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EDITORIAL

Reimagining Digital Health

Advances in Patient-Centeredness, Artificial Intelligence, and Data-Driven Research

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1 Introduction

Digital health is "associated with the use and development of digital technologies to improve health" (WHO 2024a). It differs from other forms of healthcare by using a set of digital technologies, which are smart, accessible, and connected and which become central to the process of delivering healthcare. These technologies are used in all areas of healthcare, including providing professional healthcare services (e.g., diagnosing and treating patients), the supporting processes that are needed to deliver care (e.g., task planning, allocation of resources, patient routing), research (including trial management), patient self-care and health management, and health-related innovation generally. Examples of digital health technologies include mobile healthcare apps, fitness trackers, wearables, personal healthcare devices – such as digital scales, digital chest belts, smart pillboxes, smaller devices used by healthcare professionals (e.g., sensor-equipped endocutters, digital stethoscopes, or intelligent carpets), implants (neuro-, cardiac, or other) that are equipped with sensors and network connections, robotic surgery, teleconsultations, and remote patient monitoring solutions. Increasingly, and as advocated by the WHO (2024a), digital health is associated with the use of artificial intelligence and complementary innovations, such as the use of blockchain, to deliver on its promise to improve healthcare quality, access, and affordability. These technologies on the one hand digitize healthcare and on the other hand enable new forms of interactions between patients and healthcare providers, such as sharing decisions between physicians and patients (Charles et al. 1997; Vogel et al. 2021).

While digital health fundamentally relies on technology, it does not imply that technology is the sole component or that organizational and cultural factors are not significant to its uses. On the contrary, effective developments with digital health necessitate careful consideration and research regarding how these technologies will come into play in patients' lives as well as the organizational and institutional context in which these technologies are embedded (e.g., Winter and Davidson 2019; Wessel et al. 2019; Burton-Jones et al. 2020). For instance, continuous (remote) monitoring will significantly alter the structure of healthcare professionals' work environments and how patients are managed, and self-manage, within these environments (e.g., Hochwarter et al. 2023; Davidson et al. 2023b). Moreover, although it is often stated that digital health facilitates a patient-centered shift in healthcare, research indicates that this is not always the case. Thus, intentional efforts to address unintended consequences and side effects

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of adopting digital health technologies in healthcare are essential (e.g., Barrett et al. 2012; Sergeeva et al. 2020; Ziebland et al. 2021).

Digital health is increasingly a *data-centered* paradigm. While digital health technologies generate data that are used to provide immediate feedback to its users (e.g., Constantiou et al. 2023; Davidson et al. 2023b), these technologies also produce data for secondary uses. This includes integration into large platforms and infrastructures increasingly prevalent in healthcare systems, for training algorithms, and ultimately for stimulating health research and innovation. Common ways in which data are used is in software-as-a-medical devices and AI-based decision support systems (e.g., in radiology). The U.S. Food and Drug Administration (FDA), responsible for approving and overseeing drugs and medical devices, has reviewed 692 AI-enabled medical devices (FDA 2023). While radiology predominates, other medical specialties, such as cardiology and neurology, are rapidly advancing. Notable scientific milestones in AI have been achieved in the last year such as AlphaDev for faster sorting, SynthSR for transforming brain scans for faster analysis, or GPT-4 Medprompt performing on MedQA, a dataset with 60.000 clinical questions, at an accuracy rate of 90.2% (Maslej et al. 2024). Furthermore, beyond the US, also the European Union and others are placing significant public investments into necessary data infrastructures to enable AI advances in science and medicine (e.g., Kari et al. 2023; European Commission 2022, 2024).

An intriguing aspect of digital health technologies is the generation of detailed, even intimate, data about human activities and conditions – from heartbeats to daily activities to physical locations. Digital health data can create large, population-level cohorts of individuals, who may be patients at times and healthy individuals at others and who can be digitally phenotyped using these data and AI-analytics. Such data may not be explicitly directed to specific digital healthcare services or to research projects, such as clinical trials, but instead are a byproduct of the prevalence of mobile and IoT technologies. Digital health data can enable new forms of personal insight into health, such as those heralded by the "quantified self" movement (Swan 2013; Sjöklint et al. 2015), but their governance also raises significant regulatory concerns about privacy, autonomy and choice in how individuals' personal health data are utilized across contexts, without consent, and in possibly discriminatory ways (Winter and Davidson 2019, 2022).

