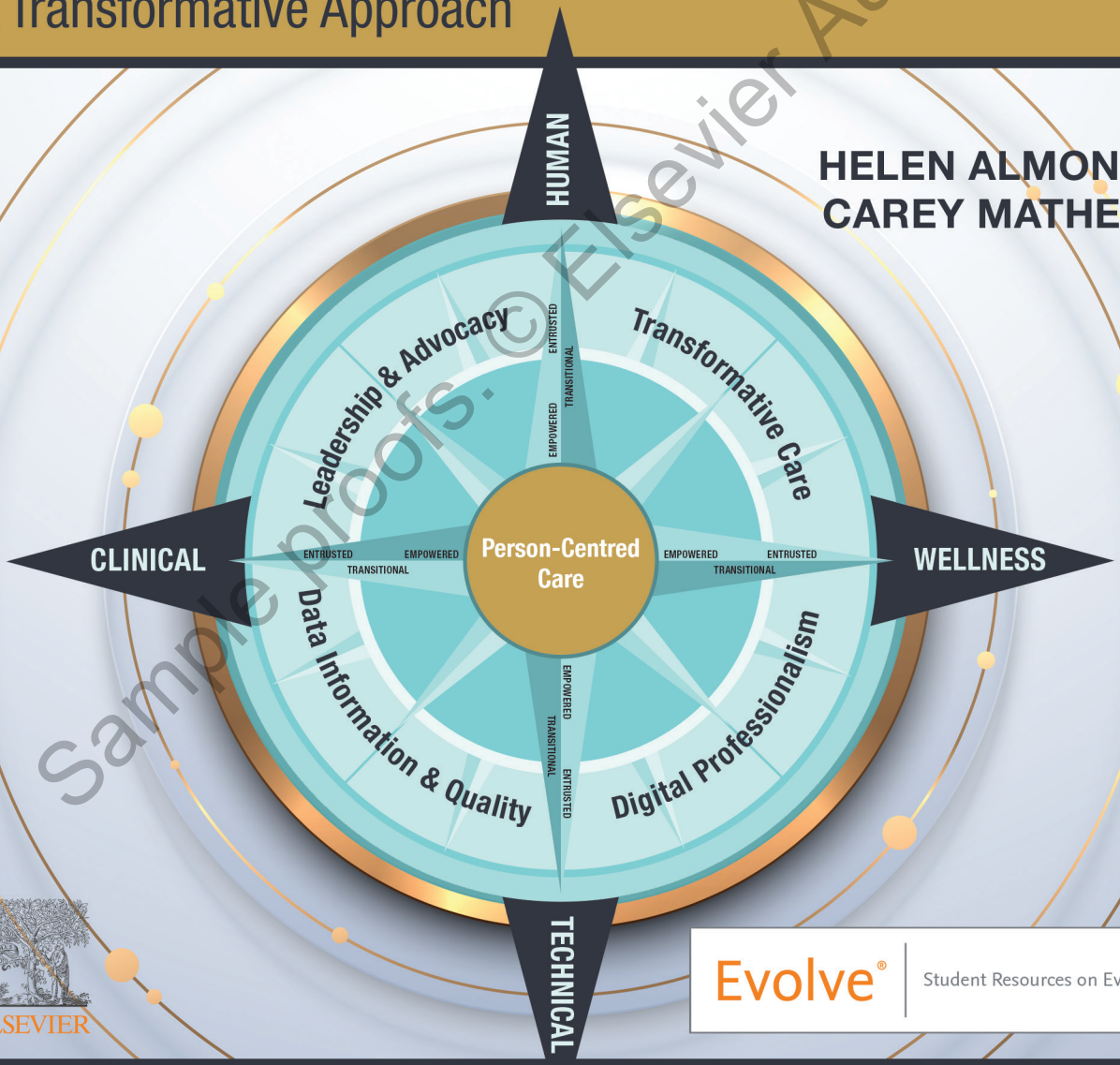
DIGITAL HEALTH

A Transformative Approach

HELEN ALMOND
CAREY MATHER



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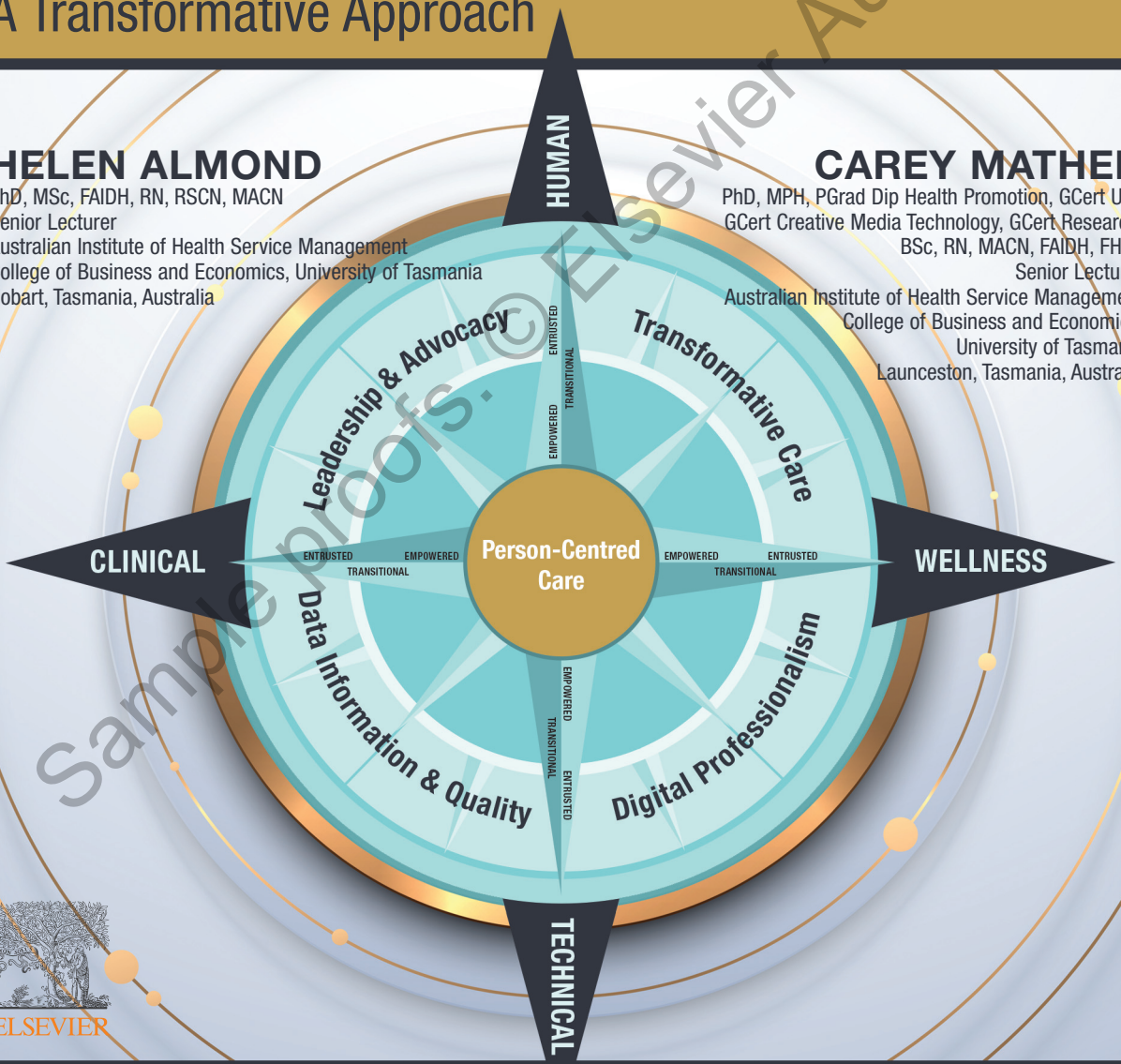

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Elsevier Australia. ACN 001 002 357
(a division of Reed International Books Australia Pty Ltd)
Tower 1, 475 Victoria Avenue, Chatswood, NSW 2067

ISBN: 978-0-7295-4423-8

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National Library of Australia Cataloguing-in-Publication Data

A catalogue record for this book is available from the National Library of Australia

Senior Content Strategist: Natalie Hunt
Content Project Manager: Kritika Kaushik
Copy edited by Leanne Peters
Proofread by Tim Learner
Index by Straive

Typeset by GW Tech

Printed in Malaysia by 1010

Last digit is the print number: 9 8 7 6 5 4 3 2 1

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Dr Helen Almond

Dr Helen Almond is well-respected, with expertise in the field of digital health and social care and healthcare governance. Alongside her PhD in information and computing, she holds qualifications as a registered nurse and registered sick children nurse, and a Master of Science in Clinical Nursing. These accomplishments highlight her extensive education and experience in the health and social care sector.

