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Mapping the Landscape: A Comprehensive Review of Digital Health Models for Equitable Access to Universal Health Coverage

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Abstract

Digital health is the appropriate application of technology to enhance the health sector. With Universal Health Coverage (UHC), not having enough money is not a major hindrance to receiving the full range of high-quality healthcare services if and when they are needed. Strategies, models, and frameworks continue to be formulated to guide operations, as well as in regulation of healthcare. This study provides a thorough analysis of digital health models for equitable access to UHC by highlighting key factors of these models, while identifying and analyzing knowledge gaps. Considering UHC and the aspect of inclusivity as espoused in the Sustainable Development Goal 3 (SDG3) that speaks of health for all in a population, this study explores models that cover a general population, and were designed with equity as a key component. The study methodology is a scoping review that uses a manual search of digital libraries and repositories, employing tailored search terms. From the results, though there exist models that address equity, there is more work required to formulate generalizable digital health models for equitable access to UHC, and majorly for developing economies. Moreover, a call to consistently adapt models that meet the target needs of a population at any given time.

Keywords: Digital health, digital health framework, digital health model, healthcare, landscape, digital health strategies, universal health coverage

Introduction

Over the years digital health has seen unprecedented expansion, bringing with it huge opportunities for positive transformation of the economy, healthcare, and the society at large. Moreover, there has been growth in developments to support the health ecosystem, including Universal Health Coverage (UHC). Target 3.8 of the Sustainable Development Goals was added in 2015 to address UHC and guided that healthcare, which covered the entire range of vital, high-quality healthcare services should be available to all people in a population without suffering financial hardship (Muthuuri, 2020) . On the other hand, technological advancements resulted to having healthcare systems integrating technology to address disparities (Ahmed et al., 2020) . Consequently, this informs digital health, which is at the nexus of the two sectors; health, and Information and Communication Technologies (ICT) (Olu et al., 2019).

Healthcare, and in this case digital health, is continuing to transform as research on health inequalities develops and the profession of technology and health advances. Furthermore, the negative consequences of COVID-19 also led to an increase in technologically assisted

healthcare solutions. With digital health and UHC garnering significant attention on the global stage, among the emergent concerns is equitable access, whose concerns continue to affect the quality of care, utilization, and expenditures of households (Okech & Lelegwe, 2015 ; Chattu et al., 2021 ; Adepoju, 2022). Further, millions of people continue to suffer digital health inequalities from having digital health opportunities and platforms that are not equitably distributed and accessible (Nsaghurwe et al., 2021 ; Chen et al., 2021 ; Dixon & Holmes, 2022; Yao et al., 2022; Hadjiat, 2023). To add on this, there also exists digital health opportunities that are not usable by proportions of people in a general population (Ghorbanian Zolbin et al., 2022).

Research over years has shown health disparities based on one or more health outcomes that negatively impact several defined populations. These disparities are drawn along the lines of those living in rural areas, those with low incomes, people of color, and members of sexual and gender minorities among others. Previous research focused on highlighting the differences and disparities (Chen et al., 2021; Yao et al., 2022). Progressively, researchers worked to uncover the root causes of the disparities, as well as a dedication to finding workable solutions. However, recent studies still point to a need for further research in promoting equitable access to healthcare (Kristjánsdóttir et al., 2023).

Models for digital health equality and equitable access to UHC are becoming more and more important (Puradiredja et al., 2022). Advances in digital health are strategically significant in the support of the work of business leaders, information systems developers, and health systems operations, as well as in research and academics. Among the proposals to promote equitable access is having guiding system models (Puradiredja et al., 2022), and inclusive co-design approaches in systems implementation (Latulippe et al., 2020; Darley & Carroll, 2022; Miller et al., 2023 ; Wambua, 2023) . Leveraging digital health to reduce societal obstacles, and increase access to high-quality, and reasonably priced healthcare is also a strategy (Olubiyi et al., 2019). This study therefore presents a comprehensive review of digital health models for equitable access to UHC.

Literature Review

Equitable access within the health ecosystem spans across sub-sectors in health such as a focus on educational access and experiences, a focus on population, and especially for the underrepresented populations, which ultimately influence access, service quality, and cost. Developed models address varied digital health issues. To solve unequal educational access and experiences for the marginalized communities in health education, Macdonald et al. (2023) prioritized EDIA (equity, diversity, inclusivity, and, access) capability. According to Macdonald et al. (2023), EDIA capability that reached out into the community offered sustainable growth routes with strong transferability to other health initiatives.

Considering digital health and healthcare in general, innovations that advance UHC, and numerous comparable models have been developed (Audi et al., 2020) . The following is a review of the various models.

