

**NANYANG
TECHNOLOGICAL
UNIVERSITY**

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**EXPLORING THE FEASIBILITY OF
TELEHEALTH IN SINGAPORE'S AGEING
CARE: A MULTI-METHODS STUDY**

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Interdisciplinary Graduate Programme

Ageing Research Institute for Society and Education

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EXPLORING THE FEASIBILITY OF TELEHEALTH IN SINGAPORE'S AGEING CARE: A MULTI-METHODS STUDY

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Interdisciplinary Graduate Programme

Ageing Research Institute for Society and Education

**A thesis submitted to the Nanyang Technological University
In partial fulfilment of the requirement for the degree of**

Doctor of Philosophy

2023

Statement of Originality

I hereby certify that the work embodied in this thesis is the result of original research, is free of plagiarised materials, and has not been submitted for a higher degree to any other University or Institution.

24 August 2023

Date

Zhang Yichi

Zhang Yichi

Supervisor Declaration Statement

I have reviewed the content and presentation style of this thesis and declare it is free of plagiarism and of sufficient grammatical clarity to be examined. To the best of my knowledge, the research and writing are those of the candidate except as acknowledged in the Author Attribution Statement. I confirm that the investigations were conducted in accordance with the ethics policies and integrity standards of Nanyang Technological University and that the research data are presented honestly and without prejudice.

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Teo Wei Peng

Authorship Attribution Statement

This thesis contains material from 2 papers published and 3 papers submitted in the following peer-reviewed journals in which I am listed as an author.

Chapter 2 is published as Zhang, Y., Leuk, J. S., & Teo, W. P. (2023). Domains, Feasibility, Effectiveness, Cost, and Acceptability of Telehealth in Ageing Care: Scoping Review of Systematic Reviews. *JMIR ageing*, 6, e40460. <https://doi.org/10.2196/40460>

The contributions of the co-authors are as follows:

- I (YZ) conceptualised the review; formulated the search strategy; conducted the literature search and screening; extracted and analysed data; and drafted and revised the manuscript.
- Ms Jessie Leuk Siew Pin (JL) assisted with screening the articles; and critically reviewed the draft of the manuscript.
- Asst Prof Teo Wei Peng (WT) provided valuable and critical insights and inputs at all stages of the review; and critically reviewed the draft of the manuscript.
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The contributions of the co-authors are as follows:

- I (YZ) conceptualised the study; created the online registration forms and semi-structured interview guide; collected and analysed data; and drafted and revised the manuscript.
- Asst Prof Edmund Lee Wei Jian (EL) obtained partial funding for the Article Process Fee; provided valuable insights into the study; and critically reviewed the draft of the manuscript.
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The contributions of the co-authors are as follows:

- I (YZ) participated in the design and deployment of the telemonitoring service in the Singapore community; participated in the Phase 1 pilot test and led the subsequent two pilot tests phase 2 and 3; conducted the literature search and formulated the user feedback for Phase 2 and 3 pilot tests; analysed the operating statistics and user feedback for all three pilot tests; drafted and revised the manuscript.
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- Asst Prof Teo Wei Peng (WT) provided valuable and critical insights and inputs at all stages of the review; and critically reviewed the draft of the manuscript.
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"I wanted myself to see what real courage is, instead of getting the idea that courage is a man with a gun in his hand. It's when you know you may be licked before you begin, but you begin anyway and see it through no matter what."

– Adapted from *To Kill a Mockingbird*, by Harper Lee

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Preface

My PhD journey started in August 2019, and the main project was carried out from 2021 to 2023, which coincided with the trajectory of the COVID-19 pandemic. As one of the earliest countries affected by the pandemic, Singapore confirmed the first case on 23 January 2020. In response, the government has implemented a “three-phased approach” to stem the tide of infections:

- 7th April 2020 to 1st Jun 2020 – “circuit breaker” phase: a nationwide partial lockdown when no one was allowed to leave home and most of the workplaces were converted to remote work
- 2nd Jun 2020 to 18th Jun 2020 – “Phase I”:
- 19th Jun 2020 to 27th December 2020 – “Phase II”:
- 28th December 2020 to 7th May 2021 – “Phase II”:
- 8th May 2021 to 13th June 2021 – “Phase 2 Heightened Alert”:
- 14th Jun 2021 to 21st July 2021 – “Phase 3 Heightened Alert”:
- 22nd July 2021 to 9th August 2021 – “Phase 2 Heightened Alert”:
- 10th August 2021 to 26th September 2021 – “Preparatory Stage of Transition”:
- 27th September 2021 to 21st November 2021 – “Phase 2 Heightened Alert”:
- 22nd November 2021 to 25th April 2022 – “Transition Phase”:
- 26th April 2022 to 12th February 2023 – “COVID-19 Resilient Nation/Acute Phase”

The COVID-19 pandemic has necessitated the closure of some healthcare services, social services, as well as research facilities, causing disruptions to the execution of research projects. Moreover, limited access to research resources and older adults’ fear of infections made the data collection even more challenging.

Notwithstanding these challenges, the pandemic also created new research opportunities in ageing care. It re-highlighted the increasing concerns for older people’s health and well-being, exacerbated the existing health disparities faced by older people, and underscored the urgency to increase their access to healthcare services.

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List of Abbreviations

AI	Artificial Intelligence
AMS	the Aerial Medical Service
AP	Ageing Health Service Provider
BP	Blood Pressure
CCTV	Closed Circuit Television
CFIR	Consolidated Framework for Implementation Research
CINAHL	Cumulative Index to Nursing & Allied Health Literature
CTS	Community Telehealth Service
DKAS	Dementia Knowledge Assessment Scale
EBP	Evidence-Based Practice
HER	Electronic Health Records
ERIC	Expert Recommendations for Implementing Change
FGD	Focus Group Discussion
GP	General Practitioner
HBM	Health Belief Model
HDB	Housing & Development Board
HPB	Health Promotion Board
HSB	Health-Seeking Behaviour
ICT	Information and Communication Technology
IDI	In-Depth Interview
IGI	Intervention-Generated Inequalities
IS	Implementation Science

IRLM	Implementation Research Logic Model
NCD	Non-Communicable Disease
NOISE	Needs, Opportunities, Improvements, Strengths, and Exceptions
OP	Older Participant
RCT	Randomised Controlled Trial
SEM	Social-Ecological Model
SMM	Safety Management Measure
SNOW	Strengths, Needs, Opportunities, and Weaknesses
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TP	Telehealth Provider
VSSC	Virtual Social Service Centre
WHO	World Health Organisation

List of Definitions

Ageism: the negative and inaccurate stereotypes, prejudice, and discrimination towards older people

Asynchronous (store-and-forward) telehealth: involves gathering health data or information and transmitting it to a doctor or medical specialist at a later time, eliminating the need for both end users to be present simultaneously

Classic theory: an established theory from fields external to IS to offer insights into the underlying mechanisms which influence implementation processes and outcomes

Clinical benefit: a favourable effect on a meaningful aspect of how a patient feels (e.g., symptom relief), functions (e.g., improved mobility) or survives as a result of treatment

Clinical intervention: a health intervention or practice being implemented with the research framework

Co-creation: a broad term with applications ranging from the physical to the metaphysical and from the material to the spiritual

Code saturation or thematic saturation: the point of identifying repetitive codes or themes without the emergence of new information or relationships

Data saturation: a stage in data gathering and analysis where additional data fail to significantly contribute to addressing the research question or replicating existing findings

Determinant framework: a framework to provide a structured approach to identifying and categorising the factors that influence the successful implementation of interventions, aiding in the development of effective strategies for implementation

Evaluation framework: a framework to offer systematic approaches to assess the effectiveness, efficiency, scalability, and sustainability of implementation efforts, which can guide researchers and practitioners in determining the impact of interventions on desired outcomes

Health-seeking behaviour: any action or inaction undertaken by individuals who perceive themselves to have a health problem or to be ill for the purpose of finding an appropriate remedy – a widely used definition in literature;

an individual's deed to the promotion of maximum well-being, recovery, and rehabilitation; this could happen with or without health concerns and within a range of potential to real health concerns – by Chinn and Kramer

Healthy ageing: the process of developing and maintaining the functional ability that enables well-being in older age

Healthy literacy: the achievement of a level of knowledge, personal skills and confidence to take action to improve personal and community health by changing personal lifestyles and living conditions

Implementation strategy: the systematic approach and technique employed to facilitate the adoption, implementation, scalability, and sustainability of evidence-based practices

Implementation theory: a specialised framework developed within the IS field to provide a deeper understanding of the complex dynamics and processes involved in successfully translating research into practice

Information and/or data redundancy: when repetitive data lead to a point where no further insights are gained

Meaning saturation: a stage in the process of data collection and analysis where issues are fully understood and no fresh insights regarding the meaning of codes or themes and their interrelations emerge

Mechanism: a causal pathway or process, i.e., the process or event by which an implementation strategy exerts its effects on the desired implementation outcomes

Outcome: the result or consequence of “deliberate and purposive” implementation efforts

Pseudo-saturation: when researchers prematurely cease data collection, overlooking alternative perspectives or vital information sources, thus mistakenly assuming saturation has been reached

Overload of information and/or data: when it is challenging to identify key themes and patterns through vast volumes of data

Process model: a model to outline and guide the systematic translation of research findings into practical applications within real-world settings

Remote patient monitoring: enables medical professionals to continuously measure and evaluate patients’ physiological parameters from a distance, by

utilising electronic devices such as wearable technologies, mobile devices, and mobile health applications

Synchronous (real-time) telehealth: similar to in-person consultation, is delivered in real-time where both the clients and providers are present and engaged simultaneously, allowing for their live communication and interaction

Tele-advice: the remote provision of health information, advice, guidance, and recommendations but not for diagnosis, prognosis, or treatment purposes

Tele-counselling: the delivery of therapy over the Internet to assist the communication between the therapist and client

Tele-education: the application of information and communication technologies in the delivery of distance learning

Tele-exercise: the delivery of physical training remotely

Tele-follow-up: the delivery of follow-up care to patients who have been triaged but not directed to the emergency department, or extending care to patients subsequent to their discharge from the emergency department, using information communication or online platforms

Tele-nutrition: the interactive implementation of the nutrition care process by a registered dietitian nutritionist

Tele-treatment: the remote provision of direct clinical care between healthcare professionals and patients/caregivers, such as history, triage, examination, diagnosis, and treatment

Telecare: the use of information, communication, and monitoring technologies which allow healthcare providers to remotely evaluate health status, give educational intervention, or deliver health and social care to patients in their homes

Teleconsultation: synchronous or asynchronous consultation using information and communication technology to omit geographical and functional distance

Telehealth: the delivery and facilitation of health and health-related services including medical care, provider and patient education, health information services, and self-care via telecommunications and digital communication technologies

Telemedicine: the remote diagnosis and treatment of patients by means of telecommunications technology” which is specifically the remote practice of medicine

Telemonitoring: the collection, transmission, evaluation and communication of individual physiological data at a distance, with the aid of health technologies including wireless devices, wearable sensors, implanted health monitors, smartphones, tablets and mobile apps

Telerehabilitation: the delivery of rehabilitative service via info-communication tools or the Internet

Theoretical saturation: the point where further data collection fails to unveil novel facets or enhance the emerging theory

SUMMARY

Ageing has emerged as a critical global issue, with older adults often experiencing greater health needs than younger generations. Unfortunately, this group is also facing challenges in accessing appropriate, affordable, and high-quality healthcare, especially amid the COVID-19 pandemic. Telehealth, delivering and facilitating healthcare and health-related services using telecommunication and digital communication technologies, offers a promising solution in ageing care spanning medical services, provider and patient education, health information services, and self-management. It can eliminate geographical and time constraints, provide socially isolated and physically homebound older individuals with a broader range of health service options, reduce the risk of infectious disease transmission, and transform health services by integrating older people's familiar environment to improve service quality and effectiveness.

Despite the growing body of evidence investigating the use of telehealth in various domains of ageing care, several notable gaps remain. Firstly, earlier studies were predominantly conducted in Western countries and may not provide sufficient insights into the global context, particularly in Asian countries. Secondly, previous studies have focused mainly on disease diagnosis, treatment, and rehabilitation but might have overlooked health promotion and disease prevention. Thirdly, there is insufficient research on the perspectives of non-users who lack access or awareness of telehealth, and those who refuse to use telehealth. Lastly, telehealth presents a specific risk in generating health

inequalities: both baseline health inequalities as well as inequalities in access, uptake, adherence, and effectiveness. Thus, it is imperative to devise implementation strategies to address these gaps.

Guided by the Implementation Research Logic Model (IRLM), this thesis consists of a series of interwoven studies with multiple methods conducted across different overlapping phases to address these gaps, spanning from the identification of determinants affecting telehealth implementation and exploring implementation strategies, to designing and evaluating telehealth interventions in the Singapore community. The overarching research question is “What is the feasibility of utilising telehealth to address older individuals’ health needs?”

Study One investigated community-dwelling older adults’ health-seeking behaviour (HSB) and associated technology utilisation, to inform possible areas in which telehealth could provide a solution. Findings highlighted three potential areas for implementing telehealth in Singapore’s ageing care: health consultation, education, and monitoring.

Study Two explored perceptions of telehealth in ageing care among older adults, healthcare professionals, social health service providers, and telehealth providers, from both users’ and non-users’ perspectives. The responses from different participant groups were highly consistent, yet some “contradicting” viewpoints and experiences were also discovered. This study uncovered various determinants affecting telehealth implementation in Singapore’s ageing care

context and summarised the corresponding implementation strategies from the perspectives of different stakeholders.

Findings from these two studies validated the potential for implementing telehealth in Singapore's ageing care. In order to design inclusive, equitable, scalable, and sustainable telehealth interventions that effectively address the health needs of older individuals, the next two studies employed a participatory approach and evaluated two telehealth interventions using effectiveness-implementation hybrid designs:

In **Study Three**, a community-based multi-user phygital telemonitoring programme was designed with the guidance of IRLM and deployed in the Singapore community to lower the barriers to accessing health technologies and promote regular self-measurement practice among the older population. This programme was pilot tested at three heartland locations progressively, and the findings consistently demonstrated its preliminary effectiveness and feasibility based on the implementation, service, and user outcomes.

Study Four piloted a pre-created synchronous tele-education prototype on dementia and co-created a user-centred tele-education programme with older adults to address their health information needs. The pilot test demonstrated the preliminary effectiveness of the tele-education prototype in improving participants' knowledge and awareness about dementia, as well as the feasibility of delivering health education via synchronous telehealth. The qualitative findings from the co-design workshop also provided

recommendations for the implementation strategies of future health education programmes.

Taking these studies together, this thesis affirmed the potential feasibility of telehealth solutions in addressing the health needs of the older population in the Singapore community. The findings collectively underscore the importance of enhancing the inclusivity, equity, scalability, and sustainability of telehealth implementation in ageing care and propose strategies for achieving this goal. The insights gained from these studies could be useful for healthcare professionals, health educators, social health service providers, researchers, policymakers, and other stakeholders in designing and implementing telehealth with and for the older population, ultimately leading to better health outcomes and improved quality of life for this demographic.

CHAPTER 1 INTRODUCTION

Let me speak on behalf of my husband. He is a chronic patient...For him, he has to go for a lot of appointments, and unfortunately, they [the appointments] are all physical, so lots of time [and] money is [are] spent. I actually stopped work[ing], so I don't earn anything, I do not have the income now because I accompany him wherever he goes for hospital appointments. I do not know how many patients are like my husband...He has many health conditions from middle-age until now [when] he is 70+, he has been ill health for quite a number of years...Now it is also hard for me to go for physical ones [activities] because every time I go out, I have to make sure there is someone around at home. Otherwise, half a day is gone just to attend a one- or one-and-half-hour session physically...You travel very long to go [to see the doctors and to other events] and going back also takes a long time. For now, because his mobility is also not so good, so quite often, in fact, most of the time, we are taking a cab. If we take a cab, it will be worse [because] [a] two-way [trip] in [a] cab is not cheap.

– Participant 09 from the study in Chapter 7

1.1 Ageing in the 21st century

The true account of this lady highlights several challenges that her husband and herself faced as an older patient with multi-morbidities and his family caregiver:

mobility difficulties, excessive time and money spent on travelling to medical institutions, and inability to engage in other life activities. Similar struggles may be also observed in many other families.

The 21st century is witnessing unprecedented demographic shifts; societies worldwide are grappling with the multifaceted implications of an increasingly ageing population. This demographic shift is a result of improved healthcare, increased life expectancy, and declining birth rates. This chapter explores the multifaceted aspects of ageing in contemporary society, focusing on individual health, family dynamics, societal structure, as well as healthcare delivery.

1.1.1 Ageing in the World

The combination of longer lifespans and lower fertility rates has resulted in an irreversible growth in the number and proportion of older people worldwide (1,2). In 2019, there were one billion people aged 60 years and above (2), and this number has increased to 1.4 billion in 2020 and is projected to reach 2.1 billion by 2050 (1). A similar trend was observed among those aged 65 years and above (from 761 million in 2021 with a prevalence of 10% to over 1.6 billion in 2050 with a prevalence of more than 16%), while the number of individuals aged over 80 years is growing even faster (3).

The United States is one of the countries with the most advanced population ageing process. Over the past century, the number of people aged 65 and older has almost quadrupled (from 4.1% in 1900 to 16% in 2019), and the absolute number has increased at least 17 times (from 3.1 million to 54.1 million) (4). Besides, the older population has also become older, with the 65-74 age group

being more than 14 times larger than that in 1900 (from 2.19 million to 31.5 million), the 75-84 age group (16 million) being 20 times larger (from 771,000 to 16 million), and the 85+ age group being about 53 times larger (from 122,000 to 6.6 million) (4).

Asia, accounting for approximately 60% of the global population (5), witnessed its population surpassing 4.5 billion in 2020 (6). Within this demographic, the older population aged 65 and above reached around 414 million, which was about 20% higher than the total population of the United States; of particular significance is the projection that one in every ten individuals worldwide will be an older Asian by the year 2060 (7,8). As of 2020, the average old-age dependency ratio in the Asia/Pacific region stood at approximately 1:10, equating to approximately 10 working-age adults supporting one older person aged over 65 (9). Across Asia, an epidemiological transition has occurred, characterised by a shift in morbidity and mortality patterns from communicable to non-communicable diseases (NCDs) (6). The emergence of diseases like COVID-19 has further exacerbated health risks for older Asians and placed significant strains on healthcare systems. While some Asian countries have made progress in improving risk factor behaviours, the prevalence of conditions such as diabetes and dementia continues to rise, potentially leading to increased levels of disability (10).

1.1.2 Ageing and Individual Health

Biologically, ageing stems from the accumulative effects of various molecular and cellular damage that occur over time. Such progressive damage manifests

as a gradual decline in both physical and cognitive abilities, heightened susceptibility to diseases, and eventually mortality (11).

Oftentimes, ageing is accompanied by various health challenges and thus older individuals are more likely to experience multiple health conditions simultaneously. Some common conditions include sensory declines (e.g., vision and hearing loss), chronic pains, osteoarthritis, chronic obstructive pulmonary disease, cardiovascular diseases, diabetes, and dementia (11). Moreover, mental health issues such as depression and anxiety often afflict the elderly, exacerbated by factors like social isolation and loss of autonomy (12).

These conditions, if well controlled, may not have great impacts on older people's well-being. Thus, healthy ageing is not about staying free from disease or infirmity, but rather "the process of developing and maintaining the functional ability that enables well-being in older age" (13), where function ability refers to possessing the capabilities that empower all individuals to pursue and achieve what they find meaningful and valuable (13). As a result, addressing the health needs of older adults requires a holistic approach, including but not limited to preventive measures, accessible healthcare services, and tailored interventions to promote physical and mental well-being. Empowering older individuals to maintain active lifestyles, pursue lifelong learning, and cultivate social connections is essential for enhancing their quality of life in the 21st century.

1.1.3 Ageing and Family

Beyond individual health, the landscape of family dynamics is also undergoing profound transformations as societies grapple with the challenges and opportunities presented by ageing populations. Extended life expectancy increases the likelihood of individuals requiring caregiving support in their later years, which places a strain on families (14). The phenomenon of “sandwich generation”, who simultaneously care for ageing parents and dependent children, is becoming increasingly prevalent (15). Balancing work, caregiving duties, and personal life creates significant stressors for individuals in this demographic. Moreover, ageing may sometimes be accompanied by social isolation, especially for those who have experienced the loss of a spouse or friend. Such isolation could have detrimental effects on mental and emotional well-being, thereby further exacerbating the challenges of ageing (16,17).

Despite these challenges, the 21st century has witnessed ageing a revaluation of traditional family roles, leading to enhanced independence and mutual support among family members. As individuals grow older, they assume new roles as mentors, passing down wisdom and life lessons to younger family members. Multigenerational families have the chance to strengthen their bonds and create lasting memories across generations (18–21). Moreover, older people could actively engage in caregiving roles and offer emotional support to younger generations, strengthening intergenerational ties. Ageing also prompts families to unite during challenging times, fostering mutual care and support when loved ones navigate the challenges of their lives (22,23). Ultimately, the opportunity

to age within a supportive and loving family environment enriches the lives of all members, creating a legacy of resilience, compassion, and shared values for generations to come.

1.1.4 Ageing and Society

Ageing, a natural and inevitable stage of life, affects not only every individual and family but also society as a whole. The extended life expectancy and reduced fertility rates result in a shrinking workforce and a growing dependency ratio, where fewer working-age individuals have to support a larger number of retirees, leading to reduced economic growth potential. Furthermore, the increased demand for health services, such as long-term care, rehabilitation, and geriatric care, places a significant strain on the healthcare system and resources, leading to concerns about the accessibility, affordability, and quality of care for this demographic. Ageism, the negative and inaccurate stereotypes, prejudice, and discrimination towards older people, remains prevalent in society, and older adults may encounter barriers to employment, healthcare, social participation, and limited opportunities for inclusion (24,25).

However, amidst these challenges, the 21st century has brought forth abundant opportunities. Older adults now have the chance to explore new hobbies, pursue lifelong learning and personal growth, and actively participate in community activities. Initiatives aimed at promoting active ageing and well-being, such as health programmes and community events, have gained traction in enhancing the quality of life and fostering independence (26). Additionally, the growing population of older adults has stimulated the emergence of the

"silver economy", catering specifically to their needs and preferences (27). This includes a wide array of products and services ranging from health technologies and age-friendly housing to leisure and travel services, all designed to offer better accessibility and comfort.

1.1.5 Ageing and Healthcare

The overall health status of a society is important for its economic growth and development (28). Among the older population, there is a significant and rising share of morbidity and mortality attributed to NCDs. Specifically, 23% of the total global disease burden is linked to disorders among people aged 60 years and above (29). According to Tang et al., a negative correlation was found between the healthcare burden and economic growth during the 20-year period between 2000 and 2019, with every 1% increase in the healthcare burden resulting in a 0.083% decrease in the growth rate of Gross Domestic Product (30). However, Cylus and Tayara adopted country and year fixed effects models and found that the slowdowns in economic growth can be mitigated when the population at that age maintains good health (31). Therefore, it is imperative to develop strategies to support healthy longevity.

The rising prevalence of age-related conditions places unprecedented stress on the healthcare systems. The increasing complexity of healthcare needs among the older population calls for multidisciplinary collaborations and specialised geriatric care services (32,33). Proactive health promotion, disease prevention, early detection, and NCD management are becoming essential in addition to disease treatment (34–37).

The strain on healthcare resources is another consequential impact of ageing. Adequate funding must be secured to meet the rising demand for medical facilities, equipment, and a health workforce specialised in geriatric care (38). The competition for resources between different age groups and healthcare priorities underscores the necessity for strategic resource management and allocation to ensure that older adults receive comprehensive care without compromising services for other demographics (39).

Thus, the delivery of health services is undergoing a transformation in response to the ageing population. Innovative digital health approaches are being integrated to improve accessibility and overcome geographical barriers, and healthcare systems are embracing person-centred care models that prioritise the preferences and goals of older patients, enhancing patient-provider relationships and promoting shared decision-making (40–43).

1.2 Technologies to Support Ageing

The concept of ageing in place has garnered increasing attention within healthcare policies and services, reflecting a growing recognition of the importance of enabling older adults to maintain their independence and autonomy within their own homes (44). The fourth industrial revolution has brought about a significant blurring of the boundaries between the digital, biological, and physical domains, and this transformation has enabled the automation of physical tasks and opened up new opportunities for the adoption of smart technologies at various levels, from individual to national and even global (45).

Due to the higher likelihood of experiencing age-related health declines as well as NCDs (2,46), the older population generally has a higher demand for health services compared to younger people. Technology emerges as a powerful enabler, offering a diverse array of tools and solutions designed to support seniors in their desire to age in place gracefully. By leveraging innovative technologies, such as smart home systems, wearable devices, and remote monitoring technologies, older adults can receive personalised support and assistance tailored to their specific needs and preferences. These technological advancements not only enhance safety and security within the home environment but also promote social connectedness, facilitate access to healthcare services, and empower older adults to actively manage their health and well-being (47).

1.2.1 Smart Home Technologies

Ageing in place refers to the desire and ability of older adults to remain living in their own places or communities as long as possible, rather than relocating to assisted living facilitated or nursing homes (48). To support ageing in place, smart home technologies, integrating Internet-enabled digital devices with sensors and machine learning at home (49), offer a transformative solution to enable older adults to maintain independence, safety, and comfort within their own homes (48,50). Some examples include temperature sensors and smart thermostats to adjust the room temperature based on the current activities and ensure constant comfort levels, smart motion sensors to detect falls or changes

in activity levels, voice assistance to set reminders and control smart appliances, and emergency alert systems to alert caregivers and emergency services (50,51).

1.2.2 Wearable Trackers

Wearable trackers have emerged as indispensable tools in promoting health and wellness, particularly among older adults, who benefit greatly from self-monitoring and engaging in physical activity interventions (52). These devices, ranging from smartwatches to fitness bands, offer multifaceted functionalities that extend beyond mere activity tracking. In recent years, wearable trackers have become integral components of behaviour change interventions, incorporating a variety of techniques aiming at fostering sustained lifestyle modifications. Through features such as real-time feedback, goal setting, and personalised activity recommendations, these trackers empower users to take ownership of their health journey and make informed decisions about their physical activity levels (52). Additionally, many wearable trackers incorporate motivational strategies, such as rewards, social support, and gamification elements, to enhance user engagement and adherence to recommended behaviours (53).

1.2.3 Exergames

Exergames, or exercise games, represent an innovative approach to promoting physical activity and improving health outcomes among individuals of all ages, including older adults. By combining elements of gaming with physical exercise, exergames offer an engaging and enjoyable way to stay active and maintain

fitness levels (54,55). These games typically utilise motion-sensing technology to track body movements and translate them into gameplay (56,57). For older adults, exergames provide an accessible and low-impact alternative to traditional forms of exercise, allowing them to engage in personalised activities like virtual dancing, yoga, or balance exercises from the comfort of their own homes (56,57). Beyond promoting physical health, exergames also offer cognitive and social benefits, stimulating mental acuity and providing opportunities for social interaction and engagement (58). As such, exergames represent a valuable tool in promoting active ageing and improving overall well-being among older adults.

1.2.4 Mobile Health (mHealth)

mHealth is a rapidly expanding field that leverages the ubiquity of smartphones and other mobile devices to revolutionise healthcare delivery and management. Through a diverse array of applications and services, mHealth empowers individuals to take control of their health and well-being anytime and anywhere. From medication reminders and symptom tracking to providing health information and supervision, mHealth offers a comprehensive suite of tools to support prevention, diagnosis, treatment, and ongoing management of health conditions (59). With the growing availability of user-friendly apps, wearable devices, and remote monitoring technologies, mHealth is transforming healthcare delivery by promoting convenience, efficiency, and personalised care (60). As the mHealth ecosystem continues to evolve, it has the potential to

revolutionise healthcare delivery, empower individuals to make informed health decisions, and ultimately improve health outcomes for people of all ages.

1.3 Telehealth

Telehealth is rapidly being embraced and seen as a convenient, safe, and cost-effective means to obtain medical information, provide medical services, and improve access to patient-centred care (61). Telehealth encompasses various modalities, such as teleconsultation, telemonitoring, and teleeducation. Teleconsultation allows patients to communicate directly with their healthcare providers synchronously or asynchronously through information and communication technologies (62), telemonitoring involves the tracking of patients' health data and transmission of such data to healthcare providers (63), and teleeducation enables the audience to receive health education from the comfort of their own homes through online platforms like Zoom (64).

Though telehealth is not a new concept (65,66), it came into the limelight in ageing care amid the COVID-19 pandemic (67). Although the older population has a higher demand for healthcare services (2,46), healthcare systems across many countries became even more strained during the pandemic and fewer resources were dedicated to ageing care (68–70). In response, there has been a substantial increase in telehealth usage in different countries. For instance, telehealth visits skyrocketed from 13,000 pre-COVID to 1.7 million in April 2020 in the US, and the total number of telehealth sessions increased nationally from October 2019 to October 2020 across almost all medical specialities including a broad range of services (71). In China, a survey of 148 doctors from 57 hospitals

in 16 provinces showed that 94.6% of the respondents adopted telemedicine during the pandemic, with 34.1% having no prior experience (72).

1.4 Ageing and Telehealth in Singapore

1.4.1 Ageing in Singapore

Prime Minister Lee Hsien Loong highlighted that the Singapore population “is not just ageing, but ageing rapidly” (73). A decade ago, in 2012, the proportion of Singapore citizens aged 65 and above stood at 11.1%. However, this percentage has risen to 18.4% in 2022 and is projected to further reach 23.8% by 2030 (74). At the same time, the median age of Singapore citizens has also seen an upward trend, increasing from 39.6 years in 2012 to 42.8 years in 2022 (74). Moreover, there has been a noticeable rise in the proportion of citizens aged 80 and above, growing from 75 thousand (2.3%) in 2012 to 1.32 million (3.7%) in 2022 (74). Consequently, ageing has brought about profound impacts on society, affecting areas ranging from the economy to the living environment, to the healthcare system (73).

The Singapore healthcare system faces multiple challenges, one of which is the scarcity of healthcare workers. In 2019, the number of doctors and nurses per 1,000 population was 2.5 and 7.5 respectively (75) and only 119 geriatric medicine specialists were available to serve approximately 600,000 older residents (76). A survey among 16 countries by Philips, a Dutch multinational technology company, found that Singapore had a low density of hospital beds and a shortage of skilled healthcare professionals (77).

Besides, other challenges were also identified in the Singapore healthcare system, for instance, ineligibility and unawareness of existing financial assistance and long waiting times (78). The combination of these problems, along with low health literacy and personal cultural values, has influenced older residents' HSB. For instance, a survey conducted in 2016 showed that over 30% of diabetes patients did not strictly follow their doctor's instructions on physical exercise, glucose monitoring, and food intake (79). In 2018, a systematic review revealed that people living in local public rental housing had poorer health status and outcomes, were less likely to participate in health screenings, preferred alternative medicine practitioners for primary care over Western doctors, and had higher hospital utilisation (80). Moreover, a qualitative study released in 2020 found that older people living alone often developed self-care mechanisms instead of seeking formal medical attention (78). These challenges highlight the need for innovative solutions to improve access to quality health services in Singapore.

1.4.2 Technology-assisted Ageing in Singapore

Singapore is a nation “where we can create possibilities for ourselves beyond what we imagined possible.”

– Prime Minister Lee Hsien Loong

In response to the increasingly heavy care burden for the older population, the Singapore government has introduced the *Smart National* health initiatives to

consistently discover innovative healthcare solutions to meet the evolving needs of its population, especially the older generation (81,82).

Several Smart Nation health initiatives have been launched, for instance, assistive technologies and robotics to improve the mobility and independence of older people and individuals with disabilities and to enhance their quality of life (83); HealthHub – the one-stop health portal to provide easy access to medical records, appointments, prescriptions, payments, and health information (84); and the National Steps Challenge™ with Healthy 365 App – the world’s first “fitness tracker-based physical activity initiative” at the national level to encourage a healthier and more active lifestyle (85).

Besides, telehealth was also introduced as an integrated and seamless means to bring more convenience to users and improve the efficiency of healthcare delivery (86). Instead of going down physically to the healthcare institutions, users could receive automated notifications of appointments via Short Message Services or mobile applications, as well as straightforward video consultations from their mobile devices in the comfort of their homes (82).

1.4.3 Telehealth in Singapore

In Singapore, smart health video consultation was first introduced in April 2017 to allow patients to remotely communicate with their care providers using video conferencing. This service has been implemented to address various medical needs such as follow-up care for paediatric eczema pharmacy consultation,

homecare services for children, lactation consultation, speech therapy, as well as post-stroke, infectious disease and cancer care (86).

As one of the earliest countries to be impacted by the COVID-19 pandemic (87) and having one of the fastest-growing ageing populations (88), Singapore has been proactively advancing telehealth services as part of its Smart Health Initiative (81). To address the challenges posed by the pandemic, the previously established nationwide telemedicine platform for migrant workers, the Telemedicine Allocation and Reconciliation System, was adapted and improved to support the Home Recovery Programme during the Delta and Omicron waves (89). During a 14-week period in 2022, the total number of telemedicine consultations hit 179,230 with more than 30% made by older adults (89).

Another example is the Primary Tech-Enhanced Care Home Blood Pressure (BP) Monitoring Programme launched collaboratively by the Ministry of Health Office for Healthcare Transformation and the three Polyclinic Clusters—National Healthcare Group Polyclinics, National University Polyclinics and SingHealth Polyclinics, with the support of the Integrated Health Information Systems (90–92). In this programme, participating patients would receive reminders and enjoy the convenience of measuring their BP at home using simple devices with readings automatically transmitted to their respective polyclinic care teams. This enables healthcare professionals to closely monitor their patients' BP, offer immediate and interactive support, and take action when necessary (e.g., make adjustments to medications) (90–92).

Besides clinical services, health promotion and social service programmes have also been adapted to an online format during the COVID-19 pandemic, allowing older participants to follow along at home. The Active Ageing Programmes initiated by the Health Promotion Board (HPB), for example, have engaged 32,000 older participants in virtual health workshops and exercise classes (93). 365 Cancer Prevention Society set up its Virtual Social Service Centre (VSSC) as an extension of the onsite programmes to address the needs of cancer patients, their family caregivers, as well as the general public (94). VSSC offers various curated activities to assist members and the general public in achieving better physiological well-being (e.g., lymphatic detox exercises, relaxation exercises, and Zumba to enhance physical health), psychological well-being (e.g., arts & crafts, Chinese calligraphy, cooking, flower arrangement classes, and virtual tours of renowned places of interests in Singapore), and social well-being (e.g., virtual support groups to foster social connections) throughout the journey of cancer prevention and fighting (94).

Despite these efforts, earlier local studies have demonstrated that older adults may not be able to access and utilise health technologies as easily and comfortably as the younger generation (95,96). When examining the acceptance of telehealth services among older adults, mixed yet limited published results were reported. For example, data from Alexandra Hospital revealed that more elderly patients at the geriatric centre were receptive to teleconsultations compared to younger patients at the general medicine department during the pandemic (97), while a survey conducted by the

Singapore Eye Research Institute found that 55% of the respondents expressed reluctance continue using digital medical services and 77.8% felt uneasy with artificial intelligence (AI) interpreting their medical results (98,99).

1.5 Rationale for Selecting Telehealth

The choice of telehealth as the research topic for this thesis was influenced by several key factors. Firstly, the COVID-19 pandemic underscored the critical importance of remote health services, leading to a surge in interest in and adoption of telehealth solutions worldwide. This heightened visibility of telehealth highlighted its potential to transform health delivery and address the evolving needs of the older population, particularly in times of pandemic. Secondly, telehealth represents an umbrella term (will introduce in Chapter 2.3.1) possibly encompassing a wide range of digital health technologies, including virtual consultations, remote monitoring devices, and mobile health applications. This breadth of scope provided ample opportunities for exploration and analysis. Lastly, telehealth offers the unique advantage of facilitating real-time intervention with a human facilitator, bridging the gap between technology and personalised care delivery.

1.6 Summary of the Gaps in Telehealth Research and Implementation

Despite the surge of interest in telehealth implementation and research, several gaps remain:

Gap 1: Earlier primary studies were predominantly conducted in Western countries and may leave limited insights into Asian countries. Therefore, research is needed to specifically address the unique factors and feasibility of telehealth adoption in Asian settings (Chapter 2.4.1).

Gap 2: Prior research was mainly conducted in clinical settings and centred on the applications of telehealth in disease diagnosis, treatment, and rehabilitation, overlooking the potential for health promotion and disease prevention (Chapter 2.4.2).

Gap 3: Current telehealth research lacks adequate exploration of the perspectives of non-users, including individuals without access to or awareness of telehealth, as well as those who choose not to utilise telehealth services (Chapter 2.4.6.3).

Gap 4: Although telehealth holds the potential to improve vulnerable groups' access to health services, it also presents a specific risk in generating health inequalities, particularly in access, uptake, adherence, and effectiveness. Therefore, it is imperative to devise implementation strategies to mitigate these inequalities (Chapter 2.4.7.3).

1.7 Aim and Research Questions

The aim of this thesis is to bridge the aforementioned gaps in telehealth implementation and research while contributing literature specific to the Asian context. The overarching research question is “What is the feasibility of

implementing telehealth to address older individuals' health needs?". The five specific objectives are to:

- O1: Identify potential domains in which telehealth could help address the unmet health needs of the older population;
- O2: Explore the determinants affecting telehealth adoption and implementation from the perspectives of older adults, healthcare professionals, social health service providers, and telehealth providers, including both users and non-users;
- O3: Draft implementation strategies for creating inclusive, equitable, scalable, and sustainable telehealth services in ageing care;
- O4: Co-design telehealth solutions in collaboration with and for older adults within the Singapore community;
- O5: Conduct pilot testing on telehealth prototypes to assess their feasibility.

1.8 Outline of This Thesis

This thesis comprises several interwoven studies (Figure 1.1) with multiple methods in the following chapters:

Chapter 2—the literature review chapter—provides a comprehensive review of the rising of telehealth to address the ageing challenges; classifications of telehealth and definitions of relevant terminologies; as well as global and local evidence on the effectiveness, feasibility, cost benefits, acceptability of telehealth, as well as factors affecting telehealth adoption. This chapter also provides an elaboration on the gaps in telehealth implementation and research.

Chapter 3 introduces the theoretical basis to guide the planning of the empirical studies; explains the rationale for selecting the participant inclusion criteria for the empirical studies; and presents how the four empirical studies were interrelated.

Chapter 4 uses in-depth interviews (IDIs) to uncover the health needs of community-dwelling older adults by understanding their HSB. The associated technology use in this process was also assessed to understand how they make decisions in using technologies, suggesting ways in which technologies can be leveraged to address these needs; and ultimately, identify potential areas in which telehealth could be implemented in Singapore's ageing context.

Chapter 5 collects the perceptions of telehealth among older adults, health professionals, managers of community organisations, and telehealth providers. Their opinions were analysed to understand the factors affecting telehealth adoption and implementation in Singapore's ageing care. Their suggested implementation strategies will be also summarised to guide the design and implementation of future telehealth interventions.

Having understood the gaps in older adults' HSB and their perceptions about telehealth, **Chapter 6** outlines the development process of a community-based telemonitoring service inside phygital booths in the Singapore community. Preliminary results of the feasibility are also presented.

Chapter 7 aims to co-design a tele-education programme with older adults to uncover their health information needs and preferences for tele-education.

Findings have the potential to guide the design and implementation of future health education programmes for the older population.

Chapter 8 summarises the key findings, contributions, and limitations of this PhD project. Implications for research and practices as well as my personal reflexivity of the PhD project are also discussed.

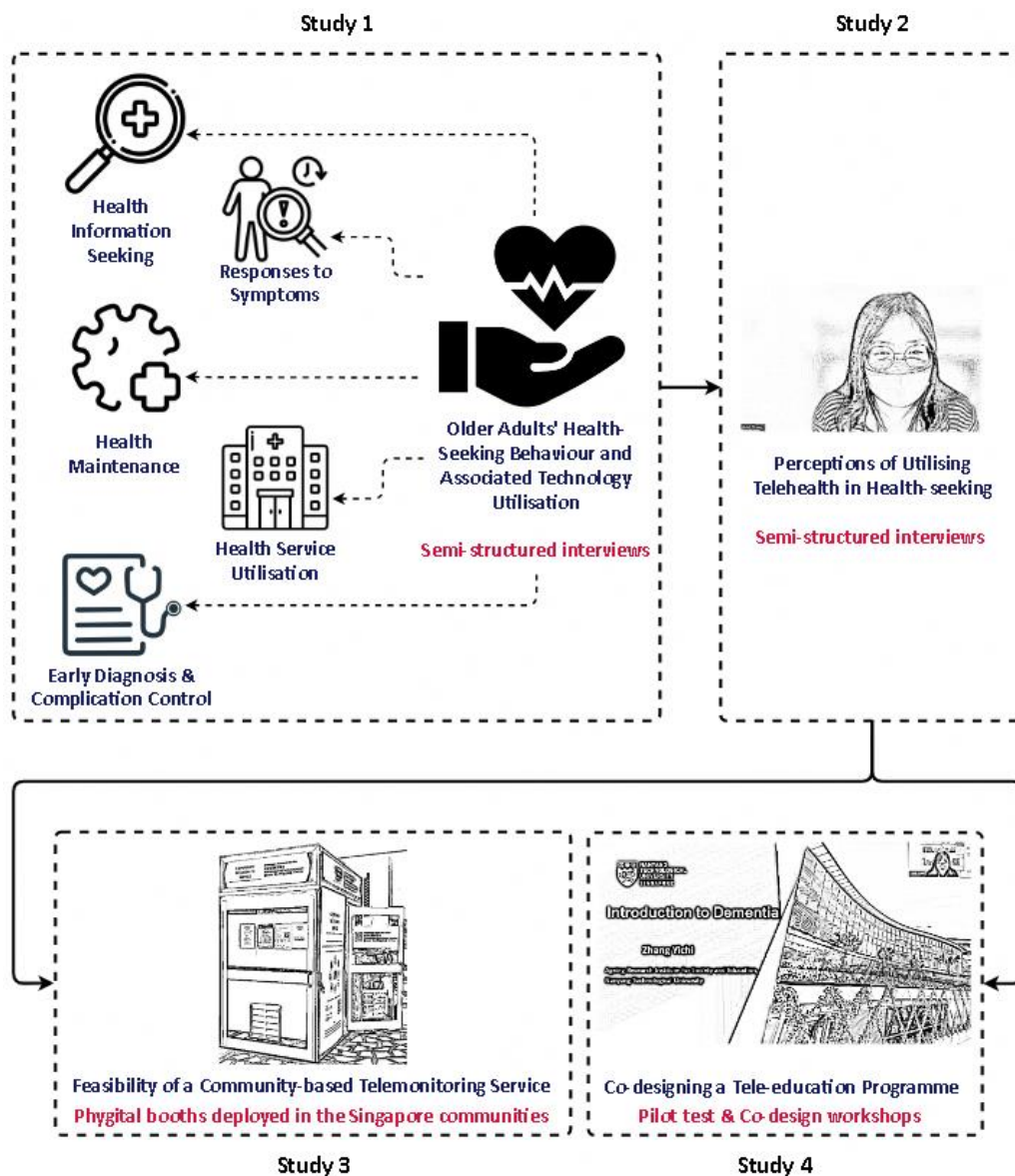


Figure 1.1 Overview of the PhD project

CHAPTER 2 LITERATURE REVIEW

Partial results of this chapter were extracted from

Zhang, Y., Leuk, J. S., & Teo, W. P. (2023). Domains, Feasibility, Effectiveness, Cost, and Acceptability of Telehealth in Ageing Care: Scoping Review of Systematic Reviews. *JMIR ageing*, 6, e40460. <https://doi.org/10.2196/40460>

2.1 Positionality Statement

Human perceptions are inherently subjective and are influenced by various factors. There has been a growing recognition that a researcher's positionality, such as their social and personal identities, experiences, beliefs, and values, can significantly influence the research paradigms (100,101). Positionality shapes not only how researchers approach and interpret their studies but also how they understand and engage with their subject matters (102,103). Therefore, recognising and articulating one's positionality is essential for ensuring transparency and reflexivity in research, by providing insight into the potential biases and perspectives that may impact the research process (103). This section will introduce my background, academic and life experiences, as well as beliefs, to offer a comprehensive overview of the lens through which I viewed and approached this research.

I was born in China, a country known for its rich cultural heritage and its rapid development in recent decades. Growing up in this dynamic environment, I witnessed firsthand the transformation of a nation that balances its deep-

rooted traditions with modern advancements. In December 2007, I moved to Singapore, a multi-ethnic country, for undergraduate study after receiving the Senior Middle 2 scholarship, which marked a significant turning point in my life.

My educational journey in Singapore was rooted in theoretical mathematics, a discipline that not only sharpened my analytical thinking and problem-solving abilities but also developed my curiosity for abstract and complex concepts. The rigorous training received in my undergraduate studies equipped me with a strong foundation in logical reasoning and critical analysis.

Upon completing my undergraduate degree, I embarked on a career in academia as a full-time teaching staff at the School of Physical and Mathematical Sciences at Nanyang Technological University. In this role, I had the chance to teach and mentor young undergraduate students, helping them navigate the challenging yet beautiful world of mathematics with my learning experiences. This teaching experience solidified my passion for education, deepened my appreciation for the transformative power of knowledge, honed my communication skills across diverse student archetypes, and enhanced my understanding of adult learning theories and abilities in curriculum design.

My personal experiences have also significantly impacted my academic journey and research interests. In 1997, my mom underwent heart surgery, and upon her recovery, she began to avoid hospitals for regular follow-ups due to the long waiting times and the lack of time doctors offered to engage her in thorough consultations. Consequently, she started self-adjusting her medications based on her perceived health status and the experiences of friends and other family

members, rather than seeking professional medical advice. Her passing in 2014 was a pivotal moment that made me realise the significant challenges and gaps in the HSBs of older adults. This experience, combined with my volunteer work at the 365 Cancer Prevention Society—a charitable social service agency where I interacted with cancer survivors and their caregivers, many of whom were older individuals—allowed me to witness the challenges they faced in accessing and utilising appropriate health and social services. These interactions deeply influenced my understanding of the critical role that social support and preventive care play in the well-being of older adults. They also motivated me to change my career path and pursue further study and research in population health.

My research journey into population health began with a project under the World Health Organisation (WHO), aiming at understanding the impacts of underground working environments on people's health. In this project, I was involved in study preparation and gained valuable experience in participant recruitment, data collection, quantitative data analysis, and manuscript writing—skills that were entirely new to me at that time. Subsequently, I had the chance to join another project aimed at developing a mobile health app for individuals with type 2 diabetes. During the four-month clinical observation at Tan Tock Seng Hospital's B2B clinic, I had the opportunity to closely observe and communicate with patients, and this experience provided me with firsthand insights into their struggles and needs. Based on our findings, we drafted an executive summary outlining the patient journey and highlighting various pain

points, using Maslow's hierarchy of needs to map how the app could address various levels of their needs. This experience also deepened my understanding of Singapore's healthcare system and re-emphasised the critical need for improving the population's access to health information and services, particularly in light of the limited and inequitable clinical resources.

Over the course of these two years, I took the initiative to self-study R programming and machine learning, writing different types of reviews, designing quantitative and qualitative studies, and analysing data, and I also had several opportunities to participate in grant applications. These experiences laid the foundation for my ongoing commitment to population health, particularly in the realm of digital health innovation and implementation.

The onset of the COVID-19 pandemic further stimulated my interest in digital health and telehealth. The pandemic further highlighted the limitations of traditional clinical care, especially in the continuous monitoring and support for community-dwelling older adults. This drove me to explore how telehealth could bridge these gaps and provide more comprehensive care to the vulnerable populations.

My beliefs are grounded in the conviction that maintaining well-being through daily routines is as crucial as disease treatment. While acknowledging that clinical interventions are undoubtedly important, I recognised the inherent challenges in providing continuous clinical care and the unmet needs among older adults. I believe that proactive preventive measures and social care can play a role in reducing the burden of diseases and improving overall health

outcomes, particularly in the ageing population. These beliefs fuelled my interest in ground-up community-based care models, which I see as essential for addressing the shortcomings of healthcare systems. These convictions have informed my research objectives, methodologies, and interpretations, ensuring that my project is not only academically rigorous but also deeply grounded in real-world relevance and a steadfast commitment to improving health outcomes for older adults.

2.2 History of Telehealth

Telehealth is one of the many new possibilities that made health services more accessible to the older population and has been widely believed to bring various benefits. For example, it expands health services by removing geographical and time boundaries (104), enables socially isolated and physically homebound individuals to access a wider range of health services (105), minimises the risk of direct transmission of infectious agents from person to person during the recent COVID-19 pandemic (106). It also redefines health services by engaging the users' familiar settings so that both the clients and the health service providers can put greater emphasis on the intervention itself, which in turn results in improved efficiency and quality of care (107). Furthermore, as hospitals and medical providers are under increasing pressure to provide quality care at lower costs, telehealth has been well received and successful across a variety of medical specialities and settings in ageing care (107), such as dentistry (108), psychiatry (109), dermatology (110), and COVID-19 consultation (111).

Although the widespread use of telehealth during the COVID-19 pandemic may have seemed sudden, its roots can be traced back to around a century ago. One of the earliest recorded examples of telehealth involved the use of radio communication in Australia in 1928. The Aerial Medical Service (AMS) founded by Reverend John Flynn, combined aviation, radio, and medicine to bring healthcare services to people in remote areas of Australia (112). Through a combination of telegraph and radio communication, doctors could diagnose and consult with patients. The AMS was recognised as a pioneer in using telecommunications technology to address limited geographical access to healthcare and remains a notable early example of telehealth (113).

In the mid-1950s, the Nebraska Psychiatric Institute began using closed-circuit television components to monitor patients remotely (114). By 1964, this institute and the Norfolk State Hospital, located 112 miles apart, established their first interactive, two-way video link (114,115). Three years later, the first comprehensive telemedicine system was deployed between Boston's Logan Airport medical station and Massachusetts General Hospital, marking a significant milestone in the evolution of telehealth (115).

The advent of the Internet has provided scientists and medical experts with an array of opportunities to deliver remote health services. By facilitating the seamless transmission of large volumes of data over long distances, digitising information, and offering substantial cost savings, the Internet has transformed the healthcare landscape and paved the way for a new era of telehealth (113).

The global impact of the COVID-19 pandemic has further triggered a notable surge in the utilisation of telehealth services (67). As the virus rapidly spread across the world, the implementation of lockdowns and temporary closures of non-essential health services posed substantial obstacles to accessing healthcare (116). Confronted with unprecedented challenges in ensuring both medical access and infection control, the traditional healthcare system faced a pressing need for innovative solutions (117,118). Consequently, healthcare professionals, researchers, and policymakers redirected their focus toward exploring the immense potential of telehealth as a new norm (117).

The onset of the COVID-19 pandemic not only resulted in a surge in telehealth usage but also sparked a considerable rise in telehealth research interest in ageing care. Figure 2.1 illustrates the trend of telehealth-related systematic reviews in ageing care, as evidenced by the literature search in the earlier scoping review (119) conducted across five major electronic databases: PubMed, Embase (Ovid), Cochrane Library, PsycINFO (EBSCO), and Cumulative Index to Nursing & Allied Health Literature (CINAHL), as well as Google search.

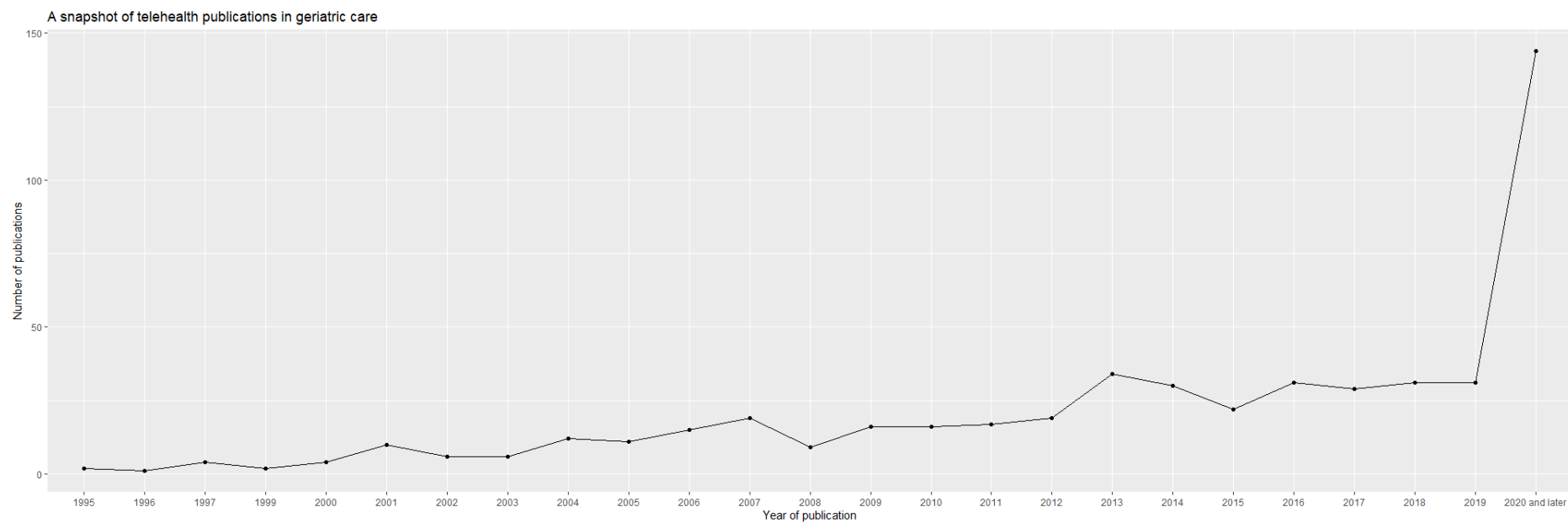


Figure 2.1 Number of systematic reviews on telehealth in ageing care, search done on 16th September 2021

2.3 Definitions and Classifications of Telehealth

As the primary focus of this thesis is on older adults, telehealth services emphasising provider-to-provider communications, as well as medical professional training and education (e.g., medical student education, nursing student education, and training for health professionals) fall outside the scope of this thesis.

2.3.1 Definitions of Terminologies

Telehealth and several other terminologies such as “telemedicine”, and “telecare”, were often used interchangeably in literature and by healthcare professionals as well as organisations (120,121). To avoid the ambiguity and confusion caused by this overlapping use of the terms, more recent studies have started to use telehealth as an umbrella term to broadly encompass all health services delivered via information communication technologies (122–124).

