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DIGITALIZATION FOR IMPROVING ELDER CARE

Edited by Subhasis Bera, Dil B. Rahut, Shu Tian, Yixin Yao, and Donghyun Park

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(i) In this publication, "$" refers to United States dollars, and "CNY" refers to yuan.

(ii) ADB recognizes "China" as the People's Republic of China; "Hong Kong" as Hong Kong, China; "Korea" and "South Korea" as the Republic of Korea; "Kyrgyzstan" as the Kyrgyz Republic; "Vietnam" as Viet Nam; "Bangalore" as Bengaluru; and "Bombay" as Mumbai.

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Abbreviations

AI	artificial intelligence
ATE	average treatment effect
PRC	People's Republic of China
COVID-19	coronavirus disease
GAI	generative artificial intelligence
GDP	gross domestic product
HA Go	Hospital Authority app
HIS	health information system
ICT	information and communications technology
IoMT	internet of medical things
IoT	internet of things
IIM	Indian Institute of Management
IPW	inverse probability weight
IPWRA	inverse probability weighted regression adjustment
ITU	International Telecommunication Union
MOH	Ministry of Health
NGO	nongovernment organization
PC	principal component
PCA	principal component analysis
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSM	propensity score matching
RRS	Rural Revitalization Survey
SAR	socially assistive robot
SEM	structural equation modeling
SHP	SingHealth polyclinic
SHVC	smart health video consultation
TMARS	Telemedicine Allocation and Reconciliation System
TNCS	Telephone Nursing Consultation Service
UNCTAD	United Nations Conference on Trade and Development
US	United States
UTAUT	Extended Unified Theory of Acceptance and Use of Technology
VAT	voice-assisted technology

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Foreword

Digital technologies have unleashed transformative potential in healthcare, reshaping how care is delivered to diverse populations. Among the most compelling areas of innovation is the integration of digital solutions in the care of older people—a domain pivotal to addressing the challenges posed by aging societies worldwide. *Digitalization for Improving Elder Care* is a timely and thought-provoking examination of how digital tools can enhance the well-being and quality of life of older populations, while considerately addressing the barriers to their effective implementation.

The book opens by identifying critical research gaps in the adoption of digital healthcare, examining structural challenges such as digital literacy, economic constraints, and infrastructure limitations. It underscores how these barriers disproportionately affect older populations, particularly in developing economies where access to resources and digital infrastructure remains constrained. Through a comprehensive analysis, the authors illuminate the intricate interplay between demographic transitions, socioeconomic disparities, and the adoption of digital solutions, providing a nuanced perspective on these complex issues.

Exploring innovations ranging from voice-assisted technology to telemedicine, the authors delve into the promise and limitations of emerging digital tools in the care of older people. Regional case studies from Hong Kong, China; India; Singapore; and Sri Lanka offer invaluable insights into how cultural, economic, and technological factors shape the adoption and sustainability of these solutions. Chapters on generative artificial intelligence and smartphone use highlight not only technological opportunities but also the psychological and social implications for older adults, underscoring the necessity of balanced and inclusive strategies.

The book advocates a multi-stakeholder approach to fostering digital inclusion, calling on governments, private enterprises, and civil society to prioritize infrastructure development, digital literacy, and equitable access to technology. As policymakers and practitioners confront the complexities of aging populations, *Digitalization for Improving Elder Care* emerges as an essential resource, shedding light on pathways to more inclusive, sustainable, and compassionate healthcare systems.

Tshilidzi Marwala
Rector of the United Nations University
Under-Secretary-General of the United Nations

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Reimagining Elder Care: Unlocking the Potential of Digitalization in Meeting the Needs

Subhasis Bera, Jie Mi, Dil B. Rahut, Shu Tian, Yixin Yao, and Donghyun Park

1.1 Introduction

Digitalization in elder care in Asian economies represents a complex, multifaceted approach to addressing demographic challenges and healthcare transformations. Technological innovations such as telehealth platforms, artificial intelligence (AI)-powered health monitoring systems, and remote care technologies are increasingly being integrated into national healthcare strategies, focusing on improving the quality of life of older people while addressing infrastructure limitations. However, implementation remains uneven, influenced by factors including digital literacy, socioeconomic disparities, technological infrastructure, and cultural attitudes towards technological intervention in healthcare. The strategic deployment of digital technologies necessitates comprehensive policy frameworks that balance technological innovation, privacy protection, and culturally sensitive care delivery, recognizing the unique demographic and socio-economic contexts of different Asian economies. This book first aims to identify the existing gap in the research on elder care and thereafter focuses on leveraging digitalization for elder care.