Healthcare Information and Management Systems Society (HIMSS) digital maturity models: Faced with the problem of not having a defined way of measuring digital transformation progress, Healthcare Information and Management Systems Society (HIMSS), developed various models. The following are digital maturity models by HIMSS:

i. *Electronic Medical Record Adoption Model (EMRAM):* a model that focuses on the use of medical records (Cresswell et al., 2019). Faced with the problem of not having a defined way of measuring digital transformation progress, this model mapped out stages, from 0 to 7, for the adoption and utilization of electronic medical records functions, and would measure levels of computerization.
ii. *HIMSS Analytics Infrastructure Adoption Model (INFRAM):* This model focuses on infrastructural adoption and utilization, in the health ecosystem (Cresswell et al., 2019).
iii. *Continuity of Care Maturity Model (CCMM):* This model focuses on continuity of care (Cresswell et al., 2019) . With this model, healthcare executives may evaluate, execute, and scale the smooth coordination of patient care across a continuum of care locations and providers (Cresswell et al., 2019).
iv. *Adoption Model for Analytics Maturity (AMAM*): Beyond clinical decision assistance, analytics may enhance a healthcare company's operational and financial elements, among other areas. This model therefore is to enhance the workforce, governance, and predictive analytics aspects of digital health (Healthcare Information and Management Systems Society, 2024a).
v. *Community Care Outcomes Maturity Model (C-COMM):* Considering that digital systems are essential to community care, this model links all non-acute care facilities and assesses the value of the digital solutions. In this manner, it allows for patients to be met where they are, get support, and provide person-centered treatment. Measurement of digital maturity of care delivery in this case is done using an eight-stage (0–7) scale, which helps to guide and explain the specific needs and characteristics of a community organization that offers non-acute care (Healthcare Information and Management Systems Society, 2024b).
vi. *Digital Imaging Adoption Model (DIAM):* To enhance patient safety, organizational effectiveness, and care quality in hospitals and diagnostic centers, this model assists healthcare organizations in measuring their capabilities linked to the secure delivery of medical imaging and related procedures. All facets of the health system may benefit from enterprise imaging made possible by DIAM, which makes it possible to manage multimedia material and digital imaging in an organized, comprehensive, effective, and efficient way (Healthcare Information and Management Systems Society, 2024c).

The various models as developed by HIMSS are a great addition to the healthcare ecosystem in that digital transformation may be reviewed over time to ascertain growth or the lack of it. Each of the deployed models is specific to a defined function, which then means that a facility may require procuring and deploying the various models to be able to measure the various functions, For example, to obtain analytics over time, a facility looking at using the HIMSS models will require DIAM, and not the rest of the models. This may be limiting to a facility that desires a single digital health model that encompasses most of its core function.

On the other hand, these models are not fully inclusive in line with UHC. For instance, EMRAM's focus was greatly on technological capabilities, neglecting service delivery and social inclusion. In this case, this model excluded human and organizational factors, which are considered enablers of transformation. Consequently, adapting this model required more tasks to be done. For instance, a case like of NHS England, whereby to adapt EMRAM for creating a Digital Maturity Index to assess hospitals' digital capabilities, required addition of other dimensions. In this case, the adaptation added the dimension of interoperability, technological readiness, and infrastructure components (Cresswell et al., 2019).

The "Evolve in Context" model: This was a model of digital excellence in healthcare that borrowed greatly from the HIMSS measurement models: EMRAM, INFRAM, and CCMM. This model examined how to evaluate digital maturity in scenarios with fluctuating objectives and goals. The flexibility of the model allowed for changes to be made along the journey of any intervention. Additionally, by leveraging the institutional and technological infrastructures already in place, this approach allowed for the measurement of digital excellence in areas where digital maturity could be customized to meet the demands of the local populace (Cresswell et al., 2019).

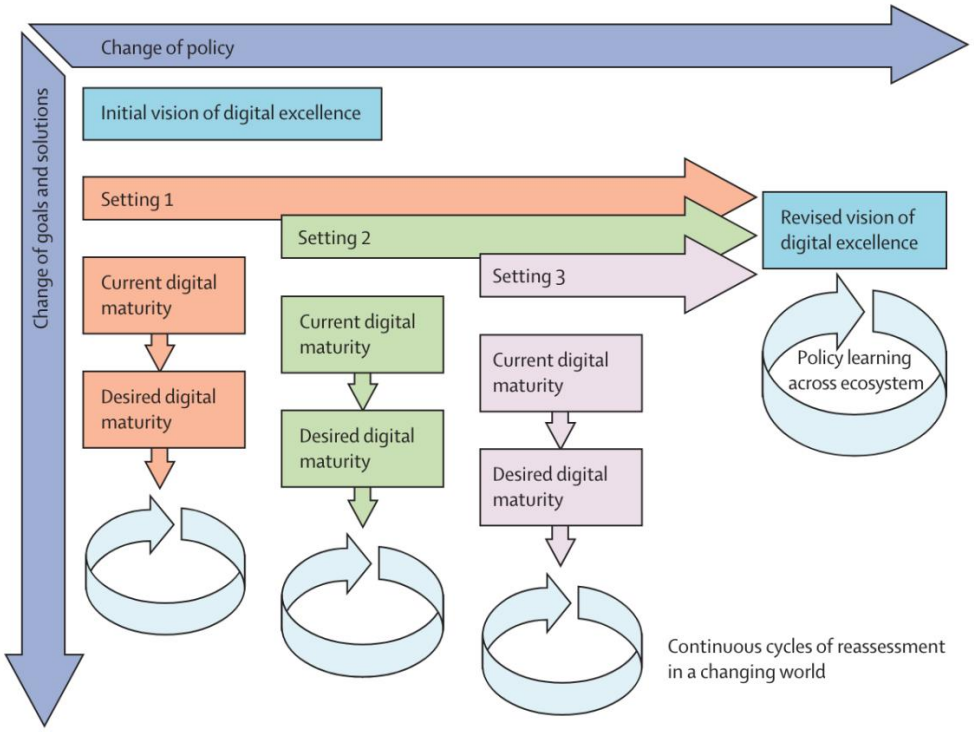


Figure 1. The "Evolve in Context" model: Source: Cresswell et al. (2019)