In this thesis, **telehealth** is defined as “the delivery and facilitation of health and health-related services including medical care, provider and patient education, health information services, and self-care via telecommunications and digital communication technologies” (125); **telemedicine** is “the remote diagnosis and treatment of patients by means of telecommunications technology” which is specifically the remote practice of medicine (125–127); while **telecare** refers to “the use of information, communication, and monitoring technologies which allow healthcare providers to remotely evaluate health status, give educational intervention, or deliver health and social care to patients in their homes” (128).

2.3.2 Classifications by Purposes

Telehealth could serve different purposes, for example, consultations with healthcare professionals, delivering health education, and monitoring health status. In this thesis, **teleconsultation** is defined as “synchronous or asynchronous consultation using ICTs to omit geographical and functional distance” (62); **tele-education** is “the application of ICTs in the delivery of distance learning” (129); while **telemonitoring** is defined as “the collection, transmission, evaluation and communication of individual physiological data at distance, with the aid of health technologies including wireless devices, wearable sensors, implanted health monitors, smartphones, tablets and mobile apps” (130).

2.3.3 Classifications by the Timing of Communication

Telehealth services can be also classified into three broad categories based on the timing of communication, namely synchronous (real-time), asynchronous (store-and-forward), and remote patient monitoring (127,131).

Synchronous telehealth, similar to in-person consultation, is delivered in real-time where both the clients and providers are present and engaged simultaneously, allowing for their live communication and interaction (127). Some common synchronous telehealth services include videoconferencing or teleconsultation, telephone calls, and live chats (125).

While synchronous telehealth offers the benefit of instant communication, it requires that both end users are simultaneously available and connected. On

the other hand, **asynchronous telehealth** involves gathering health data or information and transmitting it to a doctor or medical specialist at a later time, eliminating the need for both end users to be present simultaneously (132). This approach is frequently utilised in fields like dermatology, radiology, and pathology.

Remote patient monitoring enables medical professionals to continuously measure and evaluate patients' physiological parameters from a distance, by utilising electronic devices such as wearable technologies, mobile devices, and mobile health applications (125). This approach is commonly employed in managing NCDs or specific conditions, such as heart diseases, asthma, and diabetes mellitus. The technologies adopted have the potential to yield comparable health outcomes to traditional physical visits, while also providing higher patient satisfaction and better cost-effectiveness (133).

2.3.4 Classifications by Settings

Telehealth has been applied in different settings, clinical or non-clinical (134). In clinical settings, telehealth applications encompass a wide range of services, for example, evaluations, primary care supervision, second opinion consultations, and monitoring; while in non-clinical settings, telehealth can be utilised at home, residential care facilities, or in the community to facilitate various health-related activities, such as long-term care, education, administration, and research (134).

2.4 Evidence of Telehealth in Ageing Care

2.4.1 Locations of Telehealth Research

The earlier scoping review studied 29 systematic reviews on telehealth in ageing care and highlighted a significant geographical gap in telehealth research: the majority of primary studies were conducted in North America (the United States and Canada), Europe (the United Kingdom, France, Italy, Sweden, the Netherlands, etc), and Australia(119).

Gap 1

This may leave limited insights into the global context, particularly in Asian countries that need better support for their growing elderly population (8).

2.4.2 Domains and Settings of Telehealth Implementation

The most prevalent modalities of telehealth interventions focused on remote consultation via mobile phones or video calls (135–144), remote monitoring or telemonitoring with synchronous or asynchronous data transmission (136,141,145–147), home-based telecare services (148–151), and nurse-led telecare services (149,152). Tam et al. examined text messaging in hypertension management (153); Markert et al. investigated remote monitoring combined with health coaching (147).

Gap 2

A large proportion of the primary studies focused on curative and rehabilitative care domains (e.g., chronic disease management and symptom management

(154)) in clinical settings, and there has been a lack of published evidence on promotive and preventive care as well as those in non-clinical settings (119). Evidence has indicated that a healthy lifestyle, such as quitting smoking, limiting alcohol consumption, and increasing physical exercise, can help delay the development of many diseases, prevent the loss of functional capacity, improve the quality of life, and extend healthy life expectancy (155). Therefore, future telehealth interventions could also prioritise efforts toward health promotion and disease prevention.

2.4.3 Effectiveness

Often in telehealth, the prevailing care model remains intact, and instead, telehealth becomes an additional option for individuals who face barriers to accessing traditional healthcare services (156). Therefore, as Russel et al. emphasised, it is crucial to ensure that the quality of the care provided by telehealth is at least comparable to traditional care (156).

2.4.3.1 Individual Outcomes

Clinical benefits

A **clinical benefit** is defined as “a favourable effect on a meaningful aspect of how a patient feels (e.g., symptom relief), functions (e.g., improved mobility) or survives as a result of treatment” (157). Several systematic reviews suggested promising impacts of telehealth interventions on both older participants’ self-reported and clinically assessed health outcomes (137,139–141,143,145,148,149,152,153,158–162), hospitalisation rate (135,144),

mortality rate (135,137), and quality of life (137,143,160,161). A post-hoc analysis of a previously published systematic review with meta-analysis by Inglis et al. showed that remotely monitoring older patients with heart failure using structured telephone support or telemonitoring could reduce mortality rates and all-cause hospitalisation (163). Likewise, Tam et al. performed a meta-analysis to assess the effectiveness of text messaging interventions in hypertension management and concluded that text messaging could substantially reduce systolic BP in older adults (153). However, there is a lack of rigorous evidence to further support the clinical benefits of these telehealth interventions.

Health literacy

Health literacy is “the achievement of a level of knowledge, personal skills and confidence to take action to improve personal and community health by changing personal lifestyles and living conditions” (164). Santana et al. reported a better understanding of the basic pathology and comorbidities among older adults with Alzheimer's disease and an improvement in older adults' behaviour management skills via the use of telecare (149). Similarly, according to Costanzo et al., all the included studies concluded that participants with cognitive deficits were able to relearn everyday skills by using different technological tools, particularly when learning methods with error reduction were used (140).

Behavioural outcomes

The positive impacts of telehealth interventions on older participants' behaviours were also reported in the literature. Van den Berg et al. found that

regular personal monitoring and individual support by a healthcare provider or in the form of telemedical measurements seemed to have a positive influence on users' adherence to behavioural changes (e.g., adherence to medication, diet, physical activity, daily life activities, self-efficacy, and disease management compared with the other outcome categories) (145). Tam et al. demonstrated a moderate effect on improving medication adherence by integrating telemedicine interventions (153). Additionally, Rush et al. presented that the use of telehealth as a possible solution to modify older adults' unhealthy behaviours (e.g., smoking) was higher in rural and remote areas than in urban areas (162).

2.4.3.2 System Outcomes

Efficacy of Telehealth

Inconsistent conclusions regarding the efficacy of telehealth interventions were found in the literature. Jones and Brennan, Barlow et al., Gentry et al., and Markert et al. found some evidence of the efficacy of telehealth interventions, although more rigorous evidence is needed (143,147,148,152). In contrast, Marx et al. and Costanzo et al. did not find a difference between telemedicine and in-person diagnosis and home visits (137,140), and Sekhon et al. found inconsistent results on the reliability of telemedicine which was caused by the testing conditions and the accessibility of telemedicine (165). In addition, Markert et al. reported that the presence of humans in the interventions might influence telehealth's efficacy (147). Jones and Brennan revealed that the use

of telehealth for clinical assessment has shown great promise in the nursing process; however, it was not ready for wide-scale clinical deployment (152).

Impact of Telehealth on the Healthcare System Infrastructure

Telehealth interventions could be delivered by different technologies or platforms, and they were shown to be promising in reducing healthcare system usage. For example, Barlow et al. showed that telephone follow-up after hospital discharge was associated with reduced health service use (e.g., lower hospital admissions and costs) (148), Franek reported that home telemonitoring could reduce the use of other healthcare services with a need for further confirmation with more randomised controlled trials (RCTs) of high quality (136), and Murphy et al. demonstrated that a telemedicine-based geriatric clinic model of care had the potential to reduce acute hospitalisation and shorten the waiting times (144). In addition, the potential benefits of telehealth services in improving older adults' access to health care (139,166,167) and extending existing health services from healthcare facilities to home and community (161) were also reported.

2.4.4 Feasibility

In the literature, the feasibility of telehealth was studied using different indicators, such as usage (168), user adherence (169), dropout rates (170), technical errors encountered (170), duration of the service (170), delivery modes (171), social accountability (171), and perceived feasibility (172).

In the review by Sekhon et al., mixed results were reported on the actual rate of adherence to telehealth and the implementation of telemedicine specialists' recommendations (165). In addition, Rush et al. also indicated that half of the studies reported low adherence and modest attrition rates because of technology failure and not achieving behavioural goals, and the adherence rates were found to vary according to the nature of telehealth interventions (162). Santana et al. reported an improvement in adherence to treatment, an increase in the number of older adults accompanied by health providers, and an improvement in the quality of care (149). The meta-analysis by Marx et al. found that more than half of the studies (7/9, 78%) found a much lower attrition rate among those who used telephone consultations (0%-31%) than those who used telemonitoring devices (50%-61%) (137).

2.4.5 Cost Benefits

The shortened interaction duration, reduced unnecessary travel, and the transition of certain aspects of healthcare from clinicians to technology or directly to patients themselves brings telehealth the potential to decrease healthcare costs and increase attention (173). This raises the question of the actual cost benefits of telehealth interventions.

Marx et al. concluded that telehealth interventions were cost-effective compared with no intervention, but the cost-efficacy compared with home visits was not yet established (137). Peretz et al. found no reliable cost estimates for remote patient monitoring programme implementation, but it appeared that the cost of remote patient monitoring programmes was dependent on the

number of vital signs monitored, the complexity of the health condition monitored, and the geographic locations of the programmes (150). Among all studies included in the review by Gentry et al., only one found no healthcare cost difference between virtual consultation and in-person treatment, whereas the other studies on memory disorder clinics via telemedicine only supported cost benefits to patients and caregivers but found no evidence of cost-effectiveness for healthcare organisations (143). In dentistry, Aquilanti et al. found that telehealth interventions tended to be less costly than face-to-face oral examinations (159). In the review by Murphy et al., virtual geriatric clinics were likely to be more cost-effective, but substantial discrepancies were noted in the two studies because they used different costing models (144). The review by Rush et al. for the healthcare system and rural older adults; however, many of the cost savings resulted from the savings on travel expenses (162).

2.4.6 Acceptability

2.4.6.1 Satisfaction, Acceptability, Attitude, Experience, and Usability

Despite the surge in worldwide telehealth adoption, there is a growing concern regarding whether this rapid digitisation of health services has worked out for the older population or left them behind due to limited prior knowledge (174). User acceptance is an essential element to examine if a solution works for the users and satisfies the users' needs (175,176).

Narasimha et al. reported that 65% of the geriatric population has shown a strong will to keep abreast of current advances, despite the stereotype that

older people may be more averse to using technology for health care (142). Positive attitude toward telehealth was also reported in other reviews (138,139,143,144,149,152,159,165,166). If the attrition rate could be used as a proxy for older users' acceptance, Marx et al. found that among the geriatric population, acceptability was good for telehealth consultation but less desirable for asynchronous approaches that relied on computerised devices (137). Moreover, Costanzo et al. discovered that younger caregivers seemed more comfortable and capable of using the Internet and were more motivated to use the service (140).

2.4.6.2 Factors Affecting Older Adults' Telehealth Utilisation

In the 1970s, Urie Bronfenbrenner developed the Social Ecological Model (SEM) as a conceptual model to understand human development. It consists of nested circles centred at individuals and contains microsystem, mesosystem, exosystem, macrosystem, and chronosystem levels (177). Operationalising this model, factors affecting older adults' telehealth use could be classified into individual, interpersonal, technological, system, and policy levels (119) (illustrated in Figure 2.2).

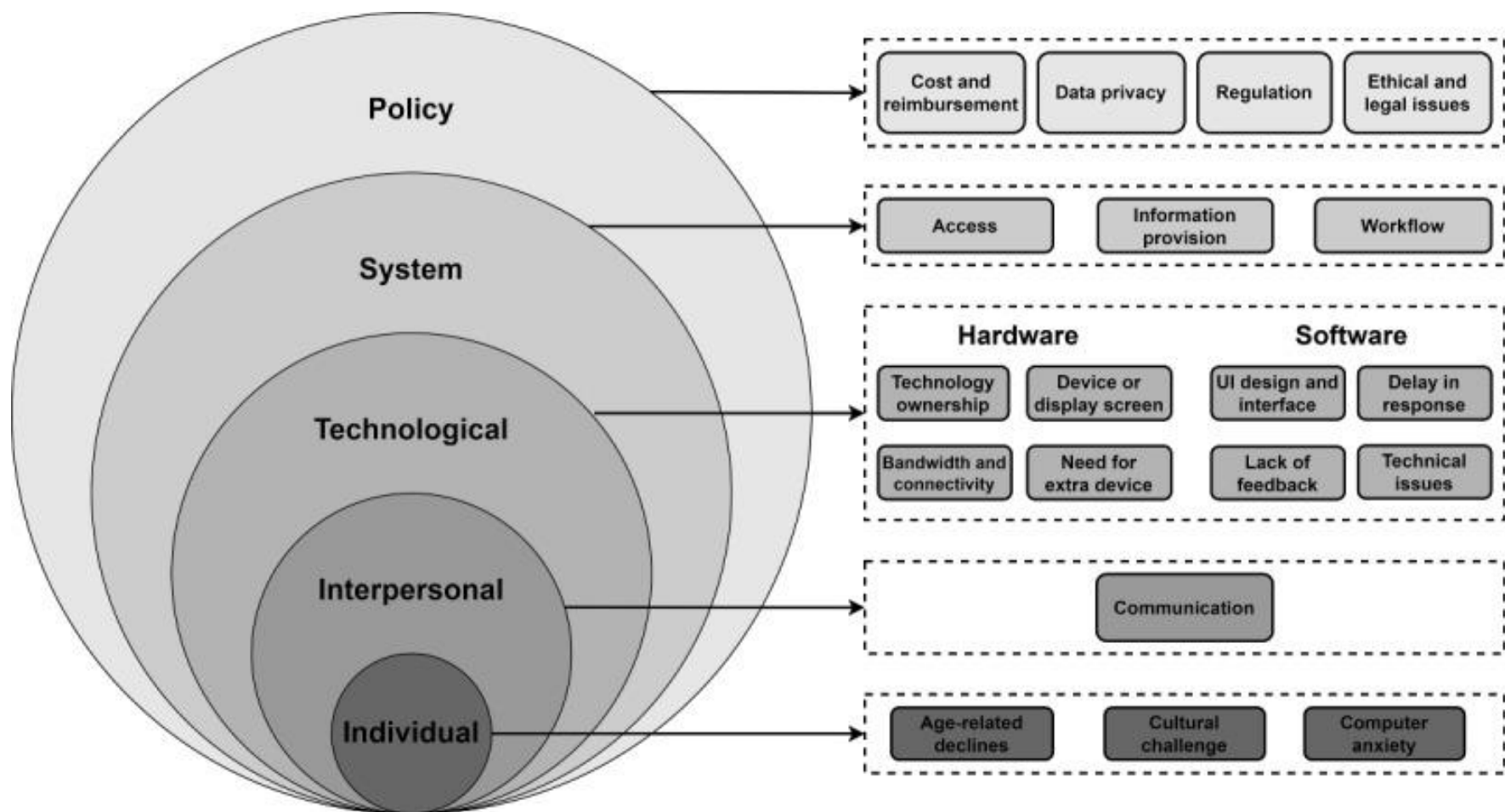


Figure 2.2 Illustration of the factors affecting older individuals' telehealth utilisation, operationalised from the Social Ecological Model (SEM) (119)

Individual Level

At the individual level, ageing-related declines in vision, perception, hearing, motor, and cognitive functions adversely affected older adults' ability to carry out tasks, thus increasing the challenge of telehealth use and the inaccuracy of assessment (138,139,142,143,160). For older adults who are unfamiliar with technologies, telehealth may also bring technical difficulties and cultural challenges (146,166), and some even drop out of the studies (145). Such factors may lead to resistance to technology use (139).

Interpersonal Level

At the interpersonal level, some healthcare providers reported difficulty in communicating and conducting proper physical examinations via telehealth owing to older patients' possible age-related declines and technological incapability (138,139,166); therefore, they were reluctant to recommend technologies. Moreover, it was recommended that more communication between patients and staff as well as between peers could create a feeling of more involved care (178).

Technological Level

At the technological level, both hardware and software factors have been reported to affect telehealth use in the older population.

Regarding hardware factors, ownership of technology (160), an effective device or display screen (142,146), bandwidth, and connectivity (143,166), along with a need for devices with widgets or multiple screens (146), could influence older

users' ability to accomplish the final goal. For example, some patients with hearing disabilities reported interference between a videophone and their hearing aids (142). The convenience of technology use can improve comfort and efficiency.

Regarding software factors, several reviews identified barriers in terms of the software and user interface design, such as inappropriate font size, unusual characters, bland graphics, poor colour contrast, and complicated menu designs (142,160). A simple and intuitive interface that requires little or no technical knowledge would better reflect normal daily activities and allow a more seamless transition toward its use (178), whereas a delay in responses, lack of feedback, and technical issues may lead to frustration for older users, which may lower their motivation to continue telehealth use (146).

System Level

An important factor regarding older adults' telehealth use is access, which may be limited by age-related sensory impairment (138,139) and unfamiliarity with technology (139), as reported at the interpersonal level. Sekhon et al. also reported that gaining a referral to a specialist who uses telemedicine was another barrier, although all physicians claimed future use of telehealth (165). In addition, scepticism about the telehealth benefits (139) and information loss owing to the inability to properly examine patients (166) were the other 2 barriers reported by healthcare providers.

Policy Level

At the policy level, several reviews reported that the cost of using telehealth and reimbursement from the government or insurance companies were barriers to telehealth adoption (143,160). Other barriers reported at the policy level are regulations (e.g., state law and licensure) as well as ethical and legal issues (liability, malpractice, and safety) (143,179).

Data privacy was a contradictory factor in these reviews. In the review by Karlsen et al. (151), possible privacy issues caused by the use of cameras and video recording tools were not seen as a problem by most older adults because the technologies were supposed to help them live safely in their own homes. In contrast, the reviews by Pool et al. and Kruse et al. reported that the privacy issue had an impact on user attitudes, intentions to adopt, and their actual use of telehealth (C. Kruse et al., 2020; Pool et al., 2022).

2.4.6.3 Gap 3

Most of the studies in the literature focused on the evaluations and experiences from users' perspectives, yet neglected the challenges faced by non-users (180). According to Van Gemert-Pijnen JE et al. and Lie et al., the challenges in the scaling-up phase are primarily attributed to non-use and high drop-out rates (181,182). Besides, other marginalised groups may include individuals who lack access to or decline to use telehealth services. Hence, it is also crucial to consider their perspectives in order to gain a comprehensive understanding of the preferences of a larger older group as well as the feasibility of implementing telehealth.

2.4.7 Telehealth and Health Inequalities

Previous chapters have introduced the benefits and potentials of telehealth, particularly in routine non-emergency care and scenarios where direct client-provider contact is not mandatory (183). Beyond its primary benefit of enhancing the accessibility to distant health services, telehealth also holds the potential to tackle inequalities in healthcare access and effectively enhance users' health outcomes, health literacy, and behavioural outcomes (184).

2.4.7.1 Intervention-Generated Inequalities

However, the challenges of catering to the needs of vulnerable groups become more pronounced with the increasing popularity of telemedicine (183). Indeed, an established phenomenon in public health, "Intervention-Generated Inequalities" (IGIs) underscores that digital health technology interventions tend to yield greater benefits for those who are already more privileged (185). Certain demographics face unique difficulties in telehealth adoption and utilisation, such as individuals with lower socioeconomic status and educational backgrounds, insufficient digital literacy, limited access to a reliable Internet connection or digital devices, and language barriers, as well as ethnic minority groups (186).

2.4.7.2 Telehealth and The Older Population

Telehealth holds the promise to promote health equality for the older population, particularly during difficult times like the COVID-19 era, however, it may also lead to further exacerbation of the existing disparities (183,187–190).

Earlier studies have reported the challenges of older individuals in adopting telehealth. Interestingly, the major barrier is not solely about access, but rather age-associated obstacles at the individual level, such as limited proficiency and familiarity with telehealth, insufficient health literacy, inadequate support obtained, and the presence of physical and cognitive impairments (183,191). Moreover, older adults could encounter difficulties in developing trust and confidence when engaging with telehealth services (183,192–195). Indeed, reports have shown that about 70% of older adults own and use a smartphone, tablet, laptop, or computer with the Internet at home, but the penetration of telehealth services is still very limited among this demographic (196).

Another notable barrier lies in telehealth design and implementation. A recent systematic review highlighted the scarcity of telehealth solutions that prioritise user-centred design, specifically catering to the distinct needs of the older population, although this group of users could gain better access to health services and derive the greatest advantages from telehealth services (197).

2.4.7.3 Gap 4

As mentioned earlier, the rapid implementation of telehealth to replace some portion of in-person services may raise a concern of further exacerbating the existing health inequalities. Moreover, telehealth has been seen as an important tool amid the pandemic, and its significance was particularly evident during periods of lockdowns. However, different reports and studies have shown that its utilisation has decreased rapidly since the resumption of in-person activities in the community (97,198–202). This shift highlights potential

challenges in telehealth's scalability and sustainability in ageing care. Thus, it is imperative to devise strategies to improve the equity, inclusivity, scalability, and sustainability of telehealth implementations.

2.4.7.4 Co-creation – Person-centred Approach

Within a health context, traditionally, patients and their caregivers were passive recipients of health services (203). However, this “one-size-fits-all” design using a top-down approach, without considering the factors varying between individuals and settings (204,205), may lead to potential problems such as a limited understanding of users' needs, reduced chance of new ideas, inefficient utilisation of resources, as well as low uptake and acceptance.

The WHO Global Strategy for Integrated People-Centred Health Services 2016 - 2026 advocates for a transformative change in the financing, management, and delivery of health services (206). This strategy emphasises the utmost importance of embracing a people-centred approach, which involves treating every user as a unique individual (207) and incorporating their preferences into the design and decision-making process (208). The goal is to create responsive health systems that effectively address contemporary health issues, such as ageing populations, multi-morbidities, and escalating healthcare expenses (203). Therefore, in addition to the existing digital empowerment interventions initiated by the local government and community organisations, strategies should be developed to improve the inclusivity, equity, scalability, and sustainability of telehealth solutions.

One suggested opportunity is to co-create or modify elements of digital infrastructure to more effectively cater to the needs of all users (174). Co-creation, according to Sanders and Stappers, is “a broad term with applications ranging from the physical to the metaphysical and from the material to the spiritual” (209). It can be conducted in different activities, such as semi-structured interviews, focus groups, observations, surveys/feedback, qualitative enquiry, guideline/literature appraisal, prioritisation/ranking, nominal group technique, Delphi technique, warm-up activities, personas, maps/user journeys and prototyping (210).

2.5 Telehealth in Singapore’s Ageing Research

Despite the efforts from the medical institutes, government agencies, and community organisations introduced in Chapter 1.4.3, there are mixed yet limited published results on these telehealth initiatives in ageing care:

- According to news reports in 2021, a survey carried out at the Singapore Eye Research Institute revealed that 55% of the respondents expressed reluctance to continue using digital medical services and 77.8% felt uneasy with AI interpreting their medical results (98,99);
- To better address older adults’ barriers to telehealth adoption (e.g., costs, access to telehealth services, trust of technologies, concerns over data privacy, and usability of telehealth platform interfaces), the geriatric centre from Alexandra Hospital implemented several strategies to increase the teleconsultation uptake among the older population: 1) partnerships with

local community clinics to streamline pre- and post-consultation laboratory tests and simple radiological examinations; 2) streamlining the workflow for patients and caregivers to arrange teleconsultation sessions, with clinic staff providing guidance and assistance via email and SMS to ensure ease of access and their comfort with the digital platform; 3) free delivery of medications to patients' home with pharmacists providing counselling via pre-dispensing calls; and 4) adapting a wide range of healthcare services into telehealth to improve the convenience for older adults and their caregivers.

The authors observed an increasing trend of telehealth visits since the start of the partial lockdown in 2020 due to COVID-19 and more elderly patients at the geriatric centre being receptive to teleconsultations compared to younger patients at the general medicine department during the pandemic. Older people could adopt and use telehealth to minimise risks and maximise benefits with the right incentives. At the same time, some barriers to telehealth implementation were also identified: lack of necessary devices at hand, lack of clinical examinations, risk of privacy and data breaches (97).

- A 2022 interview study investigating the perception and acceptability of a tele-exercise programme named the Healthy Ageing Promotion Programme for You (HAPPY). HAPPY is a group multicomponent exercise programme integrating cognitive and physical functions initially launched in 2017. During the COVID-19 pandemic, the programme transitioned to virtual delivery via Zoom, maintaining engagement with over 100 participants and eventually

expanding to include more than 700 participants by March 2021. Of the 42 participants (69.1 ± 4.7 years) involved in the virtual interviews, 91% viewed technology positively, 79% believed it promoted independence, and a similar percentage felt adequately knowledgeable with access to technical assistance. However, over half expressed hesitancy about technology, with 36% citing financial constraints (211).

2.6 Theoretical Frameworks in Telehealth Research

A theoretical framework is a critical research component, as it connects the researcher to existing knowledge (212); forms the foundational basis for a research study; guides the development of the rationale, problem statement, purpose, significance, research questions, literature review, and methodology; and serves as the essential structure that supports and anchors the entire research process (213).

To fully leverage the benefits of telehealth, it is crucial to identify and analyse the factors influencing user adoption, so that telehealth solutions can be designed more inclusively and implemented more sustainably (214). To achieve this, many prior studies have combined behaviour change theories with health service utilisation models to gain deeper insights (214–218), for example,

Health Belief Model (HBM)

The Health Belief Model (HBM) is one of the most widely used models in health psychology and public health for understanding and predicting health behaviours. Developed in the early 1950s by social psychologists Irwin M.

Rosenstock, Godfrey M. Hochbaum, S. Stephen Kegeles, and Howard Leventhal at the U.S. Public Health Service, HBM was initially adopted to explain the failure of people participating in disease prevention and detection programmes, and subsequently extend to study behavioural responses to health-related conditions (219,220).

HBM posits that the likelihood of an individual adopting a health behaviour is determined by his or her belief in the personal threat posed by an illness or disease, combined with their belief in the effectiveness of the recommended action or behaviour to mitigate that threat (220). With six core constructs (perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy), it emphasises that health-related behaviours are influenced by two key factors: 1) the desire to avoid illness or recover if already sick; and 2) the belief that a specific health action can prevent or cure the disease; and ultimately, the decision to take action is shaped by individual perceptions of the benefits and barriers associated with that health behaviour (220).

HSB has been commonly applied to study the reasons why people choose to adopt health precautionary measures and how health crisis affects their health service adoption (220). However, it was criticised due to several reasons, such as not accounting for environmental or economic factors affecting the recommended action, and assuming that everyone has access to the necessary resources, information, and services to act on their health beliefs and intentions (220).

Andersen's Health Service Utilisation Model

The Andersen's Health Service Utilisation Model was developed by a medical sociologist and healthcare services researcher, Ronald M. Andersen at UCLA in 1968 to study why a family uses health services (221), and subsequently revised in 1973, 1995, 2000, and 2001 (222). It offers a theoretical structure to understand access to and utilisation of health services and to categorise the factors that influence an individual's decision in this process, namely disposing factors, enabling factors, and need factors (223). Predisposing factors influence an individual's tendency to seek care, such as age, gender, education, and beliefs about health; enabling factors facilitate or hinder individuals' access to services, such as income, insurance coverage, and resource availability; while need factors directly impact individuals' urgency and frequency to seek care, such as perceived health status as well as the actual illness and physical conditions (222).

The HBM primarily focuses on the psychological and cognitive aspects of their health-seeking activities as well as personal perceptions and motivations to adopt telehealth; while Andersen's Health Service Utilisation Model provides a broader framework from externally social and societal perspectives for understanding access to and telehealth utilisation. In this thesis, the HBM and Andersen's Health Service Utilisation Model will be used together as the guiding theoretical frameworks to offer complementary perspectives on the factors that influence older individuals' HSB and telehealth adoption.

2.7 Reflection

To embark on an exploration of telehealth feasibility within Singapore's ageing care context, several preliminary steps are imperative. To begin with, it is essential to identify a theoretical approach that can effectively guide the design and implementation of the studies. Simultaneously, there is a critical need to uncover the health needs of the older population and identify potential domains where telehealth interventions could be implemented effectively.

CHAPTER 3 THEORETICAL APPROACH OF THIS THESIS

It's not enough to have good ideas. You need to master their implementation.

– Rossi. Luca (224)

Chapter 2.4.7 introduced that although telehealth brought various benefits and convenience to the older population, it may bring about unintended IGIs simultaneously. This underscores the importance of not only recognising the potential of telehealth solutions but also designing inclusive, effective, and scalable implementation strategies to avoid exacerbating existing health inequalities.

3.1 Implementation Science (IS)

Implementation research, “the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices (EBPs) into routine practice, and, hence, to improve the quality and effectiveness of health services and care”, arose to tackle challenges in using research for EBP in healthcare and other professional fields (225). Early research was largely empirical and lacked strong theoretical foundations of implementation, leading to an analogy of “an expensive version of trial-and-error” (226). According to a review conducted by Davies et al., only 10% of the studies provided explicit rationales for their strategies (227). Limited theoretical bases could contribute to mixed results in EBP implementation across settings, hindering the understanding of success or failure mechanisms (226). This

obstacle restricts the identification of predictive factors for successful implementation and the development of effective strategies for improved outcomes (228).

In the last decade, implementation science (IS) has increasingly emphasised the significance of establishing theoretical foundations and effective strategies for implementation. There has also been a growing interest in better understanding the mechanisms of successful implementation. Besides borrowing theories from multiple disciplines (e.g., psychology, sociology, and organisational theory), implementation studies also adopt theories, models, and frameworks that originated from IS itself (228).

Based on the three overarching aims for the use of theories, models, and frameworks in IS—describing and/or guiding the translation of research into practice, understanding and/or explaining factors influencing implementation outcomes, and evaluating implementation efforts, Nilsen summarised five distinct categories of theoretical approaches (228):

- **Process models** are models to outline and guide the systematic translation of research findings into practical applications within real-world settings, e.g., the Canadian Institutes of Health Research Model of Knowledge Translation (229), the K2A Framework (230), and the Knowledge-to-Action Model (231);
- **Determinant frameworks** are frameworks to provide a structured approach to identifying and categorising the factors that influence the successful implementation of interventions, aiding in the development of

effective strategies for implementation, e.g., the Promoting Action on Research Implementation in Health Services framework (232), Active Implementation Frameworks (233), and Theoretical Domains Framework (234);

- **Classic theories** are established theories from fields external to IS to offer insights into the underlying mechanisms which influence implementation processes and outcomes, e.g., Social Cognitive Theories, Communities of Practice, and Theory of Diffusion (235);
- **Implementation theories** are specialised frameworks developed within the IS field to provide a deeper understanding of the complex dynamics and processes involved in successfully translating research into practice, e.g., the Implementation Climate (236), the COM-B (Capability, Opportunity, Motivation, Behaviour) Model (237), and Normalisation Process Theory (238);
- **Evaluation frameworks** are frameworks to offer systematic approaches to assess the effectiveness, efficiency, scalability, and sustainability of implementation efforts, which can guide researchers and practitioners in determining the impact of interventions on desired outcomes, e.g., RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) (239,240).

3.2 SEM as a Determinant Framework

Determinant frameworks serve as essential instruments in Implementation Science to assist researchers and implementers in uncovering barriers and

facilitators across various levels of influence within a specific context. Besides the examples listed above, SEM stands as another important example and has been applied in the design and implementation of limb-loss rehabilitation programmes (241), safe practice in primary care (242), structured diabetes education (243), and anterior cruciate ligament injury prevention (244). Initially proposed by Bronfenbrenner in the 1970s (177), SEM was further refined by McLeroy et al. to foster health-related behavioural change (245).

As introduced in Chapter 2.4.6.2, SEM proposes a dynamic interplay of factors within multiple nested systems that shape individuals' behaviours and development within their environments. These systems are centred on individuals, including 1) a microsystem in which individuals directly interact with immediate settings such as family members and peers, 2) a mesosystem where individuals' microsystems are interconnected and influencing each other, such as the interactions between home and school environments, 3) an exosystem consisting of other formal and informal social structures, such as policies, mass media, and community resources; and 4) a macrosystem encompassing broader society factors, such as cultural ideologies and attitudes (177).

In this thesis, SEM will be operationalised to guide the categorisation of determinants influencing the implementation of telehealth systems or programmes across five levels, namely, the individual level (e.g., personal health, literacy or knowledge, and attitudes towards telehealth), interpersonal level (e.g., communication and trust between telehealth service clients and providers), technological level (e.g., usability and technical capabilities of a

telehealth system), system level (e.g., accessibility, workflow, manpower, and information provision within a telehealth system), and policy level (e.g., cost, regulation, and ethical considerations) (Figure 3.1).

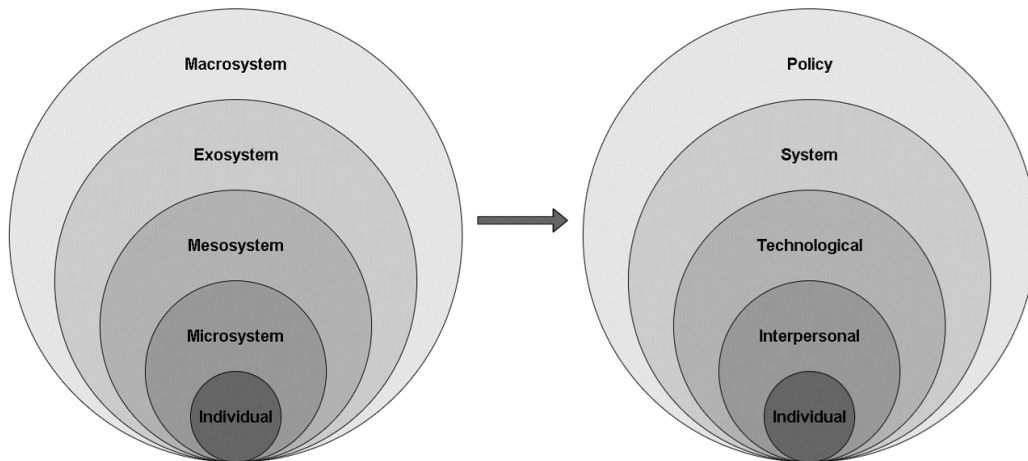


Figure 3.1 SEM (left) and the operationalised version in this thesis (right), SEM: the Social Ecological Model

3.3 Implementation Research Logic Model (IRLM)

Theoretical approaches in IS are invaluable for understanding the complexities of applying research findings in real-world contexts. However, integrating the multitude of conceptual components from various theories, frameworks, and models presents a significant challenge in implementation research. Furthermore, articulating the conceptual relationships and interconnections among these frameworks and linking them to theories could be difficult (246). Therefore, the development of a conceptually grounded organisational tool has the potential to improve the rigour, reproducibility, and overall value of implementation research in the field.

The Implementation Research Logic Model (IRLM), developed by Smith et al. in 2020, is such a tool to help plan, execute, report, and synthesise

implementation projects (247). The core elements of IRLM (Figure 3.2) comprise the determinants of implementation, implementation strategies, the mechanisms through which these strategies take effect, and the resultant impacts on both implementation and clinical outcomes (247):

- **Determinants of implementation** encompass multifaceted and dynamic factors that either facilitate or impede the successful implementation of interventions or programmes. They could act as moderators, “effect modifiers”, or mediators, thereby influencing the causal mechanisms underlying implementation processes (248). Common frameworks such as the Consolidated Framework for Implementation Research (CFIR) (249) and the Theoretical Domains Framework (234) could be used to guide the identification of these determinants in clinical research.
- **Clinical interventions** are the health interventions or practices being implemented with the research framework, which could be new treatments, programmes, or interventions aiming to improve health outcomes or address a specific health issue.
- **Implementation strategies** refer to the systematic approaches and techniques employed to facilitate the adoption, implementation, scalability, and sustainability of EBP. They consist of a diverse range of activities tailored to address the unique determinants present within a specific context. For instance, the Expert Recommendations for Implementing Change (ERIC) compilation of strategies could serve as a resource for delineating the most suitable strategies to address the barriers identified

by CFIR (250). By selecting and implementing appropriate strategies, researchers and implementers can enhance the feasibility, acceptability, and effectiveness of the intervention delivery.

- **Mechanisms**, i.e., causal pathways or processes, in other words, are the processes or events by which an implementation strategy exerts its effects on the desired implementation outcomes (248). They can involve changes in determinants, proximal implementation outcomes, aspects of the implementation strategy itself, or a combination of these factors within a multiple-intervening effect model. Although relatively few implementation studies formally test mechanisms of action, this area of investigation has garnered significant attention more recently, reflecting the growing necessity to understand how strategies operate within the field (251,252).
- **Outcomes** are the results or consequences of “deliberate and purposive” implementation efforts (253) and can be indicators of implementation processes, key intermediate outcomes of services, or desired clinical outcomes. According to Glasgow et al., the interconnected nature of implementation outcomes occurs in a logical sequence rather than a strictly linear progression (239,254,255). This sequence typically involves adoption by delivery agents, faithful delivery of the innovation, reaching the intended population, and sustaining the innovation over time. The collective impacts of these nested outcomes, combined with the effectiveness of the EBP, ultimately determine the population or public health impact of the implementation effort (254). Earlier outcomes in this

sequence can be seen as mediators and mechanisms through which strategies influence subsequent implementation outcomes. It is essential to precisely specify which strategies are theoretically intended to impact which outcomes, and through which mechanisms of action. Doing so could enhance the rigour and reproducibility of implementation research and facilitate the testing of theory (247).

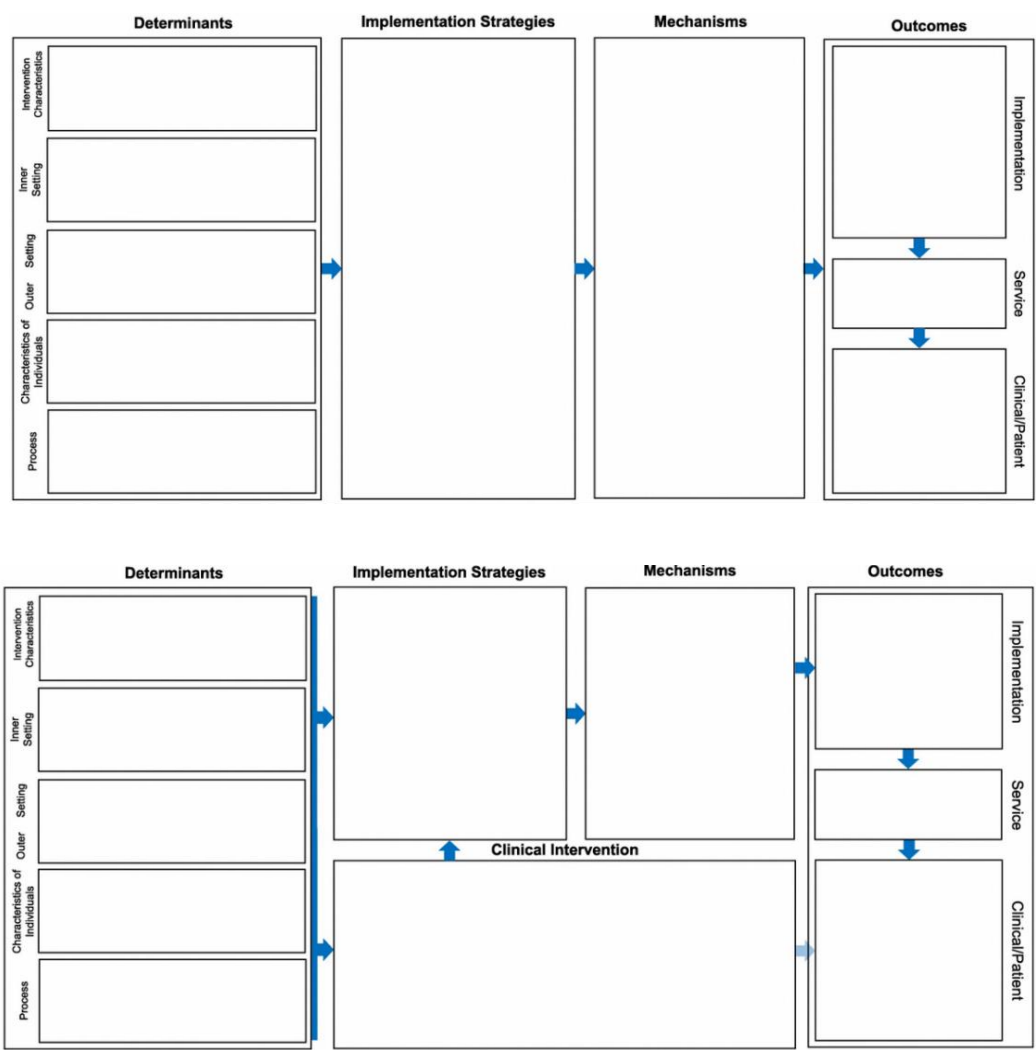


Figure 3.2 Implementation Research Logic Model (IRLM) Standard Forms (without and with Intervention) (247)

3.4 Effectiveness-Implementation Hybrid Designs

The traditional research pipeline has advocated for a staged approach to the development of EBP, which prioritises their efficacy and subsequent effectiveness under controlled settings before considering translation to and implementation of real-world practices. However, this process often leads to significant time lags between intervention development and widespread community adoption. Although IS has emerged to tackle this challenge, even with a focus on real-world implementation, following the traditional route of efficacy–effectiveness–implementation still results in notable delays (256).

Thus, Curran et al. proposed the concept of merging design elements from clinical effectiveness and implementation research in 2012, namely, a “hybrid effectiveness-implementation” typology, to accelerate translational progress, enhance the effectiveness of implementation strategies, and provide decision-makers with more actionable information (257). There are three types of hybrid designs (256):

- A **type 1 hybrid design** primarily assesses the effectiveness outcomes while also exploring the “implementability” of an intervention. This approach could help identify how to support implementation in the real world and pinpoint facilitators and barriers to guide the selection of appropriate implementation strategies;
- A **type 2 hybrid design**, in contrast, maintains a dual focus on both effectiveness and implementation outcomes. It allows for the

simultaneous pilot testing of implementation strategies during the trials for effectiveness assessment;

- A **type 3 hybrid design** places its primary emphasis on implementation outcomes, while also gathering effectiveness outcomes, which are relevant to the uptake or fidelity of the intervention.

3.5 Sample Size and Saturation

3.5.1. Importance of Sample Size

In the majority of research studies, it is impractical and impossible to investigate the entire population of interest. Thus, studies are typically conducted on samples instead, with the expectation that the conclusions drawn from these samples can be generalisable to the broader population and extrapolated to the future (258). This inherent challenge highlights the pivotal importance of an adequate sample size to ensure the validity, reliability, and eventually utility of research outcomes.

3.5.2. Sample Size Determination

Quantitative research typically employs experimental and survey methods, focusing on numeric values and measurements. Its strength lies in establishing cause relationships, testing hypotheses, and understanding the opinions, attitudes, and behaviours of a large population (259). To ensure statistical power and result validity, quantitative research employs specific sample size calculations, taking into account various factors such as confidence level, effect

size, and population variability (256). In contrast, qualitative research aims to elucidate concepts that enhance understanding of natural phenomena, emphasising the meanings, experiences, and perspectives of study participants (255). This is often achieved through IDIs, observations, or textual analysis. As qualitative research balances depth and breadth, sample sizes are determined by a prevailing concept – “saturation” (257).

3.5.3. Saturation

“Saturation” denotes the point in qualitative research when the collection and/or analysis of new data yields minimal or negligible additional insights to the study (258,259), always serving as a criterion to conclude data collection (260). Its interpretation varied across literature due to study designs, research objectives and questions, theoretical frameworks, and study assumptions (260–262).

According to a recently published evolutionary concept analysis on “saturation” in qualitative research (260), multiple surrogate terms were used by researchers in literature, such as:

- **Theoretical saturation** – the point where further data collection fails to unveil novel facets or enhance the emerging theory, which involves an iterative process wherein the researcher concurrently conducts sampling, data collection, and data analysis (263);

- **Data saturation** – a stage in data collection and analysis when additional data fail to significantly contribute to addressing the research question or when existing data are replicated (261),
- **Code saturation or thematic saturation** – the point of identifying repetitive codes or themes without the emergence of new information or relationships (261), and
- **Meaning saturation** – a stage in the process of data collection and analysis where issues are fully understood and no fresh insights regarding the meaning of codes or themes and their interrelations emerge (260);

while some related terms include:

- **Information and/or data redundancy** – when repetitive data or collected information is encountered (264,265),
- **Overload of information and/or data** – when it is challenging to identify key themes and patterns through vast volumes of data (266), and
- **Pseudo-saturation** – when researchers prematurely cease data collection, overlooking alternative perspectives or vital information sources, thus mistakenly assuming saturation has been reached (267,268).

In this thesis, the term “saturation” refers to the state of reaching both “data saturation” and “information and/or data redundancy” within the collected data. It serves as the criterion for concluding qualitative data collection across

all studies, where further data collection would become ‘counter-productive’ (269,270).

3.6 Navigating the Chapters Ahead

3.6.1. Choice of Older Participants

In this thesis, an age threshold of 50 years was selected, and there were no limitations on health conditions for the older participants. This choice was motivated by several factors:

1) Disease prevalence among people aged 50 and above:

In an earlier local population-based cross-section study involving 1,181,024 individuals, Low et al. observed a positive association between age and the mean number of NCDs. Their findings revealed that by the age of 50, more than half of the population had been diagnosed with at least one NCD (271). Moreover, statistics from the National Population Health Survey 2022 indicated that the prevalence of abdominal obesity also rose with age, with the highest prevalence observed among older adults aged between 50 and 74 years (272).

2) Lifestyle practice:

On average, the highest average daily cigarette consumption was among daily smokers above 50 years (272). Moreover, more than 60% of local citizens aged 50 and above do not participate in regular leisure-time physical activity (273), while approximately 70% of those aged 50 were facing nutritional risks (274).

3) Health screening:

The majority of individuals with undiagnosed diabetes and hypertension were between the ages of 50 and 69 years (272).

4) National and community health programmes:

50 is the minimum age criteria stipulated by local health programmes catering to older adults, such as the 'Active Ageing Programme' (275) and the 'I am a Senior' programme (276).

5) Exploratory nature of this thesis:

Given the insufficient evidence in Asia, this thesis adopts an exploratory approach, placing a strong emphasis on capturing the diversity of the older population to gain a more comprehensive understanding of their needs and challenges. By including individuals across the entire spectrum of old age and health conditions, from those in their early stages to the oldest old and regardless of health conditions, the studies could provide insights that are applicable across a broader range of individuals, thereby reflecting the complexity of the ageing population. Such an inclusive approach aligns with the principles of IS to improve the flexibility and adaptability of telehealth interventions to address the multifaceted ageing challenges.

3.6.2. Organising the Empirical Studies

The subsequent four chapters will present a series of four empirical studies to map the four core components within the IRLM: health interventions, determinants of implementation, implementation strategies, and outcomes

(Figure 3.3), aiming at systematically exploring the feasibility of implementing telehealth interventions to facilitate the health-seeking practices among older individuals. These studies will collectively contribute to the development of evidence-based telehealth designs and implementations that are both feasible and effective in improving healthcare delivery in ageing care.

- **Chapter 4 – Study One** aims to identify potential areas in ageing care for telehealth implementation in the local context by exploring how older people seek health and how they have been using technologies to assist this process. This will lay the foundation for the subsequent studies.
- **Chapter 5 – Study Two** seeks to explore the perceived determinants influencing older people's telehealth adoption and implementation, while also identifying potential implementation strategies, from different stakeholders' perspectives.
- **Chapter 6 – Study Three** and **Chapter 7 – Study Four** focus on evaluating two telehealth intervention prototypes tailored to address the identified needs and challenges in Studies One & Two. Due to the lack of literature on tele-education in health education for the public, recommended implementation strategies are also provided.

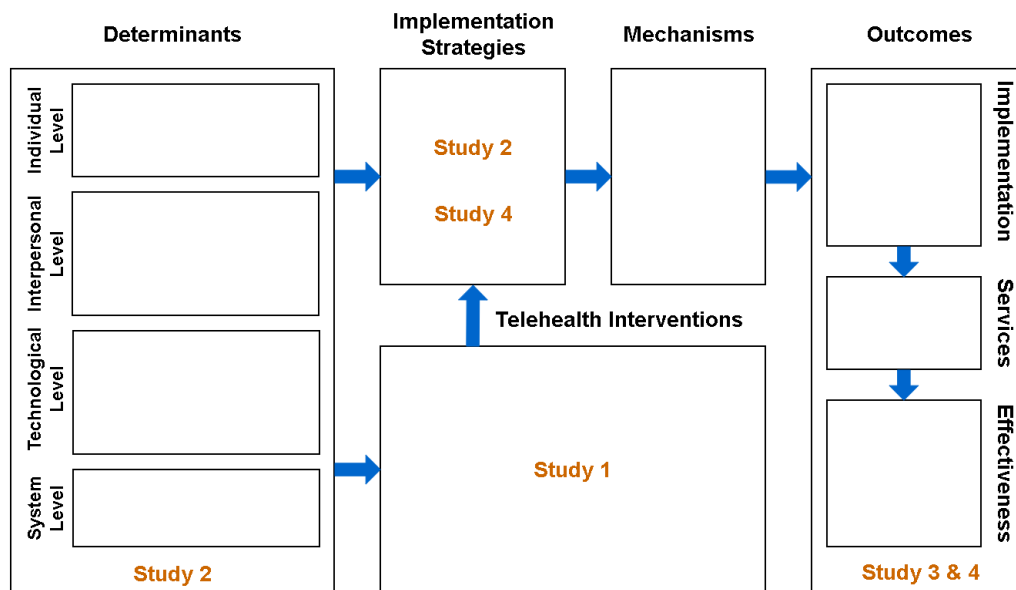


Figure 3.3 Illustration of the four empirical studies guided by the Implementation Research Logic Model (IRLM)

CHAPTER 4 STUDY ONE

“Don’t take your health for granted. Don’t take your body for granted. Do something today that communicates to your body that you desire to care for it. Tomorrow is not promised.”

— Jada Pinkett Smith (277)

Older adults often face unique health needs and challenges, such as multiple NCDs, limited access to necessary health services, and cultural beliefs. Therefore, their approaches to pursuing better health may differ from those of younger generations. Gaining insights into how older individuals seek health, access health services, and utilise associated technology could foster a comprehensive understanding of their daily practices, challenges, and preferences when accessing health services, which is crucial for identifying how telehealth could potentially effectively cater to these unique needs. Additionally, insights into HSB could inform the design of the telehealth interventions to ensure that they are intuitive, easy to navigate, and culturally sensitive. Addressing barriers to seeking health services and technologies, such as transportation limitations or discomfort with technology, can help enhance the accessibility and acceptability of telehealth for older adults. Moreover, this process may unveil previously unrecognised health needs. Therefore, the findings will be able to inform how telehealth solutions could align with this demographic’s established behaviours rather than disrupt them, and better facilitate the seamless integration of telehealth into their health routines.

Partial results of this chapter were extracted from

Zhang, Y., Lee, E. W. J., & Teo, W. P. (2023). Health-Seeking Behaviour and Its Associated Technology Use: Interview Study Among Community-Dwelling Older Adults. *JMIR ageing*, 6, e43709. <https://doi.org/10.2196/43709>

Student's roles in this study:

Study design, IRB application, participant recruitment, data collection, data analysis, and manuscript writing

4.1 Background

HSB is an important concept associated with a country's health status and economic development (278). It helps uncover the health needs and priorities of a population and informs the development of appropriate policies to address their needs and avert their disease progress (279).

In literature, a widely used definition of HSB is "any action or inaction undertaken by individuals who perceive themselves to have a health problem or to be ill for the purpose of finding an appropriate remedy" (280), and studies adopting this definition always examined the formal health system use or the process of illness responses (78,279,281,282), for example, in earlier local studies, Lee et al. studied how older people living alone in an urbanised low-income community seek healthcare when they fell sick and associated difficulties (78), Tay et al. explored the different in hospital admission duration

and the number of healthcare providers visited between the local community and imported COVID-19 cases (283), and Ang et al. assessed how domestic migrant workers used healthcare services (284).

However, this definition focuses mainly on illness behaviours (285) and ignores the importance of promoting overall health and well-being, as health is not merely the absence of disease or infirmity but rather a state of complete physical, mental, and social well-being (286). Thus, HSB could and should be viewed in a broader sense. A more comprehensive definition proposed by Chinn and Kramer is an individual's deed to the promotion of maximum well-being, recovery, and rehabilitation; this could happen with or without health concerns and within a range of potential to real health concerns (287), for instance, health promotion interventions, self-monitoring, and making lifestyle changes. This definition encompasses practices for preserving optimal wellness, preventing illnesses, and addressing any deviation from good health (278,288), which aligns with the concept of universal health coverage (i.e., all individuals and communities should have access to essential health services without facing financial hardship, covering health promotion, disease prevention, treatment, rehabilitation, and palliative care) (289).

As Chapter 1.4 introduces, the Singapore government has been constantly exploring technological solutions and promoting Smart Health Initiatives to proactively address the demographic shift and meet the older population's health needs. Despite these efforts, there remains a scarcity of studies into the patterns of the older population's HSB as well as how these technologies were

utilised in facilitating older individuals' health-seeking in the local settings. These findings will be also used to guide the design of telehealth services to meet the unmet health needs of this demographic in subsequent studies.

4.2 Aim and Research Questions

The aim of this study is to investigate HSB and potential telehealth applications among older people in the Singapore community. The hope is to gain deeper insights into how this population makes decisions when they engage with the healthcare system and use technologies, identify any unmet needs, suggest ways in which telehealth can be leveraged to address these needs, and ultimately, propose recommendations for telehealth implementation to ensure that this demographic will not be excluded from the efforts to build the smart nation. In particular, the following research questions will be addressed:

1. What are the consequences of HSB in the context of ageing in Singapore?
2. How have technologies been incorporated into older people's health-seeking?
3. What considerations do older adults factor in when choosing technologies to meet their health needs?
4. What are the potential areas for telehealth implementation to address the unmet needs of the older population?

