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HealthTech Roadmap

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FOREWORD

Under the supreme leadership of **Samdech Akka Moha Sena Padei Techo HUN SEN**, Prime Minister of the Kingdom of Cambodia, Science, Technology & Innovation (STI) is the core of future industrial development of Cambodia, in view to achieve the 2030 and 2050 goals. As such, Ministry of Industry, Science, Technology & Innovation (MISTI) and the National Council of Science, Technology & Innovation (NCSTI) has provided strategic guidance to implement the National Policy on STI 2020-2030 and the Cambodia's STI Roadmap 2030.

Together with National Strategic Development Plan 2019-2023, Health Strategic Plan 2016 – 2020, and Cambodia's STI Roadmap 2030, this National Health Technology Roadmap aims to provide strategic directions for the development of key emerging health technologies. Improving population health is a key target identified by the Royal Government in the Rectangular Strategy Phase IV.

I am confident that this Health Technology Roadmap is a crucial blueprint for stakeholders from the policy making arena, academia, private sector, general public, and development partners, to guide their common endeavors to contribute towards the socio-economic development of Cambodia

Indeed, it took a dream team of outstanding experts to produce such a critical health policy framework, essential for Cambodia.

So, I would like to take this opportunity to thank and commend the remarkable contributions of steering and technical committees for the Health Technology Roadmap, experts for the University of Puthisastra, the General Department of STI, senior officials of MISTI, and the Science Technology Policy Institute (STEPI) of South Korea.

Phnom Penh, ..22.. June 2022

Senior Minister

Minister of Industry, Science, Technology & Innovation

and Chair of National Council of Science, Technology & Innovation

***Kitti Settha Pandita* CHAM Prasidh**

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This roadmap has been written for MISTI by Dr Tineke Water University of Puthisastra, Dr Michael Renfrew Future Forum, Ms Pol Sreymom Angkor Children's Hospital, Mr Veng Mengkoung ITC consultant; Ms Eng Muyngim Research Fellow University of Puthisastra.

This roadmap was developed with the valuable input from a committee of experts with expertise in health and technology through a series of interviews, workshops, and discussions. The committee included: H.E. Prof Dr Chhem Kieth Rethy, Minister Delegate and Attached to the Prime Minister and Secretary of State at MISTI; H.E. Dr Hul Seingheng, Director General of the General Department of Science, Technology, and Innovation (GDSTI), MISTI; H.E. Dr Hok Kimcheng, Director General of the Directorate General for Health of the Ministry of Health; H.E. Neang Mao, Director General of the General Department of Information and Communication Technology of the Ministry of Posts and Telecommunications; Dr Ly Sokny Director of Department of Science, Technology, and Innovation Cooperation of GDSTI, MISTI; Dr Cheat Sophal, Director of the Department of Policy Monitoring, Inspection and Evaluation (DMIE) of GDSTI, MISTI; Dr. Srun Pagnarith, Director of Department of Science, Technology and Innovation Policies, GDSTI, MISTI; Assistant Prof Mam Sovatha, Vice Rector of the University of Health Science; Prof Heng Sopheab, Deputy Director, National Institute of Public Health; Dr Siev Sokly, Deputy Director of the Department Science, Technology and Innovation Policies, GDSTI, MISTI; Ms Taing Chanreaksmey Chief of Office of the GDSTI, MISTI; Dr Va Vandith, Deputy Director of the Science, Technology, and Innovation National Laboratory,National Institute of Science, Technology and Innovation; Dr Duong Veasna, Director of Virology, Pasteur Institute of Cambodia; Dr Khoem Namgech, Ophthalmologist, Calmette Hospital; Dr Chea Sin, Dean of Faculty of Pharmacy, University of Puthisastra; Mr Bin Socheat, Consultant, Founder and Business Manager of Peth Yoeung Hospital Operating System and Healthcare Platform; Dr Nit Buntongyi, Executive Director of Meet Doctor Group; Prof Alamgir Hossain, Vice President of the Cambodian University of Technology and Science; and Ms Nas Chakriya, Enterprise Quality Assurance Manager of PPM Pharmaceuticals. DMIE officials' administrative support is also acknowledged.

List of Abbreviation

AI	Artificial Intelligence
CAMLIS	Cambodia Laboratory Information System (CamLIS)
eHealth	Electronic Health
Hcs	Heath Centre (HCs)
HIS	Health Information system
HMIS	Health Management Information System
HRMS	Human Resource Management System
Mhealth	Mobile Health
MIS	Malaria Information system
MOH	Ministry of Health
NCDs	Non communicable diseases
PMRS	Patient Management Registration System
R&D	Research & Development
RGC	Royal Government of Cambodia
SDG3	Sustainable Development Goal 3
STEM	Science, Technology, Engineering, and Mathematics
STEEP	Society, Technology, Economy, Ecology, and Politics
SWOT	Strengths, Weaknesses, Opportunities, and Threats
STI	Science, Technology & Innovation
UNICEF	United Nations Children's Fund
UP	University of Puthisastra
VR	Virtual Reality
WHO	World Health Organization

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Executive Summary

The purpose of this project was to develop a 10-year Health Technology Road Map for Cambodia. Health technologies have a key role in contributing to improving population health and decreasing the burden of disease. A high burden of disease can impact on a country's economy through labor and productivity losses, disability, premature death, increased health service expenditure and at a social level decreased quality or disability adjusted life years. Recognizing the interlinked relationship between health, social and economic outcomes, the Royal Government of Cambodia has committed to improving population health with the support of health technologies as part of its future prosperity and economic future.

This project was undertaken through consensus building between MISTI and an expert committee to establish a vision and goals, identify priority products, services, and technologies that contributed to the conceptualization of the Health Technology Road Map for Cambodia. The mapping of Health Technology for Cambodia offers a way forward to integrate technologies and health to benefit individuals, communities, and the Royal Government of Cambodia. This process has identified the key products, services, technologies, and strategies needed to implement a plan that is both at once practical while being open to the future potential and rapid ongoing development of technology. The roadmap is based on three inter-related and reinforcing visions:

1. An Integrated One Health Approach
2. Multidisciplinary Policy and Governance for Health Technology
3. Strengthened Research and Knowledge Sharing Capacity

In order to deliver on these visions, several objectives have been defined, and considered alongside supporting technologies. In the short term, Cambodia may consider focusing investment on ensuring nationwide internet access and developing cloud computing facilities to support the increased digitalization of the health sector. In the medium term, targeted development of blockchain medical records and advanced Telemedicine infrastructure will build on earlier technological upgrading to enhance service provision. As 2030 approaches, the ambition is to have established a knowledge sharing, One Health embodied health sector, made possible through the adoption and advancement of key technologies as discussed.

Following the Health Tech reporting process, an overriding recommendation, is it will be important to design and implement an effective monitoring and evaluation system for tracking the life cycle of this roadmap. This is particularly crucial for identifying new avenues of importance and new health technologies in a dynamic sector. Cambodia may not wish to develop this system in silo, but rather collaborate with regional and supra-national partners to adopt best-practices and augment for contextual suitability where necessary. Specific recommendations are that Cambodia needs to invest in building its human resources; that there are clear financing pathways; and the development of medical infrastructure.

Health Technology Road Map Process

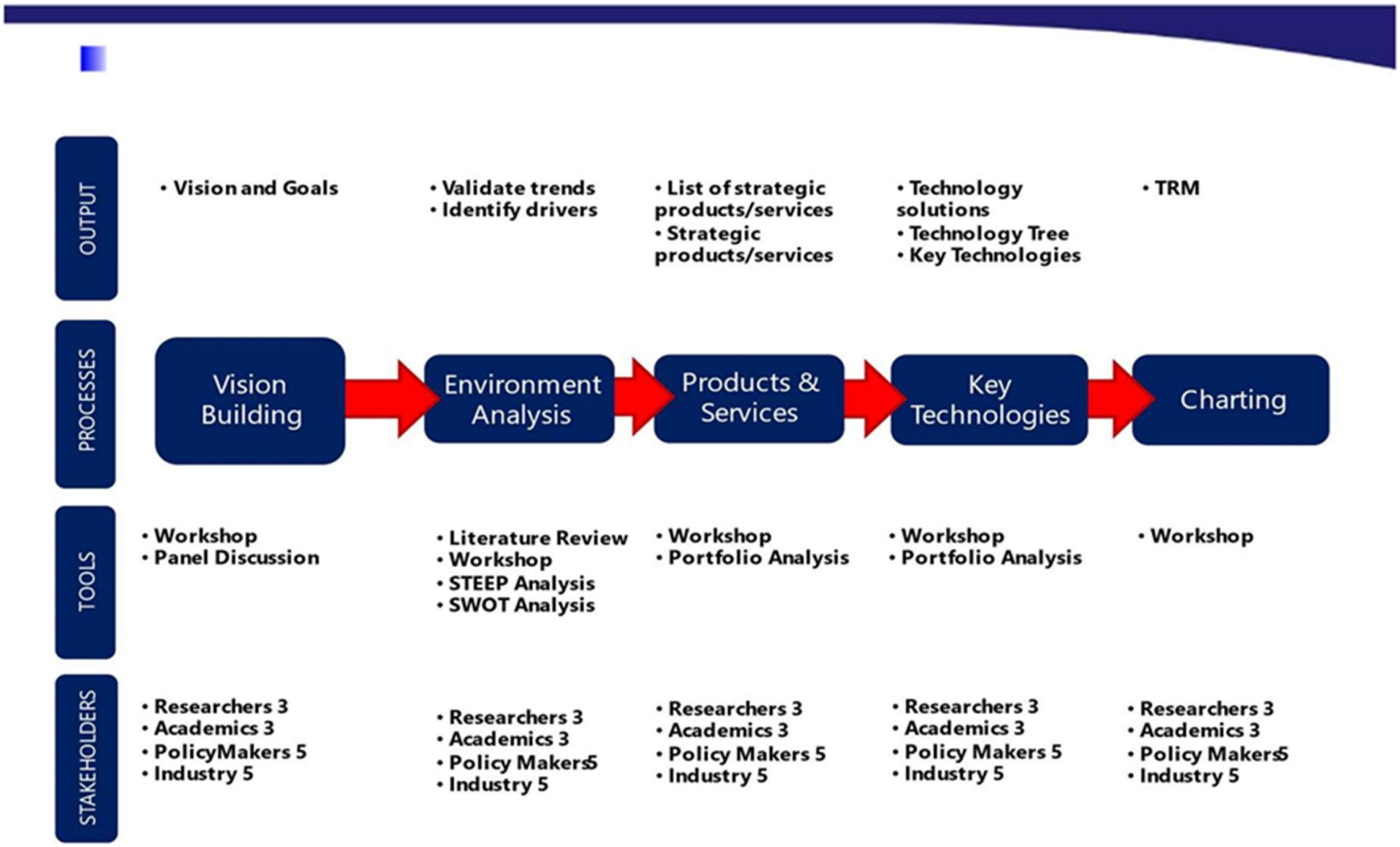


Figure 1: Mapping the process of developing the Health Technology Road Map

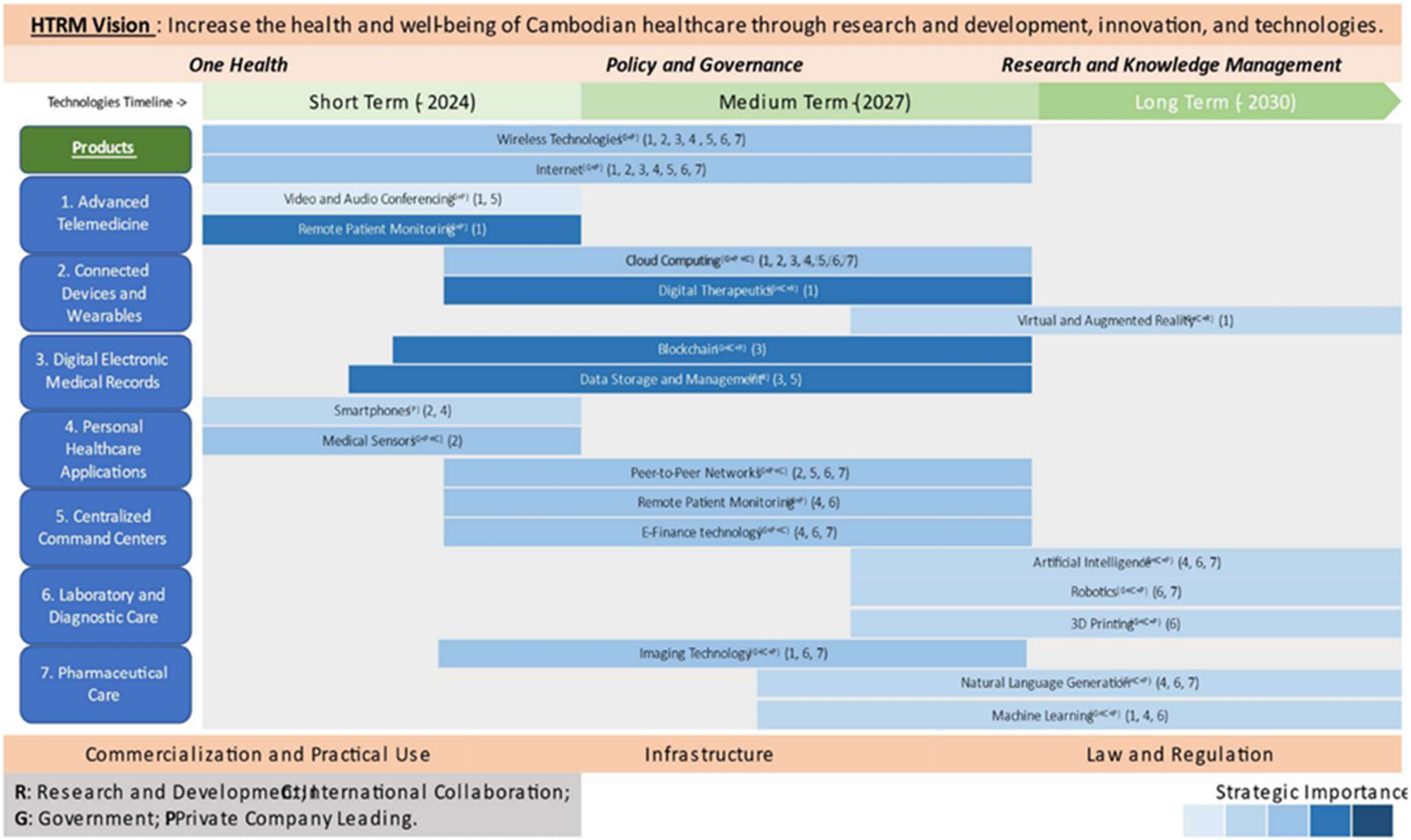


Figure 2: Infographic HTRM

I. Introduction

Background

Health Technology is defined by the World Health Organization (WHO) as the application of organized knowledge and skills in the forms of medicines, medical devices, vaccines, procedures, and systems developed to solve a health problem and improve quality of life. The importance of health technologies is linked to the Sustainable Development Goals (SDG) 3, which aims to 'ensure healthy lives and promote well- being for all at all ages', to 'achieve universal health coverage, 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'; SDG 6 clean water and sanitation; and SDG 9 which promotes inclusive and sustainable industrialization, with innovation and infrastructure, and promote new technologies and efficient use of resources.