This model was advancement from the various HIMSS models. The model factored continuity of patient care, and patient medical records which are key components of any medical facility. Moreover, facility infrastructure components were also included; therefore, enabling a better evaluation of technological impact over time. Though this model may not be fully inclusive as guided in UHC, it addresses key UHC dimensions in that through its continuous cycles of reassessments, it provides an opportunity for healthcare review which may impact on quality of service, population coverage and even cost elements in offering healthcare.

Tanahashi model: This model covers access and coverage of health services through five key dimensions: availability coverage; accessibility coverage; acceptability coverage; contact coverage; and effective coverage (Ojo, 2022). These five dimensions are presented as a series of cascades where problems at one level impact the next, leading to gaps in the quality, coverage, and cost of the healthcare system (Tanahashi, 1978; Ojo, 2022).

This model aligns to the UHC dimensions of service quality, population coverage, and cost. Despite the considered dimensions and applicability, this model's alignment was not to

digital health. However, the projected dimensions would rightly inform a digital health model for equitable access to UHC.

The Mehl's and Labrique's cascading model: This model was updated from the Tanahashi model, prioritized mHealth strategies for attaining UHC, and factored accountability, availability of commodities and equipment, availability of human resources, financial and continuous coverage, as key measures, which also informed the digital health interventions adopted by WHO for healthcare systems (Labrique et al., 2018; Ojo, 2022).

In addition to the Tanahashi model dimensions of availability coverage, accessibility coverage, acceptability coverage, contact coverage, and effective coverage (Ojo, 2022); this model added dimensions gave it a greater coverage. The cost element and the resources adaptation, coupled with a focus to digital health make this model a good benchmark for digital health models for equitable access to UHC.

A Four-Component Framework toward Patient-Centered, Integrated Mental Healthcare

This framework focuses on mental healthcare in Kenya and comprises four components: sensitization of providers; continuous supervision; continuous professional training; and empowerment of leaders, as key steps. Though not fully integrated within the health ecosystem, this proposed framework reviewed UHC as one of the key policy developments to guide the implementation of the framework (Kumar et al., 2021).

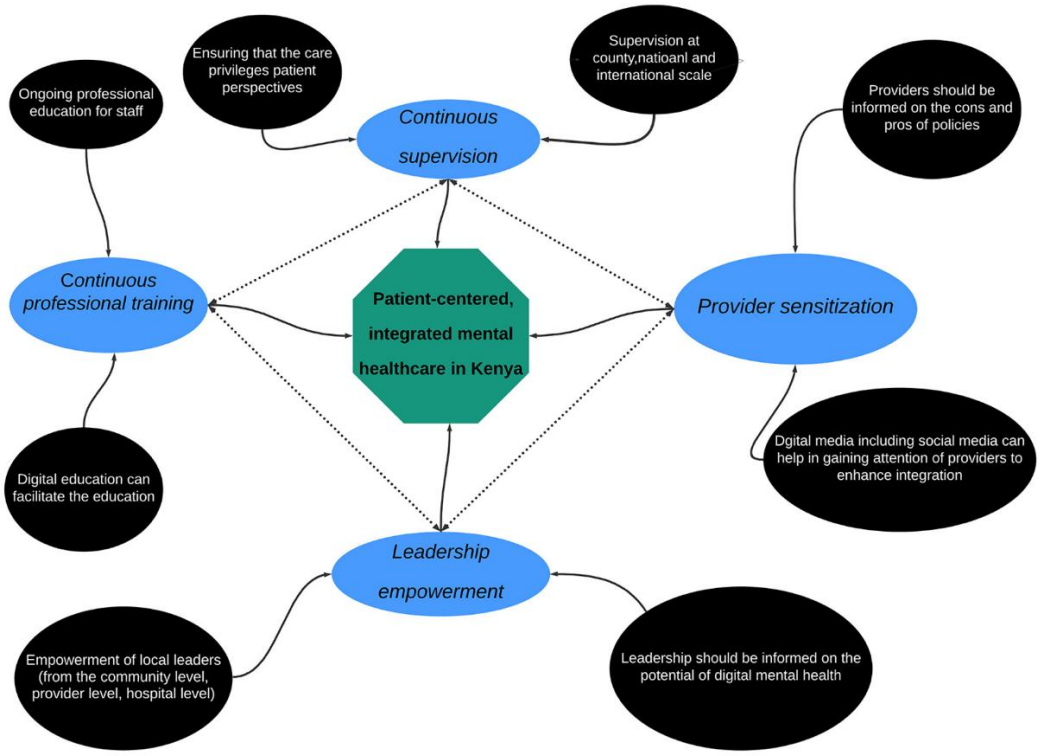


Figure 2. Four-Component framework. Source: Kumar et al. (2021)

This model informs UHC in the considered dimensions, as well as in its focus on mental healthcare which should be intentionally considered in healthcare. This model does not however, emphasize on technological inclusion which informs digital health. Moreover, the

models focus may not be considered all-inclusive for UHC in that it addresses only mental healthcare.