Dr Almond's international nursing experience spans over 40 years, and she has worked in a variety of roles and settings throughout her career. She has a passion for improving person-centred care and is dedicated to ensuring that healthcare professionals have access to accurate and up-to-date information to support their work.

As an editor, Dr Almond has been instrumental in the publication of *Digital Health: A Transformative Approach* and numerous digital healthcare-related publications. Her experience and expertise in digital health and social care have allowed her to contribute significantly to the development and editing of healthcare content, ensuring that it is informative, accurate and engaging. Helen's research areas of interest and expertise include digital health and informatics, person centred-care, complex chronic conditions, primary care and rural health. She has authored several publications on these topics.

Dr Almond's commitment to advancing health and social care professions' capability in digital health and informatics and improving person-centred care has earned her recognition and accolades from her peers. She is recognised as a Fellow of the Australasian Institute of Digital Health for her contributions to the field of digital health and informatics, representing Australia nursing informatics on The International Medical Informatics Association committee.

Today, Dr Almond continues to work as a senior lecturer and researcher, providing expert guidance to learners and authors in health and social care. Her commitment to promoting evidence-based practice and improving person-centred care has made her an asset to the Australian digital health and social care community. As an experienced digital health adviser, Helen sits on the Australian Digital Health Agency's clinical governance committee, remaining a respected and influential figure in the fields of digital health and health and social care.

Dr Carey Mather

Through her endeavours as a clinician, researcher and educator, Dr Carey Mather leads a transformative approach to health and social care. She is a registered nurse and senior lecturer in health service management. Carey has a Bachelor of Science and has achieved postgraduate certificate qualifications in university learning and teaching, creative media technology and research. She holds a postgraduate diploma in health promotion, a Master of Public Health and a PhD. Carey has worked within the health sector for over 40 years and focuses on topics and issues that impact 'point of care'. Her research interests include workforce capability, digital health, person-centredness and scholarship of learning and teaching. Carey has authored over 100 peer-reviewed journal publications as well as book chapters and position statements. She is a Fellow of the Higher Education Academy, the Australasian Institute of Digital Health and was the inaugural Policy Fellow at the Australian College of Nursing Foundation. Carey has enjoyed the opportunity to engage with contributors and facilitate development of this textbook, which aims to support learners within the burgeoning field of digital health.

ACKNOWLEDGEMENT AND PREFACE

ACKNOWLEDGEMENTS

We would like to acknowledge the group of people who have championed the development and publication of this first Australasian edition of *Digital Health: A Transformative Approach*. First, acknowledgement of Libby Houston, recently retired content strategist from Elsevier who encouraged and guided us in proposal planning and development. Second, to Kritika Kaushik, Content Project Manager for progressing the drafts and reviews as we navigated our way to publication. We would also like to acknowledge the contributors and reviewers, as without them we would not have a comprehensive Australasian digital health text for learners to use. Empowerment and transition to entrustment in digital health is the aim of this text, and we acknowledge the contributors who have shared their expertise and are enabling others to understand this rapidly evolving field. Last, we would like to thank the Australasian Institute of Digital Health for supporting this discipline and providing us with a platform to source the experts who have contributed to this book.

PREFACE TO DIGITAL HEALTH: A TRANSFORMATIVE APPROACH

As the world continues to become increasingly digitised, the realm of healthcare has undergone a significant transformation. Emergence of digital health technologies has revolutionised how health and social care is delivered. New avenues for research, diagnosis and treatment have been opened. *Digital Health: A Transformative Approach* offers a comprehensive Australasian overview of this exciting and rapidly evolving field.

This book is a timely addition to the growing literature on digital health and social care. It brings together contributions from Australasian experts in the field who offer a broad range of perspectives on the various facets of digital health, from its theoretical foundations to its practical applications. The text provides insights into how digital health technologies are being used to improve person-centred care, enhance health outcomes and empower individuals to take greater control of their health.

Chapters in this book cover a diverse range of topics, each placed in distinct units: foundations of digital health; embedding safe, ethical and effective use of digital health; integrating technology; and finally, digital health transformation. Through reflection, case studies and real-world examples, the authors illustrate the potential of technologies to transform healthcare and improve individual user's outcomes. Moreover, they offer insights into the ethical, legal and social implications of digital health, highlighting the need for careful consideration of these issues as we move towards a more digital future.

Digital Health: A Transformative Approach is an important contribution to the growing body of Australasian literature on digital health. It provides a comprehensive overview of this rapidly evolving field and will be of great interest to current and future healthcare practitioners, researchers, policymakers and anyone interested in the intersection of health and social care and technology. This book offers an insightful analysis and compelling vision of the future of healthcare.

FOREWORD

Australia and New Zealand have a long history of involvement in and leadership of digital health and health informatics on the global stage. Indeed, many of the contributing authors in this text have led and driven this progress.

As this book goes to print, healthcare systems across the globe are in turmoil ('Why health-care services are in chaos everywhere' 2023). Systems that were already stretched became overwhelmed as a result of COVID-19, and while the pandemic now assumes endemic status, our newspapers are filled with stories of ambulance ramping, extended waiting times between referral and treatment and not enough hospital beds. This is in the face of a workforce crisis so severe that most developed countries have adopted the same strategy to import skilled clinical labour, but that labour is not being found. The harsh reality is that a silver bullet to remedy healthcare's woes is not coming.

Digital health may not be a silver bullet, but the digital and data enablement of healthcare offers significant promise to being able to address the 40% of healthcare that is inefficient and wasteful (Braithwaite et al 2020), and to improve health outcomes for all citizens by increasing equity of access and by ensuring clinicians have access to relevant health information to deliver the highest quality care.

Healthcare's digital transformation journey is far from complete. Consumers by and large still do not have access to their medical information; clinicians are put under enormous pressure by not having access to comprehensive, accurate and concise information about those in their care; and managers of health services aren't able to interrogate the millions of data points their services collect to understand how to provide better quality and timely care. We have a lot of work to do, and this book offers much to prime your thinking towards how healthcare needs to evolve and transform.

I commend this book to all those interested in health transformation and the role of healthcare in our digital societies. I encourage readers to take what you learn in these pages to play an active role in shepherding your peers and colleagues through to the promised land – where 'digital health' is no longer relevant terminology, because it's 'just healthcare', it's how we do healthcare. That is, where healthcare enabled by digital and data is business as usual.

I love this quote by Dr Donald M. Berwick, Ex-President and CEO, Institute for Healthcare Improvement: 'We can have absolutely all the care we want and need ... All we have to do is organise it properly' (Levenson 2014). So, go ahead and make it happen!

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CONTENTS

5

Digital Health Technologies and Systems

Joel Scanlan, Erin Roehrer, Kristy de Salas, Matthew Springer and Ming Wong

LEARNING OUTCOMES

On completion of this chapter, learners will have the capability to:

- identify existing digital health practices and the challenges that currently hinder digital intervention practices
- recognise the key role that human-centred design plays in the success of digital health technology and system development
- apply guidelines and recommendations to the design of digital health technologies.