It is in this context that the Ministry of Industry, Science, Technology and Innovation (MISTI) established a technical committee to develop a 10-year Health Technology Road Map with the specific objectives of (1) conducting a desktop review of existing and future trends of health technologies at national, regional and global levels;(2) collect relevant information on the existing health technologies deployed in Cambodia; (3) undertake a STEEP and SWOT analysis of the existing and health technologies to contextualize the roadmap; (4) identify key products, services and technologies and recommendations that are appropriate and feasible within the Cambodian context that will contribute to improved individual and population health outcomes.

II. Country Context

Cambodia has a population of around 17 million people, with 30% of the population younger than 15 years old (UNICEF). It is estimated that approximately 2 million people live below the poverty line, with a further 4.5 million people only marginally above this with most of the group living in rural areas (World Bank, 2020). Addressing poverty and social inequality alongside health service delivery is seen as integral to improving population health (Kolesar, 2019). There have been some significant gains in rebuilding the health care system with significant drops in infant and maternal mortality (WHO, 2016). These reforms involve the development of policies and strategies

including increasing support for universal health care coverage which includes a goal of improved collection and use of health care data. However, challenges remain including lack of infrastructure, regulation, accreditation, funding, and workforce development (WHO, 2016).

In Cambodia, it is estimated that there are 6.9 nurses and midwives and 1.9 doctors per 10,000 people which is one of the lowest rates in Southeast Asia (Department of Planning and Health Information (DPHI), 2016; https://ourworldindata.org). Current spending of Gross Domestic Profit (GDP) on health is around 6% which is average in Southeast Asia, however much of this is un-pooled money on medicine and private services with only 20% of the total health funding allocated to public services (World Development Indicators, databank.worldbank.org/; National Institute of Statistics DGfH, 2015). Since 1996, financial policies have been implemented to improve access to health services particularly for the poor and at-risk communities, and implemented through fee exemptions, vouchers, and community- based health insurance, and health equity funds (government and NGOs) (Ensor, Chhun, Kimsun, McPake, & Edoka, 2017). However, access to health services remains a challenge with on approximately 0.5 visits per capita to formal health services (Ensor, Chhun, Kimsun, McPake, & Edoka, 2017). Although health expenditure has risen from$70 per person in 2000 to $300 per person in 2019, this is still much lower (adjusted for inflation and in country price) than mid-high economic countries who spend from $5,000 to $20,000 per person (https://ourworldindata.org). Between 2000 and 2019 there has been a 40% decrease in the burden of disease, measured by the number of years lost to mortality prematurely (https://ourworldindata.org).

A threefold increase in spending on children under 5 from 2000 to 2017 has seen childhood mortality decrease from 10% to 2.8% respectively (https://ourworldindata.org) however health inequality related to health expenditure (GDP) remains at 16% (https://ourworldindata.org). Out of pocket expenditure on health by households was 64.4% in 2019, which represents a significant financial burden to families in addition to being a barrier to seeking health services (https://dataworldbank.org). While deaths from non-communicable diseases dropped

to 28,659 in 2019, deaths from communicable disease [1] have been rising with 73,475 deaths reported in 2019 (http://ourworldindata).

The barriers to technology innovation in Cambodia include infrastructure and human resources. Currently there is a significant gap in digital literacy with Cambodia ranking 9.27 on the Cisco global digital readiness index in 2019, placing it in an 'accelerating' category but still lacking systems to support this (Cisco, 2019). This is likely to have changed post COVID-19 with the rapid adoption online platforms for business, education, health care and health education, however gaps remain. On the Global Cybersecurity Index, Cambodia scored 92 in 2017 – classified as the initiating stage (ITU, 2017). There also remains wide disparities between urban and rural areas with 99% of people from the lowest economic quintile living in rural areas which do not have the same access to technology, electricity and Wi-Fi/internet or telecommunications services as people in urban areas (ICF International, 2014). This means an investment in digital infrastructure is one of the most pressing priorities.

Globally there is a move to healthcare systems using technologies such as the internet of things (IoT), big data, cloud computing, and artificial intelligence to improve health care delivery and outcomes. These technologies and innovations will transform the traditional medical system in an all-around way, making healthcare more efficient, more convenient, and more personalized. It also has the potential to create solutions that democratize access to healthcare, helping patients, physicians, and providers. In order to match the global trend, it is important that Cambodia puts an emphasis on health technology. However, in reviewing the existing literature, there are many challenges that Cambodia must consider.

III. Sector Context/Status (Literature Review)

Rapid economic development, especially in Southeast Asia, has contributed to higher standards of living, but also in more pressure on organisations to provide more and higher quality health services (Sterlin, 2016). Rising middle-class incomes, and growing aging populations, are driving the demand for better healthcare services, products and infrastructure (Sterlin, 2016). Traditional and current models for

[1] Mortality from CVD, cancer, diabetes or CRD is the percent of 30-year-old-people who would die before their 70th birthday from any of cardiovascular disease, cancer, diabetes, or chronic respiratory disease, assuming that s/he would experience current mortality rates at every age and s/he would not die from any other cause of death (e.g., injuries or HIV/AIDS).

healthcare predict that the cost will soon be unsustainable, and there are already increasing pressures and challenges that face healthcare systems, in both-developing and developed nations (OECD, 2015). This requires nations to look at ways to provide healthcare that is accessible, affordable, efficient, and sustainable (WHO, 2017). It is argued that digital health can reduce costs and improve service delivery; is more accessible to patients and communities; and decreases the need for large facilities and expensive infrastructure (Matthews et al., 2019).

According to World Health Organisation (WHO), digital health is the field of knowledge and practice associated with the development and use of digital technologies to improve health (WHO, 2021). Innovations in digital health, including mobile health Apps, Telemedicine, cloud computing, robotics, 3D printing, and wearable devices, all bring new approaches to managing health conditions and providing health services. These technologies are reshaping the relationship between patients, healthcare providers, and the healthcare system. Globally, more people use the internet when looking for health information and utilising digital health related devices. A survey in 2020 found that 88% of respondents said that they were using some form of digital technology for health-related purposes which included Smartphone Apps, websites, social media, online consultations, and wearable devices (Kickbusch et al., 2021).

Moreover, the onset of the COVID-19 pandemic in 2020 has had an impact on health care organisations/systems adopting digital technologies. For example, digital vaccine certificates, QR codes and online symptom checkers, have become part of people's daily lives (Mbunge, Fashoto & Batani, 2021). The rapid move to online platforms across other sectors (such as education and business) has contributed to a 'leapfrog' ahead in Cambodia's goal towards Industry 4.0 (Findlay, Chem, & Chem, 2020).

Globally, more than 125 countries, including Cambodia, have developed strategies and policies for digital health (WHO, 2021). Some mid-high-income countries have shown the advantages of digital health in terms of healthcare service delivery, costs and saving time. For example, in Asia, countries such as Japan, South Korea and Singapore have successfully adopted digital health to develop a nationwide database of electronic health records (EHR), Telemedicine, real-time health monitoring, and research (Raghaven, Demircioglu & Taeihagh, 2021).

These technologies span a wide range of uses, from applications in general wellness to medical services/devices. Figure 2 shows the main Digital Health Tools [2].

Figure 3: Digital Health Tools

A desk top review of literature on health technologies in Cambodia show the major health technologies deployed currently in Cambodian include mHealth, e-health, health data management systems, health information systems, Telemedicine, rapid tests, and early warning systems. In addition, a review was undertaken of the current significant trends of technologies in healthcare systems and services (in low-middle income countries), including cloud computing, artificial intelligence, blockchain, machine learning, mHealth/Telemedicine, robotics, augmented reality and virtual reality, 3D printing, connected and wearable devices. For each technology, challenges and barriers were considered to adopting the technology in Cambodia.

Mobile health/mHealth

mHealth (or m-health/mobile health) includes the use of mobile devices, tablets, or computers in the practice of medicine and health care. As a subset of ehealth, mHealth is the one of the most used health technologies in Cambodia to address health issues such as non-communicable diseases (NCDs) (Steinman et al., 2020),

[2] Aitkin, M., Clancy, B., & Nass, D. (2017). The growing value of digital health. IQVIA Institute for Human Data Science, 1–76.

pharmacovigilance (for vaccinations) (Baron et al, 2013), and health messaging (Brody et al., 2017; Chhoun et al., 2019; Smith et al., 2016; Ngor et al., 2016; Dorothy et al., 2015). SMS-based text message systems are well established in Cambodia for syndromic surveillance, including health centers and reporting by health care workers (Baron et al., 2013) and has been used to link health organization databases, pharmacies, peer educators, clinics, and people living with NCDs to improve adherence to evidence-based treatment guidelines (Steinman et al., 2020). The benefits of using mobile telephone technology such as SMS text messaging, is that it is cheap, easy to implement, simple, and can be quickly to be mastered by field staff. mHealth has also been identified as a way to reach high risk populations in urban areas such as female entertainment workers with public health messaging or follow-up screening and intervention (Brody et al., 2017). mHealth can be scaled up to any health context where people have access to a mobile phone.

However, according to the recent study, mHealth is biased toward participants who are younger, more affluent, well-informed, living in urban areas who may be more accustomed to sending SMS text messages and are more likely to have access to smart phones that contain compatible font and language (Brody et al., 2017). Another challenge is that some operators offer only voice-based communications and last-generation cellular phones that do not support Khmer font or Khmer-language text (Brody, 2017). In addition, if users may not use a consistent phone number (mobile company sim cards last a month) this can also make follow up with mHealth difficult (Brody, 2017). Therefore, consideration of phone plans alongside the technology is needed to implement successful mHealth interventions. Moving forward, the adoption of mHealth needs to include developing models for culturally appropriate mHealth interventions through engaging with end-users to ensure the technology is accessible, scalable, and acceptable (Baron et al., 2013).

e-Health

E-Health is another technology widely deployed in Cambodia (Delcher et al., 2018) and is an effective surveillance and early detection tool that allows a rapid and adapted response from the health authorities (Delcher et al., 2018). Compared to mhealth, ehealth is used in a bigger domain as it includes the use of computers and networks for managing and storing medical records without using paper files. Once these tolls are set up, the cost of tool is almost zero as it is free for citizens and health care

providers; it does not require the internet to transmit or upload data in real time; and can be easily shared between different organizations for example health centers, operating districts and DSMT (Delcher et al., 2018).

Health Data Management Systems/MIS

In 2008, the malaria information system (MIS) was developed in Cambodia with the aim to generate timely, routine data on variation in diseases and reported through public health facilities and village workers (Cox, 2014). This database was then scaled up to cover all the operational (health) districts (OD) included within CNM's malaria control strategy and contained a variety of data relating to malaria case numbers and intervention coverage (Cox, 2014). The benefit of using MIS is it could be used to replace the pre-existing system of sending paper reports via Provincial Health Departments with a system through which districts (ODs) send data directly to Centers of Disease Control (CDC) (i.e., CDC, Pasteur, and Centre National de Malariologie) via email (Cox, 2014).

Therefore, MIS underlines the importance of village-level data for effective targeting of interventions including early detection, prevention, and treatment of infectious diseases. Due to the positive feedback of MIS, there is a possibility of introducing a system to routinely generate village level data in Cambodia (Cox, 2014).

However, one of the challenges of using MIS as the database is it is only as good as the quality of the data and consistent reporting at a local level. Even if most health care centers do undertake reporting, incomplete reporting can impact on the accuracy of disease incidence estimates and mask pockets of local transmission (Cox, 2014).

The success of MIS highlights the importance of building staff capacity through training programs which will also ensure capacity development, investment in human resources (not just technological) and long-term sustainability.