Taken together these challenging developments raise new questions about how to reimagine digital health to strengthen health and healthcare systems for the benefit of future generations.

2 Mechanisms of Value Creation Via Digital Health Technology

To better envision how digital health could or should develop, we consider four technology-related mechanisms that have the potential to drive value creation in the realm of digital health: (i) sensor-enabled, (ii) connected, (iii) precise and personalized, and (iv) immersive. Informed by transformative computing advances (Benlian et al. 2018), these mechanisms highlight the shifting logics of value creation in the relation of technologies and individuals, communities, and societies.

Sensor-enabled. Building upon the advances in what is known as eHealth (electronic Health) or mHealth (mobile Health), a crucial step in many digital health models is rendering data available that were previously hard to obtain or error-prone. Sensor-enabled wearables, for instance, augment or replace paper-based self-assessments or diaries. An early example demonstrating the capabilities of such sensor-enabled devices is the Apple Heart study (Perez et al. 2019),[1] which combined sensor-enabled tracking of heart rhythms with electronic surveys for patient reported outcomes (Garcia et al. 2022), and included 419,297 participants (Perez et al. 2019). This large-scale study demonstrated the ability to monitor important and meaningful health outcomes, such as the onset of atrial fibrillation, through sensor-enabled digital health artifacts, yet it also showed how the execution of monitoring at scale poses challenges in data management, participant identification, and patient adherence (Garcia et al. 2022; see also Schwartz et al. 2024).

Connected. Like in other fields (e.g., Hylving and Schultze, 2020), another crucial step in increasing value creation of digital health is building on the connected nature of sensor-enabled devices and apps to connect with larger health service systems and thus to involve more stakeholders. These include connecting sensor-enabled medical devices, mobile health apps, electronic health data portals, health data platforms, and traditional medical therapies (e.g., drug-based, psychotherapy, physical, speech, occupational, radiation, gene therapy) into an interoperable healthcare landscape. For example, Biotronik, a German MedTech firm, has established an FDA-approved remote monitoring service for patients with cardiac implants, which sends data from the implant automatically to a smart messenger station, which then transmits the data to a server where it can be accessed by a physician for review and taking actions (Biotronik 2024).

[1] Similar studies have now also been performed using other wearable devices such as Fitbits (e.g., Lubitz et al. 2022) or the Oura ring (Quer et al. 2021).

One of the recent innovations in this field is digital therapeutics (DTx), which are evidence-based, patient-directed software applications intended to improve diagnosing, treating, managing, and/or preventing diseases (Fürstenau et al. 2023). These contribute to a connected ecosystem of actors and devices, including possibilities for a connected digital patient experience with access to treatment anytime and anywhere. While presenting exciting opportunities, this degree of connectivity also heightens challenges regarding privacy and security (e.g., Sunyaev et al. 2014), interoperability (e.g., Stegemann et al. 2023), and the potential exclusion or inaccessibility for groups that are in most need (e.g., Marbin et al. 2023).

Precise and personalized. Coupled with advances in predictive analytics, the progress in contactless sensors and the availability and quality of data thus generated (e.g., Haque et al. 2020) allow for increasingly *personalized* and *tailored* health interventions. Precision medicine entails tailoring health care individually "on the basis of a person's genes, lifestyle, and environment" (Hodson 2016, p. S49). Digital health has seen increasing incorporation of and economic activity in the field of precision medicine using omics data, associated with industry-scale genome decoding, and digital phenotyping data (e.g., Gray et al. 2023; Rothe et al. 2023; Toussaint et al. 2024). Machine learning becomes a new instrument, allowing for real-time predictions (e.g., Meyer et al. 2018) and personalized therapy planning and decision support (e.g., Chen et al. 2021). This supports a richer and more complete picture of patients and their contexts, yet the pursuit of personalized healthcare also brings to the foreground challenges with patient privacy and security of health data, the tensions between data anonymization with the need to link patient-level data across diverse healthcare and regulatory contexts, and expectations about patient autonomy and choice. Changes in professional roles and challenges to how technologies can be meaningfully integrated into healthcare workflows based on efficiencies of standardized care are also apparent (e.g., Haque et al. 2020).