KEY TERMS

accessibility
Australian Digital Health Strategy
co-design
digital divide
health and social care technology
human-centred design
interoperability
New Zealand Health Strategy
digital transformation
usability

COMPASS STATEMENT

The COMPASS statement situates how Chapter 5 uses the implementation model. Digital health technologies and systems are *Systematic* and embedded in *Contexts*. This chapter focuses on how human-centred design is central to health and social care technology and system development. Transformation of health and social care environments is supported by the continuance of evolving digital *Models* to support and improve personalised care and health outcomes (Mather & Almond 2022).

INTRODUCTION

Modern health and social care is a complex ecosystem. Increasingly, these systems contain digital elements that leverage a broad range of technology. Changes to health and social care have come from the introduction of information technology and advanced computing power, and have been transformative in nearly every area of health and social care. From digital imagery-enabled ultrasound technology developed in the 1960s, to the computer systems that enabled DNA to be sequenced in the 1970s, to the health information systems (HIS) proposed and implemented in the 1980s, through to now, these are enabling personalised, informed care throughout users' lifespan. The impact of digital systems on diagnosis, prevention and care is extremely broad, and this change is accelerating—the health system is becoming an intrinsically digital system (WHO 2021).

There are currently many challenges within Australasian health and social care contexts. An ageing

population, an increase in chronic disease, and growing costs of care provision and medical research (Australian Government Department of Health 2019). New technologies, and in particular better use of digital systems to leverage the growing quantity of data being collected, are seen as possible solutions, and a further driver of adoption of digital health.

However, some of the biggest drivers of innovation in health and social care have come from outside the industry. The COVID-19 pandemic has accelerated the adoption of telehealth (Valdes et al 2022), health and social care user interest in the quantified health movement, monitoring their own health with smart telephones and watches (Michard 2021). There has also been a shift within the IT industry towards a more commoditised service provision, enabling low-cost access to data storage and analysis fuelling rapid innovation in artificial intelligence across many knowledge domains (Bohr & Memarzadeh 2020).

The future of health and social care provision will become more personalised, with increased use of virtual care and remote health (Vicente et al 2020). The number of clinical Internet of Things (IoT) devices is set to triple between 2018 and 2025, enabling remote monitoring of key health measures (Dahlqvist et al 2019, Hasan 2022), while consultations will occur online or possibly with the assistance of augmented reality or virtual technology (Yuan 2022). The vast amounts of data being collected by the sensors carried or worn by individuals will be fed into complex personalised machine-learning algorithms to provide an increasingly rich understanding of an individual's health status without even visiting a clinical practitioner. Population-level analysis will help care provision to be improved but will also inform how medications are designed and tested (see, for example, Savjnkina et al [2022], Buckley et al [2022] and Plaxco et al [2022]).

For this future of increased reliance on data and devices within health and social care provision, design of these systems needs to consider how they are used and by whom. User trust in digital devices, in relation to both privacy and ethical use of data, is vital to their success. In addition, usability of these systems from all stakeholder perspectives—whether they are users, clinicians, nurses, allied health providers, governments or hospitals—is vital. Without a considered approach, much of the potential benefits of digital health, such as enabling safer and better-quality clinical care, cost savings and increased privacy, may not be realised (Hambleton & Aloizos 2019).

This chapter will give a brief introduction to digital health technology and systems, and the importance of the transformation that has occurred. It will then examine and discuss the national digital health strategies of Australia and New Zealand in relation to important issues and assumptions that exist about digital adoption within health. Finally, the chapter will explain the importance of undertaking a design process that considers the users of the technology, before then exploring the broad range of approaches that are available to practitioners. A case study will be presented at the end of the chapter to demonstrate the important role of applying a human-centred design approach within a health and social care context.

What are Digital Health Systems?

'Digital health' is a broad term that encompasses a very wide range of technology being used to improve health outcomes of the individual, a community or a population. The World Health Organization defines digital health as:

> *The use of digital, mobile and wireless technologies to support the achievement of health objectives. Digital health describes the general use of information and communications technologies (ICT) for health and is inclusive of both mHealth and eHealth.*
>
> ***(WHO 2016)***

This broad definition is inclusive of a vast range of health technologies that have evolved into using or being connected to ICT systems or are brand-new technologies created due to external developments in ICT then being applied to health. Digital health includes a range of technologies, from using ICT systems to track and store the health data of many individuals in information systems, to a single piece of technology used to treat or monitor an individual.

The changes in how data is stored and collected has been one of the most visible examples of the digital transformation occurring within the health and social care industry. The adoption of HIS and electronic health records (EHRs) are both key examples of widespread adoption of ICT systems globally. Within Australia, My Health Record is the digital health platform that is aiming to connect an individual's care team together, increasing access to their clinical history and facilitating

closer collaboration between clinicians to improve outcomes. This collaboration is enabled through the creation of a centralised health record that can be shared between the individual, clinicians, pharmacies and other care providers.

Communication technology advancements have enabled far greater access to care through telemedicine, telehealth and other remote services. Remote care via telemedicine has enabled access to clinicians and specialists they formerly would not have been able to access. In the Australian context, one of the most discussed key use cases for the rollout of the National Broadband Network was its capacity to facilitate telehealth services. The COVID-19 pandemic greatly accelerated adoption of both telehealth and telemedicine, with many clinicians and care providers rapidly adopting the service in early 2020 and continuing to use it as a care option in the years that have followed.

The widespread adoption and continued improvement of mobile user devices, especially telephones and tablets, has resulted in the creation of a care paradigm: mHealth. With users frequently carrying the devices with them wherever they go, they have provided the perfect opportunity to track and monitor health, or to provide advice in any location. The mHealth paradigm has led to the quantified health movement, pairing devices such as telephones with other devices like watches and wrist bands that enable health and fitness to be tracked quite accurately at a low cost. These innovations are increasingly being leveraged by clinicians to monitor patients' key measures such as heart rate, blood sugar and activity.

Adoption of gaming technology as a mode of treatment has also been an active area of innovation in health for over a decade. Augmented and virtual reality technology has been used in the training of clinician staff, to facilitate remote care and to provide self-driven treatments for users. Gamified approaches, increasing the level of engagement during treatment, have been shown to improve outcomes in a broad range of contexts including mental health, physiotherapy, dentistry and other disciplines.

Digital transformation has resulted in far greater access to data about user care provision. As a result, there is an increasing evidence base to improve health outcomes, service quality and efficiency. However, with the adoption of digital systems, it is important that it is an improvement process and not merely a change process. The adoption of digital systems is not without challenges and risks. Health and social care systems are complex, and data being stored is subject to ethical and legal concerns. Usability of the systems for clinicians, patients and other users is vital. It is important that these factors are considered and addressed continuously as they may limit the potential benefits of adopting digital systems within health. The next section will briefly describe the role of national digital health strategies—to help guide and assist innovation in the sector—before examining the challenges this strategy faces in relation to adoption of technology within health and social care.

NATIONAL DIGITAL HEALTH STRATEGIES

The size and scale of the health sector, and its central role in relation to the wellbeing of citizens within countries, has seen multiple countries adopt national strategies to encourage and support the innovation that is taking place. Australia's National Digital Health Strategy (Australian Digital Health Agency [ADHA] 2018) identifies several key focus areas of concern by the Australian professional and user community and seven strategic priorities that were to be achieved by 2022. The conversion of physical to digital records has been subject to research and development of best practices over the last few decades, with the consensus focused on improved health record access, quality and sharing (Horahan et al 2014). The digitalisation of health and social care has moved from electronic records created and accessed by health and social care providers, to that of digital health records and empowering user participation with the records, users' families and other stakeholders interacting with systems. There are many factors that affect the use of digital health among providers, users and other stakeholders; unsurprisingly, this has been an area of focused research over the last few decades. The list of strategies presented within Australia's National Digital Health Strategy (ADHA 2018) is focused on the accessibility of health information, the secure transmission of health information and improvements across the user journey in terms of outcomes and costs. The seven strategies are (ADHA 2018):

1. health information that is available whenever and wherever it is needed
2. health information that can be exchanged securely
3. high-quality data with a commonly understood meaning that can be used with confidence

4. better availability and access to prescriptions and medicines information
5. digitally enabled models of care that drive improved accessibility, quality, safety and efficiency
6. a workforce confidently using digital health technologies to deliver healthcare
7. a thriving digital health industry delivering world-class innovation.

