



The Lancet and Financial Times Commission on governing health futures 2030: growing up in a digital world

*Ilona Kickbusch, Dario Piselli, Anurag Agrawal, Ran Balicer, Olivia Banner, Michael Adelhardt, Emanuele Capobianco, Christopher Fabian, Amandeep Singh Gill, Deborah Lupton, Rohinton P Medhora, Njide Ndili, Andrzej Ryś, Nanjira Sambuli, Dykki Settle, Soumya Swaminathan, Jeanette Vega Morales, Miranda Wolpert, Andrew W Wyckoff, Lan Xue, on behalf of the Secretariat of the Lancet and Financial Times Commission**

Executive summary

From the short-term and long-term effects of the COVID-19 pandemic to the health insecurities brought about by climate change, health futures are unfolding in an era of accelerating economic, societal, technological, and environmental changes. Digital transformations, which we define as the multifaceted processes of integration of digital technologies and platforms into all areas of life, including health, are central to understanding—and shaping—many of these disruptive dynamics. Because large gaps remain in the current evidence base on the interface of digital technologies and health, taking a precautionary, mission-oriented, and value-based approach to its governance is crucial.

Digital transformations as new determinants of health

Digital transformations are embedded into, and negotiated within, broader political, societal, and economic processes. Business models based on data extraction, concentrations of power, and viral spread of misinformation and disinformation represent defining features of the current phase of digital transformations. For both private actors and governments, digital tools also allow for unprecedented reach into people's everyday lives, and are being used in many countries for surveillance and political purposes. Within these wider processes of digital transformations, health is rapidly becoming a high-stake domain owing to dynamics such as the increasing economic relevance of health data and the growing appetite for digital solutions in the health-care sector, which have been substantially accelerated by the COVID-19 pandemic.

Digital transformations have the potential to bring both enormous long-term benefits and substantial disruption in many different areas of health and health care—in fact, the effect of digital transformations has been so pervasive that it might soon become a dominant prism through which we can understand and address health and wellbeing dynamics. Digital technologies are already driving health transformations both directly (through their application in health systems, health care, and self-monitoring of health status and behaviours) and indirectly (through their influence on the social, commercial, and environmental determinants of health). Moreover, due to the influence that dynamics of digital access and literacy might have on health and wellbeing outcomes, we can consider the digital ecosystem itself as an increasingly important determinant of health.

A digitally transformed universal health coverage to achieve health and wellbeing

Digital transformations call for a new understanding of the concepts of public health and universal health coverage (UHC), which reflect the extent to which digital technologies are changing notions of health and wellbeing and offering new tools through which public health goals can be achieved. However, this does not mean that achieving UHC in a digital world will only depend on a rapid pace of adoption of new technologies in health care and health systems.

On the contrary, it will be important for decision makers to adopt a mission-oriented approach to digital health innovation, which aims to diffuse the benefits of digital health technologies equitably, make their deployment economically feasible, and decentralise and democratise their control. Moreover, reimagining public health and UHC in the light of digital transformations will also mean rethinking the breadth of health services that are offered in health systems and included in the publicly financed UHC package, to better reflect those new dimensions of health and wellbeing that are directly dependent on digital technologies and their role as new determinants of health.

Putting children and young people at the centre

To ensure that everyone benefits from digital transformations of health and health care, there is an urgent need to orient digital health priorities towards the establishment of strong health and wellbeing foundations early in life. This objective will especially require adapting the health services that are traditionally considered part of UHC to reflect the needs and priorities of children and young people, which are likely to vary across age groups, communities, and levels of digital literacy. There are several reasons for putting children and young people at the centre of this effort.

First, addressing the role of digital technologies as determinants of health already in early childhood will be crucial for reducing the social and economic burdens of disease later in life. Second, the health and wellbeing outcomes of children and young people are likely to be a litmus test for the capacity of societies to harness digital transformations in support of UHC for all people. Third, although there is no universal experience of growing up in a digital world, children and young people are generally those with the highest exposure to digital technologies. As such, they are both particularly exposed

Published Online
October 24, 2021
[https://doi.org/10.1016/S0140-6736\(21\)01824-9](https://doi.org/10.1016/S0140-6736(21)01824-9)

See Online/Editorial
[https://doi.org/10.1016/S0140-6736\(21\)02219-4](https://doi.org/10.1016/S0140-6736(21)02219-4)

See Online/Comment
[https://doi.org/10.1016/S0140-6736\(21\)02212-1](https://doi.org/10.1016/S0140-6736(21)02212-1)

*Members are listed at end of the paper

Global Health Centre (Prof I Kickbusch PhD), Centre for International Environmental Studies (D Piselli MSc), Graduate Institute of International and Development Studies, Geneva, Switzerland; CSIR Institute of Genomics and Integrative Biology, Delhi, India (Prof A Agrawal PhD); Academy of Scientific and Innovative Research, Ghaziabad, India (Prof A Agrawal); Calit Research Institute, Tel Aviv, Israel (Prof R Balicer PhD); Calit Health Services, Tel Aviv, Israel (Prof R Balicer); School of Arts, Technology and Emerging Communication, The University of Texas at Dallas, Richardson, TX, USA (Prof O Banner PhD); Competence Centre Health and Social Protection, Deutsche Gesellschaft für Internationale Zusammenarbeit, Bonn, Germany (M Adelhardt MD); International Federation of Red Cross and Red Crescent Societies, Geneva, Switzerland (E Capobianco MD); UNICEF Giga (an ITU–UNICEF partnership), New York, NY, USA (C Fabian MA); International Digital Health & AI Research Collaborative, Geneva, Switzerland (A Singh Gill PhD); Centre for Social Research in Health, Social Policy Research Centre, Australian Research Council for Automated Decision-Making and Society, University of New South Wales, Sydney, NSW, Australia

(Prof D Lupton PhD); Centre for International Governance Innovation, Waterloo, ON, Canada (Prof R P Medhora PhD); PharmAccess Foundation Nigeria, Lagos, Nigeria (N Ndili MSc); Health Systems, Medical Products and Innovation, European Commission, Brussels, Belgium (A Rys MD); Independent Researcher and Policy Analyst, Nairobi, Kenya (N Sambuli BSc); PATH, Seattle, WA, USA (D Settle BA); World Health Organization, Geneva, Switzerland (S Swaminathan MD); Chilean National Research and Development Agency, Santiago, Chile (JV Morales MD); Wellcome Trust, London, UK (Prof M Wolpert PhD); Directorate for Science, Technology and Innovation, Organisation for Economic Co-operation and Development, Paris, France (A W Wyckoff MPP); The Schwarzman College, Tsinghua University, China (Prof L Xue PhD)

Correspondence to: Aferdita Bytyqi, Secretariat of the Lancet and Financial Times Commission, The Graduate Institute, Geneva 1211, Switzerland
aferdita.bytyqi@graduateinstitute.ch

to potential harms that might derive from them and uniquely equipped to shape positive health futures through codesign of digital health solutions and participatory research and decision making.

A value-based framework for governing health futures

The massive challenges and opportunities posed by digital transformations of health and health care constitute a powerful call for governance at multiple scales, which should be grounded in core Health for All values of democracy, equity, solidarity, inclusion, and human rights.

Upholding Health for All values through governance will help ensure that digital technologies enable health benefits, including positive transformation of UHC, improved access to and quality of health services, and more effective prevention and management of public health crises. However, if these values are to play a central role in shaping health futures, they must be strengthened and updated to reflect their specific relevance for, and intersection with, digital transformations.

Four action areas for sustainable health futures

The governance of digital technologies in health and health care must be driven by public purpose, not private profit. Its primary goals should be to address the power asymmetries reinforced by digital transformations, increase public trust in the digital health ecosystem, and ensure that the opportunities offered by digital technologies and data are harnessed in support of the missions of public health and UHC. To achieve these goals, we propose four action areas that we consider game-changers for shaping health futures in a digital world.

First, we suggest that decision makers, health professionals, and researchers consider—and address—digital technologies as increasingly important determinants of health. Second, we emphasise the need to build a governance architecture that creates trust in digital health by enfranchising patients and vulnerable groups, ensuring health and digital rights, and regulating powerful players in the digital health ecosystem. Third, we call for a new approach to the collection and use of health data based on the concept of data solidarity, with the aim of simultaneously protecting individual rights, promoting the public good potential of such data, and building a culture of data justice and equity. Finally, we urge decision makers to invest in the enablers of digitally transformed health systems, a task that will require strong country ownership of digital health strategies and clear investment roadmaps that help prioritise those technologies that are most needed at different levels of digital health maturity.

Introduction

We want this *Lancet* and *Financial Times* Commission on governing health futures 2030: growing up in a digital

world to be a wakeup call for health and digital policymakers. Digital technologies are transforming health, health care, and public health systems across the world, and they carry great potential to improve people's health and wellbeing. At the same time, weak governance of digital transformations has led to uneven effects globally, endangering democracy, limiting the agency of patients and communities, increasing health inequities, eroding trust, and compromising human rights, including in the field of health. As health emerges as a key driver of innovation and a business frontier for major technology companies and platforms all around the world, a value-based governance framework based on Health for All values is an urgent requirement if we want to reap the positive potentials of the interface between UHC and digital technologies.

This Commission was tasked to explore the convergence of digital health, artificial intelligence (AI), and other emerging technologies with UHC. The Commission paid special attention to children and young people (of all genders aged 25 years and younger), convinced that maximising their safety and wellbeing in an age of digital transformations represents a litmus test for the whole of society and its concern for the most vulnerable. In so doing, this Commission builds upon, and interacts with, the efforts of previous *Lancet* Commissions that have highlighted the negative effects of underinvestment in the health and wellbeing of young people and made a moral and economic case for investing in children's health and development as foundations for better health across the life course and the improvement of societies.^{1,2}

The work of this Commission began in 2019, among the growing awareness about the steep task faced by the international community in its efforts to achieve the Sustainable Development Goals (SDGs) by 2030 despite a financing gap that—before the COVID-19 pandemic—already amounted to at least US\$2.5 trillion per year.³ Within a few months, not only did the COVID-19 pandemic force us to move much of the activities online for this Commission, it also shone a light on, and raised the political profile of, many of the issues that the Commission was already aiming to tackle.

First, the pandemic underscored the extent to which our societies—and their health—now depend on digital technologies to function, and the power of large providers and platforms. Second, it highlighted some of the deep concerns that the Commissioners were expressing about the potential ethical and human rights abuses that could derive from the use of digital technologies in the areas of health and health care. Third, it influenced the dynamics of digital transformations, as the health and wellbeing challenges brought by the pandemic boosted the willingness to adopt and develop digital solutions among policymakers and the general public, or more directly forced them to do so. Fourth, it heightened the concerns about the algorithmic reinforcement of discrimination against structurally disadvantaged groups, and the role of

algorithmic processes in the dissemination of misinformation and disinformation. Fifth, it made it clear that these processes are fundamentally interconnected with broader themes of geopolitical competition, political economy dynamics, and related inequalities that are only likely to grow in relevance across potential health futures.

The scope of this Commission goes beyond a narrow technical view of digital health applications and health data use, which represent only partial components of how digital transformations affect health and wellbeing, now and in the future. Our report targets the broader societal and governance questions that emerge at the interface of digital and health transformations, and in doing so speaks directly to both health and digital communities across the public and private sectors, and in civil society.

Owing to the complex, multicausal, and constantly evolving nature of these transformations, the gaps in the current evidence base represent a substantial concern for our analysis. For example, there are ongoing debates about the effects of digital technology use on population health outcomes,⁴ including with respect to children and young people.⁵ Similarly, existing evidence on the broader societal effects associated with dynamics of data extraction and digital transformations tends to come from the social sciences, rather than medical research. However, we strongly argue against postponing an analysis of the interface between digital technologies and health until more data become available. In line with established public health practice,^{6,7} we suggest that a precautionary, value-based approach to the governance of digital transformations of health is necessary in the light of the substantial risks and opportunities involved.

Our starting point is represented by the notion that digital transformations, and the technologies that drive them, must be led by public value, and governed to benefit health and wellbeing in everyday life. Governing health futures by harnessing digital transformations means ensuring that the deployment of new tools and innovations serves to promote wellbeing, achieve UHC, and transform health systems and services to better serve patients and communities and keep them safe. A glossary of the key terms used in this report has been provided (panel 1).^{8–11}

The report

The *Lancet* and *Financial Times* Commission on governing health futures 2030: growing up in a digital world was established in October, 2019. The Commission is composed of co-chairs IK and AA, and 17 Commissioners representing a wide range of sectors, expertise, and backgrounds.

In this report, the Commission aims to outline the governance approaches and initiatives that are required to shape health futures and transform UHC in an age of increasing digital transformations. The findings of this report are shaped by an inclusive and participatory

process, with the writing of the report taking place alongside broader efforts to inspire global public and private stakeholders and involve the imaginations and voices of youth (panel 2; figure 1).^{12–14} In the past 2 years, the Commission's work has become increasingly visible through online events and policy dialogues, social media activities, and targeted stakeholder engagement. The Commission hosted or cohosted online policy and youth dialogues with partners including Wilton Park, Steyning, UK, the International Federation of Red Cross and Red Crescent Societies, WHO, World Health Summit, European Health Forum Gastein, Fondation Botnar, International Federation of Medical Students Associations, and the Global Health Young Professionals Initiative. Consultations with private sector partners were organised by the *Financial Times*. Together with UNICEF, the Commission also launched an initiative called Imagining Health Futures, which invited published science fiction authors to speculate about the future of health in writers' room workshops with global youth, culminating in short story visions of health futures.¹⁵

We also provide a conceptual framework for the report that situates health futures at the interface of digital transformations and the other transformations affecting health, public health, and health systems, and emphasise the specific implications that such transformations have for children and young people. We introduce the processes of digital transformations that affect health and that qualify as the new determinants of health and wellbeing. We discuss the required transformations of UHC in a digital age, with a focus on the specific conditions and approaches under which digital solutions can be used by different actors to strengthen public health and expand the quality, affordability, and accessibility of health services. We describe the diversified experiences and challenges of growing up in a digital world that children and young people are facing, and discuss the importance of putting their views, skills, and needs at the centre of a digitally transformed UHC. We outline the foundational entry points of a value-based framework that should guide governments and societies in preparing for and governing digital transformations to benefit health and wellbeing. Finally, we propose four action areas for the governance transformations that are required to prepare for, and shape, the intersection of digital and health transformations.

Conceptualising health futures in the digital age

Imagining health futures

Different health futures are possible. These have been described mainly from the perspective of epidemiology, health-care delivery, or technology, and focused primarily on health care, medicine, and individual patients. The COVID-19 pandemic has changed the world and put many of the expected health futures into question. The

Panel 1: Key glossary

Digital transformations

The multiple processes of integration of digital technology and data into all areas of everyday life, including health, and the resulting changes that they bring about.

Digital health

According to WHO, “the field of knowledge and practice associated with the development and use of digital technologies to improve health.”⁸ According to the US Food and Drug Administration “The broad scope of digital health includes categories such as mobile health (mHealth), health information technology, wearable devices, telehealth and telemedicine, and personalized medicine. ...Digital health technologies use computing platforms, connectivity, software, and sensors for health care and related uses. These technologies span a wide range of uses, from applications in general wellness to applications as a medical device. They include technologies intended for use as a medical product, in a medical product, as companion diagnostics, or as an adjunct to other medical products (devices, drugs, and biologics). They may also be used to develop or study medical products.”⁹

Health data

Information, covering paper, and digital records, which relate directly to the health and wellbeing status of an individual or to the health services that the individual receives, whether collected by health-care providers or by patients themselves.

Data for health (also referred to as health-related data)

Data that is not immediately related to the health and wellbeing of an individual but might be used to support health decisions, such as demographic data, telecommunications data, and weather data. These data might also include personal data that are not directly health-related (eg, location data, customer shopping data or social data collected through smartphones or self-tracking devices) but can potentially be used by health-care providers, insurers, or decision makers.

Data solidarity

An approach to the collection, use, and sharing of health data and data for health that safeguards individual human rights while building a culture of data justice and equity, and ensuring that the value of data is harnessed for public good.

Health equity

According to WHO “the absence of unfair and avoidable or remediable differences in health among population groups defined socially, economically, demographically or geographically.”¹⁰

Digital rights

Human rights and child rights applied in the context of digital environments, digital technologies, and the data they generate.

Civic technology

An approach to the cocreation and use of digital technologies that has the aim of improving transparency and public participation in democratic and decision making processes.

Precision medicine

An approach to disease treatment and prevention that seeks to maximise effectiveness by taking into account individual variability in genes, environment, and lifestyle for each person.¹¹ In this report, the rapid advances in the area of genomics are considered (and referred to) as part of the broader dynamics of digital transformations, owing to the facts that the evolution of genomic sequencing techniques is strictly related to the drastic expansion of possibilities offered by digital technologies (ie, decreasing computing costs, growing capacity for big data and data analytics), and that precision medicine depends on the combination of genomics and machine learning techniques.

Precision public health

An approach to improving population health through the use of digital and genomic technologies, which enable health organisations, policy makers, and wider health systems to guide public health practice by generating more individually tailored or community-tailored interventions and policies.

pandemic has underscored the need to include social and political perspectives, and highlighted the relevance of public health and population health-based applications of digital technologies.

Ever since the launch of the Millennium Development Goals in 2000, and especially in the lead-up to the adoption of the SDGs in 2015,¹⁶ the considerable improvements made by many countries across multiple areas of human health and wellbeing have been described as one of the great success stories of global cooperation. In keeping with these achievements, the SDGs aim for a future of ensured health and of wellbeing for all ages by 2030.

Much of the progress relates to survival and increased health and wellbeing of children and young people. From

the extraordinary global fall of maternal and child mortality to scaled-up access to antiretroviral therapy, and from continued progress towards the eradication of poliomyelitis to rapid increases in life expectancy, health futures have been imagined and discussed through the lenses of fighting disease and achieving a grand convergence in health within a few generations.¹⁷ A future of health opportunities, albeit with important caveats, has also been envisioned by other landmark *Lancet* Commissions, including the possibility of reaping very large payoffs coming from investing in health¹⁷ or the objective of ending AIDS as a public health threat by 2030.¹⁸

This disease-based perception of the mission of global health is changing, as is the development model that drives it. One of the SDG targets (target 3.8) commits the

international community to achieve UHC, including financial risk protection, access to quality essential health-care services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all. This key SDG target was also reaffirmed in the outcome document of the high-level meeting on UHC held by the UN General Assembly in September, 2019,¹⁹ together with the need to address the determinants of health.

But this optimism no longer holds as a series of interconnected crises emerge to confront health worldwide, from the short-term and long-term effects of the COVID-19 pandemic to the health insecurities brought about by climate change. It becomes increasingly clear that the narratives of linear progress fail to capture the complexities of our potential health futures, confirming the main health challenges that the *Lancet* Commission on Global Health 2035²⁰ and the Rockefeller Foundation–*Lancet* Commission on Planetary Health²¹ highlighted. Among these are the health challenges of vulnerable people in low-income and middle-income countries (LMICs), the shifting demographics and disease burden of non-communicable diseases, the inadequacy of financial arrangements to ensure UHC, and the health effects linked to dynamics of global environmental change (with an emphasis on climate change and biodiversity loss).

As we look closer at the future of children and young people born between 2000 and 2030, and in the context of the COVID-19 pandemic, we see that they have (or will have) an increased risk of falling into poverty, missing out on education, not being ensured decent work, and growing up in the midst of a climate crisis.^{22,23} Their health futures are unfolding in an era of substantial political, economic, societal, technological, and environmental transformations, which effect all areas of health and wellbeing while being personally affected by them. For these purposes, calls to rethink the concept of UHC to include not just health and clinical services, but also promote healthier societies and build resilience against future health risks, have increased.²⁴

Digital transformations

All health futures will be shaped by digital transformations and the resulting changes that they bring about. Digital transformations are major societal transformations.

In the context of health and wellbeing, our definition of digital transformation aligns with broader existing definitions of digital health, such as the one offered by Paul Sonnier: “the convergence of the digital and genomic revolutions with health, healthcare, living, and society.”²⁵

This definition reflects how lives are no longer imaginable without digital access for many people; although, there are strong differences across and within countries. The effect of digital transformations has been so pervasive that they might soon become a dominant prism through which we understand and address health and wellbeing dynamics, including for those who will remain unconnected. Indeed, in the future, we might not

Panel 2: Youth expectations of the Commission

The co-chairs and Commissioners advocated for a holistic and strategic approach to engage youth and amplify their diverse voices in the work of the Commission, agreeing that the involvement of children and young people in (digital) health decision making spaces is key to positively affecting the health futures of all people.

Along the lines of the existing efforts on youth engagement (eg, the WHO strategy on youth-centred digital health interventions),³² the Commission adopts the perspective that it is important to fully embed youth and youth organisations within institutions of power,³³ to fully create structures for meaningful youth participation, ensure that the health and wellbeing issues affecting young people are defined by young people themselves, and deliver improved (digital) health outcomes.

A central tenet of the Commission was thus the necessity of steering clear of tokenism, thereby developing a more integrated approach to involving youth in its work. With support from the Swiss Agency for Development and Cooperation, the Secretariat of the Commission was able to create several work streams for and with youth, including the establishment of a Youth Team within the Secretariat itself.

Although the work of the Youth Team and that of the Commission were separate, they were also complementary. The Commission focused on the interface between children and young people's health and wellbeing and digital transformations of health. Drawing from its Youth Strategy 2020–2023, the Youth Team instead aimed to: collaborate with a broad range of youth networks to amplify the voice of youth in the work of the Commission; expand on the issues relevant to youth identified by the Commission, bridging this report's recommendations and a specific Youth Call for Action; and identify how the work of the Commission can be further developed in ways identified as meaningful to youth.

In collaboration with Wilton Park, the Youth Team of the Secretariat co-organised a series of consultations to cocreate a standalone Governing Health Futures 2030 Youth Statement and Call for Action,³⁴ seeking to inform the Commission and guide future advocacy and dissemination activities. This global youth consultation series brought together 26 youth leaders from 23 global youth networks, representing 22 countries. Discussions focused on themes including the equity and participation gap, the choices we have, and the future we want; and sought to answer what do youth want to see in the future of health governance and what are the expectations of this Commission (figure 1).

even speak of digital health, as digital technologies become integral to how health is understood and delivered—in keeping with what has happened to other sectors, such as banking. But these transformations are not value-neutral, and they come with clear social and political costs. As new technologies are progressively introduced and replaced, the boundaries of digital transformations in health and health care are pushed forward at an accelerating pace, often without concern for their public purpose or the effects on health equity and human rights.

In this context, digital transformations are also changing our conventional understanding of the health economy. Within each country, the configuration of the actors involved in the health economy has always varied, depending on the public or private provision of health services. For example, in many LMICs, private sector companies provide a substantial share of health services. At the same time, LMIC governments are more involved than those of high-income countries (HICs)

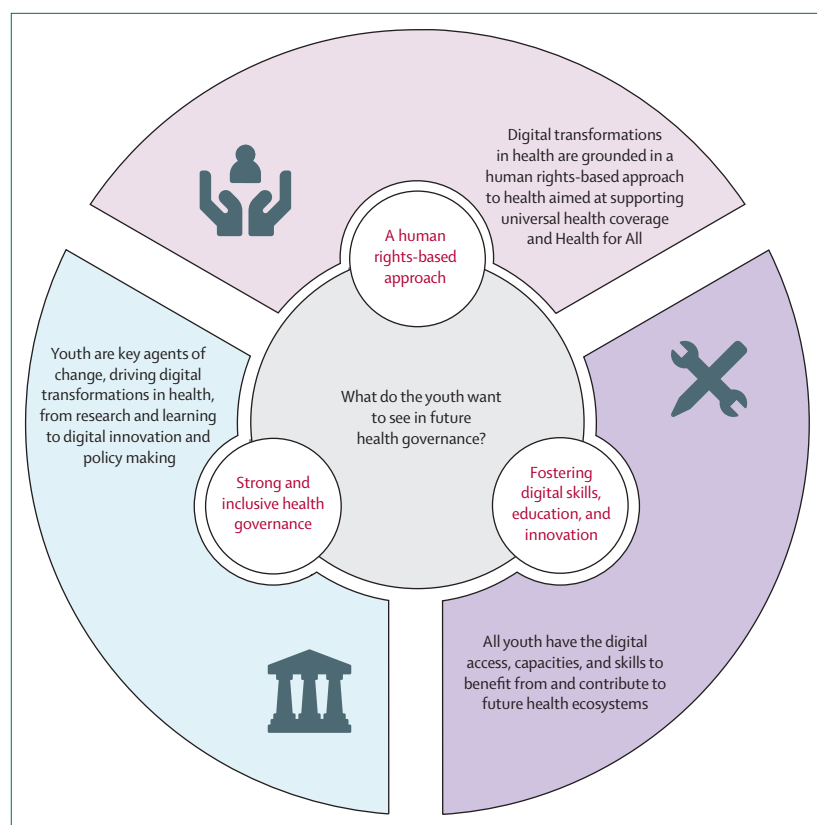


Figure 1: Summary of the results of the Governing Health Futures 2030 youth consultations

For more on Amazon Care see <https://amazon.care/about>

in health product supply chains. However, now the health economy increasingly interacts with the digital economy. In the USA alone, venture funding for digital health companies has increased constantly over the past decade, with 2020 representing a 72% increase from the record set in 2018, and a total venture funding of \$14.1 billion.²⁶ When it comes to specific technologies such as AI, the global market for AI-based hardware, software, and services in health care will reach an estimated \$34 billion by 2025,²⁷ with a potential value of \$300 billion created by 2030.²⁸

In the new dynamics of the digital health economy, traditional actors remain important, from governments financing digitally enabled health systems to health-care providers acting as venture capital investors for digital health innovations (a 2020, US-based study noted 184 such investments by health-care providers in 105 companies over the 2011–19 period).²⁹ Moreover, pharmaceutical and biotechnology firms, which research and develop new medicines, vaccines, diagnostics, and medical devices, are also increasingly taking advantage of digital technologies, whether to reduce costs, collect more diverse and higher-quality data, improve and accelerate clinical trials, or advance predictive modelling of drug treatments.³⁰

At the same time, the digital health economy is a key business frontier for new actors who have not traditionally

focused on health. First, all major technology companies (ie, Alibaba, Alphabet, Amazon, Apple, Facebook, Jio, Microsoft, and Tencent) are now expanding their reach in the health sector through the development of mobile phone-based health records, AI for health programmes, digital assistants, apps that provide health advice, wearable technologies, and other tools for health and wellbeing. Amazon Care and the Tencent Smart Hospital³¹ are examples of the technology industry's ambition to move even further into health care, whereas Amazon Pharmacy signals parallel developments in health products delivery.³² Second, telecommunication companies, internet providers, information and communications technology (ICT) hardware and software companies, and data brokers have also become essential for developing and running the infrastructure and systems required for a digital health ecosystem, from service provisioning to financial services gateways. The most data-driven companies collect, collate, analyse, and often trade enormous volumes of health data and other personal data that are used to predict disease outbreaks, identify health risks, and target individuals with personalised health promotion messages.³³ Although these trends long predate COVID-19, the pandemic has made them more visible.

In the future, the growing alliances between these and other powerful actors in the health sector (eg, doctors' networks and health insurers) might support the further privatisation of health services and normalise health data infrastructures built on the principle of large-scale data collection and exchange.³⁴ Together, private actors in the digital health ecosystem also give rise to networks of control that can nudge consumer behaviour through the tracking and profiling of personal data, and ultimately have an effect on the determinants of health.^{35,36} As multinational technology companies embed themselves deeper within countries' health systems, it will be harder to disentangle them from being an integral part of health networks and service architecture.³⁷ In this sense, the current dynamics of data extraction are increasing the risk of concentrating economic and political power in the hands of those companies that hold the greatest amount of data and technical capacity to extract value from them or, in more state-centric models, in the hands of government authorities and bureaucracies.³⁸ Although, such attempts are by no means recent, and not always successful, the pace of innovation intensifies the need to address the power imbalances and equity concerns that come with this new digital health economy as a key governance challenge.

Transformations of public health and UHC

The effects of digital transformations in health must be judged on two different axes. First, by the changes they bring to the ways in which societies define and achieve health. Second, by their ability to transform and accelerate UHC. Following the COVID-19 pandemic,

health itself has emerged as an accelerator of digital trends, and provides the opportunity to be bold and shape digital transformations to align with the mission of UHC to achieve Health for All.

At present, at least half of the world's population still do not have full coverage of essential health services. By 2030, almost 40% (3·3 billion) of the world's population will be younger than 25, and UHC will need to respond to their needs and aspirations. Although the overall risks of disease and disability are projected to continue falling for children and young people, a larger burden of disease from non-communicable diseases will most likely affect a growing number of them. In addition, injuries, chronic physical health, and mental health issues will continue to be a concern for young people everywhere,¹ raising questions around health promotion, prevention, health-care costs, and care coverage.^{39,40}

The increasing health and wellbeing effects of climate change and biodiversity loss will include the emergence of new infectious diseases and the degradation of crucial ecosystem services upon which the livelihoods of billions of people depend on.⁴¹ The long-term effects of the COVID-19 pandemic could also persist for years, affecting issues as disparate as the life opportunities of children and young people,^{42,43} access to prevention and treatment services,⁴⁴ and broader dimensions of wellbeing, such as emotional distress and mental health disorders.⁴⁵

These trends in individual and population health, which already contribute to our understanding of possible health futures, will interact in significant ways with the dynamics of the digital and data-driven transformation of health systems. On the one hand, technology continues to provide biomedicine with new and more effective ways to predict, diagnose, and treat physical and mental health challenges. Digital health, which as a concept can be said to encompass aspects including mobile health (mHealth), health information technologies, telemedicine, precision medicine, and precision public health, offers opportunities for physicians to offer more personalised care, for individuals and communities to track, manage, and improve their own health and wellbeing, and for authorities to make use of vast amounts of data for public health purposes. Digital tools are being used to address broader determinants of health, including applications in the areas of income inequality, insurance, education, and the physical environment.

On the other hand, the increasing extraction of personal data by public and private actors can lead to a wide range of negative consequences for individuals and societies, ranging from human rights infringements and extensive surveillance practices to interference with electoral and other democratic processes.^{46,47} Health and health-related data represent an important aspect of these dynamics, with the health-care sector predicted to be the fastest-growing industry in terms of data produced.⁴⁸ In addition, there is increasing evidence that

the digital ecosystem itself can negatively impinge on human health and wellbeing through its effects on the wider social, political, commercial, and environmental determinants of health. Lastly, the uptake of digital technologies in health and health care relies heavily on trust from patients, doctors, and other health system professionals.⁴⁹ However, recent research suggests that such trust can be eroded by several personal, technological, and institutional factors, including fear of data exploitation, paucity of accessibility and digital skills, and poor reputation of service providers.⁵⁰

Transformations affecting children and young people

The intersecting transformations of health and digital technologies demand that special attention be paid to future generations, who will inherit the models designed (or neglected) in the current digitally driven and data-driven world, and to children and young people, who are estimated to represent one in three internet users and are therefore in an unprecedented position to be engaged in architecting new models of digital and data governance.⁵¹

Although exposed to a substantial digital divide, children and young people's adoption of digital technologies is already higher than for the rest of the population and will increase everywhere. The lived experiences of many children are already, effectively, experiences of growing up in a digital world—an expression that describes a process whereby digital technologies and digital connectivity often permeate (almost) every aspect of their lives. However, the datafication (ie, the progressive transformation of all aspects of human life into data, which can be tracked, analysed, and even monetised) of bodies and activities⁵² that represents the dominant aspect of growing up in a digital world will also affect the experiences of those who will remain unconnected—in other words, their experiences and life opportunities will be defined by this very lack of access to connectivity.