With major breakthroughs in DNA sequencing and editing, recent and future advances in synthetic biology – a field that redesigns organisms for useful purposes by engineering new abilities or incorporating unnatural molecules to mimic emergent natural behaviors (Benner and Sismour 2005) – are set to revolutionize therapeutic interventions. These advancements will facilitate precise, site-specific treatments that directly modify bioactivity (Cubillos-Ruiz et al. 2021). As a result, the line between technology and biology is predicted to become increasingly blurred (e.g., Eslami et al. 2022; Suleyman and Bhaskar 2023). The realm of digital health, traditionally seen as a technology domain, will now be expanding into the biological realm, enhancing our capability to improve health outcomes. The integration of synthetic biology and advanced machine learning is opening up novel diagnostic and therapeutic possibilities, marking a significant shift towards more integrated and innovative healthcare solutions. Yet, besides important technological challenges, this integration also poses new challenges with regards to controlling (or containing) undesirable developments, ethical considerations, social acceptance, and trust.

Immersive. Finally, the turn towards more immersive digital experiences in healthcare, such as the use of virtual reality technologies for therapeutic applications, virtual coaches, digital twins, and bots (Makin 2019; Weimann et al. 2022; Freeman et al. 2022, 2023), prompts a critical assessment. The potential detachment patients might experience from the real world due to these digital experiences raises concerns about "losing touch" with our physical environments (Sergeeva et al. 2020) and possibly even our physical selves. Leveraging the benefits of immersive technologies while maintaining a connection to real-world experiences is a key challenge in reimagining digital health if these technologies become pervasive. This involves carefully calibrating the boundaries between digital and physical realms to ensure that while we embrace the advantages of digital innovations, we also preserve the essential human experiences and interactions that underpin effective healthcare.

3 Effects on Value Creation

These technology-infused mechanisms of value creation via digital health technology have important effects on value creation at three levels, depicted in Fig. 1: technology – individuum ①, technology – community ②, and technology – society ③.

Technology – individuum ①. With the rapid diffusion of sensor-based, connected, personalized technologies, digital health increasingly influences real world treatments for patients and helps professionals understand patients in their context. For instance, in direct patient care, we are seeing increasing support for patients within and beyond clinical care settings. Here, digital therapy companions, digital therapeutics, and digitally-enhanced assistive technologies can help patients and professionals in diagnosing, monitoring, treating, and managing diseases, as well as empowering patients in their health literacy, lessening their burdens of disease, and increasing their voice in and access to healthcare support.

The abilities of digital health technologies to cost-effectively augment and even automate (so that these technologies act autonomously) treatment-related decisions and actions are increasing. Transparency in this context is an

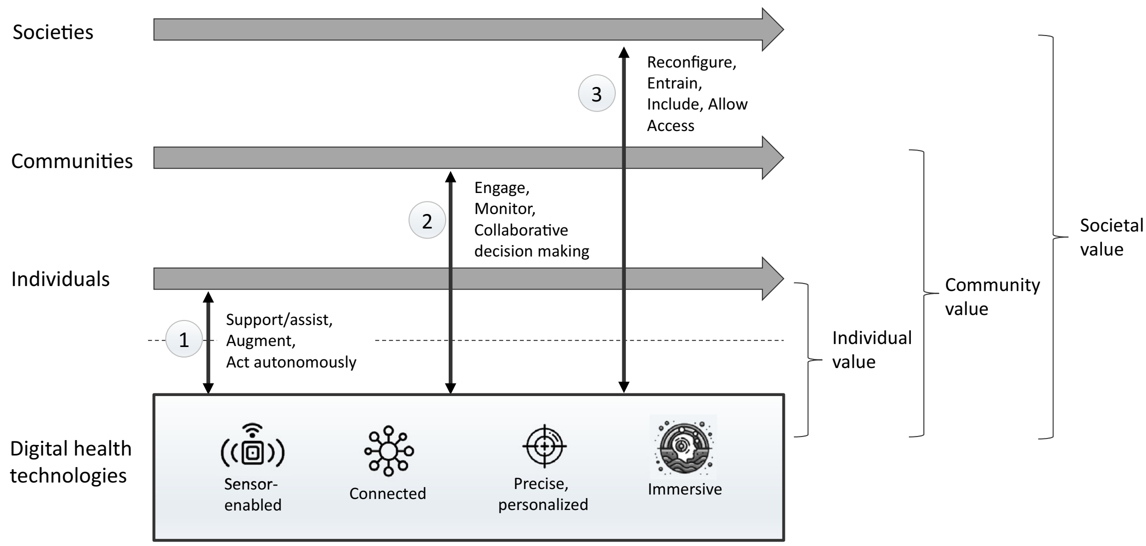

Fig. 1 Value creation through reimagining digital health

important concern, so that patients and physicians will be able to understand, process, and act effectively within these increasingly technology-induced settings. Providing adequate means for informing patients of technology-triggered actions is vital, as is balancing the benefits with risks of side-effects of such technology-infused health interventions.