Health information systems

The Ministry of Health, DPHI, developed a Master Plan for the 2016-2020 Health Information System (HIS) strategy in alignment with the Health Strategic Plan (2016-2020) and provides future directions for the formulation of roadmaps for different MOH departments, related line ministries and other implementation partners (MOH, 2017). The Ministry of Health formed the HIS sub-committee and a nationwide HIS in July

1992. The HIS bureau is currently developing and managing HMIS and Patient Management Registration System (PMRS) databases for monitoring health service delivery outputs and health profiles of the Cambodian population. Currently the web based HMIS application has reached national coverage across the national, provincial and referral hospitals, except at Heath Centre (HCs) level (MOH, 2017).

The MOH and HMIS stakeholders have made extensive use of the HMIS database to monitor and record health services performance, to provide data for research and to prepare a wide range of official and public reports on Cambodia's health system (MOH, 2017). However, the Cambodian health sector is characterized by a fragmented landscape of ICT pilot projects, a wide array of data and HISs but with significant barriers to the effective sharing of information between the various MOH departments and national programs (Liverani, Chheng, & Parkhurst, 2018).

Although the government, development partners, and the private sector are continuing to invest in various HIS initiatives, without some form of a national plan and coordination, there is a real risk of continued duplication, ineffective expenditure, and the creation of new solutions that cannot be integrated or scaled across the continuum of care (MOH, 2017).

Significant challenges in HIS reporting include frequent HIS staff turnover at the provincial, district, facility levels; lack of internet coverage in certain areas hindering use of the web system; paper-based systems which are prone to errors in data transfer; incomplete recording in registers; use of incorrect indicator definitions; infrequent cross check of data at sub national levels multiple recording sources; formal tally sheets not being used; and a lack of feedback on data reported. In the future there are plans to introduce electronic medical records; a National Health Identification system; strengthen ICD based morbidity and mortality diagnosis; and strengthen disease surveillance system (MOH, 2017).

The challenges identified in implementing HIS is ensuring alignment in what is happening at ministry level and on the ground to integrate both top down and bottom-up approaches. Developing human resources, especially in rural areas remains a priority (Khim & Annear, 2017; Ozano et al, 2018; Zhu et al, 2019). It is suggested that the collection and use of information should not impose an additional burden on the health system but be collected as a routine by-product of the health care process (Cox,

2014). Therefore, proper training and tech support should be given to staff who work at the frontlines as they are the ones who collect the data on the ground (Cox, 2014).

Other HIS initiatives in Cambodia, include the Cambodia Laboratory Information System (CamLIS) (WHO, 2019). This database allows all laboratory personnel to enter their laboratory data and perform analysis, whilst sharing this in real time with other key personnel in the Ministry of Health. From its inception, WHO has continued to support the initiative technically and financially through expert support, system setup, equipment, and provision of training. Ongoing challenges include lack of infrastructure such as limited internet connection and equipment, inadequate supply of specialised human resources and incomplete data collection (WHO, 2019).

Other HIS initiatives include Smart Hospitals.e-Health Yoeung program, was launched at Preah Ang Duong Hospital in Phnom Penh to manage the health records of patients, and help schedule appointments directly with doctors through mobile phones or other devices, and manage medical records (Raksmey, & Huaifu, 2020). Such apps are useful in places where resources are limited, under-staffed, diagnostic capacity, and there is an insufficient supply of medicines and other health commodities.

One of the ongoing challenges is the translation of pilot studies into practice or sustainable programs (the know-do gap) (Liverani, Chheng, Parkhurst, 2018; WHO, 2013). This is because of the lack of dissemination of the findings of the pilot studies, publication lag, and lack of funding for scaling up, and organizational willingness or resourcing to adopt new health innovations or evidence-based practices (WHO, 2013). This requires commitment and investment by health care professionals, organizations and health funding authorities to ensure the longevity of innovations beyond the pilot study (WHO, 2013).

More investment in high quality education to the next generation of health care professionals, and supporting health care professionals (students and workforce) for the skills they will need in the future, are pivotal in the development of the use of health technologies in health care environments (Goldin, 2016).

Telemedicine

The introduction of Telemedicine in Cambodia is vital in preparing for current and future disease outbreaks and to address issues such as an inadequate workforce, and poor knowledge of evidence informed medicine regarding disease and health care

management (Nit et al., 2021). The swift adaptation to digital platforms by the education sector in Cambodia during COVID-19, provides an example of how Telemedicine could be adopted to share medical knowledge with doctors when diagnosis or judgments are difficult. Using a Telemedicine platform can help health professionals to use new information and treatments to respond to the current pandemic/epidemic and future disease outbreaks. Telemedicine is not a new idea in Cambodia with a pilot project introduced in 2005 to explore whether accurate diagnosis and treatment could be provided to patients in a remote rural region of Cambodia (Kvedar, 2006). However, since this early pilot study Telemedicine has not been widely adopted in Cambodia, argued to be due to the variation in digital literacy amongst health professionals (Nit et al., 2021).

Overseas, some private clinics started Telemedicine consultation services for patients during the COVID-19 outbreak. The high price barrier, and limited availability of existing patient networks has led to very low participation (Nit el al., 2021). Further the guidelines for Telemedicine and safety of medical information systems used in hospitals and the regulation of Telemedicine companies have not yet been published; therefore, the protection of online personal information is an important issue. Currently because Telemedicine has not been regulated, guidelines have not been stipulated, the extent to which a company can venture into Telemedicine may be restricted.

Although there has been a limited use of Telemedicine in Cambodia, those projects which have implemented Telemedicine have demonstrated the beneficial impact on the health of communities. This illustrates the potential for simple communications technology to improve care, even to some of the most impoverished communities. However, there remain barriers that need to be addressed if Telemedicine is to be scaled up in Cambodia:

- Reduction of disparities in terms of utility of network systems between urban and rural areas.
- Digital infrastructure as a productive investment in rural areas.
- Establishment of guidelines, which includes a regional approach to include similar approaches in Southeast Asia (Nit et al., 2021).

Rapid tests

Over the past decade, the introduction of rapid diagnostic test (RDT) has been increasing with positive feedback by the users (Paz-Soldan et al., 2019). In 2012, the U.S. Defense Threat Reduction Agency Joint Science and Technology Office initiated a program to develop novel point-of-need diagnostic devices for surveillance of emerging infectious diseases such as dengue, malaria, plague, and melioidosis (Paz-Soldan et al., 2019).

Positive benefits for end users include that using a rapid test and taking the result to their health facility, may speed up diagnosis and treatment at the health facilities, reducing their inpatient stay. For example, obtaining a positive result for dengue or malaria on the rapid diagnostic device, the patient would be aware they might still need to need a confirmatory test, but they would be able to reduce the wait time for obtaining a definitive diagnosis and starting treatment by a full day (Paz-Soldan et al., 2019). However, there are concerns by health professionals around people's ability to accurately use the test, handle complicated instructions, and safety (i.e., disposal of lancets) therefore advising that frequent training and monitoring would be needed (Paz-Soldan et al., 2019).

Health system structures and differences in communities suggests the need for formative research before deployment of novel technologies. Using RDT at the community levels is positive but only if the end user has adequate knowledge and clear and well-defined instruction/training prior to using the RDT.

Early Warning Systems

Collaboration between the National Committee for Disaster Management Cambodia and People in Need (PIN) saw the rapid adoption of a COVID-19 awareness campaign as part of the disaster management programming. The campaign utilized Early Warning System (EWS) 1294, created to warn residents of impending natural disasters, by sending mobile phone alerts to people in 25 cities and provinces (Choun et al., 2020). EWS 1294 sends out voice alerts with information on COVID-19 to its registered users, using innovative Interactive Voice Response (IVR) technology. Phone alerts can also lead to improved hygiene (such as reminders around washing hands and maintaining sanitation) that can contribute to preventing adverse health outcomes such as disease transmission during a disaster. It is important to think about

how messages are sent out, how consistent these are, and that they are context appropriate to the targeted community. A strength of this initiative was that the health messages were discussed with health professionals and stakeholders prior to being sent out (Choun et al., 2020).

In reviewing the literature, it was also important to consider regional and global trends in health technologies in low-middle income countries and how these could be adopted into the Cambodian context to support the future development of health technologies in Cambodia.

Cloud Computing

Cloud computing in healthcare refers to a process of using remote servers accessed via the internet to store, manage, and process healthcare-related data. This technology enables healthcare organizations to deal with electronic medical records, patient portals, mobile apps, and big data analytics while avoiding the additional costs of preserving physical servers. Adopting cloud computing also can make healthcare data more accessible to a range of stakeholders, including healthcare workers, caregivers, insurers, and policymakers. Many countries are increasingly using cloud computing to reduce costs, increase access, improve quality, and promote innovations in healthcare. In Asia, countries such as Japan, South Korea and Singapore have successfully adopted cloud computing to develop a nationwide database of electronic health records (EHR), Telemedicine, real-time health monitoring, and research (epidemiology, monitoring etc.,) (Raghavan, Demircioglu, & Taeihagh, 2021). Scandinavian countries and the United Kingdom are amongst other countries to leverage cloud computing to enhance patient care. Cloud computing technology also enables worldwide remote access to information, automated backups, and fast recovery. Moreover, cloud computing service providers in the healthcare industry offer risk management and monitoring services to protect against unauthorised access and cyberattacks. However, adopting cloud computing still presents challenges in terms of security and privacy concerns, data ownership, and accessibility (Hucíková & Babic, 2016). In addition to these challenges, Cambodia currently has limitations in regard to resources, infrastructure and government policies (data privacy and personal data protection) to deploy this technology.

Artificial Intelligence (AI)

As the world is faced with increasing challenges from disease outbreaks, increases in NCDs, shortage of healthcare professionals and health care funding, artificial intelligence (AI) has become more prominent in healthcare delivery. AI technology can gather data, process it, create algorithms, and produce decision making options for the end-user (Hamet & Tremblay, 2017).

For example, mHealth benefits immensely from this technology as AI has algorithms, sensor technology, and advanced data techniques that transform mobile devices into full-fledged health-management platforms (Cohen, Evgeniou, Gerke & Minssen, 2020). Moreover, AI has been used to diagnose patients; but it can do much quicker, and at times more accurately than doctors can. For example, AI for eye treatment can diagnose over 50 types of eye diseases within seconds, while a human expert would probably take hours or even days to complete the same tasks (Liu et al., 2019). Therefore, AI has a key role to play in analysing large quantities of patient data and increasing the accuracy of disease detection. AI can also enhance disease surveillance, increase efficiency and decrease health professionals workloads while augmenting their knowledge and abilities in clinical decision making.

AI technology also has the potential to accelerate the operational processes of health institutions and reduce costs. According to one study physicians spend 2 hours on EHR and paperwork for every hour they spend with patients (Lee, 2016). AI can free doctors/physicians to interact more with patients, resulting in simultaneously saving time, money, and lives. However, AI also brings many challenges, including new practices for doctors to adopt, data protection and ownership, privacy issues for data used for AI model training, security, and social acceptance. In the Cambodian context, health professionals could be trained how to use these kinds of technologies, and medical/health professional education reformed by adding new digital skills for health professional education for medical, nursing and midwifery students.

Blockchain Technology

Blockchain technology has been used in various applications such as eGovernment, voting, financial exchanges, insurance, and digital health (Bell, Buchanan, Cameron & Lo, 2018). Blockchain technology has the potential to transform the healthcare systems

enabling them to exchange health information (health data) more securely between different stakeholders. Blockchain relies on cryptographic techniques that allow each participant in the network to interact with pre-existing trust between parties. The transaction records are stored and distributed across all network participants in a blockchain system.

This technology has been used prominently in EHR. Miscommunication between medical professionals costs the healthcare industry billions a year so more effective systems to sharing information could mitigate this. The decentralized nature of blockchain technology allows healthcare professionals such as doctors, nurses, and pharmacists to quickly and efficiently access patient data. Other applications of blockchain technology include being able to monitor disease outbreaks in real- time; tracing medical devices; and monitoring of pharmaceutical supply chains. During the COVID-19 pandemic, blockchain was used for identity verification in a contact tracing app and the vaccine distribution management system (Sharma et al., 2020). Challenges in adopting this technology includes inefficient technological design, high energy consumption, security, lack of adequate skill sets, and lack of regulation in the blockchain network.

Big Data and Machine Learning

Almost every aspect of life is being changed by big data and machine learning, ranging from social media to the health sector. Machine learning is a subfield of artificial intelligence. It is described as an algorithm that learns to perform tasks automatically or using data for decision-making (Jorden & Mitchell, 2015). Machine learning uses a large amount of structured and semi-structured data so that the algorithm can generate accurate results or give predictions based on the data. For healthcare, machine learning techniques are used to improve patient outcomes. The main areas of machine learning in healthcare are medical imaging (detection and diagnosis), natural language processing of medical documents and literature, and genetic information (prediction and understanding of complex diseases such as cancers and Alzheimer) (Toh & Brody, 2021). Another example of machine learning is the digitalization of medical hard copies records in Vietnam (Phung et al., 2020). Data can come from different sources, including the EHR, fitness trackers, genetic testing, and many others. However, machine learning also presents challenges such as the need for quality structured data as a lack of quality data can lead to false predictions.

mHealth and Telemedicine

The Global Observatory for eHealth of the World Health Organization defines mHealth as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices (Park, 2016). At the same time, Telemedicine uses electronic information to communications technologies to provide and support healthcare when distance separates the participants. mHealth and Telemedicine have been widely used in almost every nation worldwide, especially after the outbreak of the COVID-19 (Sun et al., 2021). An increased number of people are going online for health services, with over 350,000 mHealth apps now available in major app stores, including medical, health and fitness apps (Byambasuren, Beller, & Glasziou, 2019). These technologies present a huge opportunity in delivering health services and reducing costs to countries globally, especially in LMICs where people may not have access to more standard/high technologies or in-person health care. Current dominant apps include weight management/healthy eating, asthma, infectious and parasitic diseases, stroke/cardiovascular incidents, Alzheimer's disease, medication management, cancer, sleep, stress management, smoking cessation, etc. In recent years, mental illness has become a serious concern. A Finnish start-up Medified provides cloud-based dynamic mental health monitoring software. The software as a service platform, aids physicians in monitoring patients in real-time, helping patients get the proper treatment faster and more efficiently.