The consequences of this generational shift of experiences and practices, which we express in the notion of digital childhoods, are multifaceted. The ecosystem of digital transformations might already constitute a determinant of children and young people's health and wellbeing, both positively and negatively.⁵³ Children and young people are increasingly exposed to the harms and human rights risks that digital technologies might cause—for example, in the context of their ability to manage privacy, commercial targeting, reinforcement of gender norms and stereotypes, and hate and abuse in online environments. At the same time, and as emphasised by the Commission's Youth Statement, youth communities around the world consistently showcase the potential use of such technologies to support greater civic and political engagement and participatory research,^{54,55} and have developed new forms of digital resilience and mutual support against online harms.^{5,56} As representatives of change, young people are also fully contributing to the development and use of new

technologies and content, including for health. The extent to which they are enfranchised and involved in coshaping health futures, wherever they live, will shape the direction and dynamics of digital transformations for all people.

Digital transformations as determinants of health

Dynamics of digital transformations

Digital transformations arise from what economists call a general purpose technology—that is, one that has the power to continually transform itself, progressively branching out and boosting productivity across all sectors and industries.⁵⁷ They have proceeded at a variable pace, and exerted uneven effects, across different countries and communities, highlighting the importance of pre-existing inequalities and foundational infrastructures.

Digital transformations are data-driven and move important dimensions of human relationships into digital territories, allowing for new economic and social developments; bring about foundational changes in how our societies are organised and how we relate to our environment, one another, and ourselves; require a shift in our understanding of health and in our management of health promotion, public health, and the health-care system; accelerate the entry of new stakeholders into the health arena, providing opportunities for innovation, and new business models; still do not have a clear foundation in social values and ethical principles in relation to health and its digital determinants, challenging the vision embedded in the SDGs and in the concept of UHC; and reinforce, and create, new asymmetric power relationships and methods of control, but also provide new spaces of agency and interaction in society, economy, politics—the ultimate dynamics and effect of which we do not yet fully understand.

These changes can bring enormous long-term benefits to many different sectors, but can also cause substantial disruption. In turn, digital transformations are themselves closely connected with, and shaped by, the larger political, societal, and economic dynamics in which they are embedded (figure 2).

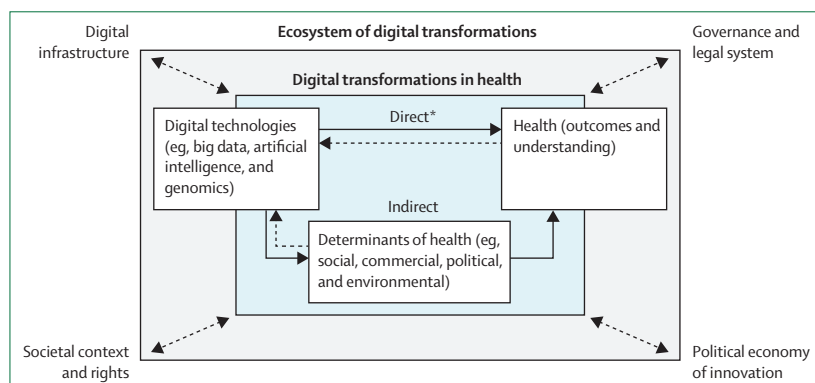


Figure 2: Conceptualising digital transformations of health

*Adoption of, interaction with, and governance of digital technologies for self-monitoring, in health care and in health systems.

These dynamics, ranging from the increasing economic relevance of health data to the emerging geopolitics of digital governance, and including the growing appetite for digital solutions in the health-care sector, all concur to make health a high-stake domain—both economically and politically.

The ecosystem of digital transformations and how it affects health

Digital transformations are embedded into, and negotiated within, broader political, societal, and economic processes. This means that different societal preferences, socioeconomic contexts, and political and institutional configurations might lead to several ways through which digital technologies are integrated into people's lives and sociotechnical systems.⁵⁸

The elements of this configuration are shown in figure 2 as the outer boundaries of the ecosystem of digital transformations, which determine its variable shape.

First, the digital hardware and software available in a country represents a fundamental base for the integration of digital technologies in people's lives and determines the ability to bridge existing digital divides and build digital readiness. Hardware and software start with baseline infrastructure, such as fibre and submarine cables, then proceed to ownership of digital devices, and then reach all the way to the richness of digital content in the domestic languages. As health systems become increasingly digital and interconnected, elements such as access to connectivity, data interoperability, and data security have also become crucial to the variable capacity of a country to leverage such technology to equitably achieve health goals.⁵⁹

Second, laws, regulations, and governance arrangements are also crucial in understanding and shaping the dynamics of digital transformations, including in the context of health. For example, regulatory choices around data control, data sharing, and data protection are most likely to prove particularly important in the context of health and health-related data, as the use of such data is uniquely characterised by the need to manage a range of competing interests between patients, governments, and other health system actors. Similarly, the governance of the internet often determines market access for technology providers, the accessibility of content, and the proliferation of misinformation or disinformation, including on health issues. As the internet has become entrenched in daily life, competing views and models about how it should be governed have begun to emerge and be championed at the national level. These views of models play a geopolitical role and contribute to the evolution of the global order.⁶⁰

Third, societal institutions have a major effect in shaping the ecosystem of digital transformations, while they are also shaped by it.⁵⁸ For example, the way in which the reuse of personal health data for public health or research purposes are regulated across different

countries might be influenced by broader societal preferences around data protection and data governance models, which include different arrangements around overall data policies and strategies, data regulations, and data architectures, infrastructures, and value chains.⁶¹ This difference in data handling policies is inevitable, since “data are in fact framed technically, economically, ethically, temporally, spatially and philosophically” and “do not exist independently of the ideas, instruments, practices, contexts and knowledges used to generate, process and analyse them.”⁶² In this sense, future models of health and health-related data governance will most likely depend on the balance struck by different social contracts around the nature of such data, the extent to which such social contracts will uphold ethical values and human rights, and the ability of societies to freely negotiate them in relation to large private companies and geopolitical powers.

Lastly, the digitalisation of transactions has led to a new political economy of innovation, not only in HICs but also in LMICs. In many sectors, online platforms⁶³ are at the centre stage of transformed markets, touching upon a wide range of aspects of life and relying on different business models to monetise data.⁶⁴ In a digital economy, data represents a good to be extracted, hoarded, and protected,⁶⁵ and health and health data are key entry points owing to the growing trend towards the self-governance of health behaviours through wearables and mobile applications.⁶⁶ New groups of actors, from big technology companies to health service providers specialising in virtual models of care, such as Teladoc, Babylon Health, or Apollo, are transforming the ways this health information is collected and shared, and the way health care is delivered.^{67,68}

The health ecosystem in the present day thus encompasses a diverse community of interconnected stakeholders that use digital technology and data for different purposes, from improving health outcomes to profit-making, and increasingly operate under several different governance regimes (ie, from open internet models to rule-based models, to authoritarian ones). Countries differ substantially in their reaction to such new business models and their implications on work standards, consumer safety, market concentration risks, and levels of societal trust. Emerging digital and data standards, which usually follow geopolitical alliances, are also often negotiated and developed under the guise of trade policy.^{69,70}

Health data as the open frontier of digital transformations⁷¹

The dynamics of data extraction are a defining factor of digital transformations. The transformations themselves, and their effects on health and digital futures, cannot be understood and effectively governed without targeting such dynamics.

Emerging technologies and innovations are crucially reliant on the availability of massive quantities of health

and health-related data, and on the growing computing capacities required to process them. Such data, which are continuously collected, used, and managed by individuals, health-care providers, and other actors in the digital health ecosystem, constitute the crucial premise, enabler, and profit centre of digital transformations of health.^{72,73}

In particular, data are increasingly seen as a powerful commodity and a major driver of change as a result of the growing economic importance of secondary use of data.⁷⁴ Although quantifying the total value of data is impossible, most estimates and methodologies agree on its enormous economic significance, whether by looking at national value chains,⁷⁵ at the economic value generated by government data and open data,⁷⁶ or at the market capitalisation and revenue streams of data-intensive companies.^{64,77}

The health sector, with its increasingly big data-driven dynamics, represents a case in point. Already in 2009, a survey of health-care executives had revealed that a large percentage of them expected that the information contained in their electronic health records would become their most valuable asset within 5 years.⁷⁸

Data that are relevant in this digital health economy can increasingly be collected from three key types of sources: (1) data stemming from electronic health records; (2) data from real-life digital trails (that include signals produced by people's everyday actions, recorded digitally through devices and sensors measuring individuals' movements and behaviours); (3) and data from virtual digital trails (information and usage patterns recorded by and derived from virtual digital media, which include social media and search engine data, digital data entry, and self-reported health-related attitudes and behaviours).

In turn, these data can be divided between: health data, which relate directly to the health and wellbeing of an individual (eg, causes of death, historical health-care background, reproductive outcomes, and quality of life), or to the services that the individual receives (eg, personal choice about selecting a treatment, and treatment reports), whether collected by health-care providers or by patients themselves; and data for health, a notion that includes those data that are not immediately related to the health and wellbeing of an individual but might be used to support health decisions, such as demographic data, telecommunications data, and weather data. Importantly, these data might also include personal data that are only indirectly health-related, such as location data, customer shopping data, or social data collected through smartphones or self-tracking devices, but which can also potentially be used by health-care providers, insurers, or decision makers.

Such data are inherently relational and heterogeneous, and thus are uniquely characterised by the need to manage a range of competing interests. These include: (1) the interest held by individuals towards improved therapies, higher quality of health-care services, and protection from human rights infringements; (2) the

interest held by governments towards creating and learning health systems and promoting efficiency in health-care delivery, scientific discovery and innovation, and evidence-based decision making for public health; (3) and the interest of other health system actors, including the private sector, towards achieving cost savings and reaping returns to discovery, innovation, and service delivery. In other words, health data does not only generate private economic value, but also produces a range of social and economic benefits to the health system.⁷⁹ The need to bring these two forms of value together to ensure that data are harnessed for the public good is explored in this report through the concept of data solidarity.

Digital transformations and the COVID-19 pandemic

With the COVID-19 pandemic, we have witnessed a further major shift. Several of the digital technologies that gained prominence during the pandemic were imagined, researched, validated, and commercially developed years ago. However, due to a scarcity of incentives and funding, and the entrenched practices of both professionals and patients, the pace of their uptake within health systems had previously been slow.⁸⁰ The pandemic increased the pressure to adopt digital solutions, influencing patient behaviour and pushing the health sector to seek out tools that had often been met with resistance before the pandemic—for example, online consultations. Although digital health experts had long called for such changes, it is difficult to say how long-lasting these shifts might be once the pandemic is over. If taken further, these transformations could radically change our understanding of health and health systems, and the way public health is practised.

On the biomedical side, current capacities for data generation, sharing, analysis, and coordinated use have underpinned COVID-19 research efforts, as shown by the fact that it took only a week for Chinese researchers to make the genetic code of the virus openly available to all scientists across the globe.⁸¹ In turn, the open availability of the genetic code of the virus permitted the development of diagnostic tools in record times. Large-scale digital data collection and globally coordinated trials have since led to a good understanding of viral spread dynamics, risk factors, and the varying effectiveness of drugs and vaccines.

Beyond biomedical aspects, the pandemic has also boosted the demand for the use of digital technologies as instruments to support broader public health goals. In doing so, this demand led to the deployment of a myriad of new digital tools (eg, digital survey apps for symptom reporting, mobile contact tracing applications, real-time monitoring for ensuring compliance with quarantine measures), but also accelerated the adoption of existing digital technologies, such as telemedicine, data exchange collaborations, and mobile health payments. The adoption of these tools has been uneven, and has arguably intensified

pre-existing social inequalities.⁸² Moreover, the vast amount of personal data required by these tools brought to the fore the question of how to ensure compatibility between a democratic understanding of data privacy and the public health requirement of disease control, and in doing so further stimulated research in this field.⁸³

More specifically, the COVID-19 pandemic highlighted the ethical, human rights, and societal trust risks that exist at the blurred line between the public and private value of health and personal data.⁸⁴ First, these tensions have been evident in the use of proximity tracing (or contact tracing) applications to monitor disease spread, some of which faced substantial criticism because of attempts to centralise data storage.⁸⁵ The use of personal mobile phone location data, facial recognition, and other technologies has posed risks to personal privacy, and yet might have benefited public health responses and opened up a window of opportunity to foster solidaristic practices in digital health.⁸⁶ At the same time, aggregated mobility data has been used to identify disease hotspots through the daily movements of people, a possibility that presents more limited privacy concerns but also suggests the need for transparent and community-based approaches to data stewardship.⁸⁷ Second, health or health-related data derived from online interactions or mobile apps has sometimes been used not to trace contacts, but more directly to restrict people's movements and monitor their compliance with rules.⁸⁸

The pandemic has influenced the dynamics of governance and collaboration between actors in the digital ecosystem, raising important questions about the role of technology companies as gatekeepers of public health decisions.³³ A case in point is the Bluetooth-based exposure notification technology for COVID-19 contact-tracing applications, which was only possible after the technology companies, Google and Apple, collaborated to ensure interoperability.⁸⁹ Another example is the reaction to the so-called infodemic—an overabundance of information and the rapid spread of misleading or fabricated news, images, and videos that spread through online social media like a virus⁹⁰—which saw WHO develop several collaborations with social media platforms to reduce misinformation.

Digital transformations as determinants of health

Within the boundaries that influence and shape the global ecosystem of digital transformations, the integration of digital technologies into people's lives drives health transformations both directly, through its application in health systems, health care, and self-monitoring of health status and behaviours,⁹¹ and indirectly, through its influence (both positive and negative) on the social,⁹² commercial,⁹³ and environmental determinants of health.⁹⁴ Moreover, we can consider the digital ecosystem itself (including the variable dynamics of digital and data access and literacy) as an increasingly important determinant of health.

As digital technologies get integrated into people's lives, the very understanding of health and wellbeing changes. For example, ever since the rise of the internet and social media, questions surrounding the positive and negative implications of the increased time spent online for social connectedness and mental health have moved to the fore of many research agendas.^{53,95} In turn, digital transformations themselves evolve whenever health and other societal considerations emerge as a leading accelerator of certain digital trends over others.⁹⁶

In the next section, we explicitly focus on digital transformations of public health and UHC. We suggest that even when not directly relating to health care or health systems, digital technologies interact with the social, political, commercial, and environmental determinants of health in important ways (figure 3).

First, the social determinants of health—including factors such as age, race and ethnicity, or socioeconomic status—play an important role in influencing how digital technologies are used for health and wellbeing purposes.⁹⁷ In addition, the relevance and usefulness of digital health technologies are heavily dependent on digital literacy (which is the varying ability of both children and adults to use such technologies and understand their risks)^{98–100} and on health literacy (which is the individual's ability to assess and make use of health information to maintain or improve their health and wellbeing).^{101,102} For children and young people, social support networks (eg, parents and teachers) play an important role in helping them navigate the digital world.¹⁰³ In the near future, the resulting disparities in the use of digital health technologies might then mediate or even reinforce existing inequities in income, social status, or access to health services.⁹²

The interconnection between digital transformations of health and social determinants becomes particularly evident with the proliferation of algorithms in the health-care sector, which might reproduce and embed into technical solutions the inequities that exist in the analogue world.¹⁰⁴ However, in the future, digital technologies will also have a profound effect on educational environments¹⁰⁵ and the future of work,^{106,107} influence whether social determinants, such as the remoteness of the place of living, are still as important as they used to be, and even affect the wider societal values that are currently institutionalised through social contracts stemming from another age.¹⁰⁸

Second, digital technologies are reshaping dynamics of social environments and affecting trust in health systems, leading authors to suggest the digital infosphere as another social determinant for health.¹⁰⁹ For example, research on antivaccination movements has long shown that the spread of misinformation and disinformation can have real-world effects on health,¹¹⁰ and a growing number of controversies suggests that an absence of patient trust in the safety of their health data can undermine medical research and uptake of digital health



Figure 3: Conceptualising the interface between digital technologies and the determinants of health

tools.¹¹¹ At the same time, the potential of social media and digital marketing can substantially be leveraged by the public (health) sector to boost health promotion and disease prevention, as shown by the efforts undertaken by WHO and many national governments to convey health messages through social media platforms during the COVID-19 pandemic.⁹⁰

Third, and more generally, digital technologies, governance, and literacy underpin the functioning of modern democracies through their positive (or negative) influence on people's exposure to marketing and political messaging, and their consequent effects on the ability of individuals to make informed decisions, both online and offline.¹¹² In doing so, digital transformations thus impinge on the political and commercial determinants of health.

Finally, digital technologies lie at the core of both negative and positive trends in the environmental determinants of health. AI and big data are involved in accelerating human pressures on the biosphere and climate systems, from supporting global production chains and allowing automatised commodity trading¹¹³ to facilitating the spread of climate denialism and misinformation online.¹¹⁴ However, the same technologies can be associated with environmental governance efforts. For example, earth observation techniques and so-called

environmental big data are proving relevant in the context of surveillance and early warning systems in areas ranging from disaster risk reduction to air pollution. These earth observation systems will be increasingly used to monitor trends in other environmental determinants of health, including land-use change and ecosystem degradation.

Digital transformations of public health and UHC

Digital transformations call for a new understanding of public health and UHC

Traditional notions of UHC do not sufficiently capture the extent to which digital transformations are affecting our understanding of health and wellbeing, and the means through which public health goals can be achieved. A new understanding of public health and UHC is necessary to harness the novel opportunities and dynamics offered by digital technologies, while mitigating potential harms through strengthened health governance.

According to the 2019 high-level political declaration on UHC adopted by the UN General Assembly, “universal health coverage implies that all people have access, without discrimination, to nationally determined sets of the needed promotive, preventive, curative, rehabilitative and palliative essential health services, and essential, safe, affordable, effective and quality medicines and vaccines, while ensuring that the use of these services does not expose the users to financial hardship, with a special emphasis on the poor, vulnerable and marginalized segments of the population.”¹⁹ When this definition is considered in the context of digital transformations and their multifaceted effects on health and wellbeing, it becomes clear that achieving UHC in a digital world will inevitably require more than the adoption of new technologies in health and health care as a means of simply increasing efficiency or cutting costs.

The first key question will be whether digital technologies help increase the availability, accessibility, acceptability, and quality of health services as we know them.¹¹⁵ The second (and related) question concerns the changing nature and direction of health care, and the possibility of making it more preventive, personalised, and mobile through the use of such technologies (eg, wearables and AI applications to improve self-care and prevention, big data and genomic technologies to enable both precision medicine and precision public health, smartphones to support telemedicine and online consultations with health professionals). Finally, the third question relates to the extent to which digital transformations will enfranchise patients and communities (and particularly vulnerable groups including children and young people) and evolve their relationship with health professionals and providers, thus helping shape the health system according to the needs of the patients and communities (figure 4).

From a practical perspective, developing a new understanding of the interface between digital transformations and UHC will thus require two synergistic efforts. First, a mission-oriented approach to digital health innovations that draws on new technologies and knowledge to attain specific goals,¹¹⁶ underlining the argument that digital transformations of health care could provide medicine with the opportunity to be more human and more humane.¹¹⁷ Translating these missions into a portfolio of policies and initiatives that help diffuse the benefits of digital health technologies equitably, make their deployment economically feasible, and decentralise and democratise their control, will inevitably be context-specific, and informed by the unique characteristics of different health systems and digital health maturity levels.

Second, digital transformations also call for a reimagining of conventional understandings of public health and UHC, to account for the new dynamics that such transformations introduce in the health ecosystem. This means that the breadth of health services that are offered in health systems and included in the publicly financed UHC package will have to expand to include those new dimensions of health and wellbeing that are directly dependent on digital technologies and their role as new determinants of health.

In this section, we identify a series of emerging public health dimensions that are being shaped by digital transformations and preliminarily outline their implications for governance.

Health systems of the future: precision medicine and precision public health

At the macro level, digital transformations can be used to improve population health through data-driven public health interventions and policies. At the micro level, they constitute the basis of emerging applications in genomics and precision medicine. A problem-solving approach must orient innovation in these areas and promote the development of working designs that create public value.

The emerging applications of big data, AI, genomics, robotics, and other digital technologies in health and health care are vast,¹¹⁸ and there is no doubt that in the future, these applications might lead to the creation of entirely new health paradigms, while also strengthening existing health systems. The term frontier technologies is frequently used when referring to these developments, aiming to capture the rapid pace of their emergence, the difficulties faced by policy makers and regulators in responding to them, and their large-scale potential effects on economies and societies.¹¹⁹ Among the technologies that do stand on the verge of mass adoption are those that enable new forms of precision medicine and precision public health—both of which have recently been described as potentially complementing conventional public health approaches in the context of the COVID-19 pandemic.¹²⁰

Personalised or precision medicine approaches, which rely on a wide range of biomarkers and other patient data (ie, behavioural data or sociomarkers), have been long associated with a promise of targeted diagnosing and treatment, and more patient-centred health care.^{121,122} As precision medicine builds on genomic technologies, molecular pathways, and real-time monitoring of conditions by patients, it is also fundamentally driven by digital transformations, because it relies on the availability of advanced computational and statistical methods.

When precision medicine involves making personalised care decisions, massive amounts of data from individuals might need to be shared. Increased opportunities for patients to become more proactive in the generation and sharing of their own data¹²³ might lead to more enfranchised patients. However, questions about health and data literacy, data security, equity, and human rights gain even more importance than in other categories of digital health applications. For example, how the incidental discovery of genetic mutations predicted to confer high-risk of cancer should be handled within an otherwise healthy child is unclear. The implications of therapies that could remove undesired genetic traits or introduce desirable ones is even more unclear, with obvious dual use concerns.¹²⁴

It has been argued that health systems need precision medicine to be able to keep up with constrained health staff situations, the rise in demand for health services, technology costs, and patient expectations towards these services.¹²⁵ However, for the clinical reality, there are challenges arising from personalised predictive models: the tools need to be in sync with workflows of practicing clinicians; the models need to be transparent enough for clinicians to understand their methods and implications; the tools should not be used beyond their ability to classify people on the basis of their risk; and they should not automatically be expected to be prescriptive (ie, able to predict the most favourable effect among several treatment options).¹²⁶

For its part, precision public health is understood as a means of improving population health through the use of new technologies—particularly genomics, geospatial modelling, and predictive analytics—which might enable frontline health organisations, policy makers, and wider health systems to guide public health practice by generating more individually tailored or community-tailored interventions and policies.¹²⁷ The COVID-19 pandemic has highlighted the immense need for public health surveillance, health intelligence, and whole-of-society responses, even beyond a specific public health crisis.

For decades, public health authorities have provided population-based health situation analyses, surveillance and annual population health reports, and trend analyses of health determinants and outcomes. Increasingly, these efforts imply collection and monitoring of real-time data

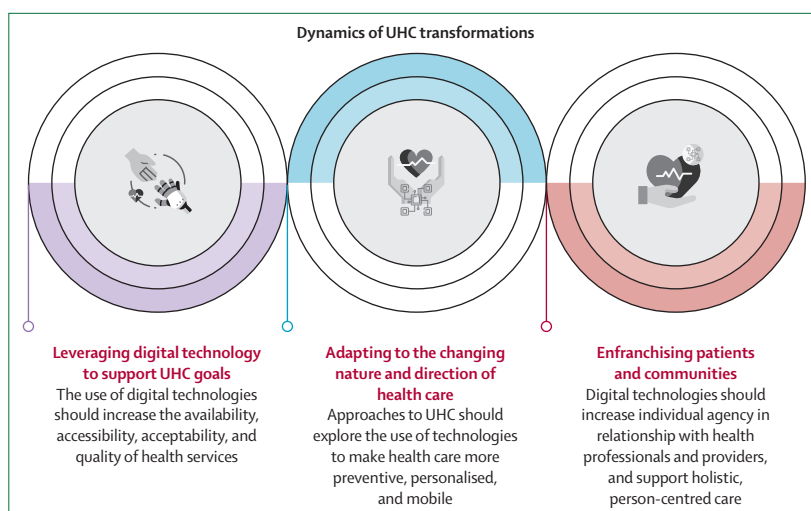


Figure 4: Three key dimensions of a digitally transformed UHC
UHC=universal health coverage.

from many sources, which require new types of data sharing agreements (eg, on mobility data) and a bringing together of diverse datasets.¹²⁸ AI-based methods, such as multilevel modelling, can support this process in new ways by extracting health and non-health data at different levels of granularity, and can harmonise and integrate information about populations and communities with epidemiological evidence, sociomarkers, or behavioural data.^{120,129} In turn, advanced data analytics is also expected to reduce health inequities by tailoring public health guidance to communities who are most at risk.

However, like precision medicine, precision public health can also bring a range of non-intended consequences as the volume of data that is potentially relevant for public health analysis increases and the risks for individuals or groups are defined, with little scope remaining for individual or community agency. For example, the uses and misuses of personal data in precision public health might undermine fundamental rights, beyond rights to privacy and self-determination, by leading to discrimination in access to services or participation in political life. At the same time, if not properly contextualised and complemented by broader public health measures, granular data about risk factors or broader social determinants might reinforce existing place-based stigma and reduce social solidarity.¹²⁰

Developing national digital infrastructures for Health for All

As access to quality health information and services becomes increasingly reliant upon digital technologies and data, ensuring equitable and affordable access to connectivity becomes a precondition for achieving UHC while addressing the risk of compounding existing inequalities.⁵⁹

Creating a robust national digital infrastructure and closing the digital divide are both necessary steps for the

transmission, processing, and storage of the data that fuels health information systems. Technologies, such as machine learning and virtual reality, depend on fast connectivity and use high volumes of data. Access to the internet is crucial for health workers working within and outside of facilities to access and share health information. Internet access is also increasingly important for individuals to manage their health and wellbeing through online platforms and devices, and to communicate with health workers. The COVID-19 pandemic highlighted the importance of universal connectivity,¹³⁰ not only for tackling health challenges but also for staying in touch with loved ones, keeping young people learning, and keeping parts of the economy running (figure 5A).^{131–133}

Figures on internet connectivity serve as a proxy for measuring the technical context of digital transformations and indicate parts of the world that are at a disadvantage for harnessing the power of data and technology for health. Between 2006 and 2018, the proportion of the world's population using the internet increased from 20% to more than 50%.¹³² Although progress has been made, the disparities between internet users continue to be substantial.

The geographical connectivity divide is particularly visible among young people (figure 5B).¹³⁴ Although almost all young people in HICs, and most young people in LMICs, are online (69% of young people aged 15–24 years), only 38% of youth in low-income countries are using the internet.¹³² To be young and offline (like 2·2 billion youth aged 25 years or younger) is to miss out on important forms of communication and opportunities to receive and share information, including health information and education.¹³⁴ Having no internet also means being excluded from online activities and communities, which contribute to young people's sense of identity and wellbeing.¹³⁵ There is also a digital gender divide shown by higher rates of computer, mobile, and internet use among men compared with women, especially in LMICs.¹³⁶

Although only half of people worldwide use the internet, almost the entire world population now lives within reach of some form of mobile broadband or internet service.¹³⁷ This gap between internet access and use shows that there are multiple barriers to meaningful access that need to be addressed, including quality of coverage, cost of connectivity and devices, lack of science, technology, engineering, and mathematics (STEM) education, digital skills and literacy, and a scarcity of relevant online content.

Moreover, national digital infrastructures can only be fully harnessed for health if individuals have a legal and secure digital identity. The right to identity is recognised as an established human right under the UN Convention on the Rights of the Child (UNCRC), and SDG target 16·9 aims to provide legal identity for all, including birth registration, by 2030. In this context, not only can digital technologies be a key vehicle to establish functioning civil registration and vital statistics systems, they can also be used as the basic building blocks for improving access to

health services and collecting reliable health data—for example, through electronic health records.¹³⁸ In turn, especially in countries where immunisation coverage exceeds birth registration rates, the digitalisation of health documents, such as child health cards, could be linked to such civil registration and vital statistics systems, thus providing all children with a unique digital identity early in life.¹³⁹ For countries that have tried to use mobile technology tools to increase birth registration rates, such as in the case of the m-Birth project in Ghana,¹⁴⁰ an absence of interoperability with other national civil registration and vital statistics systems has indeed been described as an important obstacle to the development of integrated digital identity ecosystems.¹⁴¹

Creating digitally enabled health systems

Digital health technologies are an essential part of transforming UHC, but they must be aligned with the actual needs of health systems, the health workforce, and users to do so.¹⁴² The analogue and digital components of future health systems need to be integrated in a strategic and coherent way,¹⁴³ including with children and young people's expectations in mind.

The World Health Assembly Resolution on Digital Health, unanimously approved by WHO Member States in 2018, shows a clear recognition of the potential of digital technologies to support health systems in health promotion and disease prevention, and to accelerate accessibility, quality, and affordability of health services—especially for those in hard to reach areas.¹⁴⁴ As a result, WHO has also developed a taxonomy for the use of more than 80 digital health interventions by identifying health system bottlenecks and how digital tools can help to address those constraints.¹⁴⁵ For example, the move away from paper-based and fragmented data collection and surveillance systems towards electronic health records and national health information systems (eg, on birth and death registration, tracking of health status and services, medical commodities' management, and citizen-based reporting) is an important and foundational step being taken by many countries in their digital transformation process.