EDIA capacity model

EDIA is concentrated on getting rid of structural prejudices or obstacles that limit fair chances and keep people from reaching their full potential. The four ideas that make up EDIA stand for a shared commitment to equally honoring, appreciating, and supporting each person's unique life experiences and viewpoints, regardless of how they may identify with themselves (Macdonald et al., 2023). Six dominant factors that affected EDIA capacity were identified by Macdonald et al. (2023) study. Interfaculty communication, institutional messaging, and knowledge of the EDIA language were found to be weaknesses. On the other hand, community-building activities for EDIA growth that are informal were found to be innovative assets that should be given priority. Faculty members' overall motivation to participate in EDIA was shown to be correlated with emotionally charged events (Macdonald et al., 2023).

Although not fully aligned to digital health for equitable access to UHC, this model proposes factors that impact a population. Understanding the used language and being able to communicate as guided by EDIA capacity is paramount to any system, including digital health.

National Institute on Aging (NIA) disparities model

In relation to inequalities research, this model describes four primary levels of analysis: environmental, sociocultural, behavioral, and biological, with priority emphasis areas identified within each category (Hill et al., 2015). To support our efforts to address health disparities in the aging population, the NIA Health Disparities Research Framework highlights critical components for health disparities research related to aging, offers an organizing framework for tracking progress, stimulates opportunities to better establish linked pathways, and broadens the scope for adaptable targets for intervention (Hill et al., 2015).

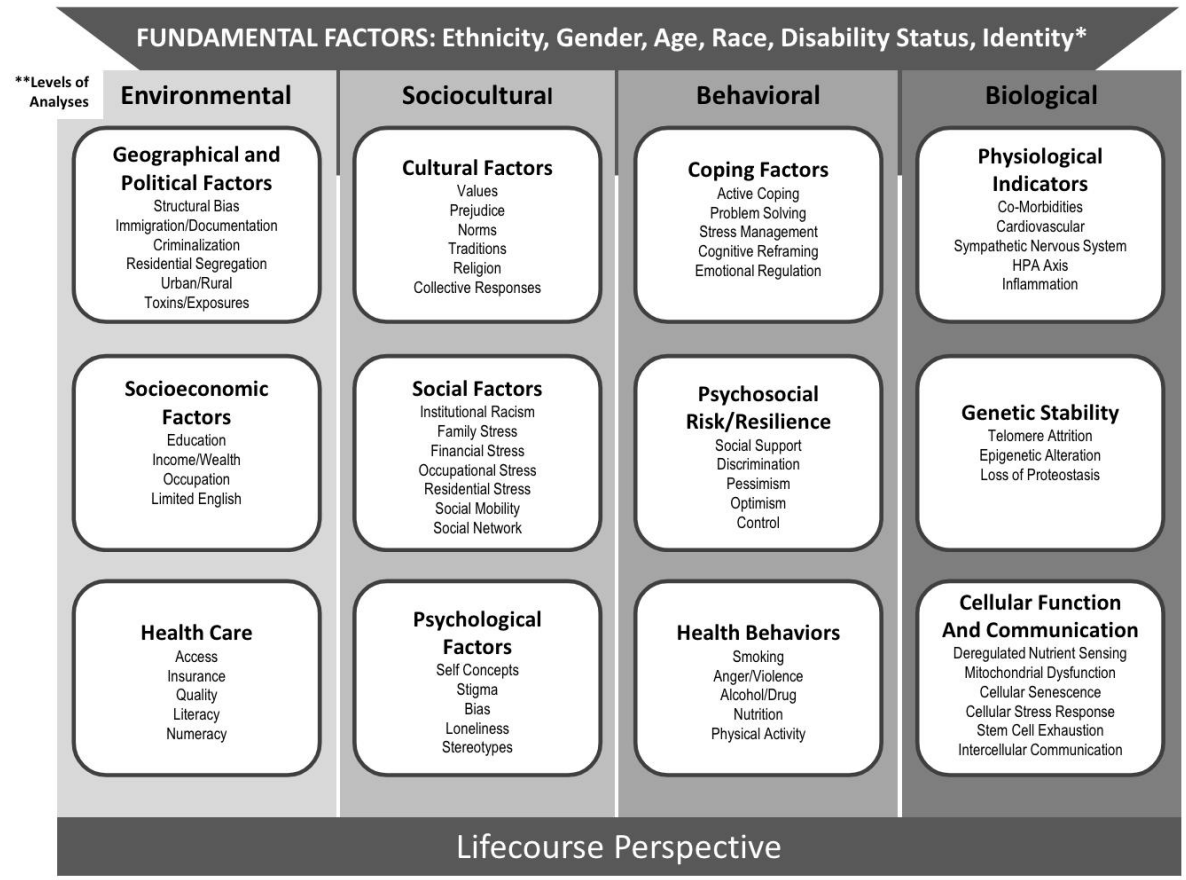
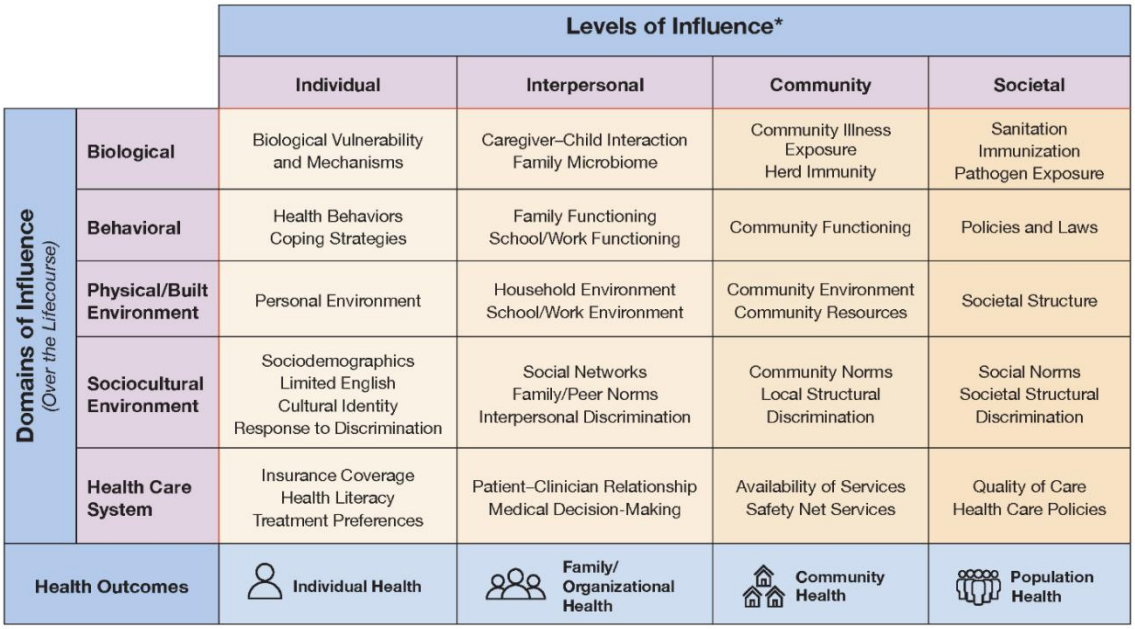