Rapid innovation and faster economic development coupled with healthcare technology development enhance human health, leading to population aging in this 21st century (He et al. 2018). This change in demographic composition posits a significant challenge to an economy due to its impacts on the labor force, productivity, healthcare costs, and social support systems. As the proportion of older individuals increases, the working-age population shrinks, leading to potential labor shortages, reduced economic output and slowing economic growth. This demographic shift eventually strains productivity and economic dynamism (Bloom, Canning, and Günther 2010).

According to the United Nations (UN), people aged 65 and above are currently the most rapidly expanding age demographic group globally. The projected share of the older population is 12% in 2030 and 16% in 2050 (WHO 2023), surpassing the share of the youth. The Asia and Pacific region is home to over half of the world's older population, projected to surpass 4.9 billion by 2030 and has the largest older population (Jayawardhana et al. 2023). This swift aging trend is common across Asian nations, and the rise of the share of the older population is faster than in developed economies. Among the economies in Asia and the Pacific, Japan has the highest share of the older population. In the People's Republic of China (PRC), the share of older individuals is projected to rise from 7% to 21% within 40 years. The Republic of Korea is expected to achieve this transition in 35 years, while Viet Nam is projected to achieve it in 40 years (ADB 2019).

This rapid aging process profoundly impacts social and economic structures. While aging represents progress in medicine, society, and the economy that has extended human life expectancy, it also brings significant challenges. In many Asian economies, this demographic shift coincides with labor market changes, technological advancements, and a backdrop of inadequate social protection policies, which currently do not cover a large proportion of older adults (World Bank 2015; Mason, Lee, and NTA Network 2022). Long-standing customs of elder care, traditionally reliant on familial support, are strained by shrinking family sizes, urbanization, and evolving social norms (Ofori-Dua 2014). The rise of nuclear families and geographic dispersion has amplified the demand for comprehensive and accessible care services (Auping, Pruyt, and Kwakkel 2015). Additionally, the growing prevalence of chronic conditions and the need for long-term care contribute to escalating costs and complexities, placing significant pressure on existing care systems. Especially after the pandemic, there is a need for reviving the human body, mind, and spirit as a first step toward rebuilding the economy and society. While the older population generates a greater demand for wellness, digital technology can promote traditional Asian wellness by reducing isolation and keeping them mentally and physically fit (Park et al. 2021).

These challenges highlight the critical need to explore alternative approaches that can enhance the quality of care while ensuring sustainability. A plethora of studies focus on the aging population, especially various aspects of elder care, and the likelihood of implementing possible solutions. Many of these studies consider digitalization as an effective and possible solution for enhancing elder care. Integrating digital technologies into healthcare delivery can make it possible to improve access, efficiency, and quality of care for the older population (Meristö and Laitinen 2020). Digital technologies, such as telemedicine, remote monitoring, AI, wearable devices, and smart homes, promise to enable personalized and proactive care. Digital technologies also empower older individuals to manage their health through communication between caregivers and healthcare providers (Siegel and Dorner 2017). However, despite the potential of digitalization in elder care, implementing these technologies faces significant challenges. Barriers such as paucity of digital literacy, accessibility challenges, higher costs, and resistance to new technologies significantly impede the adoption of digital solutions.

Moreover, unequal access to digital technologies, popularly known as the digital divide, stimulates various forms of social and economic inequality. Peine et al. (2015) documented that treating older adults merely as passive recipients rather than active participants can exacerbate the economic losses, as companies fail to capitalize on the opportunities within the "silver market," and government subsidies for gerontechnological innovations become less effective. Given these dynamics, leveraging digital technologies is essential to create more efficient and accessible care systems for the overall well-being of the older population. Although a vast amount of literature deals with care and digitalization, it is crucial to understand the literature gap to narrow the search for a solution to implement digitalization for effective care of older adults.