After the outbreak of the COVID-19 pandemic, Malaysia and Thailand introduced Telemedicine services to its citizens. Cambodia has also introduced some Telemedicine services developed by private sectors, such as Reach52 and e- Health MyCLNQ. E -Health MyCLNQ is the first and largest one-stop healthcare ecosystem and telehealth consulting platform to provide vital access to healthcare services. However, to date it has not been widely used amongst Cambodians. Barriers includes costs, language, and limited areas in Cambodia. Other concerns in adopting this technology are digital literacy among Cambodian citizens, especially older populations.

Robotics

Medical robotics is firmly established in medical environments globally. It has transformed the performance of surgeries, improved healthcare services, and shaped the healthcare systems (Ashrafian, Clancy, Grover & Darzi, 2017). The many benefits

of robotics in healthcare include high-quality patient care, operational efficiencies, and safe work environments. With the advancement of electronic sensors, mechanical systems, data, and other advanced ICTs fields, robotics plays an essential role in enhancing performance; giving flexibility to both patients and healthcare workers. While there are concerns for robotics in healthcare replacing people in the workforce there are several reasons why machines will not replace humans. Machines do not need sleep or food, and can perform and complete the same monotonous tasks for ultimate results, however cannot replace human interactions that are so important in health care environments. Currently, more and more robotics applications are being used in homecare and can save time for health care workers, allowing them to focus on other aspects of practice (Letho & Rantanen, 2017; Yang et al., 2020). In Cambodia, challenges in this area are the lack of investment in research and development and the lack of human resources.

Augmented Reality (AR) and Virtual Reality (VR)

Augmented reality (AR) technology involves modifying or enhancing the real- world environment in real-time by using displays, cameras, and sensors to overlay digital information. In contrast, Virtual Reality (VR) is a three-dimensional computer-generated world by means of an illusion of reality that allow a user to feel an experience using special perception-changing tools (Yung & Dieck, 2018). These technologies are changing the healthcare system around the world, and have supported many healthcare providers to strengthen healthcare practices and improve patient outcomes. Applications using these technologies include medical training to better perform complex operations by minimizing the risks of making surgery mistakes, robotic surgery with high precision operation with VR, therapies for patients to recover faster, post-traumatic stress and depression treatment, autism, anxiety and more. AR technology has been used in medical imaging and interventional radiology in many countries. It has potential tools to change the traditional way how images are captured. These new technologies can also support training, improve communication between doctors and patients or colleagues, and plan for clinical procedures. Many start-up companies are working on VR technology to improve self-care by allowing users to explore and interact with virtual objects in cases where this is not possible in the physical world. Scientists and researchers worldwide are exploring the power of AR/VR in medicine, however in the Cambodia's context, adopting these technologies will

mean doctors and other healthcare providers adding new digital skills in addition to their medical skills.

3D Printing

Donor shortages for organ transplantations are a major clinical challenge worldwide. Potential risks encountered with traditional donor/recipient methods include complications, secondary injuries, and limited source donors (Beyar, 2011). Three-dimensional (3D) printing technology holds the potential to solve these limitations, and increasing the availability of medical implants (Yang et al., 2018). 3D printing can be used for recreating certain drugs, prothestics, implantable medical devices, medical equipment and optimizing the supply chain. Moreover, this technology provides cheaper and way more personalized medical services. It has been used in many areas of medicine, especially in biomaterials, including blood vessels, bones, heart valves, replicating human ears/noses, synthetic skin, and synthetic organs. 3D printing technology is also used for surgical planning and education models and medical research. Researchers and companies continue to investigate and invent more products for medical areas for the future. In Cambodia, more investments (by both public and private sectors) is needed to innovate medical materials based on this technology.

Connected and Wearable Devices

Industry 4.0 is driving digital transformation. With the advancement of electronics, AI, big data, data analysis, cloud computing, and connectivity, smart wearable devices have developed rapidly in recent years, especially in healthcare. The wearable devices are widely used, and capture, analyses, and aggregates physiological data of users to improve their personal health and well-being (Ferreira et al., 2018). Many giant tech companies like Apple, Alphabet, Samsung, Sony and Microsoft are investing in this field to meet the needs of global users. Currently, these include smart wearable devices include smartwatches, hearables, fitness trackers, eye wear, body devices, and skin patches. These devices have the ability to send a user's health information to a doctor or other healthcare professional in real-time and are able to harvest a large amount of data for improving health outcomes. The data is able to be used to programmed to support the user to track their healthy decisions and set goals. Applications include sleep monitoring, respiratory monitoring, ultrasound, stroke rehabilitation, heart rate monitoring, blood- clotting sensor, and home-based therapy

for Alzheimer's disease, back pain treatment, etc. Medical wearable devices are growing in popularity and present huge benefits in the healthcare system. For example, most wearable devices are personal and users can take them with them everywhere. Another benefit of this technology is the affordable price in many countries, including Cambodia. However, this development and technology also faces challenges such as data security, trust issues, and accuracy.

Internet of Medical Things (IoMT)

The Internet of Things (IoT) means the interconnected network of physical objects or 'Things' integrated to exchange data between devices/systems using the internet (Madakam et al., 2015). For the Internet of Medical Things (IoMT), it is a network of Internet-connected medical devices, hardware infrastructure, and software applications used to connect healthcare information technology (Jain et al., 2021). More and more people have started using wearable smart devices for monitoring their health. This technique can help enable remote patient monitoring, screening, and treatment via telehealth or Telemedicine. This technology has recently been deployed in tandem with other strategies to curb the spread of COVID-19, improve the safety of front-line personnel, increase efficacy by lessening the severity of the disease on human lives, and decrease mortality rates in many countries and regions. Moreover, countries such as South Korea and Japan are developing public healthcare solutions by emerging IoMT with other technologies to improve the nation's healthcare system (Raghavan, Demircioglu & Taeihagh, 2021). However, with many advantages of IoMT and like many other technologies in digital health, there are concerns on security and privacy. Based on a recent study in 2020, more than 90% of all IoT device data transmission is unencrypted which results in being vulnerable to attacks exposing confidential information of users (Palandrani, 2020). In addition, connectivity, especially internet connection, can be a barrier to some remote communities. Furthermore, some digital health technologies require a constant connection or a data plan. Low-income households may lack a subscription, requiring them to use limited cell plan data or local public WIFI. Other concerns include language barriers, cost of adoption and technology readiness.

This scholarly review of the literature, and scoping of current and potential technologies helps to pave the way for Cambodia to consider and prepare for adopting technologies.

IV. Scope and approach

Aspiring to transform the country towards an industrialized middle-income economy by 2030, the government of Cambodia has formulated several key development plans. Health is a key sector and therefore a 10-year health technology road map to support existing policies and strategies has been formulated.

Health care environments are un-predictable and rely on scientific breakthroughs, response to rapidly changing patterns of disease (such as COVID-19), available technologies within the context of infrastructure, human resources and acceptability and accessibility of the technologies by the end user. Therefore, any plans need to consider both product and technology selection alongside the development of human resources.

In this regard, the development of a health technology roadmap for health environments include consideration of 1) local, regional and global profiles and trends; 2) potential areas for investment that are cost effective and will have significant health and economic impact; 3) delineating modalities for technology adaptation and capacity building; 4) determination of suitable technologies that can be contextualized into priority products and services; 5) identification of potential risks and mitigation strategies; and 6) indicate strategies for integration of implementation, management, and maintenance that provide the most and ongoing benefit.

The scope of this technology and roadmap is limited to products and technologies employed for the development of key products and services for health services identified in the key strategies and policies related to health and technology. Within this boundary, this technology roadmap focuses on the following key elements:

- Presenting the existing profile of health technologies at a national, regional, and global level.
- Identifying enabling factors and major challenges for the development of the health technologies in Cambodia.
- Defining the advantages of Cambodia for investing in health technologies.
- Identification of priority of key products and services for health technologies in Cambodia.
- Identifying appropriate primary and alternative technologies with possible mechanisms of acquisition; and

- Designing contextualized implementation strategies and innovative technical recommendations.

V. Demand and Supply Sides and Trend of Sector

The market for health care is difficult to analyze using standard supply and demand calculations as spending on health, as it simultaneously based on the cost of goods and services and an investment. Investment on health care today impacts on population health, which leads to increasing economic productivity and decreasing the financial and social burden of disease (mortality and morbidity). Therefore, the special features that belong to the demand and supply of health and health services are described as the input into an individual/population stock of health with an output of healthy time (Grossman, 1999).

Measuring outputs directly related to health status is difficult to quantify because the determinants of health include multiple factors including the environment, genetics, demographics, health promotion, diseases, health services, food, income, values and beliefs, education, and lifestyle. Ways of estimating the cost benefit of products and services include quality of life scores, amount of GDP spent on health to prevent and reduce mortality and morbidity, and health outcomes that can be directly attributed to a particular product, service, or technology.

Finally, consideration should be given to how the supply of any key products, services and technologies includes (1) approachability; (2) acceptability; (3) availability and accommodation; (4) affordability; and (5) appropriateness (Levesque, Harris & Russell, 2013).

Supply

On the supply side, the Cambodian healthcare market consists of several providers including public sector and private sector health centres, pharmacies, and professional medical service providers. Largely, qualified private providers and pharmacies are concentrated in urban areas. In Cambodia, it was estimated that in 2018 there were 6.9 nurses and midwives and 1.9 doctors per 10,000 people which is one of the lowest rates in Southeast Asia (DPHI, 2016; https://ourworldindata.org). Between 2000 and 2020 there has been a 67% increase in hospital beds (public and private) (https://ourworldindata.org).

Demand

Thirty percent of the population use public services with the other 70% using private services (ODC, 2014). While deaths from non-communicable diseases dropped to 28,659 in 2019, death from communicable disease [3] have been rising with 73,475 deaths reported in 2019 (http://ourworldindata). Public health is among the top priorities for development in the Rectangular Strategy Phase IV and in 2018 $485 million of the government budgets was allocated to the health sector (ODC, 2022).

A cost analysis/projection of investment to achieve the third Health Strategic Plan 2016–2020, Cambodia included cross cutting health systems costs; human resources including education training and remuneration; logistics including central medical storage operating costs; infrastructure in new facilities, renovation of existing facilities, operating cost, procurement, and maintenance; health information systems; health financing and governance (Cantelmo et al., 2018). It was estimated that the five-year cost of the strategic plan would be US$ 2974 million with resources needed to meet the needs of public health increasing from USD $32 to $38 per capita during this period (Cantelmo et al., 2018).

Table 1: Demand, Supply and Cost Benefits Overview

Demand	Supply	Cost benefits
• Universal access to health care (SDG 3, TheThird Health Strategic Plan 2016 — 2020 (HSP3) – affordable andaccessible health care • Social protection (i.e., income protection or insurance) Individual and population health andincreases in non-communicable (i.e., cardio-vascular disease (high blood	• Private and public health services (national, regional, and local level) providing community, clinic basedand tertiary services • Private and public sector innovation/developmentof technology Public and private training institutions for health care professionals	• Increased health and wellbeing • WHO Quality of life scores (WHOQUAL) • Decreased costs of health care and burden of disease (measured through percentage of GDP spent on health care and disability). • Decreased mortality and morbidity (decreased incidence

[3] Mortality from CVD, cancer, diabetes or CRD is the percent of 30-year-old-people who would die before their 70th birthday from any of cardiovascular disease, cancer, diabetes, or chronic respiratory disease, assuming that s/he would experience current mortality rates at every age and s/he would not die from any other cause of death (e.g., injuries or HIV/AIDS).

pressures, strokes/CVAs), diabetes,malnutrition (obesity andunderweight) and communicable disease (infectious i.e., COVID- 19, Dengue, Malaria, Diarrhoea, Respiratory, Rabies) • Pharmaceuticals • Access to healthy environments (i.e., water, hygiene, and sanitation. • Tertiary, primarily and public health services • Human resources - qualified health professionals, innovativetechnology developers, and experienced researchers • Early identification of disease outbreaks – surveillance, diagnosis, monitoring, and • Intervention	• International donors/partner • Infrastructure (i.e., wireless technologies, electricity, mobile technologies) • Drug companies • Production of possibilities (i.e., bundling two technologies together for example education and health) • Economies of scale (collaboration across sectors rather than siloed approaches)	and prevalence or specific diseases) • Decreased infant and maternal mortality • Increased number of health professionals trained (doctors, nurses, pharmacist, dentists, psychologists etc) • Increased economic productivity (i.e., decreased sick days for employees) • Increased health literacy • Early detection and response to disease outbreaks

VI. Sector Vision, Policy, and Strategy

Key Takeaway

As a specified strategic ambition, health technology is yet to be fully incorporated in health sector strategic development planning. The primary reference to health technology is with respect to service delivery (HSP3) and, even in this case, it is narrowed to technology and ICT. Further discussed strategic documents deal more with concepts and ambitions closely related to health technology, without specifically naming it. For example, commitments to Universal Health Care, whereby one might draw parallels with the importance of technology role as prescribed by the WHO.

Additional parallels can be drawn at the strategic level whereby national documents can highlight priorities for which health technology avenues can be mapped against.