4.3 Methods

4.3.1 Study Design

Descriptive phenomenology, also known as Husserlian or transcendental phenomenology, seeks to give equal weight to both objective and subjective experience. According to Husserl, phenomenological inquiry should be free from assumptions, philosophical or scientific theories, deductive logic procedures, and other empirical sciences or psychological speculations (290). This study adopted this approach and explored the lived experiences of older adults' HSB and associated technology utilisation through semi-structured IDIs.

4.3.2 Participant Recruitment

This study was planned during the “stabilisation phase” (291,292), when COVID-19 safety management measures (SMMs) were heightened to slow down the rate of transmission; and participant recruitment commenced in January 2022, during the “transition phase”, when groups of up to five people were allowed in social gatherings) (293). Inclusion criteria were (1) age of 50 years or older, (2) Singapore citizens or foreigners who are dwelling in the Singapore community in the long term (i.e., citizens, permanent residents, as well as work pass and long-term visit pass holders), and (3) ability to read and converse in English or Mandarin.

Convenience sampling with multiple recruitment strategies was adopted for a dual reason: 1) to R in terms of sociodemographic and socioeconomic

characteristics (e.g., age groups, ethnicities, education backgrounds, occupations, income levels, and housing types), and 2) to prepare for the unpredictable SMMs imposed owing to the COVID-19 pandemic. Before data collection, study information and recruitment posters were posted on social media platforms (Facebook and Instagram) and shared with some chat groups for older adults. Referrals were then obtained from the early participants and the recruitment was paused when no new themes were identified. Subsequently, the interviewees' profiles were reviewed, and more participants were purposively recruited from the community centres as well as public areas during the "COVID-19 resilient nation phase" when the social distancing measures were relaxed and the level of the Disease Outbreak Response System Condition was adjusted to yellow (294). The whole recruitment process ceased in July 2022, when participants' sharing of insights beyond their experiences resulted in "saturation"—the collected data became repetitive, and no further insights could be generated to add to the overall narrative.

4.3.3 Data Collection Tools

This qualitative study used two data collection tools: an online registration form and a semi-structured interview guide.

4.3.3.1 Online Registration Form

The online registration form was used to collect participants' sociodemographic and socioeconomic characteristics, existing health conditions, ownership of

mobile devices, access to Wi-Fi, and the consent of participants in the subsequent interview.

4.3.3.2 Semi-structured Interview Guide

Based on Chinn and Kramer's definition of HSB, Poortaghi et al. conducted a systematic review to examine the concept of HSB with an evolutionary content analysis approach. According to their findings, HSB has four crucial attributes, namely interactional and processing dimension, intellectual dimension, active and decision-making-based dimension, and measurable dimension (295) (Figure 4.1). That is, HSB is an ongoing process involving a logical sequence from the symptom evaluation to the decision to use different care, the individual's efforts to pursue an acceptable level of well-being, the approach to acquiring health information, and the routine of constant health monitoring and behaviour change to move toward high-level wellness (295).

The definition of HSB by Chinn and Kramer (287) and Poortaghi et al.'s model of HSB (295) were used to guide the development of the interview guide. The detailed list of guiding questions for the semi-structured interviews can be found in Appendix 1.

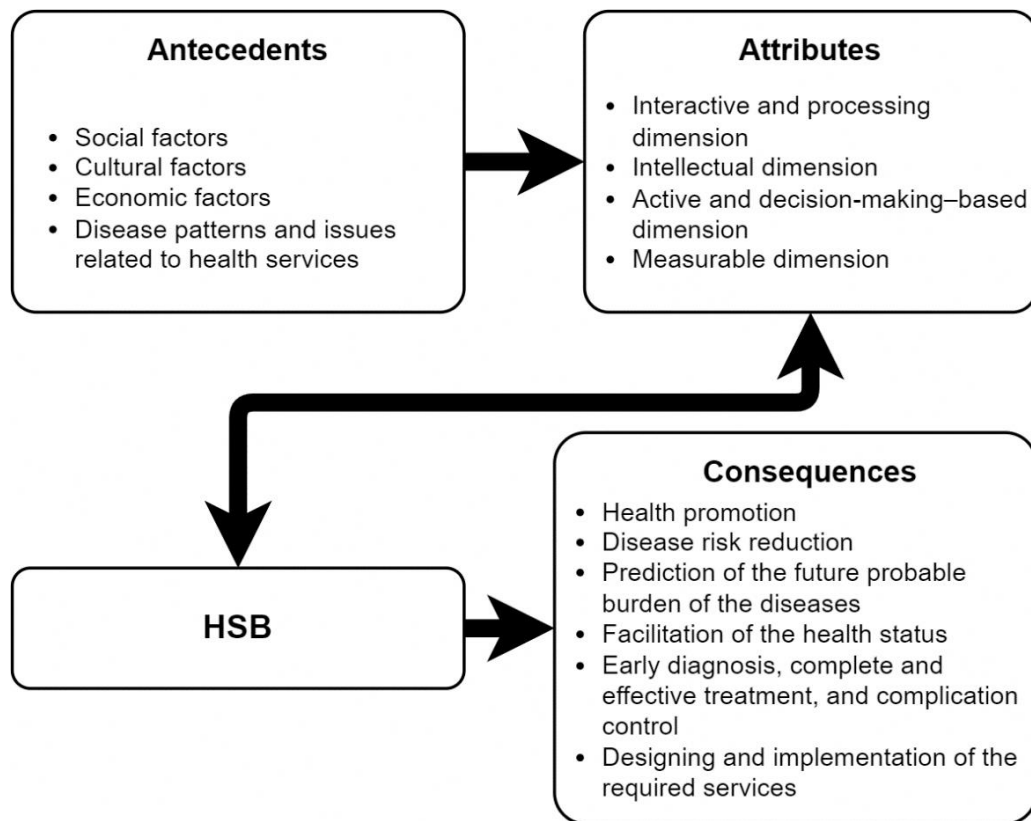


Figure 4.1 The HSB model by Poortaghi et al. (295) (HSB: health-seeking behaviour)

4.3.4 Data Collection Procedure

Data collection took place from April 2022 to July 2022. Older adults who expressed interest in participating were invited to complete the online registration form and screened to check their eligibility for the interview. Eligible participants were then informed about the data collection procedure; the recording of the interviews; and how the data would be analysed, reported, and protected through written informed consent. Only those who gave their consent were scheduled for an interview. To comply with the SMMs, Zoom (Zoom Video Communications Inc) was chosen as the default interview medium, and a manual was provided to the participants whenever needed. Participants who had unresolvable difficulty with Zoom were offered the option of a face-to-face interview. All eligible candidates were contacted either via phone calls or

WhatsApp to receive further details of the study and get their interview schedules at their convenience. Informed consent and permission for interview recording were obtained in advance. All interviews were conducted on a one-on-one basis and were video recorded.

At the beginning of each interview, the study details were explained again, and verbal consent was obtained and recorded. Field notes of observations were documented, and important findings were confirmed with the participants during the interviews to reduce misinterpretations and added to the field notes. The interview focused on three main topics: HSB, associated technology use, and how the participants selected technologies. Participants received shopping vouchers worth SGD 20 upon successful completion of the semi-structured interview.

4.3.5 Data Analysis

Every participant was assigned a unique identifier (OP XX, where “OP” stands for “older participants”) before data analysis, and all study data were deidentified during the transcription process. All interviews were transcribed verbatim in MS Word by myself, and all text data were transferred to MS Excel for thematic analysis. Participants who preferred Mandarin had their transcripts translated and reviewed to ensure the highest possible level of accuracy.

As all interview sessions were moderated by myself, data analysis was performed immediately after each interview to maintain a fresh memory, with the aid of the field notes. The individual was chosen as the unit of analysis to

identify the patterns of HSB and technology utilisation in the older population. Next, inductive thematic analysis was conducted, involving a meticulous line-by-line coding process while reading through the qualitative data. The generated codes were then grouped together based on the research questions, with pattern codes emerging to highlight recurring themes. These themes were used in the subsequent interview sessions to assess the emergence of new themes and to gauge data redundancy.

Due to the constraints of manpower, data collection and analysis were primarily conducted by myself, yet frequent discussions were held with my supervisor to review the codes and themes.

4.3.6 Ethical Consideration

Prior to the commencement of the study, approval had been obtained from the institutional review board of Nanyang Technological University, Singapore (Reference: IRB-2021-797).

4.4 Results

4.4.1 Participants

In the period from February 2022 to April 2022, 12 individuals signed up for the study after viewing the study information on social media or in chat groups for older adults, but only two (2/15, 17%) met the inclusion criteria. An additional eight participants were then recruited via the referral of the initial two eligible participants until no further insights were generated. Another five participants

with low socioeconomic status or from other ethnicities were recruited from different community centres and public areas before reaching “saturation”. In total, 13 Zoom interviews where participants remained in their homes and two face-to-face interviews were conducted at the community centres in close proximity to the participants’ residences.

The 15 participants were aged between 55 and 73 (mean = 65.8, SD = 6) years, among whom nine (60%) were female, 13 (87%) were Chinese, six (40%) were still full-time or part-time employed, and more than half (8/15, 53%) had a personal monthly income of less than SGD 1,000. All participants (15/15, 100%) owned a personal smartphone, but two (13%) of them did not have Wi-Fi access at home and relied on mobile data plans. The characteristics of the participants are provided in Appendix 2 and summarised in Table 4-1.

4.4.2 Consequences of HSB in the Singapore Ageing Context

The interviews identified five main consequences of HSB in the Singapore ageing context, namely (1) health information seeking, (2) health maintenance, (3) early diagnosis and complication control, (4) responses to symptoms, and (5) health service access.

4.4.2.1 Health Information Seeking

According to the participants, health information seeking was a proactive process for individuals to actively obtain, evaluate, and apply information related to their health and relevant health services.

Table 4-1 Summary of participants' characteristics (n = 15)

Characteristic		No. (%)
Age (in years) (65.8 ± 6.0 years)	55-59	2 (13.4)
	60-69	8 (53.3)
	70-79	5 (33.3)
Sex	Female	9 (60.0)
	Male	6 (40.0)
Ethnicity	Chinese	13 (86.6)
	Indian	1 (6.7)
	Malay	1 (6.7)
Number of known health conditions	0	7 (46.6)
	1	3 (20.0)
	2	4 (26.7)
	3	1 (6.7)
Highest education achieved	Primary and secondary	5 (33.3)
	Pre-university	4 (26.7)
	Degree and postgraduate	6 (40.0)
Employment status	Homemaker	3 (20.0)
	Retired	6 (40.0)
	Employed part-time	4 (26.7)
	Employed full-time	2 (13.3)
Estimated current personal monthly income (in Singapore dollars)	0	5 (33.3)
	<1,000	3 (20.0)
	1,000 - 1,999	1 (6.7)
	2,000 - 2,999	2 (13.3)
	3,000 - 3,999	1 (6.7)
	4,000 - 4,999	2 (13.3)
	7,000 - 7,999	1 (6.7)
Housing type	Rental flat ^a	1 (6.7)
	4 or 5-room HDB flat ^b	4 (26.7)
	Terrace House ^c	1 (6.7)
	Semi-Detached House ^d	2 (13.3)
	Condominium ^e (excluding Executive Condominium) ^f	7 (46.6)
Ownership of a smart device	Smartphone	15 (100.0)
	Tablet	7 (46.7)
	Personal laptop (not for work purposes)	11 (73.3)
Access to Wi-Fi at home	Yes	13 (86.7)
	No	2 (13.3)

^aRental flat: an affordable housing rental option for lower-income Singaporeans (296);

^bHDB flats: Housing & Development Board (HDB), a public housing type in Singapore which are affordable and can be easily purchased by the average Singaporean as they're subsidised by the government and are offered with housing grants (4-room HDB flat: three bedrooms and one living room; 5-room HDB flat: four bedrooms and one living room) (297);

^cTerrace House: a dwelling house with its own land title that forms part of a row of at least three dwelling houses abutting the common boundary party walls (298);

^dSemi-Detached House: a single-family duplex dwelling house that shares one common wall with the next house (299);

^eCondominium: an apartment that is part of a development not managed by the HDB, owned by unit owners who share common areas and facilities with other unit owners within the development (300);

^fExecutive Condominium: a strata-titled property, with comparable designs and facilities to other condominiums (300).

Two strategies regarding obtaining health information were shared by the participants: (1) participation in the health education sessions organised by the government, hospitals, universities, and other community organisations; and (2) looking for relevant information from different sources such as the web (e.g., Google, Wiki, and forums), mHealth apps, social networks (family members and friend groups), health professionals, and the fields of their medicine expertise. Sample responses are summarised in Table 4-2.

When evaluating the credibility of the health information obtained, participants adopted multiple methods: (1) relying solely on official sources, (2) seeking verification from health professionals, (3) checking the credibility of information sources, (4) searching for scientific evidence, (5) gathering information from individuals with similar experiences, and (6) self-experiment. Sample responses are summarised in Table 4-3.

Participants also shared that their health information searching and participation in health education could empower themselves with health-related knowledge. They have gained a deeper understanding of well-being and diseases, and that has led them to better awareness of their bodies and a positive shift in their health behaviour:

*I become **aware of the diseases**, and for example, I know that if I eat a lot of fatty stuff, my cholesterol will be affected, thereby **when I choose the food I will read the label**, so in my daily life, in my choice of food and all those, I **become educated**. After I know all the knowledge but don't practice in my daily life, it's like zì jǐ zhǎo sǐ [killing myself] right?*

OP05

We all understand that exercise is good for our health which I'm doing every day. Moderation is the key for any food you take, and I never take excessive [but] just moderate and take what I need. And also need to keep your mental health good, and the more you use your brain the more you can keep your brain; [if] you don't use your brain, you may get dementia. Human beings need group activities like we walk together, and we go to the SACs [Senior Activity Centres] to talk to the elderly. And this way you need friends to be able to listen to your problems, and you don't separate from society, and that might lead to some mental problems like depression and dementia.

OP06

4.4.2.2 Health Maintenance

All participants shared that they have been pursuing healthy lifestyles and strengthening social connections to maintain their physical, mental, and social capacities:

*Enough sleep, proper diet, [and] regular exercise [help me maintain my health]. [I'm] **getting myself active in daily activities, just to keep me mentally and physically engaged.***

OP03

*I have several groups like my line dancing group, [and] volunteering groups of a few institutions...These people really **keep me mentally on the spot.***

OP05

Table 4-2 Sample responses regarding participants' strategies to obtain health information

Health information searching	Method
Participating in health educational sessions	I'm a volunteer with HPB, and we do conduct health talks. I'm interested in that and I'm still active with it. They have [the] War of Diabetes, [and] some [talks] focus on exercise and nutrition. (OP02) I attended the wellness and health held by Boon Lay CC [Community Centre] last year on the 26th of December, the day after Christmas. I registered myself there to study health and wellness and they taught me to download some of the apps such as 365 [the Healthy 365 app]. I attended the health coaching course offered by NTU [Nanyang Technological University]. (OP13)
Looking for relevant information from different sources	Yes, I will check online or ask friends...I [also] use the HealthHub app...I found it very useful. And it does have family programme[s] and health tips that I can go to find out more [about them]. (OP02) Normally my friends and I will share health information in [the] WhatsApp group, we are in a retiree group. (OP06) I collect health information from the doctor. (OP08) Actually, I know all these investigations [have] done quite well because I worked in the hospital before, so I know all these tests, what they are for, and you must take some medication regularly. (OP10)

Table 4-3 Sample responses regarding evaluating the reliability of information sources

Methods of evaluating health information	SAMPLE RESPONSES
Relying solely on official sources	I will go to HealthHub by the government. (OP02)
Seeking verification from medical professionals	...I think it's still probably wise to consult a medical person. In my case, I'm fortunate to have my children who are medical[ly] trained. In the chat group, we do have doctors who are friends, so some of them will check in and advise us on whether it's true or not true, or what to do and what not to do. (OP03)
Checking the credibility of information sources	Recently I have been following a guy on YouTube and I checked the credibility of the person who produced it, so now I'm exercising with him and subscribe[d to] his YouTube channel for dumbbell exercises. So I actually checked his credibility and he is a renowned physiotherapist. I checked his background, and when I'm confident with his background, I become more confident in following the exercises that he teaches. (OP05)
Searching for scientific evidence	I don't trust completely the websites. [It] depends on what website you see. I trust completely when I go to the library and borrow books, and the book is written in black and white, but I will also need to read the qualifications of the writer, whether the writer is a doctor or a practitioner. At the same time, sometimes when I see the doctor, I will also ask the doctor. I don't actually completely trust the authority. I used to argue with the polyclinic doctor, I got fatty liver and he said it's ok to have it and everyone has it, I said no I don't agree with you, the fatty liver is a sign of [a] lifestyle problem, you cannot say everyone has it so it's normal. When I questioned him, I told him I had done research about it. I will trust the specialists more because they do all the testing. I trust evidence, everything [is] evidence-based. (OP09)

Gathering information from individuals with similar experiences	Sometimes I chat with my friends about our health status and exchange health information. (OP11) I do my homework and get some information from the Internet, even though you cannot 100% trust the Internet because sometimes there is so much conflicting information. I also get information from people who undergo all these kinds of diseases, I will ask them how do they get it, what do the doctors tell them, [and] what do the doctors advise them to do. So all this info is very handy as it's all from my friends. (OP15)
Self-experiment	I didn't think about it until I talk to you now...If I cannot find any info about medicine, I will still try it but will be very careful. The moment it gives me any negative result, I will stop it straight away. Actually, if I do it in this way, I become my own guinea pig, so I must be very careful. (OP05) I think it's based on experience, you must try it and then find oh it's true, if you don't try then don't bother. But there is no harm [in] trying. But I'm trying to be sceptical when people try to sell medicine, I try not [to] waste money buying some medicine and try, then later found it's not working. (OP14)

4.4.2.3 Early Diagnosis and Complication Control

Besides, regular health screening, follow-up care and self-measurement of physiological parameters were also reported as useful strategies for early disease diagnosis and complication control.

All participants have been undergoing regular health screenings and follow-up care, with frequency varying from several months to several years, contingent on the purposes (e.g., disease screening and NCD monitoring):

*Once every three or four months I **go for my health screening**,
once a year I **get my flu injection**, [and] once a year I **also go**
[for] ultrasounds on my lungs, chest, and prostate.*

OP08

Physiological parameters are non-invasive objective measures of a person's physiological function using simple equipment, such as pulse, temperature, BP, and respiratory rate (301). They could serve as a basic means to communicate about a person's health status and keep track of both acute and chronic conditions (301). In this study, only one of the participants reverently measured their vitals while the other six determined when to perform self-measurement based on the bodily symptoms or daily activities, whereas the rest did not practice self-measurement.

Overall, four reasons were reported: (1) self-perceived good health, (2) inability to schedule, (3) lack of necessary equipment at hand, and (4) difficulty in

obtaining accurate measurements. Sample responses are summarised in Table 4-4.

Table 4-4 Sample responses regarding self-measurement

SELF-MEASUREMENT	REASONS	SAMPLE RESPONSES
Constant self-measurement	-	I measure my blood pressure three times a day, this is the advice of my doctor from the polyclinic. I do that quite religiously and it's been very stable. I also monitor my weight and it's very stable as well. (OP08)
Occasional self-measurement	Awareness of bodily symptoms	Only when symptoms come, I will look at it ... If my BP is above 130, then I will monitor [it] every day continuously for about a week, if it doesn't come down then I will go to the polyclinic. (OP04)
	Awareness of daily activities	When I eat a lot of sugar or go out to makan [eat], I will also check my blood sugar one hour after the consumption. (OP15)
No self-measurement	Lack of necessary equipment	I used to have a blood pressure gauge, but somehow it's lost somewhere, and we are not able to take it out, so I haven't used it for quite some time. (OP14)
	Difficulty in obtaining accurate measurements	Every time my own measurement is different from the one in the clinic. (OP14)
	Perceived good health	I don't use any tools to monitor my health at home. I don't have [a] BP problem, and I have prediabetes, so I don't need to monitor. I believe the 10k steps walking can help me with that. (OP09)
	Inability to schedule	My doctor recommends me to measure my blood pressure every day at home, but a few years ago she gave me a chart to monitor my BP every day in the morning, in the afternoon and evening. I did the initial part but didn't follow up. My lifestyle is very good. Every morning I go for my very early walk at seven something, so I need to wake up early to eat my small breakfast. I need to leave the house by six something, so I never properly monitor my health. (OP07)

4.4.2.4 Self-perceived Health Statuses and Responses to Symptoms

Despite the impacts of the COVID-19 pandemic on participants' physical, mental, and social well-being, all participants perceived their health to be good to excellent and stated that they rarely fell sick. In the event of any symptoms, three different actions were taken: (1) self-treatment; (2) seeking prompt professional medical attention; and (3) undergoing a logical process from self-treatment to seeking professional medical attention, depending on the severity of symptoms. Sample responses are summarised in Table 4-5.

4.4.2.5 Health Service Access and Interaction

Health service access was studied from four dimensions—physical environment, cost, waiting time, and communication with health service providers.

All participants were satisfied with their **living and surrounding environments**. They could easily access recreational spaces (e.g., fitness facilities, parks and open spaces, and walking and cycling paths), amenities (e.g., grocery stores and health stores such as Guardian), public transportation (e.g., bus stops and Mass Rapid Transit stations), and healthcare services (e.g., outpatient polyclinics, private general practitioners [GPs], and hospitals), and this could make their life more convenient and healthier:

*My house is very **accessible**, and during Covid time we have walked to all the connectors, and we can also walk around within the whole estate.*

Good! It's within [a] 10-20 mins walk to the facilities. Every day I make the trip down to the mall with a library there and use the shopping mall and polyclinic. I also walk, it's like a form of exercise.

OP10

Table 4-5 Sample responses regarding responses to symptoms

RESPONSES TO SYMPTOMS	SAMPLE RESPONSES
Self-treatment	When I'm not feeling well, I just have a rest...I use my own "traditional" style, I drink more water when I'm getting flu or sore throat...I've practised this traditional style for more than 30 years...Up to now, I'm still diagnosed free from my diabetes, [and] high blood cholesterol. (OP15)
Seeking prompt professional medical attention	See a doctor, [I] don't buy medication from pharmacies. (OP01)
Undergoing a logical process from self-treatment to professional medical attention, depending on the severity of symptoms	If it's more of tiredness and so on, then I will probably find time to have more rest, take a nap or go to bed early on in [the] afternoon, take a nap. If I'm still not feeling good like maybe having a headache or what, I may look to taking a Panadol or paracetamol. If [it is] a more serious problem, like recently a couple of months back I had self-tested positive on [for] COVID, I will consult a doctor to find out what is the next step I have to do. (OP03) If for some reason I feel not so well, I'll give myself a break, meaning I will stay at home, just have a rest, [and] be more conscious of the thing that I eat, means I will drink more water, eat more fruits. Because of so many years since my exercise regimen, I hardly see the doctor due to some health issue, maybe for those small issues like [an] ear infection. In fact, I try to avoid taking medication, [and] that's why I try to keep my lifestyle healthy. For bigger issues or the symptoms are not improving after a few days, I will go to see a family doctor who is a general practitioner. (EP07)

In terms of **cost**, all participants shared that various government subsidies, such as the Community Health Assist Scheme, Merdeka Generation Package, and Pioneer Generation Package, enabled them to access affordable medical services:

*We have the CHAS [Community Health Assist Scheme] cards, [and] we have the Pioneer Generation card, so **the charge is minimal**, [so] I will say [it is] **very affordable**... [The health screening is] very affordable, there are two layers of subsidies.*

OP10

Regarding **waiting time**, more than 70% of the participants reported that physicians' consultations were fast, but the waiting time could be up to hours or even longer, even with an appointment:

*The **consultation is very fast**, but **the waiting time to see the doctors can take hours**.*

OP01

*My **appointment was set at 11:30 [am] in the morning [after a long weekend]**, but I did not see the doctor until 4:30 pm, that is unusual, and even the doctor said today is unusual. The **consultations are usually very fast**.*

OP06

Participants reported a general desire to engage in more health-related discussions with their healthcare providers, but the **provider-patient**

communications varied with health professionals and could affect patients' emotions:

*Very good because we have been seeing this family doctor for many many years, so we are very comfortable. **The communication is very good.***

OP07

*I hardly see GP so I cannot comment on it. I only can comment [on] those doctors that I have seen in [the] polyclinic. These **doctors keep on changing**, it's not a specific doctor. **I find it poor because sometimes I do feel that they are just doing their job only.** Poor in the sense that **I feel that sometimes they just do their job to move you away because they have so many patients.** But sometimes **there are some pretty good doctors, and they do try to explain**, so I cannot generalise that. I will see two extremes: **when I meet good doctors, I'm very happy, but when I meet these so-called poor doctors who are not with the patient, then I will say "Okay lah I go polyclinic what do you expect."***

OP09

4.4.3 Technology Utilisation in Older Adults' Health Seeking

The utilisation of technologies in each consequence of the older adults' HSB (Figure 4.2) was explored and three main themes were generated from the thematic analysis:

- Theme 1** ICTs and social media, although not primarily designed for health purposes, play a substantial role in easing the process of obtaining health information and managing symptoms;
- Theme 2** The most widely used digital technologies among the older population are mHealth apps and wearable devices, with associated wellness programmes launched by government agencies and local companies. These technologies have the potential to enhance health communication, promote health maintenance, and increase access to health services;
- Theme 3** Although the outbreak of the COVID-19 pandemic has resulted in some alterations to older adults' well-being, it has catalysed the adoption of telehealth as a complement to access healthcare services.

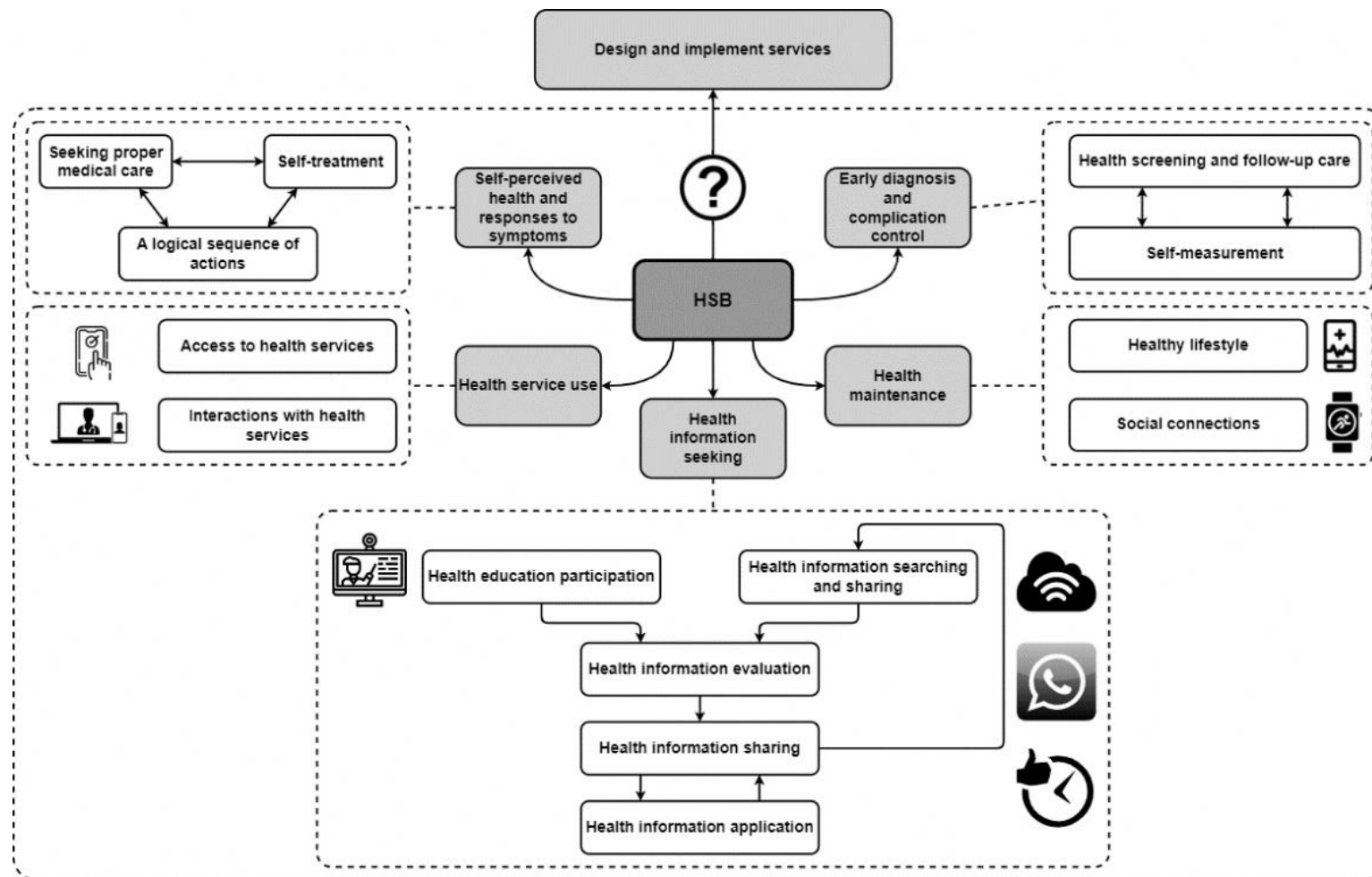


Figure 4.2 Summary of the use of technologies in older adults' health-seeking (302) (HSB: health-seeking behaviour)

4.4.3.1 Utilisation of ICTs and Social Media in Obtaining Health Information and Managing Symptoms

Apart from health professionals, ICTs and social media were also active sources for obtaining and sharing health information for most of the participants:

***Google** and read the review[s] of the medicine, then go to some **forum**. I will check as many sources as I can.*

OP05

*Sometimes I check **Facebook and YouTube**.*

OP12

*From time to time, we get [health information] from friends, we get the **WhatsApp message** to say “Hey this is good, you can try this exercise...”*

OP08

Among the participants who opted for self-treatment as their initial response to symptoms, web-based resources and peer sharing through ICTs could provide them with relevant health information, especially from friends who have experienced similar symptoms:

Sometimes [I] can see [health information] from YouTube, like you press this pressure point, you massage this area, and your BP will be reduced, or you take some kind of herbal soup.

*Information is everywhere, so it depends on how you want to capture it. I check this info on **YouTube and Facebook**.*

OP14

*Sometimes, like when I had COVID, I shared with them [my friends in the WhatsApp group] the experience of the first few hours of having it, three days of feeling about it and how I did the ART test and the results. So, it's the **sharing of experiences and exchanging thoughts about what happened, are we [we are] facing the same issues or different.***

OP03

4.4.3.2 mHealth Apps Utilisation and Wearable Devices in Health Communication, Health Maintenance and Health Service Access

Health communication leverages technological innovations, such as mass media and multimedia to spread health information, enhance public understanding of health, educate the public about health concerns, and keep critical health issues on the public agenda (160). Participants shared that they were able to locate information about health programmes and health tips through mHealth apps developed by the government:

*I use the **HealthHub app**...I found it very useful, **and it does have family programme[s] and health tips that I can go to find out more [about them].***

OP02

Most of the participants reported using various mHealth apps and wearable fitness trackers, launched by either government or local companies, to track their daily physical activities and stay motivated toward achieving their health goals. They could also receive attractive incentives from the associated health campaigns:

*I use it [Healthy 365 app] for step tracking. I **participated [in] the steps challenge as this is free money...I call it preventive medicine because they pay you to lose weight.***

OP09

*I use [the] SingTel StepUp programme also, **every month I can redeem at least two free Gigabytes for myself.***

OP14

Although most of the participants expressed frustration with the long waiting time to see physicians, a few of them shared that mHealth apps such as the HealthHub app could offer them a platform to receive real-time updates about the waiting time and manage their non-urgent appointment bookings:

*With the appointment on the HealthHub app, I **can check how many more patients [are] ahead**, then I hang out outside. It doesn't bother me if I have to wait very long.*

OP05

*I was **using HealthHub to check the information about my appointment.***

Besides managing appointments, participants said that they could also view test results and health reports on the mHealth apps:

I go there [the HealthHub app] to do [medical appointment] booking, check my appointment, and check my blood test results.

4.4.3.3 Utilisation of Telehealth in Accessing Health Services

During the COVID-19 pandemic, telemedicine served as an alternative way to access health services. A few participants have tried teleconsultation when they tested positive for COVID-19 and had to self-isolate:

*I tried to do a **virtual or teleconsult[ation]** when I self-tested **COVID**...I talked to the app on my mobile phone, and I called in to schedule an appointment with the doctor. After the consult[ation], they sent the medication in within three to four hours. The consultation, medication, and delivery were very reasonable, and it's cheaper than going to a GP.*

Several participants shared that some of their regular health education sessions were adapted to a web-based format via Zoom amid the COVID-19 pandemic, and this allowed them to continue their learning journey with tele-education:

*We had **quite a number of Zoom lectures from HPB.***

OP01

*365 [Cancer Prevention Society] sometimes have [has] little
talks about nutrition, I do go in and listen on Zoom.*

OP09

The COVID-19 pandemic did not eradicate the participants' regular health screenings, but the initial lockdown has caused some delays. Some participants chose to postpone their health screening to prevent possible infection and were offered self-tests as a substitute:

*I **didn't go for the blood test** as my husband [who is a doctor]
told me not to go. But I **still did one free test which they sent
to me**, I collected the specimen and sent it back to them.*

OP05

4.4.4 Considerations When Selecting Technologies

When asked about how to select technologies, eight factors were reported by the participants, namely, (1) perceived usefulness, (2) comprehensiveness of features, (3) perceived ease of use, (4) performance and quality, (5) recommendation by the social network, (6) cost, (7) rewards, and (8) credibility. Sample responses are summarised in Table 4-6.

Table 4-6 Sample responses regarding the choice of health technologies

THEME	SAMPLE RESPONSES
Perceived usefulness	The technology has to meet my need. [Healthy] 365 and HealthHub are just suitable for me, so I didn't go and look for other health apps. Some hospital also has an app, but whatever information in this app can be retrieved from HealthHub, so I don't use that app. (OP04)
The comprehensiveness of features	For me, it has to be something that's inconvenient, it doesn't [I don't] have to wear another device, for example, all [features] incorporated into one, like the basic thing: the steps count and somehow sleep pattern... (OP03)
Perceived ease of use	I will just try, if it's not good and I don't know how to use [it], then I will delete [it]. (OP05)
Performance and quality	We started with the Relive [Relive: Run, Ride, Hike & more] app, but then I noticed that sometimes we actually lost the satellite signal, and I complained to [the app developer] and they admit that they know they have such a problem. And then I use the Google Fit and Samsung Health, and usually the signals are very good. (OP06)
Recommendation by the social network	I follow what the health and wellness course taught me, HealthHub is the first one, [and] Healthy 365 is the second one. There are a few other apps they asked me to download, but I think HealthHub is the best. (OP13)
Cost	In terms of the cost, I will check if it's free or paid. (OP01) First, I must say I'm a stingy woman, so if it's payable, I will think twice. (OP05)
Rewards	To be frank, I don't mind using as many as possible, because they provide rewards. (OP14)
Reliability	For reliability, I will check where it's produced/manufactured. (OP01)

4.4.5 Archetypes

Participants in this study exhibited a relatively consistent response pattern. However, the results of this study, coupled with insights from the participants' observations within their social networks, have led to the proposition of four

archetypes (Table 4-7). These archetypes were designed based on factors such as the activeness level of their HSB, access to technologies, willingness to adopt technologies, and capability to use technologies:

Table 4-7 Four proposed archetypes

Archetype	Description
Archetype 1	Inactive in health-seeking
Archetype 2	Proactive in health-seeking but hesitant to adopt technologies
Archetype 3	Proactive in health-seeking and receptive to technologies, but facing challenges in accessing or using technologies
Archetype 4	Proactive in health-seeking, receptive to technologies, and able to access and use technologies

4.5 Discussion

Differing from previous research that centred on health system utilisation and responses to illness, this study enables a more comprehensive understanding of older adults' health-seeking practices, including health information seeking, health maintenance, early diagnosis and managing complications, responses to symptoms, as well as accessing and interacting with healthcare services.

Additionally, this study delves into the older adults' utilisation of technologies and their considerations when selecting technologies for health-related purposes. In contrast to the findings of an earlier qualitative study by Low et al. that older adults' HSB was technology-independent (303), the results of this study reveal a seamless integration of various technologies into the health-seeking activities of older adults.

4.5.1 Participant Recruitment

Given the absence of literature examining HSB employing this comprehensive approach, there remains a gap in understanding the factors influencing this multi-faceted behaviour. Nonetheless, prior HSB studies focusing on the health system utilisation as well as responses to illnesses, conducted both locally and internationally, highlighted the significance of sex, educational background, and employment status in shaping older adults' health-seeking practices (80,304–310). Thus, in light of the existing literature, participant recruitment in this study strives to achieve a more balanced representation across these dimensions, aiming to maximise the opportunity of reaching saturation for each factor.

While acknowledging the limitations of this qualitative study, such as subjectivity in interpreting participants' narratives, small sample size, and the majority of participants having Chinese ethnicity (13 Chinese, 1 Indian, and 1 Malay), it is also worth mentioning that the collected data were enriched by the insights shared by many participants from their social networks and communities, in addition to their personal experiences. Moreover, additional purposive recruitments beyond the saturation point have resulted in an approximation of participants' ethnic composition aligning with national census data for individuals aged 50 and above in 2022 (Chinese: Indian: Malay $\approx$ 82:7:10) (311). These efforts hold the potential to mitigate the limitations of random sampling and enhance the authenticity and transferability of the findings to similar populations, contexts, or settings in future research.

4.5.2 Consequences of HSB in the Local Ageing Context

A total of five major consequences of HSB were identified in this study, namely, health information seeking, health maintenance, early diagnosis and complication control, responses to symptoms, and health service access and interaction, consistent with the model by Poortaghi et al. (295).

4.5.3 Technology Use in Older Adults' Health Seeking

A key discovery was the older adults' wide engagement with technologies and associated health campaigns launched by the government and local companies. Supporting the findings by Low et al. (303), most participants (10/15, 67%) were motivated to use wearable fitness trackers together with mHealth apps to keep track of their physical activities. These technologies could provide users with real-time feedback and motivate them to achieve their predetermined lifestyle goals (312). Moreover, the financial incentives offered by these initiatives seemed to be an important motivator for older people to use such technologies and encourage positive changes and discourage negative ones in health behaviour.

Technologies offer a solution to overcome the challenges in health service use and interaction. Although all participants (15/15, 100%) were satisfied with their living and surrounding environments, were able to easily access primary care, and could enjoy affordable medical services through various government subsidies, they pointed out 2 challenges during the interaction with the current health systems. Similar to a theme in the findings by Lee et al. (78), many of the

participants (11/15, 73%) also shared their experience of waiting several hours for just a few-minute consultation, particularly after public holidays and during the COVID-19 pandemic. In addition, they also encountered communication barriers and even felt discouraged from engaging in further communication as they felt “pushed away” by their health professionals. These might be attributed to a shortage of health professionals in the country, as reported by the Ministry of Health that the physician-to-population ratio was 1:399 and there were only 2.5 physicians per 1000 population in 2019 (75). In addition to incorporating self-service medical booths (313), the use of digital technologies such as the machine learning–based solution being developed by the Singapore National Eye Centre, called Appointment Scheduling Optimiser, could reduce patients’ waiting time (314). Telehealth, which has the potential to reduce expenses and time spent on travelling and waiting (115), might offer another viable solution, but future studies are needed to further reaffirm the acceptability, effectiveness, and cost benefits of telehealth services.

ICT and social media expand people’s alternatives in searching for health-related information; however, they are not tailored to health intentions and cannot alleviate, diagnose, or cure diseases. In contrast to the findings by Lin et al. that only a small portion of the participants searched for health information on the web using their mobile phones (315), a high percentage of older participants in this study used their smartphones for searching and sharing health information, via web-based resources, social media, mHealth apps, and messaging through social network communication tools. This difference may

stem from the improved accessibility and easy sharing of information through mobile phones in recent years. Some of the government initiatives have also begun to harness these platforms, such as HPB's posting of health-related videos on YouTube for health promotion (316) and the launch of the official COVID-19 channels on Telegram and WhatsApp to broadcast news updates, deliver important announcements, and reduce the spread of misinformation during the COVID-19 pandemic (317). An unexpected result was that almost all participants (14/15, 93%) made an effort to question and assess the credibility of the health information. They exhibited scepticism toward the health information encountered and used various means to verify its credibility. The findings suggested that technologies have shaped health information seeking as a collective and collaborative effort—people first gather information; next, verify and circulate it through their social network; and then, apply it in their daily practice and provide feedback. Through this cyclic seeking-verifying-sharing-applying-feedback process, they can reaffirm the credibility and effectiveness of the information through firsthand experience.

Although the COVID-19 pandemic has brought some alterations to older people's well-being and disruptions to their lifestyle practices, it also catalysed technological innovation and adoption. For example, telehealth, although not a novel concept (66,318), gained increasing attention amid the COVID-19 pandemic (67). Participants in this study shared that different telehealth modalities could enable them to continue their access to healthcare services

and health education. Future studies could further evaluate the role of telehealth in ageing care.

4.5.4 Telehealth Implementation Strategies in Ageing Care

This section serves as the last consequence in the HSB model by Poortaghi et al. – design and implement needed services (295), and to answer RQ4 – What are potential areas for telehealth implementation to address the unmet needs of the older population.

4.5.4.1 Domains of Telehealth Implementation

The findings of this study collectively provide valuable insights into designing future telehealth services that effectively facilitate the HSB of older adults:

Health Monitoring

A major gap identified in the participants' HSB is the lack of self-measurement of their physiological parameters, especially for those with NCDs. Single-point measurements have shown to be less sensitive in detecting disease processes as a result of the diverse but individualised age-related physiological changes and comorbidities; whereas successive or serial measurements may enhance the sensitivity in detecting disease processes, especially when viewed in conjunction with individualised reference ranges (301).

In Singapore, some polyclinics have introduced telemonitoring services for patients with NCDs, and such services have been well accepted (92,319). Patients who rely solely on physical examinations, who do not own a personal

device, and who are occupied with daily chores can get the necessary devices and benefit from such services for NCD management, as prompt measurements can be taken beyond the healthcare settings. However, there is scarce published evidence about the uptake, effectiveness, and acceptability of these services.

Besides clinical approaches, community-based initiatives can be adopted to make technologies more accessible to the public and aid those who have difficulty obtaining accurate measurements. For example, telemonitoring kiosks with trained health ambassadors in the community can be set up to provide users with health tips and gather data to help health professionals make better decisions. By implementing these ground-up strategies, older individuals can enjoy better access to quality health services and technologies; reduce expenses associated with travel and medical equipment purchases; take a more proactive role in managing their health; and ultimately, reduce health disparities.

Health Consultation

Although all participants were satisfied with their living and surrounding environments, were able to easily access primary care, and could enjoy affordable medical services through various government subsidies, they pointed out two challenges during the interaction with the current health systems. Similar to the findings by Lee et al. (78), many of the participants shared their experience of waiting several hours for just a few-minute consultation, particularly after public holidays and during the COVID-19 pandemic. In addition, they also encountered communication barriers and even felt discouraged from engaging in further communication as they felt pushed away by their health

professionals. These might be attributed to a shortage of healthcare professionals in the country, as reported by the Ministry of Health that the physician-to-population ratio was 1:399 and there were only 2.5 physicians per 1000 population in 2019 (75).

Undoubtedly, telehealth could have the potential to reduce waiting times, and it is much easier for healthcare professionals to manage virtual appointments (320). Patients are no longer required to spend extra time waiting within medical facilities, and their health concerns could be more efficiently addressed remotely. Simultaneously, healthcare professionals can devote less time to transitioning between patients, allowing them to attend to a larger number of patients (321). Consequently, the enhanced convenience and improved work efficiency offered by telehealth have the capacity to alleviate burnout and mitigate the shortage of healthcare professionals (322,323).

Health Education

ICT and social media have expanded people's alternatives in searching for health-related information; however, they are not tailored to health intentions and cannot alleviate, diagnose, or cure diseases. Differing from the findings by Lin et al. that only a small portion of the participants searched for health information on the web using their mobile phones (315), a higher percentage of older participants in this study used their smartphones for searching and sharing health information, via web-based resources, social media, mHealth apps, and messaging through social network communication tools. This difference may

stem from the improved accessibility and easy sharing of information through mobile phones in recent years.

An unexpected result was that almost all participants made an effort to question and assess the credibility of the health information. They exhibited scepticism toward the health information encountered and utilised various means to verify its credibility. The findings suggested that technologies have reshaped health information seeking as a collective and collaborative effort—people first gather information; next, verify and circulate it through their social network; and then, apply it in their daily practice and provide feedback. Through this cyclic seeking-verifying-sharing-applying-feedback process, they can reaffirm the credibility and effectiveness of the information through first-hand experience.

These findings emphasise the potential of tele-education in the context of health information dissemination and education for older adults: synchronous telehealth facilitates direct dialogue between a larger audience and health educators, while asynchronous telehealth enables effortless "watch-later" access and sharing of reliable health information. As telehealth continues to evolve, it holds the promise of tailored, credible, and collaborative learning experiences for older adults, empowering them to make informed decisions and actively engage in their health management journey.

Encouragingly, government initiatives have capitalised on these digital platforms for health promotion, such as HPB's posting of health-related videos on YouTube for health promotion (316) and the launch of the official COVID-19 channels on Telegram and WhatsApp to broadcast news updates, deliver

important announcements, and reduce the spread of misinformation during the COVID-19 pandemic (317). These initiatives in turn open up the possibility of utilising multiple synchronous and asynchronous telehealth modalities for delivering health education.

4.5.4.2 Technology Selection

Participants shared various factors that affect their technology selection, but the results may be limited by the type of technologies that they have used before. In turn, this also implies that older adults might be granted access to a wider variety of digital technologies. Besides perceived usefulness, perceived ease of use, and financial cost found by Lin et al. (315), participants also shared that the comprehensiveness of features, quality of performance, recommendations by their social network, rewards, and credibility are the other overriding considerations. Taking these factors into consideration would be useful not only for technology developers when enhancing current technologies or creating novel ones to promote better user-centred designs, but also for policymakers in the process of digital transformation and building the “Smart Nation”.

4.5.4.3 Strategies to Target Different Groups of Potential Users

The Transtheoretical Model, also referred to as the “Stages of Changes Theory” was developed by Prochaska and Diclemente to describe individuals’ motivation and readiness to make significant lifestyle changes, such as quitting smoking or adopting healthier habits (324). The stages include pre-contemplation (no

intention to change behaviour), contemplation (awareness of a problem but no commitment to action), preparation (intent upon taking action), action (active modification of behaviour), maintenance (sustained change with new behaviour to replace the old one), and relapse (fall back into old patterns of behaviour), in a cyclic manner with each characterised by unique cognitive and behavioural patterns.

In this study, the four archetypes identified from the findings exactly correspond to the four stages:

- Precontemplation – Archetype 1: Inactive in health-seeking
- Contemplation – Archetype 2: Proactive in Health Seeking but Hesitant to Adopt Technologies
- Preparation – Archetype 3: Proactive in Health Seeking and Receptive to Technologies but Facing Challenges in Either Accessing or Using Technologies
- Action – Archetype 4: Proactive in Health Seeking, Receptive to Technologies, and Able to Access and Use Technologies

When formulating implementation strategies, it is important to note that while technologies play a promising role in assisting older people's health-seeking, they are not mandatory: people may have various reasons for using or not using technologies; therefore, it is crucial to uncover their specific health needs and address the IGIs, ensuring that no one is coerced into using technologies or excluded from digital inclusion.

Archetype 1

For archetype 1, the priority might be identifying older people's unfulfilled needs and seeking tangible resources from both healthcare and community settings. Some possible strategies include educating them about the significance of proactive HSB through public health campaigns, providing regular updates about their health status, and ensuring that they are not left behind in digital inclusion.

Archetype 2

For archetype 2, it might be helpful to work with healthcare professionals and assess the need for incorporating technologies in their health-seeking. Through this joint effort, they can determine the most suitable solutions to meet their specific needs. At the same time, they can be invited to attend health events or participate in awareness campaigns to gain first-hand experience regarding the benefits of technology and make informed decisions.

Archetype 3

For archetype 3, the focus could be on lowering the barriers to using technologies. Some possible strategies might be introducing simple technologies in small steps, offering assistance and support to build people's technology skills (e.g., the Senior Go Digital programme (325)), encouraging social engagement and creating a supportive community, and improving both user-friendliness and accessibility of technologies for the older population.

Archetype 4

Archetype 4 might be the most suitable candidate for technology use and requires the least amount of support. The focus could be on developing innovative telehealth services and policy solutions to sustain and enhance their HSB.

4.6 Reflection

Following the identification of potential areas for telehealth implementation in ageing care, it is crucial to address the following questions before proceeding with designing and implementing telehealth interventions:

- What are the determinants that support or impede the implementation of telehealth interventions in Singapore's ageing care?
- What implementation strategies could potentially enhance the adoption, implementation, scalability, and sustainability of telehealth interventions?

CHAPTER 5 STUDY TWO

“You can’t transform something you don’t understand. If you don’t know and understand what the current state of the customer experience is, how can you possibly design the desired future state?”

— **Annette Franz**, founder and CEO of CX Journey Inc

Study One identified several potential areas and general strategies for telehealth implementation. Equally significant is to delve into the perceptions of this rapidly evolving healthcare model among current and prospective users, which is pivotal to identifying the factors that facilitate or impede the effective design, successful adoption, and seamless integration of telehealth services in ageing care.

This chapter has been submitted as:

Zhang, Y., Lee, E., Teo, W. (2023) Perceptions of telehealth implementation in ageing care: a qualitative study on acceptance, determinants, and strategies.

Student’s roles in this study:

Study design, IRB application, participant recruitment, data collection, and data analysis

5.1 Backgrounds

The worldwide rising multi-morbidity among the rapidly ageing population places greater stress on the healthcare systems (326), and there has been a broad consensus that healthcare must shift from curative care to preventive care, and from hospitals to the communities (327). In Singapore, there has also been a shift in focus from disease-centric approaches to person-centred preventive care (328), from hospital to the community (326), and from traditional healthcare to digital health innovations (329). In this process, telehealth has found applications in diverse areas such as patient consultations, patient monitoring, and health promotion, spanning both clinical and community settings.

As shared in Chapter 2.5, despite efforts from the government, healthcare institutions, and social service providers, several gaps remain. Firstly, although mixed results were reported on older individuals' telehealth acceptance (Chapter 2.5), there has been a lack of studies examining what factors would affect their preference for adopting telehealth. Secondly, to the best of my knowledge, there is currently no published research available regarding social service providers' viewpoints on telehealth. In Singapore, the healthcare system "is designed to ensure that everyone has access to different levels of healthcare in a timely, cost-effective and seamless manner" (330). Besides clinical services, social services, such as home care, daycare, and stay-in care services are also available to support the residents and their families (331). They are playing an indispensable role in serving the underprivileged population and alleviating

social and health inequality (332). Therefore, the inclusion of insights from social service providers and telehealth providers could offer a more comprehensive exploration of the perspectives that were previously underrepresented.

Moreover, while many studies have used surveys or claims data to examine the older population's acceptance of telehealth (207,333,334), qualitative studies have also emerged to delve into the experiences of telehealth users from the perspectives of older patient users and physicians (335–338). However, prior research mainly focused on specific telehealth modalities or interventions and may overlook the unique and valuable perspectives of non-users (Gap 3), which may increase the risk of unintentional confirmation bias (339).

5.2 Aim and Research Questions

This qualitative study places emphasis on the general concept of telehealth and aims to gather insights from different groups of telehealth users as well as non-users who may have declined to use telehealth or have not had the opportunity to use telehealth, including older adults, ageing health service providers (healthcare professionals who work in clinical or community settings and staff from social service agencies), and telehealth providers.

This study will address the following research questions:

1. What do telehealth user journeys look like in the Singapore context?
2. What are the attitudes towards telehealth implementation in Singapore's ageing care?

3. What are the determinants that affect telehealth implementation in Singapore's ageing care?
4. What are the recommended implementation strategies that could potentially enhance the adoption, implementation, scalability, and sustainability of telehealth interventions?

5.3 Methods

5.3.1 Study Design

This study involved semi-structured interviews and was conducted concurrently with Study One.

5.3.2 Participant Recruitment

5.3.2.1 Older Adults

The older participants in this study were identical to those involved in Study One, and details regarding the recruitment process for older adults can be found in Chapter 4.3.2.

5.3.2.2 Ageing Health Service Providers

Ageing health service providers included healthcare professionals, allied health professionals and social service providers. Inclusion criteria were (1) aged 21 years or older, (2) currently working in Singapore, (3) having a minimum of two years experience working with older adults, and (4) being able to read and converse in English.

A snowball sampling approach with multiple recruitment strategies was adopted. Before data collection, study information and recruitment posters were disseminated on Facebook and Instagram. Several participants were directly contacted via WhatsApp, email, or LinkedIn. Referrals were then obtained from the early participants and the recruitment concluded in July 2022, when “saturation” was reached.

5.3.3 Data Collection Tools

This qualitative study used two data collection tools: an online registration form and a semi-structured interview guide, for both participant groups.

5.3.3.1 Online Registration Form

The online registration form for older participants has been described in Chapter 3.3.3, and the form for ageing health service providers collected information about their sociodemographic characteristics, work experience, experience with health information technology, as well as experience with telehealth.

5.3.3.2 Semi-structured Interview Guide

The interview questions for older individuals and ageing health service providers aimed to explore users’ experiences with different telehealth modalities, as well as the attitudes, concerns, and visions of telehealth of both telehealth users and non-users. The interview guide (Appendix 3) was originally developed in English and then translated into Mandarin. For telehealth

providers, questions covered their motivations, challenges encountered during telehealth implementation, experience with clients, and visions for the future of telehealth. To ensure clarity, the definition of telehealth was provided to participants at the beginning of the interviews.