The New Zealand Health Strategy: Future Direction (Minister of Health 2016) outlines the direction for the health system over the 10 years from 2016 to 2026. The strategy is aligned into five key themes: People Powered, Closer to Home, Value and High Performance, One Team and Smart System. The strategy includes a focus on providing care to citizens wherever they are located, and ensuring technological innovations are leveraged to better the health of all New Zealanders. Of relevance to digital health innovations is the Smart System theme, which focuses on the following key areas:

- discovering, developing and sharing effective innovations across the system
- taking advantage of opportunities offered by new and emerging technologies
- having data and smart information systems that improve evidence-based decisions
- having reliable, accurate information that is available at the point of care
- providing individual online health records that people can access and contribute to
- using standardised technology that allows us to make changes easily and efficiently.

This strategy is also supplemented by a Digital Health Strategic Framework (Ministry of Health 2019) and is constructing a new national health information platform called Hira (https://www.health.govt.nz/our-work/digital-health/other-digital-health-initiatives/hira-national-health-information-platform) for storing, accessing and sharing health information, with a current planned completion date of 2026.

Asian countries are also moving towards digital health ecosystems by increasing access to primary care through providing a combination of telemedicine and ePharmacy services to underserved populations, leveraging digital technologies to improve health and wellness, increasing access to acute care and managing and monitoring chronic diseases (Baur et al 2021).

For these strategies to be realised, and to ensure the authentic and safe use of digital technologies and systems by all stakeholders, several assumptions need to be unpacked and explored.

Issues for Consideration

This section will highlight and discuss challenges that need to be addressed in achieving national strategies relating to improving population health through technological innovation. Several examples where systems and technologies have fallen short of their potential will be described to illustrate the nature of the issues before we move on to discuss how such shortcomings can be avoided in the future.

Accessibility of Information and Information Centrism

One major premise of digital health is the ability to have information available for the right person, at the right place, at the right time. However, this premise is built on the assumption that readily available information will directly impact clinical outcomes.

My Health Record claims to offer benefits from the perspectives of users and health and social care professionals. From a user's perspective, My Health Record gives users the ability to control their health information securely, all in one place, which means that a user's 'health information is available when and where it is needed, including in an emergency' (ADHA 2022a). From a health and social care professional's perspective, My Health Record provides them with the health information of individuals through an online and secure system. All authorised health and social care providers can access My Health Record to view and add user health information and they can access a range of timely information about their users such as shared health summaries, discharge summaries, prescription and dispensing records, pathology and diagnostic imaging reports and immunisation information.

From an information perspective, My Health Record should solve issues related to the timely access of information in a secure manner. However, the way it is designed brings about other issues relating to the accuracy and completeness of information, illustrated by some examples below.

- My Health Record contains a list of pharmaceutical benefits scheme (PBS) medications that a user has been prescribed, but not details of whether the user has taken the medication. It also has no record of medications and supplements that a user may be

taking that have not been prescribed. Recording generic or brand-name medications may also lead to further complications with contraindications and side effects.
- User consent is required to allow data to be collected in their My Health Record. Users can also choose to remove data from their record at any time, further limiting the completeness of the record.
- Users may record all their clinical history in their My Health Record, resulting in huge chronologically ordered records, with no summary overview allowing for informed clinical decisions within constrained timeframes.

Clinical practitioners and users could be left with a My Health Record that can be dangerously incomplete, or dangerously complete. If centralising accessible data will lead to improved quality of care or clinical outcomes, there still remains challenges to be overcome when the reality of EHR systems are considered.

The availability of a large amount of information does not always lead to better outcomes, as quality, integrity and trust of the information play key roles, in addition to the availability of information.

LEARNING ACTIVITY

Mohammad has been brought up in a conservative culture in a suburb of Sydney. He has been very careful to remove all references to his prescriptions for tenofovir disoproxil fumarate and emtricitabine from his EHR. He irregularly takes these two drugs as pre-exposure prophylaxis (PrEP) to lower his risk of HIV infection while having an active sex life as part of the LGBTIQA+ community.

On his latest prescription, Mohammad has found his urination has decreased and his ankles swelling considerably. These may be temporary or serious complications related to taking PrEP, but lacking the prescription records, Mohammad needs to explain his concerns to his family friend and long-term general practitioner, creating additional risk to Mohammad's health.

Make a list of the options and difficulties that Mohammad faces in this situation. If Mohammad was in a small rural area, would he face the same options and difficulties? Identify the differences for people in rural areas.

The Digital Divide

The digital divide has shifted from a simple definition differentiating groups of people with or without computer access to a more complex definition encompassing both technical and financial abilities to make full use of the available technology (skill levels) considering access levels to the internet. With the increasing use of digital health technologies, research has shown that a range of factors including environmental, social and community, education, economic, health, and health and social care access is widening the digital divide (Ramsetty & Adams 2020).

Research undertaken in Australia (Thomas et al 2021) and New Zealand (Grimes & White 2019) on digital inclusion show that while there is some improvement in the digital divide, there is still a substantial number of individuals who are not 'digitally included'. These individuals tend to be in an older age group, are less educated, have a lower income, are unemployed or live in social housing. Table 5.1 summarises a recent survey of digital inclusion across all age ranges.

The COVID-19 pandemic has served as a catalyst for the development and adoption of digital health. Digital access is now a key factor that contributes to health outcomes and is a requirement for accessing both COVID-19-and non-COVID-19-related care (Kichloo et al 2020). Digital health is sometimes the only way that users can access general practice and specialist care services during lockdown periods. The most vulnerable population group is unfortunately the most disadvantaged group during this time of need.

There are ways to increase access to the internet and computing devices, improve digital literacy and health literacy (Eruchalu et al 2021). It is not just about having the right information but also about having the right support, confidence and ability to use tools for digital health effectively, which will determine health outcomes (Ehrari et al 2022). All Australians and New Zealanders should be equipped with the skills and the necessary infrastructure to access health services and information in a digital form and an affordable manner. This goal needs to be achieved to maximise the benefits of digital health.

Changes in Workflow and Workarounds

One of the most common reasons digital health systems fail to effectively improve quality of care and health outcomes is the incompatibility between the system/software and workflow. As a result, informal work practices, known as workarounds, are often used to circumvent hindrances brought about by new systems. One example is the use of e-referral systems. The receiving

TABLE 5.1 Understanding the Digital Divide

The Australian Digital Inclusion Index Measures the Current level of Digital Technology Access Across the Australian Population. This Table Shows the Top Reasons Digitally Excluded Australians do not Connect to the Internet More Often

Reason	National Average	35–44	45–54	55–64	65–74	75+
No need to use internet more often	65%	52%	53%	76%	73%	70%
Concerned about privacy/scams	20%	21%	24%	20%	24%	21%
Internet is not a priority	15%	2%	13%	18%	16%	20%
Not confident using internet	13%	5%	13%	10%	17%	17%
The internet is too expensive	12%	20%	8%	12%	11%	6%
Do not have access to the internet	6%	5%	3%	5%	7%	9%
Disability prevents internet use	2%	9%	2%	3%	0%	3%
Other	9%	5%	19%	10%	3%	4%

(Thomas, J., Barraket, J., Parkinson, S., Wilson, C., Holcombe-James, I., Brydon, A., Kennedy, J. (2021). Australian Digital Inclusion Index: 2021, Dashboard Dataset Release 1. Melbourne: RMIT and Swinburne University of Technology, and Telstra.)

party needs to actively download the e-referrals that have been sent through. Failure to do so creates a backlog resulting in referrals not being attended to in a timely manner and impacting the continuity of care. The workaround that has been established is to send both e-referrals and physical copies; while the e-referral goes to the practice and must be sorted through, a paper copy goes directly to the medical practitioner for triage.

