Thematic analysis of tools for health innovators and organisation leaders to develop digital health solutions fit for climate change

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ABSTRACT

Objectives While ethicists have largely underscored the risks raised by digital health solutions that operate with or without artificial intelligence (AI), limited research has addressed the need to also mitigate their environmental footprint and equip health innovators as well as organisation leaders to meet responsibility requirements that go beyond clinical safety, efficacy and ethics. Drawing on the Responsible Innovation in Health framework, this qualitative study asks: (1) what are the practice-oriented tools available for innovators to develop environmentally sustainable digital solutions and (2) how are organisation leaders supposed to support them in this endeavour?

Methods Focusing on a subset of 34 tools identified through a comprehensive scoping review (health sciences, computer sciences, engineering and social sciences), our qualitative thematic analysis identifies and illustrates how two responsibility principles—environmental sustainability and organisational responsibility—are meant to be put in practice.

Results Guidance to make environmentally sustainable digital solutions is found in 11 tools whereas organisational responsibility is described in 33 tools. The former tools focus on reducing energy and materials consumption as well as pollution and waste production. The latter tools highlight executive roles for data risk management, data ethics and AI ethics. Only four tools translate environmental sustainability issues into tangible organisational responsibilities.

Conclusions Recognising that key design and development decisions in the digital health industry are largely shaped by market considerations, this study indicates that significant work lies ahead for medical and organisation leaders to support the development of solutions fit for climate change.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Innovators in the digital health field are asked to develop solutions that are not only clinically safe and efficient, but also meet increasingly complex responsibility and environmental sustainability principles.

WHAT THIS STUDY ADDS

⇒ There is a lack of practice-oriented tools that can guide organisational leaders in supporting innovators developing environmentally sustainable digital health solutions.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Scholars, policymakers and practitioners can draw from the Responsible Innovation in Health framework to develop practice-oriented tools that can guide innovators and organisation leaders along a new innovation pathway fit for 21st century challenges to our health.

INTRODUCTION

The digital health field has exponentially grown over the past decade as innovators tackle pressing 21st century health challenges and Industry 4.0 technologies (eg, Internet of Things, robotics, cloud computing) expand ways to deliver healthcare. While the field ascribes a central role to data in healthcare, positing that 'data can help save lives around the world',[1] ethicists and civil society increasingly draw attention to the significant risks new digital technologies, especially those operating with artificial intelligence (AI), may raise (eg, privacy, bias, discrimination).[2–5]

Furthermore, the 'data as saviour' narrative sharply contrasts with the calamitous discourse surrounding the impact of the climate crisis on human and planetary health. Experts urgently call for a steep reduction of healthcare's carbon footprint and to place environmental sustainability at the forefront of all healthcare.[6–8] For instance, the International Leadership Group for a Net Zero National Health System (NHS) England invites the 80 000 global medical device suppliers of the NHS 'to decarbonise their operations by 2045 at the latest'.[9] Thus, to deliver on the promises of widespread benefits while limiting risks, digital health solutions must be safe, effective, ethical, and environmentally sustainable.[4–6 10–15]

These multiple demands place the digital health field in a difficult position. Health innovators must not only meet rigorous clinical safety and efficacy standards when developing new solutions, they must also account for complex responsibility principles (eg, explainability, accountability, transparency)[16–18] and find ways to reduce the environmental impact of their solutions. The latter is a challenging endeavour as the digital industry (hardware, software, infrastructures, supply chain) is one of the most polluting industries,[6 12 13 19] key design and development decisions are largely taken outside of the health field, environmental issues remain beyond the peripheral vision of digital

health leaders[20] and very few scholars examining healthcare's carbon footprint include the environmental impact of digital health solutions in their analyses.[7 21 22]

This significant research gap thus calls for strong medical leadership.[6 12 13] Whether through their role as Chief Medical Officer in a start-up enterprise, as in-house 'intrapreneurs', or as heads of medical departments, medical leaders are uniquely positioned to tackle 'healthcare's wicked problems', 'enacting leadership qualities that foster engagement between multidisciplinary professionals in collaborative practice and transformation'.[23]

Because solution development requires technical know-how and strong organisational leadership, we ask the following two research questions: (1) what are the practice-oriented tools available for innovators (short-hand for all those who contribute to the design and development of a digital health innovation, including, for instance, physicians, clinicians, software developers, engineers, designers) to develop environmentally sustainable digital solutions; and (2) how are organisation leaders supposed to support them in this endeavour?