Such changes clearly will affect the patient-physician relationship. The described shifts in digital health should generally help empower patients, increase the possibilities for sharing decisions between patients and physicians, and strengthen their therapeutical alliance. However, while patient engagement has long been a central value in healthcare IT research, fulfilling its promise has never been easy. Changing established scripts, frames, practices and role expectations on both the side of the clinical practitioners and patients requires major efforts. Moreover, a key frontier in the patient-centered approach involves not just considering what patients might want and then designing care giving around their decisions, but actively engaging patients or clinical care givers in co-envisioning and co-designing healthcare workflows and interventions that are tailored to their needs.

Technology – community ②. The sensor-based, connected mechanisms of digital health in collaborative decision-making highlights its role in community value creation. Digital platforms offer a powerful vantage point for understanding the nuanced health needs of a community, enabling a synergistic approach to healthcare where patients, providers, and stakeholders co-create health solutions. This collective intelligence approach ensures that health interventions are finely tuned to the community context, maximizing their relevance and efficacy. By fostering an environment where decisions are made collaboratively, digital health acts as a catalyst for community empowerment, which can enable a more democratic, inclusive, and effective health ecosystem that values the contributions and needs of all its members.

The shift towards remote monitoring and the concept of a 'hospital at home' exemplifies how digital health technologies are redefining healthcare delivery to prioritize community value. By enabling care in home and ambulatory settings, these innovations alleviate the pressures on hospital infrastructures and enhance patient convenience and comfort. This transformation supports a broader community-centric healthcare model, where the ease of access to monitoring and care strengthens the community's health resilience. The ability to manage health conditions from home not only individualizes care but also integrates it into the community fabric, ensuring that healthcare delivery aligns with the communal values of accessibility, efficiency, and personalized care.

The connected, immersive mechanisms of digital health technologies also enable creation and support for new types of health-focused communities. Through digital platforms, individuals can be empowered to take an active role in managing their health, bridging the gap between passive care receipt and active health stewardship. The introduction of gamification into health management tools can transform mundane health tasks (e.g., walking, exercise) into engaging and rewarding challenges, offering incentives for maintaining a healthy lifestyle. This approach not only motivates individual action but also fosters a sense of community as people of all ages share insights and support. The collective participation facilitated by digital health thus can contribute significantly to the creation of communal value, enhancing the overall health and well-being of society.

Technology – society ③. The sensor-based, connected, personalized and immersive mechanisms of digital health technologies together enable needs-driven, human-centered approaches to health. Such approaches rely on distilling the increasing volumes of personalized, contextual health data generated through digital health into useful theory, innovations, and clinical insights, which then can be applied to a patient population or to global health challenges, as well as in individual health interventions. Such approaches highlight not only the technology- and data-infused innovations that are possible but also consider potential ethical, social, and economic consequences, intended and unintended, of digital health. Further, these approaches accept that societal values and data-driven technologies are inherently intertwined, as noted by Gray et al. (2023) in a paper studying the emergence of genetic data markets in the US, and the fundamental moral issues around privacy and ownership arising in such settings.

At the societal level, the technological frontier in digital health is significantly influenced by artificial intelligence and its ecosystem of complementary innovations. Large Language Models (such as GPT-4, Gemini Ultra, or Claude 3), including medicine-tailored variants such as GPT-4 Medprompt or Med-PaLM 2, offer substantial opportunities for reimagining digital health. We increasingly see analytics research from IS researchers (among others) that use sophisticated machine learning approaches to predict risks and optimize treatment plans (e.g., Ben-Assuli and Padman 2020; Chen et al. 2021; Ghose et al. 2022), and begin to see first studies utilizing generative AI (e.g., Ayers et al. 2023). Advancing modeling techniques to allow for efficient personalization in "n = 1" trials, as well as accurately modeling treatment effects and unintended side effects of treatment (e.g., Kaminski 2021; Brodersen et al. 2015) will require well-crafted combinations of retrospective studies based on increasingly available digital trace data, and prospective studies that test designed interventions in the lab and also in messy real-world settings.

