challenge, as well as opportunity of Health AI in resource-limited settings could extend beyond technical; it may be the successful management of the politico-economic and sociocultural ramifications of such breakthrough technological development.

4. Conclusion

Health Artificial Intelligence offers a promising prospect for resource-limited settings to leapfrog existing limitations in health services delivery, build effective health systems, and improve health outcomes. However, before this vision can be realised, resource-limited settings ought to exercise agency in setting their own priorities, create a shared agenda, and collaboratively marshall their efforts and resources in developing Health AI to match their own needs. Resource-limited settings should aim to set normative and technical standards for their own use, in data-generation and sharing, technology development, licensing, regulation, and oversight. Doing this will allow resource-limited settings to transform themselves into producers of scientific knowledge, technologies, and tools in Health AI, from being mere consumers, and help realise the promise of Health AI in improving health outcomes for all people around the world. If resource-limited settings are able to overcome these challenges, the impact of Health AI in these settings could be transformative.

Conflict of Interest

The authors have no conflicts of interest to declare.

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