Another example is viewing pathology/radiology results. Traditionally, clinicians would look at paper copies of pathology/radiology results; however, despite the fact that results are available online now and all clinicians have to do is to log into the system and view the results, many are still requesting the results to be printed out. There are many EHR workarounds with the rationale for these identified in the literature (Blijleven et al 2017, Boonstra et al 2021). Boonstra and colleagues (2021) found that there are three types of EHR workarounds: in-system workflow; in-system data entry; and out-system workarounds. In-system workflow sequence workarounds are created because EHRs are seen as time-consuming and imposing. In-system data entry workarounds are created because of lack of time, fear of losing data, lack of knowledge, lack of functionality, lack of overview and mandated features. Out-system workarounds are created because of the lack of trust in one's own abilities, reduced user contact, lack of time and limited motivation.

Blijleven and colleagues (2017) identified a total of 15 rationales for EHR workarounds associated with people (5), technology and tools (4), organisation (4) and tasks (2) (see Table 5.2). The authors have indicated that workarounds associated with people can be addressed by training, workarounds associated with technologies and tools can be addressed through a redesign of EHRs, workarounds associated with organisations can be addressed by reviewing organisational policies and regulations, and workarounds related to tasks can be addressed through process redesign. While these are valid suggestions, it is important to note that re-designing EHRs is a complex process and often does not include clinicians, leading to frustration and disengagement of clinicians.

Digital health systems will change an organisation's workflows. Workflow redesign is a process an organisation should undertake before implementing digital health systems because it can help minimise workarounds, maximise efficiencies, enhance the quality and safety of care and improve care coordination.

Interoperability

Interoperability is paramount in digital health systems as it creates a unified ecosystem for sharing health data between health and social care providers in a meaningful and useful manner. Uncovering the full potential of digital medicine requires an interconnected data infrastructure with fast, reliable and secure interfaces, international standards for data exchange as well as clinical terminologies that define unambiguous vocabularies for communication of clinical information. In Australia,

TABLE 5.2 Identified Rationales for EHR Workarounds and their Definitions

Rationale for EHR Workaround	Definition
Declarative knowledge	Not knowing how to use (a part of) the EHR to accomplish a task
Procedural knowledge	Knowing how but not being proficient enough to use a part of the EHR to accomplish a task
Memory aid	Writing patient data down on paper (e.g. keywords) or adding visual elements to parts of text in a progress note (e.g. bold, italic or underlining) to remind oneself
Awareness	Storing patient data that are perceived important by the EHR user for other colleagues to be noticed in a data field other than the intended field in the EHR
Social norms	Informal understandings among health professionals leading to the creation and dissemination of workarounds (e.g. mimicking workarounds devised by colleagues to accomplish a task or working around the system as friendly requested or enforced by a fellow clinician)
Usability	High behavioural user cost in accomplishing a task
Technical issues	(A part of the) EHR halting, crashing or slowing down, hindering the EHR user in accomplishing a task
Data presentation	Preferring a different data view (e.g. visualisation by means of charts or graphs rather than plain text)
User data specificity	Needing to enter or request user data with greater or lesser specificity than offered or enforced by the EHR
Task interference	Inability to perform multiple tasks at once (e.g. simultaneously treating a user on a treatment table as well as entering patient data into the EHR)
Commitment to patient interaction	Valuing patient interaction over computer interaction (i.e. writing things down on paper and afterwards entering this into the EHR)
Efficiency	Using an alternative way to accomplish a task that improves actual efficiency
Data migration policy	Not having (direct) access to required historical data due to data not having been imported from previously used systems to the current EHR
Enforced data entry	EHR enforcing user to enter user data of which neither the user nor the user has knowledge
Required data entry option missing	EHR not offering the required data entry option (e.g. 3.75 mg prednisone rather than the available options of 2.5 mg or 5 mg)

(Blijleven et al 2017, p. 5)

much of our clinical data resides in isolated data silos and systems that are not compatible with one another, resulting in difficulties in data sharing.

To address the issues of interoperability, Australia and New Zealand use Health Level Seven (HL7; https://www.hl7.org/), which is a set of international standards used to provide guidance for data sharing and data transfer between various health and social care providers (Dolin et al 2001) and Systemized Nomenclature of Medicine—Clinical Terms (SNOMED CT; https://www.snomed.org/) that supports the development of comprehensive high-quality clinical content in EHRs. SNOMED CT provides a standardised way to represent clinical phrases captured by the clinician and enables automatic interpretation of these (Donnelly 2006). However, there are different interpretations of the rules, which means that one piece of information might not mean the same thing across two systems. This is based on interpretation and poses challenges to the goal of exchanging high-quality data with a commonly understood meaning.

Issues arise when the interpretation of a standard is different across different organisations, different normal

ranges are used in pathology systems and different acronyms are used within clinical settings. Transferring medication data is also problematic due to different brand names used for the same medication. While active ingredient prescribing in Australia aims to address this issue, it can be confusing for users as most remember their medications via their brand name instead of the generic name (e.g. Panadol versus paracetamol). Generic names of medications can also be different depending on the country in which they are sold (e.g. paracetamol in Australia is known as acetaminophen in the United States).

In more recent times, HL7 has developed the Fast Healthcare Interoperability Resource (FHIR), which aims to provide a sufficient degree of interoperability (transport, structured and semantic to a degree) to be useful but avoids the complexity that a complete interoperability solution entails (Braunstein 2018).

Interoperability issues pose problems for health and social care providers and users when clinical information cannot be shared across different systems and settings. It is therefore important to try and mitigate interoperability issues during software/system selection by checking if the software/system has an acceptable level of interoperability with other systems. Chapter 6 explores interoperability issues in depth.

Unintended Consequences

The introduction of digital health technologies often leads to unintended consequences, which may be positive or negative. Unintended consequences occur due to the lack of a complete understanding of clinical workflow, difficulties in predicting rare events, and more importantly, the unpredictable nature of human behaviour related to change. Many negative unintended consequences have been described, including disrupting power relationships, increased workload for health professionals, negative impact on workflow, problems associated with communication patterns and frustration with the new system. Sometimes, however, technology can bring on positive change, including ubiquitous education, better teamwork and reorganisation of workflow.

From an information perspective, the unintended consequences of digital health technologies could be related to complex clinical information not being available at point of care due to the need for digital access. Alternatively, large amounts of clinical data might lead to information overload (Sittig et al 2016). Constant alerts and alarms might lead to alarm fatigue, resulting in a clinician ignoring an important event requiring attention. From a workflow perspective, Öberg and colleagues (2018) reported that the digitalisation of primary care resulted in an increased workload. Nurses had little training and experienced 'digital chaos' and delays caused by multiple logins on unsynchronised systems. Security was often compromised because usernames and passwords were written and recorded on computer monitors or the desk to work around requirements for multiple passwords.

From an organisational perspective, disruption of the power structure in an organisation can result in negative feelings about digital health. The lack of a user's ability to innovate and change the system can also lead to frustration and disengagement (Sittig et al 2016). These issues were explored by Ziebland and colleagues (2021) who conducted a conceptual literature review on the unintended consequences of digital health technologies in primary care. The study identified three consequences: 1. disrupt power relations between users and health professionals or between different groups of health professions; 2. contribute to paradoxical outcomes; and 3. result in a potentially corrosive subculture of pessimism about digital health.