If properly governed, this increased availability and use of health data could enable more timely and transparent decision making and communication by health system managers and policy makers. For example, the population-based predictive models that underpin precision public health are suggested to present great promise in areas ranging from public health surveillance to the definition of proactive prevention strategies and effectiveness evaluation.¹⁴⁶ More generally, for more than a decade, authors have argued for learning health systems, which harness the potential of electronic health records and big data analytics to improve diagnoses, treatment decisions, and health-care processes.¹⁴⁷

In addition, digital transformations carry great potential to enhance the effectiveness, efficiency, and coverage of

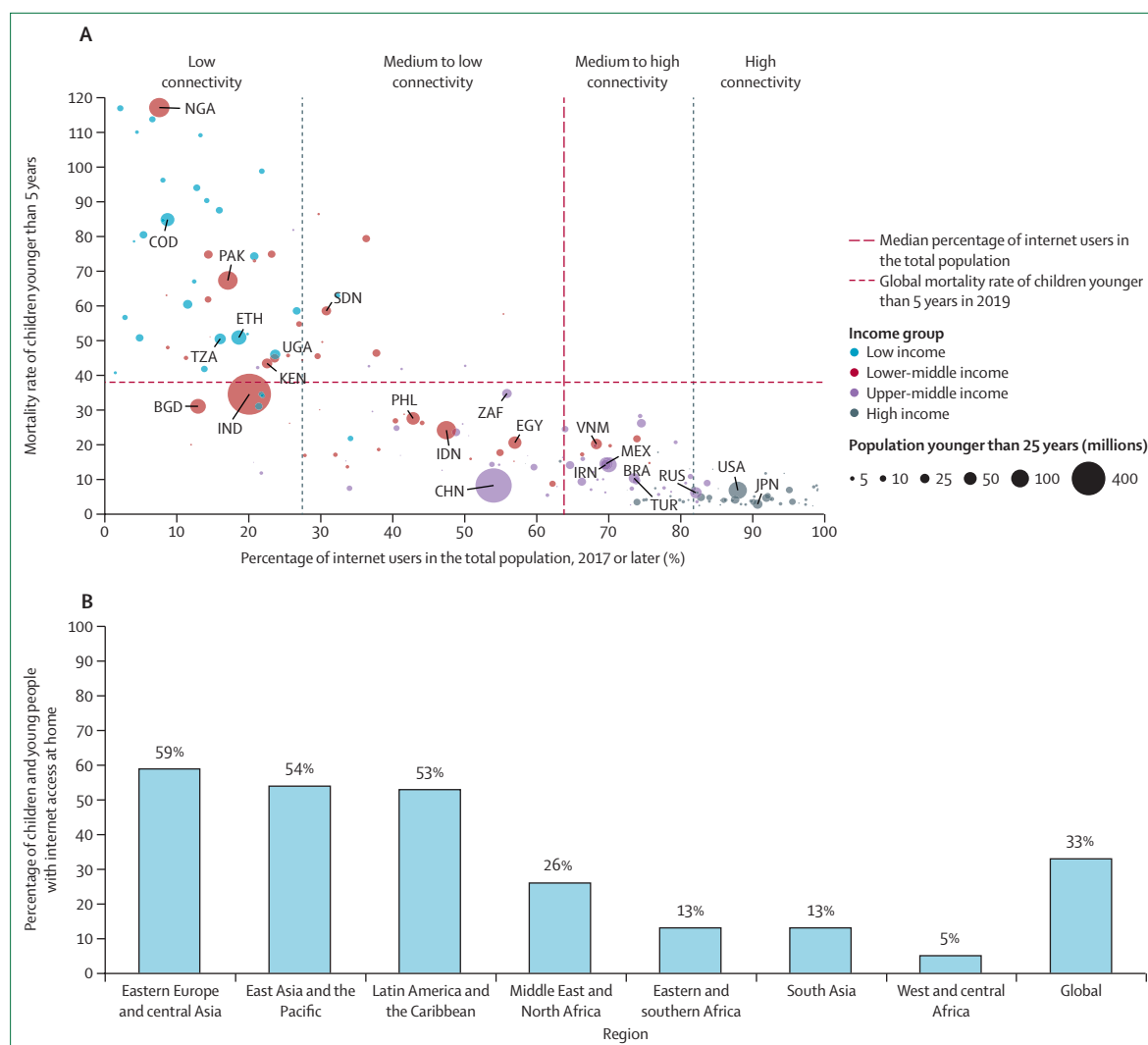


Figure 5: Health and the connectivity divide

(A) Mortality rates of children younger than 5 years and access to internet. Mortality data are from the UN Inter-agency Group for Child Mortality Estimation via the World Development Indicators.¹³¹ Internet penetration data are from the International Telecommunication Union via the World Development Indicators.¹³² Population data are from the UN Department of Economic and Social Affairs, Population Division.¹³³ NGA=Nigeria. COD=Democratic Republic of the Congo. PAK=Pakistan. ETH=Ethiopia. TZA=Tanzania. BGD=Bangladesh. IND=India. UGA=Uganda. KEN=Kenya. SDN=Sudan. PHL=Philippines. IDN=Indonesia. ZAF=South Africa. EGY=Egypt. CHN=China. VNM=Vietnam. IRN=Iran. MEX=Mexico. BRA=Brazil. TUR=Turkey. RUS=Russia. USA=United States of America. JPN=Japan. (B) Percentage of children and young people with internet access at home, by region. Reproduced from UNICEF and the International Telecommunication Union.¹³⁴

health services in contexts in which health systems are weak (eg, through client-to-provider telemedicine, health worker training and decision support, and easier commodity and stock management) and in areas where large populations of children and young people have no access to health workers, even if connectivity is not consistently available.

At the same time, WHO highlights how digital health can be characterised by “implementations rolled out in the absence of a careful examination of the evidence base on benefits and harms”, leading to the potential “proliferation of short-lived implementations” and to “an overwhelming diversity of digital tools, with a limited understanding of their impact on health systems and

people’s well-being”—for example, the possible diversion of resources from alternative, non-digital approaches that might be more effective than digital solutions.¹⁴³

First, digital technologies can expand the reach and impact of fundamental health systems dimensions—such as the need for adequate financing, leadership and governance, health workforce, and access to essential medicines—but they cannot ultimately replace them. Second, digital technologies should not preclude the provision of quality non-digital services, whenever these would be more affordable, acceptable in target communities, or simply more responsive to the challenges that policy makers are trying to solve. Third, the adoption of digital technologies should be based on

an assessment of the health system's ability to absorb such digital interventions, to avoid implementation failures caused by inadequate training, infrastructural or financial limitations, and poor access to equipment and supplies. Lastly, rollout of digital technologies should consider (and mitigate) the potential risks and harms facing those who are most vulnerable to potential abuses—for example, displaced individuals, and other children and adults in humanitarian settings (panel 3).^{148–156}

Calls for expanding the evidence base around digitally enabled health systems and developing common frameworks for assessment has already been voiced in the literature.¹⁵⁷ In line with what has been suggested by WHO, we also argue that digital health solutions can contribute to UHC only if they are characterised by health information that is aligned with recommended health practices; supported by ICT systems and communication channels that facilitate delivery and maintain cybersecurity;¹⁵⁸ embedded in value-based business and operational models; and integrated in a coherent, interoperable digital health architecture.¹⁴³

Promoting digital health readiness

To achieve UHC, an equity and rights-centred approach to digital health that prioritises those with the least power, such as children, youth, women, people with disabilities, minority groups, and marginalised communities, is required from the onset. The readiness of a country to harness digital transformations in support of UHC and better health futures should be assessed through an equity and rights-based lens.

Digital health readiness refers to the variable extent to which individuals and countries have the capacity to use digital technology and data for improving their own or their population's health and wellbeing.

High digital health readiness at individual and societal levels are a prerequisite for harnessing the benefits of digital transformations in support of UHC and putting patients first, including through democratic and digital literacy, informed citizenry, and participatory and community-led approaches to the design and deployment of digital tools. An individual's ability to benefit from digital transformations requires them to have the knowledge, skills, access, and agency needed to make free and informed choices and act independently in relation to the digital technology and data that is evolving around them and how it interacts with, and influences, their health and wellbeing.

One well acknowledged aspect of digital health readiness by governments is a country's overall level of digital development. Several initiatives, such as those led by Cisco,¹⁵⁹ Global System for Mobile Communications Association, International Telecommunication Union (ITU),¹⁶⁰ Portulans Institute and World Information Technology and Services Alliance, Organisation for Economic Co-operation and Development (OECD), and

the UN Conference on Trade and Development,¹⁶¹ have resulted in tools to measure digital readiness across countries. Common indicators used include internet usage, mobile network coverage, and the number of fixed and mobile broadband connections. In all these indices, a clear digital divide is visible in low-income countries, with high mortality rates and the largest shares of young people, ranking lowest, reflecting the ability of countries with higher incomes to invest more in the foundational infrastructure and technology required for digital health.

A growing number of tools are being developed to assess digital health readiness more specifically, many of which are based upon WHO and ITU's eHealth strategy toolkit and its seven eHealth building blocks (ie, leadership and governance, strategy and investment, services and applications, standards and interoperability, infrastructure, workforce, and legislation, policy, and compliance).¹⁶² The most promising tool for measuring digital health readiness is the Global Digital Health Index, which allows countries to self-assess their level of digital health maturity. In an effort to extend the Global Digital Health Index to more countries, Digital Square has identified proxy indicators on the basis of the World Economic Forum's Networked Readiness Index.¹⁶³

Although existing digital readiness and digital health readiness tools provide important insights into the maturity of digital infrastructure and digitally enabled health systems, they are insufficient for assessing the extent to which a country's approach to digital transformations will support the achievement of UHC for all. Some tools do include indicators to measure equity outcomes, but very few indicators are disaggregated. Overall, existing tools for assessing a country's digital health readiness are not adequately people-centred and do not consider established Health for All values, such as democracy, equity, solidarity, inclusion, and human rights. Furthermore, current approaches to assessing readiness do not consider young people's perspectives or how approaches to digitalisation might specifically affect young people's health, wellbeing, and rights—now and in the future.

A more comprehensive and ambitious way of assessing digital health readiness that encourages all actors in a digital health ecosystem to align their approach to digital transformations with their UHC and SDG goals is needed. Digital health readiness should only be seen as having been achieved when all people and their communities, the health ecosystems they interact with, and the countries they live in are prepared, equipped, and empowered to use digital technology and data to meet personal health and wellbeing needs and to improve the health and wellbeing of the whole population. This interpretation of readiness necessitates analysis of the intersecting forms of discrimination and inequalities that undermine the agency of people as holders of rights in relation to digital health. This more holistic approach to assessing readiness also requires prioritisation of those

For more on the **Global Digital Health Index** see <https://www.digitalhealthindex.org>

For more on the **Global System for Mobile Communications Association's Mobile Connectivity Index** see <https://www.mobileconnectivityindex.com>

For more on **World Information Technology and Services Alliance** see <https://networkreadinessindex.org/>

For more on **OECD** see <https://goingdigital.oecd.org/en/>

Panel 3: Vulnerable groups at the highest risk in humanitarian settings

The number of current and emerging digital health applications in humanitarian settings is vast. For example, aid providers are communicating by SMS with disaster-affected communities to provide rapid, targeted health-care advice, or to collect data on local health risks from community members. Drones are being deployed for the delivery of life-saving materials, including vaccines, to populations that are hard to reach by land. Satellites, radars, and machine-learning technologies are forecasting catastrophes, allowing for prompt resource mobilisation, community preparedness, and early action, in turn minimising health consequences. Cloud-based electronic health systems and digital identities are facilitating access to medical records of forcibly displaced populations. Connectivity is also allowing displaced populations to gather information on a new location, access educational resources, and communicate with support services and family members.¹⁴⁸

However, even when the intention is to provide humanitarian aid and health care,¹⁴⁹ personal data might also be used in efforts by state and non-state agents to identify, target, and exclude children and adults from support opportunities. The most vulnerable children and adults worldwide, such as those living in low-resource conditions or displaced from their homes due to forced migration or natural disasters, are also often the groups who are exposed to the greatest lack of control over how their biometric information and other personal details are collected and used.¹⁵⁰

Digitised wearable devices tend to simplify calculations of health status, but go even further in generating digitised data that might not be well protected from third-party use or secondary use by those who collected data that have not been consented to. Young children and adolescents in humanitarian settings are at risk of violence, exploitation, and sexual assault, and technologies that reveal their identities or activities involving data sharing can be used to facilitate such abuse.¹⁵⁶

Further, such devices can be used to show that help is being provided (by their symbolic provision) in the absence of solutions to problems, such as displacement and emergencies. Simply monitoring children's needs does not entail meeting those needs.¹⁵¹ Despite the funds invested in establishing the infrastructures required to generate datasets from digital technology use, these data are not always readily available or open to analysis, becoming ends in themselves rather than solutions to health and humanitarian problems.^{150,152}

Finally, there is the risk that untested or insecure digital health technologies will be directed at low-resource populations, including children and young people, with little regard for their safety or efficacy.¹⁵³⁻¹⁵⁵ This raises the question of the ethics of the use of such technologies and how the do no harm position can be protected.¹⁵¹

people who are most left behind at all stages of design, implementation, and monitoring of digital approaches, and greater consideration of how future generations will be affected by decisions made in the present day.

For this Commission, we worked with a group of young people to develop an overarching conceptual framework that sets out ten main enablers of digital health futures readiness (panel 4).¹⁶⁴ This framework could be used by policy makers and other stakeholders to assess their levels of readiness to harness digital transformations in support of UHC and equitable health futures. The framework puts an emphasis on futures since policy makers and practitioners must be encouraged to think about the potential effects of digital technology and data on health and wellbeing outcomes for future generations and those alive now.

Children and young people at the centre of a digitally transformed UHC

The health needs of children and young people younger than 25 years are different from those of older adults, and they also vary at different stages of life. At the same time, putting the concerns and expectations of children and young people who are growing up in a digital world at the centre of a new understanding of UHC is arguably crucial to ensuring that everyone benefits from digital transformations of health and health care.

First, the need to put children and young people at the centre of a digitally transformed UHC depends on the fact that, in keeping with the notion of lifelong health, "health in the earliest years lays the groundwork for a lifetime of wellbeing".¹⁶⁵ Ensuring that digital tools support the health and wellbeing needs of children and young people, and addressing the role of digital technologies as determinants of health already in early childhood, has the potential to improve indicators of population health, and reduce the social and economic burdens of disease later in life.¹⁶⁶ Second, children and young people are usually among the most vulnerable groups in a population, and their health and wellbeing outcomes are thus likely to be a litmus test for the whole of society's capacity to harness digital transformations in support of UHC. Third, children and young people are already those with the highest exposure to digital technologies, with young people aged 15–24 years representing the most connected age group.¹⁵⁶ As such, they are both particularly exposed to potential harms that might derive from digital technologies and uniquely equipped to shape a new UHC that includes the evolving understanding of health and wellbeing in a digital world.

The main implication of putting children and young people at the centre of a digitally transformed UHC is that the type of health services offered in digitally enabled health systems and included in the publicly financed

Panel 4: Potential enablers of digital health futures readiness¹⁶⁴

Embedding health and wellbeing in all (digital) policies

The potential benefits and risks for health systems, determinants of health, and health equity are considered in all digital and data-related policies and programmes

Engineering inclusive decision making processes

The participation of all groups, including children, youth, and marginalised communities, is a regular practice in digital health decision making, and their participation is fully resourced by relevant ministries and other digital health actors

Prioritising all people in the design

Digital technologies, initiatives, and services are designed with and for all groups that might directly use or be indirectly affected by them

Increasing digital health literacy

Governments and their partners invest in multiple forms of literacy and skills (ie, health, digital, and civic) so all people can fully benefit from digital transformations

Promoting human rights online and offline

Policies and programmes related to digital technology and data are assessed from a human rights and child rights perspective to ensure that all rights, including the right to health, are promoted and protected

Investing in equitable, digitally enabled health care

Governments, donors, and private investors target and prioritise their investments in digitally enabled health systems

and health care towards the realisation of UHC and reduced health inequities

Governing for equitable health futures

Approaches to governance of digital technology and data are grounded in equity and human rights so that the benefits of digital transformation can be realised, and the risks mitigated, for all; civil society groups led by youth and marginalised communities are able to independently assess whether governance frameworks reflect their needs

Doing no harm to the planet

Industry and governments harness digital technology and data to protect the health of our planet; proactive measures are taken at local, national, and global levels to mitigate any negative environmental effects of digital transformations of health

Connecting every household

The backbone infrastructure, hardware, and services required for reliable internet access are available, accessible, and affordable to all

Connecting every health worker and health facility

Health facilities at all levels, from national hospitals to community clinics, are connected through reliable digital infrastructure that is regularly maintained. All health workers, including community health workers, have the tools, skills, and support to effectively use digital technologies

UHC package must be adapted to the changing needs and expectations of these demographics. For example, the youth consultations held for the Commission revealed that young people aged 14–29 years expect a mix of digital and in-person health services, and that their top concerns include physical fitness, mental health, sexual and reproductive health, non-communicable diseases (especially as they get older), and the ability to access reliable health information. Young adults also point to several key qualities they expect from all in-person and online health services, including their affordability, respect of privacy and confidentiality, quality, and their responsiveness to feedbacks and inputs. These demands must inevitably be integrated into the digital transformation of UHC. At earlier timepoints, such as during infancy and childhood, digital systems might instead be seen as enablers for parents or other caregivers, ensuring a better assessment of infants and children's mental and physical development and supporting health education. Such applications would have to be tuned to different communities and levels of digital literacy, but might be most important for those groups who face challenges in accessing traditional health systems and sources of health information. Finally, because adolescents and young adults have both an understanding

of their needs and the ability to devise solutions, future health systems should, by necessity, be participatory, and enfranchise such groups as coproducers and codesigners in the development of digital health tools.

In the next section, we will specifically focus on this interface between digital transformations, UHC, and the health and wellbeing of children and young people.

Youth futures: children and young people are central to digital transformations of health

No universal experience of growing up in a digital world

All children and young people are growing up in a digital world but their lived experiences of that world, and its opportunities and risks, vary drastically depending on where they live. How young people use digital technologies to learn about and manage their health and wellbeing is also determined by a range of intersecting economic, social, and political factors.

The multifaceted intersections of digital and health transformations clearly impinge upon the transformation of health and wellbeing for children, young people, and future generations. Existing bodies of evidence, predominantly focused on HICs in Europe and North America, have already offered insights into the experiences and views of young people in relation to digital health.¹⁶⁷

The Commission, in collaboration with the International Federation of the Red Cross and Red Crescent Societies and UNICEF, consulted with young people from LMICs to capture a broader range of voices and perspectives.

These consultations show that, as with digital transformations, there is no single youth transformation, but rather multiple transformations depending on different societal and geographical contexts, and no universal experience of growing up in a digital world (panel 5; figure 6). We propose to categorise young people's experiences into six broad profiles, ranging from digitally excluded children and young people who are currently disconnected (from both the online environment and formal health systems) to digitally immersed children and young people who have access to a wide range of digital tools and services and can use them effectively to support their health and wellbeing. Young people at highest risk of disease and with the lowest access to a health worker and essential health services are usually the least connected (figure 5A).

Our conceptual typology of digital childhood profiles tries to capture how across the world, children and young people's use of digital technologies, and access to health-related information, can be mediated by several, intersecting factors including their age, sex, gender identity, location, and socioeconomic status. Within countries, there are stark divides between those young people who can leverage digital technologies to support their health needs and those who cannot. Factors, such as household rules set by caregivers, curricula and availability of technology in education settings, levels of digital literacy, gender, and government regulation of online content, can also represent important enablers or barriers to independent technology use.^{98,168} Moreover, in a context characterised by the rapid emergence (and decline) of digital trends, age difference can itself create substantially different online experiences.¹⁶⁹

Datafication of children and young people

Despite the varying experiences of growing up in a digital world, the datafication of children and young people will represent a defining feature of health futures. A trend is already evident across all age groups and countries in HICs, and increasingly in LMICs: people's use of digital technologies leaves behind data traces and trails of their personal information.

Digital health technologies include search engines, websites, online discussion forums, telemedicine and telehealth systems, electronic patient record software, mobile devices and apps, wearable devices, and elements of smart homes, such as digital home assistants and security systems. People's movements in public spaces or institutions are also recorded by an expanding array of sensor-equipped smart technologies, including digital video cameras, movement sensors, and facial recognition systems.¹⁷⁰

Panel 5: Digital childhood profiles

Digitally excluded

- A young person who has never experienced a digital environment and lives in a very poor household that cannot afford digital devices and is not served by the basic infrastructure required to get online
- Local health systems are weak, so most health information and care are provided by the community, and households might have some access to community health workers equipped with basic smartphones

Digitally limited

- A young person who has very little experience of digital environments and lives in a household with a single, shared device that can connect to the internet, but the young person's access is severely limited due to demand for the device, irregular power or connectivity, and the financial costs of data and charging the device
- Digital technology might have an effect on communicating with health providers and acquiring health information

Digitally intermittent

- A young person whose experiences of digital environments are recurrent but irregular and their household can afford digital devices and connectivity, but access is restricted due to distance from mobile networks and overall weak infrastructure
- Digital literacy is generally low, meaning that a young person receives little guidance on how to navigate the digital environment in ways that could support their health and wellbeing

Digitally cautious

- A young person who has regular access to digital environments with minimal infrastructure or cost-related barriers
- Personal anxieties and caregiver concerns about online risks limit the young person's use of digital technologies and services in support of their health and other interests

Digitally consumed

- A young person who spends excessive amounts of time in digital environments leading to substantial exposure to commercial marketing and potentially harmful content and interactions
- The young person receives little support or guidance from caregivers to help them moderate their technology use or deal with any negative effects to their health and wellbeing

Digitally immersed

- A young person who can transition seamlessly between online and offline environments and effectively use digital tools to support their health and wellbeing
- Although continuing to be exposed to online risks, adequate levels of digital literacy and a supportive environment allow the young person to understand and mitigate any risks they encounter

This datafication⁵² of people's bodies and activities can begin for children and young people even before they are born. This generates the phenomenon of the so-called datafied child¹⁷¹ (meaning a condition in which children are subjected to a continuous process of monitoring, which generates substantial amounts of data about them), resulting in datafied childhoods¹⁷² lived in datafied environments,¹⁷³ which include pregnancy and parenting apps;¹⁷⁴ digital technologies and wearable devices used to track health status, behaviours, and development;^{175,176} smart toys;¹⁷⁷ digital learning technologies and apps for

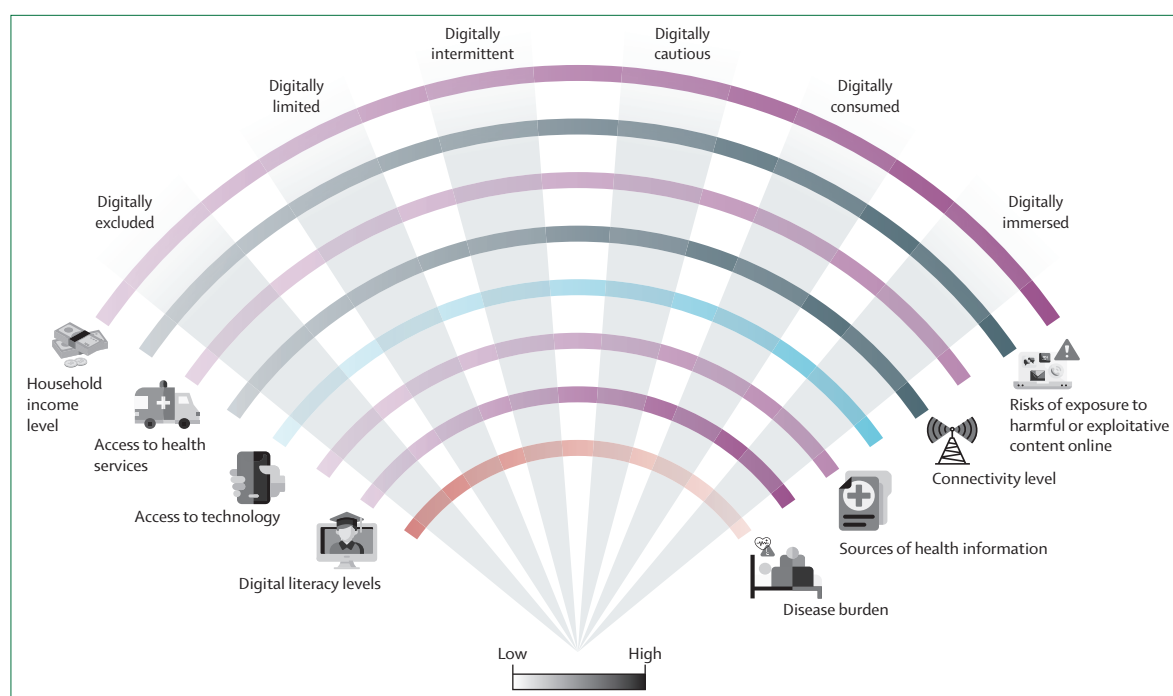


Figure 6: Visualisation of the Commission's digital childhood profiles

The six digital childhood profiles have been constructed by considering how young people's experiences of growing up in a digital world might differ across eight dimensions.

managing classroom behaviour;^{178,179} and surveillance software and devices used to monitor their attendance, progress, and safety in schools.¹⁸⁰

Across the world, young people who are connected also use a range of digital technologies to seek health information and advice and to improve their wellbeing, from more traditional forms of digital media, such as search engines and websites, to messaging platforms and social media. Young people also increasingly use devices and software designed to promote their health and fitness,^{181,182} making them one of the largest consumer groups of wearables and other activity tracking devices.¹⁸³ At a fundamental level, we are also moving towards an era of social genomics.¹⁸⁴ Although mostly limited to HICs for now, an increasing number of children and young people will grow up with availability of information about their digital genetic selves.¹⁸⁵ Taken together, emerging technologies and digital and data standards will create new paradigms of datafication and possibilities of social self-definition via a lens of data and algorithms.

The exposure of children and young people to digital technologies is already higher than for the rest of the population, as they are among the users spending the most time online.¹⁸⁶ Moreover, for younger children and adolescents, the family environment itself can be conducive to higher exposure to devices, software, and datafication.^{172,187} However, children and young people's understanding of the digitally driven and data-driven world has gaps that can result in harm to them—for

example, in the context of their ability to manage interpersonal and commercial privacy in online environments.^{98,188} The continued use of digital technologies implies that more aspects of children and young people's lives will be measured, coded, and stored than ever before; those who own and control these technologies might influence their decisions and behaviours, and put them at risk of online privacy infringement, manipulation, and commodification.

Information and misinformation that could be harmful to health also reach young people through multiple digital devices, often without their knowledge.¹⁸⁹ Half of all global advertising spending is now spent online, making digital media platforms increasingly important spaces for commercial marketing.¹⁹⁰ Digital channels might thus expose young people to unhealthy and harmful products and messages, and are also major sources of data extraction.¹⁹¹ For example, concerns have been raised about security breaches of smart toys and young users' personal information, and the commercial exploitation of these data.¹⁹²

In addition, social media platforms often enable abuses that affect the online experiences of children and young people.¹⁹³ These abuses (including harassment, cyberbullying by peers, threats of sexual violence, and body shaming), which are often motivated by race and ethnicity, sexual orientation, or gender identity, are estimated to have increased during the COVID-19 pandemic.^{194,195} Although there is evidence of overlaps between traditional

(offline) and online forms of abuse,^{196,197} and a potentially higher prevalence of the traditional form,¹⁹⁸ researchers have pointed out that there are qualitatively unique aspects to phenomena such as cyberbullying—for example, the perceived anonymity and number of perpetrators¹⁹⁹—and that increased time spent online correlates with higher risks of being exposed to such phenomena.²⁰⁰ As highlighted by the Commission's Youth Statement and Call for Action,¹⁴ forms of online abuse thus raise serious wellbeing concerns, including in terms of their influence on self-harming behaviours,²⁰¹ and in turn prompt calls for greater accountability of governments and social media companies.²⁰²

In parallel, the relationship between the time spent in online environments and dimensions, such as social connectedness and mental health, continues to be debated, with studies evidencing both the positive and negative effects of increased internet and social media use.^{53,95,203} Moreover, researchers have started to investigate the potential effects of digital technology use on the cognitive development and physical, mental, and behavioural health outcomes of both children and adolescents,^{204,205} albeit with a greater focus on the negative effects and a scarce exploration of positive outcomes and opportunities.²⁰⁶

The process of datafication does not only refer to those who are alive. Societal preferences and institutions are already reconfiguring the world that future generations will inherit. Digital and data-driven innovations, but also the rules that will govern the implementation of such innovations, are likely to shape the health and wellbeing dynamics of the world future generations grow up in. However, important gaps remain in our understanding of how such effects will unfold over time (panel 6).^{12,207–214}

Children and young people as drivers of positive health futures

An important, underlying dimension of the datafication of children and young people is in the fact that they are treated, and encouraged to view themselves, as inert, calculable data subjects.¹⁷¹ Such an approach denudes children and young people of agency and autonomy, including towards their caregivers,^{215,216} instead of promoting the role of families, schools, and peer mediation in helping children and young people develop forms of digital resilience against online risks and harms.⁵ For example, child safety and protection issues are often used as selling points by surveillance technology developers, suggesting that children require high levels of monitoring and are unable to take responsibility for their own safety. As a consequence, children and young people often have little choice in engaging with these technologies.²¹⁷ For example, when children and young people are expected to use digital learning platforms, biometric systems, or self-tracking devices at school and there is little or no option to opt out.¹⁷¹ The COVID-19 pandemic has highlighted many of these issues.²¹⁸

Similarly, in many parts of the world, young people already contribute to digital health ecosystems through health-care start-ups, advocacy, and non-profit initiatives.²¹⁹ However, investments in, and decision making on, digital health technologies and ICT systems are rarely oriented around their skills, needs, and views. In fact, both marketing strategies and policy debates are more likely to consider younger age groups as consumers of technologies and centres of data extraction, not only raising concerns for their health and wellbeing² but also potentially undermining their participatory rights.^{220,221}

If digital transformations are to be aligned with health and wellbeing across the range of potential health futures, the perspectives and agency of the generations who will inhabit such futures must become foundational pillars of any attempt to govern it. The UNCRC argues that the right to be heard applies to children of all ages and in all contexts, including health.²²² Such a need for greater intergenerational leadership and participation has been voiced in the context of planetary health, but is also emerging in the context of digital health and wellbeing.²²³

At the same time, many social movements and democratic processes driven by young people could not be envisaged without them using digital tools extensively and creatively.²²⁴ In the past two decades, more and more young people around the world have found and deployed their voices online, showcasing the potential use of digital media and technologies as crucial tools for civic and political engagement and participatory research.^{54,55} With respect to health and wellbeing, the role of online testimonials and social media has also become an important tool to create interest and appeal to a wider audience.²²⁵

The consultations held by the Commission (panel 7)²²⁶ reveal several ways in which children and young people's perspectives would be crucial drivers of digital and health transformations, while reinforcing the necessity of seeing digital tools as integrated with broader efforts to ensure UHC and strengthen health systems.

First, children and young people signal that their perception of health and wellbeing goes beyond a narrow understanding of health care, to include day-to-day concerns about fitness, nutrition, sexual and reproductive health, and self-care. For example, young people consider being online and connected to other people as an increasingly crucial part of health and wellbeing, and want services and tools, including digital ones, that promote wellbeing and support mental health to be included in the essential package of services available to all young people.

Second, young people expect a mix of digital and in-person health services that are easily accessible, responsive, and friendly towards their evolving needs and capacities. Young people consulted by the Commission expressed their preference for getting health information online or from their family and friends, over getting it

Panel 6: How digital technologies might affect children and young people's health and wellbeing over time

Digital technologies are increasingly pervasive in the lives of children and young people. Although several initiatives have explored the positive²⁰⁷ and negative effects of these technologies,²⁰⁸ substantial evidence gaps persist, particularly with respect to longer-term health effects or the effects on the lives of children and young people who have little access to digital technologies and the skills to use them. Research challenges, such as capturing diverse perspectives (acknowledging demographic variables such as age, ethnicity, race, sex and gender identity, religion, national origin, location, skill and educational level, or socioeconomic status), contextual nuances, and cross-country comparability compound the difficulty of measuring the effects over time.