To answer these questions, we analyse data stemming from a comprehensive and multidisciplinary scoping review of practice-oriented tools.[24] The tools were identified and analysed using the Responsible Innovation in Health (RIH) framework as it integrates the environmental and organisational components of health innovation within its core value domains.[25] It defines responsibility through a 'set of ethical, economic, social and environmental principles, values and requirements' that should be applied 'to address the needs and challenges of health systems in a sustainable way'.[25]

This paper's contribution to current knowledge is twofold. First, our results highlight the leadership role organisations developing digital health solutions must take on to integrate environmental sustainability as a key responsibility criterion. Then, we discuss the profound shifts needed in digital solution development practices to effectively tackle, without further contributing to, 21st century challenges to human and planetary health.

METHODS

Data collection

Our data stems from a scoping review conducted in 2021 where we searched the grey and academic literature in the health sciences, computer sciences, engineering and the social sciences to identify practice-oriented tools that aim to help digital health stakeholders make responsible solutions.

We searched six academic databases (PubMed, Web of Science, arXiv, Institute of Electrical and Electronics Engineers Xplore, IBSS ProQuest Abstracts and Sociological Abstracts), three grey databases (OpenGrey, CMA CPG Infobase and Government of Canada Publications) and used various combinations of key terms in two search engines (Advanced Google Search and DuckDuckGo). We included tools issued between January 2015 and January 2021 in English or in French that provided practical guidance on how to ensure a solution meets responsibility principles related to AI and digital solutions (eg, fairness, trustworthy) and the value domains and responsibility criteria of RIH: population health value (health relevance, ethical, legal and social issues, and health inequalities), health system value (inclusiveness, responsiveness and level and intensity of care), economic value (frugality), organisational value (business model) and environmental value (eco-responsibility).[25] Highly technical (eg, code made available on GitHub), specific (eg, a particular cybersecurity measure), and extensive (eg, ministry programme) tools were excluded from our study.

The review process led to include 56 tools (see figure 1), 19 of which were specific to the health field. The remaining 37 tools were generic and applicable to innovations across sectors, including healthcare. The types of tools found as well as the 40 responsibility principles they contained are described elsewhere.[24]

Data analysis

In this paper, we analyse a subset of 34 tools comprised of both health-specific (n=7) and generic (n=27) tools that explain to innovators and high-level executives what they should think

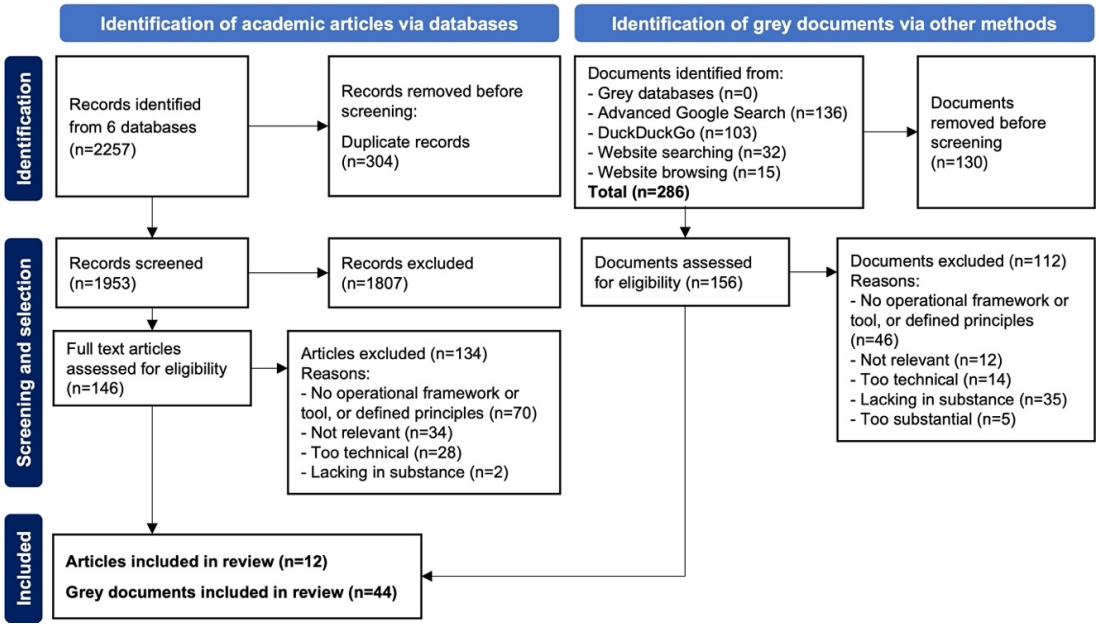

Figure 1 PRISMA-ScR (Preferred Reporting Items for Systematic review and Meta-Analysis extension for Scoping Reviews) flow chart of the scoping review.[24]