5.3.4 Data Collection Procedure

Data collection took place from April 2022 to July 2022. Older adults and ageing health service providers who expressed interest in participating were invited to complete the online registration form and screened to check their eligibility for the interview. Eligible participants were then informed about the data collection procedure; the recording of the interviews; and how the data would be analysed, reported, and protected through written informed consent. Only those who gave their consent were scheduled for an interview. To comply with the SMMs, Zoom (Zoom Video Communications Inc) was chosen as the default interview medium, and a manual was provided to the participants whenever needed. Older participants who had unresolvable difficulty with Zoom were offered the option of a face-to-face interview. All eligible candidates were contacted either via phone calls or WhatsApp to receive further details of the study and get their interview schedules at their convenience. Informed consent and permission for interview recording were obtained in advance. All interviews were conducted on a one-on-one basis and were video recorded.

At the beginning of each interview, the study details were explained again, and verbal consent was obtained and recorded. Field notes of observations were documented, and important findings were recorded and confirmed with the

participants during the interviews to reduce misinterpretations. Participants received shopping vouchers worth SGD 20 upon successful completion of the semi-structured interview.

5.3.5 Data Analysis

Every participant was assigned a unique identifier (OPXX, where “OP” stands for “older participant”; APXX, where “AP” stands for “ageing health service provider”; and TPXX, where “TP” stands for “telehealth provider”) before data analysis, and all study data were deidentified during the transcription process. All interviews were transcribed verbatim in MS Word by myself, and all text data were transferred to MS Excel for thematic analysis. Participants who preferred Mandarin had their transcripts translated and reviewed to ensure the highest possible level of accuracy. As all interview sessions were moderated by myself, data analysis was performed immediately after each interview to maintain a fresh memory, with the aid of the field notes. The individual was chosen as the unit of analysis to identify each individual’s personal experiences and perceptions.

The **telehealth user journeys** for both groups were delineated, tracing a chronological progression from initial awareness of telehealth, through the decision-making process regarding adoption and utilisation, to the completion of the sessions, based on their touchpoints within a telehealth session.

Sentiment analysis was used to gauge the **attitudes** of both participant groups towards the general concept of telehealth, as well as their intention to use the potential domains of telehealth implementation discovered in Study One—

health consultation (teleconsultation) and health education (tele-education). Health monitoring was excluded for older participants as it was generally deemed unimportant (14/15) in their health seeking, as mentioned in Chapter 4.4.2.3.

Aligning with the earlier scoping review (115), this study also operationalised SEM to explore the **determinants of telehealth implementation** in Singapore's ageing care from five levels, namely, individual level, interpersonal level, technological level, system level, and policy level. Similarly, the corresponding **proposed implementation strategies** were categorised into five dimensions: telehealth users, technology design, service execution, policy, and research.

Besides sentiment analysis, thematic analysis was also employed, involving a meticulous line-by-line coding process while reading through the qualitative data. The generated codes were then grouped together based on each research question, with pattern codes emerging to highlight recurring themes. These identified codes were used in the subsequent interview sessions to assess the emergence of new ones and to gauge data redundancy. Due to the constraints of manpower, data collection and analysis were primarily conducted by YZ, yet frequent discussions were held to review the codes and themes.

5.3.6 Ethical Consideration

This study has been approved by the institutional review board of Nanyang Technological University, Singapore (Reference: IRB-2021-797).

5.4 Results

5.4.1 Participants' Characteristics and Interview Durations

A total of 29 interviews were conducted, where 15 (51.7%) were with older adults (OP01 – OP15), 12 (41.4%) were with ageing health service providers (AP01 – AP12), and two (6.9%) were with telehealth providers (TP01 – TP02). The mean (SD) interview duration was 39 minutes (SD = 15.5 minutes) for the older participants (including the section reported in Study One) and 29.4 minutes (SD = 11.1 minutes) for the ageing health service providers and telehealth providers.

5.4.1.1 Older adults

Older participants' information, digital access, and telehealth experience were summarised in Table 5-1, and the detailed information for each participant can be found in Appendix 2. Among the 15 interviewees, 13 managed to receive the interview on Zoom, and two preferred Mandarin as their default interview language. The mean age of the older participants was 65.8 (SD = 6.0 years). One-third (5/15) of them had a primary or secondary degree, 60% were not currently working, and more than half (8/15, 53.3%) had a monthly personal income of less than SGD 1,000. All had a personal smartphone. Seven participants were telehealth users and all used telehealth services for the first time during the Covid pandemic (three received teleconsultations and five received tele-education), seven participants were not offered a telehealth option, and one participant declined the teleconsultation appointment due to scheduling conflicts.

5.4.1.2 Ageing Health Service Providers and Telehealth Providers

Out of the 12 ageing health service providers who participated in this study, nine (75.0%) were female, 11 (91.7%) were Chinese, and four (33.3%) reported having 20 to 29 years of experience with computers. Five (41.6%) of them were physiotherapists, three (25.0%) were medical doctors, two (16.7%) were dieticians, and one each of a counsellor and an assistant manager from a non-profit social service agency. Eleven (91.7%) of them were telehealth users and ten (83.3%) perceived telehealth as relevant within the Singapore context. Table 5-2 summarises their characteristics, experience with technologies, and perceived relevance of telehealth in Singapore. Detailed information for each ageing health service provider can be found in Appendix 4.

Both telehealth providers were male. One was identified as both a co-founder of a telehealth service and a medical doctor (TP01, mixed-race ethnicity), while the other one held the position of the director within a non-profit charitable healthcare organisation (TP02, Chinese ethnicity).

These 14 professional participants shared a diverse array of telehealth modalities which reflected their utilisation of telehealth within their respective roles or workplace, including teleconsultation (both synchronous and asynchronous), telemonitoring, telerehabilitation (i.e., the delivery of rehabilitative service via infocommunication tools or the Internet (340,341)), tele-follow-up (i.e., the delivery of follow-up care to patients who have been triaged but not directed to the emergency department, or extending care to patients subsequent to their discharge from the emergency department, using

infocommunication or online platforms (342)), tele-education (i.e., the delivery of health education over infocommunication tools or the Internet (125)), tele-counselling (i.e., the delivery of therapy over the Internet to assist the communication between the therapist and client(343)), tele-nutrition (i.e., the interactive implementation of the nutrition care process by a registered dietician nutritionist (344)), tele-exercise (i.e., the delivery of physical training remotely (345)), tele-treatment (i.e., the remote provision of direct clinical care between healthcare professionals and patients/caregivers, such as history, triage, examination, diagnosis, and treatment (346)), and tele-advice (i.e., the remote provision of health information, advice, guidance, and recommendations but not for diagnosis, prognosis, or treatment purposes (347)).

5.4.2 Telehealth User Journey

An illustration of the telehealth user journeys for both ageing health service providers and older clients is plotted based on participants' user experience (Figure 5.1). For each participant group, the user journey can be divided into three phases: the pre-telehealth phase, the telehealth phase, and the post-telehealth phase.

Table 5-1 Characteristics of the older participants (N = 15)

Older Participants' Characteristic (N = 15)		n (%)
Age in years, (65.8 ± 6.0 years)		
55-59		2 (13.3)
60-69		8 (53.3)
70-79		5 (33.3)
Sex		
Female		9 (60.0)
Male		6 (40.0)
Ethnicity		
Chinese		13 (86.7)
Indian		1 (6.7)
Malay		1 (6.7)
Highest education achieved		
Primary and secondary		5 (6.7)
Pre-university		4 (26.7)
Degree and above		6 (26.7)
Employment status		
Homemaker		3 (20.0)
Retired		6 (40.0)
Employed part-time		4 (26.7)
Employed full-time		2 (13.3)
Estimated monthly income in Singapore Dollars		
0		5 (33.3)
<1,000		3 (20.0)
1,000 – 1,999		1 (6.7)
2,000 – 2,999		2 (13.3)
3,000 – 3,999		1 (6.7)
4,000 – 4,999		2 (13.3)
7,000 – 7,999		1 (6.7)
Ownership of a smart device		
Smartphone		15 (100.0)
Tablet		7 (46.7)
Personal laptop (non-work purposes)		11 (73.3)
Access to Wi-Fi at home		
Yes		13 (86.7)
No		2 (13.3)
Experience with telehealth		
No experience with telehealth		7 (46.7) - Not offered with telehealth options 1 (6.7) - Rejected to use teleconsultation
Teleconsultation		3 (20.0)
Tele-education		5 (33.3)
Acceptance of the general telehealth concept		
Yes		13 (86.7)
No		2 (13.3)
Intention to use		
Teleconsultation	Yes, and would like to use	2 (13.3)
	Yes, but prefer in-person visits	6 (40.0)
	No	7 (46.7)
Tele-education	Yes	4 (26.7)
	No	11 (73.3)

Table 5-2 Healthcare professional participants' characteristics (N=12)

Health Service Provider Participants' Characteristics (N = 12)		n (%)
Age		
<30		5 (41.7)
30-35		5 (41.7)
36-40		1 (6.7)
>40		1 (6.7)
Sex		
Female		9 (75.0)
Male		3 (25.0)
Ethnicity		
Chinese		11 (91.7)
Others (Mixed-race)		1 (8.3)
Highest education level		
Degree		7 (58.3)
Master		5 (41.7)
Current job		
Allied Health Professional (physiotherapist)		5 (41.6)
Counsellor		1 (8.3)
Dietician		2 (16.7)
Doctor		3 (25.0)
Manager		1 (8.3)
Nature of the institution		
Day Rehabilitation Centre		2 (16.7)
Public Hospital		4 (33.3)
Private Clinic		2 (16.7)
Non-profit Social Service Agency		4 (33.3)
Workload (hours/week)		
40		4 (33.2)
42		3 (25.0)
42.5		3 (25.0)
55		1 (8.3)
70		1 (8.3)
Computer experience (in years)		
10-19		8 (66.7)
20-29		4 (33.3)
Experience with telehealth		
Yes		11 (91.7)
No		1 (8.3)
Perceived relevance of telehealth in Singapore		
Somewhat Irrelevant		1 (8.3)
Neutral		1 (8.3)
Somewhat Relevant		8 (66.7)
Extremely Relevant		2 (16.7)

5.4.2.1 Ageing Health Service Providers' User Journey

Pre-telehealth Phase

In the pre-telehealth phase, several essential tasks set the foundation for the successful implementation of telehealth services. This phase involved meticulous preparation, strategic planning, and thoughtful considerations to ensure the feasibility and workflow of the transition to remote healthcare.

One of the fundamental activities during this pre-telehealth phase was the review of clients' information and the development of eligibility criteria so that health service providers could appropriately identify those clients who may require in-person services as well as those who could receive telehealth services for the enrolment.

Simultaneously, health service providers would work on developing protocols and pilot testing. The protocols would be designed to optimise the telehealth experience for both providers and clients while maintaining the highest standards of care. Pilot testing could allow providers to fine-tune these protocols, ensuring that any technical or logistical challenges can be addressed before full-scale implementation.

Obtaining clients' consent was another crucial step in the pre-telehealth phase. Ageing health service providers would communicate the benefits, risks, and processes of telehealth with their clients and obtain their informed consent to be admitted.

Subsequently, health service providers would help their consented clients with appointment bookings and provide necessary technical assistance, so that these clients could be more confidently engaged in remote health communications.

Telehealth Phase

This phase was where the virtual interactions between health service providers and their clients happened, which was similar to the in-person visits, but through a virtual environment. It commenced with inviting clients to the virtual waiting room, a virtual space for both end-users to get ready for the upcoming session. To avoid possible wrong clients or scammers admitted into the session, health service providers would further verify their clients' information.

After the conversation started, health service providers would guide their clients to share their specific concerns, questions, or health issues, and provide their advice. Once the session was concluded, they may be also engaged in data entry and other follow-up actions, such as making next appointments, prescribing medications, sharing educational materials, and/or making referrals.

Post-telehealth Phase

This phase occurred after the telehealth sessions had concluded and was dedicated to optimising the overall telehealth experience and work efficiency. The first step involved debriefing and taking time to review the whole workflow. Based on the reflections, the telehealth protocols were constantly refined by identifying areas for improvement and incorporating lessons learnt from previous sessions. Additionally, equipment and platforms used in the Telehealth

Phase were regularly assessed and enhanced to ensure they met the standards for security, reliability, and user-friendliness. The last step, communications with upper management, allowed these health service providers to relay feedback from both the providers and clients as well as challenges to the higher-level management team. This was crucial for gaining support and resources for ongoing telehealth initiatives and receiving the necessary back for sustained improvement. In an iterative manner, the insights and adjustments could feed back into the pre-telehealth phase.

5.4.2.2 Older Clients' User Journey

Pre-telehealth Phase

The pre-telehealth phase for older clients began with receiving a telehealth invitation, followed by their consent. Then they would be assisted in scheduling their telehealth appointments, with some ageing health service providers providing necessary guidance or technical assistance.

Telehealth Phase

During the telehealth phase, older clients would receive appointment reminders in advance, so that they could make necessary preparations, for example, checking their devices, gathering the results of physiological parameter measurement, and stationeries ready for health education sessions. After staying in the virtual waiting room, they would be able to start their telehealth sessions once the connection was established.

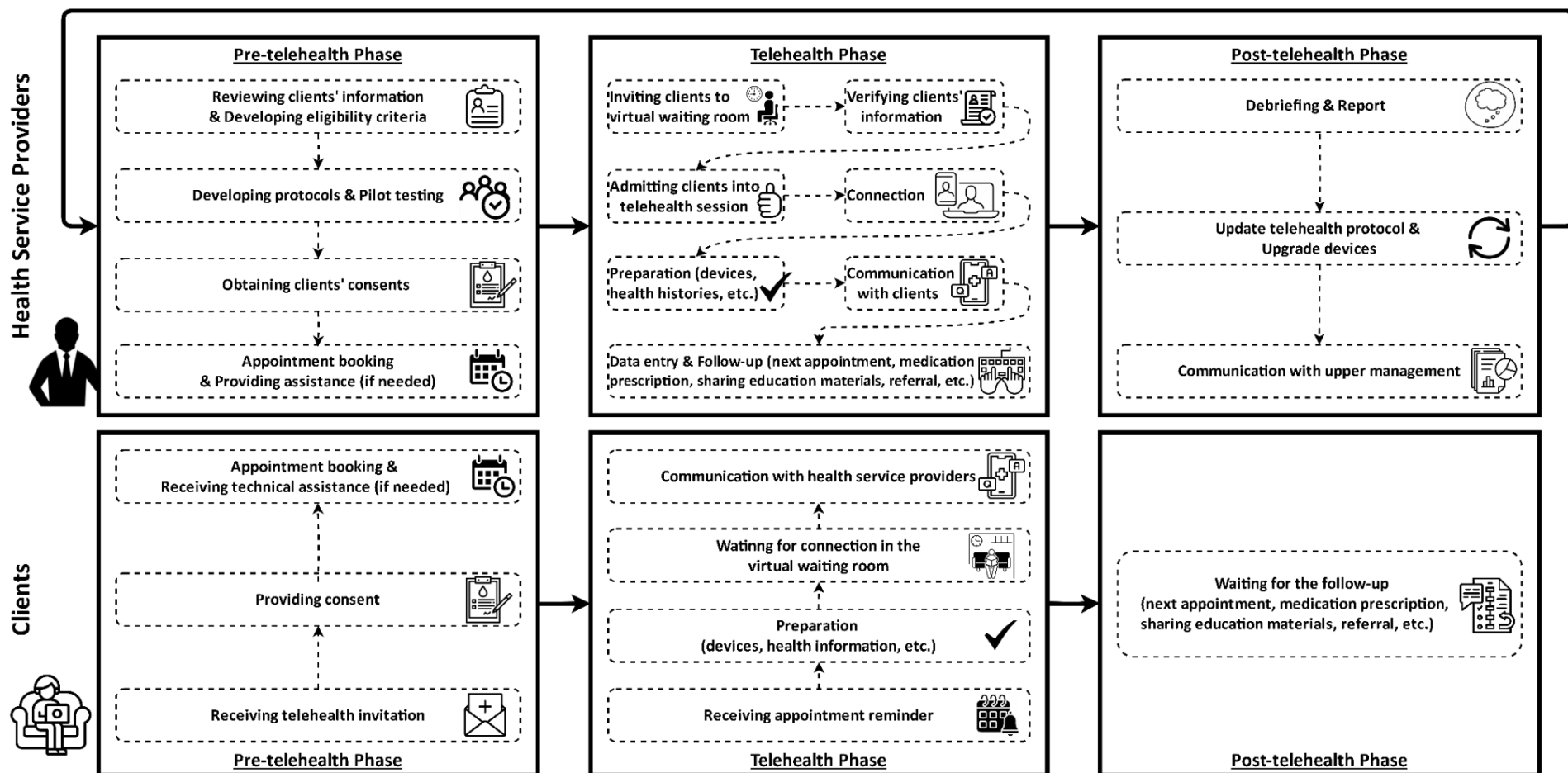


Figure 5.1 Telehealth user journey for both the ageing health service providers and clients

Post-telehealth Phase

In the post-telehealth phase, older clients would transition to the follow-up actions. This included but was not limited to waiting for the next appointment booking, medication prescription and delivery, making payments, or receiving a copy of the educational materials.

5.4.3 Attitudes Towards Telehealth Modalities

5.4.3.1 Older Adults

Thirteen (86.7%) older participants were receptive to the general telehealth concept, however, only a small portion considered different telehealth modalities useful and would be interested in using them. Eight accepted synchronous teleconsultations, among whom six still preferred in-person consultations with healthcare providers. The main reasons for the low perceived usefulness were perceived good health and convenient access to the existing primary care services, which were also influenced by the low perceived usefulness of telemonitoring:

*In my case, I only see the doctor twice per year, so I still **prefer**
to see her in person at least once a year.*

OP07

*I live nearby the KTPH [Khoo Teck Put Hospital], so I **don't**
really need telehealth [teleconsultation].*

OP15

Four participants would like to adopt or continue using tele-education as a more comfortable, convenient, and less distracting means of gaining health information. For example,

*Actually, I prefer Zoom because I have **less [fewer]** **distractions** like now. All I need is to just look at your face, whereas in the classroom I can look elsewhere. I **prefer Zoom**, and it's so **comfortable**. If I want a drink halfway, I can just go.*

OP05

Despite the low intention to use telehealth, most of the older participants perceived telehealth as relevant to the Singapore context, and would become a norm of future healthcare, for example:

*For pandemic condition[s], I cannot go out and they cannot come in, so telehealth is good. I think telehealth is **going to be very popular** in Singapore...*

OP06

*I think in the longer term, especially with the younger people, it [telehealth] **will be a norm** in a not distant future...*

OP10

5.4.3.2 Ageing Health Service Providers

Among the 12 ageing health service providers, only one did not like the idea of telehealth:

*In my opinion, I **don't like it**, it **has a big effect on our ability to do what we do in the way that I practice**, so I think it takes away quite a lot from what we do, not being able to be face-to-face with somebody.*

AP03

Due to the nature of the two telehealth providers' occupations (one medical doctor and one director of a non-profit charitable healthcare organisation), they were also working to provide ageing health services to the older population. Therefore, their responses are reported together with the ageing health service providers (called professionals for short).

Most professionals valued the benefits of telehealth, and viewed it as the future trend of healthcare, for example:

*I think this is proven to be another mode of communication with the clients, so I feel **it's good in the long term**, it also allows for flexibility, allows for convenience.*

AP10

...So there is still [a] challenge in such delivery. But will we put a stop to it? I don't think so, I think this could be one of the ways in which the future would be for care delivery. That's so far how I look at it.

TP02

Telehealth providers also mentioned that telehealth should be a complement rather than a substitute for the traditional healthcare model:

*We are **not here to disrupt**, we are **not here to replace**, we are here to offer this for them to really think about whether they will pick it [telehealth] up, pick up the offer... We **don't promote**, we give the option to them. What we want ultimately is really about tying seniors back to the primary care. **If there are doctors downstairs then just go to the doctor, if they don't provide, then then ok we may come in to fill the gap if there is a need for it. But ultimately they should go back to just one doctor and the primary care so that they know about their conditions, they know about the family history, etc.***

TP02

5.4.4 Determinants Affecting Telehealth Implementation

Both groups of participants' perceived facilitators of and barriers to telehealth adoption were categorised into the individual, interpersonal, technological, and system levels, as illustrated in the heat map (Figure 5.2 and Figure 5.3). These factors collectively could also serve as the "Determinants" component in the IRLM. Sample quotes are summarised in Appendix 5 and Appendix 6.

5.4.4.1 Older Individuals' Perceived Determinants

Individual Level

At the individual level, three main barriers to telehealth adoption were reported.

Firstly, older adults always experienced **age-related declines** in both physical and cognitive functions, such as hearing and eyesight, which may affect their ability to effectively navigate telehealth platforms and utilise digital devices.

Secondly, participants shared that they were concerned that they lack the necessary skills and familiarity with technologies to confidently engage with telehealth services, and such **digital literacy** barriers may result in challenges in operating devices, navigating software interfaces, and troubleshooting technical issues.

Lastly, due to the unfamiliarity and perceiving telehealth as impersonal compared to traditional in-person healthcare interactions, it may require a change in older people's **mindsets to improve their comfort levels** with telehealth adoption.

Interpersonal Level

At the interpersonal level, four barriers were shared. Firstly, the **lack of in-person intimacy** posed a challenge, as telehealth interactions lacked the physical presence, physical touch, and non-verbal cues that could facilitate connection and trust-building between individuals. This absence may in turn impact the quality of communication and care delivery.

Secondly, **building rapport** was difficult, as establishing a sense of mutual understanding and trust can be more challenging in virtual environments compared to face-to-face interactions.

Thirdly, **language barriers** exacerbated communication challenges, particularly in Singapore's multicultural or multilingual settings where language proficiency may vary among patients and providers. Moreover, the medical terminologies used by health service providers may not always be understood.

Lastly, **health service providers' communication styles** could impact patient-provider interactions as well as patients' engagement, comprehension, and satisfaction with telehealth services, as all individuals may have different preferences or expectations regarding communication methods and styles.

Technological Level

At the technological level, several barriers were identified.

Firstly, telehealth service quality must rely on stable and high-speed **internet connections** for seamless communication and data transmission. Inadequate internet infrastructure or connectivity issues can disrupt telehealth sessions, leading to delays, interruptions, or dropped connections, which may compromise the quality of telehealth delivery.

Secondly, **hardware** limitations posed an inconvenience for older adults, as not everyone had access to suitable devices such as smartphones, tablets, or computers equipped with the necessary features and functionalities for telehealth interactions. Insufficient, incompatible, or outdated hardware and

small sizes of devices can impede participation in telehealth services and limit individuals' ability to engage effectively with healthcare providers.

Thirdly, **data insecurity** is another significant concern, as telehealth involved the collection, transmission, and storage of sensitive health information over digital networks.

System Level

At the system level, participants acknowledged that telehealth could help them improve access to health services. They highlighted the **convenience** that telehealth could offer, allowing them to access health services from the comfort of their own homes without the need for travel or transportation arrangements. This convenience could be especially beneficial for individuals with **mobility** limitations.

In addition, telehealth can lead to **shorter waiting times** and the time spent on travelling and queueing at hospitals, clinics, and pharmacies. Participants also recognised **lower costs** for telehealth sessions compared to traditional in-person encounters. Finally, telehealth **could reduce infection risks**, especially during public health crises like the COVID-19 pandemic, by minimising in-person contact and potential exposure to contagious diseases in crowded healthcare settings.

Meanwhile, several barriers were also identified. One major concern was the **challenge of conducting sufficient physical examinations** remotely. While telehealth platforms could offer opportunities for virtual consultations, they

may lack the ability to perform comprehensive physical assessments but sometimes rely on self-reported health data, which could be inaccurate due to inaccurate device calibration or inability to perform accurate measurements.

Another barrier is the **lack of access** to telehealth services, where some participants mentioned that they were never offered telehealth options.

Insufficient manpower and resources could pose additional challenges to the widespread adoption of telehealth, where some users have reported spending extra time getting a doctor.

Furthermore, there may be **uncertainty surrounding the effectiveness** of telehealth interventions, leading to scepticism among users. Without clear evidence demonstrating the benefits of telehealth for specific health conditions or patient populations, stakeholders may hesitate to embrace these technologies fully.

Additionally, **challenges in scheduling appointments** could contribute to the barriers faced at the system level, particularly for those with fixed routines. Last but not least, confusion caused by the proliferation of similar telehealth applications and platforms can also hinder older adults' adoption.

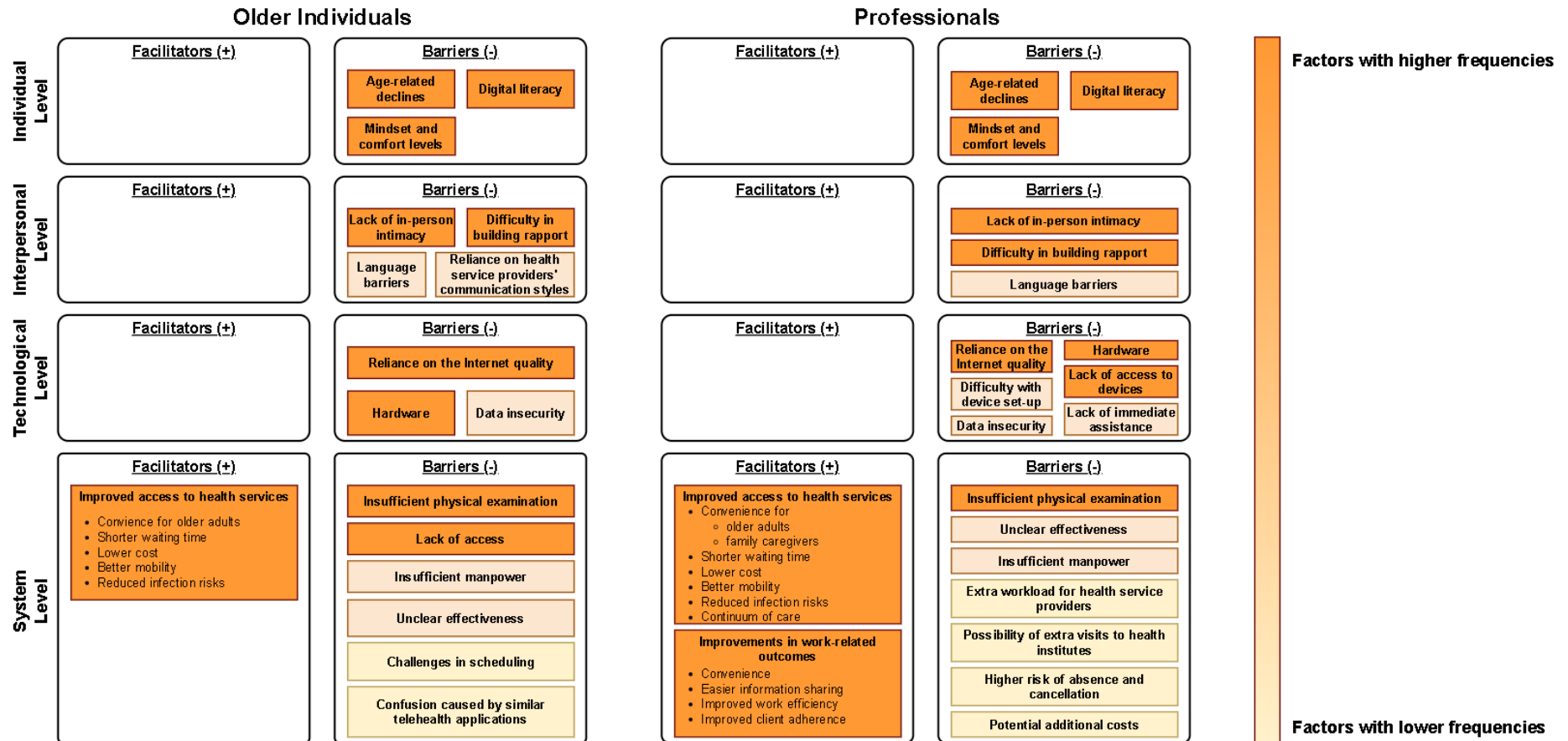


Figure 5.2 Heat map for the facilitators of and barriers to telehealth adoption among older adults and professionals (including healthcare professionals, social health providers, and telehealth providers), with a darker colour indicating higher frequencies

5.4.4.2 Professionals' perceptions

Individual Level

From the perspectives of health providers, several barriers existed at the individual level that may hinder the successful implementation and adoption of telehealth initiatives.

Firstly, older adults may experience **age-related declines**, such as physical impairments, sensory deficits, and functional limitations that could affect their ability to adopt telehealth.

Secondly, **digital literacy levels** varied not only among older adults but also among health service providers, influencing their ability and confidence to use technologies effectively.

Thirdly, **mindset and comfort levels** played a critical role in shaping the attitudes, perceptions, and readiness of older adults and health service providers towards telehealth adoption.

Interpersonal Level

Three barriers were identified at the interpersonal level. Firstly, the **lack of in-person intimacy** presented a significant challenge. Unlike traditional face-to-face interactions, telehealth encounters could lack the physical proximity that fosters a sense of connection and trust between providers and patients. The inability to establish eye contact, offer a reassuring touch, or observe non-verbal cues may hinder the development of rapport and empathy, potentially

impacting the quality of care delivered. Thus, health service providers may spend a long time or even face difficulties in **building rapport** with their clients during telehealth sessions.

Language barriers posed another challenge for health providers engaging in telehealth sessions. Some non-local doctors reported difficulties in communicating with their patients and their caregivers, especially with domestic workers who may not understand their accents or the technical jargon.

Technological Level

Four technological barriers were reported to potentially hinder the effective implementation of telehealth initiatives:

Firstly, concerns regarding **internet connectivity** were also expressed by the professionals. Some older adults had no Internet access, and utilising their data plans may result in complaints. Besides, **hardware** limitations presented another barrier to telehealth adoption among health providers, as not everyone may have a laptop, and the small sizes of mobile phones might limit the convenience of telehealth.

Difficulty with device set-up can also impede health providers' adoption of technologies. Configuring telehealth platforms, installing software updates, troubleshooting technical issues, and integrating telehealth systems with existing electronic health records (EHRs) can be complex and time-consuming processes.

Next, concerns about **data insecurity** posed another significant barrier to telehealth adoption among health providers. Telehealth platforms should rely on the secure transmission, storage, and handling of sensitive patient information, including personal health records, medical images, and diagnostic test results. However, the use of digital communication channels and cloud-based storage systems when integrating into the health infrastructure may introduce potential risks, such as data breaches, unauthorised access, and cyberattacks.

System Level

At the system level, health service providers presented several facilitators which could enhance the successful implementation and adoption of telehealth:

Firstly, **improved access to health services** could offer significant benefits for both providers and clients. Telehealth could provide convenience for older users, family caregivers, and ageing health service providers by eliminating the need for travel to healthcare facilities, reducing transportation barriers, and minimising geographical constraints. Clients can access health services from the comfort of their homes, saving time and effort associated with commuting to appointments, navigating public transportation, and waiting in crowded waiting rooms. Subsequently, this could also potentially reduce the need for their caregivers to take time off from work to accompany their family members. Similarly, health providers can enjoy the convenience of telehealth when dealing with simpler cases. Telehealth could offer shorter waiting times for clients, enabling timely access to care and fast service, which can lead to better

health outcomes and improved user satisfaction. Telehealth services also often entailed lower costs for clients compared to traditional in-person visits. Furthermore, telehealth enables better mobility for older individuals with mobility limitations, chronic conditions, or disabilities, who may face challenges accessing traditional health services. Additionally, telehealth consultations could contribute to reduced infection risks for patients, providers, and staff by minimising exposure to contagious diseases, such as respiratory viruses, during face-to-face interactions. Amidst public health crises, such as the COVID-19 pandemic, telehealth offered a safe and effective alternative to in-person visits, allowing healthcare organisations to maintain continuity of care.

Secondly, **improvements in work-related outcomes** were shared by the professionals. Certain telehealth applications have been equipped with extra features that have enabled health service providers to share information with their clients more easily. Telehealth also had the potential to enhance health service providers' work efficiency, for instance, teleconsultation enabled them to minimise the waiting time between clients, and tele-education sessions allowed more audiences to participate simultaneously. Some professionals also believed that the convenience offered by telehealth could improve their clients' adherence to their disease management and follow-up care.

Despite these facilitators, several systemic barriers also presented to impede the successful implementation of telehealth services:

Firstly, telehealth did not involve sufficient **physical examinations** or **clear physical illustrations**, and thus professionals were concerned that there might be a risk of inaccurate diagnosis or information sharing.

Secondly, according to some physiotherapists, their clients still preferred physical sessions as they could **receive immediate assistance** in case of wrong postures, loss of balance, or falls. A counsellor also expressed her concerns as she could not assess if her clients were in a safe environment during tele-counselling sessions.

Thirdly, in terms of the **effectiveness** of telehealth sessions, some professionals expressed challenges in ensuring that their clients comprehend the health information they are trying to convey. Moreover, the effectiveness of telehealth in improving clients' health outcomes remained unclear due to a lack of research studies and a short follow-up period.

Fourthly, **insufficient manpower** might bring **extra work** to the health service providers, particularly when conducting telehealth sessions was not yet part of their existing workflow. Telehealth sessions sometimes may require providers to adapt to new workflows, protocols, and technologies, which may increase administrative burdens, documentation requirements, and time commitments. Providers may spend more time preparing for virtual encounters, troubleshooting technical issues, and coordinating care remotely, leading to decreased productivity, efficiency, and job satisfaction. Moreover, providers may experience challenges in balancing telehealth responsibilities with other clinical duties, further exacerbating workload pressures and stress levels.

Additionally, providers may face challenges in managing interruptions, distractions, and competing demands during telehealth sessions, impacting their ability to focus, communicate effectively, and deliver patient-centred care.

Next, some ageing health service providers have expressed concerns that clients may require **additional in-person visits** to address medical issues that cannot be fully resolved through telehealth sessions, and this may potentially result in patient complaints. Consequently, healthcare professionals may need to spend more time managing such complaints rather than attending to more patients.

What's more, telehealth sessions may experience a risk of **higher absence or last-minute cancellations** compared to physical sessions, according to some professionals. Some providers also expressed that the cost of subscription fees for certain telehealth platforms can create an additional burden, which was why they had switched to free platforms. In addition to platform subscriptions, other **possible extra payments** might be attributed to the purchase of equipment or devices for better care quality.

5.4.5 Proposed Implementation Strategies

Both older adult and professional groups suggested different implementation strategies to facilitate telehealth implementation in ageing care. Similar to the categorisation of facilitators and barriers, the implementation strategies were also able to be organised into different levels: telehealth users, telehealth technology design, telehealth service execution, policy, and research (summarised in Figure 5.3).

5.4.5.1 Older Individuals' Proposed Implementation Strategies

According to older participants, at the user level, **training sessions** could be offered to empower older users, especially those who were not tech-savvy. Regarding telehealth technology design, participants recommended prioritising **user-centred design** to ensure that telehealth solutions are accessible, inclusive, and tailored to the specific needs and preferences of older adults. Additionally, at the telehealth service execution level, there was a consensus among participants to adopt a **hybrid format** that combines virtual consultations with in-person interactions and everyone recognises the significance of maintaining **human elements** in health service delivery. At the policy level, participants suggested the provision of **subsidies or insurance coverage** to alleviate financial barriers to telehealth access, and such information should be **made transparent** to help users make informed decisions. Sample quotes are summarised in Appendix 7.

5.4.5.2 Professionals' Proposed Implementation Strategies

The professional group also offered a comprehensive list of implementation strategies to facilitate the integration of telehealth in ageing care. At the telehealth user level, there was a recognised benefit in **empowering both older users and health service providers** through training, as well as seeking increased **support from caregivers** to facilitate care recipients' effective engagement with telehealth services. Besides, they emphasised the necessity for **user-centred design** in telehealth technology development to ensure accessibility and usability for older individuals. In terms of telehealth service

execution, there was a consensus among professionals on adopting a **hybrid approach** that combines virtual consultations with in-person interactions, while also fostering collaboration with different stakeholders to maximise the reach and impact of telehealth interventions. At the policy level, in addition to **subsidies and insurance coverage** proposed by the older participants, there was also a call for formal **integration of telehealth into the healthcare system** and increased **support and funding opportunities** from regulatory bodies. An additional level, research, underscored the importance of **research** in developing algorithms to pre-select eligible clients to ease health service providers' workload and confirm telehealth's effectiveness and cost-effectiveness to drive evidence-based telehealth implementation and innovation in ageing care. Sample quotes are summarised in Appendix 8.

5.5 Discussion

5.5.1 Principal Findings

The rapid transition from traditional healthcare to telehealth during the COVID-19 pandemic has presented some challenges for older adults (115), such as technical difficulty (Elbaz et al., 2021; Foster & Sethares, 2014), technology access and utilisation (138,142,156,162), scepticism about telehealth benefits (135), as well as concerns regarding cost (139,156) and data privacy (156,175). These barriers may hinder the widespread post-pandemic adoption of telehealth among older adults and should be factored in when designing and implementing user-centred telehealth services.

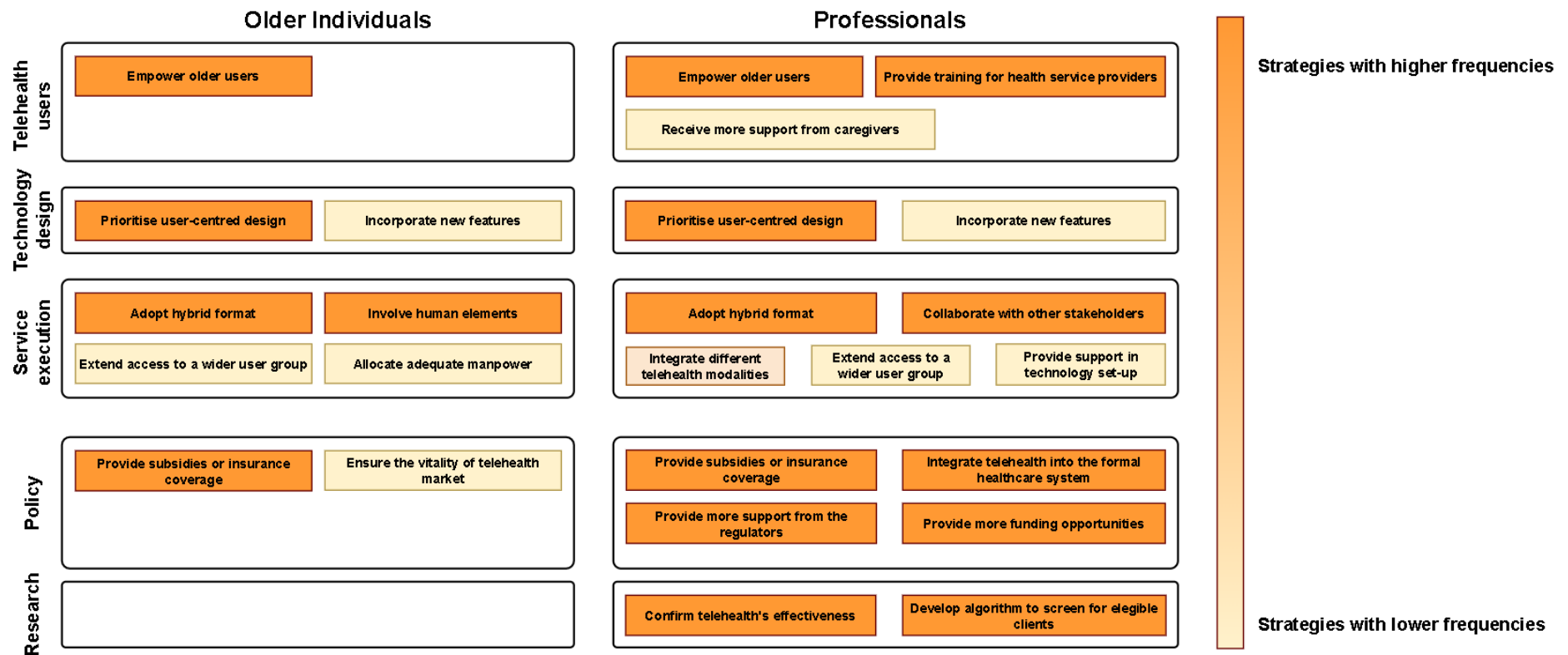


Figure 5.3 Heat map for the perceived implementation strategies among older adults and professionals (including healthcare professionals, social health providers, and telehealth providers), with a darker colour indicating higher frequencies

This interview study expanded upon the existing body of literature by incorporating perspectives from a wider spectrum of stakeholders as well as non-users, and the responses of the 29 participants from different stakeholder groups triangulate and complete each other.

5.5.2 Acceptance of the Telehealth Concept

Although the majority of the participants (13/15 older participants and 14/15 professionals) were in favour of the general telehealth concept, and perceived telehealth as not only an inevitable outcome of the current circumstances but also a transformative trend shaping the future of ageing health service delivery. However, there was a difference in older participants' perceived usefulness and intention to use telehealth:

They showed less interest in teleconsultation as they generally did not have a high demand for medical services and could easily access primary care services when needed. The earlier data analysis (302) with the same group of participants showed that they were able to be aware of bodily symptoms, and self-adjust lifestyle or help-seeking behaviour accordingly. In addition, the primary care network in Singapore with about 23 outpatient polyclinics and 1800 private clinics run by GPs island-wide (348) and offers a good level of easy and convenient access to healthcare services. However, this in turn reinforces the the potential of telehealth implementation and its significance in preventive care.

In comparison to teleconsultation and telemonitoring, tele-education seemed to be better supported where clinical safety and technological challenges were less concerning among older adults. It might be because tele-education is primarily a means for information gathering rather than a clinical practice, and the application used was relatively simple (only Zoom was reported). Meanwhile, participants also shared that they could easily access health information via different channels (e.g., social networks, health professionals, and online resources) (302), and that might be one possible explanation for why more than 70% of them did not view tele-education as essential.

5.5.3 Implementation Strategies

In traditional implementation research, implementation frameworks, such as ERIC, are often used as a guiding tool to enhance conceptual clarity, relevance, and comprehensiveness of implementation strategies. However, there remains a concern that such approaches may oversimplify or generalise the complex implementation processes and offer recommendations from implementers' perspectives since implementation is context-dependent and implementation strategies could be more successful and relevant when informed by the actual users who will use the target intervention (354). In this study, various implementation strategies were identified via interviews with different stakeholders, including both users and non-users, as well as older clients and health service providers. Many of these strategies identified are consistent with the ERIC discrete strategies list compiled based on the expert recommendations

(246), further reinforcing the validity and robustness of the study results. Some examples are summarised in Appendix 9.

In a systematic review published earlier this year, Stoumpos et al. stressed that telehealth “must be adopted in a concerted effort to resolve all the obstacles we are currently facing” (353). Participants in this study similarly advocated for coordinated actions, and put forth several possibilities for collaboration: (1) synchronous and asynchronous telehealth modalities with additional features; (2) digital technologies and human involvement; 3) various stakeholders of the telehealth ecosystem, including but not limited to older individuals, family caregivers, clinical and community health service providers, designers of telehealth platforms and services, telehealth providers, and regulators; (4) formal healthcare systems and ground-up initiatives; and (5) telehealth implementation and research efforts. By working together, it would be possible to pave the way for an inclusive, scalable, and sustainable telehealth landscape while ensuring the equitable and efficient delivery of quality health services (115).

5.5.4 Determinants Affecting Telehealth Implementation in Singapore’s Ageing Care

The COVID-19 pandemic brought about substantial disruptions in the landscape of traditional in-person health services (349,350). In response, telehealth, though not a new concept, has garnered considerable attention to complement the existing healthcare system and offer an alternative means to provide a continuum of care and alleviate the burden caused by a shortage of medical

manpower (351). Almost all participants, older participants and professionals, users and non-users, intended to use telehealth in the future or not, reached a common belief that telehealth would be the future of healthcare.

Gochhait et al. highlighted that telehealth is an important healthcare innovation, from not only technological but also cultural and social perspectives (352). It enhances access to health services as well as the efficiency of health organisations, tackling the 21st-century challenges arising from the socio-economic changes, such as increasing healthcare demands, rapidly ageing populations, rising need to manage a flood of information, and budget constraints (352,353).

Some of the reported facilitators include convenience for older clients, family caregivers, and ageing health service providers; as well as improved access to health services for older individuals (e.g., shortened waiting time, lower cost, reduced infection risks, and linking people with mobility issues to health services), and these are aligned with the results reported in my earlier scoping review (115). Moreover, the professional group also reported an improvement in their work-related outcomes—telehealth makes information sharing with their clients much easier, their work more efficient, and their clients more adherent to health services.

Besides these facilitators, telehealth has certain significant barriers that impede its wider implementation in ageing care. In this study, the reported barriers were further categorised into the individual, interpersonal, technological, and system levels, guided by and aligned with the earlier scoping review (115).

Interestingly, while the responses from different groups of participants exhibited a good level of consistency, some “contradicting” viewpoints and experiences have been observed within the study. For instance, while all participants highlighted convenience as a key advantage of telehealth, some professionals shared their increased workload due to the need for creating screening criteria and selecting eligible clients for telehealth visits, and a telehealth provider also noted instances where patients expressed dissatisfaction when telehealth failed to fully address their medical issues and healthcare professionals had to invest additional efforts in managing these complaints; some older individuals expressed interest in picking up telehealth but they may not satisfy the “eligibility criteria” set by the ageing health service providers, while some may be granted access to telehealth visits but declined the appointment due to difficulty with scheduling; many participants reported a reduced cost for telehealth visits, yet some ageing health service providers incurred extra expenses on telehealth platform subscription as well as the purchase of necessary equipment to enhance telehealth service quality; the absence of the need to attend physical appointments and reduced waiting times seemed to positively impact older people’s adherence to follow-up sessions, but the risk of absence and last-minute cancellations was also reported increased.

Such “conflicts” might arise due to the varying complexity of user journeys for older adults and ageing health service providers. In this study, the professional participant group incorporated telehealth as an integral part of their routine work procedure and had to constantly optimise the workflow to cater to the

needs of different client profiles. Therefore, their user journey was iterative and involved many other stakeholders.

At the same time, these “conflicts” further reinforce the importance of equally valuing the perspectives of both telehealth users and health service providers. These perspectives, combined with the global decline in telehealth utilisation since the relaxation of stay-home restrictions (97,194–198) make it imperative to devise sustainability strategies to enhance inclusivity and equity while maximising the positive impacts of telehealth implementations on both older users and health service providers.

5.6 Reflection

The findings from this interview study reaffirm the possibility of telehealth in ageing care in the Singapore context and prompt a series of questions for consideration:

- 1) In light of older adults’ adoption of the existing technologies to facilitate their HSB and their concerns over the technologies used in telehealth services, would it be more pragmatic to integrate and refine existing technologies into a system than invest in developing novel technologies, in order to align with users' specific needs and preferences?
- 2) With a substantial portion of older individuals still not engaging with telehealth, will ground-up telehealth initiatives, particularly in health monitoring and health education areas, be able to improve their access to and change the older adults’ attitudes toward telehealth?

- 3) How could the identified determinants and implementation strategies be utilised to guide the design and implementation of future telehealth interventions?

CHAPTER 6 STUDY THREE

This chapter has been submitted as:

Zhang, Y., Law, M., Wee, S., Lee, B., Chew, B., Lee, E., Teo, W. (2023) Feasibility of a community-based phygital telemonitoring program for older adults: A multi-site observational study in Singapore

Student's roles in this study:

Phase I implementation: Design and implementation of CTS in phase 1 with the co-founders of Technologies Pte Ltd.; liaison with sponsors and community partners; and conducting health screenings and volunteer training;

Phase 2 & 3 implementation: Grant application; leading the design and implementation; liaison with university, sponsors, and community partners; re-developing SOP, safe management measures, and volunteer training materials; volunteer recruitment; logistics planning and execution; publicity material design and community outreach; conducting health screenings and volunteer training; finance management; assisting with university and community events as well as media release; and progress report preparation;

Research design and execution for all 3 phases: literature search and user feedback survey design; IRB application; operating statistics and user feedback analyses; and manuscript writing.

One important finding from the semi-structured interviews in Study One is that most (14/15) of the older participants typically relied on the health assessments during their health screening or follow-up appointments at the healthcare institutions and did not seem to self-measure their physiological parameters outside the healthcare settings. Some contributing factors reported included the inability to schedule, lack of necessary equipment at hand, and difficulty in performing accurate measurements. In Study Two, however, the professionals emphasised that these regular consultations could only provide a snapshot of their patients' health status, and it was, therefore, crucial to gather continuous health data from their clients to more accurately reflect their actual lifestyle, medication adherence, and health conditions. This chapter presents a possible telehealth solution—a community-based multiuser telemonitoring programme to address this gap while trying to reach a potentially larger group of beneficiaries.

6.1 Background

The global challenges of ageing arise from people living longer and the dropping fertility rates (355) leading to a projected doubling of the population aged 65 years or older from 2021 to 2050 (3). It is accompanied by gradual deterioration of physical and mental capacities and increased vulnerability to diseases (1). NCDs, such as cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes, are particularly prevalent among older individuals and account for 74% of all deaths globally (356). This demographic shift brings about societal challenges from the economy to healthcare policies (1,3).

Singapore has a rapidly ageing population (357) with a surging proportion living with multiple NCDs (358–360), and on average an individual may spend the last 10.6 years of their lives in poor health conditions (1,356,361). This underscores the need for effective screening, monitoring, and educational interventions targeted at this demographic (362–364), so as to pursue diverse interests and make meaningful contributions throughout their lives (1,3).

In the traditional healthcare model, health professionals could only review their patients during in-person visits, and complications may arise along with missed opportunities for early intervention (365). This is notwithstanding underreported cases due to low participation in health screening and self-measurement practices, especially the “3-Highs” (high BP or hypertension, high blood cholesterol or hyperlipidaemia, and high blood sugar or diabetes) which disproportionately affect the underprivileged (362–364,366). Moreover, the COVID-19 pandemic led to the deferment of non-urgent health services, lowered participation in NCD and cancer screenings (367), and the safe management measures might have impacted older individuals’ healthy lifestyle practices (367).

These factors spurred the use of telehealth brought about by the advent of smart health technologies, such as wearable sensors coupled with mobile applications or computer software (368). It simplified and enhanced the access to taking serial measurements and self-monitoring of physiological parameters outside the traditional healthcare settings (368). This has shown potential in providing reliable health data and empowering older individuals, caregivers,

and healthcare professionals alike to create better awareness of one's vitals, influence health behaviours, and track interventions towards a better overall quality of life (369–371), especially when analysed in conjunction with individualised reference ranges (301).

Although local health institutes have introduced home-based telemonitoring services to aid patients in monitoring their NCDs (92,365,372–375), these services may not be readily available to those with low health screening participation or undetected conditions. Moreover, some barriers associated with this approach may make it less suitable for older adults, such as perceived low usefulness (302,376), concerns over cost (376), challenges in accessing or operating the technologies without sufficient support (302,336), as well as privacy and safety concerns (302,336).

To overcome the limited access to home-based telemonitoring, community-based telemonitoring programmes are offered to underserved populations with minimal or no cost (377,378), having the potential to bridge the digital divide and mitigate health inequalities (379). However, the lack of user engagement, a key challenge stemming from the unawareness or uncertainty about the benefits and low motivation to partake in these programmes (380,381), always results in unsuccessful implementation or low adoption (377). It is therefore crucial to assess the viability of these programmes and address potential issues before advancing further.

6.2 Aim and Research Questions

To tackle these challenges, the Community Telehealth Service (CTS), a community-based multi-user phygital telemonitoring programme, was launched and implemented amidst the COVID-19 pandemic for community-dwelling older adults. This feasibility study aims to answer the following two main research questions (RQs):

RQ1: To what extent is a community-based telehealth programme a feasible initiative in extending telehealth services to community-dwelling older adults?

RQ2: What are the key areas of improvement to motivate the uptake of community-based telehealth programmes?

6.3 Methods

6.3.1 Design of CTS

CTS¹ is a community engagement project, with the primary objectives to address older individuals' barriers in utilising technologies and to raise their awareness about the importance of regular health monitoring. Drawing upon insights from Study Two participants and existing literature on community-based telemonitoring programmes (377,379), the prototype development and

¹Disclaimer: CTS is designed **NOT** as a replacement but rather a complement to traditional healthcare delivery for the older population, by lowering their barriers to accessing personal health monitoring technologies, linking them back to the formal healthcare system, and extending healthcare beyond the clinical settings.

implementation process was informed by the identified barriers to telehealth adoption and relevant implementation strategies under the guidance of the IRLM (Figure 6.1).

The implementation strategies were first drafted under the guidance of the ERIC discrete strategies list compiled based on the expert recommendations and subsequently adapted to suit the specific Singapore local context, taking into consideration of the booth design, location choice, health assessment and technology selection, partnership, manpower, referral management system, user journey, safety, data protection, and publicity. To the best of my knowledge, this is the first community-based telehealth programme in Singapore.

Booth Design

To create a safe and private environment for this telemonitoring programme, a biosafety booth originally designed for mass swabbing exercises (382) was repurposed (Figure 6.2). The adaptable modular design of the booth allowed for customising the telemonitoring programme according to specific requirements. Additionally, the booth was equipped with an internet connection that enabled the uploading of health data, printing of health reports, and teleconsultation when necessary.