To address some of these gaps, a WHO report on youth-centred digital health interventions¹² suggested that both a landscape analysis and a needs assessment can help highlight young people's experiences and contextual realities in different regions of the world. There have been increasing calls to understand different challenges (eg, issues connected to screen time and problematic media use) and opportunities (eg, use of wearables to measure and encourage physical activity, and access to knowledge, information, and technologies, such as health bots, around sensitive or stigmatised health issues). There have also been increasing calls to include children's and young people's perspectives in the design, development, implementation, and evaluation of digital health technologies and policies, under the assumption that this will lead to a more robust data and evidence base for policy makers.^{209,210}

Among the possible forms that research activities can take in this domain, longitudinal (multicountry) research with young people can offer several benefits over other types of study design (eg, cross-sectional). First, longitudinal studies can assess how digital technologies might effect young people's health and wellbeing over time. Such technologies might not have an immediate negative or positive effect on youth but might have cumulative effects that can only be measured by long-term research.²¹¹ Second, longitudinal designs can show the effects of different determinants of health, such as socioeconomic status, education, and access to and quality of health care. Longitudinal research can also help show causal effects by collecting detailed information on the sequence of different practices and events.²¹² Third, research in multiple countries can allow for a degree of cross-country comparability, as shown by the Health Behaviour in School Age Children Study, a WHO collaborative cross-national survey that now includes 50 countries and regions.²¹³

Although a longitudinal multi-country study comes with challenges,²¹⁴ there is great promise in this research approach. Looking ahead, it will be essential to determine the study's main emphasis, further define the methodology, and convene relevant partners. It will be crucial to build partnerships with children and young people themselves to ensure that we can, together, shape evidence-based digital health innovations, policies, and programmes that amplify and value young people's voices and promote their health and wellbeing.

directly from health professionals. However, access to health facilities remains important for accessing treatment and care, and for seeking advice on more serious health conditions.

Third, children and young people demand to be given the knowledge and skills to manage their health and wellbeing in the digital world, including: digital, health, and civic literacy and skills to navigate digital environments and exert greater informed control of their personal data; health education around physical activity, dietary habits, relationships, and products, such as drugs, alcohol, and tobacco; and quality education and skills that can enable them to be part of the future workforce, so that they can build future health and digital economies that meet the needs of young people.

Fourth, young people want to be enfranchised, including through new models of participatory governance, codesign, and research.^{227,228} This means that they must be able to play a part in decision making processes that affect their health futures, including the design and governance of digital health approaches and other digital and data-driven services. Young people want to be given spaces to express their views and share their experiences about health and wellbeing, to shape and implement accountability mechanisms for governments

and private actors, to have access to an enabling environment for youth-led innovation that can allow them to design their own health futures, and to be able to rely on affordable and universal internet connectivity to be able to play an active role in governance and innovation.

Finally, as discussed in the Commission's Youth Statement, children and young people want to be protected from commercial exploitation and harmful content when they are online, to know how their health data are being collected and used, to give informed consent to the sharing of their data, and to be able to use online platforms that help them distinguish reliable health information from disinformation and misinformation.

Creating a value-based framework for governing health futures

Health for All values

Any tension between health and digital transformations should be resolved in favour of the core values of health. We argue that the governance of health futures should rely on the values set by WHO in its Health for All approach²²⁹—namely democracy, equity, solidarity, inclusion, and human rights—while also updating these values to reflect their new meanings in a digital world.

Panel 7: Young people's views on digital health

In October and November, 2020, UNICEF conducted a U-Report survey on behalf of the *Lancet* and *Financial Times* Governing Health Futures 2030 Commission to better understand the expectations, demands, and concerns of young people in relation to the use of digital technology and data for improving their health and wellbeing. The survey comprised six questions: four multiple choice questions about young people's use and views of digital technologies for health, and two open questions to capture their opinions on what governments and technology companies should do to govern digital health, and what they imagine digital health will look like in 2030.

The survey was distributed through seven national U-Report channels (Argentina, Brazil, France, Guatemala, Myanmar, Serbia, and Zambia) and through the U-Report global channel. Poll results were analysed by the Commission Secretariat to identify key themes and trends. A total of 23 435 children and young people from 176 countries participated. 86% of respondents were aged 14–29 years. 95% were from low-income and middle-income countries.

Summary of survey findings²²⁶

- 88% of respondents used some form of digital technology for health-related purposes
- Smartphone apps and websites are the most common technologies used
- Improving fitness is the most popular health-related purpose for users of digital technologies
- Smartphone apps are the most popular form of technology used for supporting fitness, whereas websites and social media are more widely used by young people concerned about other health issues, such as infectious diseases, nutrition, mental health, and reproductive health
- Half of respondents said that accessing health information was the biggest way that digital technologies can help young people manage their health and wellbeing
- Inaccurate health information is the biggest worry for young people using digital technologies, followed by concerns about their privacy, and use of digital technologies making them less physically active

What should governments and technology companies do to ensure that digital technologies improve the health and wellbeing of young people?

Governments and technology companies should listen to young people's recommendations on improving internet access and the quality of health care rather than on digital tools. Many respondents urged governments and technology companies to mitigate harms associated with the digital environment such as misinformation and harmful content. Overall, respondents believe stronger governance of digital technologies is required but they expressed a high degree of cynicism about governments' commitment to act on young people's recommendations.

When asked to imagine a world in 2030, young people were not sure how they would use digital technologies to get health information and advice in the future. There was a high level of uncertainty with many open-ended responses such as "I don't know". Young people tended to be polarised between highly dystopic and utopic imaginaries: with predictions for 2030 ranging from a "robotised" future where "everyone can access the internet" to "it will be chaos!"

Youth imaginaries on what digital health will look like by 2030 revealed several themes that are relevant for governing health futures, including: building young people's trust in health knowledge and governments; increasing health and digital literacy; building basic digital infrastructures; ensuring digital tools complement and do not undermine the importance of face-to-face interactions with health professionals; increasing the quality of internet access and health services; discouraging excessive time online; and shifting towards more personalised models of medicine.

Responses to the survey suggest that many young people had not previously thought about the role that digital technologies do—and could—play in supporting their health and wellbeing. Further opportunities should be created for young people to examine the potential opportunities and risks associated with digital transformations of health, and to relay their ideas and concerns to policy makers and technology companies, including opportunities to consult young people who cannot participate in online surveys, such as U-Report, due to insufficient connectivity and other barriers.

The previous sections have emphasised the fundamental interconnection of health and digital transformations, and preliminarily outlined a series of important challenges and opportunities for governance. But what are the values that should guide decision makers and other public and private stakeholders as they seek to harness the potential of digital technologies in support of UHC?

We argue that any approach to shape health futures through digital transformations should be grounded in the same set of universal values²³⁰ that are articulated in the 2030 Agenda for Sustainable Development¹⁶ and the

high-level political declaration on UHC¹⁹—both of which have been adopted by all UN Member States. Core to these agendas are the principles of democracy, equity, solidarity, inclusion, and human rights, which are required to achieve all dimensions of health futures, including those not immediately dependent on digital technologies. They also encourage a progressive universalism approach, which means proactively reaching populations at greatest risk of being left behind first to reduce equity gaps.

Upholding Health for All values serves to ensure that digital technologies enable health benefits including a

positive transformation towards UHC, improved access to and quality of health services, and more effective prevention and management of public health crises. In turn, these benefits will result in digital transformations of health, creating public value and actively advancing social justice, rather than promoting a siloed and ungoverned adoption of new technologies as they emerge (figure 7). However, if Health for All values are to play a central role in shaping health futures, they themselves must be strengthened and updated to reflect their specific relevance for, and intersection with, digital transformations. In this section, we build on such values to identify a series of foundational entry points for the governance of digital transformations of health, which provide a critical framing through which to understand the action areas.

Human rights and ethical principles

Digital and data-led transformations of health pose a set of novel ethical and human rights challenges. Letting digital spaces, platforms, and technologies go ungoverned risks creating what have been defined as human rights black holes.²³¹ Digital technologies will only advance social justice and reduce health inequalities if they are designed and implemented with ethical principles and human rights-based approaches in mind.

Without new digital ethics, based on integrative approaches between offline and digital rights, and centred around the protection of principles and collective values, such as privacy, equity, fairness, patient safety, and human autonomy over health-care decisions,^{232–234} health could become an entry point to the use of digital technologies in support of new forms of surveillance capitalism,²³⁵ data colonialism,²³⁶ or digital welfare dystopias characterised by a wide range of approaches to control citizens.⁴⁶ We are already witnessing such developments in several countries, as a consequence of the COVID-19 pandemic.^{237,238}

Despite the long-standing adoption of broad strategies and declaration of principles to guide digital transformations,²³⁹ in practice, many countries still do not have effective approaches to digital health that have democracy, equity, solidarity, inclusion, and human rights at the centre. Compounding pre-existing failures of many health systems to put patients and their human rights first, digital health ecosystems themselves are often developing without adequately considering the unequal distribution of power and resources that affect an individual's or community's access to, engagement with, and ability to benefit from digital health technologies.^{4,92} For their part, health professionals who are challenged to respond to the new ethical issues arising from digital health transformations, from differences in access to digital health technologies to algorithmic biases,^{240,241} are not necessarily prepared or trained for this purpose.

Established public health concepts grounded in the Health for All approach are important to ensure that

digital transformations advance social justice and promote health equity. Similarly, the realisation of human rights, including the right to health, privacy, equality, and non-discrimination, constitutes an unavoidable normative framework to orient such transformations. Although they were adopted long before many of the current digital technologies were conceived, universal human rights instruments, such as the UNCRC, apply online as they do offline, and have to be fully respected. The EU Strategy on the Rights of the Child²⁴² and the OECD Recommendation on Children in the Digital Environment²⁴³ reinforce this need.

By contrast, the absence of a strong ethical and human rights-based analysis when designing, implementing, and evaluating digital health solutions for welfare policies and programmes can lead to ignoring or exacerbating existing health inequities and other forms of discrimination, or even creating new ones. Such analysis, which is especially relevant for populations who are already at risk, such as young people, women and girls, migrants, and displaced people in humanitarian settings, must consider the specific outcomes of data-extractive processes (panel 3). For example, controversial data-sharing schemes have enabled governments to start accessing medical records as part of a welfare system's assessment processes, a development that might deter vulnerable people from seeking medical assistance when they need it²⁴⁴ and thus interfere with their rights to health and privacy.²⁴⁵

These challenges do not apply equally to all countries (or even to everyone within the same country) and are expressed differently in different political systems. First, they arise in the context of, and interact with, the emerging geopolitics of digital governance. As such, they manifest themselves with different nuances, on the basis of the specific governance approaches chosen to regulate (or not regulate) the power and agency of the actors of the digital health ecosystem, whether they are governments or the private sector.

Second, these challenges are met with vastly divergent responses across different societal contexts, given that ethical principles and human rights in the digital space are, much like their offline versions, subjected to different political systems, sociocultural understandings, preferences, and governance contexts. This has become abundantly clear during the COVID-19 pandemic. For example, consent for digital health applications to track the location of every individual to make contact tracing easier in the event of an epidemic might be given in one country but fiercely fought against in another, as might the broader consent for sharing personal information for health-care purposes.²⁴⁶

Third, these challenges are compounded by pre-existing inequalities, such as those represented by the growing digital divide. For example, the most wealthy people or households, those living in urban areas, and those that are educated are often the best placed to fully capitalise on

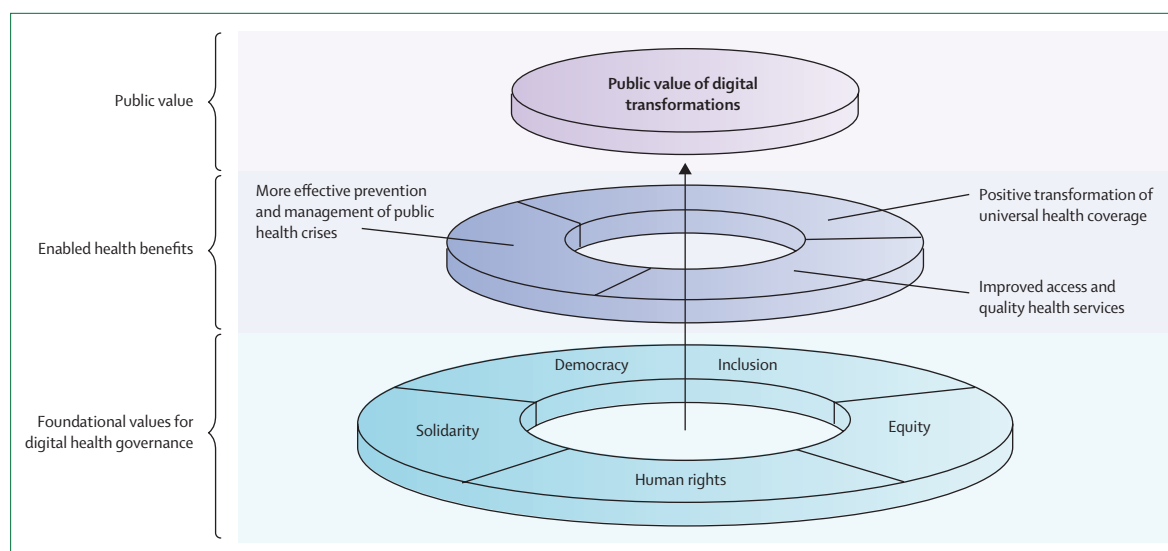


Figure 7: Conceptualising the public value of digital transformations of health

digital health technologies. Digital solutions might exclude those who most likely need them the most, such as those living in rural areas with scarce internet connectivity, women, those that are less educated, those that are impoverished, and elderly people. This risk of excluding vulnerable groups has also been debated in the context of COVID-19, as countries started to set up online registration systems for administering vaccinations.²⁴⁷ Even in countries deeply invested in digital transformations of health, such as China, the divide remains evident.²⁴⁸

Fourth, the full ethical and human rights ramifications of emerging and future technologies, are simply unknown.²⁴⁹ For example, deidentified shared genomes have been successfully used to reidentify individuals or their families and such information can be used adversely.²⁵⁰ Moreover, although legislation might prohibit discrimination on the basis of genetic data, the intersection of AI and health data has previously led to unintended racially discriminatory consequences that would require even more oversight when genomic data gets added to algorithmic black boxes—ie, all those situations in which most people are not able to understand the inner workings of the algorithmic model, thus creating problems of transparency and legitimacy.¹⁰⁴

A solidarity-based approach to health data

The way in which we collect and use health data must reflect the ways in which the social contract in health and health care is articulated in different cultural and societal contexts. Governing digital health through the prism of UHC means an approach to health and health-related data that is centred on a social contract that also applies to the digital sphere and is built on the notion of data solidarity.

Among all Health for All values, we believe that the notion of solidarity is particularly important for

understanding the opportunities and challenges brought about by digital transformations of health. The concept of UHC itself is an expression of a social contract²⁵¹ based on solidarity, which we understand as an enacted commitment to carry the costs (financial, social, emotional, and other contributions) of assisting others with whom a person or people recognise similarity in a relevant respect.²⁵² Social contracts built on a similar, solidarity-based approach emphasise the simultaneous importance of personal and collective needs, interests and responsibilities, and focus action on the space where the two overlap.²⁵³

From a UHC and public health perspective, digital health tools can provide decision makers with reliable data to deliver comprehensive health services for all in terms of planning for such services and providing care in communities.²⁵⁴ There must be a conscious effort to bring together individual health agendas—which for digital applications are more focused on aspects such as behavioural monitoring, precision medicine, and disease prediction through genomic approaches—and the more structural efforts towards broader population-based impact that have long characterised public health action.²⁵⁵

In this context, the importance of a solidarity-based approach, and of adopting a public health perspective more generally, is often not considered or is discounted. The ethical and human rights challenges that come from digitally driven and data-driven transformations of health are often confined to questions of autonomy, data ownership and control, or (on the other end of the spectrum) to public health surveillance, forcibly pinning notions of privacy and public health surveillance against each other. The misleading nature of this framing, which has already been discussed in the context of the relationship between the social solidarity basis of public health and the individual right to health,²⁵⁶ is also shown

by the debates surrounding the deployment of contact tracing technologies during the COVID-19 pandemic. On the one hand, the use of privacy-related arguments to promote an individualised understanding of health and health-related data overemphasises the idea of individual data ownership,²⁵⁷ neglects the social and relational nature of (health) data,²⁵⁸ and ignores the heterogeneity of data coming from several different sources. On the other hand, the COVID-19 response has highlighted the real risks that problematic approaches to data collection, integration, sharing, and storage could bring for privacy and other human rights, especially if applied beyond emergency measures or made available to law enforcement agencies.²⁵⁹

The notion of solidarity, as applied to health data and data for health, can be a way of rebalancing this debate by safeguarding non-extractive and trustworthy approaches to data collection, use, and sharing, building a culture of data justice and equity, and ensuring that the value of data is harnessed for public good. However, its articulation requires a new understanding of how the approaches that have emerged to govern data in our societies can be updated to reflect existing, shared goals for health and wellbeing.²⁶⁰

Inclusion and enfranchisement

AI and other digital technologies raise important issues about the way in which we imagine and represent sexuality, race and ethnicity, gender, class, geography, age, and ability. A new understanding of inclusion and enfranchisement in the context of digital health will entail forms of context-aware technical development, and innovative, local and community-led approaches to the codesign and deployment of digital tools.

Biases in public health and administration are not exclusive of digital systems. On the contrary, studies in humanities and social sciences have increasingly documented how algorithmic processes, AI, and machine learning might reproduce social patterns of bias,^{261,262} and be affected by them. In this sense, the ethical and human rights dilemmas that arise from digital transformations of health must address the challenge of promoting inclusiveness and enfranchisement of marginalised actors and vulnerable groups in broader governance systems.

A crucial obstacle to increasing the inclusiveness of digital health interventions is what some scholars call digital (or data) colonialism.²³⁶ This concept indicates all digital practices through which individuals are marginalised or dispossessed by more powerful actors (both private and public), usually based in higher-income and technologically advanced countries, through the extraction, control and use of their data. Beyond economic consequences, such loss of control over digital health futures is troubling, because health interventions that are not anchored to local contexts and understandings around health (for example, because they do not involve local

developers) might be ineffective or even harmful.²⁶³ More broadly, the massive increase in health data flows, both within and across countries, presents substantial risks of social externalities, from those linked to data storage, transfer, and anonymisation to the wider implications for power relationships and societal dynamics.

Beside the potential application of digital technologies for health to new colonialist practices, the tumultuous invention, application, and scale-up of these technologies also raise important questions about the way in which they imagine and represent sexuality, race and ethnicity, gender, class, geography, age, and ability. Experts have raised concerns that digital technologies might reproduce, and often exacerbate, historical patterns of bias, unequal distribution of power, and discrimination. These concerns, which become particularly relevant in the context of machine learning, have been raised in all social domains, including health care, and have led to calls for the adoption of decolonial²⁶⁴ and feminist²⁶⁵ approaches to AI and data science. In health, these concerns are being raised by advocacy groups and scholars in the humanities, social sciences, and health sciences.^{266,267}

This growing body of research, which addresses biases at the level of gender,²⁶⁸ race and ethnicity,²⁶⁹ disability,²⁷⁰ and indigenous populations,²⁷¹ among others, suggests that software developers and researchers alike must consider the legacy of these social biases to advance medical knowledge and improve health-care delivery. For example, existing efforts to harness advances in genomic sequencing in support of precision medicine are hindered by a lack of diversity in genomic datasets, with genomic variants coming from areas of high genetic diversity (such as from Africa or India) substantially underrepresented when compared with European populations.^{272,273}

Digital, health, and civic literacy

To create public value and contribute to UHC, digital health must be underpinned by high levels of digital, health, and civic literacy. These factors are essential to achieve health equity, strengthen democratic participation, and enable better individual and collective choices.

Robust democracies characterised by greater freedom of expression, free and fair elections, higher levels of trust and respect for the rule of law have consistently been shown to yield better outcomes in confronting health challenges, making progress towards UHC, and enabling more inclusive and transparent debates around health interventions.²⁷⁴ These fundamentals arguably become even more relevant in the context of digital transformations of health. On the one hand, strong civic technology ecosystems can play an important role in ensuring the democratic governance of digital health, and digital technologies more broadly are providing young people with crucial tools for civic participation and activism. On the other hand, private individuals (and children and young people in particular) often have little

control over their data and rare opportunities to shape, design, or monitor digital technology to ensure it meets their health and wellbeing needs. Moreover, the power asymmetries of the new digital ecosystem have undermined the agency of many national governments and their ability to exercise ownership over digital transformations' processes in the best interest of their people's health and wellbeing, as new actors hold increasing power.²⁷⁵

At the core of this democratic dilemma lies the crucial need to ensure that people have digital skills and literacy, and that governments can represent the perspectives that people express in the health domain. Ensuring equal access to STEM education for boys and girls, and providing every young person with the basic digital skills, which are required to make use of digital devices and online applications, is an increasingly important democratic requirement in the digital era. In addition, the demand for more advanced digital skills is rising across all economic sectors and quickly becoming an important determinant of young people's work readiness,²⁷⁶ including in the fields of health and health care.

At the same time, digital literacy refers not only to the applied technical skills necessary to use and access the internet, but also to the capacity to critically and confidently engage with the online environment, including its political economy and geopolitics.²⁷⁷ More broadly, as a determinant of health in its own right, it has been emphasised that digital literacy substantially interacts with other intermediate health factors and social determinants, to influence both access to digital health resources and wider health equity outcomes.²⁷⁸

For example, digital literacy is not only intertwined with conventional health literacy, but also strictly interconnected with broader democratic and civic literacy skills, in the sense that neither of these skill sets can be expressed effectively without the other in a digital age. The digital ecosystem offers new spaces for political participation and civic debate, including on health matters, but only to the extent that informed citizens are able to engage crucially with it and protect themselves and others from misinformation and abuse, such as discrimination and cybermobbing.²⁷⁹ In turn, digital and health literacy can only thrive: in equitable health systems that strive to reduce health disparities and improve access to care for all social groups; in societal contexts characterised by high levels of trust, respect for others, good governance, respect for the rule of law, independent journalism, and information stewardship; and within wider geopolitical contexts in which the perspectives of those societies can be heard within the wider governance of health and data technologies.

Shaping health futures

An approach to governing health futures in a digital world must be purposeful in the challenges it sets. All levels of governance, from multilateral forum to country

governments, regions, and cities, should ensure that digital transformations create public value, advance democracy, and uphold health and digital rights, equity, and solidarity.

The breadth and complexity of digital transformations of health suggest the necessity of governance transformations that can effectively address the multiple interweaving dimensions of health futures.²⁸⁰

First, while the internet was once primarily associated with decentralising and democratic attributes, the ecosystem of digital transformations is now one of concentrations of data, computational capacity, and power. Digital transformations are compounding or influencing power relationships between public and private actors. They are becoming embedded in broader geopolitical developments, potentially concentrating decision making (including on health matters) and expanding the power of those who control the access to, and leveraging of, health data and technologies.

Second, digital tools, platforms, and services developed by the private sector represent new objects of regulation, with different digital governance models being adopted in different societal contexts and with a growing attention to their implications for health and wellbeing. Despite the many initiatives that are being taken by governments, civil society, and private sector actors themselves, a global consensus or international instrument on digital governance seems less likely. Yet, it will be important to explore how political systems can reach agreement within the UN system and shape an inclusive digital agenda, despite their major differences.

Finally, digital transformations are providing policy makers and bureaucracies with an unprecedented set of tools for governance in areas ranging from public health surveillance to welfare systems—a dynamic that has been laid bare during the COVID-19 pandemic. Translating such tools into working designs that contribute to digitally enabled health systems and create public value will require the development of mission-oriented frameworks through which to steer innovation,²⁸¹ to ensure that digital technologies, data, and algorithms (including those adopted in health and health care) are not developed or repurposed in ways that threaten human rights, enable digital surveillance and mass monitoring, exert undue political influence, and reinforce discrimination.²⁸²

Taken together, these digital transformation trends have major implications for health and wellbeing, which have been explored in the previous sections. In this section, we propose four interacting action areas that might help address power asymmetries and rebalance trust in digital transformations of health—or digital health trust. First, we suggest that decision makers, health professionals, and researchers should consider digital technologies as increasingly important determinants of health, and address their interactions with the other determinants. Second, we emphasise the

need to build a governance architecture that creates trust in digital health and enfranchises actors at all relevant scales. Third, we call for a new approach to the collection and use of health data based on the concept of data solidarity, with the aim of simultaneously promoting individual rights and public value. Finally, we urge decision makers to invest in the enablers of digitally transformed health systems. The Commission considers the four areas to be crucial game-changers for shaping health futures and achieving a public value-driven governance of public health and UHC in a digital world.

Addressing the digital determinants of health

Digital transformations are in themselves a determinant of health, but they also interact with the many other determinants that define the health futures of children and young people. Investing in health, education, the future of work, and climate action as part of the 2030 Agenda is a necessary baseline for ensuring sustainable health futures. Investing in universal broadband access must also have the highest priority at the national and global level. The digital potential for UHC can only be achieved if the glaring gaps in connectivity are addressed with urgency.

Investing in the Sustainable Development Goals

Many policy makers put great hope in the contribution of digital technologies and ICTs to bolster sustainable development and accelerate the implementation of the 2030 Agenda, thus harnessing the positive role of digital transformations as a social determinant of health. However, for this to happen, governments and other public sector actors must invest in health, education, and jobs, and in the digital connectivity, capacities, and infrastructures that allow for their digital transformations. This objective will require both public and private investments, and public-private partnerships.³⁸ For example, thriving education systems, incorporating both analogue and digital components, will define the future wellbeing of children and young people. Education systems are crucial for addressing priority challenges, such as the cognitive development of children and their emotional and mental wellbeing. Education systems must ensure health and digital literacy, and address concerns, such as the mental health implications of online harms, competitive educational environments, and datafied childhoods.²⁸³

Similarly, ensuring decent work and preparing for workforce transition in a digital age will require labour laws that offer protection and substantial investments in equipping children and young people with STEM education and digital skills, promoting retraining programmes and lifelong learning, and mitigating the effects of emerging technologies on unemployment.²⁸⁴ These investments should also seek to bridge the gender divide in STEM and digital technologies, with girls and women still representing a small minority of digital

professionals, researchers, and developers.²⁸⁵ We know very little about the exact workforce needs of the future but we do know that the current digital skills will be the basic work skills of the future, and also in health and health care.

Addressing the digital and health divide within and between countries

Digitally enabled socioeconomic development is a high priority for LMICs and many countries wish to prioritise and accelerate digital transformations. Yet we see that the countries with the largest youth populations are often those where investments in connectivity infrastructure are underdeveloped, correlating with poor health outcomes and limiting the potential for children and young people to benefit from digital transformations and contribute to sustainable development. Although analyses from 2019 reveal a growing internet uptake and mobile-broadband subscriptions across the world, they also emphasise that an estimated 3·6 billion people remain offline, the digital gender divide is widening, and that affordability remains a challenge for many countries, especially in low-income countries.¹³²

Digital transformation strategies are essential for health too. From this perspective, the UHC mission of health and wellbeing must shape public investment and ICT markets, and regulations should be used to spur responsible innovation, rather than to create barriers. The current political economy of ICTs represents a major obstacle to the growth of a digital communications network for health. However, market-failure frameworks are not sufficient—demand-side stimulus and innovation are needed to enhance supply in LMICs and drive bottom-up innovation.

In this context, it is important to note that global access to information technology does not have to mean access to the latest technologies, as foundational investments are the most transformative in many contexts. For example, in the context of the COVID-19 response, WHO, ITU, and UNICEF proposed all telecommunications companies to help reach every person on the planet with important health messages, whatever their connectivity level, by building on existing efforts to deliver health messages to mobile phones as part of the BeHealthy BeMobile initiative.²⁸⁶ Similarly, building on the One Million Community Health Workers campaign and its Phones for Health project, a new global initiative could be launched to connect every primary health-care centre and community health worker to the internet with the use of foundational technologies, such as smartphones.

Regulating powerful players and adopting mission-oriented innovation policies

As big technology companies increasingly drive digital health and the wider health economy, proper checks and balances are needed to avoid health systems being affected by digital development pathways guided merely by economic gains, while also integrating private

For more on the One Million Community Health Workers campaign see <http://1millionhealthworkers.org/about-us/>

investment and resources in country-led efforts to strengthen health systems. From this perspective, solidarity-inspired initiatives at both international and country levels can play an important role along several dimensions.

First, governments and regional organisations should adopt mission-oriented innovation policies that choose those that are willing to stimulate investment and innovation towards the challenges of health transformation and UHC.¹¹⁶ This objective would entail the use of public policies: to shape new markets in digital health (rather than just to fix existing market failures); to create a sense of ownership among public authorities, private actors, researchers, and communities around a vision of health futures; to provide patient public finance to digital health innovation beyond basic research; and to share risks and rewards with private sector innovators through return-generating mechanisms for investments (eg, retaining equity or royalties, or capping prices of final products).

Second, although governance pathways for health futures should consider the need to leverage the skills of all actors, a new phase of regulatory action is required to fight the trends towards the increasing concentration of power and agency in the hands of digital superpowers and big, private technology companies. If left unchecked—for example, by encouraging self-regulation by large technology companies—these trends might lead to governance systems that simply reinforce power imbalances and codify forms of data colonialism and data opportunism, with the health sector representing an ideal Trojan horse (ie, obtaining access by deceit).⁸⁵ Governments should ensure the widespread application of good governance principles to digital health applications and services,²⁸⁷ anchoring their own practices to strong rules and practices around accountability, transparency, respect for the rule of law, and equity.²⁸⁸ At the same time, they should limit the massive data extraction practices of powerful private sector actors through stronger competition and data protection policies, capacity-building of independent regulators, and greater participation of the public (including young people) in regulatory bodies, building on initial efforts, such as the EU General Data Protection Regulation (GDPR), the European Commission proposals on a Digital Services Act and a Digital Markets Act,²⁸⁹ and the California Consumer Privacy Act, which enables California residents to demand information collected about them from companies that profit from consumer data.²⁹⁰

Moreover, governments should accelerate international efforts towards a fair taxation of the internet economy, seeking to address the disconnect that digitalisation has progressively created between the physical presence of technology companies and the markets in which such companies create value by interacting with users through digital channels.²⁹¹ The OECD released a report on its digital tax plans in October, 2020,²⁹² while the European

Commission has proposed new rules to ensure that digital business activities are taxed in a fair and growth-friendly way.²⁹³ A multilateral approach to the taxation of the digital economy has been described as the only approach capable of avoiding a fragmentation of the internet and addressing the equity and justice concerns of many LMICs, particularly at a time in which substantial fiscal space must be created to fund COVID-19 response and recovery.²⁹⁴ For example, the African Union has drawn attention to the rapid growth of the digital economy during the COVID-19 pandemic, which has seen big technology companies be among those experiencing the greatest market capitalisation gains in 2020,²⁹⁵ and its implications for fair taxation.²⁹⁶ As a result, a growing number of proposals for COVID-19 recovery plans focus on the possibility of using revenues from digital taxes to support health systems.^{297,298}

Building a public trust architecture for digital transformations of health

To protect individuals—especially children and young people—from negative health and wellbeing implications of digital technologies, governments must go beyond issues of data privacy, freedom of expression, and harmful online content. They must ensure responsible and ethical technology development through robust and participatory regulatory and accountability frameworks. An inclusive governance architecture that aims to build trust among all stakeholders of the digital health ecosystem is a prerequisite for digital technologies to benefit public health and UHC goals.