Another crucial frontier in societal value generation is addressing equity, and there is much progress to be made in this area. Equity relates to the "absence of unfair, avoidable, or remediable differences among groups of people, whether those groups are defined socially, economically, demographically, geographically, or by other dimensions of inequality (e.g., sex, gender, ethnicity, disability, or sexual orientation)," as defined by the World Health Organization (WHO 2024b). Whether the value-creating potential of the mechanisms discussed above (also see Fig. 1) are realized broadly, or only by select populations, depends on how digital health technologies are deployed and realized in the future.

Avoiding or mitigating inequitable value creation from digital health will require action on multiple fronts. Of note, as health datasets grow larger, it is essential to ensure that they also increase in heterogeneity to accurately reflect the diverse segments of the populations that the algorithms trained on them are intended to (or can potentially) serve. This challenge is in part statistical, involving the management of highly unbalanced datasets and the establishment of appropriate control groups, whether synthetic or otherwise. It also involves ensuring that re-identification of sensitive health information about individuals is minimized to prevent stigma or discrimination wherever possible, and that applications involving phenotyping as a basis for health services access are critically assessed and regulated. Also important will be the regulation of secondary markets for health dataset sales, including oversight of health data use for commercial purposes beyond healthcare (Winter and Davidson 2022).

4 A Research Agenda for Reimagining Digital Health

What are the implications of navigating the frontiers of human-centeredness and data-driven technologies in digital health and the opportunities for IS research to contribute to this domain? Table 1 summarizes some of the key shifts enabled by digital health technologies and suggests related questions for future research. We highlight key challenges and opportunities in the discussion that follows.

First, myriad healthcare services will be delivered virtually anywhere, disrupting many current approaches to service delivery. While healthcare has traditionally been thought of as occurring within the boundaries of confined properties, the technology-infused mechanisms discussed earlier contribute to increasingly ubiquitous, spatially distributed, health-related services occurring in local communities, such as the home or a network in which the patient is in the center of a care team (e.g., Fürstenau et al. 2021). The "hospital at home" is elaborated in Hochwarter et al. (2023). The idea is that even severely ill patients could be treated in their home with the assistance of technologies such as sensor-based monitoring, instant messaging, teleconsultations, digital therapeutics, and AI-based decision support tools (Stegemann et al. 2023). Ubiquitous healthcare also has important implications for the role of (gamified) digitized health apps which target health behavior changes that support healthier lifestyles and help prevent the development of chronic and non-communicable diseases (e.g., Schmidt-Kraepelin et al. 2020). The patient-physician interaction will increasingly be mediated by digital technologies, as healthcare professionals become "guests" in such healthcare delivery contexts (Hochwarter et al. 2023). An important implication concerns health service reimbursement models, which need to be adapted to the realities of care being delivered

Table 1 Selected future research areas in digital health

Subject area where changes are occurring	Definitory characteristics of changes	Key research questions for future scholarship on digital health
Healthcare anywhere, anytime	Healthcare anywhere, anytime denotes a shift to accessible, location-independent care through telemedicine, remote monitoring, and mobile health technologies	• How can at-home and on-demand technologies be integrated with traditional healthcare infrastructures and systems? • What is the role of digital therapeutics in future-oriented and patient-centered healthcare processes? • How can AI-based virtual (mental) health therapists be designed to compensate for increasing gaps in supply? • What is the role of gamified IS for health behavior change in supporting healthier lifestyles and preventing the development of chronic or noncommunicable diseases?
Hospital of the future	The "hospital of the future" represents a highly digitalized, AI-integrated environment, emphasizing patient-centric, efficient, and technologically advanced healthcare delivery	• How will increased monitoring and AI-based decision support solutions affect healthcare workflows, including issues of trust, human-AI-collaboration, and so on? • How can explainable AI advance clinical decision-making? • What are unintended consequences or side effects of implementing increasing amounts of digital health tools into hospitals and care facilities? • What are the implications for workload, (techno-)stress (e.g., alarm fatigue), job satisfaction, etc.?
Data platforms and ecosystems in healthcare	Data platforms and ecosystems in healthcare involve multi-lateral, multi-sided collaborations around accumulating and providing access to data in healthcare	• How open should access to health data platforms be and how can secure and easy access be provided? • How should anonymized / synthesize datasets be created to minimize re-identified of patient data while retaining the analytic value of patient-level data linkages? • How can health-related data sets be generatively recombined to enhance economic and social value from digital health? • What societal, regulatory, and market-based rules are needed to avoid discrimination based on health data while also ensuring datasets represent diverse, representative populations? • How could business models and operating models for health data platforms be developed to ensure sustainability after initial (governmental) investments? • How can we measure the economic and social impact of data platforms to justify societal investments beyond data sales?
Decentralized research and innovation	Decentralized research and innovation focus on distributed, participant-centric research models leveraging digital tools for wider, more inclusive scientific engagement	• How do we design data donation and consent solutions that ensure that rights of individuals to control their health data are respected? • How can we establish and verify a "chain of evidence" around research findings, insights, or products in distributed or decentralized research? • How can federated learning help to scale healthcare research while ensuring privacy and trustworthiness?

