

Commentary

Maturity, Safety, and Equity of AI-Enabled Systems and Triage in Integrated Primary Care

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Abstract

Artificial intelligence (AI)-enabled systems must simultaneously improve the Quintuple Aim and digital health maturity, including equitable access to and quality and interoperability of data, tools, agents, and services. This requires a comprehensive sociotechnical and global approach to cocreation, management, and governance for individuals and organizations in the ecosystem.

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Alamoudi et al [1] described the potential of artificial intelligence (AI)-enabled triage, lamented the lack of credible evidence, criticized the lack of real-world and equity-stratified outcomes, and proposed a sociotechnical approach to a “practical agenda for evaluating and governing AI-enabled triage in primary care that integrates real-world safety outcomes, equity-stratified performance reporting, and sociotechnical implementation and surveillance.” While commendable, equity aims must be set within the Quintuple Aim, which includes the cost-effective care of the individual and population, patient satisfaction, provider well-being, and equitable health for all [2], and the AI ethics and governance principles proposed by the World Health Organization (WHO) [3].

AI-enabled triage systems collect and analyze patient data to determine the urgency of care required, provide a risk assessment, and recommend a triage level, including self-care, routine review, urgent care, or emergency referral. This definition means that the management, governance, and evaluation of AI-enabled triage systems in primary care require an integrated approach where data, tools, agents,

services, and systems are integrated and interoperable with those in other parts of the health ecosystem [4].

The learning and reasoning models underlying AI-enabled triage in general/family practice and primary care must reflect their patient-centered biopsychosocial diagnostic process, including making a probability diagnosis, excluding dangerous things, identifying differentials, and elucidating “hidden” patient agendas. This requires good quality models, algorithms, and data that are consistent with local community and institutional values, benchmarks, and priorities.

Therefore, this sociotechnical agenda must be implemented within a conceptual framework that includes improving the maturity, quality, and interoperability of the essential digital health foundations to enable the individual, organization, community, and ecosystem to adopt and integrate AI-enabled systems to achieve the Quintuple Aim successfully and sustainably.

However, the rapid deployment of AI-enabled systems despite a low evidence base for safety, bias, and quality [1,5], and the low digital health maturity (DHM) of

individuals, organizations, and ecosystems raises concerns about inadequate digital transformation for health services adopting AI-enabled systems to achieve the Quintuple Aim [6].

The Digital Health Profile and Maturity Assessment Toolkit (DHPMAT) was developed to create a digital health profile and assess the DHM of health organizations and ecosystems. The digital health profile and DHM are then aligned with national, subnational, or organizational priorities to develop a realistic road map for adopting, managing, governing, evaluating, improving, and sustaining digital health interventions [4,7].

Figure 1 illustrates the use of DHPMAT to assess the sociotechnical and financial readiness of citizens, digital

health professionals, and organizations to adopt AI-enabled systems, including triage, in the integrated health ecosystem. Readiness to implement digital health systems is determined by assessing the maturity of five essential digital health foundations (Figure 1, rows): information and communication technology, Internet-of-Things, or AI infrastructure; digital public goods; platform for information sharing; enabling environment; and quality improvement, measurement, monitoring, and evaluation. The five linear stages of DHM (Figure 1, columns) describe an initial adapting and assessing stage, which matures to controlling, standardizing, optimizing, and innovating stages. Standardizing at the center of Figure 1 (bolded in red) is the keystone stage [4].

Figure 1. Indicators to assess readiness to support artificial intelligence (AI)-enabled triage and systems. incl: including; Mx: management; R&D: research and development; re: regarding.

| Essential Digital Foundations to support and sustain AI-enabled systems incl triage | Digital health maturity stages with sociotechnical indicators | | | | |
|---|--|---|--|---|--|
| | ADAPTING <i>Unpredictable Knowledge & data not shared</i> Assessing & adapting | CONTROLLED <i>Predictable & consistent Knowledge sharing started</i> Problem driven | STANDARDISED <i>Organization-wide knowledge & data sharing</i> Request driven | OPTIMIZING <i>Learning health organization Enterprise-wide knowledge sharing</i> Service driven | INNOVATING <i>Learning health ecosystem System-wide knowledge sharing</i> Value driven |
| ICT/Internet of Things (IoT)/AI “compute” infrastructure | Enterprise architecture (EA) plan for secure, reliable, & equitable ICT/IoT/AI infrastructure | Standard Operating Procedures (SOPs) for equity & standards for ICT/IoT/AI infrastructure | EA Platform with SOPs for security & equity of ICT/IoT/AI infrastructure incl data centers | SOPs for CQI of EA platform to support data & agents across organization. | SOPs to support system-wide algorithm-driven EA platform |
| Essential AI-enabled digital public goods (DPG) | Evidence-based open-source AI Triage system shortlisted as per EA Plan SOPs | AI Triage system tested for quality benchmarks and interoperability | AI Triage system performing consistently on request on the EA Platform. | CQI of AI Triage system interoperable with other AI-DPGs shared across organisation. | Enterprise-wide AI Triage system driving innovation in integrated primary care. |
| Readiness for AI-enabled information sharing | EA plan with SOPs to manage algorithm-driven data analytics & equitable sharing | SOPs to manage & govern interoperable algorithm-driven data, tools, agents & services | SOPs about quality & interoperability of data, agents & services on EA Platform in the organisation | CQI of data, agents & services shared on EA platform across the enterprise | Enterprise-wide AI-driven data linkage within a common data model for innovation |
| Enablers of trust & adoption of AI-enabled digital transformation | EA plan with road maps to develop staff & organisation in ethical & legal compliance requirements | SOPs for transparency, reciprocity, and change Mx to address ELSI & promote trust. | EA Platform compliant to regulatory, privacy, security, & education benchmarks for digitalization & AI | CQI of compliance & education support system on EA platform with citizen engagement | Enterprise-wide AI-driven innovative governance, management, & citizen engagement |
| Quality improvement, measurement, monitoring & evaluation (QIMME) | EA plan with road map to achieve a CER program with AI-driven data, agents & services | SOPs to monitor CER program of AI-driven tools & agents in the organization | EA Platform supporting CER to cocreate evidence for DHM & Quintuple Aim in the learning organization | CQI of the CER program & QIMME culture across the enterprise learning system | Enterprise-wide AI-driven R&D in equitable digitalized clinical & population health services |