More importantly, digital health can impact user–clinician and clinician–clinician interaction. Sittig and colleagues (2016) reported that the increasing focus on computer-based quality measurement negatively affects clinical workflows and user-provider interactions. Öberg and colleagues (2018) investigated Swedish primary health and social care nurses' perceptions of using digital eHealth services in support of user self-management and found that nurses perceived the digitalisation of primary care to be a threat to the nurse–user relationship and felt that they were spending too much time on administrative tasks. Similarly, Donaghy and colleagues (2019) studied video consultations in primary care in the United Kingdom and found that video consultation reduced the rapport between the health professional and the user as well as the effectiveness of the communication. It is important to be aware of the potential unintended consequences that digital health systems might cause to address them during the design and development phase.

Usability

Usability is 'a measure of how well a specific user in a specific context can use a product/design to achieve a

defined goal effectively, efficiently and satisfactorily' (Interactive Design Foundation 2022). While simply defined, it is challenging to achieve. As systems are designed, there are many factors that need to be considered to achieve this goal, particularly within a complex working ecosystem. For example, what cognitive and perceptual capacity does the user have as they interact with the system? If their attention is required as they undertake a separate task, is a visual or auditory alert most appropriate?

While the intent of moving towards digital health is to transform the healthcare industry by streamlining healthcare services and improving user safety, research has shown that there are substantial gaps between the current state of EHRs and their potential usefulness due to usability issues. EHR usability is a significant issue in digital health (Howe et al 2018), limiting success to improvements in the quality and efficacy of user care. While there is much room for improvement in the design of EHR systems, the complexity behind technical integration, design and usability means that a robust user-centred design process is often not used (Marcial 2014).

Usability issues that have been identified by Howe and colleagues (2018) include difficult data entry, inadequate alerts, inadequate interoperability, poor visual display, availability of relevant clinical information, system automation or defaults, and poor workflow support. Sittig and colleagues (2016) report that poor usability resulted in breaches of privacy and confidentiality.

These usability issues lead to a range of problems that negatively impact user safety and a health professional's quality of working life. Carayon and Hoonakker (2019) conducted a review of the literature and reported that usability issues were related to medication safety events due to medication orders with missing information and accepting duplicate medication orders. They also reported that EHRs created unmanageable demands for clinical documentation, and poor usability and workflow integration contributed to clinician burnout. Kutney-Lee and colleagues (2021) found that surgical users who received care in hospitals with poorer EHR usability were more likely to die or be readmitted compared with users in hospitals with better EHR usability. They found that poor EHR usability was associated with adverse nurse retention and surgical user outcomes. Nurses were more likely to be burnt out, dissatisfied with their job and wanting to leave compared to nurses who were using EHRs with better usability. These examples show that better usability will lead to higher EHR adoption rates, improved user safety, less clinician burnout and fewer errors. More importantly, it is important to consider the usability of a system from the diverse perspectives of different groups of users.

Challenge Summary

Healthcare is a complex, dynamic, socio-technical system, and the increased rate of digital technology adoption has increased this complexity. The national health strategy is aiming to improve care and be a positive agent of change. But the challenges outlined in this section highlight that as digital innovation in care delivery takes place, consideration needs to be given to a broad set of issues—many of which are founded on assumptions that are made about how digital technology interacts with individuals and organisations.

Improvement processes can carry an assumption that the outcome will be of benefit to all involved. However, examining the impact of digitisation within populations with low ICT literacy, the digital divide can further increase disadvantages. Such impacts can affect care received, but it can also impact clinicians and carers, increasing their workload in adapting to new systems. Change always has an impact, and the compatibility and interoperability between existing systems within health need to be considered. Health is a complex system of systems, in relation to funding and governance, and care delivery in a broad range of settings. The ability for the various stakeholders to be able to share and access data must be present. The data, recorded and altered by multiple stakeholders, including the user, can have an impact on data quality, and the treatment decisions that are made as a result. The range of unintended consequences from assumptions made in adapting complex systems is broad. Digital systems may increase access, but they can also change workloads and the power dynamic between clinician and user, and become over-reliant on data and not be user centric.

Finally, a key challenge is the usability of technology. Increasing data collection and access has the potential to enable better care, but the same systems can, when poorly designed, limit their efficacy, affect user safety and be a contributing factor to privacy breaches.

RESPONDING TO THE CHALLENGES OF A DIGITAL HEALTH FUTURE

The digital evolution in the health and social care sector has provided many opportunities for care delivery to be improved, for new methods of care to be developed

and for greater understanding of how the sector operates. However, as the previous section outlined, this process is not without its challenges and difficulties. Modern health and social care is digital health. The challenges faced in adopting a more data-driven paradigm leveraging an increasing amount of technology within health is going to continue, and so the challenges faced need to be considered and mitigated. As of November 2021, 23.2 million Australians (over 90%) have a My Health Record (ADHA 2022b), highlighting the national scale of digital health and the importance of ensuring our care delivery is as effective and efficient as possible.

Therefore, to mitigate these issues raised in the previous section, it is vital that the information technology being designed and deployed within health considers these challenges (Kushniruk et al 2010) within an informed process that matches not only the organisational goals within a long-term strategy, but also the workflows and care practices for those using the technology. It needs to be evidence based, aiming to maximise safety and health outcomes.

This section will first examine the key role that human-focused design can have within health and social care, and its need, before an overview of the wide range of applicable co-design processes that can be adopted to ensure digital health systems and technologies can be designed and constructed in a manner most likely to be successful.

A Need for Human-Focused Design

The potential for digital technology to improve health outcomes and the efficiency of care provision is strong, and is supported by the national strategy. However, the challenges that have been outlined in the previous section highlight the importance of a considered approach in the design and development of interventions and systems used within such a complex field.

Digital health has been seen by many as a tool with much potential for providing information to individuals who do not have direct access to clinicians. In a large review of interventions using mobile devices (Marcolino et al 2018), containing 371 studies and nearly 80,000 users, it was found that with only a few positive exceptions, the bulk of the studies did not reach their expected potential. Authors investigating the field (Baker et al 2014, Schnall et al 2016, Torous et al 2018) found the reason was that the interventions had not been designed according to the needs of users. Furthermore, they found many of the published studies failed to report any design approaches or usability evaluations, and those that did report on design indicated a heavy reliance on the insights gained from clinicians, rather than users.

Similarly, studies have found that systems intended for usage by clinicians are also not appropriately designed for their users. A study conducted by Kaipio and colleagues (2020) of 2560 nurses and 3013 physicians found a large disparity between the two groups in the usability of EHR systems, which were independent of the vendor for the systems, inferring common misunderstandings of workflow and expectations across the roles.

A clinician, or an expert in a field, acknowledging the potential for a new system or technology to enable better outcomes does not mean that implementation will automatically achieve the designed outcome. Evidence and design are foundational in producing interventions that have a high probability of success; that is, meeting the needs of the intended user while also achieving the safety and quality goals (Borycki 2019).

The design process is vital in ensuring IT systems and technology are safe for their use in health, are fit for purpose, can be easily used by their intended user, and are inclusive and equitable for the broad range of possible users. A human-centred design approach—aligning with person-centred care at the core of the COMPASS theoretical framework—is vital and increasing in popularity within health (Holeman & Kane 2020). According to the International Standards Organisation, human-centred design is a complex practice characterised by six principles (ISO 2019):

1. design is based upon an explicit understanding of users, tasks and environments
2. users are involved throughout design and development
3. design is driven and refined by user-centred evaluation
4. the process is iterative
5. design addresses the whole user experience, including the context in which users find themselves
6. design team includes multidisciplinary skills and perspectives.

Human-centred design processes aim to involve and understand the perspectives of the users, involving them throughout the design and development process. The process is intended to be iterative, enabling feedback from the users and other stakeholders to be implemented within the system, maximising the probability that it will be suitable to their needs. The design process

aims to be multidisciplinary, ensuring all perspectives—and in the case of digital health, technical, clinical and user—are all represented.