1.2 Digitalization for Improving Elder Care: An Analytical Literature Review

In the context of our research on "Digitalization for Improving Elder Care," we conducted a systematic literature review using Scopus, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines because of its transparency, reproducibility, and comprehensiveness in systematic reviews.

The study designs the inclusion criteria for the systematic literature review meticulously to capture the intersection of digitalization and elder care, focusing on key areas such as digital technologies, AI, information systems, and their applications in enhancing the well-being of older populations. The search query was structured as follows:

Table 1.1: Inclusion Criteria of Systematic Literature Review

Inclusion Criteria	Details
Digitalization	Digitalization, Artificial Intelligence, Digitalization, Digital Technologies, E-learning, Information Systems, Digital Technology, Information Technology
Elder Care	Care, Older Adults, Aging Population, Senior Citizens, Gerontechnology, Well-being, Health, Social Engagement, Accessibility
Policy	Policy Frameworks, Government Initiatives, Multilateral Collaborations, Digital Infrastructure, Economic Impact, Silver Market, Gerontechnological Innovations

Source: Authors.

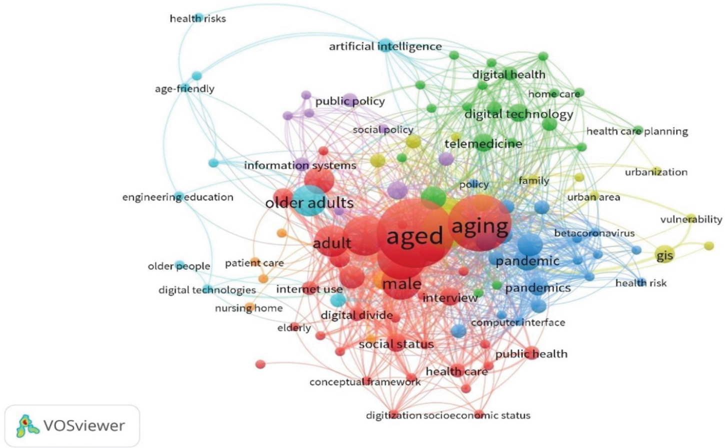
This comprehensive search strategy yielded 46 relevant articles aligned with the research objectives and contributed significantly to the existing knowledge on this topic.

By adhering to the PRISMA methodology, this study ensures that the review process is systematic, transparent, and replicable to enhance the credibility and reliability of the findings. One of the advantages of the PRISMA methodology is that it also supports the development of evidence-based policies and practices along with the alignment of academic research.

Over the period 2016–2024, the temporal trend as shown in Figure 1.1 reveals that the focal point of research moved from "health risks," "social status," and "nursing home" to "digital health," "digital technology," and "telemedicine," indicating the importance of the role of digital technologies in healthcare. While "artificial intelligence," "digital divide," and "telemedicine" are emerging topics, the digital divide and internet use also appear as newer, prominent topics, highlighting an awareness of the challenges faced by older adults in accessing and using digital technologies. Therefore, as aging populations grow, research is likely to continue expanding in digital health, AI, and the socioeconomic challenges the older population faces, as indicated by the emerging green-yellow keywords.

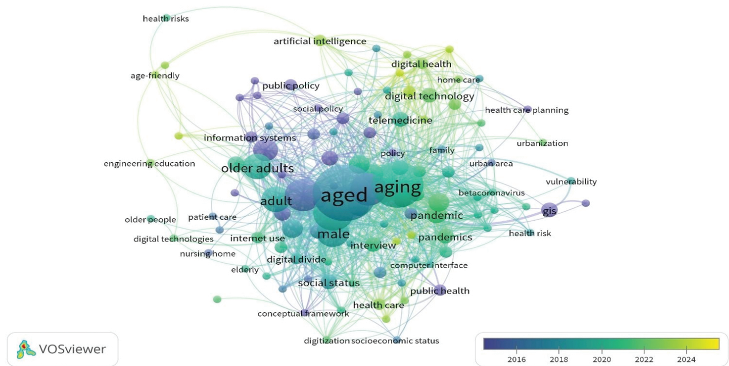
The cluster analysis indicates seven clusters in the bibliometric analysis, as depicted in Figure 1.2. These are (i) socioeconomic impact, (ii) digital health and care systems, (iii) health policy in crisis, (iv) well-being of urban older adults, (v) policy frameworks and information systems, (vi) older people and ICT, and (vii) health service and policy.