Table 1 Characteristics of the data set (n=34)

Code	Authors	Title	Focus	Environmental sustainability	Organisational responsibility
T1	AI Ethics Impact Group	From principles to practice: an interdisciplinary framework to operationalise AI ethics	Generic	X	X
T2	Avanade	Trendlines: digital ethics—'do no harm' isn't good enough—a practical guide to building ethics into your organization	Generic	X	X
T3	Deloitte	Foundation for Responsible Robotics (FRR) quality mark for robotics and artificial intelligence	Generic	X	X
T4	European Commission	Ethics guidelines for trustworthy AI	Generic	X	
T5	European Commission	The assessment list for trustworthy AI	Generic	X	X
T6	ECP Platform voor de InformatieSamenleving	Artificial intelligence impact assessment	Generic	X	X
T7	Institute and Faculty of Actuaries	A guide for ethical data science	Generic	X	X
T8	Leslie	Understanding artificial intelligence ethics and safety: a guide for the responsible design and implementation of AI systems in the public sector	Generic	X	X
T9	Machine Intelligence Garage	Machine Intelligence Garage's ethics framework	Generic	X	X
T10	Syntec numérique	Digital ethics: a guide for professionals of the digital age	Generic	X	X
T11	UK Government Digital Service	Data ethics framework	Generic	X	X
T12	Accenture Labs	Building digital trust: the role of data ethics in the digital age	Generic		X
T13	Accenture Labs	Facilitating ethical decisions throughout the data supply chain	Generic		X
T14	American Council for Technology and Industry Advisory Council (ACT-IAC)	Ethical application of artificial intelligence framework	Generic		X
T15	Association of Medical Research Charities (AMRC)	Navigating the digital health ethics landscape: questions for charities to ask digital technology company partners	Health		X
T16	Global AI	Responsible AI design assistant	Generic		X
T17	IBM	Everyday ethics for artificial intelligence	Generic		X
T18	Institute of Business Ethics	Business ethics and artificial intelligence	Generic		X
T19	KPMG	Controlling AI: The imperative for transparency and explainability	Generic		X
T20	Lapointe and Fishbane	The blockchain ethical design framework	Generic		X
T21	Mörch	The Canada Protocol: AI checklist for mental health & suicide prevention	Health		X
T22	New South Wales Government	NSW health data governance framework	Health		X
T23	Open Data Institute	The data ethics canvas	Generic		X
T24	SG	Model artificial intelligence governance framework	Generic		X
T25	The Institute for Ethical AI & Machine Learning	The Responsible Machine Learning Principles and the Machine Learning Maturity Model (AI-RFX Framework)	Generic		X
T26	The MITRE Corporation	An ethical framework for the use of consumer-generated data in health care	Health		X
T27	UK Government Department of Health and Social Care	A guide to good practice for digital and data-driven health technologies	Health		X
T28	UK Office for Artificial Intelligence	Guidelines for AI procurement	Generic		X
T29	World Economic Forum	Guidelines for AI procurement	Generic		X
T30	World Economic Forum	Companion to the model AI governance framework: implementation and self-assessment guide for organizations	Generic		X
T31	Young *et al*[39]	The Data Assembly: responsible data re-use framework	Generic		X
T32	Chen[40]	A conceptual framework for AI system development and sustainable social equality	Generic		X
T33	Vokinger *et al*[41]	Digital health and the COVID-19 epidemic: an assessment framework for apps from an epidemiological and legal perspective	Health		X
T34	van Haasteren *et al*[42]	Development of the mHealth App Trustworthiness checklist	Health		X

AI, artificial intelligence.

about and/or do to develop a responsible digital solution (see table 1). To answer our research questions, our thematic analysis focuses on two responsibility principles identified in our larger study: environmental sustainability and organisational responsibility. We define the latter as the guidance that is provided to leaders of organisations in terms of what a responsible digital solution entails and what they should do towards this end (eg, mechanisms, processes, collaborations). Recognising the plurality of approaches to thematic analysis, the one adapted to meet our study goal is located on the 'scientifically descriptive' end of the spectrum rather than the 'artfully interpretative' end.[26]

RESULTS

Guidance for innovators to develop environmentally sustainable digital solutions was found in 11 tools whereas guidance for high-level executives of organisations on a variety of responsibility issues was found in 33 tools. Though 10 of the 11 tools integrating environmental sustainability concerns also address various organisational responsibility issues (see table 1), only 4 tools provide specific guidance to high-level executives on supporting innovators in developing environmentally sustainable digital solutions. Instead, organisation leaders are guided towards other issues much promoted by ethicists, including data risk management, data ethics and AI ethics.