Ensuring health and digital rights

First and foremost, governing digital transformations inevitably means identifying new ways of protecting individuals from emerging threats to their health and wellbeing, with a focus on vulnerable groups, such as women, children, young people, and future generations (panel 8).^{299–307} These threats might range from so-called online harms (which include the exposure to illegal content and activities, online abuse, gender bias and discrimination, cyberbullying, and the effects of excessive screen time) to the broader influence of digital technologies on the social and commercial determinants of health.^{171,192}

By advocating for a new Optional Protocol to the UNCRC, the report of the WHO–UNICEF–*Lancet* Commission emphasised the need to limit the commercial marketing of products that are harmful to children, including through social media, and the inappropriate use of children's personal data.² More broadly, the same rights that people have offline must also be respected in the digital environment,³⁰⁸ and the recently adopted General Comment 25 emphasises that the articles of the UNCRC remain relevant to children's health and wellbeing in an increasingly digital world (panel 9).^{309–314}

Panel 8: Legal, governance, and technical tools to protect and promote the health of future generations

Although laws and public policies are often primarily designed to benefit the health and wellbeing of people living now, there is increasing attention towards their potential to influence systemic, and enduring change in the interests of health across the course of life and across generations. Crucially, laws can also hold institutions and other actors formally accountable for decisions and actions that could affect health, sustainable development, equity, and human rights.

Legal and governance tools

Laws and regulations for protecting and promoting population health have long been in place in most countries,²⁹⁹ and establish public health norms and standards, modify known structural risk factors for disease and injury, and enhance key protective factors, such as food, housing, education, income, employment, sanitation, social connectedness, and health care. Laws adopted over the past decade tend to concern protections related to digital health, such as regulation of emerging technologies, use and sharing of data (privacy), and intellectual property. In instances when these laws moderate exposure before conception to environmental factors that increase disease risks through epigenetic adaptations, they reduce transgenerational transmission of disease risks,³⁰⁰ and in this way, contribute to healthier futures.

Although such issue-specific laws are important, attempts to promote intergenerational wellbeing in an integrated way are also being explored. For example, the 2015 Well-being of Future Generations (Wales) Act³⁰¹ has a cohesive, overarching goal requiring “public bodies to do things in pursuit of the economic, social, environmental and cultural well-being of Wales in a way that accords with the sustainable development principle”.³⁰¹ The Act has changed how business is done and is enhancing a foresight-oriented culture. The Secretary of State and the 44 public bodies report formally on wellbeing indicators; a Commissioner for Future Generations is a visible change agent; and local-level public services boards advance action on wellbeing. A Healthier Wales is one of seven core goals. Public bodies are required to undertake horizon scanning exercises involving public, private, voluntary sectors, and members of their community to conceptualise and plan for the long-term (25 years). Financial assets are being created to benefit future generations, such as a £50 million Digital Priorities Investment Fund to transform digital services for patients, the public, and professionals, invest in data and intelligent information, adopt the latest cloud technology, and facilitate cybersecurity and resilience.

Across a range of countries, foresight architectures,³⁰² including Commissioners and parliamentary councils for future generations have been established, including in Hungary, Tunisia, Malta, the UK, Canada, Germany, Finland, and Wales. Finland’s Committee for the Future is a well established model—a 17-member parliamentary standing committee introduced in 1993. The Committee functions as an advanced think tank, particularly on science and technology policy futures cutting across governmental portfolios. It publishes a parliamentary response to the government’s Report on the Future. The analytical reports of the Committee have agenda-setting potential and include the Societal Transformation 2018–2037 report.³⁰³

Technical and policy tools

Finally, technical tools enabling long-range thinking about future generations and health are being refined and developed, and include foresight methods and impact assessments. Foresight methods are being used more widely and systematically for long-term thinking about health, health care, and digital health in government and other institutions and organisations. Methods include future literacy labs, horizon scanning, trend projections and trend (impact) analyses, participatory scenario development, backcasting, causal layered analyses, and Delphi surveys. Big data analytics capabilities are strengthening predictive capability. In 2020, WHO’s Western Pacific Regional Office used a multimethod approach in a sequence of intensive, multicountry workshops to examine possible postpandemic futures.³⁰⁴ New knowledge, perspectives, insights, and social relationships were constructed with value for national policy resets around issues including digital health and, potentially, ways of governing and working.

The quality and reliability of several types of impact assessments—health, health technology, intergenerational fairness,³⁰⁵ health equity,³⁰⁶ privacy, environmental—are improving with use. These tools are expected to be increasingly used by decision makers tasked to act and invest in the interests of the health and wellbeing of future and current generations. Impact assessments of digital health innovations will be important to ensure risks are identified and mitigated while maximum benefits are derived. In a project in Kenya, for example, an equity assessment for mobile personal health records was undertaken,³⁰⁷ which highlighted concerning implications for some community groups of using digital records, and acceptable measures for maximising benefits and mitigating risks.

From the point of view of accountability, the urgency to regulate digital technologies through adequate legal frameworks and algorithmic impact assessments that seek to identify the broader harms that might be caused by machine learning and other data-driven tools has been suggested by several authors.³¹⁵ Such efforts go far beyond data protection, even though particular features

of data protection laws remain themselves relevant, especially if health-related harms are explicitly included in such laws (eg, the requirement of consent for the use of any health-related information, the limitation of purposes for which health data might be used [or reused], the possibility of data protection impact assessments, the need to conduct regular privacy, algorithm, and security

Panel 9: Applying existing guidance on children's rights to digital health³⁰⁹

Children recognise the important role of different actors and governance mechanisms for protecting their rights and helping them derive the physical and mental health benefits that digital transformations can offer. However, children feel that, collectively, diverse stakeholders are currently failing to prioritise their rights in relation to digital transformations.³¹⁰

Existing guidance and mechanisms for digital health governance rarely situate issues within a human rights framework, let alone a child rights framework. The specific needs, rights, and aspirations of children are frequently overlooked.²⁰⁹ Furthermore, digital initiatives often reproduce problematic assumptions about children and their needs, framing them in deficit terms as either disproportionately at risk or as a source of risk to others and themselves.³¹¹

Efforts to build more robust, child-rights responsive digital health ecosystems can draw from the UNCRC, the most widely ratified treaty in the history of human rights.³¹² The UNCRC, along with its accompanying Optional Protocols and general comments, provides a ready-made framework to support ethical and effective digital health decision making that supports the rights of children everywhere.

General Comment 25, adopted in March, 2021, provides governments and other actors with specific guidance on fulfilling their obligations under the UNCRC in relation to the digital environment.³¹³ The guidance encourages governments to: use digital technologies to promote healthy lifestyles by facilitating children's access to health services and information; prevent the spread of misinformation, materials, and services that might damage children's mental or physical health; prioritise the best interests of every child in the provision, regulation, design, management, and use of digital health technologies and services; invoke legislative and regulatory powers that tackle known digital harms, such as

unhealthy engagement in social media and the marketing of unhealthy products; and ensure that children's rights are respected and protected by all organisations that collect or process their data.

In line with the UNCRC's guidance, approaches to digital health must help to progressively realise children's rights, balancing individual rights and collective benefit. The global digital health community must acknowledge the indivisibility of all children's rights, and the impossibility of considering children's right to health in isolation.

Realising the aspirations of the UNCRC in the domain of digital health will require action in three areas. First, digital health governance must create space and opportunity for ongoing, meaningful engagement of children themselves to help build children's trust in digital health systems. Second, states, businesses, and other digital health actors must commit to children's rights and routinely account for children's needs, desires, and aspirations in their approaches to digital health and the capture, storage, and usage of children's digital health data. Third, regulation, legislation, and processes of remedy for children in relation to digital health must be strengthened to account for children's rights.

A child rights-focused ethical framework to specifically guide the design, implementation, and evaluation of digital health initiatives that affect children would constitute an important advance in the quest to protect, respect, and remedy children's rights within the digital health ecosystem. However, such a framework will need accompanying internationally agreed standards put in place and periodic child rights impact assessments. Moreover, the framework must be urgently and systematically activated across the field of practice internationally, before systems, processes, and industry practices further sediment.³¹⁴

audits, and the obligation of notifying data breaches without delay).

In particular, it might be important for governments and development partners to invest in the capacity and training of offline intermediaries (eg, civil society organisations, bureaucracies, the health workforce, and local government officials), to help them understand and navigate the potential harms and risks arising from the use and sharing of health data. These offline intermediaries could act as data stewards, coordinating data sharing and management, and supporting the implementation of data solidarity approaches. In addition, intermediaries could also become reliable points of contact for communities that have been marginalised by technology because of barriers to access, scarce resources, privacy risks, and algorithmic exclusions. For example, intermediaries that already exist in communities could help people negotiate better on questions of digital technologies, including by supporting greater public

sector transparency, acting as watchdogs in case health data are used for other purposes (eg, surveillance), and facilitating access to redress mechanisms.

Taking a more anticipatory perspective, the need for action in relation to the governance of technology development is important to recognise, with a focus on strengthening transparency and accountability requirements around explainability,³¹⁶ fairness, patient safety, and the validation of use applications of emerging AI and machine learning tools. At present, the main multilateral attempt to develop a standard-setting instrument is UNESCO's work on recommendations on the ethics of AI,³¹⁷ but a 2019 review article identified 84 documents containing ethical principles or guidelines for AI—88% of which were released after 2016.³¹⁸ In health, WHO recently published its own guidance on the ethics and governance of AI applications, which endorses six ethical principles aimed at governments, developers, and users.³¹⁹ Although the guidelines largely

restate concepts that are contained in existing documents,^{320,321} the principles are specifically formulated from a health and health-care perspective, and could thus serve as the basis upon which value-based governance frameworks for digital health are built at national and subnational levels.

Enfranchising communities and advancing public participation
Beyond the protection of health and digital rights, there is also a need for forms of inclusive governance that enable individuals and groups to actively participate in and cocreate the design and implementation of digital health policy and technology, and to feed back to decision makers, development agencies, and private companies. Civic technology models, which broadly refer to the cocreation and use of digital technologies (eg, online dialogues and citizen consultations, open government data and open source software, and participatory design tools and processes) to improve public participation in democratic and decision making processes, are increasingly seen as enablers of improved public policy and service delivery, including in health.³²² In particular, civic technology models can help counteract interdependent burdens of health and digital divides and address the risk of exacerbating existing inequalities through digital applications.³²³ Participatory design solutions, open-source models, open datasets, and solidarity-based approaches to data management for the common good must be an integral component of such efforts. For example, civic technology approaches based on open data, such as the data visualisation tools deployed in Taiwan during the COVID-19 pandemic,³²⁴ might be used to complement top-down decision making,³²⁵ and therefore, increase trust in public health responses. Similarly, the role of local public health observatories³²⁶ could be leveraged to harness the active contribution of civil society to the collection of data needed for precision public health, and ensure that such data are managed transparently and used to solve local problems.

Children, young people, women, and other marginalised communities must be at the forefront of these governance transformations. The involvement of these groups is crucial in strengthening trust, promoting context-aware solutions to public health challenges, reducing built-in biases and inequalities in digital applications (including by advocating for equity frameworks for technology development and digital spaces, such as decolonial and feminist approaches),³²⁷ and building community resilience to future changes.

However, civic technology models that are focused on communities and user needs are not possible without governments taking an active role in shaping collaborative ecosystems that enable data reuse and accessibility and are designed with public good goals in mind—what some authors have referred to as digital public infrastructures or digital public spaces.³²⁸ This challenge is also captured by the concept of government as a platform, which has been

adopted by the OECD to support a culture of digital governance built on principles of transparency, integrity, accountability, and stakeholder participation.^{322,329} In the context of health, the 6th OECD Expert Group Meeting on Open Government Data has recently emphasised the importance (and challenges) of governments acting as publishers of open data to support enhanced collaboration in the COVID-19 response.³³⁰ The urgency of such collaboration is emphasised by the many experiments in participatory design that have already arisen during the pandemic, helping governments reach communities while supporting government accountability, helping debunk misinformation and disinformation, and enabling quick citizen feedback on public service delivery. For these experiments, open government data has been necessary, and has provided opportunities for transparency and bottom-up accountability.³³¹

Similar approaches could also more directly involve patients and community groups in the development of digital health applications,³³² as user-led design has increasingly been shown as a crucial means to increase their effectiveness, usability, and relevance.^{333,334} For example, such approaches might entail new forms of patient engagement through crowd sourcing, involvement of patient organisations, or the integration of stronger qualitative components in product trials.³³⁵

Governing digital transformations of health with regions and cities

A democratic and distributed governance model for digital transformations of health will inevitably have to leverage the role of local communities and subnational authorities, including cities. Essential entry points to governing health futures, including participation and enfranchisement of individuals, young people, respect of ethics and human rights, and high levels of digital trust and solidarity, are only achievable through community-based strategies built upon local needs, ownership, and priorities.³³⁶ Regions, cities, and other local authorities can thus play an important role in governing digital transformations of health to create public value for their inhabitants.

Cities around the world have increasingly promoted open government practices and civic technology models as part of a broader push towards city-level technological and data sovereignty, which could be seen as a form of data solidarity that simultaneously seeks to ensure the individual control over creation, access and use of data, and the rights of a community to manage such data for common purposes and data-driven city policies. For example, the 2017–20 Digital Barcelona Plan focuses on an open and efficient government that uses technology to transform and digitally innovate the public sector on the basis of the use of free software, the adoption of free data standards, and open, interoperable public data infrastructure.³³⁷ More broadly, initiatives such as Cities for Digital Rights and the Digital Cities Toolkit, supported by

UN-Habitat, have started to articulate overarching frameworks for similar city-level data strategies, which should be based on: data reuse and open-source licenses; the maximisation of the quality, integrity, and security of data; data management that promotes care throughout the data's life cycle; the respect of privacy and ethical considerations by design; the promotion of open data and civic participation; city residents' control over data through data commons or other forms of data stewardship; and the development of an interoperable data infrastructure.³³⁸

From this perspective, the COVID-19 pandemic has highlighted the relevance of city-level use of digital technologies for health purposes,³³⁹ but also exposed a series of crucial challenges, and particularly the need to develop better coordination between central and local governments. Absence of clear leadership and responsibilities, lack of skills, resources, and common standards for data management, and long-standing problems of data quality and interoperability, have all been described as hindering the timely release and use of public health data.³⁴⁰

Informing patients and enfranchising citizens

At a broader societal level, there must be active engagement in the digital health domain to ensure that patients, consumers, and citizens can make informed choices. In other words, public sector actors should target technical and literacy skills in digital health to avoid the risk of widening the gap in health between different societal groups, thereby further hindering levels of societal trust and increasing social and health inequities. The importance of digital health skills for transforming UHC stretches beyond the health workforce. Civic and digital (health) literacy are also fundamental enablers of public participation and informed citizenry, which can contribute to advancing social justice and health equity.

Individual initiatives seeking to improve digital health literacy among patients have progressively emerged.^{341,342} However, a strong link between these efforts and broader health system strengthening objectives is missing. To contribute to a transformed UHC, digital skills and literacy programmes should also be actively deployed to bridge health inequalities (eg, by helping individuals living in remote areas and elderly citizens to access tele-medicine solutions) and lead to increased participation in design and implementation.

In the age of misinformation fuelled by social media, building digital health literacy among patients also means having a strong public communication policy in all health subjects, including in the use of digital health technology. In the context of the COVID-19 pandemic, multiple attempts to develop such a communication policy were undertaken by WHO and the health ministries of several countries, often in collaboration with social media platforms, such as Instagram, Twitter, and Facebook. These initiatives were aimed at fighting

misinformation campaigns and promoting reliable health information.³⁴³

Beyond specific campaigns and public-private partnerships, however, governments and international organisations should also consider more institutionalised and coordinated approaches to protect democratic processes that enable citizens' agency and readiness, including the fight against online disinformation, the upholding of an informed public debate, and the protection of free and fair elections from cyber threats.³⁴⁴

Enacting data solidarity as part of a new social contract

A solidarity-based approach to health data must urgently emerge as a new public health dimension. At the global level, enacting health data solidarity depends on the effective regulation of power asymmetries through digital cooperation. At the level of national governments, research institutions, and the private sector, health data solidarity also requires a clear statement of the public health goals to be achieved through data collection, and full transparency on how data sharing will lead to better health of individuals and the community in which they live. Health data solidarity also requires establishing data institutions governing the exchange and storage of the respective data, and institutions to which people who claim to have been harmed by data use can appeal.

Meeting global challenges through digital cooperation

Many optimistic visions fail to recognise how countries might follow different pathways to realise the affordances of digital technologies due to the absence of common underlying values and a tendency to use technology for economic and geopolitical purposes.³⁴⁵ Similar dynamics might lead to further fragmentation of governance approaches and erosion of multilateralism.³⁴⁶

Digital transformations that run counter to the global good potential of digital health, including supporting higher concentrations of market power and unfettered access to and control of data,³⁴⁷ fundamentally collide with the vision of UHC futures. The world must thus act urgently to address global power asymmetries through a digital commons architecture that addresses data extraction. Digital cooperation should support a greater shift towards a vision of health data and data for health that is based on data solidarity.

The governance choice must be to advance a digital cooperation architecture that harnesses the potential of digital technologies for the global good. A high-level panel appointed by the UN Secretary-General has proposed a digital commons architecture as one of three potential architectures to support such cooperation, together with the so-called Internet Governance Forum Plus, and a distributed cogovernance architecture.³⁴⁸ These options have been recently reiterated in the UN Secretary-General's Roadmap on Digital Cooperation, with the Internet Governance Forum Plus gaining the most traction in international negotiations.³⁴⁹

In the context of health, a digital cooperation architecture could level the playing field for all stakeholders, allowing for cross-cutting participation, promoting data trust architectures between individuals, health providers and policy makers, and providing some regulation guard rails through guidance on human rights, data protection, and interoperability. A distributed cogovernance model or digital commons architecture (as opposed to the Internet Governance Forum Plus) would bring a greater shift towards a vision of data that are pooled in local contexts for local use-cases, before extending outward for broader access. These types of models would also require a greater private sector mindset shift, whereby value would be not in hoarding data but in data imagination (eg, new use-cases, algorithms, and user interfaces that are tailored to health-care workers or patients in specific contexts), and would rely on existing governance initiatives rather than support the development of new regulations and contracts in which there is risk of time being wasted on building consensus.

For more on OpenHIE see
<https://ohie.org>

Defining health data and principles on the basis of data solidarity

Although specific principles for data governance in health care have been advanced by international institutions, such as the OECD,³⁵⁰ unpacking health data governance frameworks from the broader data governance models that have emerged in different societal contexts, ranging from the EU GDPR³⁵¹ to the Cybersecurity Law adopted in China in 2017, remains difficult.³⁵² Different types of health and health-related data might be defined differently across different pieces of legislation and subjected to different regulatory requirements, due to the absence of a widely agreed notion of what health data actually consists of.

A first step to build health data solidarity must thus be an attempt to distinguish public interest from private interest in data use. For example, the EU's GDPR provisions on health data foresaw the special public significance of this type of data in public health emergencies, long before the COVID-19 pandemic. Although criticised for its lack of clarity,³⁵³ the GDPR opened the possibility of permitting the processing for reasons of public health of certain categories of personal data without the consent of the data subject, but also recognised the right of EU Member States to pass additional protective legislation relating to the processing of genetic data, biometric data, or data concerning health.

A second, resulting step consists in the development of a clear international taxonomy of health data that can be used to diversify the levels of protection and the rules governing their use and sharing while mediating among existing national approaches. These approaches range from the privacy-oriented one adopted by the GDPR and in legislatures around the world (including India, Japan, Australia, Canada, the UK, and California, USA) to the one defined by the 2017 Chinese Cybersecurity Law,

which affords the government greater powers in monopolising and centralising data flows.³⁵⁴ Under a similar taxonomy, health and health-related data could be diversified either according to their health purposes (eg, health data proper in regards to data for health) or to their official, collective, or privy (eg, related to people but not collective and not in need of being authenticated) nature, mirroring a proposal by Snower and colleagues.³⁵⁵

A third step is clear taxonomy of health data and related regulatory proposals that could underpin attempts to establish international standards for health data interoperability, an absence that has been described for years as a major roadblock to the development of learning health systems.³⁵⁶ Such standards could build on existing efforts to create health information sharing architectures through an open and collaborative approach, such as the one adopted by the OpenHIE community of practice. In turn, they could also support emerging efforts to establish interoperable cross-country infrastructures for data access, such as the one envisioned by the European Commission in anticipation of its 2021 proposal for a European Health Data Space.³⁵⁷

Lastly, globally agreed rules on the sharing of health and health-related data would also be important for realising another cross-border dimension of data solidarity, namely the transparent sharing of data during public health emergencies and pandemics. From this perspective, the COVID-19 pandemic has laid bare the limitations of the International Health Regulations' provisions on information sharing,³⁵⁸ and prompted urgent calls for the inclusion of data sharing issues in the fledgling negotiations on a potential pandemic treaty under WHO.³⁵⁹

Building data institutions for data solidarity in health

Solidarity-based approaches to health data can only emerge if people and organisations trust that shared data are not misused or stolen during the time they remain available for those who need it. Moreover, such approaches need to overcome existing challenges hindering the transparent and timely sharing and oversight of health data for medical and public health research. These challenges, which have become particularly visible during the COVID-19 pandemic, include compliance with data protection requirements but also extend to broader cultural and economic incentives for monetising data.³⁶⁰

Governance proposals have thus started to emerge on the need for new data institutions (within and beyond the health sector) that could take over this data stewardship role to build trust, protect data security, rebalance power in the data economy, and address the dualism that exists between the individual right to privacy and the increasing need for data-solidarity approaches.

Innovative data stewardship models are being tested in different contexts,³⁶¹ and although the evidence base is still poor, the first indications are that they can be effective in enabling people to better control and manage their data and deploy it for personal and common purposes, also in

health.³⁶² Data trusts, for example, have been defined as legal structures that provide independent stewardship of data, aggregating data from multiple sources and deciding who has access, under what conditions, and to whose benefit.³⁶³ By contrast, data cooperatives allow data subjects to voluntarily pool their data together,³⁶⁴ retaining control over how such data are managed for mutual benefits and how these benefits are shared.³⁶⁵

In the health sector, the different models that have been explored involve public data trust approaches (eg, Sweden's electronic health records model, which allows citizens to view their medical data and see who accessed it on a national electronic health record),³⁶⁶ public benefit data trusts that manage data provided voluntarily for a public purpose (eg, local public health observatories that use neighbourhood data on environmental quality gathered through citizen science initiatives), and various forms of data research trusts in which health data coming from different organisations are made available securely to health professionals, researchers, or the private sector for research purposes (eg, the Health Data Research UK). At the international level, one such example is the International Digital Health and AI Research Collaborative, a new initiative that is currently being incubated as a neutral, trusted, and multistakeholder platform for a distributed and collaborative approach to data use in global research collaborations, with the aim of bringing focus to emerging digital health capabilities and networks in LMICs.

More broadly, several think tanks and non-government organisations have suggested similar attempts to address imbalances in the data economy and underline the collective and community dimensions of data rights. These proposals start from the premise that privacy-related harms (including gender bias and discrimination) are often community harms, which affect broader groups of people. At the same time, community-based solutions to data stewardship might increase trust in, and acceptability of, specific secondary uses of personal data for public purposes, and pooling data rights might ensure better bargaining with technology companies and generate value for communities. Therefore, these proposals suggest the need for community-based data trusts, whereby the trustee would consist of a representative body for that community or, according to some, of local or central governments themselves.³⁶⁷

Finally, the emphasis put on increased individual control and risk minimisation in many current health data governance systems, as useful as this approach has been to date, is most likely to also engender problematic expectations for data subjects, especially given uneven levels of digital literacy globally and between generations. As a result, it might become important for health care and research organisations to establish bodies with health data stewardship responsibilities, including harm mitigation functions, such as the capacity to provide

redress to individuals who can plausibly make a case that they suffered substantial and undue harm by data use, and that of monitoring harms reported as being caused by big data practices.³⁶⁸

Investing in the enablers of a digitally transformed UHC

Governing data-driven transformations of health must ultimately aim to strengthen UHC. To do so, governments must capture the potential of digital approaches to increase connectivity between actors (ie, patients, providers, payers, and policy makers) and health system components (eg, drugs and commodities, workforce, information, financing, and leadership) in the national digital health ecosystem, with the objective of shaping a digitally enabled UHC.

Increasing country ownership of digital health strategies

Countries are at different stages in their journey to digital health maturity. Guides including the WHO-ITU eHealth Strategy Toolkit and the Digital Implementation Investment Guide have highlighted how considerations relating to leadership, strategic planning, and governance are among the important building blocks for the success and sustainability of such a journey. As more LMICs progress to higher levels of digital health maturity, they should thus take steps to drive their own digital transformations. As shown by the case of countries such as Tanzania, the development of a coherent health enterprise architecture and of a digital health investment roadmap, both of which can help the government, donors, and the private sector align their investment decisions with health system needs, is particularly important.³⁶⁹

At the same time, many national digital health strategies, including some of those discussed in panel 10, are often written and conceived by external consultants, highlighting the urgency of more neutral guidance and capacity-building activities. To succeed, these activities must address the expressed needs of the officials and professionals that they target—for example, by tailoring content to local contexts, including case studies and applied projects in the training curricula, incorporating advocacy and communication skills, and broadening their scope to include government and non-governmental actors beyond ministries of health.³⁷⁰

Donors, development partners, and global investors should encourage these efforts towards greater country ownership of digital transformations and implementation of national digital health strategies, including by ensuring that their investments are aligned with broadly agreed principles, such as the Digital Investment Principles. Among other things, the Principles call upon donors to prioritise investments in national plans that incorporate digital public goods, invest in sustainable country capacity for digital health governance and leadership, and support countries at a level that is appropriate to their level of digital health maturity. A digital health readiness assessment framework such as

For more on **Health Data Research UK** see <https://www.hdruc.ac.uk/about-us/>

For more on the **International Digital Health and AI Research Collaborative** see <https://i-dair.org>

For more on **Digital Investment Principles** see <https://digitalinvestmentprinciples.org>

the one presented in this Commission could be particularly suited for this purpose.

The development of national frameworks for health data governance represents another important component of broader efforts to increase country ownership of digital

health strategies,³⁷¹ especially as country-level definitions for health data and health data standards are still missing in many countries,³⁵⁰ and even electronic health records are not always part of integrated health information exchange systems.³⁷² In recent years, WHO has tried to

Panel 10: Approaches to digital health in the world's youngest countries

The Commission gathered information about approaches to digital health taken in different parts of the world, particularly in countries where young people younger than 25 years make up a substantial proportion of the population. Africa is a region of particular interest to the Commission because it is home to the countries with the largest proportions of young people aged 25 years and younger. Furthermore, almost a third of children younger than 15 years have been estimated to be living in Africa by 2030, the only region of the world where the population of children younger than 5 years is greater than the population of people older than 65 years.

Reviewing the content of a national digital health strategy provides a helpful overview of a country's vision and priorities for digitally transforming their health system; although, it does not necessarily reveal whether such vision and priorities have actually been implemented. The Commission reviewed the latest available digital health strategies for ten African countries with high youth populations: Cameroon, Democratic Republic of the Congo, Ethiopia, Liberia, Malawi, Mali, Niger, Nigeria, Tanzania, and Uganda. Through an analysis of each strategy's content, we sought to understand which level of digital transformation countries are focused on, and what kinds of governance challenges they have identified. We also assessed the extent to which children and young people are considered in approaches to digital health and whether the Commission's foundational entry points are being considered.

Nine of the ten countries had current strategies focused on some aspect of digital transformations of the health system at the time of our review. The latest available strategy of Mali was published in 2013 and is due for update. All ten strategies reflect their respective government's aspiration to use digital technologies and data to improve the performance of health systems and achieve better health outcomes for the population. The situation analysis within each strategy describes both important health challenges and relatively low levels of digital maturity. All strategies place strong emphasis on building the foundations required for the effective use of digital technologies and data. With the exception of Mali, all strategies draw heavily on WHO-ITU's 2013 National eHealth Strategy Toolkit and many strategies are structured according to the Toolkit's seven building blocks.

Each strategy has a strong emphasis on strengthening integrated health information systems to improve data collection and use for decision making. In the cases of Ethiopia, Liberia, and Malawi, health information systems are the primary focus of the strategy. In all countries, increasing the availability of high-quality data,

and the capacity of the health workforce to use that data, are recognised as essential for optimising the efficiency and effectiveness of health services. In addition to strengthening health information systems, all strategies outline plans to use telemedicine, mobile health, or eHealth tools to improve quality and increase service coverage, especially for underserved populations. Tanzania is unique in having a strategy that includes a reference and commitment to explore and research emerging technologies, such as artificial intelligence.

Although the national health strategies of all ten countries prioritise newborn baby, child, and adolescent health, none of the digital health strategies reviewed included any specific consideration of children and young people in the development and application of digital technologies or management of health data. The context sections of several strategies did reinforce that improved child and adolescent health are intended outcomes of digital health. Some also mentioned their country's young population and opportunities presented by so many young people entering the workforce to support the transformation agenda. None of the strategies referenced the involvement of children and young people in the development or monitoring of the strategy. Neither did any of the strategies allude to the potential risks to young people's health and wellbeing as a result of digital transformations.

Alignment with the Commission's foundational entry points varied across the ten strategies. Nine of ten strategies are aligned to the SDGs and the realisation of UHC. The exception is Mali's strategy, which predates the adoption of the SDGs and high-level political commitments to UHC. Eight of ten strategies explicitly reference equity as a core principle and the remaining two countries (Cameroon and Democratic Republic of the Congo) indirectly support the use of digital health to reduce health inequities through their alignment with an equity-focused national health strategy. Five strategies explicitly talk about the need for an ethical approach to digital health; one strategy (adopted by Liberia) references the need for users of health information systems to be trained in ethics; and the remaining four do not mention ethics. Only two strategies (adopted by Malawi and Uganda) outline a human-rights based approach. Two strategies (adopted by Mali and Niger) note that the Right to Health is enshrined in the country's constitution and one (adopted by Nigeria) references the Right to Privacy. Three strategies (adopted by Ethiopia, Liberia, and Tanzania) do not use rights language but indirectly talk about the need to protect individual privacy and confidentiality.

(Continues on next page)

(Panel 10 continued from previous page)

Only four strategies refer to the inclusion of communities. Two strategies (Ethiopia and Uganda) are explicit about the importance of involving communities in planning, implementation, and monitoring. Niger commits to civil society involvement in creating a legal framework for digital health. Although none of the strategies applied solidarity as a framework, Cameroon's and Uganda's strategies both recognise the need for approaches to data governance that balance individual and public health needs.