Figure 1.1: Cluster Analysis



Source: Authors.

Figure 1.2: Timeline Clusters



Source: Authors.

i) Socioeconomic impact

The cluster analysis in Table 1.2 reveals that "social interaction" has the highest average citation count (114), highlighting a strong research focus on the role of digital technologies in enhancing social connectivity among the older population. The term "middle-aged," with an average citation score of 58, also draws significant attention, indicating its role as an intermediary demographic in studies on elder care. This emphasis on social factors suggests that socioeconomic impacts are central to discussions on digitalization in elder care.

High average citations for terms like "self-care" and "subjective well-being," along with notable link strengths (110 and 31) and occurrences (9 and 3, respectively), underscore significant research interest in understanding the benefits of digitalization on individual well-being among the older population. Additionally, this cluster highlights "internet access" and "usage among older adults" as essential components for effective digital care. However, the "digital divide" emerges as a critical issue, with a link strength of 44 and three occurrences, underscoring the barriers to equitable access to digital technologies. Furthermore, the moderate link strengths (38 and 42) and occurrences (2 and 3) emphasize the role of digital tools in managing health and disabilities.

The findings illustrate that leveraging digitalization in elder care requires a comprehensive approach that addresses health, socioeconomic dimensions, and accessibility. High-impact areas such as social interaction and self-care are essential for enhancing quality of life, suggesting that targeted digital interventions can play a transformative role in well-being and autonomy.

Table 1.2: Cluster Analysis Score

Labels	Cluster	Weight (Links)	Weight (Total link strength)	Weight (Occurrences)	Score (Avg. citations)
adult	1	54	82	7	16
aged		95	208	16	33
aging		16	16	2	9
aging		89	169	13	45
caregiver		12	15	2	28
conceptual framework		14	14	2	16
controlled study		22	31	4	15
digital divide		35	44	3	24

continued on next page

Table 1.2 *continued*

Labels	Cluster	Weight (Links)	Weight (Total link strength)	Weight (Occurrences)	Score (Avg. citations)
digitization	1	15	15	2	45
disability		37	38	2	10
e-government		22	22	2	28
education		28	32	2	15
elderly		13	13	2	9
female		73	130	10	16
health care		30	42	3	6
information technology		48	65	6	25
internet		67	110	9	47
internet use		26	31	3	20
interview		43	57	4	20
major clinical study		42	63	5	29
male		64	111	8	19
middle aged		59	87	5	58
priority journal		36	52	4	36
public health		31	35	3	7
qualitative analysis		28	32	2	6
qualitative research		24	29	2	3
questionnaire		23	30	2	18
self-care		28	30	2	19
social interaction		37	40	2	114
social status		44	65	4	25
socio-economic status		16	16	2	13
socioeconomics		31	35	2	13
standards		21	22	2	9
subjective well-being		4	4	2	41
chronic disease	2	18	20	2	20
content analysis		21	22	2	2
delivery of health care		23	25	2	0
digital health		22	25	3	4
digital technology		22	25	4	21
health care delivery		56	77	5	25

continued on next page

Table 1.2 *continued*

Labels	Cluster	Weight (Links)	Weight (Total link strength)	Weight (Occurrences)	Score (Avg. citations)
health care personnel	2	31	37	3	4
health care planning		12	12	2	7
health care system		23	24	2	6
health information technology		24	24	2	18
home care		20	21	2	8
information processing		20	23	2	36
medical information system		27	31	2	1
neighborhood		8	8	2	13
perception		12	12	2	5
physical activity		18	18	2	10
review		22	25	2	6
semi structured interview		27	31	2	1
technology		27	30	2	107
telehealth		38	43	3	71
telemedicine		48	57	4	73
betacoronavirus	3	33	41	2	152
communication		58	74	4	37
computer interface		37	39	2	56
computers		33	41	2	152
coronavirus infection		33	41	2	152
covid-19		58	82	5	64
digitalization		38	42	3	49
elderly care		43	48	3	34
elderly population		42	47	3	56
health policy		40	42	3	59
health risk		25	25	2	63
interpersonal communication		58	74	4	37
pandemic		58	82	5	64
pandemics		51	70	4	77
pneumonia, viral		33	41	2	152
policy		34	34	2	50
policy approach		25	26	2	60