Table 1 continued

Subject area where changes are occurring	Definitory characteristics of changes	Key research questions for future scholarship on digital health
Sustainable digital health for society	Sustainable digital health focuses on eco-friendly, resource-efficient healthcare technologies that are designed and managed according to societally agreed ethical principles	• Are digital health technologies serving the needs of currently underserved populations? • What regulatory or market incentives are effective at directing innovations towards societally impactful outcomes? • How can we design gamified health apps in an ethically sound way that promotes self-care but also account for potential side effects (e.g., addictive behavior)? • How can we reduce the carbon (environmental) footprint of healthcare facilities and organizations, using digital technologies? • How can product architectures with their physical and digital components be redesigned to enable circularity? • What unintended consequences and side effects (e.g., rebound effects) could first-order sustainability-enhancing technologies have?

anytime, anywhere, transcending the traditional sectors of ambulant, stationary, and rehabilitation care.

A second observation is that health care activities remaining in the hospital setting will look much different in the future. One aspect is "illuminating the dark spaces" (Haque et al. 2020), the idea that a hospital, a nursing home, or any other care facility will be equipped with sensors, cameras, and wearables surveilling patients and care givers and continuously collecting real-time, detailed data. These data will illuminate activities throughout the hospital, making variations in practices and patient outcomes more visible and open to process efficiency and effectiveness improvements. Illuminating also includes technologies providing explainable decisions or support based on collected data (e.g., Toussaint et al. 2024) such as explainable AI for diagnostic algorithms, which will be critical to the acceptance of advanced technologies.

In these and other ways, the hospital of the future will be a highly technological setting, not only the Intensive Care Unit, but every area will be digitized. This digital health transformation requires policy and organizational research, as well as technology-centric projects, to realize fully the potential benefits. For instance, focusing on a needs-driven, human-centered approach to health services delivery will require rethinking which areas should be first to use artificial intelligence innovations, not only where data are readily available for training AI algorithms, but also where health services enhanced by AI could make the biggest impact on patient health outcomes. When considering potential research projects, IS researchers could look for opportunities in underserved or ill-equipped areas, as well as among patient populations in healthcare facilities that require additional support urgently. Importantly, a human-centered approach will need to consider patients and professionals as humans, with their fears, flaws, but also with immense problem-solving and cognitive capacities. Fears need to be treated seriously around patient safety, privacy, and the actual usefulness of these technologies (Dehling and Sunyaev 2023). Research in this domain will require collaborations across technology designers, medical researchers, and behavioral and organizational researchers to address these challenges.

A third observation is health care services are moving beyond the boundaries of single providers and towards larger ecosystems, where resources, including health data, will be widely shared (Thiebes et al. 2023). Along with regulatory and market changes, digital health technologies are major drivers of this shift. There is a long history of technology providers, medical informatics researchers and government regulators working towards technologically interoperable health data systems for clinical care that would enable data sharing across care settings, with much work remaining to be done. More recently, the emergence of large data platforms and data spaces, which bring together data from multiple contexts, research trials, and life areas of a person, is creating treasure troves of health-related data that offer a much richer and complete view of the health and life of persons and the needs of populations. Questions arise around how these vast, heterogeneous data repositories can be utilized, what machine learning can accomplish, and what the eventual outcomes of investing in these repositories will look like. In addition to the developments around generative AI (e.g., Feuerriegel et al. 2024) and foundation models (e.g., Schneider et al. 2024), data-centric AI (Jarrahi et al. 2023) will put increasing emphasis on the training data used to develop AI applications, seeing data as containing historical biases and gaps that needs to be dealt with explicitly. "In the backroom of data science" (Parmiggiani et al. 2022) we find that data are messier and data sets are stitched together more than we might expect. This creates intriguing questions around data quality, not only in a technical sense, but as a social process, that need to be addressed to keep the increasing complexity of a data-centric AI paradigm in healthcare (and elsewhere) at bay.