All ten strategies recognise the need for stronger governance of digital health and data. The legal and regulatory environment

for digital health is acknowledged to be weak in all countries, particularly in relation to protecting data security and confidentiality. Several strategies (Cameroon, Mali, Niger, Nigeria, and Uganda) note the existence of data protection laws but state that they are insufficient for governing health data. None of the strategies makes any reference to governing other aspects of digital transformations (such as the internet or digital health technologies) or the growing number of digital health actors that might have an effect on the achievement of health goals, particularly for children and young people.

develop a shared understanding about health data, with both Resolution 71.7 on Digital Health¹⁴⁴ and the WHO Draft Global Strategy on Digital Health 2020–2025,⁸ emphasising the importance of digital health ecosystems in which such data are simultaneously protected by high safety and security standards and seamlessly exchanged and shared for public interest purposes with the consent of patients and individuals. A similar attempt to define adequate data approaches for use in country-level health care has been done by the OECD, which defines eight elements that must be in place for good governance for personal health data, ranging from the presence of legal frameworks providing for adequate data protection safeguards to the use of best practices in data deidentification, and the periodic review of governance mechanisms to respond to the emergence of new data sources and technologies.³⁵⁰

At the same time, country champions that are accelerating digital transformations of their health systems through improved collection and use of data already exist. For example, Finland has started to update its legislative framework to regulate the secondary use of health data for research, public decision making, start-ups, and small and medium enterprises, creating a data permit authority.³⁷³ Other OECD countries that have developed health data governance frameworks to support the use of data held in electronic health records for monitoring and research purposes include (but are not limited to) Norway, Poland, Iceland, Denmark, and New Zealand.³⁵⁰ Lastly, non-OECD countries such as Tanzania are also making substantial steps to build on their existing work of digitalising health data and move towards greater integration and use of such data, as part of their broader digital health strategies.³⁷⁴

Financing digitally enabled health systems and identifying best buys

Aligning health systems with digital transformations can create additional burdens on health systems, especially in resource-poor settings and in the absence of substantial multistakeholder collaboration and overall integration of digital health solutions in wider governance

systems.³⁷⁵ To address financing issues, it will be important to both solve the challenges facing commercial models of digital health innovation and identify context-specific best buys in digital health, which include digital public goods.

The sustainable financing of digital health innovation is a crucial component of any effort to achieve UHC and ensure that the deployment of digital tools in fragile contexts and among vulnerable populations avoids placing additional burdens on the individuals who will be using them. There are numerous bottlenecks and market failures that prevent commercial models of digital health innovation from supporting UHC in LMICs, including the limited visibility of the demand for ICT services in unconnected areas, the need to subsidise initial costs or derisk private investments, and the fact that for many countries the most transformative digital tools are not frontier technologies but foundational solutions, including smartphones, interoperability standards, workforce and supply chain information systems, and privacy and security policies and practices.

This is why, besides large private actors, governments and donor countries (panel 11; figure 8)^{376–381} must be able to finance digital health innovation and a digitally enabled UHC through smart, mission-oriented investments, which strike a balance between supporting new solutions and connecting to (sometimes simpler) existing tools, thus contributing to bridging the digital divide. In other words, countries need to consider the place of digital health investment as part of wider health system financing and national digital health strategies. A costed digital health investment roadmap, together with a strategy for planning, costing, and implementing digital health applications, such as the Digital Implementation Investment Guide developed by WHO in 2020,³⁸² might help countries prioritise those best buys that lead to actual improvements in productivity or cost savings, while allowing the possibility to reallocate the budget to other areas of needs.³⁸² Adopting such a roadmap would be particularly important for those countries that are in the early stages of their digital health maturity, and often have a tremendous challenge

moving from digital health interventions driven by external donors and partners towards domestic ownership of digital transformations of health. Best buys in digital health, in this sense, are necessarily context-specific, require interoperability with the systems already in place, and must be preceded by basic building blocks, such as ICT infrastructures, digital identification systems, skills development, and legal frameworks.

At present, the evidence base for best buys in digital health is still small and must be expanded. At the most basic level, investing in public goods, such as disease prevention and surveillance tools, should be considered a priority over treatment, because the relevant software is usually low-cost and can support decision making. Similarly, even when moving to next-level investments in treatment and diagnostics, which involve a greater involvement of the private sector, it might be more cost-effective and impactful to direct public resources towards interventions that are supportive of UHC and can be made available to all, rather than necessarily on the most advanced technologies.

In this context, an important role is already being played by digital public goods, which are defined as open-source software, open data, open AI models, open standards, and open content, which adhere to privacy and other applicable laws and best practices (and to the principle of do no harm), and help to attain the SDGs.³⁴⁹ The promotion of digital public goods, as a complement to, and foundation for, commercial solutions, is increasingly considered a key enabler of a transformed UHC. Many of the first applications of the concept have indeed been in the context of health, such as the DHIS2 health information system,³⁸³ the OpenMRS electronic medical records system, and the iHRIS software for health workforce information. Countries, such as Tanzania³⁸⁴ and Rwanda,³⁸⁵ have already begun to roll out such tools as part of wider pushes to develop interoperable health information exchange systems. However, scaling-up the contribution of digital public goods to UHC will largely hinge on the extent to which existing platforms will be used to enable the development, financing, discovery, sharing, and adaptation of such technologies across multiple countries, as suggested by the report of the UN Secretary-General's High-Level Panel on Digital Cooperation.³⁴⁸ The number and reach of initiatives in this field is rapidly expanding. WHO explicitly frames its Digital Health Atlas as a global public good that enables users to improve the planning, use, and coordination of digital health information systems through an open-source technology registry platform. At the same time, multistakeholder collaborations, such as the Digital Public Goods Alliance and the 2016–2026 Digital Square initiative aim to facilitate the discovery, development, use of, and investment in digital public goods. For example, Digital Square has supported 27 digital public

goods for health, and released a Global Goods Guidebook to showcase those that it has approved for investment.³⁸⁶

Preparing a new digitally literate health workforce for digital transformations

There can be no UHC transformation and no digital transformations of health without policies that accelerate the education, training, and awareness-raising of current and future health professionals, policy makers, and regulators. Building digital skills in the health workforce means creating many opportunities for youth employment at the intersection of health and digital transformations.

To achieve a digitally enabled UHC, it will be crucial to harness and build the digital skills of young people, whose employment as health and social care workers has risen substantially in the past few decades and who are projected to fill most of the newly created health and social care sector jobs.³⁸⁷ Initiatives, such as the WHO Global Health Workforce Network's Youth Hub, emphasise that the future workforce that will deliver UHC and achieve the SDGs will be a young and largely female workforce, but for this to happen, governments must substantially invest into the education, training, and employment of health workers, and particularly of women and girls.

Training curricula are key tools for building the digital health and data literacy of the health workforce, including social workers and care workers, but also of health policy makers and regulators. Some examples of curriculum updates (or initiatives that promote such updates) already exist, but they must be scaled up and integrated in broader educational frameworks for health professionals.³⁸⁸ Life-long training programmes must include periodic updates on new technological developments and protocols, and more generally build the digital skills for health professionals by equipping them with the capabilities and tools they need to provide higher quality and more patient-focused care, especially in rural and remote areas. Even beyond health professionals, however, there is a need to build the common knowledge base of a new digital health workforce that can scale and sustain digital transformations of health—for example, in the areas of health information management and health informatics.³⁸⁹

Recommendations

Health futures are being decided now. Our world is being confronted with many overlapping threats and crises. Of particular concern is the little progress on the achievement of the SDGs—which have been further pushed back by the COVID-19 pandemic—not only in relation to health but also including issues such as access to clean water and sanitation, gender equality, education, poverty, inequality, environmental stewardship, and climate action. At the same time, health futures are also being shaped by digital transformations of information and communication, education, commerce, work, social

For more on **OpenMRS** see <https://openmrs.org/>

For more on **iHRIS** see <https://www.ihris.org/about>

For more on **WHO's Digital Health Atlas** see <https://digitalhealthatlas.org/en/-/>

For more on the **Digital Public Goods Alliance** see <https://digitalpublicgoods.net/about/>

relationships, and in health and health care. Business models based on increasing data extraction and concentrations of power, together with governments' use of digital tools for surveillance purposes and human rights infringements, are defining features of these transformations.

Digital transformations carry extraordinary potential to improve health, reduce health inequities within and between countries, close gender gaps, protect the most vulnerable, and strengthen democratic participation. To leverage these opportunities, all public and private stakeholders should contribute to the development of a governance architecture based on democracy, equity, solidarity, inclusion, and human rights. Innovative forms of stewardship, regulatory frameworks, and accountability can no longer be deferred until we know more—they need to be prioritised now, especially in light of the substantial risks involved.

In particular, this Commission urges action in four main areas that all stakeholders can contribute to by 2030 to ensure that digital transformations are harnessed for sustainable health futures. We use 2030 as the ultimate deadline for our recommendations, to coincide with the original vision of the Commission, but also to highlight the tightly knit interface that exists between the governance of digital health and the achievement of global goals around UHC and the SDGs. Simultaneously, we recommend shorter deadlines for specific actions, which we believe are especially urgent, foundational, or achievable within a different timeframe.

Whenever possible, we suggest that our recommendations are taken forward and incorporated within existing monitoring and accountability frameworks, leveraging the role of multilateral forum, such as the UN General Assembly, the World Health Assembly, or the OECD. However, we also underline the urgency of developing new forms of participatory and bottom-up accountability, including by equipping transnational multistakeholder coalitions, civil society organisations, health workers associations, patients' networks, and local government officials to act as stewards and watchdogs for digital transformations of health.

Addressing the role of digital technologies as determinants of health

Digital transformations—or the exclusion from their affordances—are already affecting all peoples and all areas of life and health. The effects of digital technologies, platforms, and services as crucial determinants of health are important to consider, and their influence on other determinants is important to address.

All public and private actors should urgently scale up their investments in health, education, the future of work, and climate action, and strive to close the global financing gap for the achievement of the SDGs by 2030. These investments should be seen as a necessary baseline

Panel 11: Development assistance for digital health

In contexts in which development assistance constitutes a crucial component of the health economy, the usefulness of digital technologies for improving public health and health-care systems is increasingly highlighted by donor and partner countries alike. Many donor countries have developed strategic documents for how to use digital technologies in their work.^{376–378} Specifically for health, however, the strategic backing is less structured, with the US Agency for International Development being the only development agency having published a strategy specifically for digital health in 2020, called Vision for Action in Digital Health.³⁷⁹ The second largest donor country, Germany, mentions digital technologies in its 2020 Global Health strategy as a means of strengthening health systems, but a coordinated plan across the country's global health activities has not been formulated.³⁸⁰

The extent to which these intentions are followed through with investments and project support in partner countries has not been analysed systematically to date. Building on data from the OECD Creditor Reporting System, a novel approach based on machine learning was used to understand the volume of bilateral development assistance projects of the G7 countries that use digital technologies in general, in health, and with youth as a beneficiary group in mind. The fundamental idea of this approach is to relabel each project according to the project descriptions that are self-reported by the donor countries and harmonised by the OECD Development Assistance Committee.

Figure 8A summarises the headline findings of the research and presents aggregates for the total bilateral G7 disbursements official development assistance projects. In the period from 2016–18, the G7 disbursed annually on average around \$95 billion for bilateral official development assistance projects. Only around 1.4%, or \$1.31 billion, included digital technologies in one way or the other. A sizeable share of these projects was related to projects in the health sector (or had a health-related goal). Almost a third (\$424 million) of the investment volume in digital technologies is health related. Many of these projects have children and young people as beneficiary groups (37% or \$157 million).

Looking at the results by donor country, large differences among the G7 countries become visible (figure 8B), with Canada and the USA retaining relatively high shares of investments with digital technologies (4.2% vs 2.2%).

A country-wise analysis is also insightful when it comes to the share of health-related projects that explicitly mention digital technologies (figure 8C). Particularly, the UK, with investments worth more than 8% of the bilateral official development assistance for health going into projects that use digital technology (about \$62 million annually in the observed time window).

Although data limitations and the analytical approach imply that these numbers are likely to be lower estimates of the actual investment volumes, they provide a quite drastic difference in the donors' focus on digital health as part of their development assistance.

OECD=Organisation for Economic Co-operation and Development.

for ensuring sustainable health futures in the face of digital transformations.

Governments, in partnership with private sector and civil society, should also close all digital and health divides by 2030, including by achieving universal, affordable, safe, and meaningful connectivity as a human right and a public good, as it will substantially enable the provision of other public goods (including UHC) and will help countries progress more rapidly to higher levels of digital health maturity.

Public actors must stimulate investment and innovation towards health transformations and UHC.

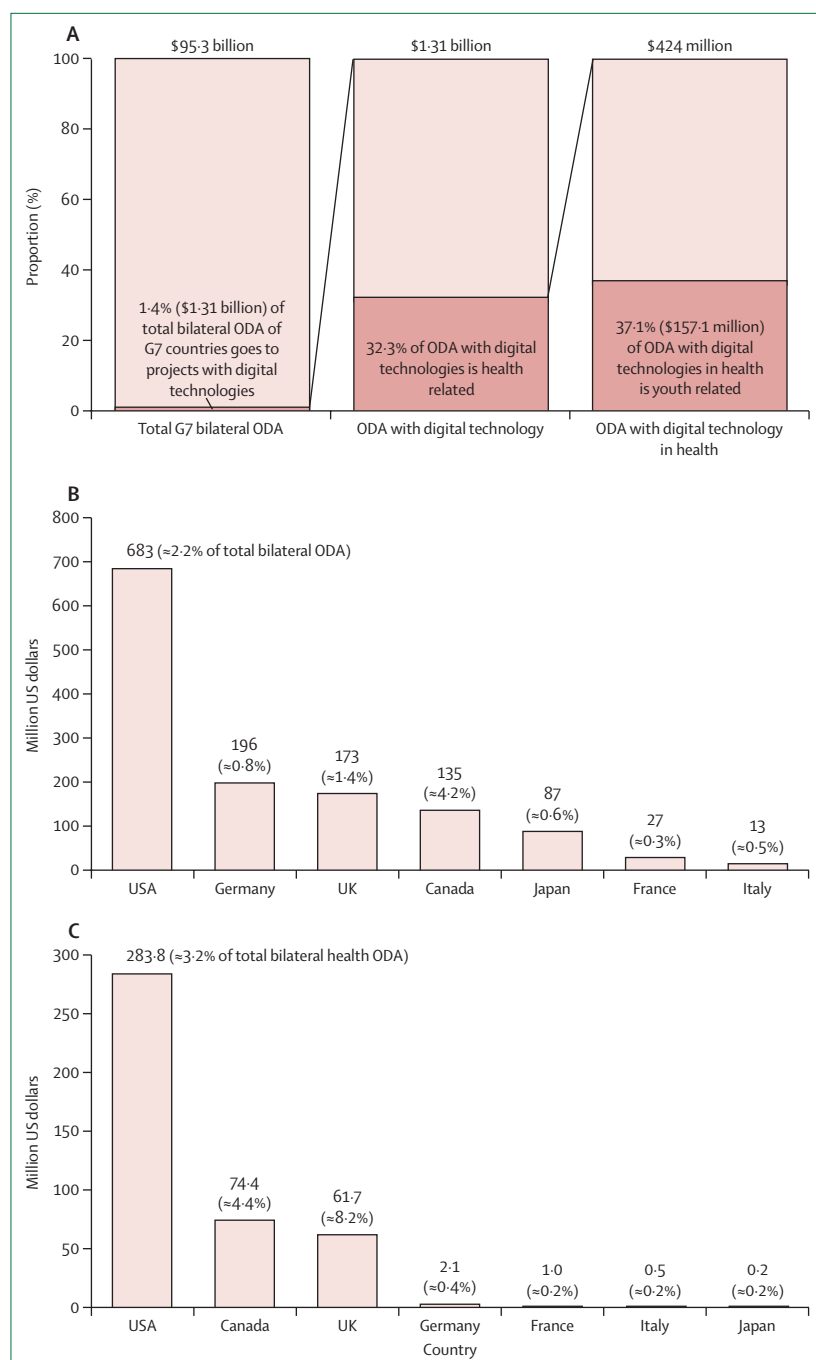


Figure 8: Digital technologies and health in official development assistance

(A) Bilateral ODA from G7 countries with a focus on digital technology, digital technology in health, and youth-related digital technology and health activities in relation to total ODA (average annual disbursements in the period between 2016 and 2018). (B) Bilateral ODA with a digital technology focus by donor country per year (average annual disbursements between 2016 and 2018, in million US dollars). (C) Bilateral ODA with a digital technology and health focus by donor country per year (average annual disbursements between 2016 and 2018, in million US dollars). The numbers are limited to projects falling under the categories of ODA Loans, ODA Grants, and Equity Investment. Data used for analysis are based on OECD CRS Bulk Data.³⁸¹ ODA=official development assistance.

By 2023, all governments should have updated their programmes and policy frameworks in the area of research, technology, and innovation to ensure that

they reflect the twin priorities of shaping new markets in digital health while fighting the trends towards the increasing concentration of power and agency in the hands of big, private technology companies.

Research institutions and youth organisations should expand the knowledge base on the effects of technologies and algorithms on health and wellbeing, including by launching a multidisciplinary, longitudinal, multicountry study on the effects of digital transformations on children and young people.

Building a public trust architecture for digital transformations of health

Building digital trust among all stakeholders of the digital health ecosystem arguably represents the most urgent area of action for governing health futures, as its positive effects will cut across (and facilitate the uptake of) all other interventions recommended in this report. We urge a whole-of-society effort, which stretches from ministries of health and representatives of health professionals and patients to local governments and private companies.

By 2025, all governments should adopt country-wide strategies to safeguard health and digital rights, including regulatory measures to protect children and young people against online harms, training of offline intermediaries to act as health data stewards, and promotion of strong transparency and accountability requirements for emerging AI and machine learning applications in health.

All national and local governments should enfranchise communities and advance public participation in the codesign and implementation of digital health policy and technology—for example, through public consultations, open data strategies, and forms of bottom-up accountability and oversight in relation to the use of health data by public and private actors.

By 2030, all national and local governments should codevelop strategies for a democratic and distributed governance model for digital transformations of health, which leverages the role of regions and cities. This strategy should include policies and investments to improve data interoperability, clear allocation of responsibilities, common standards for data management, and the training of local government officials to act as health data stewards at the community level.

By 2030, all governments should also implement large-scale civic and digital health literacy efforts as part of national education, health, and digital strategies. These include platforms and initiatives that harness people's civic engagement and active participation in cocreating health data, digital tools, and health narratives that help fight health disinformation. Governments should also urgently develop new areas of public health legislation by regulating business practices and algorithms that contribute to misinformation and disinformation in health and health care.

Enacting an approach to the governance of health data on the basis of data solidarity

A solidarity-based approach to health data has three key components: giving people a greater control over their data as active decision makers, ensuring that the value of data is harnessed for public good, and moving society towards equity and justice by counteracting dynamics of data extraction. There are several specific steps that stakeholders might take to strengthen health data solidarity, in addition to other actions highlighted in these recommendations that would also have a positive effect.

Building on ongoing multilateral discussions about the future of global digital cooperation, the UN General Assembly, the UN Secretary-General's Envoy on Technology, and the Internet Governance Forum community should strive to advance a digital cooperation architecture on the basis of the concept of digital commons, with the objective of addressing concerns around data extractive practices and promoting data trust architectures in health between individuals, health providers, and policy makers.

By 2023, under the aegis of WHO and in collaboration with private sector stakeholders and civil society organisations, governments should develop a clear international taxonomy of health data, globally agreed rules and processes for health data sharing, and international standards for health data interoperability. Of particular importance will be a commitment to increased transparency and compliance with health data sharing responsibilities during public health emergencies and pandemics.

By 2030, all countries should have in place data institutions, such as data trusts and cooperatives, that can help unlock the public value of health data while safeguarding rights; build trust in the process of health data sharing; provide opportunities for delivering redress from data misuse; and ensure that data users and intermediaries are held accountable. Health care and research organisations should also appoint health data stewards to ensure adherence to health data governance standards.

Investing in the enablers of a digital transformation of public health and UHC

Digital transformations can provide substantial benefits for health promotion, public health, and health care. Because of these benefits, digitally enabled health systems based on the Health for All values are a matter of great urgency for the achievement of UHC.

By 2025, all national governments should enhance the content and implementation of their digital health strategies, including by making use of a comprehensive digital health readiness assessment framework, such as the one proposed in this report, increasing country ownership of digital health strategies through building capacity for digital health governance and leadership, and adopting health data governance frameworks and

costed digital health investment roadmaps. Donor countries should incorporate these objectives in their official development assistance strategies, and together with other non-state development partners should ensure that all investments are aligned with the Digital Investment Principles.

National governments, in partnership with WHO and non-governmental organisations, should also develop the evidence base around the identification of best buys in digital health that are aligned with each country's levels of digital health maturity. These best buys might include foundational solutions and open-source digital public goods, which can enhance interoperability, avoid vendor capture, and provide the basis around the type of commercial models to build.

By 2030, all national governments, with assistance and coordination from relevant regional organisations, should have in place permanent programmes to support the life-long training of the current health workforce, and the training and education of young health professionals, to be well prepared for digital transformations of health and data-driven health systems.

Conclusion

In this Commission, we viewed digital transformations of health through the lenses of UHC and Health for All values. At the centre of our analysis is the redistribution of power and agency for the benefit of health. We require digital technologies that work for health, address its determinants, and build on broader efforts to overcome digital divides and achieve sustainable development. We also juxtapose a digital governance model on the basis of data extraction with one based on data solidarity, digital trust, accountability, and public participation, which we believe holds the key to advancing health equity and reconciling privacy concerns and public value. If governments were to adopt such an approach to governing digital transformations, it would give us hope for an era of progress towards sustainable health futures.

Secretariat of the *Lancet* and *Financial Times* Commission

Aferdita Bytyqi, Christian Franz, Whitney Gray, Louise Holly, Micaela Neumann, Lipsa Panda, Robert D Smith, Enow Awah Georges Stevens, Brian Li Han Wong

Contributors

All authors made contributions towards the scope, structure, intellectual content, and key messages of this Commission. All authors made contributions to specific sections of this Commission, reviewed and edited the drafts, and approved the final version. The work was done under the leadership of the Commission co-chairs (IK and AA). All authors and members of the Secretariat of the *Lancet* and *Financial Times* Commission have accessed and verified all the data in this Commission.

Declaration of interests

DP, IK, AA, and the Secretariat of the *Lancet* and *Financial Times* Commission report grants in support of the work of the Commission from Botnar Foundation, Children's Investment Fund Foundation, Wellcome Trust, Swiss Agency for Development and Cooperation, and Deutsche Gesellschaft für Internationale Zusammenarbeit. All other authors declare no competing interests.

Acknowledgments

We acknowledge Zulfiqar A Bhutta, Marelize Gorgens, Adele Waugaman, Effy Vayena, Githinji Gitahi, Priya Balasubramaniam, Peter Waiswa, Enrico Coiera, Srinath Reddy, Till Baernighausen, and Ania Calderon for the peer review of the report. We acknowledge Nick Couldry and Ulises A Mejias for their detailed expert responses on data governance and attending consultations. We acknowledge Sally Fawkes for contributing to panel 7 in the report. We acknowledge Urs Gasser, Sandra Cortesi, and Alexa Hasse for contributing to panel 5 in the report and their detailed expert responses. We acknowledge Astha Kappor for her detailed expert responses on health data governance. We acknowledge Baharak Courtney Doagoo, Renee diResta, Amanda Third, Benjamin Hancel, Catharine Fleming, Georgina Theakstone, Lilly Moody, Philippa Collin, Teresa Swist for contributing background papers that informed the work of the Commission. We acknowledge Cecilia Emilsson for her detailed expert responses on open government data. We thank the International Federation of Red Cross and Red Crescent Societies (IFRC) and the participants who contributed to the IFRC-led consultation on Enabling Digital Health Futures in Humanitarian Settings held over the course of four sessions on June 16–26, 2020. We thank the participants who contributed to the Geneva-based International Organizations' consultations held over the period of September, 2019, to April, 2021. We thank the participants, sponsors, and partners who contributed to the Youth Consultation in Lagos, Nigeria, on March 12, 2020, and PharmAccess for hosting, cosponsoring, and facilitating the workshop and consultation report. We thank Andrew Jack and all participants who contributed to the *Financial Times* national convenings in India on June 8, 2020, and in China on Sept 25, 2020, and to the Africa regional convening on Dec 2, 2020. We thank all the participants for attending and contributing to the consultation meetings at Wilton Park, Steyning, UK: the visioning the future: horizons for health and digital technologies meeting was held on Sept 3–4, 2020, and the equitable health futures in AI meeting was held on Oct 19, 2020. We thank the following organisations which contributed to the Wilton Park Governing Health Futures 2030 Youth Consultation: what do youth want to see in the future of health governance held on Jan 20–21, 2021: International Federation of Medical Students' Associations, Restless Development, Alaga Health, Commission on Population and Development Philippines, Experto PlayLabs, Youth and Media—Digitally Connected Network, Association of Schools of Public Health in the European Region, Young Experts: Tech 4 Health, Global Health Workforce Network, Politics4Her, UN Youth Envoy, Women in Global Health, IFRC, Youth LEAD, Global Health Young Professionals Initiative, Commonwealth Youth Health Network, Mentally Aware Nigeria Initiative, Young Team Caribbean and African Health Network, Junior Doctors Network, International Pharmaceutical Students' Federation, Australian Medical Student Association, Foraus (The Swiss Think Tank on Foreign Policy), Young Professionals Chronic Disease Network, Mentally Aware Nigeria Initiative, and the Canadian Nursing Students Association. We thank WHO, Beijing, China, and the China Academy of Information and Communications Technology for cohosting and supporting the Consultation on Digital Transformation in China on Jan 28, 2021, and extend special thanks to Gauden Galea, Mengji Chen, Shan Xu, and all the participants who contributed to the consultation. We thank the members of the IFRC Youth Commission (Aimé Gilbert Mbonda Noulou, Francisca Milena Chacón Retana, Marcel Štefánik, Shi Jie Chew, and Madzhit Kimuzaev) for sharing insights into young people's experiences of growing up in a digital world. We thank the members of Young Experts: Tech 4 Health (Ahmed Taha Aboushady, Kathryn Pundyk, Sahil Tandon, and William Wai Hoi Yeung) for their contributions to the development of the digital health futures readiness framework. Finally, a special thanks to our Commission partners from Wilton Park (Lisa Elvy, Wendy Head, Nancy Lee, Natalie Taylor) and Alison Dunn, Rapporteur, for hosting the consultations.

References

- 1 Patton GC, Sawyer SM, Santelli JS, et al. Our future: a *Lancet* Commission on adolescent health and wellbeing. *Lancet* 2016; **387**: 2423–78.
- 2 Clark H, Coll-Seck AM, Banerjee A, et al. A future for the world's children? A WHO–UNICEF–*Lancet* Commission. *Lancet* 2020; **395**: 605–58.
- 3 OECD. Global outlook on financing for sustainable development 2021: a new way to invest for people and planet. Paris: OECD Publishing, 2020.
- 4 Chauvin J, Perera Y, Clarke M. Digital technologies for population health and health equity gains: the perspective of public health associations. *J Public Health Policy* 2016; **37** (suppl 2): 232–48.
- 5 Hooft Graafland J. New technologies and 21st century children: recent trends and outcomes. OECD Education Working Papers No 179. Paris: OECD Publishing, 2018.
- 6 Martuzzi M, Tickner JA, eds. The precautionary principle: protecting public health, the environment, and the future of our children. Copenhagen: World Health Organization, 2004.
- 7 Kriebel D, Tickner J. Reenergizing public health through precaution. *Am J Public Health* 2001; **91**: 1351–55.
- 8 WHO. Global strategy on digital health 2020–2025. Geneva: World Health Organization, 2021.
- 9 US Food and Drug Administration. What is digital health? Sept 22, 2020. <https://www.fda.gov/medical-devices/digital-health-center-excellence/what-digital-health> (accessed March 26, 2021).
- 10 WHO. Social determinants of health? 2021. https://www.who.int/health-topics/social-determinants-of-health#tab=tab_3 (accessed March 26, 2021).
- 11 Precision Medicine Initiative Working Group. The precision medicine initiative cohort program—building a research foundation for 21st century medicine. Bethesda, MD: US National Institutes of Health, 2015.
- 12 WHO. Youth-centred digital health interventions: a framework for planning, developing and implementing solutions with and for young people. Geneva: World Health Organization, 2020.
- 13 Wong BLH, Smith RD, Siepmann I, Hasse A, Tandon S. Youth engagement in digital health: a critical perspective towards meaningful youth agency in governance. 2021. <https://www.medicumundi.ch/de/advocacy/publikationen/mms-bulletin/digital-health-a-new-era-of-global-health/kapitel-3/youth-engagement-in-digital-health-a-critical> (accessed March 28, 2021).
- 14 Governing Health Futures 2030 Commission. Youth statement and call for action. 2021. <https://www.governinghealthfutures2030.org/pdf/report/YouthStatementAndCallToAction.pdf> (accessed Oct 24, 2021).
- 15 Governing Health Futures 2030 Commission. Imagining Health Futures. 2021. <https://www.governinghealthfutures2030.org/imagining-health-futures-a-unicef-commission-initiative/> (accessed March 23, 2021).
- 16 UN General Assembly. Transforming our world: the 2030 agenda for sustainable development. New York, NY: United Nations, 2015.
- 17 Jamison DT, Summers LH, Alleyne G, et al. Global health 2035: a world converging within a generation. *Lancet* 2013; **382**: 1898–955.
- 18 Piot P, Abdool Karim SS, Hecht R, et al. Defeating AIDS—advancing global health. *Lancet* 2015; **386**: 171–218.
- 19 UN General Assembly. Political declaration of the high-level meeting on universal health coverage. General Assembly Resolution 74/2. New York, NY: United Nations, 2019.
- 20 Jamison DT, Summers LH, Alleyne G, et al. Global health 2035: a world converging within a generation. *Lancet* 2013; **382**: 1898–955.
- 21 Whitmee S, Haines A, Beyrer C, et al. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–*Lancet* Commission on planetary health. *Lancet* 2015; **386**: 1973–2028.
- 22 Office of Global Insight and Policy. Prospects for children: a global outlook through 2025. New York, NY: United Nations Children's Fund, 2021.
- 23 World Economic Forum. The global risks report 2021, 16th edn. Geneva: World Economic Forum, 2021.
- 24 Shroff ZC, Marten R, Vega J, Peters DH, Patcharanarumol W, Ghaffar A. Time to reconceptualise health systems. *Lancet* 2021; **397**: 2145.
- 25 Sonnier P. The fourth wave: digital health. Independently published, 2017.
- 26 de Silva J, Zweig M. 2020 Market insights report: chasing a new equilibrium. 2020. <https://rockhealth.com/reports/2020-market-insights-report-chasing-a-new-equilibrium/> (accessed March 29, 2021).