continued on next page

Table 1.2 *continued*

Labels	Cluster	Weight (Links)	Weight (Total link strength)	Weight (Occurrences)	Score (Avg. citations)
psychology	3	37	39	2	56
respiratory disease	3	33	41	2	152
user-computer interface	3	48	52	3	37
accessibility	4	29	32	3	33
aged, 80 and over	4	51	71	4	68
aging population	4	65	94	9	39
family	4	31	37	2	109
geographic information system	4	20	22	2	17
GIS	4	13	17	4	20
mobility	4	17	17	2	14
quality of life	4	26	31	3	33
spatial analysis	4	7	8	2	20
urban area	4	20	21	2	20
urbanization	4	7	7	2	14
very elderly	4	55	80	5	54
vulnerability	4	9	11	2	29
access to information	5	30	33	2	12
aging policy	5	14	17	2	3
government	5	46	55	3	20
information system	5	34	38	3	73
information systems	5	31	34	3	25
information technology policy	5	14	17	2	3
organization and management	5	47	56	4	72
public policy	5	17	17	3	31
social policy	5	28	30	2	7
state government	5	14	17	2	3
age-friendly	6	8	9	2	5
artificial intelligence	6	17	17	3	4
digital technologies	6	6	7	2	0
engineering education	6	10	10	2	0

continued on next page

Table 1.2 *continued*

Labels	Cluster	Weight (Links)	Weight (Total link strength)	Weight (Occurrences)	Score (Avg. citations)
health risks	6	3	3	2	6
information and communication technology		38	45	3	18
latent class analysis		12	13	2	2
older adults		36	43	7	15
older people		4	4	2	10
rural community		8	9	2	5
health care policy	7	26	28	2	37
health service		44	51	4	25
health services needs and demand		19	20	2	72
long term care		17	18	2	36
nursing home		9	9	2	36
patient care		17	18	2	36

Source: Authors.

ii) Digital health and care system

Cluster analysis highlights digital health and care systems as a key research area, with a significant focus on terms like "telemedicine," "telehealth," and "technology," each showing high average citation scores (73, 71, and 107, respectively). This interest reflects a growing focus on remote healthcare services, underscoring the challenges of delivering healthcare in rural and remote areas. Addressing these challenges requires innovative digital technologies to enhance healthcare delivery in underserved regions, where issues like "healthcare delivery" and "accessibility" are central concerns.

Effective healthcare provision in remote areas depends on robust "medical information systems" and "health information technology," as evidenced by moderate link strengths (31 and 24), emphasizing the role of information systems in health data management. Such health data are essential for tailoring digital tools to manage chronic conditions and support physical activity among older people. Additionally, digital technologies enable "home-based care," offering practical solutions for maintaining healthcare quality and accessibility in remote settings.

This cluster analysis reveals that digital health and care systems require an integrated approach, combining technology, remote service delivery, and health information systems to meet diverse healthcare needs. High-impact areas like telemedicine and health information technology are critical to advancing healthcare delivery, emphasizing the value of digital tools in modern, accessible healthcare solutions that support the well-being of older populations.

iii) Health policy in crisis

The exploration of remote healthcare facilities underscores the potential for digital technologies to address the unique challenges posed by pandemics. This cluster analysis reveals that effective communication and adaptive health policy in the context of COVID-19 require a multifaceted approach that integrates health risk management, digitalization, and strategic policy decisions. High-impact topics such as pandemic response and specific health risks are central to understanding the broader implications of global health crises.

The terms "betacoronavirus", "coronavirus infection", "viral pneumonia", and "respiratory disease" each have high average citation scores (152), reflecting substantial research interest in both the health risks and the technological dimensions of coronavirus disease (COVID-19) management. This approach highlights the critical role of clear communication, targeted policies, and digital tools, such as telehealth and data-driven health platforms, in managing and mitigating the impacts of health crises. Such comprehensive strategies are essential for enhancing pandemic resilience and ensuring healthcare systems are better prepared for future outbreaks.

iv) Well-being of older urban adults

The effectiveness of digital healthcare systems relies on the digital literacy of recipients, a skill often lacking in rural areas due to limited access to digital technologies. As a result, research on well-being tends to focus on "well-being of older urban adults," where access to digital resources is higher than its counterpart. Cluster analysis of this research highlights key themes associated with aging populations, including family dynamics, quality of life, accessibility, and mobility, along with using technological tools like GIS for spatial analysis to address urban mobility and vulnerability issues.

