**DIGITAL HEALTH INTERVENTIONS TO IMPROVE PATIENT OUTCOMES**

*Outline of the chapter*

1. *Introduction*
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4. *Current trends in digital health*
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**Introduction**

Digital health is revolutionising the healthcare sector, moving away from the traditional ‘one-size-fits-all’ approach of healthcare management towards real-time personalised monitoring and therapeutic care. Digital devices have the potential to improve our ability to diagnose accurately, treat diseases and to enhance the delivery of healthcare for individual patients, as well as empowering patients to have more control over, and make better-informed decisions about, their health. The concept also offers numerous opportunities to facilitate prevention, early diagnosis of life-threatening diseases, and management of chronic conditions outside of traditional health care settings.

Digital technologies introduce novel opportunities to address health system challenges,

and thereby offer the potential to enhance the coverage and quality of health practices and

services . Digital health interventions may be used, for example, to facilitate

targeted communications to individuals through reminders and health promotion messaging

in order to stimulate demand for services and broaden access to health information. Digital

health interventions may also be targeted to health workers to give them more immediate

access to clinical protocols through, for example, decision-support mechanisms or telemedicine

consultations with other health workers

**Important terminologies in field of digital health**

1. Digital health, or the use of digital technologies for health, has become a salient field of practice for employing routine and innovative forms of information and communications technology (ICT) to address health needs. More recently, the term digital health was introduced as “a broad umbrella term encompassing eHealth (which includes mHealth), as well as emerging areas, such as the use of advanced computing sciences in ‘big data’, genomics and artificial intelligence”
2. eHealth is defined as the use of information and communications technology in support of health and health-related fields”.
3. Mobile health (mHealth) is a subset of eHealth and is defined as “the use of mobile wireless technologies for health”.
4. A digital health intervention is defined here as a discrete functionality of digital technology that is applied to achieve health objectives and is implemented within digital health applications and ICT systems, including communication channels such as text messages. The range of digital health interventions is broad, and the software and technologies – digital applications – that make it possible to deliver these digital interventions continue to evolve within the inherently dynamic nature of the field.

**Background**

The recent COVID-19 pandemic has highlighted the critical importance of digital technologies in healthcare , with many people coming to rely on the internet and digital devices for access to medical services and treatments. Indeed, development of transformative digital health tools has reached peak pace, with many emerging devices promising to revolutionise aspects of patient care. Healthcare systems are gradually recognising that adoption of modern technologies could streamline the patient pathway, from identification of symptoms to treatment and long-term support. This paradigm shift has the potential to widen access to healthcare provision, reduce costs, and provide services tailored to individual needs.

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(ICT) to address health needs.

**Classification of digital health interventions**

The digital health interventions are organized into the following overarching groupings

based on the targeted primary user:

1. **Interventions for clients:** Clients are members of the public who are potential or current users of health services, including health promotion activities. Caregivers of clients receiving health services are also included in this group.
	1. Targeted client communications
		1. Transmit health event alerts to specific population groups
		2. Transmit targeted health information to clients based on health status or demographics
		3. Transmit targeted alerts and reminders to clients
		4. Transmit diagnostics results or availability of results to clients
	2. Untargeted clients communication
		1. Transmit untargeted health information to an unidefined population
		2. Transmit untargeted health events alerts to undefined group
		3. Peer group for clients
	3. Personal health tracking
		1. Access by client to own medical records
		2. Self monitoring of health or diagnostic data by clients
		3. Active data capture or documentation by client
	4. Citizen based reporting
		1. Reporting of health system feedback by clients
		2. Reporting of public health events by clients
	5. On demand information services to client
		1. Client look up of health information
	6. Client financial transactions
		1. Transmit or manage out of pocket payments by clients
		2. Transmit or manage vouchers to client for health services
		3. Transmit or manage incentives to client for health services
2. **Interventions for healthcare providers:** Healthcare providers are members of the health workforce who deliver health services.
	1. Client identification and registration
		1. Verify clients unique identity
		2. Enroll client for health services
	2. Client health records
		1. Longitudinal tracking of client health status and services
		2. Manage client’s structured records
		3. Manage clients unstructured clinical record
		4. Routine health indicator data collection and management
	3. Health care provider decision support
		1. Provide prompt and alerts based according to protocol
		2. Provide checklist according to protocol
		3. Screen clients by risk or other health status
	4. Telemedicine
		1. Consultation between remote client and health care provider
		2. Remote monitoring of client health or diagnostic data by health care provider
		3. Transmission of medical data to healthcare provider
		4. Consultation for case management between health care provider
	5. Health care provider communication
		1. Communication from health care provider to supervisor
		2. Communication and performance feedback to health care provider
		3. Transmit routine news and workflow notifications to healthcare provider
		4. Transmit non routine health events alerts to health care provider
		5. Peer group for health care provider
	6. Referral coordination
		1. Coordinate emergency response and transport
		2. Manage referrals between points of service within health sector
		3. Manage referrals between health and other sectors
	7. Health worker activity planning and scheduling
		1. Identify clients in need of services
		2. Schedule health care provider activities
	8. Health care provider training
		1. Provide training content to health care provider
		2. Assess capacity of health care providers
	9. Prescription and medication management
		1. Transmit or tract prescription orders
		2. Track clients medication consumption
		3. Report adverse drug events
	10. Laboratory and diagnostic imaging management
		1. Transmit diagnostic result to health care provider
		2. Transmit and track diagnostic orders
		3. Capture diagnostic results from digital devices
		4. Track biological specimens
3. **Interventions for health system or resource managers**: Health system and resource managers are involved in the administration and oversight of public health systems. Interventions within this category reflect managerial functions related to supply chain management, health financing, human resource management.
	1. Human resource management
		1. List health workforce cadres and related identification information
		2. Monitor performance of health care providers
		3. Manage certification/registration of healthcare providers
		4. Record training credentials of health care providers
	2. Supply chain management
		1. Manage inventory and distribution of health commodities
		2. Notify stock level of health commodities
		3. Monitor cold chain sensitive commodities
		4. Register licensed drug and health commodities
		5. Manage procurement of health commodities
		6. Report counterfeit or substandard drug by clients
	3. Public health event notification
		1. Notification of public health events from point of diagnosis
	4. Civil registration and vital statistics
		1. Notify birth events
		2. Register birth events
		3. Certify birth events
		4. Notify death events
		5. Register death events
		6. Certify death events
	5. Health financing
		1. Register and verify clients insurance membership
		2. Track insurance billing and claims submission
		3. Track and manage insurance reimbursement
		4. Transmit routine payroll payment to health care providers
		5. Transmit or manage incentives to healthcare providers
		6. Manage budget and expenditure
	6. Equipment and asset management
		1. Monitor status of health equipment
		2. Track regulation and licensing of medical equipment
	7. Facility management
		1. List health facilities and related information
		2. Assess health facilities
4. **Interventions for data services:** This consists of crosscutting functionality to support a wide range of activities related to data collection, management, use, and exchange.
	1. Data collection, management and use
		1. Non routine data collection and management
		2. Data storage and aggregation
		3. Data synthesis and visualization
		4. Automated analysis of data to generate new information or predictions on future events
	2. Data coding
		1. Parse unstructured data into structured data
		2. Merge, de –duplicate and curate coded database o terminologies
		3. Classify disease codes or cause of mortality
	3. Location mapping
		1. Map location of health facilities/structures
		2. Map location of health events
		3. Map location of clients and household
		4. Map location of health care providers
	4. Data exchange and interoperability
		1. Data exchange across systems

**Current trends in digital health**

* Healthcare devices have the capability to improve real-time, accurate diagnosis and treatment of disease. They allow medical care to percolate not just traditional clinical settings, but also homes, workplaces and travel locations. In this manner, participatory medicine lessens the burden on physical healthcare establishments, whilst providing patients with care that integrates with their daily lives.
* Devices can empower patients to self-advocate, gain control over their care and make better-informed decisions about their health. Digital healthcare also offers new ways to facilitate prevention and management of chronic conditions at the population level.
* In the traditional model of healthcare, the general population tends to seek medical advice when new symptoms appear and they attend a check-up with a General Practitioner (GP). This model is changing with the increasing availability of affordable consumer technology, such as wearables, which give patients direct access to information about their health by providing real-time clinical data, a relatively new trend known as Quantified Self (QS).
* According to a recent report, the wearable medical device market is expected to reach more than US $90.4 billion by 2022 . Currently, Apple has the majority market share (34.1%), followed by Xiaomi and Samsung .
* Facilitated by devices and technology, patients are taking an enhanced interest in their own daily health, often without the support of healthcare professionals.
* The use of patient-specific clinical data and Electronic Healthcare Records (EHRs) can pave the way for personalising treatments for patients. For example, 3D printing technologies have been applied for the on-demand production of dosage forms tailored to individual patients, with customised dosages, drug combinations, shapes, sizes, and drug release profiles, at the point-of-care such as within hospital or community pharmacies.
* The field of robotics is also being exploited to support multiple healthcare services. In particular, large robots are being used to expedite medication dispensing and perform surgical procedures, whilst smaller ones are remotely guided to accurately deliver drug substances to targeted disease sites within the body.
* Other digital tools including medical drones, can be used to improve medicine and treatment access, especially for patients who have mobility challenges or those who live in poorly accessible locations. Similarly, medical drones can be used to collect samples for delivery to local hospitals and clinics, facilitating and accelerating services that normally take time or are unattainable using road transport methods .
* With many medical devices now having the ability to connect to and communicate with other devices or systems, remote monitoring can be performed in a continuous manner, enabling prompt interventions. Indeed, these transformative technologies are contributing towards large-scale cyber physical systems, using in-built sensors, Internet of Things (IoT), and cloud computing. These integrated systems of information and communication technologies (ICTs) allow previously isolated devices to collaborate, enabling closed-loop sensing, data collection, and on-demand outputs tailored to the needs of the individual.