Figure 3. National Institute on Aging (NIA) disparities model. Source: Hill et al. (2015)

While the NIA disparities model is not essentially a digital health model for equitable access to UHC, it depicts key necessary factors. This model considers demographic variables as fundamental factors, making it a model that advances population coverage which is a key dimension of UHC. Further, despite that the models focus was on disparities related to the aging population, its levels of analysis are adaptable in models for other population groups (Hill et al., 2015).

National Institute on Minority Health and Health Disparities (NIMHD) Research Framework

This model was an adaptation of the National Institute on Aging (NIA) disparities model, with the addition of the health care system domain due to its particular importance to health (Richardson et al., 2022). The framework makes it easier to evaluate the possibilities, gaps, and advancements in the minority health and health disparities research. The model incorporates a life course perspective component that highlights the significance of taking into account lifetime-extending factors in determining health inequalities, and it specifies that health outcomes can span numerous levels (National Institute on Minority Health and Health Disparities, 2018).



		Levels of Influence*			
		Individual	**Interpersonal**	**Community**	**Societal**
Domains of Influence *(Over the Lifecourse)*	**Biological**	Biological Vulnerability and Mechanisms	Caregiver–Child Interaction Family Microbiome	Community Illness Exposure Herd Immunity	Sanitation Immunization Pathogen Exposure
	Behavioral	Health Behaviors Coping Strategies	Family Functioning School/Work Functioning	Community Functioning	Policies and Laws
	Physical/Built Environment	Personal Environment	Household Environment School/Work Environment	Community Environment Community Resources	Societal Structure
	Sociocultural Environment	Sociodemographics Limited English Cultural Identity Response to Discrimination	Social Networks Family/Peer Norms Interpersonal Discrimination	Community Norms Local Structural Discrimination	Social Norms Societal Structural Discrimination
	Health Care System	Insurance Coverage Health Literacy Treatment Preferences	Patient–Clinician Relationship Medical Decision-Making	Availability of Services Safety Net Services	Quality of Care Health Care Policies
Health Outcomes		**Individual Health**	**Family/ Organizational Health**	**Community Health**	**Population Health**