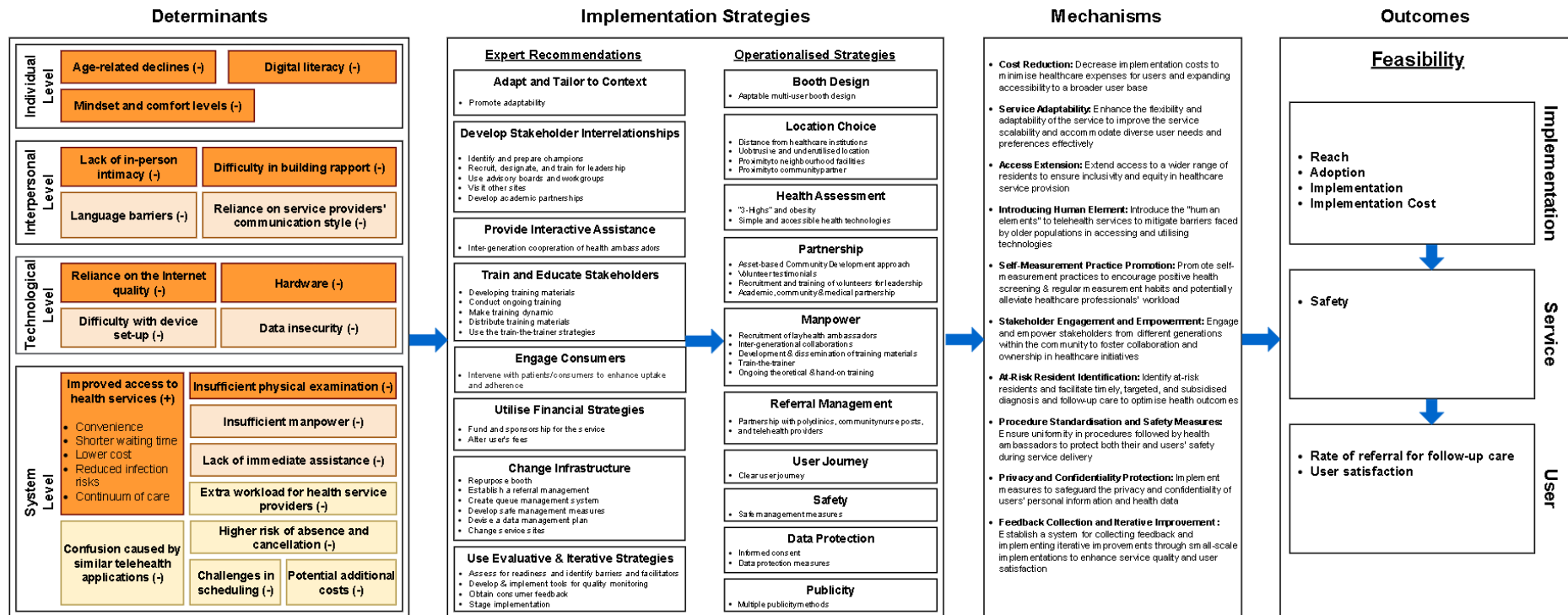


Figure 6.1 Proposed IRML to guide the design and implementation of CTS (IRML: Implementation Research Logic Model, CTS: Community Telehealth Service)



Figure 6.2 Original biosafe booth designed for mass swabbing exercises (left) (382) and the repurposed booth (right)

Location Choice

Various factors contributed to the location of booth deployment, including the distance from healthcare institutions, proximity to neighbourhood shops, and the unobtrusive and underutilised nature of the location. Other practical aspects were also factored in, such as the availability of public utilities, for instance, electrical plugs for booth operation, washrooms and water dispensers for health ambassadors, and CCTV surveillance for booth security. Additionally, the location should be near the community partners on the ground to ensure a smooth day-to-day operation.

Target Population

While the primary focus was on Singapore residents (including foreigners) aged 50 and above, CTS remained open to the younger age groups. Within this broader range, priority was given to those who were born in or before the 1950s as well as the low-income groups (household monthly income per person lower than SGD 2,000).

Health Assessments and Technologies

In a survey with 4,549 community-dwelling Singapore residents aged 60 years and above, 38% of the respondents reported fair or poor perceived health, with “3-Highs” ranking among the most prevalent self-reported NCDs (359). The obesity rate has also been observed as a noticeable increase across all age groups since 2017, particularly among individuals aged 50 to 74 years (360).

However, these statistics may be underreported due to a concerning high prevalence of undetected cases (362–364,366).

To tackle the rising prevalence and undetected cases of the "3-Highs" and overweight/obesity in the Singapore population, various health assessments were integrated into the telemonitoring programme, including an AI-assisted eye screening; cordless upper arm BP and heart rate measurement; smart scales for measuring weight, body mass index and body fat composition; as well as capillary blood glucose measurement.

Partnership

In this telemonitoring prototype, the Asset-Based Community Development approach (383) was adopted and placed great emphasis on community empowerment as a critical element in ensuring engagement from all stakeholders and fostering a sense of shared ownership. Through partnerships with the community centres, government and social service agencies, medical and academic institutions, as well as corporate sponsors, collaborative efforts were capitalised on diverse expertise and resources to support the implementation and scalability of the initiative. This multi-sectoral approach not only enhanced the reach of the service but also promoted synergy and collective action towards improving health outcomes in the community.

Manpower

Study One uncovered a major gap in older adults' HSB—a lack of self-measurement of physiological parameters, particularly among individuals with

NCDs. Participants cited difficulties in obtaining accurate measurements as an obstacle. Study Two delved into the perceived barriers to telehealth implementation, and key barriers reported by both older adults and professionals included older people's age-related declines, insufficient digital literacy, varying comfort levels with telehealth usage, perceived lack of in-person intimacy, language barriers, and concerns about inadequate physical examination. In response to these challenges, participants recommended incorporating human elements and adopting a hybrid format as potential implementation strategies. In response, the integration of the health ambassador programme emerged as a key strategy in CTS design and implementation to facilitate the health monitoring process.

To achieve this, health ambassadors were recruited via different sources. Project information was disseminated within NTU and interested students were invited to register their interest and undergo interviews with the organising committee. The initial group of public volunteers were sourced from the HPB Health Ambassador Programme, while the subsequent cohorts consisted of the Phase I beneficiaries and individuals recruited from the Rotary Clubs in Singapore.

Prior to their onboarding, all health ambassadors were required to participate in both online and on-site training sessions. The online training comprised pre-recorded videos covering topics such as PDPA compliance, booking appointments, conducting various health assessments, interpreting health results and offering lifestyle advice based on Singapore clinical guidelines, booth

maintenance, safety protocols, and the SOP. During the on-site training, ambassadors gained hands-on experience with the entire workflow and conducted health assessments on each other, under the supervision of the organising team. All training materials were reviewed and assessed by medical professionals.

The main objective of recruiting both student and public health ambassadors was to enlist their collaboration to co-manage the booth (Figure 6.3). This collaborative approach aimed to enhance technical proficiency, engage users from different generations, and create a warm and welcoming environment specifically designed for the older population. These health ambassadors volunteered on shifts, with each lasting a maximum of four hours.





Figure 6.3. Photos of a health ambassador pair (photos were taken by Caroline Chia / WhatAreYouDoing.sg) (384)

Referral Management System

The integration of a referral management system was a pivotal and essential component of the prototype. Recognising the importance of seamless coordination and collaboration with healthcare providers, a streamlined procedure was established to ensure that users in need could be identified and referred to polyclinics and community nurse posts to receive timely, targeted, and subsidised diagnosis and follow-up care.

User Journey

The user journey in this telemonitoring prototype is illustrated in Figure 6.4. Health ambassadors would first verify users' identities using a secure registration system on smart tablets; then guide the users through the profile surveys with health history, various measurements, and communication of the results as well as any remarks from the users. Users' eye reports would be sent

to the Singapore National Eye Centre for manual verification, while the other devices had been approved by the Health Sciences Authority and were able to provide immediate results under the operation of trained health ambassadors. In the event of abnormal readings, users would be directed to the referral system for professional diagnosis and follow-up care.

Safety

Personal safety was the primary concern during the development of the telemonitoring prototype. To address personal safety, the booth was equipped with various safety features, including UV-C lighting disinfection, a positive-negative pressure environment, and disinfectant misting. Additionally, the queue management system ensured safe management and prevented overcrowding by requiring users to make advanced bookings through a QR code link, messaging service, or assistance from health ambassadors. Thorough risk assessments were conducted prior to the deployment and continuously reviewed to mitigate potential risks. Safety measures and standard operating procedures, such as donning personal protective equipment, cleaning high-touch areas, and ensuring appropriate work-rest cycles, were also strictly adhered to.

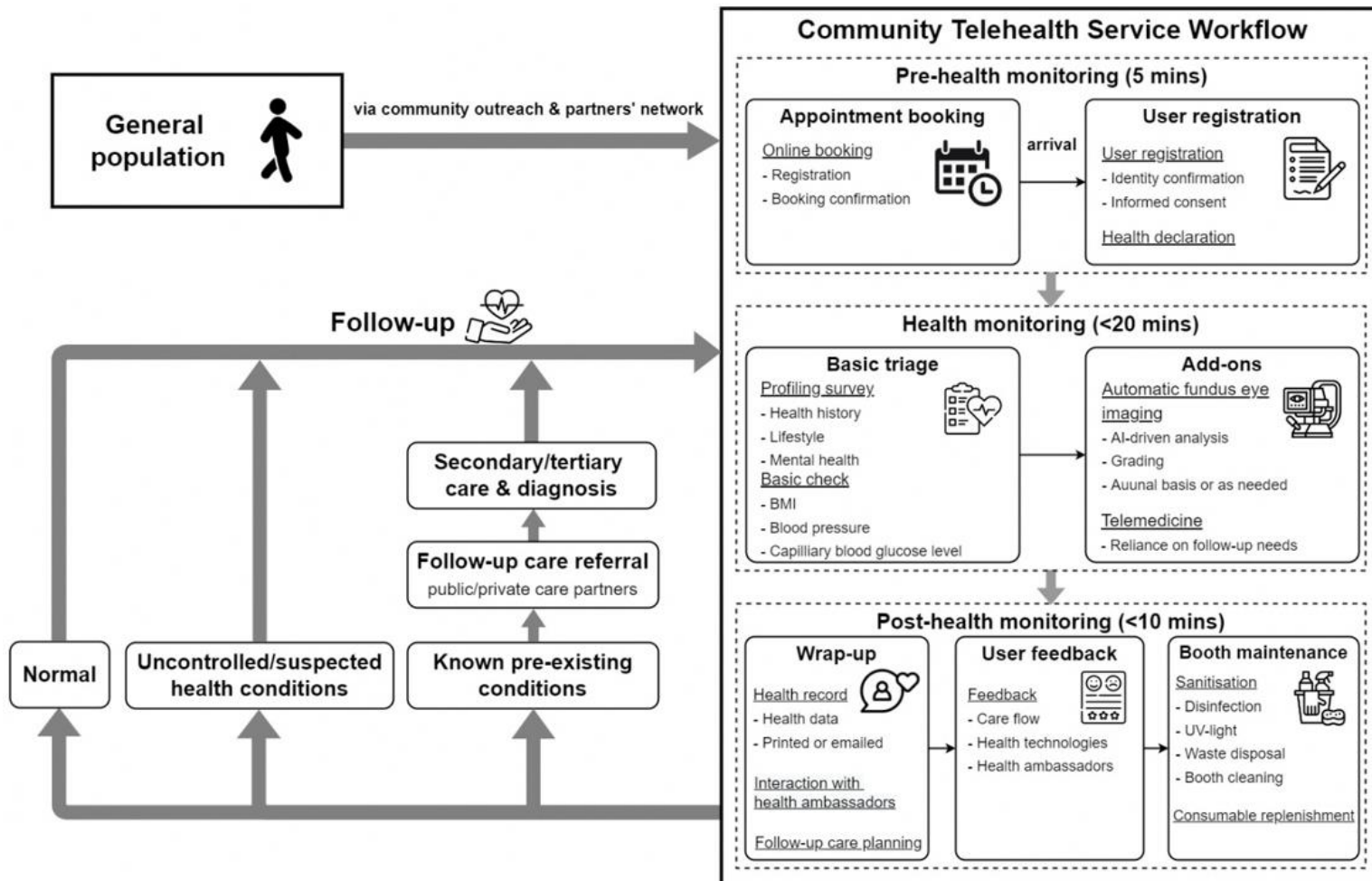


Figure 6.4 Overview of CTS phygital telehealth user journey (CTS: Community Telehealth Service)

Data Protection

This telemonitoring prototype also prioritised data protection measures, which included employing a secure online booking platform, compliance with the Personal Data Protection Act, and obtaining informed consent from all parties involved. Users' personal data were anonymised all data transfers were encrypted and conducted only by authorised personnel. These measures were put in place to safeguard the privacy and confidentiality of users' personal information and health data.

Publicity

Various publicity methods were adopted, such as posting on social media platforms, door-to-door publicity, displaying publicity posters in the lift lobbies and on digital display panels of residential blocks, roadshows, and media mentions.

6.3.2 CTS Implementation

CTS was deployed in three phases progressively. In Phase 1, the programme prototype was deployed in the Northeast of Singapore daily from mid-January to the end of February 2021, after the circuit breaker (385). The aim of this phase was to rapidly collect preliminary feedback from the users, and their responses were used to enhance this programme for later phases.

Based on user feedback in Phase 1, various enhancements were brought to Phases 2 and 3. In Phase 2, CTS was launched in the West, from the end of

September 2021 to the end of March 2022. Due to the heightened safety measures to slow the spread of coronavirus (Ministry of Health Singapore, 2021d), the programme was temporarily closed for two months from October to December 2021. In Phase 3, the programme was launched in the East in January 2022 and remained operational for a three-month period until March 2022. Details of the implementation of CTS across three phases are summarised in Table 6-1.

6.3.3 Outcome Measures

The evaluation of the CTS prototype employed a hybrid type 3 design (252,253), which collects preliminary effectiveness results while mainly focusing on implementation outcomes.

Guided by Bowen et al. (386), feasibility in this study was measured from three dimensions: (i) **implementation outcomes** (the extent to which CTS was successfully executed), measured by reach (number of users as well as the number of health screenings and volunteer training sessions conducted), adoption (number of participating community partners, social service agencies, medical partners, and academic partners), implementation (number of operating hours, cancellation and no-show rates), and implementation cost; (ii) **service outcomes**, measured by safety; and (iii) user outcomes, measured user satisfaction (measured by the user feedback survey). Preliminary effectiveness was measured by the rate of referral for follow-up care as a proxy. Key areas of improvement were summarised by users' feedback and observations during the programme implementation.

All users were invited to fill out an online feedback survey at the conclusion of their screenings, and their participation was encouraged but not mandatory. In Phase 1, the feedback survey encompassed six short questions to explore users' experience with appointment booking, rating of the waiting time, satisfaction with health ambassadors' instructions, overall experience, intention to continue using CTS, and perceptions of the programme (Table 6-3).

In Phases 2 and 3, the Telehealth Usability Questionnaire developed by Parmanto et al., a robust tool to assess the usability of telehealth implementation and services (387), was adapted to a 24-item 5-point Likert scale with an extra open question to cover various usability factors of the enhanced services, including publicity, registration and waiting time, service reliability, interaction with health ambassadors, perceived usefulness and ease of use, quality of services, satisfaction and future use, and potential areas to improve (Table 6-4).

6.3.4 Data Analysis

Quantitative data were analysed using RStudio, while qualitative data were analysed using manual topic analysis, given that the number of qualitative feedback responses was manageable and could be effectively analysed manually.

6.3.5 Ethics Considerations

This project was approved under the Graduate College – Community Engagement Project (CEP), Nanyang Technological University (388). Approval to

utilise fully anonymised retrospective data generated from the project has been granted by the university's Institutional Review Board (IRB-2022-970).

6.4 Results

6.4.1 Feasibility

6.4.1.1 Implementation Outcomes

The operating statistics are summarised in Table 6-2.

Reach and Implementation

In Phase I, CTS was operated for a total of 236 hours with 627 screenings (277 males, 350 females, mean age = 57.0, cancellation/no-show rate was about 26.8%). Additionally, 55 students and 11 community health ambassadors were trained, while another 45 registered volunteers were waiting for training. In Phase 2, CTS was open for 290 hours (243 hours for health screening, 47 hours for volunteer training), and completed 103 screenings (30 males, and 68 females with five returning users, mean age = 65.0 years, cancellation/no-show rate was about 15.6%). In Phase 3, the total number of operating hours was 126 (90 hours for health screening, 36 hours for volunteer training) with 79 screenings conducted (38 males with 3 returning users, 37 females with 1 returning user, mean age = 68.0 years). A total of 81 new health ambassadors (30 students, and 51 from the public) were trained in Phases 2 and 3.

Adoption

During phase I, partnerships were established with four community partners, two medical partners, and six corporate partners. Fundings were received from five sources, including research grants, university community engagement project funding, as well as corporate sponsorships. As the service progressed into Phases 2 and 3, these numbers expanded, with six grantors, ten government and community partners, two medical partners, and eight corporate sponsors. Additionally, an additional academic partnership was established.

Implementation Cost

The implementation costs for all three phases were estimated based on the sponsorship with actual claims made to research funding and university community engagement project funding. The implementation costs for Phase 1 and Phases 2 & 3 were SGD 19,884.73 and SGD 3806.24 respectively.

6.4.1.2 Service Outcome – Safety

The project remained incident-free throughout all three phases, with no occurrences of COVID-19 infections, injuries, or data breaches reported. This absence of incidents underscores the effectiveness of the safety protocols and the diligence of all stakeholders in maintaining a secure and safe environment.

Table 6-1 Details of the implementation of CTS across three phases (CTS: Community Telehealth Service)

Element	Phase 1	Phase 2	Phase 3
Period of Deployment	9 th January to 27 th February in 2021	25 th September 2021 to 31 st March 2022 (temporary closure from October to December 2021)	3 rd January 2022 to 31 st March 2022
Location	Punggol 21 Community Centre (Northeast) – located near digital ambassadors who could assist older adults in improving their digital skills	Bukit Batok (West) – located beside the partner senior centre	Chai Chee (East) – located near the partner non-profit charitable healthcare organisation
Operating hours	9 am to 5 pm daily	Flexible opening hours based on the booking and volunteers' availability with at most 3 days per week	
Health assessments and technologies	• Weight • Body mass index • Body fat • Muscle • Visceral fat • BP • Heart rate • Glucose level • Eye health and risk of cardiovascular diseases – sent to the Singapore National Eye Centre for manual verification)	• Mental health test using WHO-5 • Weight • Body mass index • Body fat • Muscle • Visceral fat • BP • Heart rate • Glucose level • Eye health (risks of diabetic retinopathy, glaucoma, and age-related macular degeneration) – automatically generated by the eye machine	

Referral management system	Sent those reports with possible abnormalities to Sengkang Hospital Community Nurse Post	Referred users with possible abnormalities to a National University Polyclinic nearest to users' homes, and included brief notes in the printed health reports	Referred users with possible abnormalities to SATA CommHealth, a non-profit charitable healthcare organisation, and included brief notes in the printed health reports
Publicity	• Social media • Door-to-door publicity • Displaying publicity posters in the lift lobbies • Media mentions	• Social media • Door-to-door publicity • Community outreach • Roadshow	• Social media • Door-to-door publicity • Community outreach • Displaying publicity posters on digital display panels of residential blocks • Roadshow
Implementation costs	• SGD 19,884.73	• SGD 3806.24 (excluding in-kind contributions from NTU)	
Number of participating partners	• Grantors: 5 • Community partners: 4 • Medical partners: 2 • Corporate sponsors: 6	• Grantors: 6 • Government/Community partners: 10 • Medical partners: 2 • Corporate sponsors: 8 • Academic partner: 1	

6.4.1.3 User outcome

Preliminary Effectiveness – Referral rates

The collaboration among community networks, legal entities, medical institutes, the general public, and corporate sponsors highlighted the potential complementary role of CTS alongside the existing healthcare infrastructure. Moreover, 163 (26.0%) users were referred to the community nurse post and Singapore National Eye Centre for follow-up care in Phase 1. The referral rates in phases 2 and 3 were not tracked due to different medical partners and the local context involved.

User Satisfaction

In Phase 1, a total of 389 user feedback responses (response rate = 62.0%) were received, and the responses were predominantly positive (Table 6-3), where 83.3% of the users were satisfied with 66.8% of users were able to book an appointment independently, while the rest required some assistance from either their social networks or the health ambassadors. Moreover, 94.1% of the users were happy with the entire experience, 99.7% of the users found the verbal instructions given by the health ambassadors satisfactory, and 99.7% expressed overall satisfaction with the experience. In general, 98.5% of the users expressed interest in continuing to use the CTS booth as a community resource for health monitoring.

In Phases 2 and 3, a total of 73 feedback responses (61 responses in Phase 2, and 12 responses in Phase 3) were received. The results indicated that the

majority of users were satisfied and perceived CTS as a usable programme. Table 6-4 presented the survey items along with a summary of the subscale scores.

6.4.2 Key Areas for Improvement

While CTS received a high level of acceptability across all three phases, user feedback also highlighted potential areas for improvement. Building upon the insights collected from Phase 1, enhancements were implemented in Phases 2 and 3, such as

- assigning volunteers to timely answer users' inquiries via WhatsApp messages,
- upgrading health monitoring technologies to reduce technical glitches,
- refining the training and assessments for health ambassadors to address human errors and facilitate effective troubleshooting,
- streamlining the registration process, enhancing the user-friendliness of the registration platform, and sending booking confirmations and reminders through messages,
- incorporating mental health assessment with WHO-5,
- translating the publicity materials into not only Chinese but also Malay and Tamil,

- involving medical students and health professionals to enhance the abnormality detection algorithms by taking possible age-specific reference ranges into consideration, allowing users to choose if they would like to be referred to follow-up care with medical partners;
- improving the physical environment by providing fans both inside and outside the booths, as well as increasing the seating capacity in the waiting area, and
- adjusting the operation hours based on the health ambassadors' availability.

In addition to these readily achievable improvements, three more popular realms suggested were: (1) extending the current spectrum of health assessments, (2) providing additional educational health information, and (3) upgrading the current referral management system.

Table 6-2 Summary of the operating statistics

	Location 1	Location 2	Location 3
Total number of operation hours	236 hours (health screening and volunteer training were held concurrently)	• 243 hours – screening • 47 hours – volunteer training	• 90 hours – screening • 36 hours – volunteer training
Total number of screenings conducted	627 screenings • 277 males • 350 females • Mean age = 57.0 years	103 screenings • 30 males • 68 females (5 returning users) • Mean age = 65.0 years	79 screenings • 38 males (3 returning users) • 37 females (1 returning user) • Mean age = 68.0 years
Cancellation and no-show rates	About 26.8%*	About 15.6%*	About 11.2%*
Referral rates	26.0%	Untracked	Untracked
Total number of volunteers trained	• 55 student volunteers • 11 community volunteers • 45 more volunteers on the waitlist	• 30 student volunteers • 51 community volunteers (excluding volunteers trained at location 1)	

* Some walk-in visitors may have requested partial screenings that were not accounted for in the registration system

Table 6-3 Summary of user feedback in Phase 1

Item	Phase 1 (n = 389) Response rate = 62.0%
1. Did you register an appointment timeslot by yourself?	• 66.2% - Yes • 33.8% - No
2. How do you find the waiting time required from the start of the booth session to receiving your health report?	• 83.3% - Appropriate • 10.8% - Too short • 5.9% - Too long
3. How do you find the verbal instructions given by the health ambassadors?	• 79.9% - Very clear • 14.1% - Clear • 5.7% - Acceptable • 0.3% - Unclear
4. How do you find the overall CTS experience?	• 78.1% - Very good • 18.0% - Good • 3.6% - Acceptable • 0.3% - Not good
5. Overall, do you want to continue seeing and using the CTS booth as a community resource for health monitoring?	• 98.5% - Yes • 1.5% - No

Table 6-4 Summary of user feedback in Phases 2 and 3

Item	Phase 2 (n = 61) Response rate = 59.2%		Phase 3 (N = 12) Response rate = 15.2%	
	Mean	Mode	Mean	Mode
Publicity				
How did you know about CTS?	• CTS publicity materials (n = 22) • Door-to-door publicity (n = 15) • Passing-by (n = 10) • Referral from the social network (n = 6) • Social media (n = 8)		• CTS publicity materials (n = 3) • Door-to-door publicity (n = 4) • Passing-by (n = 5)	
Registration and waiting time				
Did you register for CTS by yourself? If not, who helped you with the registration?	Yes (n = 34) No (n = 27) • Health ambassadors (n = 15) • Family members or helpers (n = 9) • Staff from the community centre (n = 3)		Yes (n = 5) No (n = 7) • Health ambassadors (n = 7)	
I think the waiting time is appropriate.	4.8	5	4.3	5
Reliability of health monitoring				
I think the visits provided over CTS are the same as in-person visits to the clinics.	4.3	5	3.8	3
When the machine/equipment/monitor reported any error (e.g., the glucose meter showed an error message or the eye machine cannot capture eye images), the health ambassador could resolve the issue easily and quickly.	4.4	5	4.1	4
The health ambassadors could clearly tell me the problems with the health indicators shown in the health report.	4.7	5	4.3	5
I have confidence in the health ambassadors' skills.	4.5	5	4.3	5

I have got sufficient information about my health conditions.	4.6	5	4.0	4
Interaction with health ambassadors				
I feel that the health ambassadors cared about me.	4.8	5	4.3	4
I had enough time to talk and interact with the health ambassadors.	4.7	5	4.3	4
I felt I was able to express myself effectively.	4.6	5	4.3	4
I could hear the volunteers/health ambassadors clearly in CTS.	4.8	5	4.4	5
I feel that the health ambassadors talked to me in a way that was easy to understand.	4.8	5	4.4	5
I felt comfortable communicating with the volunteers/health coaches.	4.8	5	4.4	5
Usefulness and ease of use				
CTS improves my access to healthcare services.	4.6	5	4.3	4
CTS saves me time travelling to a hospital or specialist clinic.	4.6	5	4.4	5
CTS provides for my healthcare needs.	4.4	5	4.1	4
CTS is simple to use.	4.7	5	4.4	5
Quality of service				
My interaction with CTS is pleasant.	4.8	5	4.4	5
I think CTS is well-organised.	4.7	5	4.3	4
I feel that the service that CTS provided is satisfactory.	4.8	5	4.3	5
Satisfaction and future use				
CTS is an acceptable way to receive healthcare services.	4.7	5	4.3	4
I would use CTS again.	4.6	5	4.4	5
Overall, I am satisfied with CTS.	4.7	5	4.3	4

6.5 Discussion

6.5.1 Community-based Telehealth Programme Feasibility

The rapidly growing ageing population, coupled with the rising prevalence of NCDs and mental health conditions, places escalating pressures on the traditional healthcare delivery model, rendering disease-centric approaches insufficient and unsustainable in the long run (34,326). This calls for a paradigm shift towards preventive care (73,389,390), the creation of new healthcare infrastructure (73,391–393), and the expansion of social and long-term care services within the community (73,394–397), as well as the adoption of technologies to support ageing in place (44,398,399).

CTS is designed to complement the traditional healthcare model by lowering barriers to accessing personal health monitoring technologies, extending the reach of healthcare beyond the clinical settings, and establishing the connection between the older population and the formal healthcare system. Building upon community-based telehealth programmes found in existing literature (377,379), the design, implementation, and evaluation of CTS was driven by IRLM incorporating different determinants and corresponding implementation strategies identified by Study Two as well as the expert recommendations (ERIC). This comprehensive approach aims to improve the rigour and reproducibility of such community-based telehealth services and address the gaps in older individuals' HSB while mitigating IGIs.

Findings from this study demonstrate the feasibility of CTS within the Singapore community, measured by its implementation outcomes (reach, adoption, implementation, and implementation cost), service outcomes (safety), and user outcomes (user satisfaction), as well as its preliminary effectiveness (referral rate). It is the aspiration that this research paves the way for more comprehensive community-based telehealth programmes to effectively address the health needs of the older populations, enhance their access to health technologies, raise their health awareness, encourage their proactive engagement in health maintenance, and ultimately reduce health disparities.

6.5.2 Community-based Telehealth Programme Implementation

Technology advancements have enabled individuals to remotely monitor their physiological parameters outside the clinical settings and seek actionable insights for improving health outcomes (400,401). Besides income, education, employment, and environment, digital technology has emerged as a key determinant of health (402,403). It is noteworthy that while digital health interventions are intended to reduce health inequalities by extending access to health services and addressing unmet health needs through personalised care, there is a concern that they might unintentionally exacerbate health inequities to some extent (335,404,405). Therefore, digital inclusion-informed strategies are needed in designing community-based telehealth programmes.

In response, a “phygital” approach was adopted to combine both digital and physical elements. While it is important to acknowledge that the implementation of the health ambassador scheme in CTS may limit the

generalisability of the findings to other community-based telehealth programmes that lack or have minimal human support (377), it is believed that this approach brings significant value to service delivery. For example, Courtney et al.'s study raised several concerns such as older residents' overreactions to mild abnormalities in the health data, the potential risk of using the kiosk as a substitute for regular or urgent healthcare services, and the false reassurance of BP alone being a comprehensive indicator of overall health status (379). The well-trained health ambassadors could play a crucial role in mitigating these concerns. Besides conducting health measurements and generating health reports, they assist users in explaining their measurements based on local clinical guidelines and taking notes of some remarks (e.g., their perceived health, and self-observed individualised reference ranges) in the reports. This combination of subjective perceptions and objective measurements enhances the delivery of more person-centred care (406). Additionally, health ambassadors could offer actionable advice for lifestyle modifications to positively impact health outcomes; they can also actively encourage all users to undergo regular health screenings at medical institutions and refer them to appropriate medical partners for follow-up care when necessary.

Such a comprehensive approach serves to not only minimise the potential misinterpretation of health data but also fosters a proactive mindset towards maintaining overall health and well-being. This also emphasises the importance of maintaining a comprehensive record of users' health-related information. The integration of these diverse objective health data points, subjective self-perceived health status, potential individualised reference range, and lifestyles,

together with users' participation in community events and health promotion activities, could support primary care providers in forming a more complete and personalised understanding of an older individual's health. This, in turn, enables the delivery of more effective, customised, and equitable healthcare services.

However, challenges arise as these data often remain disconnected from primary care records, possibly due to data inconsistency, lack of standardised data handling and ownership protocols, concerns of breaching data privacy and confidentiality, as well as the risk of generating inaccurate or incomplete data (395,396). Addressing these gaps and establishing mechanisms to bridge them could be a dedicated effort moving forward.

6.5.3 Potential Areas for Improvement

Based on user feedback, one of the most anticipated improvements is the inclusion of additional health assessments. Advancements in technology have made it possible to incorporate point-of-care tests, such as urine dipsticks, for remote patient monitoring, even by non-medical individuals (409). Moreover, future enhancements may involve integrating physical performance and muscle strength tests (e.g., handgrip strength) and cognitive assessments. Nonetheless, additional research efforts are needed to validate these tests when administered by trained non-medical personnel to a specific subgroup of the population in non-clinical settings.

The second important area for improvement is to enhance the competencies of the health ambassadors through additional professional training and

assessments, ultimately certifying them to assume the role of health coaches over the long term. This transformation will further empower them to assist their clients in providing tailored and unwavering support, navigating available resources, identifying health goals, creating actional plans for sustainable behaviour changes, and making well-informed decisions towards healthier longevity (410–412).

Furthermore, another direction is the provision of more health information, which also aligns with participants' interest in Zhang et al.'s study (377). Besides, it was observed that a considerable proportion of users who, despite having borderline health conditions or being diagnosed with NCDs, opted out of health screenings, refused medication, or discontinued follow-up care. Guided by these insights, future efforts will work towards implementing different health promotion interventions targeted at empowering older adults to take control of their health journeys and encourage proactive engagement in decisions that impact their overall well-being (160).

The referral management system was observed as another opportunity for improvement. During Phase 1, some delays were encountered, primarily attributed to the reliance on medical partners to initiate contact with users as well as their increased workload amid the pandemic. As CTS transitioned into Phases 2 and 3 where users were given the full autonomy to make decisions, new challenges surfaced: some users refused the referrals, and it was difficult to track their progress. These experiences underscore the importance of establishing efficient and timely communication channels with medical partners

to ensure the seamless provision of quality care across the care continuum. Moreover, robust strategies should be also devised to effectively engage older people and sustain their engagement within the care continuum, contributing to better overall well-being within the community.

6.6 Reflection

CTS has demonstrated its potential as a feasible programme within the Singapore community. Moving ahead, efforts will revolve around several key areas: incorporating and validating additional health assessments when administered by non-medical personnel to different subgroups of populations outside the clinical settings; designing health promotion interventions to empower the older population; conducting comprehensive assessments to uncover the unmet health needs of the older population; as well as crafting scalability and sustainability strategies while rigorously evaluating the long-term impacts of CTS to unlock its full potential in addressing health inequalities among the older population.

CHAPTER 7 STUDY FOUR

This chapter has been published as:

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Student's roles in this study:

Study planning, IRB application, tele-education prototype design, participant recruitment, data collection (conducting co-design workshops and evaluations), and data analysis (both quantitative and qualitative)

To address the questions raised at the end of CHAPTER 5 and one key area for improvement suggested by CTS users in Study Three—providing more health educational information, one possible solution is to embrace a participatory approach and extend invitations to both existing and prospective users, thereby fostering collaborative co-designing of telehealth services.

7.1 Background

Older adults are at a higher risk of major health conditions (1,413), and prioritising and improving their health has the potential to prevent and delay the onset of chronic diseases, enhance their independence and involvement in

family and social activities (414), and reduce the impacts on the economy and healthcare expenditures (31,415).

Health promotion activities are the primary strategies that empower individuals to take control of and improve their health (416). Health education is one of the strategies used in health promotion, having the potential to enhance individuals' understanding of health and healthcare, equip them with the essential knowledge to make informed decisions about healthcare choices (417) and control the onset and progression of diseases and disabilities (418). Historically, health promotion activities often overlooked the older population due to the belief that their lifestyle and health habits were deeply ingrained and resistant to change (151), and it was not until the 1990s that WHO stressed the significance of health education to provide support for older individuals' healthcare needs (419).

Emerging evidence has shown that limited health literacy is associated with poor health outcomes in older individuals (420,421), and thus health promotion and education have become a crucial component of different healthy ageing frameworks. For example, one of the overarching goals of the Healthy People 2030 framework emphasises “promote healthy development, healthy behaviours, and well-being across all life stages” (410).

Health education for the public in Singapore plays a pivotal role in raising public health awareness and improving the well-being of the community. For instance, HealthHub offers various educational programmes such as *Nutrition Facts And Information On Eating Healthy, and Let's BEAT Diabetes* (423). Besides, hospitals

and community organisations also organise regular public health talks (412–414).

Despite these efforts, a survey conducted by Aviva revealed that although the local residents are in general happy with the health services, there exists a notable demand calling for more health education and information sharing to inform personal health decisions (427). The survey findings along with one potential area to improve identified in Study Three also underscored the significance of arming the public with ample, precise, and tailored health information to empower the public (427).

Several concerns have been highlighted in current community health education programmes designed for older people, for example, outdated formats and content being simple and lacking standardisation and personalisation (416). Additionally, challenges faced by the older individuals were also well-documented, such as busy schedules due to medical appointments, family responsibilities, and social engagements (417), as well as a tendency to resist or show low interest in health-related information (409,418). Consequently, the development of effective design and implementation strategies, along with engaging the target population, is crucial. In Pennucci et al.'s proposed framework for enhancing the design and implementation of health promotion and preventative intervention (419), co-design emerges as one of the most effective methods of engaging laypeople through active participation.

In literature, health education for older people has been implemented through various modes, including printed materials, software and video, as well as mock-

up and telephone support (420), and the COVID-19 pandemic has further expedited the digitisation of health education (64,421,422). Synchronous telehealth-delivered education, or tele-education, offers several strengths, for example, structured learning to ensure learners stay on track, increased real-time interaction and collaboration, and immediate feedback (423). While tele-education has been adopted in medical student education (424), health and social care professionals' education (425), and continuing health education programmes (426,427), there is limited published evidence regarding its application in health education for older adults.

7.2 Aim and Research Questions

This study aimed to engage older adults in the co-design process of the tele-education implementation strategies and investigate how this mode of health education delivery could potentially impact older adults' health knowledge. The following questions will be addressed:

- (1) What are the potential effects of tele-education on older adults' health knowledge and awareness?
- (2) What is the feasibility of tele-education for delivering health education to older adults?
- (3) How receptive are older adults to the participatory approach in an online environment?
- (4) What are the recommended strategies for designing and implementing tele-education programmes for older adults?

7.3 Method

7.3.1 Study Design

This study employed a participatory approach in an online environment, incorporating mixed methods within the rapid prototyping. Rapid prototyping was used to facilitate the swift creation, testing, and refinement of the prototype (428). It also served to introduce participants to the concept of tele-education and offer them an initial experience, factoring in the fact that some older adults may not have had prior exposure to health education or telehealth. The evaluation of the prototype employed a hybrid type 2 design (240,241), which has a dual focus on the preliminary effectiveness and implementation outcomes. This study has been approved by the Institutional Review Board (Reference: IRB-2022-733).

7.3.2 Creation of the Tele-education Prototype

The prototype creation was guided by instructional design, a systematic process of creating instructional materials and learning experiences to support the learners' acquisition of new knowledge, skills, and attitudes (429).

7.3.2.1 Platform

During the COVID-19 pandemic, Zoom gained popularity and was widely adopted for healthcare purposes (430). It is a free application that can be downloaded on mobile devices, laptops, or desktops. Its various features, such as screen sharing and chat functions, allow users to interact with each other and participate in discussions during a session. Additionally, it offers customisation

options like virtual backgrounds, breakout rooms, and polling, which can be tailored to fit the specific needs of an educational setting. Due to its accessibility, low costs, convenience, interactivity, customisability, and security, Zoom meeting was selected as the medium of the tele-education prototype. Considering the possibility that some participants may join the session on their mobile phones, the Zoom polling feature was used for the knowledge assessments to minimise any inconvenience that may arise from switching to another application.

7.3.2.2 Topic

Singapore is facing a rising challenge of dementia due to its rapidly growing older population. As per the official statistics, approximately 10% of individuals aged 60 years or above are affected by dementia (431), with the majority of them residing in their communities and relying on their spouses and children as primary caregivers (432). Some common difficulties reported by dementia caregivers included mental stress, financial burdens associated with caregiving, challenges during the COVID-19 pandemic, and feelings of loneliness and rejection (433). Moreover, the general public was also reported to have limited knowledge and awareness of dementia, as well as discomfort when interacting with affected individuals (434). Given these challenges faced in Singapore, dementia was selected as the health topic for the prototype.

7.3.2.3 Content

WHO has identified five main themes of dementia education or health campaigns targeting the general public (435), namely: “raising public awareness and understanding of dementia, reducing the stigma of dementia and challenging discriminatory behaviour, recognising the early signs of dementia to aid early diagnosis, living well with dementia, and the importance of a healthy lifestyle and reducing risk”. The prototype was designed as a 45-minute session in accordance with these themes and provided evidence-based information on a variety of topics related to dementia, including symptoms, complications, pathology, strategies for risk reduction, screening, and caregiving. In addition, locally relevant and available resources were also shared with the participants. All materials underwent a review process by the team to ensure their credibility and suitability in the local context.

7.3.2.4 Language

Although Singapore is a multilingual society with multiple official languages and various spoken languages including dialects, the prototype was created solely in English for several reasons. First, working on a single language allowed the team to focus the resources and efforts on perfecting the prototype, as well as testing and fine-tuning the prototype more easily before extending it to other languages. Second, using a single language ensured that terminologies were standardised and consistent throughout the prototype, to avoid confusion and reduced effectiveness caused by variations in terminologies across languages.

7.3.2.5 Learning Theories

Transformative learning and the “Learn, Unlearn, Relearn” were the two main adult learning theories adopted in the health education prototype creation, as older adults’ acquisition of new knowledge is affected by their accumulated knowledge and experience over time, as well as their beliefs and attitudes (418). The former theory involves critically examining one’s beliefs and assumptions as a means of personal growth (436); while the latter stresses the importance of continuously learning, discarding outdated or incorrect information, and regaining new knowledge (437). Both theories underscore the need for ongoing personal growth and development to make sense of the learners’ lives.

These two theories emphasise the potential impacts of participants’ prior knowledge on the effectiveness of the education delivery, thus, it is crucial to gauge the extent of knowledge transfer. On account of this, a dementia knowledge assessment was planned at the outset of the session (baseline test or pre-test), serving a dual purpose: to (i) evaluate participants’ baseline dementia knowledge; and (ii) enable the instructor to identify any misconceptions and thereby adjust the teaching approach accordingly. The same set of questions was posed at the end of the prototype (post-test) to determine if there had been any alteration in participants’ understanding of dementia.

7.3.3 Participant Recruitment

The inclusion criteria included: 1) age at 50 or above; 2) long-term Singapore residents dwelling in the community (i.e., citizens, permanent residents, as well as work pass and long-term visit pass holders); 3) ability to read and converse in English; and 4) openness to using or learning to use Zoom. Participant recruitment commenced in December 2022 and employed a convenience sampling approach with multiple recruitment strategies: disseminating study information and the recruitment poster on social media platforms such as Facebook and Instagram as well as elderly chat groups, community outreach at senior centres, reaching out to previous study participants who had provided consent for future research studies, and obtaining referrals from early participants.

During participant recruitment, individuals who expressed interest in participating in the study were invited to complete an online registration form to collect their sociodemographic and socioeconomic characteristics, as well as their pre-existing health conditions. Those who met the eligibility criteria were then contacted via WhatsApp or Short Message Service to receive further details of the study, schedule a co-design workshop, and provide written informed consent for study participation and video recording.

7.3.4 Data Collection

Data collection took place in February 2023 (Figure 7.1) and all co-design workshops were conducted on Zoom and video recorded for data analysis

purposes. Each session consisted of three sections: (i) a pilot test for the participants to test the feasibility and preliminary effectiveness of the pre-created tele-education prototype; (ii) Focus Group Discussion (FGD) to collect participants' learning experience and their perceptions; and (iii) feedback to capture participants' satisfactions and feedback to the co-design workshops. The moderator guide is summarised in Appendix 10.

The size of each session was limited to a maximum of ten. Field notes of participants' responses and interactions were also taken during each session. Participants received shopping vouchers or mobile banking transfers worth SGD 30 upon successful completion of the study.

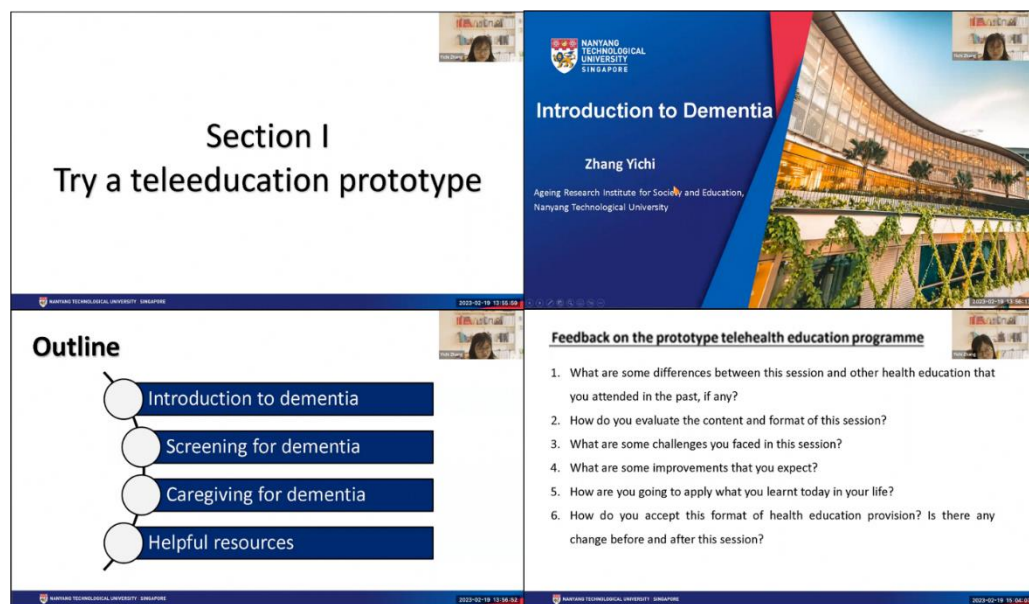


Figure 7.1. Screenshots of the tele-education prototype

7.3.5 Outcome Measures

Multiple outcomes were collected to answer the research questions.

7.3.5.1 Preliminary Effectiveness of the Prototype

The effects of the prototype on participants' knowledge and awareness of dementia were measured by both quantitative scores from the pre-post dementia knowledge assessment and qualitative data from participants' feedback. The knowledge assessment adopted the Dementia Knowledge Assessment Scale (DKAS), which was originally developed as a 27-item tool in 2015 and revised into a 25-item scale in 2017 (438,439). DKAS has been validated and applied in different countries (78,439,440) as a reliable tool (Cronbach's alpha $\alpha = 0.85$ for the original scale applied among 3649 people) assessing four subscales of dementia knowledge: Causes & characteristics (7 items), Communication & behaviour (6 items), Care considerations (6 items), and Risks & health promotion (6 items) (439). The original version is a Likert scale with five options, but the number of options was reduced to three in this study due to time constraints, cognitive load concerns for older adults, as well as possibly reduced usability of Zoom on smartphones. Participants were awarded 2 points for correct answers, 1 point for selecting "Unsure" as the only option for uncertainty, and 0 points for choosing a wrong answer, with a maximum total score of 50. The questions were reviewed before the study to ensure that they suited the local context.

7.3.5.2 Feasibility of the Prototype

The feasibility of the prototype was measured by different outcomes in this study as recommended by Bowen et al. (374), including implementation and practicality (duration and participants' ability to carry out the activities in the

session), participants' acceptance (satisfaction and perceived appropriateness in local setting), demand (perceived impacts), and possibility to expand, mostly through participants' feedback. Other outcomes, such as possible areas for improvement, health information needs, and implications for practice were also gathered from participants' feedback.

7.3.5.3 Perceptions of Tele-education

SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis is a widely used strategic planning tool that assesses both internal factors (strengths and weaknesses) as well as external factors (opportunities and threats) that could impact an organisation, a plan, a project, a person, or a business activity (441). However, it tends to focus on identifying problems rather than finding solutions and has a negative framing (442). The NOISE (Needs, Opportunities, Improvements, Strengths, and Exceptions) analysis is well-suited to complement SWOT analysis as it could assess the current situation and strategies to improve in the future state (442). In this study, the two tools were merged, and a SNOW (Strengths, Needs, Opportunities, and Weaknesses) analysis was conducted to guide the development of the moderator guide for collecting participants' feedback using semi-structured questions (Appendix 10).

7.3.5.4 Satisfaction with the Co-design Workshop

Participants' satisfaction with the co-design workshops was assessed by a 15-item feedback form (443) with 11 rating items on the organisation, time management, delivery, moderator, performance, and intention to participate in

future research; and another four questions on participants' experiences and their expectations.

7.3.6 Data Analysis

Every participant was assigned a unique identifier (P01 – P35) before data analysis, and all study data were deidentified during the transcription process. All interviews were transcribed verbatim in MS Word by myself, and all text data were transferred to MS Excel for thematic analysis.

As all co-design sessions were moderated by myself, data analysis was performed immediately after each interview to maintain a fresh memory, with the aid of the field notes. The individual was chosen as the unit of analysis to explore participants' personal experiences. Next, inductive thematic analysis was conducted, involving a meticulous line-by-line coding process while reading through the qualitative data. The generated codes were then grouped together based on the research questions, with pattern codes emerging to highlight recurring themes. These themes were used in the subsequent interview sessions to assess the emergence of new themes and to gauge data redundancy.

All quantitative data analyses were performed using RStudio Version 2022.12.0+353. A paired t-test and Wilcoxon signed-rank test were used to evaluate the sample mean difference in the pre-post education DKAS scores.

Due to the constraints of manpower, data collection and analysis were primarily conducted by YZ, yet frequent discussions were held to review the codes and themes.

7.4 Results

7.4.1 Participants' Characteristics

When reaching “saturation”, 32 older individuals expressed their interest in participation, and 25 of them managed to participate in one of the seven FGDs (seven individuals were unreachable). An additional session was conducted with ten more participants referred by the early participants to further validate the findings and enhance the authenticity and transferability of the research.

Out of the 35 participants recruited, about two-thirds were female (24/35, 68.6%) and the majority (33/35, 94.3%) of them were Chinese. Their age ranged from 53 to 82, with a mean of 66.0 (SD = 6.3). Slightly more than half (19/35, 54.3%) had an education level higher than secondary school, and half of them (18/35, 51.4%) had at least one pre-existing health condition. Table 7-1 summarises the demographic characteristics of the participants, with details listed in Appendix 11.

7.4.2 Preliminary Effectiveness of the Prototype

7.4.2.1 Dementia-related Knowledge

Misconceptions About Dementia

During the pilot test, some misconceptions of dementia were observed, for instance, “dementia cannot be avoided in older people”, “dementia is solely genetic”, “people with dementia will completely lose their ability to perform

tasks”, “dementia is fatal”, and “older people with memory loss must have dementia”.

Table 7-1 Demographic characteristics of the participants

Characteristics		n (%)
Age (66.0 ± 6.3)	50-54	1 (2.9)
	55-59	4 (11.4)
	60-64	10 (28.5)
	65-69	10 (28.5)
	70-74	8 (22.9)
	75-79	1 (2.9)
	80+	1 (2.9)
Gender	Female	24 (68.6)
	Male	11 (31.4)
Ethnicity	Chinese	33 (94.3)
	Indian	2 (5.7)
Highest education level achieved	Secondary or below	16 (45.7)
	Pre-university	8 (22.9)
	Degree and postgraduate	11 (31.4)
Marital status	Married	23 (65.7)
	Single	11 (31.4)
	Widowed	1 (2.9)
Living alone	No	27 (77.1)
	Yes	8 (22.9)
Occupation	Employed full time	2 (5.7)
	Employed part-time	10 (28.5)
	Homemaker	2 (5.7)
	Retired	17 (48.6)
	Self-employed	4 (11.5)
Pre-existing health condition	None	17 (48.6)
	Moderate high BP/hypertension	14 (40.0)
	Diabetes	7 (2.0)
	High cholesterol	8 (22.9)
	Hyperthyroidism	1 (2.9)
	Heart disease	1 (2.9)
	Cancer	1 (2.9)
	Fatty liver	1 (2.9)
	Osteoporosis	1 (2.9)

DKAS Scores

Out of the 35 participants, one encountered technical failure with his smartphone and joined the session together with the other participant, one was late and missed the pre-education knowledge assessment, while another one

failed to submit answers for the first two subscales in the pre-education assessment due to Internet connection issues. As a result, a total of 32 and 34 full responses were received for the pre-education and post-education knowledge assessments respectively.

Table 7-2 summarises the DKAS scores. At baseline, the mean total score was 34.53 (SD = 7.41) out of 50, and the mean scores for the four subscales were 9.19 (SD = 2.88) out of 14, 6.38 (SD = 2.95) out of 12, 10.61 (SD = 1.75) out of 12, and 8.33 (SD = 2.42) out of 12. After the pilot test, significant improvements were observed in the mean scores of all four subscales [subscale 1: 10.24 (SD = 3.17), $p < 0.05$; subscale 2: 7.18 (SD = 2.93), $p < 0.05$; subscale 3: 11.65 (SD = 0.88), $p < 0.001$; and subscale 4: 9.68 (SD = 1.65), $p < 0.001$] as well as the total score [38.74 (SD = 6.14), $p < 0.0001$]. Figure 7.2 to Figure 7.4 illustrate the boxplots of the comparisons of the total score, each subscale score, and each group's score before and after the education.

7.4.2.2 Perceived Impacts of the Prototype

Many participants shared that they acquired deeper knowledge about dementia, corrected some misconceptions, and increased their awareness after trying this prototype. They also shared that this prototype could aid them in gaining a more profound comprehension of people with dementia and the responsibilities of dementia caregivers. This understanding, in turn, could enable them to communicate more effectively with others. Moreover, all participants expressed their desire to apply the knowledge acquired in this session to motivate their learning, enhance their self-care practices, share the information

within their social network, and extend assistance to those in need. Sample quotes are summarised in Appendix 12.