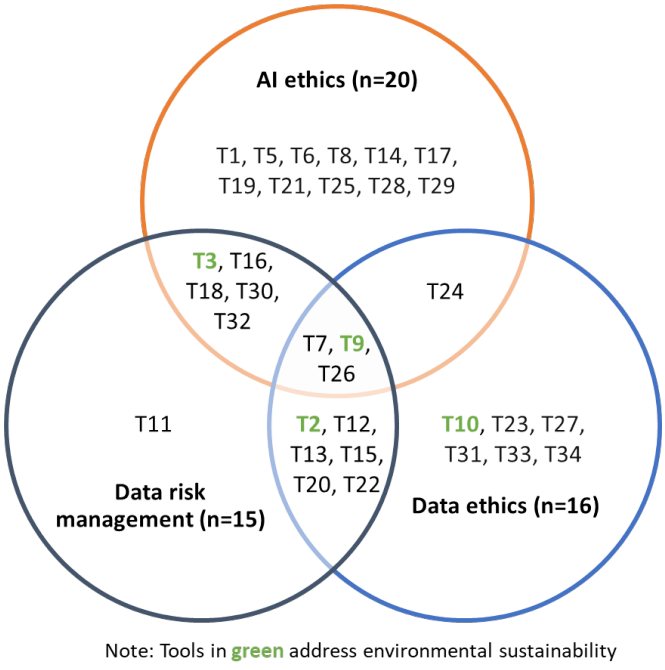

Figure 2 Thematic overlaps in the tools for leaders. AI, artificial intelligence.

Tools for innovators

Guidance to develop environmentally sustainable digital solutions is found in 11 tools, none of which stem from the health field. The information provided to define what environmental sustainability entails remains limited and the ways to put this principle into practice vary greatly across the tools. Beyond energy efficiency and waste reduction, we found no overarching themes that were shared by many tools and could have captured their respective focus (eg, hardware reuse, data frugality, net climate positive data centres). Illustrative excerpts of the tools as well as their complete references are found in online supplemental material while the identification codes used for citation purposes below are found in table 1.

Generally, environmental sustainability is defined as the consideration of a digital solution's impact on the environment throughout 'the design, development and maintenance process' (T3), as well as the 'entire supply chain' (T4; T5). Tools focus on reducing the consumption of energy and materials (T7) and the production of pollution and waste (T2) in order to 'mitigate the worst effects of climate change' and safeguard 'future generations' (T1). Towards this end, T5 encourages the development of digital innovations that are not only environmentally friendly but that also tackle 'areas of global concern, for instance, the Sustainable Development Goals', thus drawing attention to both 'the (potential) positive and negative impacts of the AI system on the environment' (T5).

Several measures are proposed to put this principle into practice, mainly by first assessing the environmental impact throughout the life cycle (T4; T5), such as the 'energy-cost of storing and processing large volumes of data' (T7), and then deploying mitigation strategies (T11), including the use of 'low-energy and low-waste technologies' (T2), 'power-efficient data centres [and] less power consuming machine learning models' (T1). For T10, 'primary energy, greenhouse gas emissions, water, the depletion of abiotic resources, paper' and e-waste should be assessed 'at least every 2 years' using 'recognised and auditable indicators (Green IT or WWF France)'.

Overall, these tools emphasise energy efficiency as well as the reduction of waste and pollution to limit the environmental impact of digital solutions and their effect on climate change. Though life cycle analyses are proposed, the tools do not address the complete life cycle of the physical components required to operate digital solutions, that is, from resource extraction (eg, rare-earth minerals) to end-of-life disposal. While T1 is concerned with the well-being of future generations and T5 invites innovators to develop solutions with a positive impact, none of the tools address how the environmental impacts of these solutions and their physical components currently affect human health.

Tools for organisation leaders

Guidance for high-level executives was found in 33 tools (see online supplemental material for illustrative excerpts). Though responsibility characteristics and implementation practices vary across the tools, key themes emerged around data risk management, data ethics and AI ethics. We found very little information explaining how high-level executives can support the development of environmentally sustainable digital solutions (see figure 2).