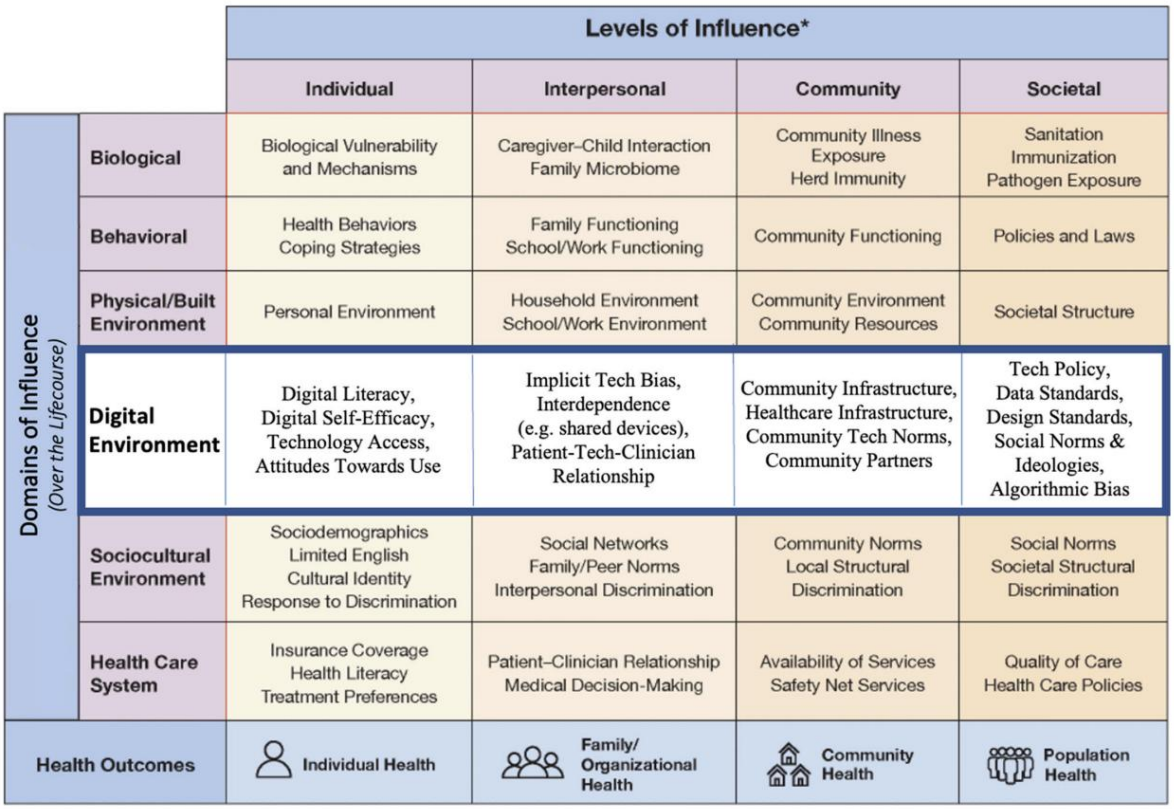
Figure 4. National Institute on Minority Health and Health Disparities (NIMHD) Research Framework
Source: National Institute on Minority Health and Health Disparities (2018)

The adaptation of this model enhanced its initial focus from fundamental demographic factors to now include the health care system. This adaptation, when aligned to the levels of influence, allowed for advanced evaluation of health outcomes related to population coverage, service quality and cost. Hence an adapted model that well aligned to the UHC dimensions. On the other hand, though this model was not exclusively aligned to digital health, it presents factors adaptable to digital health for equitable access to UHC.

Framework for Digital Health Equity

This framework expanded NIMHD research framework, by including a digital environment domain (Richardson et al., 2022). The model was published in 2019, incorporating the digital environment domain because of its critical role in the health ecosystem (Richardson et al., 2022). The model is divided into domains: biological, behavioral, physical/built environment, sociocultural environment, and healthcare system. The model groups determinant domains based on the socio-ecological model's levels, whereby the physical/built environment, the sociocultural environment, and the healthcare system domains are where Social Determinants of Health (SdoH) are mostly featured (Richardson et al., 2022).

The digital environmental domains highlight key Digital Determinants of health (DDoH). The DDoH refer to digital environment conditions that impact a broad spectrum of risks and consequences related to health, its function, and the general quality of life, at the individual, interpersonal, communal, and societal levels. These conditions comprises access to digital literacy, technology tools, and community infrastructure like broadband internet, which impact equitable access to healthcare, and therefore negative effect to digital health equity (Richardson et al., 2022).



Domains of Influence (Over the Lifecourse)	Levels of Influence*			
	Individual	**Interpersonal**	**Community**	**Societal**
Biological	Biological Vulnerability and Mechanisms	Caregiver–Child Interaction Family Microbiome	Community Illness Exposure Herd Immunity	Sanitation Immunization Pathogen Exposure
Behavioral	Health Behaviors Coping Strategies	Family Functioning School/Work Functioning	Community Functioning	Policies and Laws
Physical/Built Environment	Personal Environment	Household Environment School/Work Environment	Community Environment Community Resources	Societal Structure
Digital Environment	Digital Literacy, Digital Self-Efficacy, Technology Access, Attitudes Towards Use	Implicit Tech Bias, Interdependence (e.g. shared devices), Patient-Tech-Clinician Relationship	Community Infrastructure, Healthcare Infrastructure, Community Tech Norms, Community Partners	Tech Policy, Data Standards, Design Standards, Social Norms & Ideologies, Algorithmic Bias
Sociocultural Environment	Sociodemographics Limited English Cultural Identity Response to Discrimination	Social Networks Family/Peer Norms Interpersonal Discrimination	Community Norms Local Structural Discrimination	Social Norms Societal Structural Discrimination
Health Care System	Insurance Coverage Health Literacy Treatment Preferences	Patient–Clinician Relationship Medical Decision-Making	Availability of Services Safety Net Services	Quality of Care Health Care Policies
Health Outcomes	Individual Health	Family/ Organizational Health	Community Health	Population Health

Figure 5: Framework for Digital Health Equity. Source: Richardson et al. (2022)

Relating this model to the NIA disparities model and the NIMHD research framework, from which it is enhanced, this model now directly informs digital health. The added digital environment domain presents the technological considerations across the levels of influence, which spans across individual to the society levels. This way, presented in a health ecosystem, this model will factor in the technological interventions and therefore give a better evaluation of disparities related to digital health.