High-impact areas, particularly those related to family dynamics, show elevated citation averages, suggesting these themes are relevant for policy development. Furthermore, the prevalence of nuclear family structures in urban settings, which often lack sufficient family support for older members, underscores the need for service providers and digital technologies to deliver essential services and support daily needs. This research points to the critical role that digital solutions and policy innovations play in enhancing the well-being and independence of older individuals in urban contexts.

v) Policy frameworks and information systems

A robust and efficient healthcare system requires gathering, storing and analyzing data and information. An information system is an integrated set of components for collecting, storing, and processing data and providing information, knowledge, and digital products. Therefore, for policy formation and providing healthcare to the older population, healthcare "information system management" is an essential component. This cluster highlights the importance of information systems with a high average citation score (i.e., 73), incorporating technology, social, and public policies. While the varying weights and occurrences reflect the depth of the discussion and focus areas, high average citations on "organization and management" suggest significant influence or interest within academic or practical applications.

vi) Older People and ICT

This cluster focuses on the influence of information and communication technology (ICT) on older adults, encompassing themes related to health risks, well-being, and digital adaptation. As cognitive flexibility and technology adoption rates tend to decrease with age, integrating digital technology into healthcare and support systems presents distinct challenges. Consequently, the design of these technologies demands age-friendly and intuitive approaches, particularly for rural populations with limited digital exposure.

Emerging themes such as robotics, AI and advanced digital tools highlight the growing interest in leveraging innovative technologies to enhance elder care. One of the biggest challenges in using digitalization for care is to connect the digital world with the physical world. Robotics and AI can potentially connect these two worlds to monitor and access real-time data. While some economies, such as Japan, are increasingly using robotics, the adoption of robotics in developing economies remains a challenge due to its high cost, paucity of integrated infrastructure and demand for personal touch. The differing emphasis within the cluster reflects varying levels of weights in these areas, with high citation scores for "older people" indicating significant academic and practical interest in understanding the needs and experiences of this demographic. This focus underscores the importance of targeted, accessible technological solutions to support aging populations' well-being and healthcare needs.

vii) Health services and policy

Health services and policy encompass the organized efforts to enhance the delivery, quality, and accessibility of healthcare within a population. Provision for offering health services depends on the demand. However, demand is also conditional on the "healthcare policy". Demand for healthcare again is classified as "short-term care" and "long-term care". Depending on the types of demand, service providers offer "patient care" at home or care at the "nursing home". This cluster highlights the gap between healthcare practice and public policy and seeks a solution to build a sustainable and effective health system that responds to societal needs.

1.3 Digital Healthcare Transformation: Strategic Challenges and Measurable Impacts

Considering the cluster and research gap, this book focuses on innovative digital solutions to address issues pertaining to elder care in the context of the demographic transformation of Asia and the Pacific. This book analyzes the pertinent issues in three parts. Part I deals with understanding the care landscape of older people in the digital era, while Part II pertains to regional insights into digital healthcare for older adults. Part III focuses on Bangladesh; the PRC; Hong Kong, China; India; Singapore; and Sri Lanka to comprehend the various aspects of elder care and solutions through digitalization.

Although digital technologies have the potential to provide solutions for elder care, they are not free from challenges when implemented, especially in developing economies. After understanding the thematic analysis for finding the research gap in the introduction chapter, Chapter 2 by Talukder, Islam, and Zahin deals with the barriers to digital healthcare adoption among older populations. Chapter 3 pertains to the demographic transition of the older population. By analyzing the role of digital technologies, the study by Tiwari underscores disparities in digital infrastructure and economic development, exacerbating existing divides in technology adoption and accessibility among older populations. The study further examines demographic trends, revealing contrasting outcomes. Economies with advanced healthcare and social support systems experience lower suicide rates among older adults, while low-income economies experience higher suicide mortality rates due to resource constraints and lack of mental health support. A study by Guite in Chapter 4, delves into the potential of voice-assisted technology in transforming elder care, focusing on personalized and accessible healthcare services. The study suggested in the era of digital technology, through concerted efforts and strategic investments in voice-assisted technology, healthcare systems can effectively meet the challenges posed by the aging demographic and ensure equitable access to quality healthcare for older people.