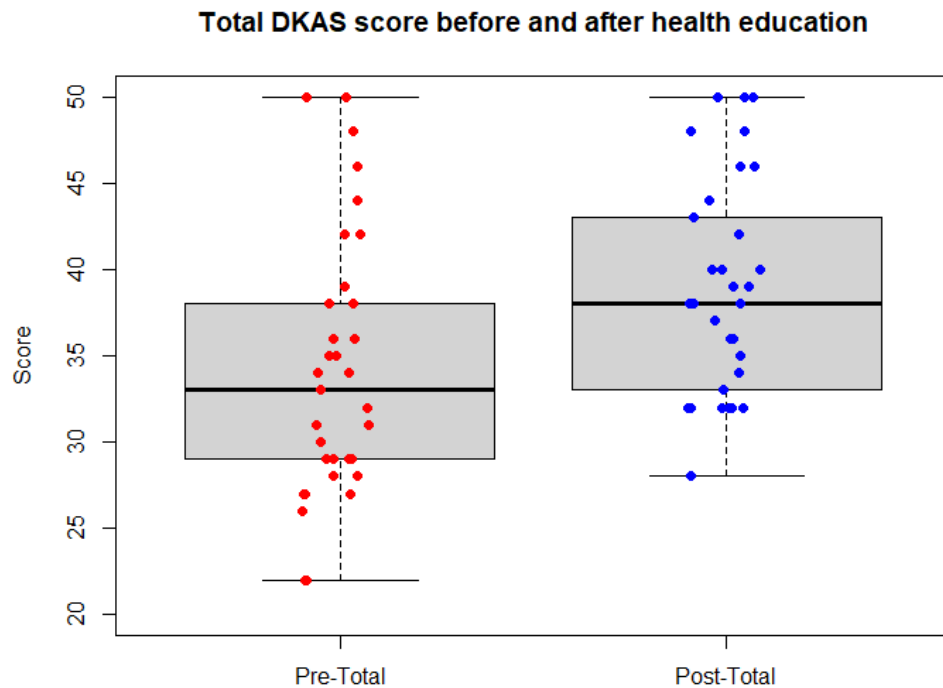


Figure 7.2 Boxplot of the total DKAS score before and after health education (DKAS: Dementia Knowledge Assessment Scale)

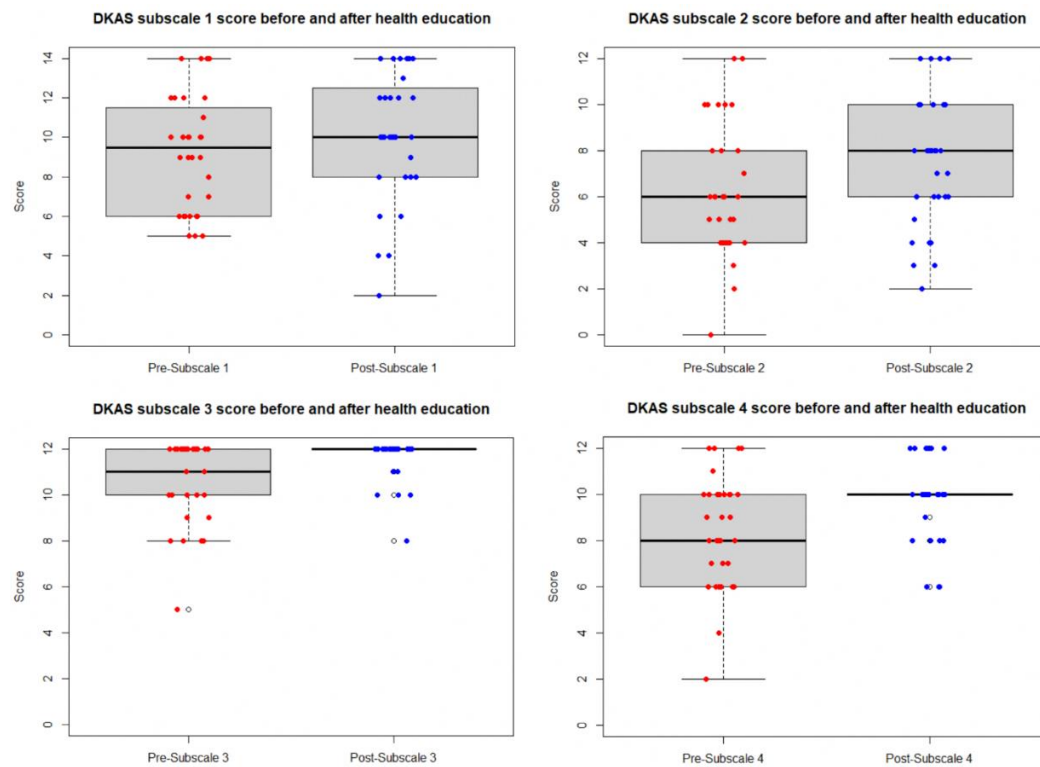


Figure 7.3 Boxplots of the DKAS subscale scores before and after health education (DKAS: Dementia Knowledge Assessment Scale)

Table 7-2 Summary of the DKAS score statistics (DKAS: Dementia Knowledge Assessment Scale)

Subscale	Item	Pre-score Mean (SD) (N = 32)	Post-score Mean (SD) (N = 34)	Pre-education subscale Mean (SD)	Pre-education subscale Mean (SD)	p-value
Causes and Characteristics	1. Most forms of dementia do not generally shorten a person's life.	0.66 (0.94)	0.74 (0.96)	9.19/14 (2.88)	10.24/14 (3.17)	0.049* [†]
	2. Blood vessel disease (vascular dementia) is the most common form of dementia.	1.03 (0.90)	1.24 (0.99)			
	3. People can recover from the most common forms of dementia.	1.66 (0.60)	1.79 (0.59)			
	4. Dementia is a normal part of the ageing process.	1.34 (0.90)	1.47 (0.90)			
	5. Dementia does not result from physical changes in the brain.	1.50 (0.80)	1.65 (0.77)			
	6. Planning for end-of-life care is generally not necessary following a diagnosis of dementia.	1.31 (0.97)	1.35 (0.95)			
	7. Alzheimer's disease is the most common form of dementia.	1.69 (0.59)	2.00 (0.00)			
Communication and Behaviour	8. It is impossible to communicate with a person who has advanced dementia.	0.81 (0.97)	1.24 (0.99)	6.38/12 (2.95)	7.18/12 (2.93)	0.014* ^{††}
	9. A person experiencing advanced dementia will not generally respond to changes in their physical environment.	0.69 (0.93)	0.47 (0.86)			
	10. It is important to correct a person with dementia when they are confused.	1.38 (0.94)	1.35 (0.95)			
	11. People experiencing advanced dementia often communicate through body language	1.21 (0.89)	1.24 (0.96)			
	12. Uncharacteristic behaviours in a person experiencing dementia are generally a response to unmet needs.	1.36 (0.86)	1.44 (0.86)			
	13. Medications are the most effective way of treating behavioural symptoms of dementia.	0.94 (0.93)	1.44 (0.89)			
Care Considerations	14. People experiencing dementia do not generally have problems making decisions.	1.88 (0.48)	2.00 (0.00)	10.61/12 (1.75)	11.65/12 (0.88)	0.00076*** ^{††}
	15. Movement is generally affected in the later stages of dementia.	1.76 (0.61)	2.00 (0.00)			
	16. Difficulty eating and drinking generally occurs in the later stages of dementia.	1.61 (0.66)	2.00 (0.00)			

	17. People with advanced dementia may have difficulty speaking.	1.85 (0.44)	1.85 (0.50)			
	18. People experiencing dementia often have difficulty learning new skills.	1.76 (0.61)	1.94 (0.34)			
	19. Daily care for a person with advanced dementia is effective when it focuses on providing comfort.	1.76 (0.61)	1.85 (0.50)			
Risks and Health Promotion	20. Having high blood pressure increases a person's risk of developing dementia.	1.24 (0.83)	1.88 (0.48)			
	21. Maintaining a healthy lifestyle does not reduce the risk of developing the most common forms of dementia.	1.09 (1.01)	1.82 (0.58)			
	22. Symptoms of depression can be mistaken for symptoms of dementia.	1.76 (0.61)	1.97 (0.17)	8.33/12 (2.42)	9.68/12 (1.65)	0.00056***††
	23. The sudden onset of cognitive problems is characteristic of common forms of dementia.	0.61 (0.83)	0.41 (0.82)			
	24. Exercise is generally beneficial for people experiencing dementia.	1.94 (0.35)	1.94 (0.34)			
	25. Early diagnosis of dementia does not generally improve the quality of life for people experiencing the condition.	1.70 (0.73)	1.65 (0.77)			
-	Total	34.53 (7.41)	38.74 (6.14)			5.69e-05****†

† Passed Shapiro-Wilk Test (normality test), and therefore used paired t-test

†† Failed Shapiro-Wilk Test (normality test), and therefore used non-parametric Wilcoxon signed-rank test

* P ≤ 0.05

** P ≤ 0.01

*** P ≤ 0.001

**** P ≤ 0.0001

SD: Standard Deviation

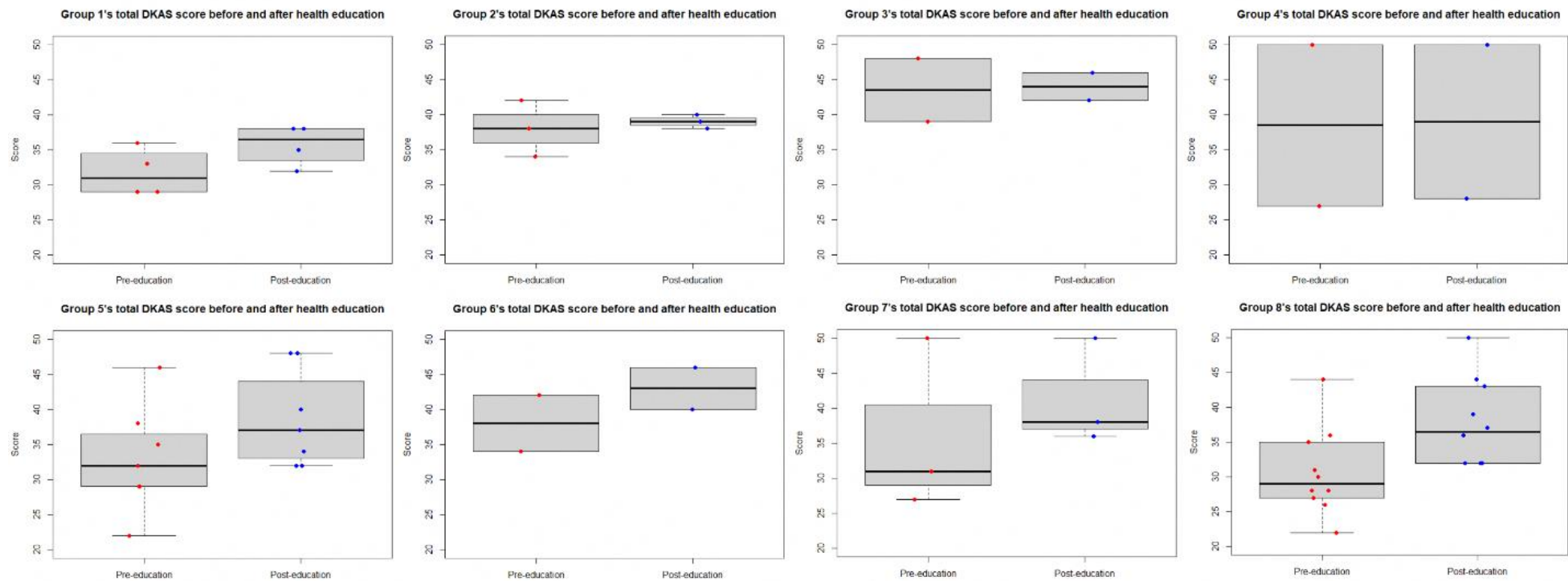


Figure 7.4 Boxplots of the total DKAS scores by group (DKAS: Dementia Knowledge Assessment Scale)

7.4.3 Feasibility of Tele-education

7.4.3.1 Duration and Ability to Carry Out the Activities in the Session

The durations of the eight pilot-test sessions ranged from 40.3 minutes to 100 minutes with a median of 53.6 minutes and a mean of 70.2 minutes.

All participants who joined the co-design workshops on their own smartphones or laptops (34/35) shared that they could follow the instructor and did not encounter any difficulties, except for occasional Wi-Fi instability. Sample quotes are summarised in Table 7-3.

7.4.3.2 Satisfaction and Perceived Appropriateness in Local Setting

Although the majority of the participants were new to tele-education, all of them expressed satisfaction with this mode of receiving health education and found it easy to understand and relevant to the Singapore local context. Some participants shared that their daily schedules were packed with household chores or caregiving duties, making tele-education the ideal choice for them.

In addition, participants anticipated the integration of health promotion campaigns with tele-education to enhance the impact of dementia awareness initiatives. Suggestions included organising regular health promotion events and reaching out to less engaged older adults, incorporating free or subsidised dementia screenings into annual medical check-ups, and designing a tag for individuals with dementia to encourage public assistance and support when needed. These initiatives would serve to expand the reach of awareness efforts,

target a wider group of audience, and cultivate a dementia-inclusive society.

Sample quotes are summarised in Appendix 13.

Table 7-3 Sample quotes regarding participants' ability to carry out the activities in the prototype

Theme	Sample Quotes
Most participants could follow the instructor and did not encounter any difficulties.	"I didn't come across any challenges." (P08) "I'm comfortable with this." (P09) "I think it's quite simple" (P11)
One participant reported occasional Wi-Fi instability.	"For myself, I don't know whether you noticed just now I got disconnected for [a] very short time twice. Maybe it's my connection issue here, so I was lost for one or two minutes at that time just trying to connect." (P30)

7.4.3.3 Demand and Possibility of Expansion

All participants recognised the significance of educating the older population about dementia, a growing health concern among Singapore's ageing population. They believed that such education could increase their awareness about dementia, facilitate early precautionary measures, and empower individuals to provide better care for their loved ones. They also mentioned that this topic addressed their needs and expressed their desire for the prototype to evolve into a comprehensive tele-education programme. Sample quotes are summarised in Table 7-4.

Besides dementia, participants expressed their desire to incorporate a broader range of topics into the tele-education programme. They stressed the importance of acquiring both medical knowledge and practical strategies for prevention and management. The suggested topics are summarised in Table 7-4.

Table 7-4 Sample quotes regarding participants' perceived possibility of expansion and demand

Theme	Sample Quotes
All participants believed that such education could increase their awareness about dementia, facilitate early precautionary measures, and empower individuals to provide better care for their loved ones.	See Appendix 12.
Participants expressed the desire for the prototype to evolve into a comprehensive tele-education programme.	“This topic is a very common topic, and is a topic that is of much interest to people aged 65 and above. I think behind our minds, we have this question “Will dementia actually hit me?” so this being the kind of general environment, I suppose if you put it into the telehealth education programme, it should be very popular and welcoming.” (P27)
Besides dementia, participants expressed their desire to incorporate a broader range of topics into the tele-education programme.	• Silent killer diseases (e.g., high blood pressure/hypertension, diabetes, high cholesterol, cancer, osteoporosis, blood circulation, and cardiovascular diseases) • Eye diseases • Skin diseases • Kidney stones & gallstones • Frailty and mobility • Mental health • Nutrition and healthy cooking, • Simple home exercises and muscle-building • Vaccination • Supplements • Caregiving tips • Traditional Chinese Medicine • Quality information searching

7.4.4 Perceptions of Tele-education – SNOW Analysis

The thematic analysis yielded 38 themes that delineated the strengths, needs, opportunities, and weaknesses (SNOW) of tele-education for the older population, encompassing various aspects such as health education design, human (older learners and instructors), technology, and environment (healthcare system and policy) (Figure 7.5). Sample quotes are summarised in Appendix 14.

7.4.4.1 Strengths

Participants acknowledged tele-education as a convenient method for receiving health education, as it eliminated the need for travel to physical locations. Instead, they could partake in the educational sessions from the comfort of their environment, enabling them to stay relaxed and attentive. Additionally, the tele-education platform could provide a valuable opportunity for individuals who are less socially active to interact with others without the pressure of speaking in front of a public audience.

7.4.4.2 Weaknesses

While tele-education presented several benefits, participants expressed a sense of reduced interpersonal communication and intimacy compared to in-person sessions. They also highlighted the reliance on Internet connectivity for the quality of tele-education and raised potential usability challenges posed by small device sizes. Furthermore, participants felt a lack of immediate support in the event of technical issues, particularly when they were alone.

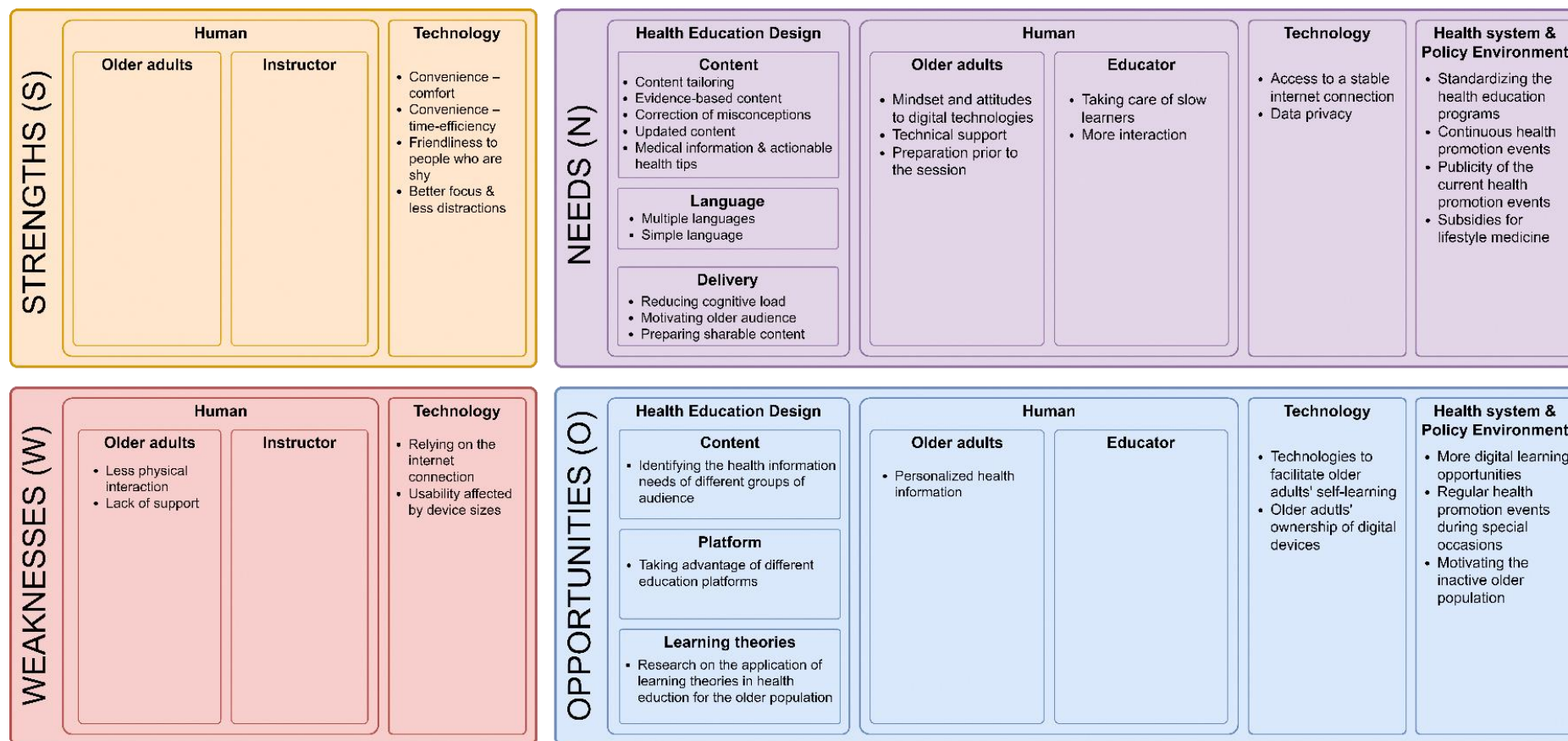


Figure 7.5 SNOW analysis results (SNOW: Strengths, Needs, Opportunities, Weaknesses)

7.4.4.3 Needs

Health Education Design

Participants stressed the importance of tailoring the health education content to the specific needs and preferences of older adults. They highlighted the need to rectify misconceptions, offer practical tips, and ensure the credibility and up-to-date nature of the information provided. Participants also acknowledged that not all health information may apply to everyone and therefore should be shared with caution. They emphasised the importance of adjusting the language to accommodate the spoken languages and literacy levels of the older audience. Strategies to minimise cognitive load and motivate older adults to embrace new information were seen as crucial. Participants also expressed the value of making educational materials sharable for future reference and easy to share with others. Additionally, some participants mentioned the benefit of involving family caregivers, including domestic workers, in the health education process.

Human

To maximise the impacts of tele-education, learners may benefit from adopting a positive mindset and attitude towards new health information and digital technologies and acquiring technical skills or receiving technical support. Some participants found it beneficial to prepare their questions ahead of time, enabling them to actively participate and engage in more meaningful and in-depth discussions with health educators. It was also crucial to recognise that older learners have varying levels of literacy and learning capacities, and health educators should be attentive to those who may require additional time and support. Facilitating ample opportunities for audience interaction would help

ensure that all participants can effectively follow along and actively engage with the educational material.

Technology

Participants emphasised the importance of having a reliable Internet connection to maintain the quality of tele-education. They also expressed the need for better protection of their personal data in the online learning environment.

Healthy System and Policy Environment

Some participants mentioned their limited awareness of health promotion events, indicating the need for improved publicity efforts to enhance public awareness. They also emphasised the importance of organising these events on a regular basis to achieve long-term impacts. Furthermore, participants recognised the potential confusion that may arise from distinct health information provided by different health education programmes, which underscored the importance of standardising and ensuring the consistency and credibility of health information. Moreover, some participants highlighted that financial constraints could hinder their implementation of personalised lifestyle practices, suggesting the need to lower these barriers for a smoother transition from health knowledge to practices.

7.4.4.4 Opportunities

To address these needs, participants offered several suggestions on the implementation strategies. One recommendation was to collaborate with community organisations to identify different target audience groups and gain a deeper understanding of their specific needs prior to designing health

education programmes. Additionally, taking advantage of various modes of education delivery and offering a hybrid format concurrently could cater to the diverse needs of the audience. Exploring the application of adult learning theories in health education for older adults was also highlighted as an interesting area for further exploration.

It was also noted that general health information may not be universally applicable, and blindly following such information without consulting health professionals could potentially pose risks to individuals' health. To mitigate this, personalised health information was proposed as a promising complement to general health education programmes. This approach would provide guidance and support tailored to individuals based on their unique circumstances.

Publicity of the current health promotion events could be further strengthened, for example, by organising health promotion events on designated special occasions on a regular basis to reinforce public awareness and engagement. Additionally, leveraging AI algorithms, such as ChatGPT, could be explored to provide accessible and interactive platforms for individuals to self-access information and resources. Furthermore, strategies should be developed to address the digital divide and ensure that everyone has equal opportunities to benefit from health education initiatives.

7.4.5 Workshop Evaluation

Participants' evaluation of the co-design workshops (Table 7-5) demonstrated well acceptance of the co-design workshops. Key aspects that were identified as interesting and valuable included the acquisition of new knowledge, the pre- and post-assessment of dementia knowledge, active participation of the participants, engaging interactions between participants and the moderator, the moderator's effective presentation and sharing, and the recognition of tele-education as a viable method for receiving health education. Feedback for potential improvements included the suggestions of involving more individuals in future FGDs to gather a broader range of personal experiences and ensure a manageable duration of the co-design workshops.

Table 7-5 Participants' evaluation of the co-design workshops

Items	Quartiles & Median (N = 35)			
	1st quartile (Q1)	Median	3rd quartile (Q3)	Mean
1. The workshop was very organised.	4	4	5	4.4
2. Time was well managed during the workshop.	4	4	5	4.3
3. The workshop was delivered clearly.	4	4	5	4.3
4. The moderator was well prepared.	4	5	5	4.5
5. The moderator was responsive to the questions.	4	4	5	4.5
6. The moderator encouraged everyone to speak.	4	4	5	4.5
7. The workshop format was appropriate for the audience.	4	4	5	4.4
8. The workshop has achieved its objectives.	4	4	5	4.3
9. I understand the concepts presented in the workshop.	4	4	5	4.5
10. I enjoyed the workshop.	4	4	5	4.4
11. I would like to participate in such workshops again in future.	4	5	5	4.4

7.5 Discussion

7.5.1 Principal Findings

Since the outbreak of the COVID-19 pandemic, different local health institutes and organisations have adapted the traditional health education sessions to online platforms. Examples include virtual health workshops and exercise workshops offered by the HPB Active Ageing Programmes (93), CARPET skills/competencies in National Health Group (444), and the exercises, cooking, and educational workshops by the Virtual Social Service Centre of the 365 Cancer Prevention Society (94). To the best of my knowledge, there has been no published evidence regarding the design, public awareness, effectiveness, and acceptability of these programmes, or the preference of older adults regarding health education topics and delivery (94).

To bridge this gap, this study employed a participatory approach and engaged community-dwelling older adults to pilot test the synchronous tele-education prototype and share their opinions. This approach could foster meaningful dialogue and facilitate a shared understanding of priority areas for intervention among the research team and the target population (445). The findings of this study encouragingly demonstrated the feasibility and preliminary effectiveness of such a mode in providing dementia education and provided valuable insights into the design of future health education initiatives in both physical and virtual environments. Moreover, participants' satisfaction with the co-design

workshops further highlighted the successful implementation of the participatory approach in an online environment among older adults.

7.5.2 Effectiveness of Tele-education

In this mixed-methods study, participants' significant improvement in dementia knowledge measured by DKAS and the insights shared regarding the perceived effects of the tele-education prototype on their knowledge and behaviour intentions triangulate and provide additional confirmation of the promising effectiveness of this synchronous tele-education prototype. Aligning with the earlier interview study in (290), the finding underscores the potential for technology-driven interventions in health information dissemination, behaviour change promotion, and health empowerment among older adults. It is also worth noting that "knowledge does not change behaviour is useless". Therefore, it is also crucial to supplement health education initiatives with tailored strategies or interventions to encourage active engagement and promote sustained behaviour changes among the older population.

7.5.3 Feasibility of Tele-education

To evaluate the feasibility of the prototype, multiple outcomes were measured and they collectively indicated that tele-education can be a viable method for delivering dementia education to older individuals. As part of the Smart Nation initiative, the Singapore government and authorities have been actively promoting positive digital habits across all age groups to build a digitally inclusive nation (446). Efforts have been made to assist the older generation in accessing technologies at lower costs (447) and developing technological skills

(313,448). It is encouraging to see that more older adults are recognising the benefits of technologies and embracing them in their health-seeking activities (290).

Participants acknowledged that synchronous tele-education combines the benefits of various health education modes: it allows learners to conveniently access important health information and engage in real-time interactions while receiving immediate feedback from both their peers and health educators, all without the need for travel or additional expenses. Meanwhile, it is important to note that tele-education may not be suitable for every individual due to different factors like age-related declines, limited access to technologies, poor internet connectivity, lack of digital literacy, concerns about privacy, inadequate training or support to navigate and utilise platforms, and potential challenges in engaging in a virtual learning environment (449). These barriers should be taken into consideration in the design process to ensure that tele-education reaches the appropriate target audience and effectively addresses their specific needs and circumstances.

7.5.4 Involvement of Older Adults in the Co-design

In recent years, there has been a noticeable surge in interest in the active involvement of older adults in the technology co-design (450). In this study, participants expressed high satisfaction with and a strong willingness to continue their engagement in such participatory approaches. Their feedback re-emphasises that co-design represents a form of "mutual learning" and fosters a reciprocal knowledge exchange among designers and potential users (451).

Despite the challenges posed by various factors reported in the literature, such as relationship and trust building, knowledge acquisition, and co-design skills (387), the findings highlight the potential feasibility of engaging older adults in the participatory approach in an online environment, ultimately contributing to the co-development of more inclusive and equitable telehealth programmes.

7.5.5 Recommendations for Health Education Design and Implementation

The findings also suggest that the success of a health education programme is the co-product of various factors, such as design factors (e.g., content, language, delivery, and interaction), human factors (e.g., audience's literacy levels, health educators' communication skills, and feedback), technological factors (e.g., access, design, and privacy), and environmental factors (e.g., social, healthy system, and policy environment). Building upon these findings, we propose a set of recommendations for refining the prototype and designing future health education programmes to maximise their effectiveness and improve their inclusivity among the older population (Table 7-6).

Table 7-6 Set of participants' recommended implementation strategies for future health education

Factor	Sub-factor	Participants' Recommended Implementation Strategies for Future Health Education Program	Supporting Literature
Health education design	Content	The educational content should be customised to address the health needs of the target audience group and suit the local context.	(405,452)
		The content should be evidence-based and constantly updated.	(452)
		It is important to keep learners informed about the generalisability of the health information provided.	(452)
		Incorporating real-life examples or personal experiences can resonate empathically with older learners.	(409)
		Balancing medical knowledge (what and why) with actionable tips (how) is key to maximising the practicality and effectiveness of health education.	(405)
		Introducing the interconnection of different diseases across different human body systems can provide a holistic understanding and motivate proactive involvement in disease prevention, screening, and treatment.	
	Language	Making educational content available in multiple spoken languages can reach a wider audience.	
		Reducing technical jargon and using simple terminologies can ease older adults' understanding of health information.	(405)
	Delivery	Implementing strategies to reduce cognitive load, such as content chunking, eliminating unnecessary information, minimising distractions, highlighting key information, improving content readability, and using multiple modalities, can enhance engagement.	(421,425)
		Offering health education in a hybrid format (e.g., physical, synchronous tele-education, and pre-recorded videos/sharable materials) provides flexibility and reaches a broader audience group.	
		Conducting smaller group health education or health coaching sessions allows for individualised health information delivery.	
	Interaction	Using two-way communication and creating more interaction opportunities could better engage and motivate older adults compared to one-way, didactic sharing by the health educator.	(421,425)
Human	Learner	Older learners should be motivated to accept new health information and technology use and be provided with assistance and support when necessary.	(405)

	Health educators	Health educators should closely monitor older learners' learning progress during an education session to identify any potential confusion or difficulty, adjust the pace, and provide immediate clarification or support.	(409)
		Providing feedback could help learners identify any misconceptions or additional clarifications required, visualise their progress and achievements, and reinforce the important health messages. On the other hand, it can also help health educators receive constructive inputs on their performance and learners' effectiveness, identify potential improvements, and assess if the learning objectives have been achieved.	(409)
Technology	Design	Improving the design of technologies to be more user-friendly for older adults facilitates their health education.	(405,452)
	Access	Addressing the digital divide and enhancing older adults' access to technologies, from ownership to proficiency, is crucial.	(452)
	Privacy	Personal information should be better protected to alleviate older people's data privacy concerns.	
Environment	Social	It would be beneficial to leverage families and social networks to promote health education initiatives and provide technical support.	(421,425,468)
	Health system and community	Standardising health information across different education programmes prevents confusion and the potential spread of misinformation.	(452)
		Engaging community organisations in the identification of specific needs among the target audience for health education and actively involving them in the implementation process is of utmost importance.	
		Complementing health education with other health promotion or awareness initiatives spreads the impact and creates a supportive environment for older adults.	
		Continuity and regularity of health education sessions reinforce and update health information, leading to cumulative effects on older individuals' knowledge and behaviour change.	
	Policy	Subsidies on lifestyle medicines can lower barriers to adopting a healthy lifestyle, work in conjunction with health education efforts to facilitate the transformation of health information into sustained behaviour change and mitigate health disparities among older adults.	

7.6 Reflection

This study embraced a participatory approach by involving community-dwelling older adults in the co-designing process of a synchronous tele-education programme. The findings not only underscore the significance of engaging older adults in public health education initiatives but also demonstrate the potential of tele-education. The insights and recommendations shared by the participants could be used to guide the future scaling-up of a comprehensive tele-education programme. Moving forward, further directions will focus on collaboration with health institutes, agencies, and community organisations, as well as a systematic evaluation of the long-term impacts of tele-education programmes.

CHAPTER 8 DISCUSSION

8.1 Introduction

This thesis employed a multi-methods approach to answer the overarching research question: “What is the feasibility of utilising telehealth to address older individuals’ health needs?” The four studies span the entire process from exploring potential domains for telehealth implementation to understanding the various determinants that influence telehealth adoption and implementation, and finally to co-designing and evaluating telehealth prototypes. Collectively, they provide evidence supporting the feasibility of telehealth in the context of ageing care within the Singapore community.

This chapter is organised into eight sections. Chapter 8.2 presents a point-by-point summary of the findings, while Chapter 8.3 provides an overall discussion. Chapter 8.4 explores the implications of these findings for health practices that could apply to both Singapore and other countries. Chapter 8.5 highlights how the findings can contribute to the existing body of knowledge and Chapter 8.6 is my reflexivity regarding the choice of telehealth modalities in Study Three and Study Four, methodology, data collection, and data analysis. In Chapter 8.7, the limitations of this thesis, including those related to its scope, design, and methodology, are discussed, followed by concluding remarks in Chapter 8.8.

8.2 Summary of The Key Findings of Each Study

Study One

Study One adopted a qualitative IDI approach and aimed to broadly explore the potential areas for telehealth implementation in Singapore's ageing care. The key findings are summarised in point form below:

What are the consequences of HSB in the context of ageing in Singapore?

A total of five major consequences of older adults' HSB were identified, namely, health information seeking, health maintenance, early diagnosis and complication control, responses to symptoms, as well as health service access and interaction, aligned with Poortaghi's content analysis.

How have technologies been incorporated into older people's HSB?

- Technologies have played a substantial role in facilitating community-dwelling older adults' HSB in the Singapore community.
- ICTs and social media, although not primarily designed for health purposes, play a substantial role in easing the process of obtaining health information and managing symptoms.
- Among all digital technologies, the most widely used among the older population are mHealth apps and wearable devices, with associated wellness programmes launched by government agencies and local companies. These technologies have the potential to enhance health

communication, promote health maintenance, and increase access to health services.

- Although the outbreak of the COVID-19 pandemic has resulted in some alterations to older adults' well-being, it has catalysed the adoption of telehealth as a complement to access health services.

What considerations do older adults factor in when choosing technologies to meet their health needs?

- Eight factors were identified regarding older people's choice of technologies to address their health needs, namely, (1) perceived usefulness, (2) comprehensiveness of features, (3) perceived ease of use, (4) performance and quality, (5) recommendation by the social network, (6) cost, (7) rewards, and (8) credibility.
- Older individuals' preferences and needs should be taken into consideration during telehealth design and implementation to promote user-centred designs.
- Although health innovations play a promising role in facilitating older people's HSB, they may not be suitable for every individual. Therefore, it is crucial to uncover each archetype's specific needs and ensure that no one is forced to use technologies or left behind in digital inclusion.

What are the potential areas for telehealth implementation to address the unmet needs of the older population?

- A major gap identified regarding participants' HSB is the lack of self-measurement of physiological parameters, especially for those with NCDs. Some contributing factors include self-perceived good health, scheduling difficulties, lack of necessary equipment, and difficulty in obtaining accurate measurements. Thus, clinical and community-based telemonitoring services have the potential to provide them with better access to quality health services, promote a proactive role in managing their health, and reduce health disparities.
- Other potential areas for telehealth implementation include consultation and health education.

Study Two

Study Two aimed to explore the perceptions of telehealth among older adults, healthcare professionals, social service providers, and telehealth providers, from both users' and non-users' perspectives. Moreover, this study explored the determinants and potential strategies for telehealth implementation in Singapore's ageing care. The key findings are summarised in point form below:

What is the acceptability of telehealth in Singapore's ageing care?

Most participants accepted the telehealth concept and viewed it as an inevitable and transformative trend in future healthcare delivery. However, the intention to use telehealth was notably low.

What are the determinants that affect telehealth implementation in Singapore's ageing care?

Different determinants at the individual, interpersonal, technological, system, and policy levels stood as barriers to the wider implementation of telehealth in ageing care. A common consensus among all groups of participants was that telehealth could not and should not fully supplant traditional in-person care but rather complement it.

What are the perceived implementation strategies that could potentially enhance the adoption, implementation, scalability, and sustainability of telehealth interventions?

Participants shared various implementation strategies from telehealth users, technology design, service execution, policy, and research perspectives. Successful telehealth implementation would require concerted efforts and collaboration among older individuals, family caregivers, health service providers, researchers, and policymakers.

Study Three

In this study, a telehealth prototype was developed, aiming to address one major gap in older adults' HSB identified in Study One—lack of self-measurement practice. The prototype was implemented in three phases progressively and its feasibility was assessed using a hybrid type 3 study design. The key findings are summarised in point form below:

To what extent is a community-based telehealth programme a feasible initiative in extending telehealth services to community-dwelling older adults?

- The implementation strategies to reduce the IGIs demonstrate CTS' feasibility in the Singapore community, from its implementation, demand, integration, technical practicality, acceptability, and preliminary effectiveness perspectives.
- The implantation of the health ambassador programme has the potential to value-add to the service delivery. The well-trained health ambassadors could lower the older individuals' barriers to health technology utilisation, assist users in explaining their physiological parameters, provide actionable recommendations for lifestyle modifications, and link users back to the existing healthcare system. Such a comprehensive approach could address the concerns raised in literature and foster a more proactive HSB.
- CTS could provide a more comprehensive record of users' health-related information, which is emphasised by ageing health service providers and telehealth providers in Study Two.

What are the key areas of improvement to motivate the uptake of community-based telehealth programmes?

According to the users, possible areas for improvement of CTS include providing additional health tests, offering more health information, and enhancing the current referral management system.

Study Four

To address a potential area for enhancement raised in Study Three—offering more health information among the elderly, a tele-education prototype was created. This study aimed to engage older adults in the co-design process of a tele-education programme and investigate how this mode of health education delivery could meet their specific needs. The findings are summarised in point form below:

What are the potential effects of tele-education on older adults' health knowledge and awareness?

The significant improvement in the post-learning DKAS scores along with participants' sharing regarding the perceived effects of the tele-education prototype on their knowledge and behaviour intentions demonstrated the preliminary effectiveness of this synchronous tele-education prototype and reinforced the significance of involving this demographic in health education initiatives.

What is the feasibility of tele-education for delivering health education to older adults?

Participants' ability to carry out the activities in the co-design workshops, satisfaction with the prototype and their perceived appropriateness in the local setting, perceived impacts of this prototype, as well as the successful implementation of the prototype have collectively indicated the feasibility of synchronous tele-education to deliver dementia education.

How receptive are older adults to the participatory approach in an online environment?

- Participants expressed high satisfaction with and a strong willingness to continue their engagement in such participatory approaches.
- The potential feasibility of engaging older adults in the participatory approach in an online environment would ultimately contribute to the co-development of more inclusive and equitable telehealth programmes.

What are the recommended implementation strategies for designing and implementing tele-education programmes for older adults?

- Despite having various benefits, synchronous tele-education may not be suitable for every individual, therefore, the design for future health education programmes should reach the appropriate target audience and effectively address their specific needs and circumstances.
- A set of recommended strategies for implementing future health education programmes has been proposed, including design considerations (e.g., content, language, delivery, and interaction), human-related factors (e.g., audience' literacy levels, health educators' communication skills, and feedback), technological aspects (e.g., access, design, and privacy), and environmental factors (e.g., social, healthy system, and policy environment), aiming to maximise their effectiveness and improve their inclusivity among the older population.

8.3 Overall Discussion

My earlier scoping review of systematic reviews highlighted that telehealth has been utilised across various domains in ageing care worldwide and demonstrated its considerable potential to enhance health service delivery for the older population (119). It has shown promise in enhancing access to health services, reducing healthcare costs, and improving both health outcomes and behaviour outcomes of older adults. In Singapore, telehealth has been also recognised as a key element of the Smart Healthcare initiatives (81), which underscores its increasing relevance in the national healthcare agenda, particularly as Singapore faces the dual challenges of an ageing population and a growing demand for more efficient and accessible healthcare solutions.

In Chapters 6 and 7, the feasibility of the two telehealth prototypes was evaluated using Bowen et al.'s feasibility framework (390). Building on these evaluations, the following discussions will explore the broader feasibility of telehealth in the context of Singapore's ageing population.

8.3.1 HSB Revisited and Potential for Telehealth

Traditionally, HSB has been studied as the actions that individuals take in direct response to symptoms of illnesses (78,283,285,286). This approach has focused on responses to health challenges and treated HSB as a straightforward decision driven by individual perceived health needs (289). In contrast, this thesis adopted Chinn & Kramer's definition (291) and explored the complexity and multifaceted nature of HSB. Such a comprehensive understanding of HSB

recognises that HSB is not merely a series of isolated individual actions but is deeply embedded within broader social contexts. Aligning with Poortaghi et al.'s results (299), the findings of this thesis demonstrate that older individuals in Singapore do not navigate their health-seeking journey in isolation. Indeed, their HSB is shaped by the interactions within their social networks, the influence of government initiatives and social services, as well as engagements with various technologies.

Social Networks to Facilitate Health Seeking and Decision-Making

Social networks play a pivotal role in facilitating HSB and the decision-making process for older adults. A key finding from the studies is the proactive participation of older adults not only in managing their own health but also in shaping the HSB of their social networks. For instance, some participants have taken on roles as health ambassadors within their communities, actively promoting healthy behaviours and practices among their peers. Some rely on their social networks—family members and friends—as informal yet crucial support systems and primary sources for health information.

Rather than being passive recipients of health information, they proactively leverage their social circles to obtain, process, and reshare health-related knowledge. This dynamic process involves more than just sharing experiences or seeking advice; it encompasses a deliberate exchange of information, where older adults discuss health concerns, explore self-management strategies, and seek recommendations on appropriate health services. This exchange of

information can reinforce or challenge their pre-existing beliefs and attitudes toward health services, thereby influencing their subsequent health behaviours.

However, such reliance may also introduce challenges. The accuracy and reliability of shared information can vary; misinformation, coupled with differing levels of health literacy within these networks, can adversely impact health choices and potentially lead to harmful outcomes (469,470). To mitigate these risks, it is essential to empower key influencers within social networks—such as family members, friends, as well as community volunteers and leaders—through targeted health education programmes designed to enhance their ability to recognise, evaluate, and disseminate credible health information. Additionally, integrating healthcare providers into these social networks, either through regular participation in community forums or by endorsing peer support groups, can bridge the gaps between professional medical advice and the informal sharing of information (471).

Responses to Government Initiatives and Social Services

In recent years, the Singapore government has launched different initiatives aiming at promoting healthy lifestyles, improving chronic disease management, and encouraging early detection of health conditions, such as the National Step Challenge and Healthier SG initiative (85,472). Studies have shown that these initiatives have been effective in improving participants' healthy behaviours (473–475). In addition, in response to the growing diversity of experiences, aspirations, and needs among Singaporeans, the 2023 Action Plan for Successful Ageing has been updated to focus on community-based strategies and

incorporates a broad spectrum of ground-up initiatives designed to improve the health and well-being of older adults, as well as supporting them in successful ageing (476).

However, the success and impacts of these initiatives largely depend on the ability and willingness of individuals, particularly older adults, to actively engage with the programmes. The findings of this thesis reveal that many older adults have been proactively participating in these national and community-based initiatives. One of the key factors driving their engagement appears to be the incentives received which also serve as a vital motivator for their healthier lifestyle choice, suggesting that well-structured reward systems can play a crucial role in the adoption and sustained impacts of such programmes.

Engagement with Technologies

Digital-first Singapore was developed as a strategic initiative, aiming to transform health, transport, urban living, government services, and businesses through a Digital Government, Digital Economy, and Digital Society (477). To promote digital inclusion, the Singapore government and social service agencies have been actively offering digital training among its citizens, and many older adults are gradually becoming more confident with adopting technologies. Initiatives like the Seniors Go Digital programme and courses offered on MySkillsFuture and OnePA have provided opportunities for older adults to learn how to use digital devices, software, and platforms (478–480). As seen in Study One, many older participants were already using wearable trackers and mobile apps to maintain healthy lifestyles; while in Study Four, all participants could

follow my instructions and did not encounter any difficulties during the whole co-design process in the online environment. These demonstrate their growing comfort with certain types of technologies.

However, despite this increasing engagement, Study Two revealed that many older adults still harboured concerns about their digital competency, which was recognised as a barrier to telehealth implementation. Even with prior experience using health-related apps, they were hesitant to adopt telehealth services due to worries about their ability to navigate these platforms effectively. These underscore the need for ongoing support and education to build confidence and ensure that telehealth services are accessible and beneficial to more older adults in the nation. Furthermore, In Study One, older adults identified eight key factors influencing their technology adoption. These factors highlight the importance of designing technologies and digital health services that are not only functional and user-friendly but also tailored to the specific needs and preferences of older users.

Telehealth to Identify and Address the Unrecognised Needs

The design and implementation of telehealth prototypes in Studies Three and Four were driven by needs. For example, 14 out of the 15 participants in Study One did not perform continuous monitoring of their physiological parameters, largely due to self-perceived good health, a lack of awareness about the importance of self-measurement, and the absence of necessary devices and skills to perform accurate measurements. This is particularly concerning given that, in many countries, including Singapore, a significant proportion of

individuals living with chronic diseases are not well-managed, which puts them at high risk for developing complications in the near future (481). Additionally, many individuals with chronic conditions remain undiagnosed and therefore untreated, further exacerbating these risks (482).

However, in Study Three, as users engaged more deeply with CTS, they began to identify previously unrecognised needs—realising the value of continuous self-measurement as part of their health management strategies and expressing desires for more personalised health information, especially for those with abnormal test results. This shift in perception underscores the promise of telehealth to help identify new needs and adopt practices that can potentially enhance health outcomes.

8.3.2 Feasibility of Telehealth in Singapore’s Ageing Care

Beliefs and Acceptability

Despite a shared belief among older adults and professionals that telehealth is the inevitable and transformative trend in future healthcare delivery, the studies highlighted a nuanced difference in how telehealth is perceived among older adults before and after direct exposure to different telehealth modalities. In Study Two, many older participants initially equated telehealth solely with teleconsultation, despite being introduced to a broader range of telehealth modalities during the IDIs. This limited understanding led to a notably low intention to adopt telehealth, reflecting their unfamiliarity with its full scope.

In contrast, findings from Study Three and Study Four revealed a more positive perspective among those who had hands-on experience with the two telehealth prototypes. Telehealth users expressed high satisfaction and demonstrated a strong intention to continue using telehealth services in the future, even if it was their first time engaging with such services.

These disparities underscore the importance of real exposure in shaping attitudes toward telehealth. Conceptual understanding alone may not be sufficient to drive adoption; actual use of telehealth tools may lead to greater acceptance and a more favourable view of their potential benefits. These findings suggest that efforts to promote telehealth should focus not only on educating older adults about the concept but also on providing opportunities for hands-on experience, helping them overcome initial hesitations and build confidence in using these technologies and services.

Implementation and Limited Efficacy

Given the global evidence of telehealth's feasibility and its prominent role in Singapore's healthcare innovation efforts, it becomes increasingly important to explore how telehealth can be effectively implemented to meet the specific health needs of the older population. Study Two identified multiple factors that affect telehealth implementation across different levels, considering perspectives from both telehealth deliverers and recipients, as well as from users and non-users.

While there was a high degree of consistency in the factors identified from both groups, some conflicting views emerged. These differences highlight the importance of taking both perspectives into account during the design and implementation of telehealth solutions. The reported implementation strategies from this study laid a solid foundation for the design of the telehealth prototypes in Studies Three and Four, ensuring that they were both user-friendly and aligned with the needs and capabilities of the older population.

The limited efficacy of telehealth services, as demonstrated by evaluating the prototypes in Studies Three and Four, offers important insights into the potential and challenges of telehealth in ageing care. Promising outcomes, such as over a quarter of CTS users being referred for further follow-up and some even receiving new diagnoses after using the service, highlight telehealth's potential for abnormality detection. The tele-education prototype also proved effective in correcting misconceptions about dementia, improving dementia-related knowledge, increasing awareness of dementia symptoms and healthier lifestyles, and understanding the challenges of people with dementia and their caregivers.

Similar to prior research (483), an important finding from Study Three was the potential cost savings for multi-user telehealth services. By allowing multiple users to access telehealth services, resources such as manpower, equipment, and digital platforms can be shared among users, thereby reducing individual costs. This approach has the potential to not only make telehealth more affordable for older adults but also optimise the use of necessary resources.

Moreover, the social aspect of multi-user services may encourage higher adoption rates as older adults can support each other in learning and using new technologies. These findings suggest that designing telehealth services to accommodate group use could be a cost-effective strategy for extending access to more potential users.

8.4 Implications for Practice

The findings from this thesis highlight the transformative potential of telehealth in facilitating older adults' HSB and addressing their unmet health needs. To maximise the potential of telehealth, practical strategies could be developed and implemented across various areas, hoping to provide recommendations for the successful implementation and integration of telehealth into Singapore's ageing care. At the same time, it is also important to note that telehealth may not be appealing, needed, or suitable for everyone (484). Therefore, it is crucial to provide alternative options and support, ensuring that individuals have the flexibility to choose the healthcare approach that best suits their needs and preferences.

8.4.1 Improving HSB of Older Adults

Improving the HSB of older adults is the first critical practice implication for enhancing their overall well-being and ensuring their effective utilisation of available health services. A key strategy is to enhance the overall health literacy of older adults, for instance, by promoting the importance of continuous monitoring of their health and teaching them how to evaluate the credibility of

health information. It is equally crucial to educate them about navigating the full range of health services available and how these services can meet their specific needs. Tailored educational programmes and community outreach initiatives are instrumental in bridging the gap between knowledge and practice, empowering older adults with the necessary information and confidence to seek care more effectively and make better-informed health decisions.

Moreover, Study One reveals that HSB is a social process rather than an individual choice. Thus, creating a supportive environment that encourages older adults to adopt proactive HSB is essential. By actively engaging family members, caregivers, social networks, and healthcare professionals in health management discussions, older adults can receive the encouragement and assistance needed to pursue timely and appropriate care (485,486). Additionally, social services that facilitate access to health information and support services can help reinforce the importance of proactive health management and make it easier for older adults to seek necessary care.

8.4.2 Promoting Telehealth Awareness and Support For Both Telehealth Recipients and Deliverers

The success of telehealth in ageing care may hinge on widespread awareness among older adults. Study Two revealed that many older adults were unfamiliar with telehealth, indicating a need for targeted awareness campaigns. These campaigns could focus on demystifying telehealth, explaining its benefits, and illustrating how it can complement traditional healthcare. Community outreach,

media campaigns, and engagement with social networks are other essential components in raising public awareness (487).

Healthcare professionals also play a pivotal role in promoting telehealth awareness among older adults, particularly given their trusted position in the health-seeking process (488). However, for them to effectively advocate for telehealth, it is crucial that they themselves are fully aware of its benefits and confident in its applications. In Study Two, professionals shared that some health service providers might be also hesitant to prescribe telehealth services due to unfamiliarity with the technologies, concerns about its effectiveness, or uncertainties regarding its integration into traditional healthcare models. To overcome these barriers, continuous education and training for healthcare professionals are essential, to not only enhance their understanding of telehealth but also equip them with the knowledge to address any concerns that their clients may have (488).

8.4.3 Enhancing Technology Access and Infrastructure

Providing Digital Training

In Study Two, almost all participants expressed that older adults' concerns about their digital competency could be a barrier to telehealth adoption. Therefore, to ensure that older adults can confidently engage with telehealth, it is crucial to continue providing tailored training and support programmes that address these concerns effectively. These programmes could focus on digital upskilling and provide older-user-friendly support materials, to empower older

individuals to engage confidently with digital health services (489). It is also crucial to develop user-friendly telehealth technologies, platforms, and services that cater specifically to the needs or are easily adapted for older adults, for example, using simpler navigation design or reducing cognitive load (490).

Improving Access to Technologies

Investing in broadband infrastructure is fundamental for ensuring accessibility for all users. Additionally, offering financial assistance or subsidies for telehealth devices and utilisation can make these technologies and services more accessible, especially for low-income older individuals.

Integrating Telehealth into Healthcare Infrastructure

Streamlined operations and more efficient workflows are essential for telehealth service delivery. Thus, it is also vital to ensure that telehealth systems can be seamlessly integrated into the current healthcare models. Telehealth platforms should be designed to be compatible with the existing technology and healthcare infrastructure, while also adhering to interoperability and data security standards (491,492). This will facilitate the smooth exchange of user information and support a coordinated approach to care.

8.4.4 Telehealth Service Design and Implementation

Involving Potential Users in the Co-design Process

Findings from Study Three and Study Four underscore the importance of a participatory approach in co-developing telehealth services. Participants who

engaged directly with the telemonitoring and tele-education prototypes showed high satisfaction and acknowledged that some of their needs could be addressed by telehealth more effectively. More importantly, many of them discovered more unrecognised needs after using the prototypes. This reinforces the value of involving older adults in the co-design process to ensure that telehealth solutions are practical and inclusive.

Ground-up Initiatives as a Complement

It has been recognised that ground-up initiatives are playing a key role in empowering and supporting vulnerable groups in Singapore (493). Study Three further underscores the importance of ground-up approaches by demonstrating how the involvement of various stakeholders in the design and implementation process could significantly enhance telehealth's acceptability and effectiveness. At the same time, as highlighted in Study Two, the ground-up initiatives must be supported by broader policy frameworks and healthcare infrastructure. Integrating these efforts with top-down strategies can ensure that telehealth services align with national healthcare objectives, adhere to interoperability standards, and are supported by sufficient resources.

Human Remains an Indispensable Element in Telehealth

While technology is a critical enabler of telehealth, this thesis underscores the indispensable roles that the human elements play in the effective delivery and adoption of telehealth services—a bridge between technology and users. Technologies alone cannot and should not fully replace the nuanced care that

humans provide, especially in ageing care. Thus, the “Digital First but not Digital Only” Approach (494) should be adopted to maintain the presence and engagement of healthcare professionals, caregivers, and community support systems as integral components during telehealth design and implementation.

Engaging the Non-professionals in Telehealth Implementation

This thesis also validated the strategy of involving individuals with no medical background, or even lay people, in telehealth implementation to address the manpower shortage concerns reported in Study Two. In study Three, the involvement of well-trained health ambassadors, either students or community members who received specialised training to assist with telehealth implementation, has been proven feasible. These health ambassadors were able to bridge the gap between technology and older users by guiding them through the telehealth journey, assisting them with technology utilisation, and providing personalised lifestyle recommendations. This approach not only alleviated concerns about insufficient digital competency and shortage of manpower but also encouraged a more proactive approach to older people’s health management. Thus, integrating the training of laypeople could contribute to more scalable and sustainable telehealth solutions.

8.4.5 Policy development

Regulations for Better Effectiveness and Safety

To facilitate the implementation of telehealth, policymakers should establish and continuously enhance quality and safety standards to ensure that

telehealth services are delivered safely and effectively, with clear protocols for patient care and data security in place. The recognition of telehealth as a legitimate component of healthcare delivery through licensing and accreditation is another important step.

Financial Assistance and Incentives

Study One and Study Two highlighted that financial accessibility is key to health service utilisation among older adults. Thus, it is crucial that telehealth services are reimbursable, for example under national healthcare financing schemes & subsidies, making them affordable to encourage older adults to try and continue using telehealth services. Besides, financial rewards as well as funding for health service providers and telehealth providers could motivate them to expand telehealth services, as shared in Study Two.

Ongoing Evaluation and Improvements

Finally, ongoing evaluation is essential to the success of telehealth initiatives. Policymakers should support research that assesses the impact of telehealth on health and behavioural outcomes, patient satisfaction, healthcare costs, and other long-term societal impacts. Supporting the expansion of successful pilot programmes could ensure that a wider population can benefit from these innovations. Additionally, fostering a culture of continuous improvement is vital to adapt to the evolving needs and technological advancements.

8.5 How the Findings Add to the Field of Knowledge

The COVID-19 pandemic has prompted a critical re-evaluation of how health services are delivered (453). As healthcare systems across the world grapple with the challenges posed by the pandemic, there has been a growing recognition of the potential for telehealth to provide more convenient and non-inferior health solutions at a lower cost. Despite its various benefits, telehealth adoption has been paradoxically slow in ageing care settings (454). Thus, it is crucial to rethink how the traditional healthcare model could embrace the opportunities presented by telehealth as a complementary and transformational tool to better address the evolving needs of the older population. This thesis attempts to address multiple gaps, thereby contributing to the field by advancing knowledge through rethinking theories, refining methodologies, generating novel empirical data, and informing practice. The following sections present how this thesis could add to the field of knowledge.

8.5.1 Theoretically

Traditionally, HSB has been predominantly focusing solely on illness responses or the formal health system utilisation, as pointed out in Chapter 4.1. This thesis challenges this unidimensional lens and places an equal emphasis on the practices for preserving optimal wellness, preventing illnesses, and addressing any deviation from good health, as suggested by Chinn and Kramer (275). By adopting this multi-dimensional approach, the findings not only enrich our understanding of HSB but also provide a more holistic foundation for designing

targeted interventions and policy initiatives aimed at improving healthcare access and outcomes.

In implementation research, oftentimes the established models or frameworks are chosen for identifying determinants of implementation (e.g., CFIR) and devising implementation strategies (e.g., ERIC project). However, there might be a concern that relying solely on these frameworks may oversimplify the intricate factors within a specific setting. Therefore, this thesis relied on empirical data, allowing for a more open-ended exploration of data directly from participants' perspectives.

SEM was adapted when exploring the determinants influencing telehealth implementation in study two, to feature nested circles centred on the individuals and contain individual, interpersonal, technological, system, and policy levels (115). By doing so, it is possible to study the dynamic interplay among different levels of influence while maintaining a focus on individuals as the central point of analysis (455,456) and ensure that telehealth interventions are tailored to meet their specific needs, preferences, and factors of individuals.