**Popular technologies used in digital health interventions**

**Sensors**

Sensors will play a pivotal role in the future of modern medicine by facilitating remote diagnosis and patient monitoring . Sensors are devices used to measure and record physical, chemical, and/or biological signals. Sensors which incorporate a biological component to detect signals are more precisely defined as biosensors.

**3D printing**

With this technology doctors can create tools that accurately follow a patient’s unique anatomy. 3D printed tool are used to make the placement of restorative treatments (screws, plated and implants) more precise, resulting in better post operative results. It is possible to 3D print plastic parts of the equipment. This reduces costs and time spent waiting to receive a new medical device form external supplier.

**Robotics**

Increasingly, robots are being applied to automate and/or provide high level precision for the operation of a myriad of medical tasks. Key examples include minimally invasive surgery; hospital disinfection; communication with isolating or infectious patients ; lifting patients; and phlebotomy. In addition, the pharmaceutical sector is embracing robotics for streamlining their manual services and as drug delivery tools.

**Internet of things (IoT)**

IoT refers to a set of physical, electronic devices that communicate with one another by remotely exchanging data over the internet. It is a platform that aims to automate processes by interconnecting multiple devices (e.g., sensors, robots and computers), removing the need for human involvement . IoT seeks to converge a myriad of physical and virtual digital technologies to enact the decisions but in an automated manner.

**Opportunities in digital health interventions**

* Digital technologies provide concrete opportunities to tackle health system challenges, and thereby offer the potential to enhance the coverage and quality of health practices and services.
* Digital health interventions may be used, for example, to facilitate targeted communications to individuals in order to generate demand and broaden contact coverage.
* Digital health interventions may also be targeted to health workers to give them more immediate access to clinical protocols through, for example, decision-support mechanisms or telemedicine consultations with other health workers. The range of ways digital technologies can be used to support the needs of health systems is wide, and these technologies continue to evolve due to the inherently dynamic nature of the field.
* Digital health interventions are applied within a country context and a health system, and their implementation is made possible by a number of factors including:
	+ The health domain area and associated content;
	+ The digital intervention or functionality provided;
	+ The software and communication channels for delivering the digital health intervention; and mediated by
	+ A foundational layer of the ICT and the enabling environment
	+ Furthermore, these components need to be made appropriate to the local context and ensure effective implementation through reflection on the behaviour and organizational changes that would also be required. Lastly, digital health interventions are intended to fit into an overall digital health architecture.

**Challenges and threats in digital health interventions**

Despite the numerous benefits of digital health technologies, a number of challenges for their adoption still remain.

* The integration of tools into existing healthcare structures, the need for data security and protection, as well as provision for potentially high entry costs.
* The risk of making all processes autonomous should be evaluated for their effects on healthcare services (e.g., dramatic implications in case of system failures) and social welfare (e.g., limited job opportunities if human jobs are replaced by robots).
* To build an equitable model of digital healthcare, it is imperative that those lacking the personal funds to purchase devices are not left behind; often these patients have the potential to benefit most from the innovative technologies.
* Amid the heightened interest, digital health has also been characterized by implementations rolled out in the absence of a careful examination of the evidence base on benefits and harms. The enthusiasm for digital health has also driven a proliferation of short-lived implementations and an overwhelming diversity of digital tools, with a limited understanding of their impact on health systems and people’s well-being.
* This concern was highlighted most notably in the consensus statement of the WHO Bellagio eHealth Evaluation Group, which opened by stating: “To improve health and reduce health inequalities, rigorous evaluation of eHealth is necessary to generate evidence and promote the appropriate integration and use of technologies.” While recognizing the innovative role that digital technologies can play in strengthening the health system, there is an equally important need to evaluate their contributing effects and ensure that such investments do not inappropriately divert resources from alternative, non-digital approaches.
* At present, the lack of thorough regulatory and legal framework remains the principal barrier restricting the free uptake and use of digital technologies within healthcare. One of the main concerns for regulatory systems is to ensure that patients can use digital technologies with confidence, whilst their identities and data are safeguarded. In this regard, it has been proposed to create a “Meaningful Regulation”, which is a regulatory framework that regulates the use of digital technologies

**Conclusion**

In healthcare, digital solutions have been adopted with zeal, but there is paucity of evidence for benefits and harms of these solutions. The impact, immediate or long term, of digital applications on healthcare has not been assessed. With the overwhelming numbers and types of digital solutions, it is becoming increasingly important to develop evidence-based insights for the integration of these solutions in routine medical care.

Digital transformation has instigated a paradigm shift within healthcare, changing the way treatment is managed and provided. The use of sensor devices has empowered clinicians, enabling them to monitor and diagnose disease conditions more efficiently and accurately. 3D printing has been increasingly investigated as a modern way for manufacturing medicines to meet patients’ individual needs. In the case of robots, their applications span across several healthcare applications, ranging from

 Digitalization can certainly empower and enable patients and physicians to achieve health objectives. The World Health Organisation has released guidance for digital health after a critical review of available evidence for the benefits, harms, acceptability, feasibility, resource use and equity considerations of digital health interventions. This guidance can potentially inspire and impact future research endeavors for digital applications.

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