Although Part II deals with regional insights into digital healthcare for older people, the focus remains on telemedicine, smart healthcare, and digital transformation in providing care in different economy-specific frameworks. Employing a case study approach for Singapore and Hong Kong, China, Luk and Lishan in Chapter 5 analyze the benefits and barriers to using telemedicine and critical factors for future use and growth of telemedicine. While telemedicine reduces the risk of infection and transmission, the lack of digital literacy, the perceived lack of human touch, the lack of financial means and unstable internet connectivity at home were key barriers to the use of telemedicine in older patients in both economies. The study suggests that infrastructure, legislation, digital literacy training, and social influence are critical for the use, growth, and sustainability of telemedicine in the long run.

Rapid innovation in digital technology has enhanced the connectivity among the various devices and consequently created a platform for smart care. Comparing the challenges of adopting digital technologies for elder care in developing economies, in Chapter 6, Yao, Chen, and Bera highlight the potential of smart care and identify the challenges in providing smart care facilities for older people in the PRC. Despite the potential, the study identifies insufficient platform promotion and funding supply issues and a lack of a unified standard to build a smart care platform as the major hindrances to implementing smart care. To address these issues, the study emphasizes enhancing international cooperation and knowledge sharing in smart technologies for elder care and exploring diverse investment and financing methods to support smart platforms.

Despite rapid innovation and user-friendly design, digital literacy is the prerequisite for adopting digital technologies as healthcare tools. A study by Padmakanthi and Mi in Chapter 7 analyzes the potential of digital technologies for elder care in rural Sri Lanka and finds that older individuals tend to exhibit lower digital literacy. Subsequent analysis indicates that the availability of resources and affordability are critical for enhancing the digital literacy level of rural older residents in Sri Lanka. Therefore, there is a need for digital literacy programs to train users and promote digital healthcare.

Part III consists of three chapters dealing with the impact of technology on well-being and elder care. Shareef, Mahmud, Raj, Attar, and Huda discuss the global trends and opportunities of healthcare driven by generative artificial intelligence (GAI) and analyze the behavioral attitude of older people of Bangladesh in Chapter 8.

Since healthcare technology integration into the healthcare system suffers from cost issues, coordination among the stakeholders and training, are increasing attempts to provide healthcare through smartphones. Li and Ma capture objective well-being and subjective well-being using multiple indicators in Chapter 9. They find that in the PRC, older rural residents' smartphone use significantly improves their objective well-being outcomes regarding commercial medical insurance ownership, organic food consumption status, and daily milk consumption. However, smartphone use is detrimental to older rural residents' subjective well-being outcomes, manifesting as life satisfaction and happiness. The impact of smartphone use on achieving subjective and objective well-being varies based on gender and living arrangements, indicating a need for targeted strategies or policies to promote digital healthcare for the older population.

Considering gender as a crucial factor, Bera and Paul analyze the determinants of technology adoption by older women in India in Chapter 10. This empirical study reveals that perceived performance expectancy of digital technology varies across genders, with social influence amplifying its effect among older adults. Moreover, effort expectancy or perceived ease of use significantly impacts the adoption of digital technology, and cultural norms shape gender-specific perceptions. These outcomes also suggest targeted intervention to enhance healthcare for older populations.

1.4 Conclusion

The rapid development of digital and healthcare technologies challenges the traditional healthcare system because of its reach and widespread capability. However, despite the potential, digital technology adoption in assisting in elder care and providing healthcare faces various challenges, especially in developing economies. While a few economies have exhibited improved adoption of digital healthcare technologies by providing infrastructure and formulating regulations, this book identifies a shortage of digital literacy, perceived expectations, and issues related to ease of use as major hindrances. Although there is a difference between assisting in elder care and providing healthcare, challenges in adopting digital technology remain similar. Since these challenges are subjective and vary across regions and economies, there is a need for targeted strategies for elder care for both subjective and objective well-being.