Data risk management

For organisation leadership, data risk management involves identifying and mitigating risks to businesses (eg, reputation) and to customers or the public (eg, biased data, security breaches) (T7; T9; T12; T13; T16; T18; T30; T32). It relies on ensuring quality data (eg, accuracy, currency, relevance, reliability), quality AI model training and testing in situ and continuous review and monitoring of risks post-deployment (T30). Increasingly, 'industry best practices and engineering standards' are made to align with 'relevant data protection laws' (T30), which include questions of data privacy, protection and sharing (T13) throughout the innovation's life cycle (T16).

Data ethics

However, for several tools, a standard risk management approach complying with the law does not sufficiently protect the business nor the customers or the public. Authors of these tools therefore strongly recommend that digital innovation stakeholders adopt 'a wide array of data ethics practices throughout their data supply chains' (T12). For T2, following ethical principles not only minimises legal, 'operational, brand and strategic risks', but 'good digital ethics practices can create value' for both 'shareholders and other stakeholders', as 'people want to work for, invest it, buy from and live near companies that behave ethically'.

Organisations' leaders are therefore instructed to set and follow a code of data ethics (T13; T30) and develop an organisational 'culture of data ethics' (T26). Towards this end, a variety of measures are proposed, for instance: data ethics training courses and access to ethics expertise for staff (T10; T13; T26), 'engaging with appropriate ethical bodies' (T7), appointing a Chief Digital Ethics Officer 'tasked with ensuring the overall coherence of the company's 'ethics and digital' policy' (T10), appointing a Data Sponsor 'with control over strategic direction [and] duties of ownership on behalf of the organisation' (T22) and establishing a data ethics committee to review ongoing data practices and 'be available for consultation when dilemmas arise' (T13).

AI ethics

For AI solutions, high-level executives are oriented towards strong internal governance mechanisms as they are essential to implement data risk management strategies and data ethics across the organisation (T12). To this end, 'top management' must 'set clear expectations/directions for AI governance within the organization', 'responsibilities for managing model risks and ensuring regulatory compliance should be clearly established and documented' and 'individual project team leads and officers should be held accountable for the AI projects' (T30). The issue of accountability, though 'central to the definition of good practice in corporate governance', brings additional challenges in the AI field, as model development is 'largely outsourced by companies rather than developed in-house' (T18).

Consequently, a culture of transparency must underlie governance and accountability measures. Steps towards such a culture include explaining 'how AI is used in decision-making […], what are its benefits [and] steps taken to mitigate risks' (T24), 'disclosing the manner in which an AI decision affects individuals and if the decision could be reversible' (T30) and developing a 'culture of dealing openly with mistakes' (T1). A transparent approach paves the way for 'instituting mechanisms to assure end-to-end auditability' (T8). Auditability is strongly recommended as it 'demonstrates the responsibility of design and practices' and thereby 'contribute[s] to the trustworthiness of the AI system' (T24).

Environmental sustainability

Only four tools (T2, T3, T9 and T10) in our data set explicitly provide guidance to organisation leaders to support the development of environmentally sustainable digital solutions, namely on the consideration of the environmental impact 'when choosing suppliers' (T9) and the implication of a manager to 'draw up an action plan' that respects 'recognised standards […] when entering into any contract that has consequences for the environmental footprint of the IT system' (T10).

DISCUSSION

In response to pressing calls to 'green' the digital health sector in the age of climate change,[6 12 13] we drew from the environmental and organisational value domains of the RIH framework to search for and analyse practice-oriented tools that guide the development of environmentally sustainable digital health solutions. Aiming to identify tools for innovators to develop environmentally sustainable digital solutions and for organisation leaders to support them in this endeavour, our study results indicate that there is currently a dearth of such tools (see the Centre Hospitalier de l'Université de Montréal's tool for a notable exception published after our data collection[27]). Although a few tools in our data set draw attention to a solution's environmental impact and propose mechanisms to reduce its carbon footprint, none of these tools offered a comprehensive approach to sustainable digital solutions, none came from the health field and we found little-to-no guidance for organisation leaders to support the development of such innovations. Much cited organisational responsibility and ethical concerns, such as data risk management, data ethics and AI ethics did not intersect with environmental concerns.