Strategy and Policy Overview

Underpinning the development of the Health Technology Roadmap (HTRM) for Cambodia are national and international visions, policies and strategies that provide a foundation and a takeoff point for future directions in health technologies. The rest of this section provides overview and context for each of the nine listed documents.

Master Plan for Quality Improvement in Health 2017-2022 (MOH, 2016)"

The Master Plan for Quality Improvement in Health marks the second five-year plan by the MOH focused on quality improvement in the sector. The plan builds on the progress of the first plan, which itself was based on the strategic objectives outlines in the Third Strategic Health Plan (detailed below). The master plan is designed to guide implementation, monitoring, and evaluation of these key strategic areas. The master plan does not itself contain explicit reference to health technology. However, the outlined key strategic areas can be considered key pathways towards developing an effective health technology landscape. For example, (3) Professional Development strategies may be enhanced by effective use of health technologies such as online training platforms to support (4.4.) capacity building in governance and management.

The Third Health Strategic Plan 2016 – 2020 (HSP3) "Quality, Effective and Equitable Health Services" (Department of Planning and Health Information, 2016)

The HSP3 identifies 6 task team focuses (noted below) that are central to delivering an improvement in health service delivery (coverage, quality, and equity). The Minister of Health is the leader in decision-making, supported by the Technical Working Group for Health (TWGH) secretariat, while the implementation of the process is managed, coordinated, and facilitated by the director of the Department of Planning and Health Information (with technical support from the six task teams – (1) Health System Financing, (2) Health Workforce Development, (3) Essential Support Systems, (4) Health Infrastructure Development, (5) Health Information Systems, (6) Health Service Governance).

Challenges identified relevant to Health Technology:

- “Inadequate quality health services in both public and private sector.” Effective delivery of quality health service is constrained by inadequate resources, mainly under-staffing, limited diagnostic capacity, and insufficient supply of medicines and health commodities”. Health Tech has a crucial role to play in addressing issues surrounding resource limitations, particularly through improved allocation mechanisms, upskilling of practitioners, address of ‘at-home’ treatment, and improved diagnostic capability.
- “Limited capacity of public health services to deal with public health emergencies.” Health Tech with respect to knowledge management, forecasting, and resultant early-warning response will be crucial in addressing such concerns.
- “High level of (Out of Pocket) OOP spending on health” and a requirement to go beyond current Health Equity Fund Schemes. Health Tech is relevant to social insurance schemes with respect to data point identification, categorization, and management for more efficient record keeping and support allocation. It speaks to the process of health service delivery around vulnerable-population identification and support.
- “Low investment in medical technology and ICT with limited capacity at all levels to analyze, interpret and use data, limited use of health data and information in clinical and administrative areas, and multiple M&E frameworks, indicators, and reporting systems.” Of the highlighted key-challenges, this is the single one that makes explicit reference to technology.
- “Inappropriate health-seeking behavior of the population, especially in rural/remote areas with delays in seeking care, self-medication etc.” Health Tech can support the issues identified in rural populations through Telemedicine and digital tools.
- Limited investment in ICT despite its increased use within medical venues and in the MOHs Health Management Information System (HMIS).

Key recommendations relevant to Health Tech:

The recommendations are made on the basis that the MOH is well positioned to improve the quality-of-service delivery, and to improve the equity of distribution in health services.

- Invest in a stronger and more effective system for pre- and in-service training for health professionals to enhance clinical and managerial competencies to further the quality of health services and their delivery.
- Invest in appropriate technology and its use, for medical education and health service delivery and management, to enhance knowledge and diagnostic capacity of health providers; improve information for decision-making; and monitor and evaluate the health system performance.

Summary: The main reference to health technology is with respect to service delivery: incorporating, distribution, identification, resource allocation, qualification of relevant personnel, and database systems. There is some reference to diagnostic equipment, but equity is the focus. The strategic plan requires conceptualizing Health Technology in its broadest sense. Rather it refers to specific applications of technology and ICT.

Cambodia-WHO Country Cooperation Strategy 2016-2020 (WHO, 2016)

The purpose of this country cooperation strategy (CCS) was to provide medium- term strategic vision support to Cambodia, by the WHO, in support of the kingdom's national health policies, strategies, and plans. Specifically, the strategy was drafted in parallel to the above discussed Third Health Strategic Plan 2016-2020. The report mentions the supporting roles of the 2030 Agenda for Sustainable Development and the United Nations Development Assistance Framework 2016–2018 for Cambodia. The vision and mission of the CCS were as follows:

- Vision: Attainment by all Cambodian people of the highest possible level of health.
- Mission: Provide leadership to support the Government and people of Cambodia in response to their health needs.

Strategic priority 2 is of particular interest to health technology as it is for the purpose of 'Advancing universal health coverage'. Health Tech is noted to be of crucial importance by the WHO in advancing the UHC globally. Page 10 of the strategy provides an interesting linkage diagram highlighting the strategic priority alignment between the CCS, HSP3, and SDGs.

Summary: There is no mention of technology in any sense in this document. Instead, there is a commitment to advancing UHC. Given the WHO own acknowledgment of technologies' role in UHC implementation the strategic development is highly likely to have considered this space.

Cambodia's Science, Technology & Innovation Roadmap 2030

The roadmap was endorsed by National Council of Science Technology & Innovation in 2021 to provide direction for the implementation of the National Policy on Science, Technology, and Innovation 2020-2030. It notes that innovation is pivotal in addressing developmental issues including access to drinking water, eradicating neglected diseases, or reducing hunger. The national policy articulates the 'health and biomedical' as one of five priority domains and Cambodia's Science, Technology & Innovation roadmap 2030 aims to be enhanced through a five-pronged strategy of: governance, education, research, collaboration, and ecosystem. This approach acknowledges that innovation is co-created by networks of actors and takes place in specific contexts and proposes that promoting innovation requires a systemic approach. The document makes several recommendations for next steps in relation to the "Five Pillars of the Cambodia's STI Roadmap 2030". Each set of recommendations is rooted in one of the pillars and has been summarized below.

1. Improving Governance: As defined in the Rectangular Strategy and Vision 2050, MISTI is the lead coordinator of the National STI Policy, and with the National Council of Science, Technology & Innovation (NCSTI) to set the direction of STI policies. This includes governance on budget and focus on socioeconomic development. The STI roadmap proposes 3 actions and instruments to meet the targets.
2. Building human capital: There are several specific targets to promote scientific culture, increase STEM knowledge transmission, and measure progress (see page 10 for the list). The STI roadmap proposes 4 actions and instruments to meet the targets.

3. Strengthening research capacities: The STI roadmap proposes 3 actions and instruments to meet the targets outlined around research capacity (see page 15 for the list).
4. Increasing collaboration and networking between stakeholders and the National Innovation System: The STI roadmap proposes 3 actions and instruments to meet the targets outlined around research capacity (see pages 19 and 20 for the list).
5. Fostering an Enabling Ecosystem: The STI roadmap proposes 3 actions and instruments to meet the targets outlined around research capacity (see pages 24 and 25 for the list): Enhancing innovation capacities of SMEs.

Summary: The STI Roadmap provides a fundamental opportunity for health technology stakeholders to align strategic goals within a holistic framework of national development. The driving pillars of the roadmap are each pertinent to the landscape that HT can be developed within, from process, to procedure, to practice.

Rectangular Strategy Phase IV

The Rectangular Strategy is conceptualized as a top-notch socioeconomic development agenda for Cambodia and has, as of 2018, entered its fourth phase. This phase is seen as crucial in delivering Cambodia to upper-middle income status as the kingdom experiences a "New Transformation." In terms of healthcare, its quality is noted as a challenge facing the kingdom, "in spite of remarkable improvement in public services." Rectangle 1 goes on to highlight the focus on human resource development, improved quality of technology, and improved healthcare. Each of these features has implications for the financing, approval, and use of health technologies to meet these ends. Specific recommendations related to health, that are of relevance to health technology are as follows (and can be further found on page 24 of the strategy document):

- Further implementing and updating "Health Strategic Plan 2016-2020" to enhance the quality, effectiveness, and equity of health services.
- Pushing for UHC in the Kingdom.
- Increasing investment in healthcare infrastructure and medical technology. Summary: The Rectangular Strategy is the top-tier strategic document governing the aspirations of growth and development in the kingdom. It has specific identification of the required roles of health technology (and Health Tech

relevant objectives) helps to cement its importance. This strategy should be considered a motivation for the Health Strategic Plans, such that it helps identify key pathways and objectives to be incorporated.

IDPoor System

As noted on the IDPoor database, "The IDPoor Programme, established in 2006 within the Ministry of Planning, is part of the Royal Government of Cambodia's ongoing efforts to reduce poverty and support socioeconomic development throughout the country." It supports in government identification of vulnerable populations in need of pro- poor measures. The program provides updated information on such populations to government that they may receive assistance.

Summary: An IDPoor system helps policy makers and stakeholders to effectively target health technology interventions within the correct target groups. In addition, vulnerable populations can be surveyed to identify specific development needs.

Sustainable Development Goal 3

The Sustainable Development Goals (SDGs) are a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity. Cambodia has its own set of SDGs, the Cambodian SDGs (CSDGs). These are the nationalized framework for Cambodia based on Global SDGs. In both cases, SDG3 is of particular relevance as it is specifically related to health: "Ensure healthy lives and promote well-being for all at all ages". Beyond the targets that the goal establishes, the strategy calls for universal access to health technologies.

Summary: The SDGs provide a necessary criterion for evaluation that can be contextualised nationally and compared globally. This is of crucial importance when considering investment and adoption of health technologies in addressing the specific national requirements (while also along for best practice exchange and lessons learned).

Health intervention and technology in support of universal health coverage

The 67th World Health Assembly saw the approval of resolution WHA67.33 concerning the importance of health intervention and technology assessment in the support of UHC. It notes that a major challenge for health systems and for achieving UHC is the

pursuit of equity, quality of care and efficiency. In particular, and in pursuit, there is an issue in evaluating the available health technologies and strategies. Health technology assessment is therefore advocated as it is the systematic evaluation of properties, effects and/or impacts of health technologies and interventions.

Summary: The importance of resolution A67/33 is in its acknowledgement of the importance of health technology in achieving UHC. Whereby UHC is the ambition of the RGC (and its development partners) as noted in the SDGs, CSDGs, HSP, and Rectangular Strategy (to name a few).

The Kingdom of Cambodia Health System Review

The Health Systems in Transition (HiT) profiles are country-based reports that provide a detailed description of a health system and of reform and policy initiatives in progress or under development in a specific country. The report provided an overview of the information technology side of health technology. Noting that, “The use of ICT and other infrastructure and technologies remains limited but has strengthened in recent years with technical and financial support from international agencies”. Of particular note in this review is the identification that even in cases where medical technology is of quality, there remains an associated shortfall with the quality of clinician skills.

Summary: Whilst this report is one of the older documents in this summary, the acknowledgement of technical capacity gaps is still very relevant today. It is a good review for comparison and goal setting. In addition to the current technologies being deployed in Cambodia there are also trends in health care and health technologies that should be considered. These include the move to a One Health approach for public, environmental, and veterinary health and disease outbreaks; trends in new technologies that can be adopted into low resource settings; and disruptive technologies. As outlined by the WHO (2021), One Health (OH) is an approach to designing and implementing programs, policies, legislation, and research in which multiple sectors communicate and work together for the pursuit of better public health outcomes. Noting the broad classification of OH, there are areas of work in which an OH approach is particularly relevant including: food safety, the control of zoonosis, and combating antibiotic resistance. The motivation of an OH approach is rooted in the recognition of the interconnection between people, animals, plants, and their shared environment. Whilst the recognition of interplay and interrelation in our shared environment is not new, many factors have changed the interactions in our shared

environment in recent year (CDC, 2021). Human populations are growing and expanding into new geographical areas, changing climate conditions and land use, and increasing in the movement of people, animals, and animal products across borders. Such factors have contributed to the spread of existing and new zoonotic disease such as rabies, Ebola and now COVID-19.

VII. Building Vision and Goals

Vision

The Cambodian Health Technology Roadmap vision is for the "Increase the health and well-being of Cambodian through research and development, innovation and technologies" [4]. This is underpinned by three interrelated pillars of Technology, One Health, Governance, and Research. Each pillar of the vision is discussed further below.

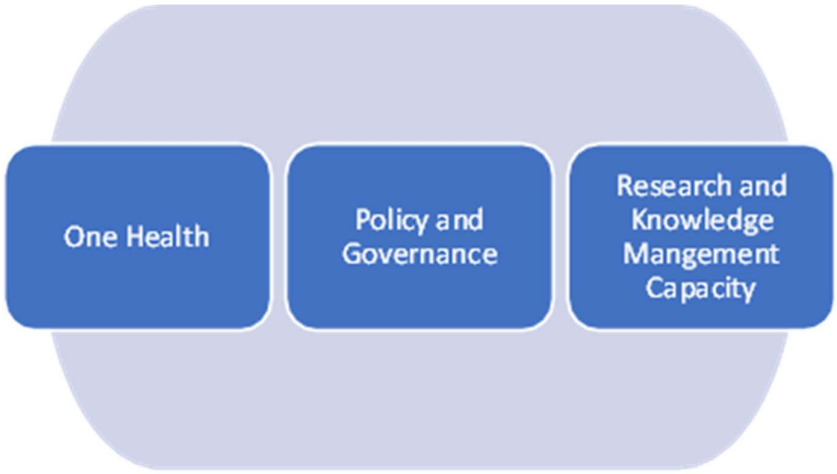


Figure 4: 3-pillar Health Technology Roadmap Vision

[1] An Integrated One Health Approach

Firstly, the health technology roadmap envisions an integrated and nationwide One Health approach that aligns the individual health objectives covering human health, environmental health, and animal health.