Dover and Belon's model

This model is a health equity measurement framework that measures social inequalities in health. In this model, the hierarchical distribution and unequal allocation of power, prestige, and resources within economic and cultural social contexts is referred to as social stratification (Dover & Belon, 2019). This process places people in a social location that is determined by a variety of intersectional factors, including age, income, location, gender, ability, and occupation, in addition to other social factors. Dover and Belon's model informs the Digital Health Equity Framework (DHEF) (Dover & Belon, 2019).

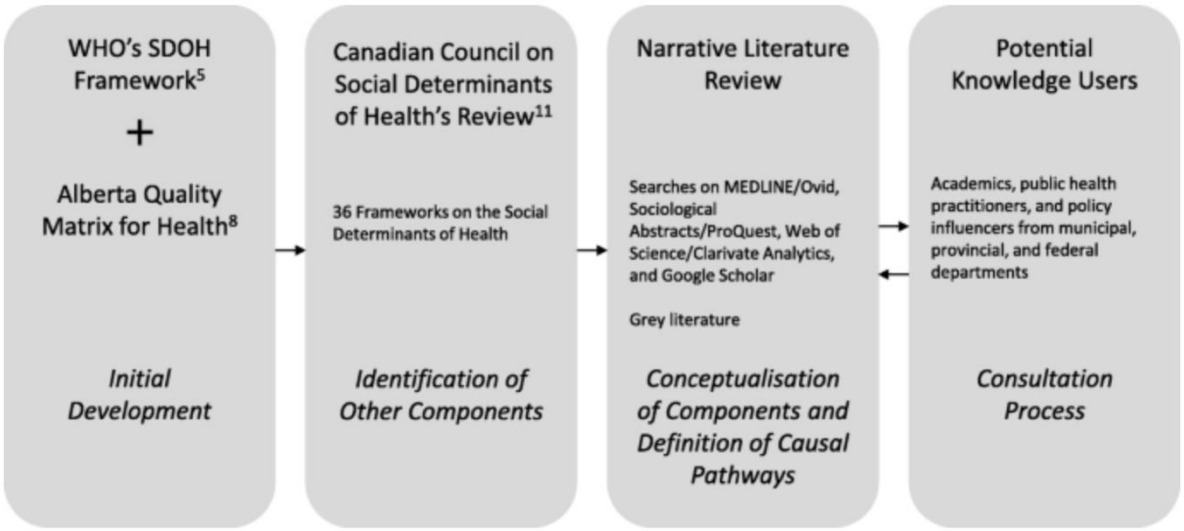


Figure 6. Health Equity Measurement Framework. Source: Dover and Belon (2019)

This model uses social stratification that factors in demographic variables to measure health equity. In as much as this model is a health equity model, it does not appear to exclusively speak to digital health, where technology consideration is a key factor. However, the considered social factors would impact digital health as well.

Digital Health Equity Framework (DHEF)

To start with, DHEF considered that, in addition to person-centered care, health providers should get training on digital health equity, and it should be promoted on a personal, institutional, and societal level (Crawford & Serhal, 2020) . This model can be used to consider health equity factors. Similar to Dover and Belon's model, DHEF digital determinants of health interact with the individual's present demands and state of health as well as other intermediate health variables such psychological stresses, prior medical problems, attitudes and actions connected to health, and the environment (Crawford & Serhal, 2020).

Comparable to the framework for Digital Health equity which expanded the NIMHD research framework by including a digital environment, this model (DHEF) considers digital determinants of health. Therefore, this model informs digital health for equitable access to UHC.