Contribution of the study

Because 'cleaning up the ICT sector is a global problem that needs global collaboration to mitigate negative environmental and health impacts',[6] our study contributes to the literature advocating for the 'greening' of healthcare systems by drawing attention to the importance of also considering the environmental impact of the digital solutions currently promoted as means to reduce a healthcare system's carbon footprint, such as virtual care.[7 21 22] This is especially important as medical leaders will play a key role in the establishment of the 'virtual models of healthcare delivery' that 'are expected to increase' following the COVID-19 pandemic.[28]

Although the health literature has seen a rapid growth in digital and AI ethics,[4] our results highlighting the lack of practice-oriented tools instructing organisation leaders towards the development of environmentally sustainable digital health solutions points to a regrettable missed opportunity for the field. In the context of a planetary climate crisis, failing to foreground and fully articulate the environmental impact of such solutions[11] is likely to impede the development of digital health solutions fit for climate change. Consequently, significant delays in the deployment of environmentally responsible digital health solutions are to be expected.

As such, our study brings to the fore the pressing role that leaders of organisations producing digital health solutions must take on to transition environmental sustainability from an 'add-on' issue to a cornerstone health issue placed on an equal footing with ethics, clinical safety and efficacy[29] as the latter are no longer sufficient to ensure the health and well-being of patient populations in the age of the Anthropocene.[6] By increasing lethal exposure to record-breaking temperatures, food and water insecurity and infectious disease transmission, climate change 'over-burden[s] the most vulnerable populations' and 'threatens to reverse years of progress in public health'.[6]

Without strong medical leadership prioritising the environmental sustainability of digital health solutions, innovators will be limited in their capacity to develop solutions fit for climate change and their efforts may result in 'greenwashing' the industry rather than engaging in transformational change. This is a pressing issue, as Kickbusch, *et al*[30] explain: 'with the current global trends, digital health technologies may become 'trapped' in development paths steered by profit and economic grains, without any real added value for health systems and society'. It is in this context that innovators call for policy to transform the

'double burden' of designing technologies that meet health and environmental criteria into a 'single duty to care'.[29] They are joined by health system experts calling for policy to integrate a sextuple aim to quality healthcare by also caring for 'patients, costs, providers, population equity and the planet'.[31]

Implications for medical leaders

Because 'medical leaders will need to be change agents and lead the change as AI transforms the healthcare system in the coming years',[32] our results underscore the urgent need for more practice-oriented tools that can guide both innovators and organisation leaders to integrate environmental sustainability throughout the innovation pathway.

Furthermore, the gap in tools points to the profound shifts needed for the digital health sector to embrace new technological and organisational models of innovation development and use (see figure 2). Scholars and practitioners can draw from prime examples already making headway to develop practice-oriented tools that can guide developers and organisation leaders along a new innovation pathway fit for the health, environmental and economic challenges of the 21st century.[33]

For instance, beyond aiming to reduce the energy consumption and waste production of new digital technologies, digital sobriety practices[13] and frugal digital innovation[34] help to re-think why new technologies should be developed, how and for whom. These eco-responsible approaches also align well with health equity concerns now that digital technologies have become 'super social determinants of health'.[35]

At an organisational and economic level, the way the RIH framework considers business models[25] and the growing interest towards circular economy practices are carving out new roads in the medical device industry.[8] RIH provides measures organisations can implement to ensure innovations provide more value to users and society (see T9 in online supplemental material for a great example) while circular economy practices re-think the linear supply chain in order to keep 'manufactured products in circulation' and reduce 'resource input, waste and emission and energy leakage by slowing and closing material and energy loops'.[8] In the digital world, repairability, modular design and low-tech movements work well with circular economy approaches. Finally, building on such approaches, Raworth's work inspires innovators and societal leaders to go beyond carbon neutrality and envision a regenerative economy.[36] Net positive models are few in the digital industry, but the Ecosia search engine is a striking example where the company, a Certified B Corporation,[37] produced twice the amount of renewable energy than it consumed.[38]

Limitations, further research, and conclusion

The scope of our study is limited to a data set assembled within a larger scoping review aimed at identifying practice-oriented tools to support the development of responsible digital innovations. Further interview-based research could explore in greater depth how organisation leaders integrate environmental considerations throughout the development of a digital health solution, especially as the literature is rapidly growing. Such studies urgently require a dedicated academic stream of research for this topical subject.

By focusing on only 2 of the 40 principles identified in our larger study, our thematic analyses may have omitted links between other principles that could further shed light on our research questions.

Recognising that key design and development decisions in the digital health industry are largely shaped by market considerations, this study indicates that significant work lies ahead for medical and organisation leadership to support the development of solutions fit for climate change. Health innovation scholars as well as health policymakers and digital health regulators should seek to swiftly address current research and policy gaps.

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