[4] This vision has been determined in line with the expert opinions of review committee for Health Technology strategy in Cambodia, in addition to extensive desk review, national strategic objectives, and the current health policy landscape in the kingdom.

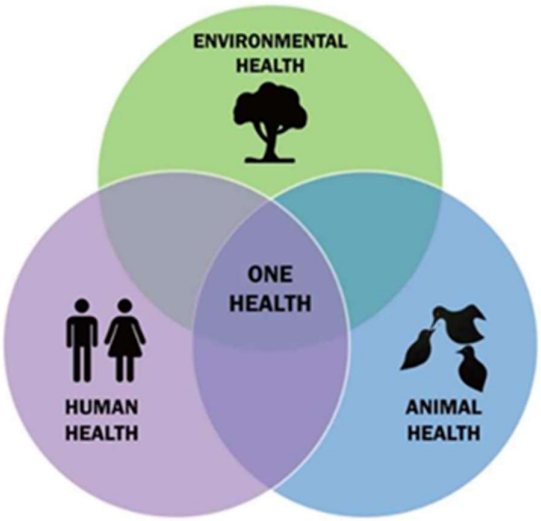


Figure 5: One Health Approach

[2] Multidisciplinary Policy and Governance for Health Technology

The successful planning, adoption, and execution of health technology intervention, policy, and governance requires collaboration and knowledge sharing between stakeholders from a diverse and inclusive background. This pillar is crucial with respect to the ensuring that health technology adoption is working in line with national policies and strategies such that interventions are complimentary to addressing priority development needs. By the same token, research institute actors must be consulted in order to ensure that a transparent process that minimizes oversight in planning and execution. At the forefront of the collaboration, in many ways, it is the role of the private sector in brining technologies to market. As a collective, government, research institutions and the private sector require a collaborative process for the purpose of defining and executing a health technology roadmap that ensures maximum effective intervention impact around developmental, personal, and economic lines.

[3] Strengthened Research and Knowledge Sharing Capacity

Health technology prioritization requires an enhanced local decision-making context (as outlined in vision 2). However, in order for this to be the case there must exist a robust technical research landscape. This vision outlines the collaboration between stakeholders in this space – including hospitals, universities, research institutions, the private sector, the ministry of health, and other related ministries – to develop a robust research culture in the kingdom, alongside Knowledge Management processes in industrial sector.

To care for patients effectively, healthcare providers and staff must be able to share not only clinical knowledge, but also knowledge around organizational processes and procedures and current drug and treatment information. Given that healthcare is a knowledge-driven industry, a healthcare knowledge management system is crucial in creating a more efficient flow of information between all providers and staff.

In the context of Health Technology, a robust knowledge management system is expected to deliver enhanced and effective decision making with respect to health technology adoption and implementation. This is in addition to supporting a continuous- learning environment that promotes collaboration and knowledge exchange.

Goals

Following the outline of the health technology roadmap's vision, it is important to map the goals and objectives that are considered crucial to achieving the vision. In total there are nine reinforcing goals, and each will be described in detail below.

[1] Applied Research and Capacity Building

The purpose of supporting research ecosystems is for innovating (research and development) in technologies; monitoring and evaluation of impact in individuals /population health (physical, social, and cultural); increasing efficiency and effectiveness of products and services; supporting evidence-based medicine/public health and policy making; promoting knowledge sharing and dissemination; and supporting the development and capacity of researchers and research institutions. This is crucial to developing an effective One Health approach and strengthening research and knowledge sharing capacities.

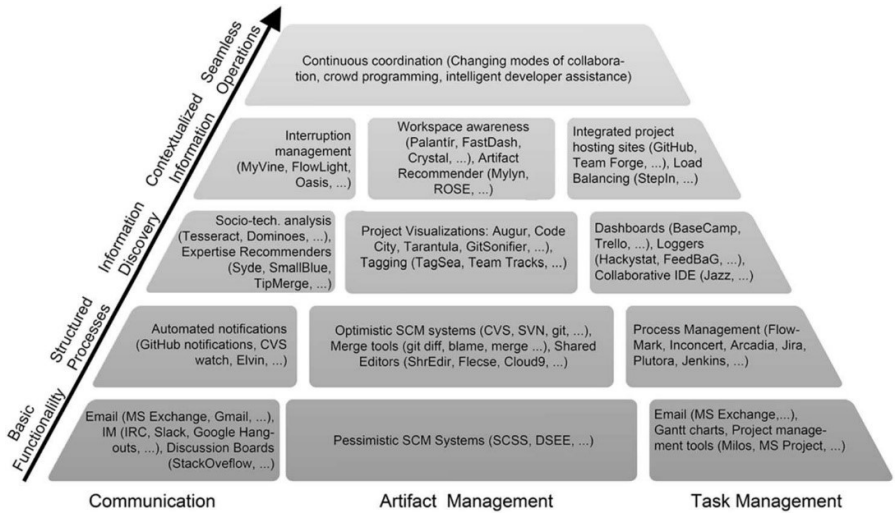
[2] Integrated Knowledge Management Interface

The purpose of the Knowledge Management process is threefold: [1] to share perspectives, ideas, experience, and information; [2] to ensure that these features are available in the right place at the right time to enable informed decisions; and [3] to improve efficiency by reducing the need to rediscover knowledge.

Information technology (IT) provides the technical foundation that facilitates the implementation of a knowledge management system. The table below provides a list

of IT functionalities that support key functions that enable knowledge management. An integrated knowledge management interface is again crucial for One Health outcomes and collaboration around governance.

Table 2: Knowledge Management IT Functionalities

Function	Technology
Communication	Internet, wireless networks, cell phones, computers, software, middleware, Video conferencing, social networking, media application and services.
Coordination	Coordination Pyramid (Sarma, 2019) 
Group Process Support	Hardware, software, applications, databases, communication, and internet.
Storage and Retrieval	Cloud computing, database management, information retrieval, hypertext.
Presentation	Presentation software
Numerical Computation	Statistical analysis packages, computational algorithms
Location, filtering	AI, GPS, Intelligent Agents
Symbolic Processing and Reasoning	AI, Expert systems.

[3] Human Resource Upskilling

Proper management of human resources is critical in providing a high quality of health care. Human resources, when pertaining to health care, can be defined as the different kinds of clinical and non-clinical staff responsible for public and individual health intervention (WHO, 2000).

Beyond the educational upskilling for digital technologies required, there will be a need to adopt a suitable Human Resource Information System (HRIS) to address potential suture issues in healthcare management. This will be crucial for record-keeping, compliance, efficiency, and sectoral strategy. Human resource upskilling is necessary for the human resource requirements for an enhanced and resilient healthcare system across all three visions.

[4] Sustained Investment

It will be necessary for the upgrading and nationwide adoption of health technologies, for human resource upskilling, and for ultimately delivering an enhanced and robust health technology ecosystem. Figure 4 below captures nine value-pools (Cohen et al., 2020) for investment in contemporary health technologies that will be relevant for the kingdom.

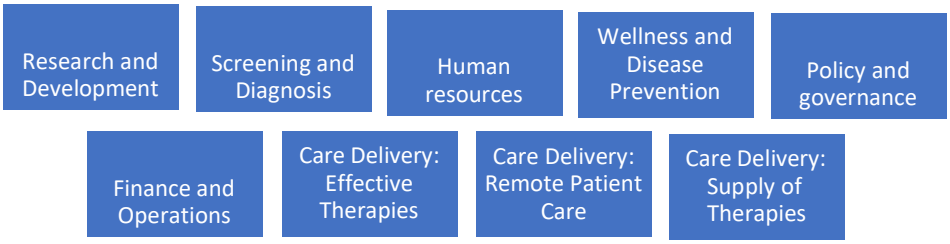


Figure 6: Healthcare Value pools

[5] Digital Health Infrastructure

Digital health is uniquely positioned to enhance the way we detect and manage infectious diseases. There are five features of digital health infrastructure that are targeted for enhancement. Table 3 considers each in turn below. Digital health infrastructure, as detailed below will help to enhance the diagnosis, treatment, and patient outcome factors. It is a crucial component feeding into an integrated One Health approach.

Table 3: Digital Health Features

Feature	Overview
Surveillance	The WHO defines public health surveillance as, the continuous and systematic collection, analysis, and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice (WHO, 2020).
Screening	In the current context of Covid-19, screening is particularly salient. The use of technology has the potential to screen travelers based on symptoms and travel history.
Triage	Online tools can be used to prioritize the treatment of patients based on the severity of their condition. This is of particular importance in Cambodia where transport networks and resources are often a hindrance in the rural context.
Diagnosis	Following digital triage, patients could benefit from an at-home diagnostic service. For example, like over-the-counter genetic or urinary tract infection tests, patients could receive a test kit via mail or courier delivery.
Monitoring	A patient's measurements can be directly transmitted to healthcare providers or other monitoring entities using remote monitoring technology. Remote monitoring technologies can connect wirelessly to networks via Bluetooth, WiFi, or cellular connection.

[6] Self-health management and personalized care

Advances in technology have made it possible for many standard diagnostic and health monitoring procedures, traditionally carried out by qualified personnel within medical facilities, to be reliably undertaken by patients or care givers in their own homes with a minimum of basic training. There has also been a dramatic increase in the number and diversity of both sources of information on health issues and the possibilities for sharing information and experiences over ICT-based social networks. At the medical and consumer level both medical devices and wearables have the potential to be repurposed to detect emerging patterns that are indicative of disease outbreaks. For example, Fitbit devices have been used to inform timely and accurate models of population-level influenza trends (Radin et al., 2020). Additionally, smart thermometers have provided a novel source of information for influenza surveillance and forecasting (Milla et al., 2018). Self-health management is both an improved outcome of One Health, and a crucial component to delivering strengthened research and knowledge sharing capacity.

[7] Digital Electronic Medical Records

In order to support the effective and precise data management of personal health files it will be crucial for Cambodia to develop a central digital medical records system. A digital health record (DHR) is a digital version of a patient's paper chart. DHRs are real-time and patient-centred records make information available instantly and securely to authorized users. While a DHR does contain the medical and treatment histories of patients, it is built to go beyond standard clinical data collected in a provider's office and can be inclusive of a broader view of a patient's care. Digitalized medical records help support policy and governance with key available data.

VIII. Environment Analysis (STEEP and SWOT)

STEEP

The figure below provides an overview of the STEEP analysis undertaken during the expert panel sessions. The insights contained where developed in collaboration between experts in the working group.

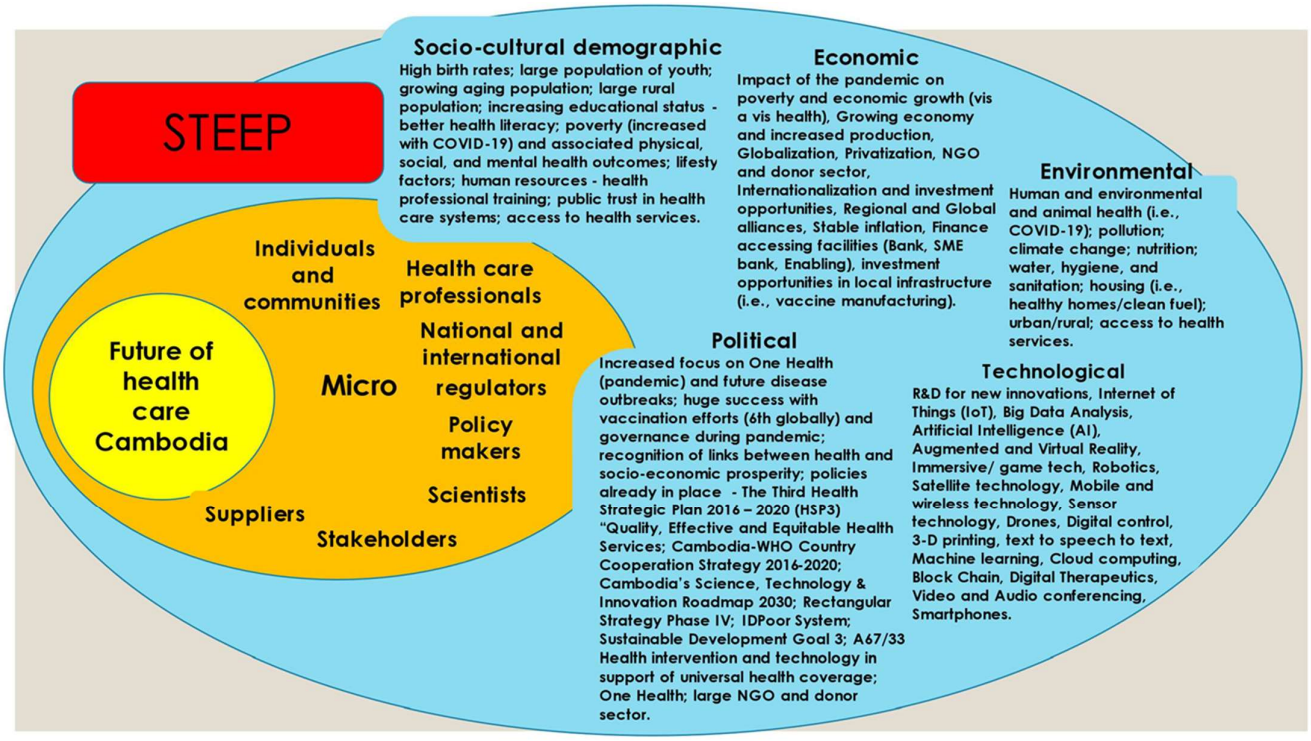


Figure 7: STEEP Analysis

Trends/Drivers SWOT

There are three major features that have been considered in the development of the health-technology roadmap: One Health; Health Technology Trends; and National Context [5]. Each is reinforcing to the overall vision and contextualization of the pathways forward. Each has undergone a SWOT analysis that will be outlined below.