Pressing organizational and regulatory questions about governance of these data platforms thus must be answered, such as which data to share and how to handle very sensitive data that, if revealed, could harm a person, leading to stigma or discrimination (Davidson et al 2023a). Given the incalculable value of health data to support healthcare innovation or for resale in other sectors, there are concerns about the dynamics within and competition among emerging ecosystems. As these ecosystems are necessarily incomplete, design and policy questions arise, such as: Which ecosystem will be the most fertile and for what purposes? Where are the boundaries of an ecosystem drawn and where does another begin? Will ecosystems be defined by single keystone actors, as is the case with many digital platforms, including the ones in healthcare? And, how can national policy ensure equal and fair competition among potential innovators operating in such ecosystems?

Regarding digital health innovation, which is often driven by private startups and high-tech firms, there are pressing questions about regulatory oversight and how to use and integrate real-world health data (such as that aggregated in ecosystems) into innovation process, while ensuring that the procedures are rigorous and validated. For instance, data platforms owners are already thinking of offering validation of algorithms, developed by researchers or firms based on previously collected data, as a service to these organizations. More broadly, we see data platforms emerging as intermediaries in the health innovation processes, eventually also affecting how regulators would see the value and operational control of these platforms. Contributing to resolving these complex regulatory issues will require that IS researchers stretch field boundaries beyond technology design and organizational concerns to embrace the broader perspective of public policy research (Davidson et al. 2023a).

Given the enormity of digital health possibilities and importance of health in human society overall, how we individually, nationally and societally develop and apply powerful digital capabilities have important implications for ethical and societal priorities. Considering how digital health can be made more inclusive, ensuring that advances can benefit diverse populations equitably rather than exacerbating health disparities, and engaging with societal and ethical implications generally can occur in two ways: (i) on individual projects, by considering ethical and societal implications as an integral aspect of the research process; and, (ii) as a special focus area within the subfield of digital health research, since many ethical and societal challenges will be common across projects. For instance, consideration of the consequences for equity of access to costly, digitally-enhanced treatments that could widen the digital divide by excluding individuals or populations that lack sufficient resources, or the implications of increased surveillance and health data collection for the individual's privacy, autonomy, and lifestyle choices, could inform decisions about which digital health projects to fund or to participate in as well as how to direct projects towards socially desirable ends.

Acknowledging our planetary boundaries, and the impact that digital health may play in exhausting its resources is an even broader concern that can engage some researchers in the IS field. For instance, 83 million wearable devices entered the European market in 2020 with an expected global annual growth rate of nearly 20% by 2027. Many devices are intended for one-time-use, then to be discarded and disposed of. There is ample evidence that the general linear trend in resource consumption and environmental waste that prevails in all areas of our lives is even more pronounced in healthcare, given issues with contamination and recycling of bio-medical waste affecting patient safety. The concept of the circular economy necessitates a reimagining of production and consumption as cyclical rather than linear processes. These processes are designed to keep materials in the loop to minimize resource use and waste. In addition to conventional electronics and plastics waste recycling techniques, this includes applying reduce and reuse techniques for product development (e.g., Zeiss et al. 2021), including those in digital health. IS scholarship has recognized the potential to develop digital technologies such as digital product passports, sharing economy platforms and digital design technologies, and is studying their intended and unintended effects (e.g., Zeiss et al. 2021). The digital health field offers important and exciting opportunities to extend such research to consider the added complexities of digital health, such as contamination risks and business model design (e.g., Rønn et al. 2023), and is rapidly growing environmental impacts.

5 Papers in the Special Issue

The papers of the special issue offer a look into current and future research, with some of the finest scholarship on the subject available today.