- 27 Working Group on Digital and AI in Health. Reimagining global health through artificial intelligence: the roadmap to AI maturity. New York, NY: Broadband Commission for Sustainable Development, 2020.
- 28 International Telecommunication Union. Assessing the economic impact of artificial intelligence. Geneva: International Telecommunication, 2018.
- 29 Safavi KC, Cohen AB, Ting DY, Chaguturu S, Rowe JS. Health systems as venture capital investors in digital health: 2011–2019. *NPJ Digit Med* 2020; **3**: 103.
- 30 Chilukuri S, Westra A. Digital R&D: the next frontier for biopharmaceuticals. London: McKinsey and Company, 2017.
- 31 TenCent. Bridging gaps in healthcare industry with technology. Nov 8, 2018. <https://www.tencent.com/en-us/articles/2200933.html> (accessed March 29, 2021).
- 32 Luthi B. Amazon launches Amazon Pharmacy to sell prescription drugs nationwide. Dec 4, 2020. <https://www.investopedia.com/the-impact-of-amazon-pharmacy-on-u-s-healthcare-5089736> (accessed March 29, 2021).
- 33 Storeng KT, de Bengy Puyvallée A. The smartphone pandemic: how big tech and public health authorities partner in the digital response to COVID-19. *Glob Public Health* 2021; **16**: 1482–98.
- 34 Wilbanks JT, Topol EJ. Stop the privatization of health data. *Nature* 2016; **535**: 345–48.
- 35 Christl W, Spiekermann S. Networks of control: a report on corporate surveillance, digital tracking, big data and privacy. Vienna: Facultas Verlags- und Buchhandels AG, 2016.
- 36 Pasquale F. The black box society: the secret algorithms that control money and information. Cambridge, MA: Harvard University Press, 2015.
- 37 Webster P. Digital health technologies and health-care privatisation. *Lancet Digit Health* 2019; **1**: e161–62.
- 38 The World Bank. World development report 2021: data for better lives. Washington, DC: The World Bank, 2021.
- 39 Bennett JE, Kontis V, Mathers CD, et al. NCD countdown 2030: worldwide trends in non-communicable disease mortality and progress towards Sustainable Development Goal target 3.4. *Lancet* 2018; **392**: 1072–88.
- 40 WHO. Inheriting a sustainable world: atlas on children's health and the environment. Geneva: World Health Organization, 2017.
- 41 Whitmee S, Haines A, Beyrer C, et al. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *Lancet* 2015; **386**: 1973–2028.
- 42 The Lancet. Generation coronavirus? *Lancet* 2020; **395**: 1949.
- 43 UN General Assembly. Impact of the coronavirus disease pandemic on contemporary forms of slavery and slavery-like practices: report of the Special Rapporteur on contemporary forms of slavery, including its causes and consequences. New York, NY: United Nations, 2020.
- 44 Robertson T, Carter ED, Chou VB, et al. Early estimates of the indirect effects of the COVID-19 pandemic on maternal and child mortality in low-income and middle-income countries: a modelling study. *Lancet Glob Health* 2020; **8**: e901–08.
- 45 Pfefferbaum B, North CS. Mental health and the COVID-19 pandemic. *N Engl J Med* 2020; **383**: 510–12.
- 46 UN General Assembly. Report of the Special Rapporteur on extreme poverty and human rights. New York, NY: United Nations, 2019.
- 47 UN General Assembly. The right to privacy in the digital age: report of the United Nations High Commissioner for Human Rights. New York, NY: United Nations, 2018.
- 48 Reinsel D, Gantz J, Rydning J. The digitization of the world: from edge to core. Framingham, MA: International Data Corporation, 2018.
- 49 Vayena E, Haeusermann T, Adjekum A, Blasimme A. Digital health: meeting the ethical and policy challenges. *Swiss Med Wkly* 2018; **148**: w14571.
- 50 Adjekum A, Blasimme A, Vayena E. Elements of trust in digital health systems: scoping review. *J Med Internet Res* 2018; **20**: e11254.
- 51 Livingstone S, Carr J, Byrne J. One in three: internet governance and children's rights. Florence: United Nations Children's Fund, 2016.
- 52 van Dijck J. Datafication, dataism and dataveillance: big data between scientific paradigm and ideology. *Surveill Soc* 2014; **12**: 197–208.
- 53 Dienlin T, Johannes N. The impact of digital technology use on adolescent well-being. *Dialogues Clin Neurosci* 2020; **22**: 135–42.
- 54 Gibbs L, Kornbluh M, Marinkovic K, Bell S, Ozer EJ. Using technology to scale up youth-led participatory action research: a systematic review. *J Adolesc Health* 2020; **67** (suppl): S14–23.
- 55 Middaugh E, Clark LS, Ballard PJ. Digital media, participatory politics, and positive youth development. *Pediatrics* 2017; **140** (suppl 2): S127–31.
- 56 Livingstone S, Haddon L, Vincent J, Mascheroni G, Ólafsson K. Net children go mobile: the UK report. London: The London School of Economics, 2014.
- 57 Mühleisen M. The long and short of the digital revolution. *Finance Dev* 2018; **55**: 5–8.
- 58 Coiera E. The cognitive health system. *Lancet* 2020; **395**: 463–66.
- 59 Timmermans S, Kaufman R. Technologies and health inequities. *Annu Rev Sociol* 2020; **46**: 583–602.
- 60 O'Hara K, Hall W. Four internets: the geopolitics of digital governance. Waterloo, ON: Centre for International Governance Innovation, 2018.
- 61 OECD. The path to becoming a data-driven public sector. Paris: OECD Publishing, 2019.
- 62 Kitchin R. The data revolution: big data, open data, data infrastructures and their consequences. London: SAGE Publishing, 2014.
- 63 OECD. An introduction to online platforms and their role in the digital transformation. Paris: OECD Publishing, 2019.
- 64 Li WCY, Nirei M, Yamana K. Value of data: there's no such thing as a free lunch in the digital economy. RIETI discussion paper 19-E-022. Tokyo: The Research Institute of Economy, Trade and Industry, 2019.
- 65 OECD. The digital economy, new business models and key features. In: Addressing the tax challenges of the digital economy. Paris: OECD Publishing, 2015.
- 66 Murgia M, Harlow M. How top health websites are sharing sensitive data with advertisers. Financial Times. Nov 13, 2019. <https://www.ft.com/content/0fbf4d8e-022b-11ea-be59-e49b2a136b8d> (accessed March 29, 2021).
- 67 Insider Intelligence. Big tech in health care: here's who wins and loses as Alphabet, Amazon, Apple, and Microsoft target niche sectors of healthcare. Feb 14, 2021. <https://www.businessinsider.com/2-14-2021-big-tech-in-healthcare-report?r=US&IR=T> (accessed March 29, 2021).
- 68 LaRock Z, Ahmed E, Finley D. The digital health ecosystem: where players across the ecosystem stand on digital transformation and what healthcare's new normal looks like. Dec 22, 2020. <https://www.businessinsider.com/digital-health-ecosystem?r=US&IR=T> (accessed March 29, 2021).
- 69 Gao H. Data regulation in trade agreements: different models and options ahead. In: Smeets M, ed. Adapting to the digital trade era: challenges and opportunities. Geneva: World Trade Organization, 2021.
- 70 Foster C. Digital trade and global governance of the digital economy. Oct 30, 2020. <https://ict4dblog.wordpress.com/author/cgfoster/> (accessed March 29, 2021).
- 71 Needleman SE, Copeland R. Google counts on Fitbit to make imprint in health market. Nov 6, 2019. <https://www.wsj.com/articles/google-counts-on-fitbit-to-make-imprint-in-health-market-11573052061> (accessed March 29, 2021).
- 72 Crosley S, Martinez C. A taxonomy of definitions for the health data ecosystem. Washington DC: Future of Privacy Forum and Plano, TX: The Information Accountability Foundation, 2019.
- 73 Habl C, Renner A-T, Bobek J, Laschkolnig A. Big data in public health, telemedicine and healthcare: final report. Luxembourg: Publications Office of the European Union, 2016.
- 74 The Economist. Data is giving rise to a new economy. May 6, 2017. <https://www.economist.com/briefing/2017/05/06/data-is-giving-rise-to-a-new-economy> (accessed March 29, 2021).
- 75 Statistics Canada. The value of data in Canada: experimental estimates. Ottawa, ON: Government of Canada, 2019.
- 76 Berends J, Carrara W, Radu C. Analytical Report 9: the economic benefits of open data. Luxembourg: Publications Office of the European Union, 2020.
- 77 PWC. Putting a value on data. London: PricewaterhouseCoopers, 2019.

- 78 Harper EM. The economic value of health care data. *Nurs Adm Q* 2013; **37**: 105–08.
- 79 Marjanovic S, Ghiga G, Yang M, Knack A. Understanding value in health data ecosystems: a review of current evidence and ways forward. Santa Monica, CA: RAND Corporation, 2017.
- 80 Coiera E. Why system inertia makes health reform so difficult. *BMJ* 2011; **342**: d3693.
- 81 Cohen J. Chinese researchers reveal draft genome of virus implicated in Wuhan pneumonia outbreak. Jan 11, 2020. <https://www.sciencemag.org/news/2020/01/chinese-researchers-reveal-draft-genome-virus-implicated-wuhan-pneumonia-outbreak> (accessed March 27, 2021).
- 82 Frederick WAI. What happens when people stop going to the doctor? We're about to find out. Feb 2, 2021. <https://www.nytimes.com/2021/02/22/opinion/medical-care-coronavirus.html> (accessed March 27, 2021).
- 83 Stasavage D. Democracy, autocracy, and emergency threats: lessons for COVID-19 from the last thousand years. *Int Organ* 2020; **74**: E1–17.
- 84 Cave S, Whittlestone J, Nyrop R, O hEigeartaigh S, Calvo RA. Using AI ethically to tackle COVID-19. *BMJ* 2021; **372**: n364.
- 85 McDonald S. The digital response to the outbreak of COVID-19. March 30, 2020. <https://www.cigionline.org/articles/digital-response-outbreak-covid-19> (accessed March 29, 2021).
- 86 European Commission. Proposal for a regulation of the European parliament and of the council on European data governance (Data Governance Act). Brussels: European Commission, 2020.
- 87 Buckee CO, Balsari S, Chan J, et al. Aggregated mobility data could help fight COVID-19. *Science* 2020; **368**: 145–46.
- 88 Goh B. China rolls out fresh data collection campaign to combat virus. Feb 27, 2020. <https://www.itnews.com.au/news/china-rolls-out-fresh-data-collection-campaign-to-combat-coronavirus-538635> (accessed March 29, 2021).
- 89 Sharon T. Blind-sided by privacy? Digital contact tracing, the Apple/Google API and big tech's newfound role as global health policy makers. *Ethics Inf Technol* 2020; published online July 18. <https://doi.org/10.1007/s10676-020-09547-x>.
- 90 WHO. Immunizing the public against misinformation. Aug 25, 2020. <https://www.who.int/news-room/feature-stories/detail/immunizing-the-public-against-misinformation> (accessed March 27, 2021).
- 91 Lupton D. Self-tracking modes: reflexive self-monitoring and data practices. *SSRN* 2014; published online Aug 21. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2483549 (preprint).
- 92 Azzopardi-Muscat N, Sørensen K. Towards an equitable digital public health era: promoting equity through a health literacy perspective. *Eur J Public Health* 2019; **29** (suppl 3): 13–17.
- 93 McKee M, van Schalkwyk MCI, Stuckler D. The second information revolution: digitalization brings opportunities and concerns for public health. *Eur J Public Health* 2019; **29** (suppl 3): 3–6.
- 94 Jones N. How to stop data centres from gobbling up the world's electricity. Sept 12, 2018. <https://www.nature.com/articles/d41586-018-06610-y> (accessed March 27, 2021).
- 95 Orben A, Przybylski AK. The association between adolescent well-being and digital technology use. *Nat Hum Behav* 2019; **3**: 173–82.
- 96 Coiera E. Four rules for the reinvention of health care. *BMJ* 2004; **328**: 1197–99.
- 97 Hardiker NR, Grant MJ. Factors that influence public engagement with eHealth: a literature review. *Int J Med Inform* 2011; **80**: 1–12.
- 98 Baum F, Newman L, Biedrzycki K. Vicious cycles: digital technologies and determinants of health in Australia. *Health Promot Int* 2014; **29**: 349–60.
- 99 Livingstone S, Stoilova M, Nandagiri R. Children's data and privacy online. Growing up in a digital age. An evidence review. London: London School of Economics and Political Science, 2019.
- 100 O'Connor S, Hanlon P, O'Donnell CA, Garcia S, Glanville J, Mair FS. Understanding factors affecting patient and public engagement and recruitment to digital health interventions: a systematic review of qualitative studies. *BMC Med Inform Decis Mak* 2016; **16**: 120.
- 101 Latulippe K, Hamel C, Giroux D. Social health inequalities and ehealth: a literature review with qualitative synthesis of theoretical and empirical studies. *J Med Internet Res* 2017; **19**: e136.
- 102 Kim H, Xie B. Health literacy in the eHealth era: a systematic review of the literature. *Patient Educ Couns* 2017; **100**: 1073–82.
- 103 Lupton D. Data assemblages, sentient schools and digitised health and physical education (response to Gard). *Sport Educ Soc* 2015; **20**: 122–32.
- 104 Obermeyer Z, Powers B, Vogeli C, Mullainathan S. Dissecting racial bias in an algorithm used to manage the health of populations. *Science* 2019; **366**: 447–53.
- 105 Broadband Commission for Sustainable Development. The digital transformation of education: connecting schools, empowering learners. Geneva: International Telecommunications Union, United Nations Educational, Scientific and Cultural Organization, and United Nations Children's Fund, 2020.
- 106 World Economic Forum. The future of jobs report 2018. Geneva: World Economic Forum, 2018.
- 107 Frank MR, Autor D, Bessen JE, et al. Toward understanding the impact of artificial intelligence on labor. *Proc Natl Acad Sci USA* 2019; **116**: 6531–39.
- 108 Shafik M. What we owe each other. A new social contract. London: Bodley Head, 2021.
- 109 Morley J, Cowls J, Taddeo M, Floridi L. Public health in the information age: recognizing the infosphere as a social determinant of health. *J Med Internet Res* 2020; **22**: e19311.
- 110 OECD. Combating COVID-19 disinformation on online platforms. Paris: OECD Publishing, 2020.
- 111 Nature Medicine. Patient trust must come at the top of researchers' priority list. *Nat Med* 2020; **26**: 301.
- 112 Lewandowsky S, Smillie L, Garcia D, et al. Technology and democracy: understanding the influence of online technologies on political behaviour and decision-making. Luxembourg: Publications Office of the European Union, 2020.
- 113 Galaz V. Global environmental governance, technology and politics. The Anthropocene gap. Cheltenham: Edward Elgar, 2014.
- 114 d'I Treen KM, Williams HTP, O'Neill SJ. Online misinformation about climate change. *Wiley Interdiscip Rev Clim Change* 2020; **11**: e665.
- 115 WHO. Anchoring universal health coverage in the right to health: what difference would it make. Policy brief. Geneva: World Health Organization, 2015.
- 116 Mazzucato M. Mission-oriented innovation policies: challenges and opportunities. *Ind Corp Change* 2018; **27**: 803–15.
- 117 Topol E. Deep medicine: how artificial intelligence can make health care human again. New York, NY: Basic Books, 2019.
- 118 Snyder M, Zhou W. Big data and health. *Lancet Digit Health* 2019; **1**: e252–54.
- 119 UN Department of Economic and Social Affairs. World economic and social survey 2018: frontier technologies for sustainable development. New York, NY: United Nations, 2018.
- 120 Zhou A, Sabatello M, Eyal G, et al. Is precision medicine relevant in the age of COVID-19? *Genet Med* 2021; **23**: 999–1000.
- 121 Hays P. Personalized medicine: paradigm shift or revolution. *Genet Med* 2019; **21**: 1662.
- 122 Marcon AR, Bieber M, Caulfield T. Representing a "revolution": how the popular press has portrayed personalized medicine. *Genet Med* 2018; **20**: 950–56.
- 123 European Science Foundation. Personalised medicine for the European citizen. Towards more precise medicine for the diagnosis, treatment and prevention of disease (iPM). Strasbourg: European Science Foundation, 2012.
- 124 Agrawal A. Genetic editing in humans: guiding change. Dec 30, 2020. <https://www.orfonline.org/expert-speak/genetic-editing-humans-guiding-change/> (accessed March 29, 2021).
- 125 Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. *Nat Med* 2019; **25**: 44–56.
- 126 Shimon N, Dagan N, Balicer R. Digital health driven prevention as clinical reality. *Eurohealth (Lond)* 2019; **25**: 15–17.
- 127 Weeramanthri TS, Dawkins HJS, Baynam G, Bellgard M, Gudes O, Semmens JB. Editorial: precision public health. *Front Public Health* 2018; **6**: 121.
- 128 Khouri MJ. Precision public health: what is it? May 15, 2018. <https://blogs.cdc.gov/genomics/2018/05/15/precision-public-health-2/> (accessed March 29, 2021).
- 129 Rasmussen SA, Khouri MJ, Del Rio C. Precision public health as a key tool in the COVID-19 response. *JAMA* 2020; **324**: 933–34.

- 130 Broadband Commission on Sustainable Development. The state of broadband 2019: broadband as a foundation for sustainable development. Geneva: International Telecommunications Union, and UN Educational, Scientific and Cultural Organization, 2019.
- 131 UN Inter-agency Group for Child Mortality Estimation. Under-five mortality rate—total. 2020. <https://childmortality.org/data> (accessed July 5, 2021).
- 132 International Telecommunication Union. Percentage of individuals using the internet (excel). 2019. <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx> (accessed July 5, 2021).
- 133 UN Department of Economic and Social Affairs. Population Division: world population prospects [dataset]. 2019. <https://population.un.org/wpp/Download/Standard/CSV/> (accessed July 5, 2021).
- 134 UNICEF and ITU. How many children and youth have internet access at home? Estimating digital connectivity during the COVID-19 pandemic. New York, NY: United Nations' Children Fund, 2020.
- 135 OECD. Students aged 15–16 who feel bad if no internet connection is available. 2018. <https://goingdigital.oecd.org/en/indicator/06> (accessed March 29, 2021).
- 136 Equals Global Partnership and United Nations University. Taking stock: data and evidence on gender equality in digital access, skills and leadership. Tokyo: United Nations University, 2019.
- 137 International Telecommunication Union. Measuring digital development: facts and figures 2019. Geneva: International Telecommunication Union, 2019.
- 138 Berkley S. Immunization needs a technology boost. *Nature* 2017; 551: 273.
- 139 Gavi, The Vaccine Alliance. Fingerprint records and digital health cards to help solve global identity crisis. July 31, 2018. <https://www.gavi.org/news/media-room/fingerprint-records-and-digital-health-cards-help-solve-global-identity-crisis> (accessed March 29, 2021).
- 140 Births and Deaths Registry and UNICEF Ghana Country Office. Assessment of the m-Birth project in Ghana. New York, NY: United Nations Children's Fund, 2018.
- 141 Africa Digital Rights Hub. Ghana's identity ecosystem. Accra: Africa Digital Rights Hub Publishing, 2020.
- 142 Labrique A, Vasudevan L, Mehl G, Rosskam E, Hyder AA. Digital health and health systems of the future. *Glob Health Sci Pract* 2018; 6 (suppl 1): S1–4.
- 143 WHO. WHO guideline: recommendations on digital interventions for health system strengthening. Geneva: World Health Organization, 2019.
- 144 World Health Assembly. Resolution 71.7 on digital health. May 26, 2018. https://apps.who.int/gb/ebwha/pdf_files/WHA71/A71_L7-en.pdf (accessed March 29, 2021).
- 145 WHO. Classification of digital health interventions v1.0. Geneva: World Health Organization, 2018.
- 146 Cohen-Stavi CJ, Balicer RD, Leventer Roberts M. Innovation in health care for proactive care delivery and strategic clinical decision-making: integrating research, technology and practice. *Public Health Panorama* 2018; 4: 471–90.
- 147 Friedman CP, Wong AK, Blumenthal D. Achieving a nationwide learning health system. *Sci Transl Med* 2010; 2: 57cm29.
- 148 The International Federation of Red Cross and Red Crescent Societies. Enabling digital health futures in humanitarian settings. 2021. <https://www.governinghealthfutures2030.org/pdf/resources/IFRCEnablingDigitalHealthFutures.pdf> (accessed Oct 24, 2021).
- 149 Scott-Smith T. Humanitarian neophilia: the 'innovation turn' and its implications. *Third World Q* 2016; 37: 2229–51.
- 150 Read R, Taithe B, Mac Ginty R. Data hubris? Humanitarian information systems and the mirage of technology. *Third World Q* 2016; 37: 1314–31.
- 151 Sandvik KB. Making wearables in aid: digital bodies, data and gifts. *Journal of Humanitarian Affairs* 2019; 1: 33–41.
- 152 Roth S, Luczak-Roesch M. Deconstructing the data life-cycle in digital humanitarianism. *Inf Commun Soc* 2020; 23: 555–71.
- 153 Arora P. The Next Billion Users. Cambridge, MA: Harvard University Press, 2018.
- 154 Sandvik KB. Protecting children's digital bodies through rights. Oct 30, 2019. <https://www.openglobalrights.org/protecting-childrens-digital-bodies-through-rights/> (accessed March 29, 2021).
- 155 Nathaniel R, Campo S. Displaced children and emerging technologies: Save the Children's opportunities for investment and impact. London: Save the Children International, 2019.
- 156 UNICEF. The state of the world's children 2017: children in a digital world. New York, NY: United Nations Children's Fund, 2017.
- 157 Labrique A, Vasudevan L, Weiss W, Wilson K. Establishing standards to evaluate the impact of integrating digital health into health systems. *Glob Health Sci Pract* 2018; 6 (suppl 1): S5–17.
- 158 HIMSS North America. 2018 HIMMS Cybersecurity Survey. Chicago, IL: Healthcare Information and Management Systems Society, 2018.
- 159 CISCO. Cisco digital readiness index. 2019. <https://www.cisco.com/c/en/us/about/csr/research-resources/digital-readiness.html> (accessed March 23, 2021).
- 160 ITU. ICT Development Index. 2017. <https://www.itu.int/net4/ITU-D/idi/2017/> (accessed March 23, 2021).
- 161 UN Conference on Trade and Development. The UNCTAD B2C E-commerce Index 2020: spotlight on Latin America and the Caribbean. New York, NY: United Nations, 2020.
- 162 WHO and International Telecommunication Union. National eHealth strategy toolkit. Geneva: World Health Organization and International Telecommunications Union, 2012.
- 163 Digital Square. Market maturity methodology. 2020. https://wiki.digitalsquare.io/index.php/Market_Maturity_Methodology (accessed March 29, 2021).
- 164 Governing Health Futures 2030 Commission. Digital health futures readiness policy brief. 2021. <https://www.governinghealthfutures2030.org/pdf/policy-briefs/DigitalHealthFuturesReadiness.pdf> (accessed Oct 24, 2021).
- 165 Centre on the Developing Child. The foundations of lifelong health are built in early childhood. Cambridge, MA: Harvard University, 2010.
- 166 National Research Council and Institute of Medicine. Children's health, the nation's wealth: Assessing and improving child health. Washington, DC: The National Academic Press, 2004.
- 167 Lupton D. Young people's use of digital health technologies in the global north: narrative review. *J Med Internet Res* 2021; 23: e18286.
- 168 Kardefelt-Winter D, Twesigye R, Zlámal R, et al. Digital Connectivity during COVID-19: access to vital information for every child. New York, NY: United Nations Children's Fund, 2020.
- 169 Pew Research Center. Teens, social media and technology 2018. May 31, 2018. <https://www.pewresearch.org/internet/2018/05/31/teens-social-media-technology-2018/> (accessed March 29, 2021).
- 170 Lupton D. Digital bodies. In: Andrews D, Silk M, Thorpe H, eds. Routledge handbook of physical cultural studies. London: Routledge, 2017: 9.
- 171 Lupton D, Williamson B. The datafied child: The dataveillance of children and implications for their rights. *New Media Soc* 2017; 19: 780–94.
- 172 Mascheroni G. Datafied childhoods: contextualising datafication in everyday life. *Curr Sociol* 2020; 68: 798–813.
- 173 Hintz A, Dencik L, Wahl-Jorgensen K. Digital citizenship and surveillance society. *Int J Commun* 2017; 11: 731–39.
- 174 Thomas GM, Lupton D. Playing pregnancy: the ludification and gamification of expectant motherhood in smartphone apps. *M/C Journal* 2015; 18.
- 175 Leaver T. Born digital? Presence, privacy, and intimate surveillance. In: Hartley J, Qu W, eds. Re-orientation: Translingual, Transcultural, Transmedia. Shanghai: Fudan University Press, 2016.
- 176 Mascheroni G. Researching datafied children as data citizens. *J Child Media* 2018; 12: 517–23.
- 177 Holloway D, Green L. The Internet of toys. *Commun Res Pract* 2016; 2: 506–19.
- 178 Williamson B. Learning in the 'platform society': disassembling an educational data assemblage. *Res Educ* 2017; 98: 59–82.
- 179 Jarke J, Breiter A. The datafication of education. *Learn Media Technol* 2019; 44: 1–6.
- 180 Taylor E. Surveillance schools: a new era in education. In: Surveillance schools: security, discipline and control in contemporary education. London: Palgrave Pivot, 2013.
- 181 Gard M, Lupton D. Digital health goes to school: implications of digitising children's bodies. In: Taylor E, Rooney T, eds. Surveillance Futures: social and ethical implications of new technologies for children and young people. London: Routledge, 2016.

- 182 Rich E. Childhood, surveillance and mHealth technologies. In: Taylor E, Rooney T, eds. *Surveillance futures: social and ethical implications of new technologies for children and young people*. London: Routledge, 2016: 132–46.
- 183 Gartner. Gartner says worldwide wearable device sales to grow 17 percent in 2017. Aug 27, 2017. <https://www.gartner.com/en/newsroom/press-releases/2017-08-24-gartner-says-worldwide-wearable-device-sales-to-grow-17-percent-in-2017> (accessed March 27, 2021).
- 184 Shanahan MJ. Social genomics and the life course: opportunities and challenges for multilevel population research. In: National Research Council. *New directions in the sociology of aging*. Washington, DC: The National Academies Press, 2013.
- 185 Conley D, Fletcher J. The genome factor: what the social genomics revolution reveals about ourselves, our history, and the future. Princeton, Oxford: Princeton University Press, 2017.
- 186 OECD. Measuring the digital transformation: a roadmap for the future. Paris: OECD Publishing, 2019.
- 187 Barassi V. BabyVeillance? Expecting parents, online surveillance and the cultural specificity of pregnancy apps. *Soc Media Soc* 2017; 3: 1–10.
- 188 Kidron B, Rudkin A. Digital childhood: addressing childhood development milestones in the digital environment. London: 5Rights Foundation, 2017.
- 189 UNICEF. Children and digital marketing: rights, risks and responsibilities. New York, NY: United Nations Children's Fund, 2018.
- 190 Enberg J. Global digital ad spending 2019. March 29, 2019. <https://www.emarketer.com/content/global-digital-ad-spending-2019> (accessed March 29, 2021).
- 191 WHO Regional Office for Europe. Monitoring and restricting digital marketing of unhealthy products to children and adolescents. Copenhagen: World Health Organization, 2019.
- 192 Holloway D. Surveillance capitalism and children's data: the internet of toys and things for children. *Media Int Aust Inc Cult Policy* 2019; 170: 27–36.
- 193 Livingstone S, Smith PK. Annual research review: harms experienced by child users of online and mobile technologies: the nature, prevalence and management of sexual and aggressive risks in the digital age. *J Child Psychol Psychiatry* 2014; 55: 635–54.
- 194 World Childhood Foundation, End Violence, ITU, et al. COVID-19 and its implications for protecting children online. New York, NY: United Nations Children's Fund, 2020.
- 195 Barlett CP, Simmers MM, Roth B, Gentile D. Comparing cyberbullying prevalence and process before and during the COVID-19 pandemic. *J Soc Psychol* 2021; 161: 408–18.
- 196 Lazuras L, Barkoukis V, Tsorbatzoudis H. Face-to-face bullying and cyberbullying in adolescents: trans-contextual effects and role overlap. *Technol Soc* 2017; 48: 97–101.
- 197 Kowalski RM, Limber SP, McCord A. A developmental approach to cyberbullying: prevalence and protective factors. *Aggress Violent Behav* 2019; 45: 20–32.
- 198 Modecki KL, Minchin J, Harbaugh AG, Guerra NG, Runions KC. Bullying prevalence across contexts: a meta-analysis measuring cyber and traditional bullying. *J Adolesc Health* 2014; 55: 602–11.
- 199 Kowalski RM, Whittaker E. Cyberbullying: prevalence, causes and consequences. In: Rosen LD, Cheever NA, Carrier LM, eds. *The Wiley Handbook of Psychology, Technology, and Society*. Hoboken, NJ: Wiley-Blackwell, 2015.
- 200 Álvarez-García D, Núñez Pérez JC, Dobarro González A, Rodríguez Pérez C. Risk factors associated with cybervictimization in adolescence. *Int J Clin Health Psychol* 2015; 15: 226–35.
- 201 John A, Glendenning AC, Marchant A, et al. Self-harm, suicidal behaviours, and cyberbullying in children and young people: systematic review. *J Med Internet Res* 2018; 20: e129.
- 202 UNICEF. UNICEF poll: more than a third of young people in 30 countries report being a victim of online bullying. Sept 4, 2019. <https://www.unicef.org/eca/press-releases/unicef-poll-more-third-young-people-30-countries-report-being-victim-online-bullying> (accessed March 29, 2021).
- 203 James C, Davis K, Charamaraman L, et al. Digital life and youth well-being, social connectedness, empathy, and narcissism. *Pediatrics* 2017; 140 (suppl 2): S71–75.
- 204 Rosen LD, Lim AF, Felt J, et al. Media and technology use predicts ill-being among children, preteens and teenagers independent of the negative health impacts of exercise and eating habits. *Comput Human Behav* 2014; 35: 364–75.
- 205 Bavelier D, Green CS, Dye MWG. Children, wired: for better and for worse. *Neuron* 2010; 67: 692–701.
- 206 Gottschalk F. Impacts of technology use on children: exploring literature on the brain, cognition and well-being. Paris: OECD Publishing, 2019.
- 207 Cortesi S, Hasse A, Lombana-Bermudez A, Kim S, Gasser U. Youth and digital citizenship+: understanding skills for a digital world. Cambridge, MA: Berkman Klein Center for Internet & Society at Harvard University, 2020.
- 208 OECD. Children in the digital environment: revised typology of risks. Paris: OECD Publishing, 2021.
- 209 Holly L. Health in the digital age: where do children's rights fit in? *Health Hum Rights* 2020; 22: 49–54.
- 210 Deelstra J. Digital tools can support “health for all”—if we consider these three things. Jan 14, 2020. <https://www.path.org/articles/digital-tools-can-support-health-for-all-if-we-consider-these-three-things/> (accessed March 29, 2021).
- 211 Kardefelt-Winther D. Children's time online and well-being outcomes. In: Burns T, Gottschalk F, eds. *Educating 21st century children: emotional well-being in the digital age*. Paris: OECD Publishing, 2019: 141–62.
- 212 National Research Council. Leveraging longitudinal data in developing countries: report of a workshop. Washington, DC: The National Academies Press, 2002.
- 213 HBSC. About HBSC. 2021. <http://www.hbsc.org/about/index.html> (accessed March 17, 2021).
- 214 Third A, Lala G, Diniz De Oliveira J, Bellerose D, Theakstone G. Young and online: children's perspectives on life in the digital age (the state of the world's children 2017 companion report). Sydney, NSW: Western Sydney University, 2017.
- 215 Barron CM. ‘I had no credit to ring you back’: children's strategies of negotiation and resistance to parental surveillance via mobile phones. *Surveill Soc* 2014; 12: 401–13.
- 216 Gabriels K. ‘I keep a close watch on this child of mine’: a moral critique of other-tracking apps. *Ethics Inf Technol* 2016; 18: 175–84.
- 217 Barassi V. Datafied citizens in the age of coerced digital participation. *Sociol Res Online* 2019; 24: 414–29.
- 218 Vosloo S, Penagos M, Raftree L. COVID-19 and children's digital privacy. April 7, 2020. <https://www.unicef.org/globalinsight/stories/covid-19-and-childrens-digital-privacy> (accessed March 29, 2021).
- 219 Pinet M, Sanyu P, Youn A. Advancing youth-centred digital ecosystems in Africa in a post-COVID-19 world. London: Overseas Development Institute, 2021.
- 220 Hasse A, Cortesi S, Lombana-Bermudez A, Gasser U. Youth and artificial intelligence: where we stand. Cambridge, MA: Berkman Klein Center for Internet & Society at Harvard University, 2019.
- 221 Landsdown G. Every child's right to be heard: a resource guide on the UN Committee on the Rights of the Child General Comment No 12. London: Save the Children and United Nations Children's Fund, 2011.
- 222 UN Committee on the Rights of the Child. General Comment No 7 (2005): implementing child rights in early childhood. New York, NY: United Nations, 2005.
- 223 Zeinali Z, Bulc B, Lal A, et al. A roadmap for intergenerational leadership in planetary health. *Lancet Planet Health* 2020; 4: e306–08.
- 224 Couldry N. Why voice matters: culture and politics after neoliberalism. London: Sage Publications, 2010.
- 225 Jenkins H. How young activists deploy digital tools for social change. Sept 25, 2017. <https://clalliance.org/blog/how-young-activists-deploy-digital-tools-for-social-change/> (accessed March 29, 2021).
- 226 Governing Health Futures 2030 Commission. Digital health futures: insights into young people's use and opinions of digital health technologies—summary report of a 2020 U-Report poll. 2021. <http://www.governinghealthfutures2030.org/wp-content/uploads/2021/09/Digital-health-futures-U-Report.pdf> (accessed Oct 24, 2021).
- 227 Cortesi S, Hasse A, Gasser U. Youth participation in a digital world: designing and implementing spaces, programs, and methodologies. Cambridge, MA: Berkman Klein Center for Internet & Society at Harvard University, 2021.