Table 4: One Health SWOT

SWOT	
One Health	
Strengths	**Weaknesses**
• One Health provides an integrated approach to identifying, monitoring, treating, and resolving health care events • Vaccination programs benefit from the sectoral collaboration under One Health • Cambodia has an existing mechanism of coordination between animal health and human health.	• Currently there is a lack of coordination on environmental health • Lack of investment (Ex. Government support) • Limitations around qualified human resources (particularly veterinary epidemiology) • Weak coordination among the three components (environment, human, animal) • One Health has not been set as a national priority.
Opportunities	**Threats**
• Development of One health surveillance system using mobile apps • Funding and program: SEAOHUN 6, (Cambodia One Health University network) • Government underlines the importance of one health (STI ecosystem report, General Directorate of Animal Health and Production, MoH) • Health Resource Management System7 • Raising awareness of the One Health	• No minimum standard for quality check on animal/animal meat (cross border). • No compensation to farmers for zoonotic outbreak. • Lack of technical/financial support in a timely manner. • Climate change, air pollution, water pollution, and soil pollution

[5] The working group consists of a panel of experts who formed the expert baseline for determining what was important for developing this roadmap.
[6] Southeast Asia One Health University Network
[7] Following expert review, HMRS was identified as an opportunity.

approach within the public. • Mhealth applications to support One Health adoption. • Advancement of health technology	

Table 5: Technological Trends and Disruptive Health Technologies SWOT

SWOT	
Technological Trends and Disruptive Health Technologies[8]	
Strengths	**Weaknesses**
• Unifying patients' data • Facilitate data history tracking formore accurate health management • Minimum administrative time • Less expenses and less doctor consultation time • Data analysis for public health measure and disease trend.	• Access to internet at country level • Weak infrastructure • Investment; Start-up; entrepreneurship • Human resource; Lack of • Knowledge from research
Opportunities	**Threats**
• Increasing digital infrastructure in health system. • Increasing in investment on digital infrastructure (example, Cambodia Digital Economy and Society Policy Framework). • Policy for the implementation of personalized medicine. • Health insurance & Universalhealth Care system. • Education on digital health literacy.	• System crash and loss of all data. • Cyber security. • Personal data exploitation. • Rejection by users.

[8] Technological Trends and Disruptive Technology. For the SWOT analysis conducted for Technological Trends, a series of technologies were outlines and then analysis was conducted with respect to the Cambodian application of Digital Medical Health Records. The technologies identified were as follows: AI, Nanotechnology, Cloud computation/Big data, Mhealth, Blockchain, Machine learning, Ehealth, Telemedicine, Personal health, and Wearables.

Table 6: National Context SWOT

SWOT	
National Context	
Strengths	**Weaknesses**
• Rectangular Policy – with an emphasis on Health and Wellbeing • Integrated Framework for Cambodia's STI Roadmap to Improve the Health, Education and Agriculture domain • Health Strategic Plan 2016-2020 (2021-2026 in Progress) • Public-Private-Partnership • Engagement • International Engagement • Creation of in charge coordinating body on STI, Ministry of Industry, Science, Technology & Innovation (MISTI), and having National Council of Science Technology & Innovation as • supreme body	• Insufficient funding support for innovation, entrepreneurship. • Lack of digital health infrastructure & technology adoption • Lack of policy to develop skills and reskills people • Lack of collaborative effort among actors • Lack of support for research, research informed education, quality of data, ethical issues
Opportunities	**Threats**
• Funding support – start-up, innovation & research (Khmer Enterprise, Techo Start up Center) • Large young population (about 60%) • Health related universities/research institution for skill development and research activities • Development partners' collaborative supports • Commitment to STI support from • government	• Lack of Investment for Health Innovation • Lack of Skill, Reskilling & Joint Implementation Policy • Lack of Digital Health Application Development Companies • Limited Quality Research • Geo-Politics Issues • Insufficient Laws and Policy for Data Protection & Ethical Issues.

IX. Strategic Products/Services[9]

Technology (Product/Services) candidates

Some new technologies are reshaping the relationship between patients, healthcare providers, and the health system. As healthcare systems face global challenges, digital technology could be the potential to transform medicine and the health industry in a sustainable way.

There are several technology products that are considered as candidates for adoption.

Advanced Telemedicine: Telemedicine allows patients to communicate with a healthcare provider using technology, as opposed to physically visiting a doctor's office or hospital. With Telemedicine, you can discuss symptoms, medical issues, and more with a healthcare provider in real time using video, online portals, and email.

Connected Devices and Wearables: Wearable technology in healthcare includes electronic devices that consumers can wear, like Fitbits and smartwatches, and are designed to collect the data of users' health and exercise. These devices can even send a user's health information to a doctor or other healthcare professional in real-time.

Digital Electronic Medical Records: A digital electronic medical record is an electronic (digital) record of medical information about a person that is stored on a computer, or computer network system. An electronic medical record includes information about a patient's health history, such as diagnoses, medicines, tests, allergies, immunizations, and treatment plans.

Personal Healthcare Applications: Personal healthcare applications are those that you can use in conjunction with your provider-based health regimen. They offer health tracking and reporting, medical reminders, and communication with your provider. Some serve as the platform for virtual visits.

Centralized Command Centers: A Health System Command Center provides a critical operational component that leads to a resilient, responsive healthcare system.

[9] Strategic products and services were identified through the expert committee and in relation to relation to Cambodia's strategic healthcare priorities. Further consensus driven adoption is recommended to take place in policy crosspollination with technology and digital economy frameworks including the Cambodia Digital Economy and Society Policy Framework 2021 – 2035.

It is a centralized hub made up of an interdisciplinary team to coordinate care across their systems, expand patient access, and continually improve healthcare outcomes.

Laboratory and Diagnostic Care: Laboratory tests and diagnostic care procedures are tests used to check if a person's health is normal. For example, a lab can test a sample of your blood, urine or body tissue to see if something is wrong. A diagnostic test, like blood pressure testing, can show if you have low or high blood pressure.

Pharmaceutical Care: Pharmaceutical Care services are patient-centred services aimed at empowering patients and/or caregivers to take charge of their medication needs and achieve the best health outcome. Pharmaceutical Care is meant to complement existing patient care practices to make medication therapy more effective and safer.

X. Prioritization of Product Services

Prioritization is determined using a scaling from 1 to 5. The scaling is as follows:
1 = Not at all important / 2 = slightly important / 3 = moderately important / 4 = very important /5 = extremely important. Each product/service was ranked by 13 expert members (researchers, industry, policy makers) during the workshop.

Table 7: Product Services

Technology	Criteria			
		Feasibility		
	Strategic Importance	Short-Term 2024	Middle-Term 2027	Long-Term 2030
Advanced Telemedicine	5	4	5	5
Connected Devices and Wearables	5	4	5	5
Digital Electronic Medical Records	5	4	5	5
Personal Healthcare Applications	4	3	4	4

Centralized Command Centers	4	3	4	4
Laboratory and Diagnostic Care	4	3	4	4
Pharmaceutical Care	4	3	4	4

The prioritization scaling was finalized during the report writing process. It was informed by the Health Technology Roadmap visioning workshop with feedback and insights from the thirteen-person committee. It is consensus built and reflects the importance of technologies required for meeting the visions and goals of the roadmap.

Key Technology

The table below provides a detailed overview that brings together this roadmaps vision, objectives, strategic products, and supporting technologies.

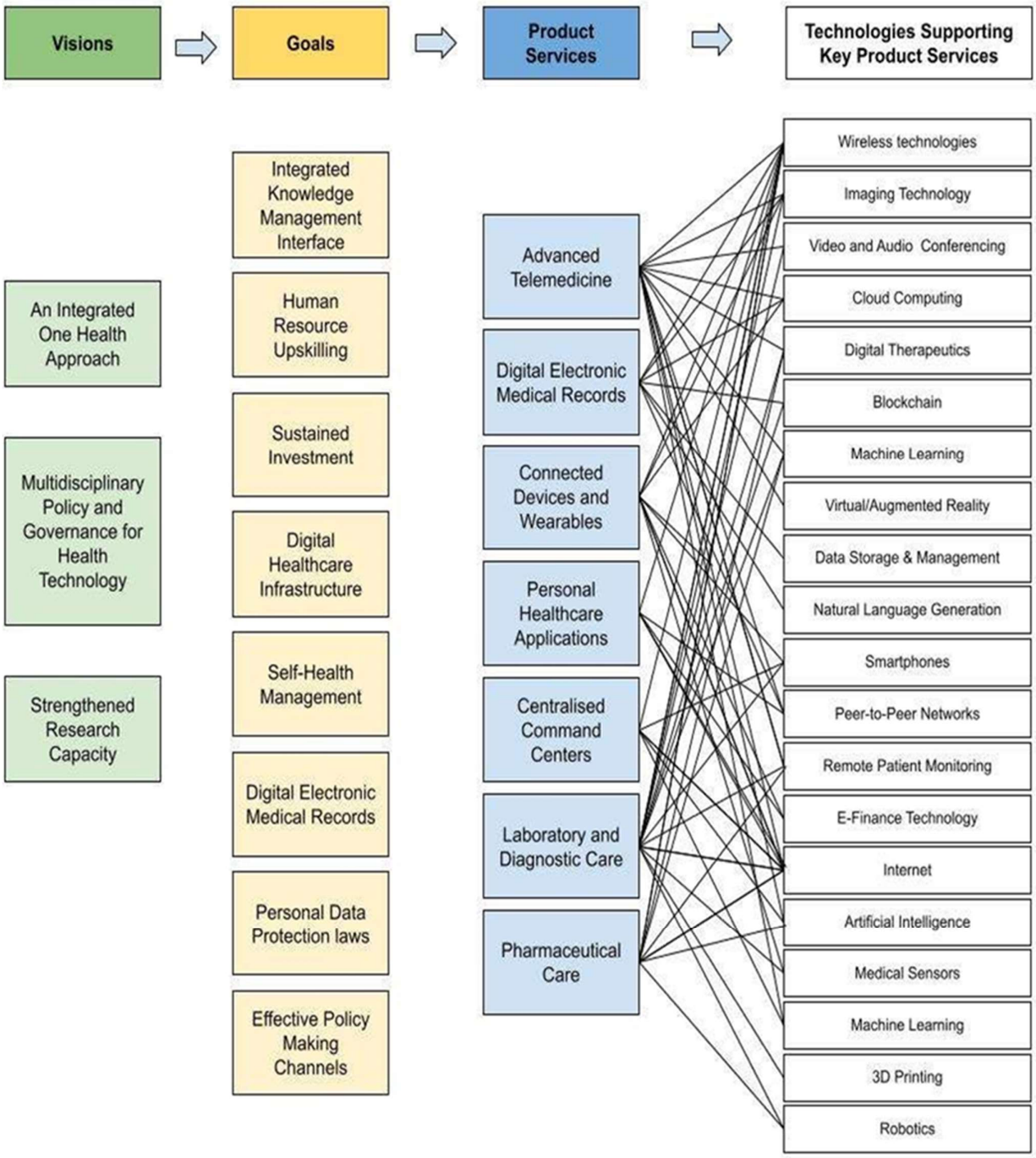


Figure 8: Key Technologies Link to Product/Services, Goals, and Visions[10]

[10] Please find an index of terms in Annex 1 of the report. It contains descriptions for the 'Technologies Supporting Key Product Services'.

XI. Charting Macro/Technology Roadmap

Product: Advanced Telemedicine		Short Term			Medium Term			Long Term	Target			
		2022	2023	2024	2025	2026	2027	2028-2030	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target										
Key Technologies	Wireless Technologies	Design and Implement NationwideWireless Strategy (G + P)							75%	25%	-	Mbps
	Internet	Design and Implement Nationwide Internet Strategy (G + P)							75%	25%	-	National Coverage
	Video and Audio Conferencing	Adopt standard practice regulations for video and audio (G + P)							100%	-	-	At least one standard practice regulation for video and audio conferencing will be created with specialized area

	Remote Patient Monitoring	Design and adopt standard practice regulations for RPM (G + P)				at least one design and adoptstandard practiceregulation for Remote Patient Monitoring will be drafted
	Cloud Computing	Design and Implement Nationwide Cloud Computing Strategy (G + P + IC)	66%	100%	-	Number of server is available with cloud designation
	Digital Therapeutics	Design and Implement Nationwide Digital Therapeutics strategy (G + IC + R)	34%	100%	-	# Of intervention areas
	Virtual and Augmented Reality	Design & adopt standard practiceregulations for V&AR (P + IC + R&D)	-	40%	100%	# Of applications incorporating virtual or augmented reality
Commercialization and Practical Use		Support for developing Telemedicine	R: R&D IC: International Collaboration G: Government P: Private Company Leading			
Infrastructure		technologies and platform.				
Law and Regulation		Identification, feasibility study, and adoption of				

Product: Digital Electronic Medical Records		Short Term			Medium Term			Long Term	Target			
		2022	2023	2024	2025	2026	2027	2028-2030	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target										
Key Technologies	Wireless Technologies	Design and Implement Nationwide Wireless Strategy (G)							75%	25%	-	Mbps
	Internet	Design and Implement Nationwide Internet Strategy (G							75%	25%	-	% Of National Coverage
	Cloud Computing	Design and Implement Nationwide Cloud Computing Strategy (G +P + IC)							100%	-	-	Server Availability withCloud Designation
	Blockchain	Design and Implement Nationwide Blockchain Strategy (G + R&D + IC)							50%	50%	-	#Of Blockchain Medical Record Systems

	Data Storage and Management	Upgrade Data and Storage Management Strategy (P + R&D)	60%	40%	-	Storage capacity to support medical record storage
Commercialization and Practical Use		Support for developing digital records technologies and platform.	R: R&D IC: International CollaborationG: Government P: Private Company Leading			
Infrastructure		Identification, feasibility study, and adoptionof necessary technology and physical infrastructure.				
Law and Regulation		Review of outstanding laws, drafting of new regulations, and adoption of best practice.				