Engaging Stakeholders in Co-Design Towards Suitability and Acceptability

Several different frameworks are relevant to digital technologies, and provide some support during the selection and implementation of systems. Each framework offers its own focus and benefits, with most of the focus on stakeholders in some form. A human-centred approach aims to ground the design process within the needs and constraints of stakeholders—whether they are direct users of the system or not. Within health, a broad range of systems and technologies are designed and adopted for a wide range of stakeholders. An EHR, for example, has stakeholders with a range of skill and knowledge levels, from the individual who owns the record—who could be from a diverse range of socioeconomic and cultural backgrounds—to their health and social care providers, which span pharmacists to clinical practitioners, nurses and medical specialists. Systems that interact with EHRs have a broad set of technical and usability needs to be met for it to be safe and effective.

The core challenges described in this chapter were that: users of digital health technologies, whether they be clinicians or users, have the capability to engage in learning and using digital health technologies (education, training and appropriate skills are provided as needed); users have the opportunity within their workflow to effectively use these technologies (they have the time and social support to engage with and integrate these technologies into their activities); and they have an appropriate amount of motivation to use these technologies (they see a personal or social benefit to their use). One of the core challenges described in this chapter was that users of digital health technologies, whether they be clinicians or users, have the capability to engage in learning and using digital health technologies (education, training and appropriate skills are provided as needed), that users have the opportunity within their workflow to effectively use these technologies (they have the time and social support to engage with and integrate these technologies into their activities), and that they have an appropriate amount of motivation to use these technologies (they see a personal or social benefit to their use). We have learned, however, that opportunities commonly aren't provided. Evidence (Johnson 2006) suggests that many users of digital technologies are not provided with appropriate training and education to effectively use systems, which leads to misunderstandings of their operations and subsequent workarounds being employed. Health and social care professionals are also often required to use these technologies alongside the various clinical tasks that comprise the substantive part of their roles, and so new technologies, while promising, have the potential to be burdensome on users as they add extra activities in an already overwhelmed workforce. Furthermore, evidence has shown us that not all potential users of these technologies are motivated to do so (Boonstra et al 2021), as the benefits are not seen to outweigh the costs of new activities and requirements for change.

The field of behavioural psychology informs providers and users that lacking any of capability, opportunity or motivation will lead to a lack of response to behavioural change targets (Michie et al 2011, Willmott et al 2021, Yadav et al 2021). In this instance, the behaviour that champions of digital technologies seek to achieve is the adoption and effective use of these technologies. Therefore, this lack of capability, opportunity or motivation among digital health users bodes poorly for the achievement of adoption and use goals, and is indicated by acceptability failures offered throughout the literature (Burr & Morley 2020, Klonoff 2019).

Furthermore, the field of technology acceptance indicates that not all users are as willing as each other to adopt technologies. While some are eager to try new innovations early, others may be more sceptical of change and require time and examples of successful use by others before they will adopt new technologies (Rogers et al 2014). Literature and experience also inform providers that users' intention to use a new technology is directly affected by their perceptions of its usefulness and ease of use (Davis 1989). That is, users must see a technology as easy to use and useful for them to consider adopting it. Therefore, it is vital to understand the nature of users, their expectations, their perceptions and their concerns, and take those into account in the design of new digital technologies.

Co-design is one method within the fields of project management, software development, interactive design and human factors engineering that promotes the core imperative to improve the acceptability of systems. Engagement of users at all stages of the development cycle in a process of co-design is promoted (Norman & Draper 1986). For example, within interactive design, the PACT (People, Activities, Context

and Technology) analysis framework promotes a consideration of people as the first step in developing interactive digital products (Benyon 2014). Similarly, the systems development lifecycle (Ruparelia 2010) drawn from the field of software engineering leads developers through a process of analysing the needs of users as one of the first steps in designing usable software. Further, IT project management commences with a process of user requirements engineering to identify the needs of users and the benefits that will be realised from new systems development (Westland 2007).

While each framework in Table 5.3 might be perceived as a linear lifecycle of action, in fact, each of these recognises that the achievement of user goals and

TABLE 5.3 The Location of Stakeholder Engagement within Design Frameworks

The Shaded Cells Indicate Where User Needs are Considered

Frameworks	Purpose	Variables/ Activities					
PACT	A framework from interaction design that considers the different ways in how people use technologies to perform tasks (Mostajeran et al 2019, Rosson et al 2002)	Understand people (users)	Understand usage activities	Understand usage contexts	Understand technology options		
Systems development lifecycle (SDLC)	Not specific frameworks, but a process to guide the development of software artifacts; typically, a linear process that does not include any dynamic involvement by users outside of the prescribed cycle (Adanna & Nonyelum 2020)	Planning	Analysis of needs	Design	Development	Testing	Implementation and maintenance
Interactive Design	Iterative process used to guide development of interactive software artefacts (Silver 2007)	Establish User requirements	Design Alternatives	Undertake Prototyping	Undertake Evaluation		
IT project management	A lifecycle guide to support the activities of project management of IT solutions (Grit 2021)	Initiation	Planning and requirements engineering	Execution	Closure		
Benefits management	Guidelines to identify the benefits to be provided by a digital system (Ward & Daniel 2012)	Identify and structure benefits	Plan benefits realisation	Execute benefits plan	Review and evaluate results	Establish potential for further benefits	

subsequent acceptability and adoption of digital technologies requires an iterative approach of user needs collection, analysis, prototyping and evaluation, ensuring that users are engaged in each cycle and that their needs and concerns are included at each stage of design.

A question therefore arises: How do we get users to engage as co-designers through the lifecycle of digital technology development?

1. The first step in co-design is to understand the nature of the stakeholders of the digital technology. A review of stakeholders should be undertaken that identifies all those interested parties who will either impact, or be impacted by, the development of the digital technology. The output of this step will consist of a stakeholder analysis that allows for the identification of the interaction and communication needs of each stakeholder, and the identification of those who should be included as subject-matter experts or typical type users in the design process (Brugha & Varvasovszky 2000).
2. The second step is to understand the nature of the users of the proposed digital technology. For example, it is known from literature that not all users are the same, and people vary across many attributes including physical, psychological, social and emotional attributes. These differences all directly impact a person's likelihood of adopting a technology, and so need to be carefully understood (Benyon 2014). Engaging stakeholders and users in the development of a portfolio of personas that represent typical user types, their characteristics and their needs, during the design process as an output of this step can focus preliminary design decisions towards the user (Benyon 2014).
3. A third step is to understand the nature of the job, tasks or activities undertaken by the proposed users of the digital technology to ensure achievement of 'usefulness' (Kim 2015). Undertaking a task analysis in which the activities of users are mapped and analysed provides a visual breakdown and detailed understanding of the nature of the activities and supports the development of a digital technology that supports or enhances these activities.
4. A fourth step would be to use the outputs of the previous steps to engage potential users in the conceptual design of prototype interfaces and functionality of the digital technology (Preece et al 2015). In doing so, users are actively co-designing their own processes, interactions and interfaces, and evaluating them iteratively.

These four steps will ensure that:

- a broad range of users and stakeholders are recognised and included in the process of co-design (as a result of developing the stakeholder analysis)
- the nature and needs of users is well understood (as a result of co-developing a portfolio of user personas)
- the nature of the tasks and activities of the users is well understood (as a result of co-developing scenarios and maps of processes and tasks)
- that the functionality and interfaces of the digital technology are iteratively co-designed (as a result of the generation and evaluation of prototypes).