NOTES: CER=Comparative Effectiveness Research; CQI=Continuous Quality Improvement; DPG=Digital public goods; EA=Enterprise architecture, ELSI=Ethical, legal & social issues; ICT=Information & Communication Technology; IoT=Internet of Things; Mx=management; R&D=research & development; SOP=Standard Operating Procedures

Many organizations often skip maturity stages, usually because politicians favor “shiny new toys” over upstream essential but unglamorous standards and quality work to achieve an enterprise architecture that supports

interoperability. This lack of well-implemented standards, along with proprietary systems in a competitive business environment, explains why interoperability remains a longstanding challenge and digital health interventions

frequently fail to realize their potential benefits. It is also why the DHPMAT encourages the cocreation and use of open-source digital public goods.

Cocreation, including co-design, coimplementation, comonitoring, co-evaluation, and coimprovement over the development life cycle, is encouraged as a sociotechnical process to ensure that individual digital competencies and organizational DHM are improved concurrently with the Quintuple Aim [1,2,4]. Cocreating safe, useful, and usable cost-effective AI-enabled systems requires mutually trusting relationships among consumers, technology vendors, and health professionals in organizations and ecosystems. A fair and just regulatory framework that covers intellectual property (IP) and social capital is essential to cocreating, managing, governing, and sustaining digital assets equitably in local organizations and communities.

The balance between proprietary (private good) and open-source (public good) business models for digital health should be managed, especially in less-resourced countries. Proprietary organizations such as OpenAI have scraped the internet for diverse personal and public information, without formal consent from or payment to IP owners, to develop the generative pretrained transformer and large language model that underpin ChatGPT. Ironically, ChatGPT is now proprietary, and OpenAI is accusing DeepSeek, an open-source AI technology, of IP theft. OpenAI also illustrates the need for caution about AI-driven organizations with questionable business and humanitarian ethics [8].

A problem with terminology standards is the comodification of SNOMED-CT (Systematized Nomenclature of Medicine—Clinical Terms) and pharmaceutical classifications/vocabularies to be sold as proprietary

terminology servers, adding financial and access barriers to semantically interoperable health information systems. In contrast, the WHO *International Statistical Classification of Diseases, 11th Revision (ICD-11)* is an open-source digital terminology public good and an alternative to SNOMED-CT. This private versus public good tension is inherent in every sector of the global economy [9].

Cocreating AI technology as a digital public good in a networked multilateral world is attractive. However, the corruption of efforts to develop digital public goods during COVID-19 by profit-seeking “big tech” and “big pharma” led to expensive suboptimal “shiny new toys” as well as vaccine, antiviral, and food apartheid. This continues to exacerbate inequity, morbidity, and mortality among people on the wrong side of the race, age, gender, poverty, and cultural divides [10].

While capitalist economies have greater inequality than socialist ones, both must deal with inequity as unintended sociotechnical consequences of development. Will the capitalist approach with privately owned corporations and “trickle-down-economics” or the socialist approach with state-controlled enterprises be more successful in minimizing digital health inequity [10]?

Equity-stratified AI-enabled health systems, including triage, must simultaneously improve the Quintuple Aim and DHM, especially access to high-quality and interoperable data, tools, agents, and services. This requires comprehensive sociotechnical and intersectoral approaches to investment, cocreation, management, governance, and quality improvement of digital tools to benefit individuals, organizations, and global ecosystems.

Conflicts of Interest

None declared.

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Abbreviations

AI: artificial intelligence

DHM: digital health maturity

DHPMAT: Digital Health Profile and Maturity Assessment Toolkit

ICD-11: *International Statistical Classification of Diseases, 11th Revision*

IP: intellectual property

SNOMED-CT: Systematized Nomenclature of Medicine—Clinical Terms

WHO: World Health Organization

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