The research commentary by Baird and Xia (2024) featured in this special issue provides an in-depth discussion of precision health and its implications for digital health application design and research. Defining precision digital health as "digital technologies for health and health care that account for individual variability," the researchers consider how heterogeneity in patients' response to treatments can be identified and then integrated with digital health for more precise, personalized health interventions. The authors consider statistical and technological methods to apply in a three-step process of first identifying health phenomena subject to heterogeneity in patient responses to treatments, then utilizing conventional statistical methodologies or advanced machine learning technologies to identify subgroups and causal sources of heterogeneity, and finally, to incorporate advanced technologies, including sensor-based data and generative AI, in the design of digital health interventions that reflect individual patients' characteristics and contexts. The authors conclude with recommendations for how research and design that integrates digital health and precision health concepts might develop.

Binzer et al. (2024) address the critical roles that trust plays in consumer adoption of digital health applications in their contribution to this special issue. The researchers theorize that the governance of digital health apps (here, a personal health record, or PHR) by either public or private provider types will have a differential effect on trust pathways that influence a consumer's willingness to use digital health. Drawing on privacy calculus and privacy control perspectives to develop a sectoral theory of privacy calculus, they demonstrate the differential effects of perceived benefits, risks, and privacy controls on intention to use (and download) the PHR app, based on the sector (private, public) sponsoring the digital app. These findings have practical implications for the positioning and marketing of apps such as PHRs to address consumers' privacy concerns.

The paper by Müller and Reuter-Oppermann (2024) featured in this special issue, exemplifies the needs-driven aspect of digital health in a design science research project. Going beyond the initial problem formulation of a project charter, the researchers delve into real and pressing issues from a user perspective – how to motivate and enable people to donate blood in resource-scarce environments. The context of this paper is particularly compelling as it focuses on blood donation management in Ghana and South Africa. Here, the authors identify a concrete problem and develop a novel solution based on a set of well-justified technologies. Their blood donation behavior change support system (BDBCSS) provides a resource for other researchers and practitioners to consider in their future projects.

Health analytical developments are exemplified in the paper by Finze et al. (2024), featured in this special issue. The researchers use a well-known machine learning approach (support vector regression) to derive quality-of-life assessments from voice data snippets of seniors. This approach could reveal insights into nuances of clinical scorings that might be overlooked in self-reported or professionally-rated scorings. It also indicates potential for time savings and efficiency gains in documentation, which are crucial in a healthcare system increasingly burdened by a growing number of elderly and chronically ill patients.

The paper by Baum et al. (2024), featured in this special issue, exemplifies a study that addresses a specific challenge in equity, notably pertinent in the ongoing debate around gender medicine on social media. The authors spotlight particular topics and communities within this discourse, thereby directing our attention to the nuanced dynamics and conversations that shape the understanding and representation of gender medicine in digital spaces. By doing so, they contribute to a deeper comprehension of how social media platforms and digital interactions can influence and reflect public perceptions and discussions about gender-specific health issues.

The work by Fechner et al. (2024), featured in this special issue, addresses contemporary challenges in personalized healthcare. Based on the case of individualized bladder monitoring for patients with neurogenic lower urinary tract dysfunction, the authors conduct a design science research study that results in prescriptive knowledge for the design of tailorable healthcare information systems and showcases how smart wearables can empower patients in chronic disease management. The main contribution of their work consists of three propositions for secondary design mechanisms that culminate in a revised version of the Theory of Tailorable Technology Design.

Another important AI-based technology in advancing patient-centered care is embodied conversational agents that can act as virtual coaches to support health behaviors. Aiming to advance our prescriptive knowledge on this promising technology, Schlieter et al. (2024), conducted a design science research project implementing a virtual coaching solution to support older patients' home rehabilitation for two neurological (stroke and Parkinson's) and two cardiological (heart failure and ischemic heart disease) pathologies. Following the design science research approach, the work contributes to healthcare IS research by providing a clinically validated set of design principles, meta-requirements, and design features for virtual coaching solutions in rehabilitation.

6 Conclusion

The digital health field is strong and growing, and IS scholarship plays an important role in furthering research and innovation in healthcare. We will increasingly see inter- and transdisciplinary teams tackling grand challenges of our time related to a healthy and satisfactory life. The issues that arise are, however, pressing and require deep technological understanding and insight as well as social and organizational theorizing, which we hope to inspire through this special issue.

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