In doing so, a user's capability to use a new digital technology is enhanced as their attributes and challenges are understood and designed for, their opportunity for using the new technology is enhanced as it is designed specifically for their needs and circumstances, and their motivation for using the new technology is enhanced as it is designed for them and by them in accordance with the demands of their activities. Furthermore, users involved in co-design often become champions during the implementation of new digital technologies, and thus can serve as examples for those who require more time and illustration of use prior to their own acceptance. In co-designing, users support the achievement of usefulness by ensuring the design represents the tasks and activities undertaken by them and their colleagues, and the achievement of ease of use due to co-design based on their own capabilities and those of their colleagues, thus providing a better understanding of how the system will be used and perceived in the real world. This enables the designed output to align to the intended goals, maintaining privacy over user data and ensuring safe and effective provision of care.

An example of a co-design process that is currently being undertaken in New Zealand is the Hira platform mentioned earlier. This long design and development process, set to be completed in 2026, proudly states that it is a co-design process, inclusive of Māori and with key stakeholders included within the governance group to provide input.

CONCLUSION

Modern health and social care systems are digital health systems: over 90% of Australians have an EHR. The use of digital apps, tools and services is the preferred way to manage their health and wellbeing. Health and social care professionals also take advantage of innovative

tools, integrating them with their workflow and improving efficiency. To aid in this transformation, and to aid in the innovation taking place, countries are adopting a national health strategy that includes digital technology throughout—aiming to provide protection and confidence in healthcare systems. However, adoption of new technology and systems within health and social care is not a simple or straightforward process, but one that raises multiple issues and challenges. The adjustment of existing systems to become more connected raises issues relating to compatibility and interoperability. Assumptions about how individuals interact with and use technology impact care providers and users alike. It can result in dramatically increasing workloads of care providers or increasing existing barriers to care for those who have limited access or experience with modern technology. Many of the issues discussed are not intentional, but second-order effects from innovations being adopted without due care being given to ensure the changes are inclusive and equitable to all.

Implementing new systems and technology for widespread adoption requires a thorough design process which is focused on the intended users. Within health, this can include a broad range of users, including non-professional caregivers, nurses, medical practitioners and support staff. Co-design is an effective process to ensure all stakeholder perspectives are gathered and integrated into the design. This process is not only focused on what the users need, but how they will use it and how it will interact with existing systems and processes. A holistic approach that is inclusive of stakeholders' capabilities, opportunities and motivations is vital to ensuring an effective and accessible solution is created. Finally, a case study was presented showing the impact of a poorly considered design process, which resulted in issues arising once the intervention was opened to a broader group of users. It serves to illustrate the importance of a person-centred approach, even when those developing systems have all the best of intentions in wanting to provide care to others. It is the process that enables them to achieve their goals.

KEY CONCEPTS

- Healthcare is a complex dynamic socio-technical system, and the increased rate of digital technology adoption has increased this complexity.
- National strategies have played a key role in increasing access and directing the development of digital health technologies to scale to population size.
- Co-design in the development of digital health interventions is important to ensure equity of access to all users.
- Stakeholder engagement is vital in ensuring systems are fit for purpose, while also being safe and secure.

DISCUSSION QUESTIONS

1. Identify the range of digital health systems you have encountered either in your workplace or as a consumer of health services.
2. Reflect on the digital health strategies presented in the chapter and reflect on the assumptions that underpin them.
3. What unintended consequences have you come across in your workplace or as a user of health services? Did it have a positive or negative impact on the provision of health and social care services?

CASE STUDY

This case study includes the need for co-design and the unintended consequences when co-design is not attempted or is attempted through proxies that are not representative of all stakeholders. Co-design for the safe, ethical and effective use of digital health needs a holistic and authentic approach that requires approximate leveraging of data, considerations of the digital divide and data-driven approaches that are user-centred.

Chronic obstructive pulmonary disease (COPD) is a challenging lung disease, but there is strong evidence that a carefully designed exercise program is beneficial for COPD sufferers (Spruit et al 2016). Dr Osborne has spent significant time analysing evidence to see how the data could be leveraged to find ways to support users to complete their exercise programs. In response to this, Dr Osborne created a team with an ICT professional, Dr Li,

Continued

CASE STUDY—cont'd

to develop a game that would be both engaging for COPD users and provide rewards for compliance with the designated exercise program.

Dr Li was able to reach out through her university's alumni program to three people who were undergoing treatment for COPD. Working with Dr Osborne and the three COPD users, Dr Li developed a game that accessed each user's EHR, identified their individual exercise requirements and presented those requirements as an online garden. When the users were compliant with their exercise regimens as measured by their smart watches and smart phones, new and more interesting plants were available to plant in the online garden. And if users were not compliant, the garden would wilt and die.

The concept was motivational because all three users were avid gardeners and enjoyed adding new plants to their online gardens. During the design process, Dr Li was able to understand how the users preferred to interact with the game and what features would be appealing and motivating. Dr Osborne was pleased because the users were almost always compliant with the exercise requirements over the 3-month trial period, and this led to improved health outcomes for the users. This encouraged Dr Osborne and Dr Li to take their new game to a wider audience.

Abby, Ben, Chad and Dana were introduced to the system by Dr Osborne and were very interested in playing a game to monitor their exercise, because all four of them found exercise to be pretty stressful and unfulfilling as a prescribed activity. Dr Osborne and Dr Li were anticipating another successful trial due to the new users' desire to make exercise more engaging. They were pleased that the co-design process was proving successful for the next round of users.

When Abby first logged into the garden game, she could not make the game work. She had been told it was very simple to use, but it kept on nagging her about an EHR. Abby did not have an EHR. She did not want the government knowing her business. When Dr Li had designed the system in consultation with the original three COPD users, all of them had EHRs, and an alternative interaction method was not required. This identified for Dr Li that a greater understanding of the nature of the stakeholders was required.

Dr Li checked with Ben to ensure that he did have an EHR, and Ben's EHR was complete and up to date, including the exercise requirements for his COPD. Ben logged into the system successfully but could not understand how the system was meant to measure how much exercise he was doing. Ben had a laptop computer from 2012, a cheap dumb phone and no smart watch. Dr Li's original user co-designers were middle-class university graduates with access to smart phones, smart watches and laptops that were less than 3 years old, well beyond Ben's socioeconomic level and purchasing power. This identified for Dr Li that a greater exploration of the stakeholders' technological capabilities was required.

Dr Li was even more thorough with Chad's check. Chad had an EHR and all the technology required to monitor their health, but their clinical practitioner had accidentally entered a requirement of a 1000 m walk, instead of a 100 m walk, so Chad was failing to meet their goals every day. This was very discouraging for them because their online garden died. Chad was over-performing in terms of their exercise requirements, but the incorrect goal setting led them to be discouraged and to abandon the game. This identified for Dr Li the need to verify the quality of data in EHRs before relying on that technology.

Dr Li was much more careful with verifying Dana's EHR and technological capabilities to ensure that she didn't face the problems that the others did. Dana had the correct technology, had an EHR and the goals within the EHR were correct. Dana hated gardening. She participated for 15 minutes before knowing that this system wasn't going to work for her. Dr Li went back to the drawing board. There was a lot more co-design necessary because not only were the processes and interfaces with Dr Li's new game important, but also the users' perception of the interactions was critical to success. But with these experiences, Dr Li was able to create a better outcome.

Questions

1. Co-design requires the inclusion of all stakeholders during the development process of digital health interventions. Reflecting on the case study, what guidelines could have been adopted to ensure the co-design resulted in a more robust and relevant intervention for the end users?
2. Co-design challenges often involve overcoming barriers to digital adoption by different cohorts in the target stakeholder group. This can be overcome by reviewing and addressing some of the assumptions made for, and on behalf of, the stakeholder group. What assumptions needed to be challenged for the co-design process to have greater success?
3. What impact has the current co-design had on the ability of both healthcare providers and users to operate the game in a safe, effective and ethical manner?
4. What needs to change to improve the safety, effectiveness and appropriateness of the game for future users?
5. Identify and discuss systems that you have come across with good usability and poor usability.

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