Moreover, the assessment of telehealth feasibility in Study Three and Study Four extends beyond singular metrics by drawing upon Bowen's framework. By integrating multiple dimensions of feasibility outcome measures, this assessment could offer a holistic perspective on the feasibility and effectiveness of telehealth interventions. It facilitates a nuanced evaluation that accounts for the multifaceted nature of telehealth implementation, thereby enhancing the validity and transferability of the findings.

8.5.2 Methodologically

To address Gap 4, the challenges in telehealth design to mitigate IGIs, this thesis is exploratory in nature. The planning of the four empirical studies was guided by the IRML, which serves as a structured “roadmap”, facilitating the investigation of the overarching research questions, while enhancing the rigour and reproducibility of the interventions (231). These studies collectively cover the entire spectrum of telehealth development, spanning from telehealth design to implementation and evaluation.

Chapter 2.4.7.4 introduces different activities used in user-centred co-creation, and in this thesis, multiple of them, such as IDIs, observations, FGDs, as well as surveys and feedback were adopted to actively engage the target population and gain more insights into their unique needs and preferences. This approach ensures that the designed interventions could be user-centred and tailored to meet their specific needs. Study Two, in particular, introduced several improvements over prior studies in literature: firstly, by involving social service providers, it addresses the unique context in Singapore where social services complement clinical services to enhance residents' well-being; secondly, the inclusion of individuals with no prior telehealth experience broadens the scope, addressing Gap 3 by incorporating perspectives from non-users and facilitating a more comprehensive exploration of the factors influencing telehealth implementation.

8.5.3 Empirically

Feasibility evaluations of the two telehealth prototypes employed effectiveness-implementation hybrid designs. Quantitative approaches, such as surveys and usability testing, were adopted to collect data on the preliminary effectiveness of the interventions, technological preferences, and user satisfaction. This comprehensive approach enables the triangulation of research findings, validation of the results, and generation of insights that inform telehealth practice and policy implications. This could contribute to addressing Gap 1 by providing new evidence in an Asian setting and Gap 2 by looking into promotive and preventive care.

With the emergence of the COVID-19 pandemic, there has been an unprecedented acceleration in not only the adoption of telehealth solutions but also innovative approaches to health service delivery worldwide. Thus, this thesis is also timely and has the potential to provide more insights into telehealth design, implementation, and evaluation on a global scale.

8.6 Reflexive Considerations

Reflexivity is a vital component of research that involves ongoing self-examination and critical reflection on the researcher's own role, biases, and influence throughout the research process (499). It strengthens the credibility and rigour of the research work, ensuring that findings are not unduly influenced by researchers' own perspectives or assumptions (500). Moreover, reflexivity promotes transparency, as it encourages researchers to openly

discuss the potential impacts of their positionality on the research outcomes (499). This awareness can foster a more ethical and responsible approach to research, where the complexities and nuances of the study are acknowledged and thoughtfully addressed. This section will present my reflexivity regarding the choice of the telehealth modalities, methodology, data collection, and data analysis.

8.6.1 Choice of the Telehealth Modalities

In this project, the choice of the telehealth modalities in Study Three and Study Four was affected by both the specific needs of the older population and considerations regarding practical constraints. I included teleconsultation initially as a potential area of focus, particularly based on the insights gained from Study One. However, I chose to focus on community-based telemonitoring and tele-education due to several reasons. Firstly, my lack of a medical background and the absence of healthcare providers as collaborators in the project made teleconsultation an impractical option. Secondly, participants from Study Two shared that they could generally have easy access to polyclinics or GPs in their neighbourhoods and expressed concerns about the accuracy of remote diagnosis. Thus, they still preferred face-to-face consultations. Lastly, I recognised that many residents were either not visiting healthcare professionals or not adhering to medical advice in my past volunteering experience and clinical observations. This underscored the need for ground-up initiatives that could reconnect these individuals with the healthcare system or, at the very least, help them recognise the importance of doing so.

8.6.2 Methodology

Coming from a background with theoretical mathematics and quantitative research when first entering the population health field, I was initially more inclined toward quantitative approaches. However, as I delved deeper into public health research, I recognised the limitation of purely quantitative methods in capturing the nuanced and lived experiences of older adults. This awareness drove me to adopt a participant-centred approach, ensuring that the voices of the older adults were not just heard but were central to the study.

My positionality as an outsider to the healthcare profession but an insider to the experiences of older adults in community settings also played a significant role in shaping my methodological choices. I was aware of the potential biases that could arise from my lack of formal training in healthcare, which made me more cautious in data interpretation. At the same time, my personal experiences and volunteer work have given me a unique perspective on the challenges of older adults, which I wanted to incorporate into my research. This dual perspective led me to prioritise methodologies that would allow for participant voices to be heard and for their experiences to be fully understood. Consequently, I placed a strong emphasis on qualitative methods, such as IDI and FGD, to complement the quantitative data, ensuring that the research not only captured statistical trends but also provided a rich and contextualised understanding of the research question.

8.6.3 Data Collection

The first aspect of reflexivity in data collection is about ethical considerations of working with a vulnerable population. Being aware of the potential power dynamics at play (501–503), especially when conducting IDIs or FGDs with older adults who might feel obliged to participate or provide socially desirable responses. To mitigate this, I made sure that study information and informed consent were clearly explained prior to data collection. I also emphasised that participation was entirely voluntary with no negative consequences for withdrawal. Drawing on the communication skills developed during my volunteering for the cancer patients among whom mostly are older individuals, I also sought to create a rapport with my participants, from the initial contact before data collection till today. I encouraged a conversational style that would help them feel comfortable and valued. This approach not only enhanced the quality and reliability of the data but also aligned with the standard of conducting research that is both ethically sound and genuinely representative of the participants' experiences.

The second aspect concerns the potential bias. As an outsider of the healthcare field, I was mindful of the potential for my own biases to influence the data collection process. To mitigate this, I approached the participants with humility and openness, making sure that my role as a researcher was not to impose my assumptions but to encourage them to speak freely and share their experiences in their own words; I focused on listening and learning from their lived experiences. Additionally, I respected participants' preferences, such as

choosing not to switch on camera on Zoom, understanding that creating a safe and comfortable environment could potentially influence the quality and authenticity of the data collected.

8.6.4 Data Analysis

Subjectivity is inherent in qualitative data, but it isn't necessarily a drawback as long as researchers remain aware of potential biases and actively manage them (504–506). During data analysis, I was aware of how my previous experience with older adults and my strong belief in the importance of social service could influence my analysis. These prior experiences might have predisposed me to highlight themes that resonated with my views while overlooking data that conflicted with my expectations. Thus, I continually questioned my assumptions at each stage of the data analysis and considered alternative interpretations that might challenge my initial thoughts when interpreting the data.

Due to the limited manpower, I conducted all data analysis by myself. To further address the potential bias, I also had regular discussions with researchers both within and outside the field. These discussions provided invaluable perspectives through different lenses that helped balance my interpretations and ensure that the findings were grounded in the data rather than being skewed by my personal beliefs. This collaborative effort was instrumental in achieving a more nuanced and comprehensive understanding of the findings, as it integrated multiple viewpoints and reduced the risk of any single perspective, including my own, dominating the analysis.

8.7 Limitations and Future Research

There are several limitations to the scope, design, and results of the four empirical studies.

- i. As telehealth is still in its infancy in Singapore, these studies were mostly exploratory in nature and involved qualitative data collection. Thus, there is a potential for bias in the findings, primarily due to the limited sample sizes employed. For instance: in Study Two, almost all participants from the professional group were telehealth users, possibly overlooking the perspectives of non-users. While this may suggest a high adoption rate of telehealth in Singapore, there is a lack of statistics to support this conjecture. Moreover, recruitment efforts in Studies One, Two, and Four were constrained by my language proficiency, limiting participation to English- and Mandarin-speaking individuals, thereby potentially skewing the sample towards those of Chinese ethnicity and neglecting the needs and preferences of minority groups.

Although all participants in these studies were encouraged to go beyond their personal experiences and share their observations and relevant volunteering experiences with the other older population groups in the community, there remains a possible risk of overlooking the perceptions, needs, and preferences of their counterparts. Future research could extend to a more diverse participant pool, including more non-users as well as Malay, Tamil, and Chinese dialect speakers.

In addition, Zoom was chosen as the default medium for Studies One, Two, and Four, although participants were not required to have high digital proficiency and were provided with technical assistance. This choice might still introduce a potential bias towards individuals who are more comfortable with technology, more proactively engaged in health-related activities, and possess better technology access. To mitigate such bias in future research, it would be beneficial to conduct on-site co-design workshops and engage with individuals who are not as digitally proficient and proactively involved in health-seeking.

- ii. The studies were conducted during the COVID-19 pandemic, and telehealth-related policies in different counties may have undergone some alterations. Study Two highlighted lower costs as a facilitator for telehealth implementation among older individuals, yet it is crucial to note that the professional group also incurred additional expenses for telehealth platform subscriptions. While the literature has also reported lower cost as one facilitator, it questions if the perceived cost savings may also stem from the reduced transportation expenses (158) besides government subsidies being available (470,471), as presented in Chapter 2.4.5. Thus, future research could employ more rigorous and robust study designs to further validate these findings, particularly after the subsidies were ceased (472).
- iii. There was a trade-off between the rigour and practicality of the data collection tools. The feedback form used in Phases 2 and 3 of Study

Three was considered lengthy by many users and has caused low feedback participation. Future research could work on the development of a shorter yet more user-friendly version for future assessments. Moreover, the DKAS scoring system was adjusted in Study Four for pragmatic reasons, and it is important to acknowledge that its validation was beyond the scope of this study and challenging to undertake with a limited sample size. Future investigations will rigorously examine how validated questionnaires can be effectively employed within the tele-education setting.

- iv. Only feasibility outcomes were measured in Study Three, due to the time constraints, heightened Covid restrictions, and inability to collect more health data from the users. In the future, more rigorous research could be conducted in collaboration with medical institutions and community organisations to evaluate the long-term impacts of this service, such as user retention, effectiveness, and cost benefits.
- v. Although this thesis adopted a systematic approach to explore the dynamics of telehealth adoption in Singapore, some findings may not be applicable to other countries. For example, teleconsultation was not perceived as useful by most of the participants due to various reasons:
 - 1) Singapore has a small geographical size and highly accessible healthcare system with health facilities typically within close proximity;
 - 2) Singapore is also a multi-lingual country, and language barriers may pose a challenge for older individuals who cannot speak English or

Mandarin to communicate via or use the teleconsultation platforms; and

3) Cultural beliefs and individual preferences for symptom management may also lead to a prioritisation of in-person visits or even home remedies. However, since each nation has a unique healthcare landscape and sociocultural context, it is imperative to be cautious and to recognise the contextual nuances and adapt interventions accordingly when extrapolating these findings to other countries.

8.8 Concluding Remarks

Despite having a history of nearly a century, telehealth has been underutilised for a very long time. During the COVID-19 pandemic, it gained remarkable attention and was used to substitute some parts of in-person health services. Usability and attrition are common challenges with digital health implementation; therefore, it is crucial to adopt a systematic and comprehensive approach to understand the needs of the target users and inform the design, implementation, and evaluation of new solutions.

This thesis started with delving into the HSB of community-dwelling older people to uncover their efforts in maintaining their well-being. The identified consequences of HSB revealed potential areas in which telehealth could be implemented. The subsequent semi-structured interviews probed the perceptions of telehealth in ageing care among different groups of stakeholders, fostering a comprehensive understanding of their experiences, determinants affecting telehealth implementation, as well as their perceived implementation

strategies. These insights set the stage for the design, implementation, and evaluation of two telehealth prototypes, focusing on promotive and preventive care within the community.

This thesis brought forth several findings: (1) a broader outlook on HSB is essential for comprehending the health needs of older individuals; (2) technologies have played a substantial role in facilitating older adults' HSB, reflecting considerable progress in government- and community-driven initiatives to enhance their digital literacy and health awareness; (3) although older adults, ageing health service providers, and telehealth providers shared relatively consistent perceptions of telehealth, there were still some “contradicting” experiences, necessitating effective strategies to cater to the needs of both end-user groups simultaneously; (4) the potential of tele-education and telemonitoring prototypes to enhance older users' HSB is evident, underscoring the promise of scaling up telehealth to preventive and promotive care; (5) the human elements remain indispensable in telehealth encounters for older individuals.

Moving ahead, the tele-education and telemonitoring prototypes will be scaled up into a comprehensive telehealth ecosystem, with the active involvement of older individuals at every stage and firm collaborations with healthcare institutions and community organisations, to further enhance their inclusivity, equity, scalability, and sustainability.

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Appendix

Appendix 1 Semi-structured interview guide for Study One

DIMENSION	INTERVIEW QUESTIONS
Intellectual dimension	1. How do you rate your overall health status? 2. How do you maintain your physical and mental health? 3. How often do you go for regular health screenings? 4. What were some changes in your health status, health routine, and health screening during the COVID-19 pandemic?
Interactional and processing dimension	1. What do you do when you feel unwell? 2. How do you feel about the environment of and around your place? 3. How far is the polyclinic/GP that you usually visit away from your place? 4. In general, how long do you spend waiting for seeing the doctors? What about the time spent inside the consultation rooms? 5. How much are you charged by visiting polyclinic/GP (e.g., disease treatment, health screening)? 6. Are you keen to know more about your health and talk to the doctors? 7. How do you find communication with health professionals?
Active and decision-making-based dimension	1. How do you look for health information? 2. How do you trust the health information that you find? 3. How do you follow the advice/tips given by these resources? 4. Did you attend any health education? How do you evaluate it/them? 5. Can you give some examples of how you practised what you learnt in health education in your daily life?
Digital technology utilisation	1. What are the purposes of using digital tools/health apps, if any? 2. How do you choose digital tools, given that there are various such applications in the market?

Appendix 2 Details of the characteristics of the older participants in Study One and Study Two

UID	Age (years)	Sex	Ethnicity	Highest education achieved	Employment status	Estimated monthly income in SGD	Housing type	Ownership of a smart device	Access to Wi-Fi at home	Past experience with telehealth
OP01	73	Female	Indian	Degree	Homemaker	0	Condominium (excluding Executive Condominium)	Smartphone, Tablet	Yes	Tele-education
OP02	65	Female	Chinese	O-Level	Homemaker	0	Condominium (excluding Executive Condominium)	Smartphone, Tablet	Yes	Tele-education
OP03	64	Male	Chinese	Postgraduate	Retired	3,000 – 3,999	Condominium (excluding Executive Condominium)	Smartphone, Tablet, Laptop	Yes	Teleconsultation
OP04	69	Female	Chinese	A-Level/ Diploma	Employed part-time	1,000 – 1,999	Condominium (excluding Executive Condominium)	Smartphone, Tablet, Laptop	Yes	Tele-education
OP05	61	Female	Chinese	Postgraduate	Retired	<1,000	Terrace House	Smartphone, Tablet, Laptop	Yes	Tele-education
OP06	72	Male	Chinese	Degree	Employed part-time	7,000 – 7,999	Condominium (excluding Executive Condominium)	Smartphone, Tablet, Laptop	Yes	Teleconsultation, Tele-education
OP07	68	Female	Chinese	O-Level	Homemaker	4,000 – 4,999	Semi-Detached house	Smartphone, Laptop	Yes	Rejected teleconsultation

OP08	73	Male	Chinese	A-Level/ Diploma	Retired	4,000 – 4,999	Semi-Detached house	Smartphone, Laptop	Yes	No
OP09	68	Female	Chinese	Degree	Retired	0	Condominium (excluding Executive Condominium)	Smartphone, Laptop	Yes	No
OP10	74	Male	Chinese	A-Level/ Diploma	Retired	0	Condominium (excluding Executive Condominium)	Smartphone, Laptop	Yes	No
OP11	65	Female	Chinese	Primary 6 or below	Employed part-time	<1,000	Rental block	Smartphone	Yes	No
OP12	71	Female	Chinese	Secondary School	Retired	0	4-room HDB flat	Smartphone, Tablet, Laptop	Yes	No
OP13	55	Female	Chinese	Degree	Employed part-time	<1,000	4-room HDB flat	Smartphone, Laptop	No	Teleconsultation
OP14	55	Male	Chinese	A-Level/ Diploma	Employed full-time	2,000 – 2,999	4-room HDB flat	Smartphone	No	No
OP15	62	Male	Malay	N-Level/ITE	Employed full-time	2,000 – 2,999	5-room HDB flat	Smartphone, Laptop	Yes	No

^aRental flat: an affordable housing rental option for lower-income Singaporeans (284);

^bHDB flats: Housing & Development Board (HDB), a public housing type in Singapore which are affordable and can be easily purchased by the average Singaporean as they're subsidised by the government and are offered with housing grants (4-room HDB flat: three bedrooms and one living room; 5-room HDB flat: four bedrooms and one living room) (285);

^cTerrace House: a dwelling house with its own land title that forms part of a row of at least three dwelling houses abutting the common boundary party walls (286);

^dSemi-Detached House: a single-family duplex dwelling house that shares one common wall with the next house (287);

^eCondominium: an apartment that is part of a development not managed by the HDB, owned by unit owners who share common areas and facilities with other unit owners within the development (288);

^fExecutive Condominium: a strata-titled property, with comparable designs and facilities to other condominiums (288).

Participants	Interview Questions
Older adults	In this interview, telehealth refers to any health and health-related services that are done remotely. For example, you can talk to your doctors on Zoom instead of going down to the polyclinics, or you can measure your blood pressure at home every day and your blood pressure machine can directly send your results to the nurses for review, or you can attend health education session online at home. Have you tried any of the telehealth techniques before? 您以前使用过远程医疗技术吗? <u>If yes:</u> 7.3.7 When did you use it? (e.g. before/during Covid pandemic)? 是在什么时候?(例如新冠流行之前/之后) ? 7.3.8 In what settings did you use it? 是在什么情况下使用的呢? 7.3.9 What kind of training or support did you receive prior to using it? 在使用它之前, 您有没有接受过什么样的培训或支持? 7.3.10 How was your experience? Did you come across any difficulties or challenges? How did you solve them? 您的使用经历怎么样?遇到过什么困难或挑战吗?是怎么解决的? 7.3.11 How do you accept the usage of telehealth? 您是否接受远程医疗的使用? 7.3.12 Do you have any concerns regarding telehealth? 您对远程医疗有什么担忧吗? 7.3.13 What are your expectations about telehealth (technology, delivery, settings, features, etc.)您对远程医疗有什么期望 (例如: 技术、模式、使用环境、功能等)? <u>If no:</u> 1. What do you think about the usage of telehealth in clinical settings? What about non-clinical settings? 您如何看待远程医疗在临床环境中的应用?那么非临床环境呢? 2. If you are offered such a technique, when do you think it is a good time to have a try? 如果有人向您提供这样的技术, 您认为什么时候是尝试的好时机?

	3. What settings are you planning to use such an app in? 您打算在什么环境中使用这样的应用程序? 4. Before you use it, what kind of training or support do you think you might need? 在使用它之前, 您认为您可能需要什么样的培训或支持? 5. Do you have any concerns regarding telehealth? 您对远程医疗有什么担忧吗? 6. What are your expectations about telehealth (technology, delivery, settings, features, etc.)? 您对远程医疗有什么期望(例如: 技术、模式、使用环境、功能等)?
Ageing health service providers	In this interview, telehealth refers to any health and health-related services that are done remotely. <u>Telehealth deployment</u> 1. When was telehealth introduced into your department for the first time? 2. Did telehealth make its debut on some special occasion? 3. Who were the patients and caregivers prescribed with telehealth? 4. How was telehealth delivered? In what settings? 5. Has the deployment of telehealth changed during the Covid pandemic? <u>Effect of telehealth</u> 6. In your opinion, how does telehealth affect consultation efficiency? 7. In your opinion, how does telehealth affect health monitoring efficiency? 8. What is your take on how telehealth impacts the costs for patients? 9. In your opinion, how could telehealth influence patients' health outcomes? <u>Perceptions of telehealth</u> 10. Could you describe your experience with telehealth? 11. How do you perceive telehealth?

	12. Can you describe some barriers to using telehealth on your end? (technical issues, users' digital literacy, integration with the infrastructure, access to user health data) 13. What about patients' and caregivers' experiences? Do they have any difficulties using telehealth (initial use, concerns: clinical safety, data security)? <u>Support of using telehealth</u> 14. Is there any training provided to you prior to using telehealth? Did the training also apply to the patients and caregivers? 15. How can you obtain additional support when there are difficulties with telehealth? Did the support also apply to the patients and caregivers? <u>Future of telehealth</u> 16. What are some efforts being made in your department/clinic/hospital and the whole healthcare system to promote telehealth? 17. Do you know any policies that support the use of telehealth? How do you envision the future of telehealth in clinical settings? What about non-clinical settings?
Telehealth providers	<u>Motivation & vision to develop telehealth</u> 4) Can you introduce your product (will first read about the product and may ask a few questions about the interesting features)? 5) What was your motivation when you first decided to develop telehealth products? 6) What benefits did you aim to bring to the users? 7) What were some difficulties you came across during the development process (technical, design)? 8) What were some challenges you came across during the promotion and deployment of telehealth (technical, government policy)? 9) What do you think are the most important considerations when you develop and deploy your telehealth product? <u>Telehealth users</u> 10) Who are your target users? (patients, caregivers, health care professionals, non-clinical staff, etc.) 11) In what ways do you see your product helping users? (save cost, provide more efficient healthcare, improve health outcomes)

- 12) Did you notice any differences between the users in Singapore and in other countries (for global companies)?
- 13) What are the changes in the user groups before and during the Covid pandemic?

Challenges of using telehealth

- 14) How has the user feedback been?
- 15) What are some difficulties associated with their use? What did you do to overcome these difficulties?

Supports to facilitate telehealth utilisation

- 16) What kind of support/assistance do you offer to your users?

Future of telehealth

- 17) What are some efforts being made on your end, in clinical & non-clinical settings, and the whole healthcare system to promote telehealth? (e.g. integration of telehealth with the healthcare infrastructure)
 - 18) How do you envision the future of telehealth in clinical settings? What about non-clinical settings?
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Appendix 4 Details of the characteristics of the health service provider participants in Study Two

UID	Age	Sex	Ethnicity	Nationality	Highest education level	Current job	Nature of the institution	Workload (hours/week)	Computer experience in years	Experience with telehealth	Perceived relevance of telehealth in Singapore	Telehealth-related terminology
AP01	30	Female	Chinese	Malaysian	Bachelor	Allied health professional (Physiotherapist)	Private clinic	42	15	Yes	Somewhat Relevant	Telerehabilitation
AP02	35	Male	Mixed race	UK	Master	Allied health professional (Physiotherapist)	Private clinic	40	20	Yes	Somewhat Relevant	Teleconsultation (Synchronous & Asynchronous), Telerehabilitation
AP03	35	Male	Chinese	Singaporean	Master	Doctor	Public hospital	55	25	Yes	Extremely Relevant	Teleconsultation (Synchronous), Tele-follow-up
AP04	44	Female	Chinese	Singaporean	Master	Doctor	Public hospital	42	19	Yes	Somewhat Relevant	Teleconsultation (Synchronous)
AP05	34	Female	Chinese	Singaporean	Master	Allied health professional (Physiotherapist)	Public hospital	42	25	Yes	Somewhat Irrelevant	Telerehabilitation
AP06	28	Female	Chinese	Singaporean	Degree	Doctor	Public hospital	70	23	No	Somewhat Relevant	Teleconsultation, Tele-follow-up, Tele-education
AP07	28	Female	Chinese	Malaysian	Degree	Allied health professional (Physiotherapist)	Day rehabilitation centre	40	15	Yes	Somewhat Relevant	Telerehabilitation

AP08	28	Female	Chinese	Malaysian	Degree	Allied health professional (Physiotherapist)	Day rehabilitation centre	40	10	Yes	Neutral	Telerehabilitation
AP09	30	Female	Chinese	Permanent resident	Degree	Dietitian	Non-profit Social Service Agency	42.5	10	Yes	Extremely Relevant	Teleconsultation (Synchronous), Tele-education
AP10	40	Female	Chinese	Singaporean	Master	Counsellor	Non-profit Social Service Agency	40	15	Yes	Somewhat Relevant	Tele-counselling
AP11	27	Female	Chinese	Malaysian	Degree	Dietitian	Non-profit Social Service Agency	42.5	17	Yes	Somewhat Relevant	Tele-counselling, Tele-education, Tele-nutrition
AP12	29	Male	Chinese	Singaporean	Degree	Assistant Manager	Non-profit Social Service Agency	42.5	18	Yes	Somewhat Relevant	Tele-education, Tele-exercise, Tele-counselling

Appendix 5 Sample quotes of older participants' perceived determinants affecting telehealth implementation in ageing care

Category	Level	Determinant	Sample Quote
Facilitators	System	Improved access to health services	<u>Convenience for older adults</u> "I'm reluctant to go out of the house as I have to get dressed up, put on shoes, carry a backpack with everything, and go out to see a doctor. Telehealth fits my lifestyle." (OP13) <u>Shorter waiting time</u> "My daughter advised me that I should actually consult the doctor [using telehealth] because they will also be able to dispatch me the medicine without having the need for me to go and queue up at the hospital or at the polyclinic, so I did that...After the consultation, they sent the medication in within three to four hours." (OP03) <u>Lower cost</u> "The consultation, medication and delivery were very reasonable, and it's cheaper than going to a GP." (OP03) <u>Better mobility</u> "Some patients who might have [a] mobility problem, and telehealth will be good for them." (OP06) <u>Reduced infection risks</u>

			"I was Covid positive, and I didn't want to go and spread [it] to others in the waiting area. So I think it's a good way of isolating myself but still getting certain teleconsultation done." (OP03)
Barriers	Individual	Age-related declines	"When people reach my age, the[ir] eyesight may not be good, and [their] hearing may also have some problems. (OP01)"
		Digital literacy	"We teach them how to do that (make and change appointment[s], change languages of the app, and change the font size) and they go back home, but one day they come back again and say they cannot do [it] again." (OP04) "You know in my generation, we are so used to going face-to-face with a doctor and then a lot of people in my generation do not speak English, do not use phones or IT technologies, they are not IT savvy. Telehealth is something new to my generation, and I will say it] to you too. I know that you can talk to a doctor through Zoom like I'm talking to you, and then prescribe medicine or advise me on certain thing[s]. I don't know how to operate; I still prefer face-to-face." (OP08) "We elderly are not very familiar with those technologies and applications, and I think it's troublesome. Now we can do all the tests at the polyclinics very conveniently and just need to make an appointment, and we don't need to wait very long... I think long-distant communication using [a] laptop or phone is very troublesome. The government trained us how to use [them], but we forget very fast without using them." (OP12)
		Mindset and comfort levels	"But I have to accept it, I have to change my mindset as a whole. Either [Whether] see[ing] the doctor physically or virtually, it's just my personal feeling, but as long as I can get the results and whatever I want to get from there, it doesn't matter, that's my mindset change." (OP04)

Interpersonal	Lack of in-person intimacy	"I still prefer the physical touch. I feel like talking to a robot when the doctor is on the end of the phone." (OP02) "It's a sense of feeling, you can see the visual, the person's expression, and trust whatever he says when we meet face to face. When we are talking Zoom, I feel like looking at a photo with voice, and the body language is not very pleased [pleasant]." (OP04) "After the pandemic, if I am given two choices, either using telehealth or go[ing] to the clinic physically, I will go to the clinic because I can see the doctor face to face, I can explain the things and ask questions easier. The experts say that the verbal part of the communication is only 7% of what people try to express, their tone is another 38%, and the remaining 55% is actually in their body language. When you go to see the doctor, he is facing you and then he can see all your body language. When we are sitting here looking at each other, you only see half of my body, you cannot see my entire body, and there might be some gaps in the communication between two people, that's my feeling." (OP06)
	Difficulty in building rapport	"I have been seeing her (my doctor) for so many years, so I am very comfortable to talk [talking] to her using telehealth, unless it's a new doctor then I will feel more distant. For some reason, if I have to telehealth with her, then I will do it." (OP07) "If I see a new doctor, I don't trust him/her compared to the one I always see." (OP11)

		"I feel it's better than WhatsApp, as I cannot see whom I'm talking to (on WhatsApp). I don't mind the normal communication on WhatsApp, but for telehealth, I prefer to see the face on the screen, I feel more comfortable and trust the person on the other hand." (OP13)
	Language barriers	"I'm also a digital ambassador with the IMDA [Infocomm Media Development Authority], so I do training for the seniors... From my experience of weekly training and teaching the elderly how to use phones, the main thing is the language. We need to teach them how to change to different languages, from English to Chinese and Malay." (OP04) "I can accept this form, provided that I'm familiar with the medical terms." (OP15)
	Relying on health service providers' community style	"Also, there is a difference in the doctors. The first doctor kept on asking me what my symptoms are (running nose, sore through), and I kept on asking what medicine he would give me. He was more concerned about my symptoms, and I was more concerned about the medication I needed to take. The second doctor was good, he actually explained the whole situation so I understood. So it's actually dependent on the doctor on the videos." (OP06)
	Technological	Reliance on the Internet quality "Sometimes, the strength of the Internet also affects the quality, sometimes it can go off. The reliability of the Internet can be jeopardised." (OP05) "One thing which is not good is that they need to video call, but because of Covid, I have to stay in the room and the room is very far from the WIFI unit. Voice calls are still ok, but [for] video calls, sometimes I cannot see them at all. But the doctor said must voice call and cannot video call." (OP06)

	Hardware	“The screen size of my phone is very small so it's not convenient. We are not seriously sick, and the phone size is so small, I don't have a laptop, so I still prefer the traditional face-to-face sessions.” (OP12) “What I see is a lot of seniors, they like to have the app, but their devices are not up to date. So, they cannot download the app on their devices... my experience is that the option is a good phone, and some brands like Oppo, [and] Xiaomi are sometimes very hard to get into the government. I think there are some issues with these phones. Sometimes even though the seniors already have new phones, they still cannot download the apps even though they have the latest model.” (OP04)
		“I’m also concerned about information leaking. Information can be stolen.” (OP05) “Another issue is the patient record privacy. Even like hospitals, they lost the patients' records and those things, and it's very commonplace for telehealth, it's even easier for people to steal the patients' reports.” (OP06)
	System	“The issue is when there is a need to use the equipment, as we are using different equipment. Every time my own measurement is different from the one in the clinic, so the calibration of the equipment is an issue, and the figure I give them may not be the correct figure. Then the diagnosis will be different or wrong. Apart from the equipment factor, the human factor is another issue as we are not medically trained.” (OP14)
		“So far it was not offered to me.” (EP10)
		“The challenge, the difficulty with the software was more getting hold of a doctor when you call them. If you want to put on hold, he puts you on hold for probably

		up to five minutes because the system is searching for the next doctor... I tried and waited up to three rounds to get a doctor...The main challenge is the way that teleconsultation has to schedule in [with] a physical doctor, so the main challenge is the resource to staff up the time slot... But the reality is because [that] you are limited by the number of doctors who were available to staff the different timeslots.” (OP03)
	Unclear effectiveness	“Definitely, the effectiveness is not as good as the physical sessions, I think it can be dull sometimes.” (OP01) “I think it's still important to see the doctor in person. For example, I’m having a pain, and I feel that it's very difficult for the doctors to see and be able to diagnose right.” (OP02)
	Challenges in scheduling	“Last year I was offered to do a telehealth check with the doctor, I eventually cancelled because I had to fix the timing with the doctor so she can Zoom and talk to me. This is a bit inconvenient for me because every day I’m outside in the morning to do my workout and will be outside until I come back by noon. So I’m afraid that I might just forget her after I come back, that's why I cannot do this tele/video with the doctor. That's why I cancelled it and eventually, I went in person to see her.” (OP07)
	Confusion caused by similar telehealth applications	“Right now, it seems like too many Apps [were] available on the market, more than 10 as I understand now.” (OP06)

Appendix 6 Sample quotes of professionals' perceived determinants affecting telehealth implementation in ageing care

Category	Level	Determinant	Sample Quote
Facilitator	System	Convenience	<u>For older clients</u> “During Covid it helped us realise that there are certain conditions that you can actually review over teleconsultation, you don't really need the patients to come all the way down.” (AP06) “I think the good thing about video and voice calls is that it's convenient. It's easier to set the time with the client, and you don't need to fix the location because it's online, so it's much more convenient.” (AP10) <u>For family caregivers</u> “This can also be done by Zoom to discuss with family members because maybe they don't have any more leaves, they are not able to take time off to come to discuss about the progress of seniors, so this could be one area we can discuss about how the progress is, what is the outcome and where we are going.” (TP02) <u>For ageing health service providers</u> “Usually, it's the most straightforward cases, like back pain or knee arthritis where it's quite straightforward in terms of the management, like given the medications or physiotherapy to try out then it's quite easy to monitor their progress because we just need to know whether the pain has improved and whether their function has improved and it's quite easy to assess over telemedicine... The teleconsultation would have been faster, because they enter the room straight away, and then after the meeting is over then you can start the next session already...” (AP06)

		“Then at [in] the later part of the telerehab[ilitation] services, actually I find it much easier to explain to the family members and patients as well.” (AP07)
	Improved access to health services	<u>Shorter waiting time</u> “So as to the waiting time, if you are at home, that is not considered as waiting time because you have other things to do and personal life, whereas you go to the clinic, you are just waiting there, you have to wait inside or outside or around just to make sure your number is called.” (TP02) <u>Lower cost</u> “I think it's cheaper because telerehab[ilitation] is usually just 30 mins, and they will go by their means-test subsidy level. So actually it's cheaper and they [do] not need to come over to our centre, and they [do] not need to pay the transport fee.” (AP01) <u>Better mobility</u> “In Singapore, it's not so bad because it's quite a small country, but even then sometimes transport is not easy for elderly patients or those with disabilities, so it is a useful platform.” (AP06) “Sometimes it [telehealth] also helps the patient, if he or she really cannot step out and go to visit the clinic or do some healthcare-related things.” (AP11) <u>Reduced infection risks</u> “The other consideration will be infection, all the sick people are sitting in the clinic. One thing that teleconsultation can provide is that you are really sick, do you want to be sitting there waiting for one hour, I don't think so right, so you want to be at home and be resting to get service via Zoom.” (TP02)

		<u>Continuum of care</u> “Especially during the Covid pandemic, some patients may not be able to come for various reasons, so that's where it's playing an important role in establishing the continuity of our care.” (AP04) “They [the members] are quite comfortable to share with me online as well, where they can describe on the spot, maybe they are facing the problem right in front of them, say having a little bit [of] nausea after treatment right yesterday, so they wouldn't wait until the next appointment when they meet me physically, so they describe again and maybe sometimes they forgot or they don't really describe it. So teleconsultation helps to assess the real condition as well sometimes, where they can describe immediately what happened yesterday or right now or earlier on.” (AP09)
	Improvements in work-related outcomes	<u>Easier information sharing</u> “I think that they [some applications] had an exercise library in there as well, that you could send to the patient, I think, and you could also like rebook appointments through that APP, and it would send emails and links automatically.” (AP02) <u>Improved work efficiency</u> “I think tele-education is very useful, for example, our ultra plastic clinic, they have an online education like Zoom class. They feel very efficient because you can Zoom a few patients at once.” (AP03) “The teleconsultation would have been faster, because they enter the room straight away, and then after the meeting is over then you can start the next session already.” (AP06) <u>Improved client adherence</u>

			"I think it's a useful platform, especially for more stable straightforward conditions where you don't have to trouble the patient to come all the way down to the hospital just to follow up on a condition that especially if they are really feeling much better than at least it can close the loose ends as well, because sometimes patients if they feel better. If there's no option for the teleconsultation, they may choose not to come back to follow-up in the clinic setting but if you give them the option of teleconsultation then, I guess, they are more inclined to just follow up to give an update on their progress so that's a good way of catching these patients." (AP06)
Barriers	individual	Age-related declines	"I think we in the first place actually took all the people with cognitive deficits out already, even though they have a caregiver because sometimes we need to make sure that they feel it in a safe environment before we can do what we need to do. And also with the people who have visual impairment, it is even a bigger problem, because I think a lot of the telehealth feedback and all that, even though there is audio, some of the visual things like they need to move to target etc., so it's not very suitable for those with visual impairment. For those with hearing impairment, even phone calls are quite a problem already. whether it is a communication, but if they have hearing problems, I think [telehealth] may not be also the best mode of delivering the session." (AP05)
		Digital literacy	<u>Older adults</u> "I think the interface is easy enough, but I realised that what we are used to and what they are used to are very very different. So even adjusting the screen, etc. which we think is very very natural for us because we use it in our daily work and all that, but [they] don't find it easy at all, so I think the simple interface for us is not so simple for them." (AP05) <u>Health service providers</u> "Sometimes people who are working there are not very tech savvy, they themselves are still struggling to [with] how to use those things. Again the things like BP machines or glucometers are there, their concern is always [a] liability, what if I did wrong, and then I give the wrong image,

		and then there was a wrong diagnosis, so there is always this fear about what the consequences [are] if I don't do it correctly, not intentionally but not knowing [the mistakes]. So these are some of the challenges that they mentioned.” (TP02)
	Mindset and comfort levels	<u>Older adults</u> “When they were first offered telerehab[ilitation], some will reject it], some feel no need lah, I am not good at phones, which makes sense, some are willing to try, they are more motivated.” (AP01) “The other issue is that I deal with older people in my daily work, so [and] I think right now, they may not be ready to do it.” (AP05) “We are very clear about what we are here for, we are here for the seniors and to provide patient-centric care. In terms of selecting the staff [and] talking to them, changing their mindset is really a big challenge because you are talking about changing the way in which we do things and deliver the care.” (TP02) <u>Health service providers</u> “So there will be worry and then of course the different comfort levels seen from some of the doctors. Some of the doctors are very senior, they may [be] okay by telling them about the conditions they may be able to make the decision, some will say “oh no no no I want examination”, so there is still [a] challenge in such delivery. But will we put a stop to it? I don't think so, I think this could be one of the ways in which the future would be for care delivery. That's so far how I look at it.” (TP02)
Interpersonal	Lack of in-person intimacy	“...So compared to face-to-face or in-person [consultations where] you can really tell by the [facial] expression, the body language, etc., which on teleconsultation may or may not be manifested or picked up by the doctors. Again, the personal touch is very important to us, and

		most of the time, the non-verbal communication speaks more than you tell the doctors, so that is definitely a challenge.” (TP02)
	Difficulty in building rapport	“...Bear in mind [that] a lot of the people that we are trying to provide education to are in pain and the suffering, so I think a key element that needs to be achieved before you start to deliver an educational intervention is that you need to develop a rapport with somebody and they need to understand that you're trying to help them and that you have empathy and understanding about the condition, and that seems to be a lot easier to do when you're in a room face to face with somebody and you know the body language is much easier to pick up on new general demeanour, is much easier to pick up on versus when you're through a screen.” (AP02) “Our social service centres have staff, programme executives, [and] administration staff there, so when you go over there, they also build rapport with them in person. The trust should be still there because they have already built that rapport prior. but let's talk about new members, then I will say it's a bit of a challenge because we don't see that person in real life before, I would say that it will still build trust, but it takes longer with you, maybe after the person comes like 5 or 6 times or X number of times I keep seeing the same person like keep seeing you, then we will build that rapport online. It's the same but it will take longer.” (AP13)
	Language barriers	“Obviously, I am from England and I've been living in Singapore for eight years. And as you can tell, I have, I do have an accent so communication difficulty is something that I have lived with for quite a while, but it does seem to be worse when you're online, when you're talking online, and so yeah you know you'll get like you know when he was asking questions earlier, the line will drop out or the signal is not good, or something like that, so I do get the occasional communication issues but that to me isn't the real issue with telehealth it's more that you know you're not able to be there in person.” (AP02)

		"We tried to introduce those technologies only when there is a caregiver or when there is somebody to help them with that. But the issue was also that a lot of caregivers are domestic workers, they don't understand English or Mandarin language and the instructions in terms of set-up and all that, they all come in their own languages, so there was also some language barrier faced." (AP05)
Technological	Reliance on the internet quality	"Wi-Fi [problem] is quite limited and I think some part, maybe 10 or 20% of the elderly, they don't even have Wi-Fi on their devices." (AP05) "Some elderlies don't have a Wi-Fi subscription at their homes, so normally they will use their own mobile data, and they might complain that their data will be running low after the Zoom meeting because the whole activity or exercise session is about 45 mins to an hour. So they will say their data ends fast." (AP08)
	Hardware	"Other than that, playing around with the application [is] also [a barrier]. Because if they are using their phone, the screen is small for them to see as well, and not all of the seniors have a laptop. Also, communication online becomes more difficult." (AP08)
	Difficulty with device set-up	"Teleconsultation may take a bit longer in connecting, make sure the mic test of the sound, make sure he or she can see us, these will be a little bit [of more] time used just to set up." (AP04)
	Data insecurity	"In terms of integrating telehealth into the health infrastructure, it's a problem because of the data privacy. Because previously, we had tried to use a few technological devices like Fitbit and trackers and things that will help with patient safety or measuring people's weight. When it involved data anonymity, the security in the hospital where there are a lot of patients' details and they feel it's very sensitive, so there are a lot of barriers to cross in order for them to approval all these kinds of things that may eventually need to breach the security which they consider the privacy of the data." (AP05)

System	Insufficient physical examination	“Actually, yes in the way that certain things like some symptoms that we cannot examine on the spot, then it will become a problem. But let's say if they have some leg pain, then it's better we take a look at their leg. It's a little bit difficult to assess. ... For DFU [diabetic foot ulcers], it's good that we can actually check them, examine the foot, for example, not just looking at the foot, but also feeling for the foot, feel for the pulses, feel for capillary refill whether the flow is ok, then look for whether the skin is impaired, look at the wet spaces even between the clothes, so it's a little bit difficult to actually do that via Zoom.” (AP04) “Often during the physical session, we are able to share, because, for nutrition, dieticians like us have a lot of physical tools, like we got folks, spoons, we got the actual food to show them to let them do [an] intervention and to education them, e.g., this is how much you should eat, so by having the actual food together with them and let them see oh this is the food serving size, it actually made them think more and then we can share more. But if I go through phone call[s] or Zoom, I [still can] show you a bowl, but my bowl and your bowl may be different because Zoom can be [cause] different sizes. [The] phone call is even worse, I can only hear what you say, like if you tell me a bowl, I don't know how big your bowl is.” (AP11) “Even it [physical examination] can be done, it's different, the colour of the tongue is different, and the face, etc. So it takes longer to be sure that the appropriate care and diagnosis is given rather than rushing so that things will go wrong. So I think being professional, care professionals, safety is still the main priority, so they want to make sure that they provide the right care and uphold safety.” (TP03)
	Lack of immediate assistance	“They didn't like to do so-called virtual or non-face-to-face sessions because they still prefer the touch and the familiarity with the physiotherapists to correct them in person, whether they did it wrongly or to observe them or to help them in case of loss of balance or falls.” (AP05)

		“Yeah, I think the difference will be, for online or video [calls], it can affect, depends on what kind of situation, because that you didn't see a person face-to-face, so sometimes it will be really hard to know whether the person is in a safe environment, that's one thing. Safety is a concern. For example, if you see a person being abused, you cannot do anything. So, safety, [or] if the environment is safe or not is a concern. The second concern is if the person is really showing [himself/herself]. Because you only see the face, so maybe the person [seemed to be] ok, but probably if you see the person in real life there could be some things that we may not be able to see, because [in] online [environments] you can only see a portion of that person.” (AP10)
	Unclear effectiveness	“I think it is a bit slower because there's this online thing you know connection problems and then I have to wait for the full response and stuff like that. So that is issues know you can't talk and examine at the same time, so this efficiency probably reduce a little bit.” (AP03) “I think it depends on how independent [are] the patients, that's my perspective, how independent the patients can be. Some patients actually know how to take charge of, take control of their own health, they know what medications to take, they are able to titrate their insulin, they are able to monitor their sugar [level] independently, [and] they are able to listen to instructions. Some patients may be at the start or maybe at some point in time, they may not be so good at taking care of themselves, so this is where we have to write things out on a piece of paper and show them or show the caregiver. If they may not be able to cope with medication changes very well, this is where we try to reinforce the messages. In telehealth consultations, I'm not sure that communication will go through, but I'm able to tell them face-to-face and get them even read it to me, tell me how you take the medicine.” (AP04) “In terms of outcomes, I cannot say because we didn't really collect data and compare those who have telerehab[ilitation]and those who do not have [tele]rehab[ilitation], [although] we still see their improvements along the way, along the time.” (AP01)

		"I also don't know we didn't see anybody long enough, because we were able to see them in person again soon afterwards. So from my own practice, I can't tell you the effect on the outcome[s], because when we did it [used telehealth], it was during the circuit breaker which was only really for a short period of time. And then we were able to see them again afterwards, so how much that block of telehealth affected the overall outcome I couldn't really say." (AP02)
	Insufficient manpower	"This is not part of the workflow, they [health service providers] do it because they see that there is a need there to serve, but again the challenge is that they don't have enough manpower. Amongst all the things that they have to do and running the programme, these are the additional things so it's a challenge." (TP02)
	Extra workload for health service providers	"Usually, we will have inclusion criteria, we won't explain it to everyone, but we will explain it to those who are needed or who are suitable, because at least they need to be tech-savvy or there is a caregiver to help, or they have that technology for example, at least they need a smartphone. If they do not have a smartphone, then we won't recommend or explain to them. Because if we explain, they also cannot get a smartphone to do the telerehab[ilitation] as well... If there is a hearing issue, because we need to talk a lot, so I think we wouldn't include them." (AP01) "On our end, we also have cut down the teleconsultation because the clinic numbers have been going up again, so it's probably just easier to see everyone rather than having to screen through and decide who is suitable for teleconsultation because that [pre-screening] process also takes time." (AP07)
	Possibility of extra visits to health institutes	"But what if the doctors said, "Oh your conditions cannot [do teleconsultation], you must come down"? So there is always this frustration...Specially Singaporeans are very impatient, so they will say "Walao, cannot ah, then why you asked me to do [teleconsultation], why you are providing this, etc." Then we have to manage a separate set of challenges and managing

		expectations, and we will be complained and complained. So professionals end up having to manage expectations, manage complaints, wherever there is a complaint there is a reason for it, but you rather spend the time looking after the seniors.” (TP02)
	Higher risk of absence and cancellation	“So I think for us the challenge is not about using the technology, it's about making sure the clients really attend to the timing that we have agreed upon because phone calls and Zoom sometimes they will tell you “Oh I’m sorry I missed it because I suddenly got something on”, but [for] physical [sessions] it's very very unlikely because often they will be at the centre doing some activities, then they stay back for us, unless they are down with diseases and illnesses. But for Zoom or phone calls, we are scheduling the time and data often because suddenly I cannot make it, I forgot, so even though we made appointments, they just forgot. So there is a higher risk of last-minute absence.” (AP11)
	Potential additional costs	“We use it [a telehealth application] on the desktop mostly, and it was designed for telehealth. But now I think if we had to pay for that, [if] we have to pay a subscription, so now it's done via Zoom or maybe WhatsApp.” (AP02) “Cost will probably go up a little bit, in terms of buying the hardware and the software for telehealth.” (AP03)

Appendix 7 Sample quotes of older participants' perceived implementation strategies to facilitate telehealth implementation in ageing care

Level	Implementation strategy	Sample quote
Telehealth users	Empower older users	"For anything new, the health ministry or the authorities must educate us so there has to be a learning process on our part because the element of trust is still not there. I think there needs to be a teaching process, teaching seniors how to use smartphones." (OP05)
		"But some elderly may not know, may not be educated in this area, [and] may not have access to the equipment. So there is a need of [for] more education in this area." (OP14)
Technology design	Prioritise user-centred design	"When people reach my age, the[ir] eyesight may not be good, and [their] hearing may also have some problem[s]. Simple features are preferred." (OP01)
	Incorporate new features	"There is still a long way to go with perhaps additional machine learning and AI [Artificial Intelligence] incorporated in[to] the app, so you probably have the doctors, especially if you are short-handed. So if you can put in, incorporates that then AI and ML [Machine Learning] type of concept into the app itself, then the client can actually self-help [with] some of the information and education without a doctor to talk to them. We can actually go to the apps and have one common place where we can look at some of the common answers to for example, Covid is a big thing now or other issues related to it through Q&A or FAQ or AI type of concept, it can help the patients address their concern. I think it will be an area that will be good to work on in research and also improving the solutions." (OP03)
Service execution	Adopt hybrid format	"Maybe a hybrid session, a mixture of physical and telehealth sessions, is acceptable, but the first session is important, so a physical session is preferred." (OP02) "But I can accept the blended format, at least having seen him the first time. As a senior person, we read the other person via body language. So if I'm seeing him for the first time, and he examines my head [and] my leg, I can examine him, and I can sense that he is a very

	concerned doctor, and he knows what he is doing. After that Zoom consultation is acceptable to me.” (OP05)
Involve human elements	“Maybe it (telehealth) can [be] applied to some certain centres or nursing home[s] because there are people who will attend to the technology, people who will attend to the use of the equipment, I think this set-up will be better. But as individual[s], it's more likely to be [on] a case-by-case basis. There must be some third party in between, because there can be some hang-up, even in the Zoom sessions, then the person will be very confused about what to do. The setting should be more like a centre where someone can help with technology, maybe it's better to do [it] in a group, some people can help moderate and make sure everything goes smoothly and ensures everything goes back to normal when there are any issues.” (OP14)
Extend access to a wider user group	“So far it was not offered to me. But of course, I should be able to adapt to [it], but so far nobody offered me this. Anyway, I think I can accept it, but no one offered it to me.” (OP10) “I think the idea of using telehealth is very good, it reduces travelling, provided that it must be provided to the correct audience.” (OP14)
Allocate adequate manpower	“So the expectation I think is that the moment I make a call, I expect somebody to be there, especially a doctor to be there... I think maybe can put a certain call waiting time to tell the patients that ‘okay you have to wait between 3 to 5 minutes or 5 to 10 minutes and then set an explanation. I was initially quite impatient, after two calls they still put me on a circle, and then the third time to get through. Especially if you are sick and not feeling well, it's very irritating to have to wait for somebody. Actually, it's not different from going to [the] clinic and queue[ing] two hours, but to me, if you can set an expectation that by the third attempt or within 15 minutes you should get a doctor, then I think the update may be better.” (OP03)

		"The problem is if they (doctors) have the time to attend it or not. Doctors have a lot of patients, maybe they don't have the luxury to Zoom or do all these. We need to be realistic." (OP15)
Policy	Provide subsidies or insurance coverage	"Other features like telemonitoring or tele-education are additional features that if the client or patient is willing to sign on to because I believe there will be additional costs in terms of the fees to go follow-ups and also for other information that they have to share. But if you make it something affordable something reasonable maybe more people will accept that as a standard feature that you can offer to the patient." (OP03) "And because right now, some of the apps are connected to some insurance companies, some can be claimed using MediSave and some cannot, it's very confusing." (OP06)
	Ensure the vitality of telehealth market	"I think the government is planning to have the health care service app by next year, and they should limit the number of apps but still maintain several apps so that they can maintain the competition." (OP06)

Appendix 8 Sample quotes of professional participants' perceived implementation strategies to facilitate telehealth implementation in ageing care

Level	Implementation strategy	Sample quote
Telehealth users	Empower older adults	"I think it will be good if we can have, I'm not sure if the government is doing [this], but our society provides like digital training for those seniors to make use of their phones or tablets to access our online resources and also our classes as well, so this will be very much beneficial to our members, especially for those who are not that IT savvy. For now and then, we have more apps and also websites which is[are] very fancy and maybe more informative for them, it will be good if the government have those training or courses that are free to give to the elderly citizens to sign up." (AP09) "It's just not something new to them, and hopefully, with IMDA push out to have more ambassadors teaching the seniors how to use it [teleconsultation], hopefully, it will become more widespread in terms of such use..." (TP02)
	Provide training for health service providers	"I think at this point, because I'm one of the champions to push this activity, you need to really educate your therapists. So, your patients will be using telerehab[ilitation] more. I think we need systemwide management support to support the therapists to go and try using telerehab[ilitation], to understand telerehab[ilitation] first, then more patients will benefit from telerehab[ilitation]. I think we need to put in efforts to train them [the therapists] to make them believe that this can work..." (AP01)
	Receive more support from caregivers	"If their family is supportive and able to [use telehealth], then [there is] no difficulty prescribing." (AP03) "For those who have [a] hearing impairment, they have caregivers, so we communicate quite a lot with the caregivers as well who help to communicate with the patients. Usually,

		caregivers are the ones who help to pack the medicine, administer the medications, monitor their sugar and blood pressure, usually there is a caregiver with them.” (AP04)
Technology design	Prioritise user-centred design	“The system itself must be elder-friendly and foolproof, [maybe users can just] press a button.” (AP03)
	Incorporate new features	“We don't really record the sessions, because when you record, you need to know where you need to store the video, [and] then what is your data protection, and the session is 30 mins, there will be 30 minutes of the video, and then the data will be a lot, so I think that's why we are saying we are still at infant stage because there might be suitable software for telerehab[ilitation] for everything. If you have any incident happen, you can record, [and] replay back the video as well.” (AP01)
Service execution	Adopt hybrid format	“Department-wise, during Covid we tried to push towards using online consultations as much as possible during the lockdowns and also we do a lot of like phone support as well, so now we almost exclusively do face-to-face consultations, but then we will do like text support through like WhatsApp and stuff like that, so people will text us with questions or they will update us on progress and things like that we don't use any apps to monitor them while they are not with us.” (AP02) “I think it's good to do hybrid as well, where some senior people who are interested to come in person or on-site to have a session that will be good, where we can see each other, we call that human connectivity, the communication and also the feeling will be different online. But well, we do have members having problems of [with] transportation or they are feeling tired, but they want to attend as well, then it's good to have [a] hybrid, so they can go online for workshops and also classes. [The] same thing goes to [for] consultation, it's good to have online sessions in their own place that they can describe to you comfortably, not like rushing to the hospital or to our centres to only have that appointment.” (AP09)

Collaborate with other stakeholders	"I think system-wide, we need to support the therapists a bit better like scheduling, [the] camera of the patients, I think overseas there is a motion-capture camera, so the patient walk[s] around, the camera can just go around, they don't need to move up and down all the things. I think these technical things can be still improved." (AP01) "I think support from management and [the] company will be important if you want to run this telerehab[ilitation] services, because we need things like earpiece[s] to hear better, we need things like amplifier or speaker so that we can hear them better, or we will need a space with sufficient equipment so that we can also run the telerehab[ilitation] services." (AP07)
Integrate different telehealth modalities	"But if you're talking about monitoring for other things like the patients' activity, or pain something like that, we have not yet embarked on such monitoring using telehealth yet, but there is something for the future, and we are quite excited to start because this will give you more data points on the patient's recovery, more than just the time that he comes to follow-up." (AP03)
Extend access to a wider user group	"Of course, we wouldn't include them [those who are digitally illiterate] in our criteria, I think that will be a barrier, but slowly this will be changing. [The] government is teaching them how to use mobile phones, how to use Wi-Fi, how to use WhatsApp." (AP01) "For some of them, there is resistance in the beginning, but after [the] trial they feel ok." (AP01)
Provide support in technology set-up	"I think for the placement, with the technology issues, the first-time physical demo with them is important to make sure [the] caregiver/the patients know how to place it [camera]. I think the session needs to be short and sweet but effective, so for the therapists you need to know in doing this period, what you want to target...Of course, there is [are] some technical issues, e.g., Wi-Fi [is] not stable, I think this can be solved. This may happen in the

		first session, and you need to spend a bit more time to settle with them. After the second time, actually it's quite easy if they pick up. So I think it needs to be short and sweet but targeted.” (AP01) “Before we even started telehealth services, we would actually guide them [on] how to place the phone, some of them actually came to the centre before they started telehealth, so we would tell them ‘Okay, at this angle you should place your phone, and from what distance then you chair would face so that I can see the whole picture’.” (AP07)
Policy	Provide subsidies or insurance coverage	“It's just how we utilise it for the patients and I think one aspect is cost, how to reduce the cost for the patients using telehealth...Government subsidy for telehealth: It is something you want to pursue, and one of the big roadblocks is government subsidies because the patient is dependent on cost.” (AP03) “It all depends on the subsidy, every scheme is slightly different so that would be driven mostly by their insurance carrier and their policies.” (TP01)
	Integrate telehealth into the formal healthcare system	“I’m sure you have heard this: a senior says “Oh tomorrow I’m going for a blood test, I will see a doctor soon, so this week I eat very healthy hor”, so the doctor will say “Oh it looks very good”, but after that, they go back to usual ways of things, so things won’t work out. Another example is when you are in the hospital, you eat all the healthy things, the doctors would say “Okay, we have adjusted your medication, it’s perfect, very good, well-controlled” but when they go out, what do they eat, char kway teow, eat all the seafood, fried foods, it’s not the usual lifestyle that is based on, so the information in the community is very important. You can adjust and adjust, unless you know what they eat, [and] what is the normal blood pressure or the sugar level. It’s not, it doesn’t work that way, you want better results, you need deeper information to cover.” (AP03)

	"I think technology is advancing quite fast, so if there's a way to track for example like exercise, check their eating and physical activity levels, measure their BP and do some objective clinical measures, I think It would be useful for the device or the app to be able to capture all that, that would be great as well. Then outside of that, there are also lots of things that we also think [are] quite important for the patient to be able to save for themselves, so even the subjective measures or interviews that we need to go to see how they are feeling, for example, life-space questionnaire or emotional or psychological measures that you can usually [be] asked by a questionnaire, even MMSE, etc. if can be administered and recorded within the app itself and then sort of let the person to conduct the session, to know if it's within the normal range or not, and whether we can proceed to advise and all that I think will be quite useful." (AP05)
Provide more support from the regulators	"Initially, the challenges were around not necessarily a regulatory in the regulations, were not permitting telemedicine, but a grey area where it was not clear whether telemedicine was something that was supportable in this market. So we spent quite a bit of time working with regulators and with other sort of established groups to see how to best overcome that challenge." (TP02)
Provide more funding opportunities	"Of course, if there is any funding, we hope so and it's good in future we hope to have our apps or our portals that our members can log in to book a slot with us, then it's very easy to check on their progress as well, if we have that database or apps, you know one user account can access a lot of things, and at the same time we can find us easily, in the meanwhile before they meet us they can reduce some queries as well. It's to ease their daily problems and difficulties." (AP09) "So are they [staff who are not proficient with technologies] resisting it? I don't think so, as long as there is enough training, enough manpower, enough resources, I think they may [be

		receptive] and it may be easier if the policymaker thinks a bit that this should be part of it, so they implement and fund. I think that would be great.” (TP02)
Research	Confirm telehealth’s effectiveness	“On the whole, I think it's still manageable, it's still ok, [and] it still worked out fine, but going forward maybe research is needed to see the long-term impact[s] of telehealth on the health outcomes, perhaps compare with those with just face-to-face throughout the visit journey.” (AP04) “We will definitely need research because we will try to run these telerehab[ilitation] services actually not much local context, mostly from overseas, and I will say most contexts including telehealth [teleconsultation], not so much for telerehab[ilitation]. So if we can have those data, it will be great.” (AP07) “It would be good to have a school or university to come in and see what the effect is and how is it. I think it’s not just the clinical effect, we are also looking at the psychological effects, other costs like social costs, etc. For example, my parents are sick, but because I can do teleconsult[ation], so I don’t have to apply [for] leave, so these costs are going to the family members. So there are many many things that could be studied. I think other countries are more advanced to look at social cost and emotional cost, but I’m not too sure if Singapore has such in-depth studies on this. [We can study] the impact, the many dimensional, multi-faceted impacts. It will be good if we can look at [it] thoroughly, e.g., people are recovered, but what is recovered?” (TP02)
	Develop algorithm to screen for eligible clients	“We also need help to figure out whether there can be like algorithms to help choose the patients based on the computer systems [for] which patients are suitable to [for] follow-up teleconsultation, then that might make things easier.” (AP06)

Appendix 9 Sample implementation strategies identified matching with those from the ERIC project

Implementation strategy identified in this study	Implementation strategies from the ERIC project with definitions
Empower older users and health service providers	Conduct educational meetings: Hold meetings targeted toward different stakeholder groups (e.g., providers, administrators, other organisational stakeholders, and community, patient/consumer, and family stakeholders) to teach them about the clinical innovation. Conduct educational outreach visits: Have a trained person meet with providers in their practice settings to educate providers about the clinical innovation with the intent of changing the provider's practice. Conduct ongoing training: Plan for and conduct training in the clinical innovation in an ongoing way.
Prioritise user-centred design	Conduct local needs assessment: Collect and analyse data related to the need for the innovation. Intervene with patients/consumers to enhance uptake and adherence: Develop strategies with patients to encourage and problem solve around adherence. Obtain and use patients/consumers and family feedback: Develop strategies to increase patient/consumer and family feedback on the implementation effort.
Adopt hybrid format Involve human elements	Facilitation: A process of interactive problem solving and support that occurs in a context of a recognised need for improvement and a supportive interpersonal relationship. Identify and prepare champions: Identify and prepare individuals who dedicate themselves to supporting, marketing, and driving through an implementation, overcoming indifference or resistance that the intervention may provoke in an organisation.
Extend access to a wider user group	Change service sites: Change the location of clinical service sites to increase access.