Product: Connected Devices and Wearables		Short Term			Medium Term			Long Term	Target			
		2022	2023	2024	2025	2026	2027	2028-2030	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target										
Key Technologies	Wireless Technologies	Design and Implement NationwideWireless Strategy (G + P)							75%	25%	-	Mbps
	Internet	Design and Implement Nationwide Internet Strategy (G + P)							75%	25%	-	National Coverage
	Smartphones	Full Nationwide Adoption of Smartphones (P)							100%	-	-	# Of smartphones paired with a health wearable
	Cloud Computing	Design and Implement Nationwide Cloud Computing Strategy (G + P + IC)							100%	-	-	Server Availability with Cloud Designation
	Medical Sensors	Design and Implement Nationwide Cloud Computing Strategy (G + P + IC)							100%	-	-	Variation and number of medical sensor type
	Peer-to-Peer Networks	Design and Implement Nationwide Peer-to-Peer Strategy (G + P + IC)							34%	100%	-	Creation of a P2P healthcare network
Commercialization and Practical Use		Support for developing wearable and health device technologies and platforms.							R: R&D IC: International Collaboration			

Infrastructure	Identification, feasibility study, and adoption of necessary technology and physical infrastructure.	G: Government P: Private Company Leading
Law and Regulation	Review of outstanding laws, drafting of new regulations, and adoption of best practice.	

Product: Personal Healthcare Applications		Short Term			Medium Term			Long Term	Target			
		2022	2023	2024	2025	2026	2027	2028-2030	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target										
Key Technologies	Wireless Technologies	Design and Implement Nationwide Wireless Strategy (G + P)							75%	25%	-	Mbps
	Internet	Design and Implement Nationwide Internet Strategy (G + P)							75%	25%	-	National Coverage
	Smartphones	Full Nationwide Adoption of Smartphones (P)							100%	-	-	Number of smartphones paired with a health application.
		Design and Implement Nationwide Cloud Computing Strategy (G + P + IC)							100%	-	-	Server Availability

	Remote Patient Monitoring	Design & adopt standard practice regulations for RPM (G + P)	34%	100%	-	% Of remote patient access
	Financial Technology (FinTech)	Design and Implement Nationwide E-finance Computing Strategy (G + P + IC)	34%	100%	-	% Of payments made by Financial Technologies
	Artificial Intelligence	Design and Implement Nationwide AI Strategy (G + P)	-	75%	100%	Number of applications utilizing AI
	Commercialization and Practical Use	Support for developing personal healthcare application technologies and platforms.	R: R&D IC: International Collaboration G: Government P: Private Company Leading			
	Infrastructure	Identification, feasibility study, and adoption of necessary technology and physical infrastructure.				
	Law and Regulation	Review of outstanding laws, drafting of new regulations, and adoption of best practice.				

Product: Laboratory and Diagnostic Care		Short Term			Medium Term			Long Term	Target			
		2022	2023	2024	2025	2026	2027	2028-2030	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target										
Key Technologies	Wireless Technologies	Design and Implement Nationwide Wireless Strategy (G + P)							75%	25%	-	Mbps
	Internet	Design and Implement Nationwide Internet Strategy (G + P)							75%	25%	-	National Coverage
	Cloud Computing	Design and Implement Nationwide Cloud Computing Strategy (G + P + IC)							100%	-	-	Server Availability with Cloud Designation

	Financial Technology (FinTech)	Design and Implement Nationwide E-finance Computing Strategy (G+P+ IC)	50%	100%	-	% Of payments made by Financial Technologies
	Peer-to-Peer Networks	Design and Implement Nationwide Peer-to-Peer Strategy (G + P + IC)	50%	100%	-	A P2P healthcare network
	Remote Patient Monitoring	Design & adopt standard practice regulations for RPM (G+ P)	50%	100%	-	% Of remote patient access
	Artificial Intelligence	Design and Implement Nationwide Wireless Strategy (G + P)	-	25%	100%	Number of applications utilizing AI
	Robotics	Procurement and design strategy for robotics (G + P)	-	25%	100%	Number of robots involve in laboratory procedures
	3D Printing	3D Printing rolloutstrategy (P)	-	25%	100%	Number of 3D printed products in medical treatment

Commercialization and Practical Use	Support for developing laboratory and diagnostic care technologies and platforms.	R: R&D IC: International Collaboration G: Government P: Private Company Leading
Infrastructure	Identification, feasibility study, and adoption of necessary technology and physical infrastructure.	
Law and Regulation	Review of outstanding laws, drafting of new regulations, and adoption of best practice.	

Product: Pharmaceutical Care		Short Term			Medium Term			Long Term	Target			
		2022	2023	2024	2025	2026	2027	2028-2023	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target										
Key Technologies	Wireless Technologies	Design and Implement Nationwide Wireless Strategy (G + P)							75%	25%	-	Mbps
	Internet	Design and Implement Nationwide Internet Strategy (G + P)							75%	25%	-	National Coverage
	Cloud Computing	Design and Implement Nationwide Cloud Computing Strategy (G + P + IC)							100%	-	-	Server Availability with Cloud Designation
	Financial Technology (FinTech)	Design and Implement Nationwide E-finance Computing Strategy (G+P IC)							50%	100%	-	% Of payments made by Financial Technologies
	Peer-to-Peer Networks	Design and Implement Nationwide Peer-to-Peer Strategy (G + P + IC)							50%	100%	-	A P2P healthcare network

	Artificial Intelligence	Design and Implement Nationwide Wireless Strategy (G + P)	-	75%	100%	Number of applications utilizing AI
	Robotics	Design and Implement Nationwide Robotics Strategy (G + P)	-	75%	100%	Number of robots involve in laboratory procedures
Commercialization and Practical Use		Support for developing pharmaceutical care technologies and platforms.	R: R&D IC: International Collaboration G: Government P: Private Company Leading			
Infrastructure		Identification, feasibility study, and adoption of necessary technology and physical infrastructure.				
Law and Regulation		Review of outstanding laws, drafting of new regulations, and adoption of best practice.				

Product: Centralized Command Centre		Short Term			Medium Term			Long Term	Target			
		2022	2023	2024	2025	2026	2027	2028-2023	Short Term	Medium Term	Long Term	Measure
		Performance Indicator and Target										
Key Technologies	Wireless Technologies	Design and Implement Nationwide Wireless Strategy (G + P)							75%	25%	-	Mbps
	Internet	Design and Implement Nationwide Internet Strategy (G + P)							75%	25%	-	National Coverage
	Cloud Computing	Design and Implement Nationwide Cloud Computing Strategy (G + P + IC)							100%	-	-	Server Availability with Cloud Designation
	Data Storage and Management	Upgrade Data and Storage Management Strategy (P + R&D)							60%	40%	-	
	Peer-to-Peer Networks	Design and Implement Nationwide Peer-to-Peer Strategy (G + P + IC)							50%	100%	-	A P2P healthcare network

	Video and Audio Conferencing	Adopt standard practice regulations for video and audio (G + P)	100%			
Commercialization and Practical Use		Support for developing a Centralized Command Centre system.	R: R&D IC: International Collaboration G: Government P: Private Company Leading			
Infrastructure		Identification, feasibility study, and adoption of necessary technology and physical infrastructure.				
Law and Regulation		Review of outstanding laws, drafting of new regulations, and adoption of best practice.				

XII. Conclusion and Recommendations

Conclusion

The mapping of Health Technology Road Map offers a way forward to integrate technologies and health to benefit individual, communities, and the Royal Government of Cambodia. This process has identified the key products, services, technologies, and strategies needed to implement a plan that is both at once practical while being open to the future potential and rapid ongoing development of technology.

The roadmap proposes that Cambodia's health technology roadmap vision should be rooted in three inter-related and reinforcing visions:

1. An Integrated One Health Approach.
2. Multidisciplinary Policy and Governance for Health Technology.
3. Strengthened Research and Knowledge Sharing Capacity.

In order to deliver on these visions, several objectives have been defined, and considered alongside supporting technology. In the short term, Cambodia may consider focusing investment on ensuring nationwide internet access and developing cloud computing facilities to support the increased digitalization of the health sector. In the medium term, targeted development of blockchain medical records and advanced Telemedicine infrastructure will build on earlier technological upgrading to enhance service provision. As 2030 approached the ambition is to have established a knowledge sharing, one health embodied health sector, made possible through the adoption and advancement of key technologies as discussed.

Recommendations

Following the Health Technology Road Map reporting process, there are three key recommendations to be made. Each recommendation considers the visions and goals with respect to Cambodia's current development status, resources, and stated growth trajectory. As an overriding recommendation, it will be crucial to design and implement an effective monitoring and evaluation system for tracking the life cycle of this roadmap. This is particularly crucial for identifying new avenues of importance and new

health technologies in a dynamic sector. Cambodia may not wish to develop this system in silo, but rather collaborate with regional and supra-national partners to adopt best-practice and augment for contextual suitability where necessary. The recommendations are as follows:

[1] Cambodia needs to invest in building its human resources. For the health technology roadmap to be successful there will need to be human personnel available to support the adoption, application, and evaluation of the technologies identified and prioritized. Medical professionals will be crucial to successful adoption from a clinical sense, whilst policy and governance professionals will require an enhanced knowledge of the One Health space.

[2] A clear financing pathway. It is important that a financing plan is developed alongside lines of responsibility for the stakeholders involved in the execution of the health technology roadmap. Priorities will need to be set in terms of health outcomes and targets so that health technologies can be costed accordingly.

[3] Development of medical infrastructure. In order to support the process of development in the health sector, as aided by health technology, there must be investment in the physical infrastructure. This will support the ability to undertake higher quality research due to the availability of better data.

Annex

Annex 1: Index of Terms

Technology	Description
Wireless Technologies	Wireless technology refers to technology that allows us to communicate without using cables or wires. Wireless technology includes RF radio frequency (RF) and infrared respectively (IR) waves.
Imaging Technology	Imaging technology is the application of materials and methods to create, preserve, or duplicate images. Imaging science is a multidisciplinary field concerned with the generation, collection, duplication, analysis, modification, and visualization of images, including imaging things that the human eye cannot detect.
Video and Audio Conferencing	A form of online meeting where two or more people engage in a live audio-visual call. With a strong internet connection, the participants can see, hear, and talk to each other in real time, no matter where in the world they are.
Cloud Computing	Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user. Large clouds often have functions distributed over multiple locations, each location being a data center.
Digital Therapeutics	Digital therapeutics, a subset of digital health, are evidence-based therapeutic interventions driven by high quality software programs to prevent, manage, or treat a medical disorder or disease.
Blockchain	A system in which a record of transactions made in bitcoin, oranother cryptocurrency are maintained across several computers that are linked in a peer-to-peer network.
Machine Learning	The use and development of computer systems that can learn and adapt without following explicit instructions, by using algorithms and statistical models to analyze and draw inferences from patterns in data.

Virtual/Augmented Reality	Virtual Reality is the technology that provides almost real and/or believable experiences in a synthetic or virtual way, while Augmented Reality enhances the real world by superimposing computer-generated information on top of it.
Data Storage and Management	Data storage refers to the use of recording media to retain data using computers or other devices. Data storage management helps organizations understand where they have data, which is a major piece of compliance. Compliance best practices include documentation, automation, anonymization, and use of governance tools. Immutable data storage also helps achieve compliance.
Natural Language Generation	Natural language generation (NLG) is the use of artificial intelligence (AI) programming to produce written or spoken narratives from a data set.
Smartphones	A mobile phone that performs many of the functions of a computer,typically having a touchscreen interface, internet access, and an operating system capable of running downloaded apps.
Peer-to-Peer Networks	A peer-to-peer (P2P) network is group of computers, each of which acts as a node for sharing files within the group. Instead of having a central server to act as a shared drive, each computer acts as the server for the files stored upon it. When a P2P network is established over the Internet, a central server can be used to index files, or a distributed network can be established where the sharing of files is split between all the users in the network that are storing a given file.
Remote Patient Monitoring	Remote patient monitoring is the collection, storage, and evaluation of health information (patient's vital signs, blood sugar levels, etc.) through live monitoring via devices that transmit information from the home or care facility to a provider.
E-Finance Technology	The provision of financial services and markets using electronic communication and computation
Internet	The Internet is a global computer network providing a variety of information and communication facilities, consisting of interconnected networks using standardized communication protocols.

Artificial Intelligence	Artificial Intelligence is the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.
Medical Sensors	A device designed to respond to physical stimuli such as temperature, light, magnetism, or movement, and to transmit resulting impulses for interpretation, recording, movement, or operating control.
3D Printing	3D printing is the action or process of making a physical object from a three-dimensional digital model, typically by laying down many thin layers of a material in succession.
Robotics	Robotics is an interdisciplinary branch of computer science and engineering. Robotics involves design, construction, operation, and use of robots. The goal of robotics is to design machines that can help and assist humans.

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