- 228 International Telecommunication Union. ITU 2020 youth engagement survey. 2020. <https://www.itu.int/generationconnect/itu-2020-youth-engagement-survey/> (accessed 23 March 2021).
- 229 WHO Regional Office for Europe. Health21: the health for all policy framework for the WHO European Region. Copenhagen: World Health Organization Regional Office for Europe, 1999.
- 230 UN Sustainable Development Group. Universal Values. 2021. <https://unsdg.un.org/2030-agenda/universal-values> (accessed March 29, 2021).
- 231 Bachelet M. Human rights in the digital age: can they make a difference? Oct 17, 2019. <https://www.ohchr.org/EN/NewsEvents/Pages/DisplayNews.aspx?NewsID=25158&LangID=E> (accessed March 29, 2021).
- 232 Grote T, Berens P. On the ethics of algorithmic decision-making in healthcare. *J Med Ethics* 2020; **46**: 205–11.
- 233 Habli I, Lawton T, Porter Z. Artificial intelligence in health care: accountability and safety. *Bull World Health Organ* 2020; **98**: 251–56.
- 234 Academy of Medical Royal Colleges. Artificial intelligence in healthcare. London: Academy of Medical Royal Colleges, 2019.
- 235 Zuboff S. The age of surveillance capitalism: the fight for a human future at the new frontier of power. London: Profile Books, 2019.
- 236 Couldry N, Mejias U. The costs of connection: how data is colonizing human life and appropriating it for capitalism. Stanford, CA: Stanford University Press, 2019.
- 237 Freedom House. Freedom on the net 2020: the pandemic's digital shadow. Washington, DC: Freedom House, 2020.
- 238 Illmer A. Singapore reveals COVID privacy data available to police. Jan 5, 2021. <https://www.bbc.com/news/world-asia-55541001> (accessed June 29, 2021).
- 239 World Summit on the Information Society. Declaration of principles—bridging the information society: a global challenge for the new millennium. Dec 12, 2003. https://www.itu.int/dms_pub/itu-s/md/03/wsis/doc/S03-WSIS-DOC-0004!!PDF-E.pdf (accessed March 29, 2021).
- 240 Makri A. Bridging the digital divide in health care. *Lancet Digit Health* 2019; **1**: e204–05.
- 241 The Lancet Digital Health. Race to end health inequities. *Lancet Digit Health* 2020; **2**: e380.
- 242 European Commission. EU Strategy on the rights of the child. Brussels: European Commission, 2021.
- 243 OECD. Recommendation of the Council on children in the digital environment. Paris: OECD Publishing, 2021.
- 244 Bulman M. DWP plans to obtain people's medical data will deter benefit claimants accessing healthcare, doctors warn. Feb 26, 2019. <https://www.independent.co.uk/news/uk/home-news/dwp-benefit-claims-medical-data-sharing-nhs-healthcare-doctors-charities-a8797991.html> (accessed March 29, 2021).
- 245 Krakower DS, Gruber S, Hsu K, et al. Development and validation of an automated HIV prediction algorithm to identify candidates for pre-exposure prophylaxis: a modelling study. *Lancet HIV* 2019; **6**: e696–704.
- 246 Gasser U, Ienca M, Scheibner J, Sleigh J, Vayena E. Digital tools against COVID-19: taxonomy, ethical challenges, and navigation aid. *Lancet Digit Health* 2020; **2**: e425–34.
- 247 Guo E. Getting vaccinated is hard. It's even harder without the internet. Feb 3, 2021. <https://www.technologyreview.com/2021/02/03/1017245/broadband-digital-divide-senior-citizens-pandemic/> (accessed March 29, 2021).
- 248 Hong YA, Zhou Z, Fang Y, Shi L. The digital divide and health disparities in China: evidence from a national survey and policy implications. *J Med Internet Res* 2017; **19**: e317.
- 249 Sulmasy DP. Naked bodies, naked genomes: the special (but not exceptional) nature of genomic information. *Genet Med* 2015; **17**: 331–36.
- 250 Ahn S. Whose genome is it anyway? Re-identification and privacy protection in public and participatory genomics. *San Diego L Rev* 2015; **52**: 751–806.
- 251 Kickbusch I. UHC2030 statement at the UN high-level meeting on UHC 23/09/19. 2019. https://www.uhc2030.org/fileadmin/uploads/uhc2030/Documents/UN_HLM/UHC2030_Statement_HLM_UHC.pdf (accessed March 29, 2021).
- 252 Prainsack B, Buyx A. Thinking ethical and regulatory frameworks in medicine from the perspective of solidarity on both sides of the Atlantic. *Theor Med Bioeth* 2016; **37**: 489–501.
- 253 Prainsack B. The “We” in the “Me”: solidarity and health care in the era of personalized medicine. *Sci Technol Human Values* 2018; **43**: 21–44.
- 254 Deelstra J. Using the power of data to achieve universal health coverage. July 18, 2018. <https://www.path.org/articles/using-power-data-achieve-universal-health-coverage/> (accessed March 29, 2021).
- 255 Galea S, Annas G. Achieving the goals of public health. March 9, 2018. <https://www.bu.edu/sph/news/articles/2018/achieving-the-goals-of-public-health/> (accessed March 29, 2021).
- 256 London L, Himonga C, Fick N, Stuttaford M. Social solidarity and the right to health: essential elements for people-centred health systems. *Health Policy Plan* 2015; **30**: 938–45.
- 257 Prainsack B. Logged out: ownership, exclusion and public value in the digital data and information commons. *Big Data Soc* 2019; **6**: 1–15.
- 258 Neff G, Tanweer A, Fiore-Gartland B, Osburn L. Critique and contribute: a practice-based framework for improving critical data studies and data science. *Big Data* 2017; **5**: 85–97.
- 259 UN. COVID-19 and human rights: we are all in this together. New York, NY: United Nations, 2020.
- 260 Mills P, Miller J. Why we need a new social contract for data in healthcare. March 21, 2019. <https://www.weforum.org/agenda/2019/03/why-we-need-a-new-social-contract-for-data-in-healthcare/> (accessed March 29, 2021).
- 261 Eubanks V. Automating inequality: how high-tech tools profile, police, and punish the poor. New York, NY: St Martin's Press, 2018.
- 262 Noble SU. Algorithms of oppression: how search engines reinforce racism. New York, NY: New York University Press, 2018.
- 263 Arora P. Digital gods: the making of a medical fact for rural diagnostic software. *Inf Soc* 2010; **26**: 70–79.
- 264 Mohamed S, Png MT, Isaac W. Decolonial AI: decolonial theory as sociotechnical foresight in artificial intelligence. *Philos Technol* 2020; **33**: 659–84.
- 265 D'Ignazio C, Klein LF. Data feminism. Cambridge, MA: MIT Press, 2020.
- 266 Parikh RB, Teeple S, Navathe AS. Addressing bias in artificial intelligence in health care. *JAMA* 2019; **322**: 2377–78.
- 267 Gianfrancesco MA, Tamang S, Yazdany J, Schmajuk G. Potential biases in machine learning algorithms using electronic health record data. *JAMA Intern Med* 2018; **178**: 1544–47.
- 268 Cirillo D, Catuara-Solarz S, Morey C, et al. Sex and gender differences and biases in artificial intelligence for biomedicine and healthcare. *NPJ Digit Med* 2020; **3**: 81.
- 269 Benjamin R. Assessing risk, automating racism. *Science* 2019; **366**: 421–22.
- 270 Whittaker M, Alper M, Bennett CL, et al. Disability, bias, and AI. New York, NY: AI Now Institute, 2019.
- 271 Mann M, Daly A. (Big) Data and the North-in-South: Australia's informational imperialism and digital colonialism. *TV New Media* 2018; **20**: 379–95.
- 272 Pereira L, Mutesa L, Tindana P, Ramsay M. African genetic diversity and adaptation inform a precision medicine agenda. *Nat Rev Genet* 2021; **22**: 284–306.
- 273 Jain A, Bhojar RC, Pandhare K, et al. IndiGenomes: a comprehensive resource of genetic variants from over 1000 Indian genomes. *Nucleic Acids Res* 2021; **49**: D1225–32.
- 274 Bollyky TJ, Kickbusch I. Preparing democracies for pandemics. *BMJ* 2020; **371**: m4088.
- 275 The Economist Intelligence Unit. Democracy Index 2020: in sickness and in health? <https://www.eiu.com/n/campaigns/democracy-index-2020/> (accessed March 29, 2021).
- 276 International Telecommunication Union. Digital opportunities: innovative ICT solutions for youth employment. Geneva: International Telecommunication Union, 2014.
- 277 UNICEF. Children's rights and business in a digital world: access to the internet and digital literacy. New York, NY: United Nations Children's Fund, 2017.
- 278 Crawford A, Serhal E. Digital health equity and COVID-19: the innovation curve cannot reinforce the social gradient of health. *J Med Internet Res* 2020; **22**: e19361.
- 279 Pieper AK, Pieper M. The insulting Internet: universal access and cyberbullying. *Univers Access Inf Soc* 2017; **16**: 497–504.

- 280 Fountain JE. The wicked nature of digital transformation: a policy perspective. Jan 20, 2019. <https://dubaipolicyreview.ae/the-wicked-nature-of-digital-transformation-a-policy-perspective/> (accessed March 27, 2021).
- 281 Mazzucato M. From market fixing to market-creating: a new framework for innovation policy. *Ind Innov* 2016; **23**: 140–56.
- 282 Anderson J, Rainie L. Net threats. July 3, 2014. <https://www.pewresearch.org/internet/2014/07/03/net-threats/> (accessed June 22, 2021).
- 283 OECD. Education in the digital age: healthy and happy children. Paris: OECD Publishing, 2020.
- 284 Neufeind M, O'Reilly J, Ranft F. Work in the digital age: challenges of the fourth industrial revolution. London: Rowman and Littlefield, 2018.
- 285 OECD. Bridging the digital gender divide: include, upskill, innovate. Paris: OECD Publishing, 2018.
- 286 International Telecommunication Union and WHO. ITU–WHO joint statement: unleashing information technology to defeat COVID-19. April 20, 2020. <https://www.who.int/news/item/20-04-2020-itu-who-joint-statement-unleashing-information-technology-to-defeat-covid-19> (accessed March 29, 2021).
- 287 Dong L. Good governance is the missing prescription for better digital healthcare. Dec 10, 2019. <https://theconversation.com/good-governance-is-the-missing-prescription-for-better-digital-healthcare-128375> (accessed March 29, 2021).
- 288 Marcelo A, Medeiros D, Ramesh K, Roth S, Wyatt P. Transforming health systems through good digital health governance. Manila: Asian Development Bank, 2018.
- 289 European Commission. Europe fit for the digital age: commission proposes new rules for digital platforms. Dec 15, 2020. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2347 (accessed March 29, 2021).
- 290 State of California. California Consumer Privacy Act of 2018. June 29, 2018. https://leginfo.ca.gov/faces/billTextClient.xhtml?bill_id=20170180AB375 (accessed March 29, 2021).
- 291 OECD. Addressing the tax challenges of the digital economy—action 1: 2015 final report. Paris: OECD Publishing, 2015.
- 292 OECD and G20 Inclusive Framework on BEPS. Cover statement by the Inclusive Framework on the reports on the blueprints of pillar one and pillar two. Paris: OECD Publishing, 2020.
- 293 European Commission. Fair taxation of the digital economy. March 21, 2018. https://ec.europa.eu/taxation_customs/business/company-tax/fair-taxation-digital-economy_en (accessed March 29, 2021).
- 294 Ortiz Freuler J. The case for a digital non-aligned movement. June 27, 2020. <https://www.opendemocracy.net/en/oureconomy/case-digital-non-aligned-movement/> (accessed March 29, 2021).
- 295 Financial Times. Prospering in the pandemic: 2020's top 100 companies. Jan 1, 2021. <https://www.ft.com/content/f8251e5f-10a7-47f7-a9047-b438e4d7f83a> (accessed April 1, 2021).
- 296 African Union. Taxing the digital economy: COVID-19 heightens need to expand resource mobilization base. Aug 24, 2020. <https://au.int/en/pressreleases/20200824/taxing-digital-economy-covid-19-heightens-need-expand-resource-mobilization> (accessed March 29, 2021).
- 297 Oxford Business Group. Can digital taxes help fund the COVID-19 recovery in emerging markets? June 24, 2020. <https://oxfordbusinessgroup.com/news/can-digital-taxes-help-fund-covid-19-recovery-emerging-markets> (accessed March 29, 2021).
- 298 Stolton S. Commission mulls digital tax to fund Europe's multi-billion euro recovery. May 27, 2020. <https://www.euractiv.com/section/digital/news/commission-mulls-digital-tax-to-fund-europes-multi-billion-euro-recovery/> (accessed March 29, 2021).
- 299 Burris S, Wagenaar AC, Swanson J, Ibrahim JK, Wood J, Mello MM. Making the case for laws that improve health: a framework for public health law research. *Milbank Q* 2010; **88**: 169–210.
- 300 Dolinoy DC, Jirtle RL. Environmental epigenomics in human health and disease. *Environ Mol Mutagen* 2008; **49**: 4–8.
- 301 Welsh Government. Well-being of future generations (Wales) Act 2015. London: The Stationery Office, 2015.
- 302 Fawkes S. Taking the long view in health policy making: the use of futures studies. PhD thesis, LaTrobe University, 2010.
- 303 Linturi R, Kuusi O. Societal transformation 2018–2037: 100 anticipated radical technologies, 20 regimes, case Finland. Helsinki: Committee for the Future, 2018.
- 304 Gariboldi MI, Lin V, Bland J, Auplish M, Cawthorne A. Foresight in the time of COVID-19. *Lancet Reg Health West Pac* 2021; **6**: 100049.
- 305 Zuber S. Measuring intergenerational fairness. In: González-Ricoy I, Gosseries A, eds. Institutions for future generations. Oxford: Oxford University Press, 2016: 65–82.
- 306 Povall SL, Haigh FA, Abrahams D, Scott-Samuel A. Health equity impact assessment. *Health Promot Int* 2014; **29**: 621–33.
- 307 Were MC, Sinha C, Catalani C. A systematic approach to equity assessment for digital health interventions: case example of mobile personal health records. *J Am Med Inform Assoc* 2019; **26**: 884–90.
- 308 Human Rights Council. Resolution adopted by the Human Rights Council: the promotion, protection and enjoyment of human rights on the internet. New York, NY: United Nations, 2012.
- 309 Third A, Collin P, Fleming C, et al. Governance, children's rights and digital health. 2021. <https://www.governinghealthfutures2030.org/pdf/resources/AmandaThirdEtAlReportOnChildRights.pdf> (accessed Oct 24, 2021).
- 310 Third A, Moody L. Our rights in the digital world: a snapshot of children's views from around the world. London: 5Rights Foundation, Western Sydney University, and the London School of Economics and Political Science, 2021.
- 311 Third A, Collin P, Walsh L, et al. Young people in digital society: control shift. London: Palgrave MacMillan, 2019.
- 312 UN. Convention on the rights of the child. 1989. <https://www.ohchr.org/Documents/ProfessionalInterest/crc.pdf> (accessed March 29, 2021).
- 313 UN Committee on the Rights of the Child. General comment No 25 (2021) on children's rights in relation to the digital environment. New York, NY: United Nations, 2021.
- 314 Livingstone S, Lansdown G, Third A. The case for a UNCRC General Comment on children's rights and digital media: a report prepared for the Children's Commissioner for England. London: LSE Consulting, 2017.
- 315 Kak A, Richardson R. Artificial Intelligence policies must focus on impact and accountability. Centre for International Governance Innovation. May 1, 2020. <https://www.cigionline.org/articles/artificial-intelligence-policies-must-focus-impact-and-accountability> (accessed March 29, 2021).
- 316 London AJ. Artificial intelligence and black-box medical decisions: accuracy versus explainability. *Hastings Cent Rep* 2019; **49**: 15–21.
- 317 Ad Hoc Expert Group (AHEG) for the preparation of a draft text of a recommendation on the ethics of artificial intelligence. First draft of the recommendation on the ethics of artificial intelligence. Paris: United Nations Educational, Scientific and Cultural Organization, 2020.
- 318 Jobin A, Ienca M, Vayena E. The global landscape of AI ethics guidelines. *Nat Mach Intell* 2019; **1**: 389–99.
- 319 WHO. Ethics and governance of artificial intelligence for health: WHO guidance. Geneva: World Health Organization, 2021.
- 320 Montréal Declaration Responsible AI. Report of the Montreal declaration for a responsible development of artificial intelligence. Montreal, QC: Montreal Declaration for a Responsible Development of AI, 2018.
- 321 OECD. Recommendation of the council on artificial intelligence. Paris: OECD Publishing, 2019.
- 322 OECD. The OECD digital government policy framework: six dimensions of a digital government. Paris: OECD Publishing, 2020.
- 323 Robinson L, Cotten SR, Ono H, et al. Digital inequalities and why they matter. *Inf Commun Soc* 2015; **18**: 569–82.
- 324 OECD and TheGovLab. Open data in action: initiatives during the initial stage of the COVID-19 pandemic. Paris: OECD Publishing, 2021.
- 325 Wang CJ, Ng CY, Brook RH. Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive testing. *JAMA* 2020; **323**: 1341–42.
- 326 WHO. Providing health intelligence to meet local needs: a practical guide to serving local and urban communities through public health observatories. Geneva: World Health Organization, 2014.
- 327 Goldsman F, Venturini J. Building a feminist Internet. Feb 10, 2021. <https://www.cigionline.org/articles/building-feminist-internet> (accessed March 29, 2021).
- 328 Zuckerman E. The case for digital public infrastructure. Jan 17, 2020. <https://knightcolumbia.org/content/the-case-for-digital-public-infrastructure> (accessed June 30, 2021).

- 329 OECD. Recommendation of the Council on Open Government. Paris: OECD Publishing, 2017.
- 330 6th OECD Expert Group Meeting on Open Government Data. Open data & COVID-19: looking forward towards government readiness and reform—summary record. Paris: OECD Publishing, 2020.
- 331 OECD. Towards open data. 2020. <https://www.oecd.org/going-digital/topics/public-governance/> (accessed March 29, 2021).
- 332 Baker TB, Gustafson DH, Shah D. How can research keep up with eHealth? Ten strategies for increasing the timeliness and usefulness of eHealth research. *J Med Internet Res* 2014; **16**: e36.
- 333 IMS Institute for Healthcare Informatics. Patient apps for improved healthcare: from novelty to mainstream. Parsippany, NJ: IMS Institute for Healthcare Informatics, 2013.
- 334 Lupton D. The digitally engaged patient: self-monitoring and self-care in the digital health era. *Soc Theory Health* 2013; **11**: 256–70.
- 335 Birnbaum F, Lewis D, Rosen RK, Ranney ML. Patient engagement and the design of digital health. *Acad Emerg Med* 2015; **22**: 754–56.
- 336 Avila Pinto R. Digital sovereignty or digital colonialism? *Int J Hum* 2018; **15**: 15–27.
- 337 Barcelona City Council's Office for Technology and Digital Innovation. Barcelona City Council technological sovereignty guide. Barcelona: Barcelona Digital City, 2017.
- 338 Digital Cities Toolkit. Data for public good. https://unhabitat.org/digitalcities toolkit/toolkits/DCT_Data%20For%20Public%20Good.pdf (accessed March 29, 2021).
- 339 Jansen M. City examples of digital rights in times of COVID-19. May 13, 2020. <https://citiesfordigitalrights.org/city-examples-digital-rights-times-covid-19> (accessed March 29, 2021).
- 340 Emilsson C, Chauvet L, González-Zapata F, Rivera Perez A. The interdependency of data governance and open government data: lessons from COVID-19. Aug 7, 2020. <https://zenodo.org/record/3978270#.YC5NnS1Q3s2> (accessed March 29, 2021).
- 341 Digital Unite. The digital health champions network. <https://www.digitalunite.com/digital-health-champions-network> (accessed March 29, 2021).
- 342 European Health Management Association. IC-Health—improving digital health literacy in Europe. <https://ehma.org/research-projects/past-projects/ic-health-improving-digital-health-literacy-europe/> (accessed March 29, 2021).
- 343 WHO. Countering misinformation about COVID-19. May 13, 2020. <https://www.who.int/news-room/feature-stories/detail/countering-misinformation-about-covid-19> (accessed March 29, 2021).
- 344 Piccone T. Democracy and digital technology. *Int J Hum* 2018; **15**: 29–38.
- 345 McDonald S. Coronavirus: a digital governance emergency of international concern. May 20, 2020. <https://www.cigionline.org/articles/coronavirus-digital-governance-emergency-international-concern> (accessed March 29, 2020).
- 346 Broadbent M. Internets or splinternets? The consequences of European tech sovereignty. Aug 10, 2020. <https://www.csis.org/analysis/internet-or-splinternet-consequences-european-tech-sovereignty> (accessed March 29, 2021).
- 347 Bajgar M, Calligaris S, Criscuolo C, Timmis J. Superstar firms are running away with the global economy. Nov 14, 2019. <https://hbr.org/2019/11/superstar-firms-are-running-away-with-the-global-economy> (accessed March 29, 2021).
- 348 UN High-Level Panel on Digital Cooperation. The age of interdependence. New York, NY: United Nations, 2019.
- 349 UN General Assembly. Road map for digital cooperation: implementation of the recommendations of the High-level Panel on Digital Cooperation. Report of the Secretary-General. New York, NY: United Nations, 2020.
- 350 OECD. Health data governance: privacy, monitoring and research—policy brief. Paris: OECD Publishing, 2015.
- 351 European Parliament and Council. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC. May 04, 2016 <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02016R0679-20160504&from=EN> (accessed March 29, 2021).
- 352 Qi A, Shao G, Zheng W. Assessing China's cybersecurity law. *Comput Law Secur Rep* 2018; **34**: 1342–54.
- 353 Eiss R. Confusion over Europe's data-protection law is stalling scientific progress. *Nature* 2020; **584**: 498.
- 354 Maranto L. Who benefits from China's cybersecurity laws? June 25, 2020. <https://www.csis.org/blogs/new-perspectives-asia/who-benefits-chinas-cybersecurity-laws> (accessed March 29, 2021).
- 355 Snower D, Twomey P, Farrell M. Revisiting digital governance. Oxford: Oxford University, 2020.
- 356 McLachlan S, Dube K, Johnson O, et al. A framework for analysing learning health systems: are we removing the most impactful barriers? *Learn Health Syst* 2019; **3**: e10189.
- 357 European Commission. European Health Data Space. https://ec.europa.eu/health/ehealth/dataspace_en (accessed March 29, 2021).
- 358 Lencucha R, Bandara S. Trust, risk, and the challenge of information sharing during a health emergency. *Global Health* 2021; **17**: 21.
- 359 Nature. Wanted: rules for pandemic data access that everyone can trust. *Nature* 2021; **594**: 8.
- 360 The Lancet Digital Health. Transparency during global health emergencies. *Lancet Digit Health* 2020; **2**: e441.
- 361 Open Data Institute. What do we mean by data institutions? Feb 10, 2020. <https://theodi.org/article/what-do-we-mean-by-data-institutions/> (accessed March 29, 2021).
- 362 Data Trusts Initiative. Selecting a data sharing structure: a value-based choice. March 27, 2020. <http://www.datatrusts.uk/blogs/selectingdatastructures> (accessed March 29, 2021).
- 363 Open Data Institute. Data trusts summary report. London: Open Data Institute, 2019.
- 364 Ho C, Chuang T. Governance of communal data sharing. In: Daily A, Devitt K, Mann M, eds. Good data. Amsterdam: Institute of Network Cultures, 2019.
- 365 Craglia M, Scholten H, Micheli M, et al. Digitranscope: the governance of digitally-transformed society. Luxembourg: Publications Office of the European Union, 2021.
- 366 Hägglund M, Scandurra I. Patients' online access to electronic health records: current status and experiences from the implementation in Sweden. *Stud Health Technol Inform* 2017; **245**: 723–27.
- 367 Kapoor A. Data stewardship: collective bargaining for privacy. Oct 3, 2020. <https://www.orfonline.org/expert-speak/data-stewardship-collective-bargaining-for-privacy-74488/> (accessed March 29, 2021).
- 368 McMahon A, Buyx A, Prainsack B. Big data governance needs more collective responsibility: the role of harm mitigation in the governance of data use in medicine and beyond. *Med Law Rev* 2020; **28**: 155–82.
- 369 Watts G. The Tanzanian digital health agenda. *Lancet Digit Health* 2020; **2**: e62–63.
- 370 Digital Square. Digital health applied leadership program: needs assessment findings. 2021. https://wiki.digitalsquare.io/images/5/51/Final_DHALP_Needs_Assessment_Presentation_.pdf (accessed March 26, 2021).
- 371 OECD. Health in the 21st century: putting data to work for stronger health systems. Paris: OECD Publishing, 2019.
- 372 Oderkirk J. Readiness of electronic health record systems to contribute to national health information and research. Paris: OECD Publishing, 2017.
- 373 Lilja J. Secondary use of health data—the new Finnish Act. Nov 19, 2019. <https://www.roschier.com/newsroom/secondary-use-of-health-data-the-new-finnish-act/> (accessed March 29, 2021).
- 374 Bennett A, Goertz H. Governing data for better health. June 26, 2020. <https://www.path.org/articles/governing-data-better-health/> (accessed March 29, 2021).
- 375 Olu O, Muneene D, Batarangaya JE, et al. How can digital health technologies contribute to sustainable attainment of universal health coverage in Africa? A perspective. *Front Public Health* 2019; **7**: 341.
- 376 USAID. Digital strategy 2020–2024. Washington, DC: United States Agency for International Development, 2020.
- 377 BMZ. Digitalisierung für entwicklung. 2019. <https://www.bmz.de/resource/blob/23424/be7b98c74717536246125b8b5cbddcff/smateriale405-digitalisierung-data.pdf> (accessed March 29, 2021).

- 378 Department for International Development. DFID digital strategy 2018 to 2020: doing development in a digital world. Jan 23, 2018. <https://www.gov.uk/government/publications/dfid-digital-strategy-2018-to-2020-doing-development-in-a-digital-world/dfid-digital-strategy-2018-to-2020-doing-development-in-a-digital-world> (accessed March 29, 2021).
- 379 USAID. Vision for action in digital health, 2020–2024: accelerating the journey to self-reliance through strategic investments in digital technologies. Washington, DC: United States Agency for International Development, 2020.
- 380 Germany Federal Government. Global health strategy of the German Federal Government. Frankfurt: Druck- und Verlagshaus Zarbock, 2020.
- 381 OECD. Creditor reporting system. 2021. <https://stats.oecd.org/Index.aspx?DataSetCode=crs1> (accessed Jan 1, 2021).
- 382 WHO. Digital implementation investment guide (DIIG): integrating digital interventions into health programmes. Geneva: World Health Organization, 2020.
- 383 Nicholson B, Nielsen P, Saebo J, Sahay S. Exploring tensions of global public good platforms for development: the case of DHIS2. In: Nielsen P, Kimaro H, eds. Information and Communication Technologies for development. Strengthening southern-driven cooperation as a catalyst for ICT4D. Cham: Springer, 2019: 207–17.
- 384 DHIS2 Documentation. Tanzania: integrated health information architecture. <https://docs.dhis2.org/en/topics/user-stories/tanzania-integrated-health-information-architecture/architecture.html?> (accessed March 29, 2021).
- 385 DHIS2 Documentation. Rwanda HMIS powered by DHIS2. <https://docs.dhis2.org/en/topics/user-stories/rwanda-hmis-powered-by-dhis2.html> (accessed March 29, 2021).
- 386 PATH. Digital Square Global Goods Guidebook. Seattle, WA: PATH, 2021.
- 387 Youth Hub, Global Health Workforce Network, and WHO. Youth and decent work in the health and social care sector. Geneva: World Health Organization, 2019.
- 388 European Commission. Digital is transforming medical doctors' daily work: deans and student doctors agree on common principles to adapt medical doctors' training. May 3, 2019. <https://ec.europa.eu/digital-single-market/en/news/digital-transformingmedical-doctors-daily-work-deans-and-student-doctors-agree-common> (accessed Sept 20, 2020).
- 389 Wong BLH, Khurana MP, Smith RD, et al. Harnessing the digital potential of the next generation of health professionals. *Hum Resour Health* 2021; **19**: 50.

© 2021 Elsevier Ltd. All rights reserved.