	Promote adaptability: Identify the ways a clinical innovation can be tailored to meet local needs and clarify which elements of the innovation must be maintained to preserve fidelity.
Collaborate with different stakeholders	Build a coalition: Recruit and cultivate relationships with partners in the implementation effort.
Provide technical support	Centralise technical assistance: Develop and use a centralised system to deliver technical assistance focused on implementation issues. Provide local technical assistance: Develop and use a system to deliver technical assistance focused on implementation issues using local personnel.
Integrate telehealth into the formal healthcare system	Use data warehousing techniques: Integrate clinical records across facilities and organisations to facilitate implementation across systems.
Allocate more funding opportunities	Access new funding: Access new or existing money to facilitate the implementation.
Conduct research studies to confirm telehealth' effectiveness	Conduct iterative small tests of change: Implement changes in a iterative fashion using small tests of change before taking changes system-wide. Tests of change benefit from systematic measurement, and results of the tests of change are studied for insights on how to do better. This process continues serially over time, and refinement is added with each cycle. Develop academic partnerships: Partner with a university or academic unit for the purposes of shared training and bringing research skills to an implementation project. Purposely reexamine the implementation: Monitor progress and adjust clinical practices and implementation strategies to continuously improve the quality of care.

Part 1: Feedback on the prototype telehealth education programme

1. What are some differences between this session and other health education that you attended in the past, if any?
2. How do you evaluate the content of this session?
3. How do you evaluate the format of this session?
4. What are some challenges you faced in this session?
5. What are some improvements that you expect?
6. How are you going to apply what you learnt today in your life?
7. How do you accept this format of health education provision? Is there any change before and after this session?

Part 2: General health education and health information needs

8. Besides topics about frailty, what other topics do you think are important to you?
9. Can you recall any changes in your health information needs from the past to the present?
10. If you are offered a tele-education on these health topics, what formats (purely tele-education, purely physical, or hybrid format), class size, frequency and duration do you prefer?
11. Do you have any concerns about tele-education?

Ending questions

12. Before we end this co-design workshop, is there anything that you feel is important, but we didn't cover?

Appendix 11 Detailed demographic characteristics of participants in Study Four

UID	Age	Sex	Ethnicity	Highest education achievement	Marital status	Living alone	Employment status	Personal monthly income in SGD	Housing type	Pre-existing health condition
P01	71	Female	Chinese	O-level	Single	Yes	Retired	0	4-room HDB flat	None
P02	64	Male	Chinese	A-level/Diploma	Married	No	Self-employed	2,000 – 2,999	4-room HDB flat	Diabetes, Hypertension, High cholesterol
P03	55	Female	Chinese	A-level/Diploma	Married	No	Part-time	2,000 – 2,999	5-room HDB flat	None
P04	57	Male	Indian	Postgraduate	Single	Yes	Full-time	4,000 – 4,999	5-room HDB flat	None
P05	69	Female	Chinese	O-level	Married	No	Retired	0	HDB studio apartment for seniors	Diabetes, Hypertension
P06	66	Female	Chinese	O-level	Married	No	Retired	0	Condominium (excluding EC)	None
P07	71	Male	Chinese	Some secondary	Married	No	Retired	0	HDB studio apartment for seniors	None
P08	73	Male	Chinese	Degree	Married	No	Part-time	7,000 – 7,999	3-room HDB flat	Hyperthyroidism
P09	68	Female	Chinese	O-level	Married	No	Homemaker	0	4-room HDB flat	Hypertension
P10	68	Female	Chinese	Degree	Married	No	Retired	0	5-room HDB flat	None
P11	63	Female	Chinese	Degree	Married	No	Retired	4,000 – 4,999	Semi-detached house	None
P12	64	Male	Chinese	Postgraduate	Married	No	Self-employed	2,000 – 2,999	3-room HDB flat	Hypertension
P13	82	Female	Chinese	O-level	Married	No	Retired	0	5-room HDB flat	Heart disease
P14	60	Female	Chinese	A-level/Diploma	Married	No	Retired	4,000 – 4,999	5-room HDB flat	None
P15	59	Female	Chinese	O-level	Married	No	Homemaker	1,000 – 1,999	Executive condominium (EC)	Hypertension
P16	73	Female	Chinese	O-level	Single	No	Retired	0	4-room HDB flat	Hypertension High cholesterol

P17	56	Male	Chinese	A-level/Diploma	Married	No	Full-time	2,000 – 2,999	4-room HDB flat	Moderate high blood pressure with medication
P18	62	Female	Chinese	Degree	Single	No	Retired	<1,000	5-room HDB flat	None
P19	64	Male	Chinese	Postgraduate	Married	No	Self-employed	3,000 – 3,999	5-room HDB flat	None
P20	63	Female	Chinese	A-level/Diploma	Single	Yes	Retired	0	2-room HDB flat	Diabetes, Hypertension, High cholesterol
P21	76	Male	Chinese	A-level/Diploma	Married	No	Part-time	1,000 – 1,999	Terrace House	Hypertension
P22	53	Female	Chinese	Postgraduate	Married	No	Part-time	4,000 – 4,999	3-room HDB flat	None
P23	67	Female	Chinese	A-level/Diploma	Married	No	Retired	0	3-room HDB flat	Diabetes
P24	68	Female	Indian	O-level	Single	Yes	Retired	0	3-room HDB flat	None
P25	74	Female	Chinese	O-level	Widowed	No	Retired	1,000 – 1,999	Condominium (excluding EC)	High cholesterol, Hypertension
P26	60	Male	Chinese	Some secondary	Single	Yes	Part-time	<1,000	3-room HDB flat	None
P27	72	Female	Chinese	Degree	Single	Yes	Retired	<1,000	5-room HDB flat	Hypertension, Cancer, High cholesterol, Fatty liver, Osteoporosis
P28	68	Female	Chinese	O-level	Married	No	Part-time	1,000 – 1,999	3-room HDB flat	None
P29	72	Male	Chinese	A-level/Diploma	Married	No	Retired	<1,000	3-room HDB flat	None
P30	63	Female	Chinese	O-level	Single	Yes	Retired	<1,000	3-room HDB flat	None
P31	68	Female	Chinese	O-level	Married	No	Self-employed	<1,000	3-room HDB flat	Diabetes, Hypertension, High cholesterol
P32	68	Male	Chinese	O-level	Single	No	Part-time	1,000 – 1,999	3-room HDB flat	Diabetes, Hypertension,

P33	62	Female	Chinese	Degree	Married	No	Part-time	1,000 – 1,999	5-room HDB flat	High cholesterol None
P34	70	Female	Chinese	O-level	Married	No	Part-time	<1,000	Terrace House	High cholesterol
P35	65	Female	Chinese	Postgraduate	Single	Yes	Part-time	1,000 – 1,999	4-room HDB flat	Diabetes, Hypertension

Appendix 12 Sample quotes regarding participants' perceived impacts of the prototype

Theme	Sample Quotes
The tele-education prototype helped participants acquire deeper knowledge about dementia, corrected some misconceptions, and increased their awareness.	"I'm new to dementia because I haven't come across any of my relatives having dementia before. At least I learnt a lot today." (P02) "I think some of the topics discussed are quite eye-opening, some can be applied, some can be learned, some also can be shared with your friends, especially 1 in 10 Singaporeans have dementia, and something we mentioned that is interesting." (P04) "I think you chose a very good topic for mental wellness, especially during this Covid period. A lot of people are feeling lonely, and mental health is really something that is really affecting a lot of people. So I think you chose this topic is very good, and it's something that is quite new, and we are all learning, and I think overall I would say I do learn a lot about dementia today." (P06) "Maybe there are some resources around us, but maybe we are not aware. We don't bother until I attend this tele-education, that's where awareness comes in lah." (P12) "We have a general sense of the illness, but we don't really understand the details and sometimes we could give the wrong answers because we thought we were right. I like your set of questions than true and false because it cut the answers very well exactly what it meant rather than a general one." (P19) "I think the content is very educational. [There are] a lot of things we heard, but we are not sure. [It's] informative. After attending this, we are more sure and assertive... Actually, what you are doing now is actually related to what P22 said, how to recognise misinformation on dementia. But now we are more sure. So when we talk to people we are more assertive. It depends on what we are doing, and sometimes we need to be better in certain topics." (P21)

	“By answering these questions, first of all, you can know how much you know about it, whether it’s right or wrong. Actually, by reading the questions, I actually have a wider view of what it can and may not be. I mean so far dementia people who suffer this and that, but we never look into those questions you give us, we never look more in-depth like those questions. We just say okay this person has dementia and he/she is doing this and that, we read in [the] newspaper that people are getting lost, that’s it. By doing those questions, we can sort of understand better and know okay, this is what it is all about.” (P24) “Initially I could not answer a lot of questions so I put “unsure”. But after attending after you have explained, I find that I’m able to answer some of the questions accurately, then I say well it’s good for someone who doesn’t know anything about dementia.” (P28)
The tele-education prototype aided participants in gaining a more profound comprehension of people with dementia and the responsibilities of dementia caregivers, which in turn could enable them to communicate more effectively with other people.	“Basically look out for, like you say, now I’m equipped with this knowledge, I will not purposely or make it so obviously “Are you ok or not ah?” I won’t purposely go to look for dementia people. But just understand the caregiver, you know sometimes I see caregiver pushing the dementia patient or whatever, now I understand why because they [the caregivers] themselves are frustrated, they can burn out also, they are human beings. [This session] is more eye-opening, and I will see how I can help to understand the caregiver and dementia patients and apply what I learnt today.” (P12) “For me, I’m a volunteer to interview the seniors. So I recently came across one, I think she has dementia, so I want to know more about this so that I can understand her behaviour.” (P13) “For example, as a volunteer, now I’m able to communicate better because I understand more on [about] this topic. Caregivers actually are very stressed, especially in their family, the spouse has to take care of another spouse, and you know between spouse and spouse they take things for granted. So that’s why people want to send the patient to the nursing home, it’s because of this reason, because they find it very difficult to communicate, they just don’t want to listen, but they will listen to another person but on the same thing.” (P21) “Speak and treat kindly daily to dementia patient and join dementia support group[s].” (P26)

Participants would like to apply the knowledge acquired to	motivate their learning	"I want to know more about dementia. I think a lot of people are concerned, especially my group of friends, they are very worried." (P21) "I actually pick up some very good points that I can use for myself to do some self-assessment, or I am given information that I can actually further explore on my own, if I want to go slightly further, because this topic is a very common topic, and is a topic that is of much interest to people aged 65 and above." (P27)
	enhance their self-care practices	"For me, I find the session very informative, [covering] how to prevent and what are the early symptoms, so that we ourselves are aware and take note of all these things, as well as the people surrounding you, [like] our family members. We are ageing, but not only we are ageing, [but] our family members are also ageing, we have to be aware of the signs, symptoms of all these things, and to prevent, and if we find out that there is [diagnosis], then we have to prevent it for further deterioration. So [it is important to] take precaution." (P03) "Eat healthily, sufficient sleep, and also walking exercise, healthy living!" (P05) "I think all the preventive measures we mentioned are useful, like keeping ourselves active physically as well as mentally, that's the thing I learnt today lah." (P06) "I think I need to stay socially and mentally active. If any of my family members get dementia, I will know a little bit better how to take care of them." (P23) "I agree with P25 that we should stay active, and we can pick up something like arts. I volunteer with the Sports Hub and try to walk every day and meet people, young and old, go out for lunch and all that. And I learn languages, I learn French, Italian, German and Mandarin. I can play a little bit of piano, I'm learning piano. I'm learning ukelele. I read books, and I try to go out. I cannot stay home, I'm so lonely, and this may lead to dementia haha. I have a group of friends, I go with my ex-colleagues, some of them are older than me, [and] some are younger than me. So we just meet and then have lunch and talk and talk. Yeah, laughter is very

		important because [if] we cannot laugh and smile, we feel miserable, then our life is miserable, and it may lead to dementia!" (P24) "Going to a healthy lifestyle, have to make more small efforts, have to go out more often. If possible, maybe we can take some short courses, maybe in art, drawing, etc. And keep the mind active. Some people do volunteer work." (P25) "Actually, today one is a very good lesson, and another thing I like to share is my own mom...So now what I feel [that] the most important thing is what the doctor said "You retired, you cannot sit at home and watch TV, you have to read, not only read but also read it out to make your brain work. Sometimes even nowadays I have this memory problem, not so good now. I'll try to recall and make my brain work, this is what my doctor told me. I think we need to do is to exercise. I retired in 2008 but I keep doing stuff, freelance or admin [jobs], and if I have the time I will hit the gym every day; if not at least every other day. This is what I can do for myself now to keep myself healthy. I make sure I have lots of things to do, even at home. I'll try to draw something, and I'll try to make my brain work." (P34)
	share the information within their social network	"We can call people to look out, especially in the ageing society. We can also share the[se] tips [on how to reduce the risk of dementia] with my friends. I am already doing some of the checks like going for checks, but I never know all these can also contribute to dementia, and diabetes, [and] high blood pressure can also contribute to a higher risk of dementia. Now I know, so I can tell my siblings and friends to go to check also." (P04) "Right now everybody hopes to be healthy, but how? Eat well, how? Exercise, how? We know in words, but how do we go about it? So if we can teach or show people the steps [of] how to build muscle, okay this is what you're gonna do, then it may motivate people, oh this is how, not that bad, not that difficult, so I start doing it. Because you can tell me [to] eat healthy, so what? You know but you cannot apply. Knowledge must go into action, and action can be one step at a time, considering now we are talking about older people right? So one step at a time, one step at a time, then gradually they get used to it." (P11)

		“Actually, it will help, because there are many people who are in contact with people with dementia. They don’t know what to do, they are actually quite lost. So that the little [things] we know from today’s session, we can share with them.” (P24)
	extend assistance to those in need	“After you tell me all these and listening to so much information and knowledge, emotionally I feel I can do more, maybe volunteer.” (P12)

Appendix 13 Sample quotes regarding participants' satisfaction with the prototype and perceived appropriateness in the local setting

Theme	Sample Quotes
All participants expressed satisfaction with the tele-education prototype and found it easy to understand, although most of them were new to tele-education.	“Basically I find the information here is quite clear, very direct, easy to understand...” (P04) “Assume that I have enough time, then this format is okay, because if very comfortable to sit and home and do Zoom. This is the first time I really do something on Zoom for so long, I’ve never really done it on Zoom before. I managed to keep myself occupied on Zoom. It is something new I learnt.” (P05) “To me, I think both ways are ok. I prefer this, if this is the mode for communication over Zoom, I think I would rather choose this option [rather than] go for physical or on-site.” (P06) “I agree with P11 that I’m very comfortable with Zoom because it really saves time, saves transport. Each time I attend a one-hour activity or half an hour activity, if I have to go onsite, it’s actually one whole afternoon wasted. And we have so many events back to back sometimes, if it is with Zoom, you can go through all the Zoom sessions because they are back-to-back. No time [is] wasted on travelling. But if you have to do it onsite, you probably have to accept only one of the session[s] and maybe you have to cancel it. So for me, Zoom is very comfortable.” (P10) “Actually, for me, I am really quite happy on Zoom. In fact, Covid actually created a lot of good things for me. I mean as far as I’m concerned, some people like to go out, I don’t like to go out, so I take up a lot of courses whenever it’s on Zoom because I find that it really saves a lot of time and personally for me having a Zoom education, I really like it because I find that travelling out is really a lot of time taken, and even telemedicine, when I go for the blood test, all the doctor need to do is to just call me and tell me my result and explain to me. I really like [it, I] think it’s a fantastic idea. Otherwise, we have to travel to the hospital, [and] wait for half an hour or one hour for the doctor to tell me the same thing, whereas I can stay at home and just talk to a doctor for 10 or 15 mins. So if you ask me if [a] telehealth programme, [a] tele-education programme is good for me, I like it. It saves up on my travelling, I don’t have to travel, it saves a lot of time. Especially for us women, we have a lot of things to do at home on the day.” (P11)

	“Tele-education is ok, you can go even more high-tech.” (P12) “I also feel that [tele-education] is very convenient, I don’t have to go here and there, I can just stay home.” (P13) “I think it’s good overall, it’s a good introduction... I think it [your prototype] is very good as a basic education programme for people to have this awareness.” (P18) “I’m very happy [about tele-education].” (P21) “Generally, if it’s just conducted in a simple way I think it’s okay like this, there is no stress on us, so we are very comfortable. Today one is okay, comfortable.” (P32) “This Zoom session is very very good.” (P34)
Some participants shared that their daily schedules were packed with household chores or caregiving duties, making tele-education the ideal choice for them.	“For me, I like Zoom a lot, as what the other two participants mentioned. but let’s speak on behalf of my husband, he is a chronic patient, actually, I always wonder why this tele-education thing cannot be opened wider to people like him... I actually stopped work[ing], so I don’t earn anything, I don’t have the income now because of my husband because I accompany him wherever he goes for hospital appointments...Now it’s also hard for me to go for physical ones because every time I go out, I have to make sure there is someone around at home. Otherwise, as P10 and P11 said, half a day is gone just to attend a one or one and half hour session physically. If it’s all under this tele-education, then it really saves a lot of precious time and money.” (P09)
participants anticipated the integration of health promotion campaigns with tele-education to enhance the impact of dementia awareness initiatives, for example, 1) organising regular health	1) “Is there a particular date we set it to promote dementia in Singapore or in the world? It would be good during this period [to have health education], because most of the working people will be so drawn in their working life, the awareness of their parents and relatives developing such signals will not come to an awareness until things happen, then it may be too late. So if the government could systematically educate people through [about] all these different diseases, this kind of activities will help to remind people every year like Valentine’s Day. Every year you have a promotion that talks on this topic will help to bring about awareness and bring people to learn more about these signals.” (P19)

promotion events and reaching out to less engaged older adults, 2) incorporating free or subsidised dementia screenings into annual medical check-ups, and 3) designing a tag for individuals with dementia to encourage public assistance and support when needed.

2) “Do you think any healthcare, hospital, or institution can give us [a] discount or voucher for cognitive screening for dementia? If the early screening of dementia can be incorporated into the health screening, it’s a good idea. (P05)

“Like what we have this year, they checked for chronic diseases like 3 High’s, if they can include this dementia screening into the yearly health screening for the seniors, I think that will be good.” (P06)

“I just want to say whether there is a possibility to add on to our those functional assessments and screenings.” (P09)

“I think increasingly over the last 10 years, a lot of talks about dementia, so I think a lot of people gradually know more about dementia a little bit here and there, and maybe we experience family members or friends having dementia. So I think knowledge alone may not help, [but] if you make it a compulsory kind of add-on to our health check, that will be a good start, then it’s not just information but action also. If you leave to everybody “Okay, it’s up to you whether you want to check or not”, then nobody will want to check. But if you make it maybe not to spend money on MRI/CT scan[s], because those are expensive, but at least the basic first, maybe cognitive tests. After the cognitive tests maybe there is some suspicion that you are getting dementia, then the next level will be probably some other tests before the CT scan, or maybe go straight to [a] CT scan, but at least a preliminary so-called, since this is so common right, preliminary, compulsory kind of a test during a health screening. It’s just like the blood test, everyone goes for the 6-month blood test.” (P11)

“They [the current annual health screening items] don’t extend it [dementia screening] to us.” (P13)

“Just now the lady mentioned about dementia screening, and this should really be part of the annual screening now. It’s a very important topic.” (P28)

3) “For people with dementia [especially for those whose conditions are] severe, do they have a tag so that people know if they are lost? But I think it would be a very good initiative if we can do it and write their caregivers’ names, contact numbers, or even home addresses [on the tag so we can help them].” (P08)

Appendix 14 Sample quotes of the SNOW analysis result (SNOW: Strengths, Needs, Opportunities, and Weaknesses)

Category	Level	Theme	Sample Quotes
Strengths	Technology	Convenience - comfort	"For me, I prefer online, I can sit in my comfort." (P03) "I think for me, this telehealth education programme online saves us the time to go down to the site to do it. So, on that, it saves our time, and you do it at [in] the comfort of your own home, so that is the pro of having tele-education over Zoom. To me, I think both ways are ok. I prefer this, if this is the mode for communication over Zoom, I think I would rather choose this option [rather than] go for physical or on-site." (P06)
		Convenience – time-efficiency	"I think for me, this telehealth education programme online saves us the time to go down to the site to do it. So, on that, it saves our time, and you do it at [in] the comfort of your own home, so that is the pro of having tele-education over Zoom. To me, I think both ways are ok. I prefer this, if this is the mode for communication over Zoom, I think I would rather choose this option [rather than] go for physical or on-site." (P06) "I agree with P11 that I'm very comfortable with Zoom because it really saves time, saves transport. Each time I attend a one-hour activity or half an hour activity, if I have to go onsite, it's actually one whole afternoon wasted. And we have so many events back-to-back sometimes, if it is with Zoom, you can go through all the Zoom sessions because they are back-to-back. No time [is] wasted on travelling. But if you have to do it onsite, you probably have to accept only one of the sessions and maybe you have to cancel it. So for me, Zoom is very comfortable." (P10) "Actually, for me, I am really quite happy on Zoom. In fact, Covid actually created a lot of good things for me. I mean as far as I'm concerned, some people like to go out, I don't like to go out, so I take up a lot of courses whenever it's on Zoom because I find that it really saves a lot of time and personally for me having a Zoom education, I really like it because I find that travelling out is really a lot of time

			taken, and even telemedicine, when I go for the blood test, all the doctor need to do is to just call me and tell me my result and explain to me. I really like [it, I] think it's a fantastic idea. Otherwise, we have to travel to the hospital [and] wait for half an hour or one hour for the doctor to tell me the same thing, whereas I can stay at home and just talk to a doctor for 10 or 15 mins. So if you ask me if [the] telehealth programme, tele-education programme is good for me, I like it. It saves up on my travelling, I don't have to travel, it saves a lot of time. Especially for us women, we have a lot of things to do at home on the day." (P11) "I also feel that [tele-education] is very convenient, I don't have to go here and there, I can just stay home." (P13) "Tele-education is more convenient for the participants because they can log on to the laptop anytime, they don't have to travel to the location. Because if you are doing a physical one, then we have to travel to the place and there is a time wastage. [Tele-education] is more efficient." (P22)
		Friendliness to people who are shy	"For online sessions, if I'm very shy to speak, so I just type into the chat. Maybe one advantage of online is you can type if you are shy to speak or unmute [yourself]." (P12)
		Better focus & less distractions	"And the information is more targeted, because sometimes in a physical environment [people] can get easily distracted right when somebody is beside you or they are eating? But now we can just find a quiet place and do this tele-education. I think the concentration for the participants, for me in particular, is much better." (P22)
Weaknesses	Human – older users	Less physical interaction	"Face-to-face [education] also has its own advantages, you already see the person in-person, then [the] interaction is there lah." (P03) "There is interaction physically, maybe we are the old-fashioned type." (P05)

		"Of course [for] physical [sessions, there are] more interactions, in the sense that the person can have eye contact, can see more things, and can do the activities together, more interactions lah. Online [sessions are] quite difficult, but still can be done." (P12) "I also recognise that some people prefer onsite where they can actually see it, and can ask questions, better for interaction, then perhaps some sessions can be onsite. For food, I think there are many things [that] can be shared for food, you can have some cookery class to show people how they can prepare nutritious food for the family as well. It's not just for the patient." (P18) "But by talking and listening from others, then there is some kind of we can retain something, so more interactions." (P24)
	Lack of immediate support, particularly when users are alone	"Btw I cannot see the "CHAT" button, I don't see anywhere I can actually write. So what I mean is that sometimes the small issues come up, unless you get someone that can help on the spot. But if not, then you wouldn't know how to do it." (P30) "it's quite general. It depends. you have to adjust the pace [so that] the person is able to learn. If the person is a slow learner, then the person who conducts [the session] has to guide and encourage him, you don't leave him behind. Otherwise, he will not complete the course. Whereas in the class, let's see if the person doesn't know, they will turn around left and right and try to catch up, you know [that he has some difficulty following]. But alone in the room, you have nobody to guide you, so that's a difference." (P33)
	Technology	"I don't have Wi-Fi, I'm using telephone data. I have 20 GB every month, so I reserved 15 GB for today's session. I didn't use my phone much this much and reserved my data for today's session... Yes, it's acceptable, provided that I still have the data." (P05)

			“For myself, I don’t know whether you noticed just now I got disconnected for [a] very short time twice. Maybe it’s my connection issue here, so I was lost for one or two mins at that time just trying to connect.” (P30)
		Usability challenges posed by small device sizes	“We are seniors and we may consider the font size [in Zoom poll] small lah. Another thing is that we can enlarge it lah to change our text feature, because before it’s small. Sometimes we may not see some parts [on the slides] due to resolution problems, so maybe you need to get the resolution right [to] fit the screen size.” (P12)
	Needs	Health education design – content	
		Tailored content	“Because it's very hard to get the audience that is of the same standard, so if you just do public announcements that come and listen, you will have all kinds of people, some catch it [while] some don't catch it. So that's my view. So if you want that tailoring, you can approach these organisations, mainly the family centres or social centres, so they have their own group of [the] same standard of seniors.” (P11)
		Evidence-based content	“And it’s also good that you quoted some research to support what you say so that we know the information is reliable. I think it’s quite easy to understand, no technical words.” (P22) “[We can have more such kind of sharing], but not from TokTok or YouTube, because sometimes it’s all nonsense. It should be real news.” (P24)
		Correction of misconception	“I think it’s actually quite good even for other form[s] of tele-education on other illnesses like osteoporosis because we have a general sense of the illness, but we don’t really understand the details and sometimes we could give the wrong answers because we thought we were right. I like your set of questions then true and false because it cut the answers very well exactly what it meant rather than a general one. Because a lot of people just generalise a lot of things, and then they let it be because that seems to be the way health education is portrayed in the media like [the] newspaper.

		They give very general idea[s], but they don't really go too specific. But your set of questions cut it very clearly whether it is on the right or on the left kind of things, so I like them. Maybe you can work out something which allow[s] us to have that kind of listing of questions which actually it's also good to use as conversation starters among friends, I mean I would probably use that the next time I meet up with my friends and then talk about what it is. a lot of people try to give a general idea of the illness, it will be good to actually correct the people that this is what exactly it is." (P19)
	Constantly updated content	"The content is very important. Fortunately, we are a bit more educated, we are a bit more receptive to what are you telling us, and we [are] also hungry for knowledge especially these are very relevant, actually more for the retirees or for the elderly. I think your content must be forever evolving, there is always something new, and then that would attract us. Because if I can find it on Google, I don't come to you already." (P21)
	Medical information & actionable health tips	"I think [more disease-related medical knowledge] will be good. You know the existing programme like diabetes education, they actually do a lot in the area of education [educating] diabetics [patients] about how to look after themselves, how to give injections, how to take care of medication, diet, etc. Those are quite hands-on kinds of education, they really educate until the person knows as much as healthcare personnel, so I think the diabetics themselves are quite motivated to learn. I'm not sure whether for this one [it] is pre-diagnosis, you know you want to educate them when they are still young before the onset of dementia. So it's the kind of approach [that] possibly might be a bit different, because the other one the diabetics they are already diagnosed. So you know they are very motivated to learn how to handle their own illness, but for this one, they may feel I'm extremely well, why I need to learn all these things, so might need to find ways to overcome this kind of objection." (P10) "Can we have it on both medical and lifestyle?" (P12) "My challenge is what I'm going to do next, but now I know. Sometimes I wanted to do but as you say I don't want to put it into practice, then [it] can be a challenge." (P21)

Health education design – language	Multiple languages	“Because this is basically in English right, it is also good to [adapt it to cover] other older populations to cover the other three official languages, so there is a wider reach, rather than just English-speaking ones. Maybe different sessions for different languages, because some people may prefer Mandarin, Malay or Tamil, so you cannot have all of them in the same session, otherwise it becomes very difficult to teach. So you may want separate sessions for Mandarin, Malay, or Tamil speakers. I’m talking about the four main languages, of course, we cannot have all languages. If you cannot have four different sessions for different languages, then maybe can have different subtitles in different languages. But these are quite important information that you want people to know actually.” (P04) “If you are aiming for the general public, maybe Mandarin is a better language than English.” (P08) “And also they probably, unless you have it in Mandarin, or Malay or something, I think English is quite limited among the seniors.” (P10) “Not everyone understands English right, a lot of seniors are dialect-speaking or Mandarin-speaking, so not everybody understands English lah.” (P11) “You said not everyone can understand English, then Mandarin is very very varied depending on where they come from, is there a possibility of being just [a] simple Mandarin language? And in your faculty, maybe people who know Cantonese, Hokkien, don't give them a very deep [difficult document] like what you give us the slides all that, just talk to them, and talk to the ambassadors there, some may be able to speak Cantonese, some may speak Hokkien, some may speak Malay, can just give them the simple thing, not factual knowledge. I don’t think they want all this knowledge. Just have some conversation, give them some outline of it, and say if you want anything you can go to this place if you are not so sure you can go there. I’m very sure people are receptive, they really need help. Just give them some informal ones. So if you ask me what I see just now [in the session], I can only tell you some. So just general normal layman conversation! They will understand if it’s in their language.” (P24)

	Simple language	“Certain things need to [be] memorise[d] like some technical ones, that one you must explain then we understand. So memorise keywords, but please explain then we get it, we absorb it lah. Certain keywords must [be] memorise[d], but explanation helps.” (P12) “I think it [the prototype] is quite easy to understand, no technical words. But it’s not too simple, we can get the message effectively.” (P22)
Health education design - delivery	Reducing cognitive load	<u>Duration</u> “The other thing is I think if telehealth is on the phone, it might be a bit too long because for example we spend about one hour, but I think if you really use [tele-education] maybe half an hour lah, holding their telephone and listening to all these may not be so appropriate.” (P11) “Tele-education is very targeted, but then the span of our focus [is not long], so you should not make it too long. Too long it won’t be good lah. I think maybe one hour is good enough. I’m saying that our focus [is only one hour], [and] after one hour we don’t know where our minds go already. Especially at home, because [on] Zoom, you are in another environment, so we have priorities in attending to other activities, and then halfway they will disappear. one hour very focused is very good to learn if they know they are able to learn within a very short period, then they do like to spend their one hour.” (P21) “But as P21 mentioned, keep it short and sweet, because after a while our minds tend to wander. I think it’s about right.” (P21) <u>Presentation – multimodal texts</u> “I’m a person who would love to read, so for me, the content is very good, very informative, thanks for that. However, keep in mind that some of us are very visual, so besides the words, you can have

		more pictures to keep them awake. Because it's online, you need to attract your learner, so make your presentation more attractive, insert some videos, pictures, music, maybe some music, maybe some video clips. That would be good" (P03) "it's too wordy, too much [many] words [and] no pictures. After a while you read [and] read, you are very tired. Maybe it can be intermingle[d] with some pictures, real-life pictures, or maybe a short video clip to emphasise some of the points, that would be more interesting with more visual elements, [it will not be very] static." (P04) "But I think many of the other telehealth education programmes use a lot of diagrams [but] not so many texts. So it really depends on your audience, to some maybe this is too brief, but some others they may not be able to follow. Maybe videos [and] role play in [the] video[s] will be good, a bit more visual. For me, it [the language used] is ok, [but] I don't know for other seniors, whether it's easy for them or not. Maybe you want to test it out." (P10) "Because you know, a lot of seniors really cannot [read texts to follow], some of them may not be able to understand so many words, so I guess [it is] not easy for older people to understand. So visual is very important" (P11) "But online, I would prefer to have a lot of visual images, because I'm left-handed and I'm a very visual guy. I see pictures I remember better than just using PowerPoint, and then sometimes the PowerPoint, wah seven eight points I cannot remember ah, I must take photo eh. So maybe a short PowerPoint with visual images, pictures would be very helpful." (P12) "For your tele-education, there are a lot of texts, videos might be more informative, because I think some of the explanations may actually be more vivid and clear. If you could [find] some form of a video of the behaviour of the person, but of course you may have to obscure the face and so on for [the] protection of that person. I mean it helps to actually illustrate the form of behaviour [that]

		dementia people may resort to, rather than just words. I mean it [text] does convey a sense of what it is, but I think some videos, maybe some pictures can be more informative in that sense.” (P19) <u>Content – incorporating real-life experiences of people with dementia and their caregivers</u> “I’m sure in your other groups there may have been participants who are actually in direct contact with people with dementia, and they can actually share more [of] the help. Maybe you and the other participants [can share] because there is [are] real-life experiences.” (P25) “I think the last suggestion another participant mentioned [adding in the sharing of first-hand experience on taking care of dementia people to gain a better understanding of why it is so important to do early screening, early treatment, and early intervention] would make the session more interesting and more related to reality.” (P27) “I think it will be good if we have [something] like the caregiver or somebody in the profession of taking care of some dementia patients, to at least participate a bit, maybe in the background as a participant to listen to what we commoner do not have real experience in, and then after that she can give us some pointers to look out on.” (P35)
	Motivating older audience	“You know the existing programme like diabetes education, they actually do a lot in the area of education [educating] diabetics [patients on] how to look after themselves, how to give injections, how to take care of medication, diet, etc. Those are quite hands-on kind[s] of education, they really educate until the person knows as much as healthcare personnel, so I think the diabetics themselves are quite motivated to learn. I’m not sure whether for this one is pre-diagnosis, you know you want to educate them when they are still young before the onset of dementia. So it’s the kind of approach [that] possibly might be a bit different because the other one the diabetics they are already diagnosed. So you know they are very motivated to learn how to handle their own illness, but for this one, they may feel I’m extremely well, why I need to learn all these things, so might need to find ways to overcome this kind of objection.” (P10)

	Preparing sharable content	“If this is something that can be available online where you can access any time, and you can use that to share with your friends or whoever you need to share. So you can have a platform to share rather than you have to attend the session in order to learn [the Zoom link can be shared with others, not like the physical sessions which need registration to attend].” (P04) “Not sure whether we will get a copy of what we learn, because I think it’s very interesting that I keep this at hand, and every time I forget I can go back and read, eh you must do this must do this. I’m not sure if we can get a copy lah. I’m actually taking notes.” (P12) “[By] having the physical copy, at least I can remember [the knowledge]. At the end of the year, somebody talks to me about dementia, I won’t say yeah I attended it, and I forgot what she said about it. If I have the thing [the physical copy] in my phone, I can give people something from what I can recall, or at least I can talk and say by looking at that, I can actually recall what you said. But if I can’t recall the main points, then I still can recall what you said. Actually, it will help, because there are many people who are in contact with people with dementia. They don’t know what to do, they are actually quite lost. So that the little [things] we know from today’s session, we can share with them. I think the hard copy you showed us just now [is] right, at least we have something to talk [about] and share with them.” (P24) “And one thing I can envisage is that it’s on an online basis, you can actually do it on your own, meaning pre-recorded it and it is played out, and it can become something like a self-help instrument or exploration. Because if I have an issue, [for] most of us the first thing is [to] go and find information, how should I approach to solve the problem or something like that? So I see the potential here for this kind of approval, it helps the individual to do problem-solving.” (P27)
Human – older adults	Mindset and attitudes	“Before covid, we were comfortable and we would like to interact with people and we go face-to-face. But since Covid, we learn how to go digital because we cannot go out [at] that time and we learnt that online is much better. I mean the time we were forbidden to meet each other so we learnt

	toward digital technologies	that actually through this method it's better and at our own comfort, just access and we could interact with people, and we can see each other actually. So it's better. We don't need to go out." (P03)
	Technical support	"For myself, I don't know whether you noticed just now I got disconnected for a very short time twice. Maybe it's my connection issue here, so I was lost for one or two mins at that time just trying to connect. Btw I cannot see the "CHAT" button, I don't see anywhere I can actually write. So what I mean is that sometimes the small issues come up, unless you get someone that can help on the spot. But if not, then you wouldn't know how to do it." (P30)
	Preparing prior to the session	"It will be good that the person do[es] some read-up before participating in the programme, I think the questions asked will be more in-depth and maybe more specific to what they are looking for to get an answer from the programme itself." (P33)
Human – health educator	Taking care of slow learners	"Sometimes I don't know which one is the correct answer, so I just estimated, agar agar [an estimate] yah. I try to do as best as I can. After listening to you, I still have doubts. Maybe [it is because] we already have a mindset, so could not absorb the reality so fast." (P25) "In tele-education or Zoom education, the person that conducting it must be able to seize whether everybody follows, some are slow learner[s], so he has the help the person along. Otherwise, after a while, he'll be lost. And if he asks too many questions, he may hold everybody up and he may not be comfortable to [for] us. So understanding by the educator is very important. Otherwise, after one lesson that person would not want to join anymore because he is lost. So helping the weak [learner] along is very important." (P32) "you have to adjust the pace [so that] the person is able to learn. If the person is a slow learner, then the person who conducts [the session] has to guide and encourage him, you don't leave him behind. Otherwise, he will not complete the course... So if you think that you are going too fast to catch sometimes, then you have to slow down and try to guide the other few along. Yes, the instructor needs to have that level of understanding, you know how the student follow[s] the course." (P33)

	More interaction	“Interaction is very important... Actually, on Zoom you can split the class into different groups and then have their group discussion on certain subjects and then ask them to present what they are thinking of after the breakout session.” (P08) “If there is a pre-recorded session with all the answers on the screen so that I can pause and read, I can learn more. Because sometimes for pre-recorded sessions if I just play the whole video, maybe after half of the time my mind will go somewhere else. It’s not like now I’m looking at you. Pre-recorded ones may be distracted.” (P12)
Technology	Access to a stable Internet connection	“I don’t have Wi-Fi, I’m using telephone data. I have 20 GB every month, so I reserved 15 GB for today’s session. I didn’t use my phone much this much and reserved my data for today’s session... Yes, it’s acceptable, provided that I still have the data.” (P05)
	Data privacy	“The concern is because you are recording, so sometimes we are worried that we are exposed to social media, etc.” (P03) “Of course, before we started you mentioned that this will be used for your research and it will only be seen by you. If someone in your faculty wants to know more, I’m sure you are the only one who can key in and show them. Having said that, I think if the person like the presenter tells us that this will be kept confidential, then we will have the trust that you will keep it [confidential]. Of course, we have to see what is the purpose of [the session], we cannot just believe anybody who give[s] us Zoom and from anywhere, any sources and then he says don’t worry don’t worry, we keep your data private and confidential. We have to know. We know you, and [in case] anything happens, we can go to your university, we know your name and we can go [to find you]. But if we don’t know, somebody from some X Y company, then maybe we have to be more careful. I think I will be more careful.” (P24) “The only thing is as long as our sharing is kept confidential, it’s not for public sharing, but of course, you can quote.” (P35)

Health system & policy environment	Standardising the health education programmes	“Can I understand what is your objective of this tele-education programme? If it is a national programme where it should be rolled out in all over Singapore. Because right now there are many different groups, [and] charitable organisations, everybody is doing their own thing, so if you are telling me that you want to do one as a national programme to unite, you know all the different charitable organisations to send in one message instead of so many people doing their own things, then this tele-education can be a very general programme where you just want to provide a very general kind of exposure, and then from there you give resources where they should go to find out more, maybe [in that way] your reach will be more throughout the whole Singapore, because right now all the different groups when do they, they only can capture a very tiny group of people. So as a national programme, you want to get as many people to go through this programme, to be educated.” (P10) “So it’s everybody echoing the same thing, and you just do that one thing, and that’s it. Maybe it’s a good approach.” (P10)
	Continuous health promotion events	“[Community health club and other programmes] are good, but such programmes should be ongoing. Sometimes they are very hot for a while then after some time just die off. So maybe community centres can help organise more regular programmes, not just once a while but more regular, maybe quarterly.” (P17)
	Publicity of the current health promotion events	“[And more publicity should be done to gain more awareness of these facilities, otherwise it’s a waste.” (P17)
	Subsidies for lifestyle medicine	“When you have a problem you go to a hospital and they will send you to a rehab centre where you actually go for coaching, you are not going there to exercise, the point is telling you what kind of exercise you should do because of your condition, then after that they referred me to a gym and then

			they don't call you as members, they call you patients. And the gym is not the crowded one, it's more focused, and we need to pay for it. Now I have [a] problem with it because [the] government does not recognise it, exercise actually is important, is equally important as taking medication. There are subsidies for medications, but no subsidies on [for] exercise. And I dropped this one, when I joined that one for 20 sessions, I had to pay \$250. Then after five or six years, it came up to double. I don't receive any subsidy, but it's very important for me." (P21)
Opportunities	Health education design – content	Identifying the health information needs of different subgroups of audiences	"Because it's very hard to get the audience that is of the same standard, so if you just do public announcements that come and listen, you will have all kinds of people, some catch it [and] some don't catch it. So that's my view. So if you want that tailoring, you can approach these organisations, mainly the family centres or social centres, so they have their own group of the same standard of seniors." (P11) "You said not everyone can understand English, then Mandarin is very very varied depending on where they come from, is there a possibility of being just [a] simple Mandarin language? And in your faculty, maybe people who know Cantonese, Hokkien, don't give them a very deep [difficult document] like what you give us the slides all that, just talk to them, and talk to the ambassadors there, some may be able to speak Cantonese, some may speak Hokkien, some may speak Malay, can just give them the simple thing, not factual knowledge. I don't think they want all this knowledge. Just have some conversation, give them some outline of it, and say if you want anything you can go to this place, [or] if you are not so sure you can go there. I'm very sure people are receptive, they really need help. Just give them some informal ones. So if you ask me what I see just now [in the session], I can only tell you some. So just general normal layman conversation! They will understand if it's in their language." (P24)
	Health education	Taking advantage of different	"If this is something that can be available online where you can access any time, and you can use that to share with your friends or whoever you need to share. So you can have a platform to share rather

design – platform	education platforms	than you have to attend the session in order to learn [the Zoom link can be shared with others, not like the physical sessions which need registration to attend].” (P04) “One important thing is to get them to put on their names when they join Zoom rather than just use “Samsung phone”. Many people just say this is a Samsung phone and you don’t know them. What I did was even for those who don’t want to turn on the video, I will ask them, call their names and ask the questions...Actually, on Zoom you can split the class into different groups and then have their group discussion on certain subjects and then ask them to present what they are thinking of after the breakout session.” (P08) “Actually, I think you can have nuggets of a few minutes of intensive exercise. [For] online [ones,] you just give a link or just where they can access online and they can do it by themselves. They just follow the video and then do it. Sometimes I think it doesn’t even have to be a group session, it could be an individual session that they can do at their own time when they are free. Because sometimes if it’s a group session, I think you have to meet the timing, and you have to cancel some other activities. So that one is also a problem. So I think with nuggets of information online where they can easily access, they can do it on their own. It will also be good. So now and then you have a group session, give them some motivation, give them some tips, and then in other times they can pick it up in their own time.” (P10) “And as for the recording, that’s the good thing about technology, you can put up the pre-recorded sessions on YouTube, etc. If people cannot register, then they can watch it online and replay the video. If they wish to have more interactions, then they can join the live Zoom or live physical classes. So it gives a lot of flexibility to people to learn.” (P18)

Health education design – learning theories	Research on the application of learning theories in health education for the older population	“You are actually dealing with adult learning.” (P21) “I think this is as much as you can do, but maybe if you have a longer timeframe, instead of showing the information, you can ask them in questions and let the participants find out the information from the resources that you have given them, then they are more involved. I went to the museum and they gave me some questions to find out in [about] the exhibits, I think that was really helpful. It makes it more exciting also for the participants. At the end of the session [they can] come up with something.” (P22)
Human – older learners	Personalised health information	“For example, I know my exercise, I go there and will do [the] treadmill, there are a few equipment[s] that I will go as a routine, or I call it a programme. And how this programme actually developed is not from me because I attended a therapeutic gym before, and based on my condition they came up with this programme for me, and surprisingly, every patient has their own programme depending on their condition. So it may not be the same one, because some exercise may not be good for you but maybe very good for me, so if I try to be smart and say hey this is very good because it’s very good one me, but I’m not a professional. Exercise, is actually better to be personalised, because for example for [in] my case, I was told by my therapist that “Uncle you don’t bend too far down forward because of your spine condition, but you can bend backwards, and your knees can do only this exercise, you cannot do that exercise because it will hurt your knee.” Then I said “wow hurt my knee then I don’t need to exercise”, [then he said] “oh don’t worry, actually there is another exercise which is helpful for your spine but without hurting your knee.” These are the things that will be lacking here, [which are] what I’m going to do next and do it correct. My therapist said “uncle, you can do 100 times, but no use one, you make your situation worse because what you do is the wrong thing...I go to the SG Active gyms, but there are no therapists, only people in charge, they don’t care what you are doing.” (P21) “With the Internet, I think we have a lot of information coming in. I mean whenever I need any information, I just google. But I think the difference now is to distinguish between what is the right

		kind of information, whether they are reliable or not. [P21: you are right, you are right. I'm just about coming to that. Nowadays there is a lot of misinformation. It can be a topic itself you know?] And some information is not wrong, but does not apply to me as well, because I need to know myself in order to assess if the information is suitable for me, even though it's right in general. That is also another level. So it's actually not the case of not enough information, it's a case of too much information." (P22)
Technology	Technologies to facilitate older adults' self-learning	"I think maybe you can come up with something like AI-type interaction like ChatGPT where people can talk about all their problems then the other side maybe is the doctor or maybe some AI thing. Because some people are afraid of sharing, so something like AI may be helpful.[moderator: the information shared by AI may not be true or may not be suitable in the Singapore context]. Yeah, that's right. It should be a restricted one, maybe not the general one open to everybody, maybe only a certain area, it's specific to maybe dementia health education. [Do you mean that we design another mini version of ChatGPT or kind of chatbot] Yeah that will be good." (P29)
	Older adults' ownership of digital devices	"The only concern is that people need to have a device to access tele-education, but I don't know what the proportion of people who don't have a mobile phone or laptop.] [P21: And also whether they know how to use, and whether they are willing to learn how to use is another issue. It's a reach-out, and need to see the percentage, and think about how to reach out to these people. But you can make use of the social service centre, [and] the family centres where they can help you group these seniors to get a venue or the facilities there. They can also help you filter out the audience, so they can help your group and you know how to conduct tele-education." (P22)
Health system & policy environment	More digital learning opportunities	"We all have to learn actually and gradually we have to go to [in] that direction, using online platforms, see now it's a digital world. So although you say Kahoot, maybe some are not familiar, but people have to learn, have to make efforts to learn." (P03) "I can tell you those who are over [the] 70s did not have a chance to go for English education, some of them do not have smartphones, or even if they have smartphones they are very scared to use a smartphone because they are afraid they'll get [a] scam. Because now everybody is telling them [to]

		be careful, be careful, don't click here click there, because scammers [are] around, so the seniors are very scared to use online gadgets." (P10) "We live in Singapore, so we have to learn, right now it's Zoom, I also struggle with Zoom during the Covid because I went to sign up [for] a course and it was all on Zoom, and it was like three times a day. So now I also learn more about Zoom, where to find the buttons, etc. This is how we get along in life. You have to move with the flow." (P35)
	Regular health promotion events during special occasions	"It would be good during this period [to have the health education], because most of the working people will be so drawn in their working life, the awareness of their parents and relatives developing such signals will not come to an awareness until things happen, then it may be too late. So if the government could systematically educate people through [about] all these different diseases, this kind of activities will help to remind people every year like Valentine's Day. Every year you have a promotion that talks on this topic will help to bring about awareness and bring people to learn more about these signals." (P17)
	Motivating the inactive older population	"I think for more senior people, we need them to be more digitally inclined. [P21: Those are the pioneer generation. Normally those people are very active, you should look for those who are not so active and see how to get these people out of their comfort zone. It is the most difficult. For people like us, we are very active, we already know what to do to take care of ourselves. You can start with working with some platforms]" (P21 & 22)