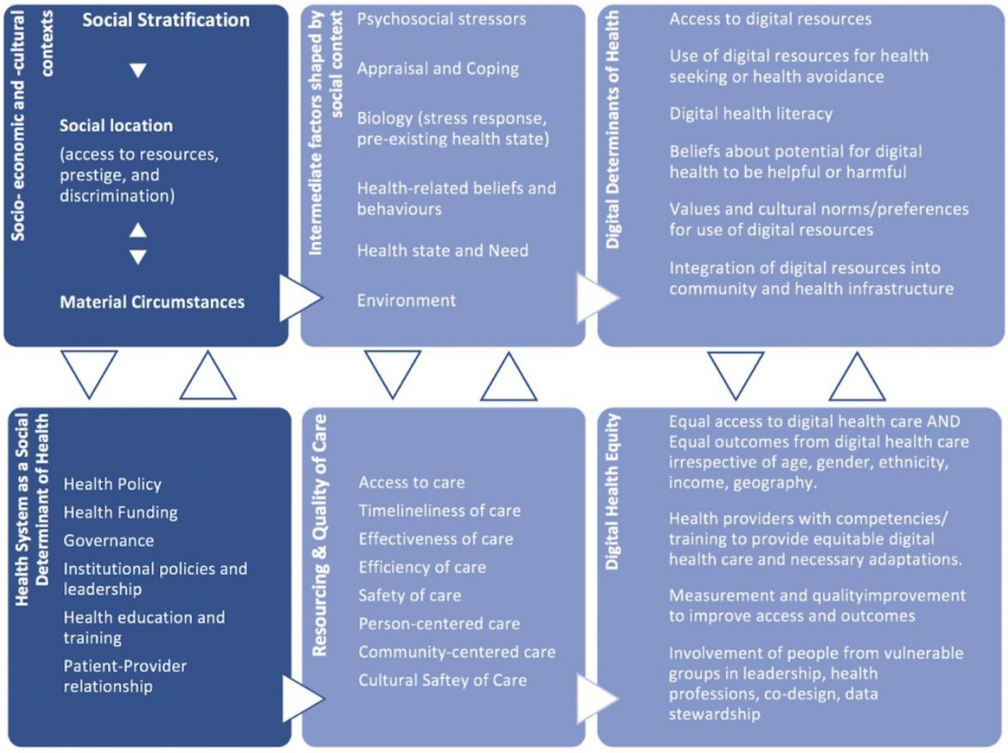


Figure 7. Digital Health Equity Framework. Source: Crawford and Serhal (2020).

Methodology

To provide a comprehensive review of digital health models for equitable access to UHC, a scoping review methodology as guided by Munn et al. (2018) was employed. The core search terms included in this study were "digital health", "equity", "equitable access", "universal health coverage", "healthcare", "model", "strategy", "framework", and "ehealth". Digital copies of the relevant documents were downloaded from the search results. The inclusion criteria to the review were all documents that addressed digital health models for equitable access to healthcare and universal health coverage.

To ensure a thorough and organized search process, searches were conducted on the various digital libraries and repositories. The process involved using the identified search terms, with manual searches also included to ensure completeness in the search process (Townsend et al., 2023).

While we provide a thorough analysis of digital health models for equitable access to UHC, we do not claim to have included all the provisions that may be important for equitable access to UHC in technology and digital health research. Moreover, the field of digital health encompasses a wide range of study domains. To maintain the relevance of this study, the review was limited to digital health models for equitable access to UHC.

Discussion

Given the technological advances and the changes within the health ecosystem and beyond, model developments, adaptations, and enhancements are required to inform progress and to support and guide operations with the changing goals and targets (Cresswell et al., 2019). Considering UHC which advocates for inclusivity across its main dimensions of population coverage, service quality, and cost, designed models, regardless of their focus should reach out to the communities and remain people-centered (Macdonald et al., 2023).

The various models reviewed offered guideline to key aspects that impact health outcome. To start with, the models by HIMSS (EMRAM, INFRAM, CCMM, AMAM, DIAM, and C-COMM) (Cresswell et al., 2019), guided on healthcare measurements (Cresswell et al., 2019), whereas the four-component framework that suggested sensitization of providers, continuous supervision, continuous professional training, and empowerment of leaders, as key steps to mental healthcare, through in the issue of routine practices in health (Kumar et al., 2021). Additionally, the Tanahashi model covered access and coverage of health services (Ojo, 2022), and was adapted by the Mehl's and Labrique's cascading model, which prioritized mHealth strategies for attaining UHC (Labrique et al., 2018). Further, the NIMHD Research Framework, an adaptation of the NIA disparities model, added the healthcare system domain as a key factor to health. NIMHD was further expanded by the Digital Health Equity framework to including a digital environment domain (Richardson et al., 2022). Hence, all reviewed models existed to address a key element in health.

In line with digital health for equitable access to UHC, three of the reviewed models stood out. The digital health framework (DHEF) by Crawford and Serhal (2020), presented a model for use to consider digital health factors. The framework for digital health equity introduced a digital environment domain which allowed for consideration of digital health interventions in healthcare (Richardson et al., 2022). Moreover, the Mehl's and Labrique's cascading model considered digital health in adapting the Tanahashi model (Labrique et al., 2018; Ojo, 2022).

Conclusion

Digital technology advancements continue to influence the digital health ecosystem. The inclusion of digital health tools and technologies like Artificial Intelligence (AI), the Internet of Things (IoT), among other technologies impact health, to the extent of the kinds of services offered, information systems deployed, and even the digital health programmes available. Further, a more receptive political environment, and a rising body of digital health data, demonstrates the effectiveness of digital health tools and technologies, which ultimately are paving the way for digital health to become a crucial component of healthcare delivery.

On the other hand, when access to face-to-face treatment is not an option, like was the case during the COVID-19 period, health systems, in particular, become aggressive in developing measures to assist patients in getting access to digital health services, and programs. Therefore, it is important that these systems consider the appropriate factors and are people-centered, for effectiveness. Moreover, models that consider varied digital health tools and technologies, digital health services, digital health programs, and digital health information systems, and are adaptable to changes within the digital health ecosystem and beyond, should be explored.

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