Through case studies from diverse Asian contexts, this book provides insight into the effectiveness of digital health interventions, examining both the opportunities and obstacles that stem from assisting with healthcare for the older population. Although there is unanimity that digitalization has the potential to enhance elder care, considering various economy-specific studies, this book highlights that there is a need to consider both subjective and objective well-being while implementing digitalization. Therefore, there is a need for targeted intervention to enhance the care and healthcare of older populations.

This book underscores the importance of involving older individuals as active participants in a digital economy rather than passive recipients, a step essential to bridging the digital divide. With practical recommendations for policymakers and practitioners, this book is a significant resource for advancing efficient, dignified, and high-quality care for older populations in the digital age.

These discussions highlight the need for inclusive policy frameworks and targeted strategies to ensure digitalization fosters equitable access to healthcare services rather than amplifying existing inequalities.

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PART I

Understanding the Care Landscape of Older People in the Digital Era

2

Barriers to Digital Healthcare Adoption Among Older Populations: A Comprehensive Review of Challenges and Policy Solutions

Md. Shamim Talukder, Quazi Tafsirul Islam, and Afrin Zahin

2.1 Introduction

The demographic landscape of the world is rapidly changing; the increasing share of older people within populations around the globe is advancing quickly. The enormous increase in life expectancy is responsible for this demographic transition, an indicator attributed to advances in medicine and better living conditions (Lawrence, Hancock, and Kisely 2013). Furthermore, this transition is a characteristic of not only industrialized economies but also an international process that involves both the wealthiest and the poorest states, while showing equally noticeable implications about various areas of public life, including healthcare, economics, and the labor force (Bloom and Luca 2016). There is also a changing demographic shift, reflected by an increase in long-term illnesses, thus greater demand for health services and social care can be expected, as well as overall differences in the structure of the workforce and economy (Bloom, Canning, and Lubet 2015). Further, the process of feminization of aging, which states the rising number of women in the older population, presents distinct difficulties, such as elevated poverty rates among older adults and a greater need for specialized technology-supported healthcare services (Davidson, Digiacomo, and McGrath 2011).

In the digital era, different aspects of people's lives have undergone major transformations, one of which is healthcare. Digital health technologies can include a wide array of tools, such as those mentioned above, like telemedicine and wearable health monitors, but may also relate synergetic tools integrated with machine learning, assertive technology, artificial intelligence-driven personal or public analytics on one's health data collected from fit bits to intelligent home systems. Such innovations could revolutionize elder care in that remote health monitoring could be facilitated. It would also ease communication between them and their providers, enabling easier and more timely interventions. For example, in helping to make older people more independent and secure, wearable devices, as well as smart home technology, have assumed a crucial role (Talukder et al. 2021). Wearable devices can monitor and measure critical physiological markers, detect cases of falling, and even predict future health issues through data analysis as well (Marakhimov and Joo 2017).

Telemedicine platforms facilitate in-home consultations between older patients and medical specialists, therefore mitigating the need for frequent hospital visits, which can lead to physical strain and increased travel expenses (Hoque and Sorwar 2017). According to Jarvis, Sartorius, and Chipps (2019), smart houses have sensors that help with daily activities like reminding people to take their medicine or turning on emergency response systems. By enabling relationships with colleagues, family, and friends, digital platforms such as online communities and video conferencing platforms help older people feel less alone (Thangavel, Memedi, and Hedström 2022). They are able to maintain their social networks in spite of their physical separation because of this. According to Lumsden et al. (2016), gamification of cognitive activities might improve their appeal and efficacy as regular mental workouts.

However, several drawbacks should be considered when using technological tools to support older people in their care (Hoque and Sorwar 2017; Talukder et al. 2020a). Some older citizens may have little understanding of electronic gadgets or the use of the internet, and thus, embracing digital health tools can pose a challenge (Bucci et al. 2019). According to a Pew Research Center study, the percentage of use of the internet among older Americans, 65 years or above, stands at 53%, and among them, many face difficulty in using digital tools and interfaces (Zickuhr and Madden 2012). Although the advantages of digital health technologies are a globally well-discussed and well-researched topic, older people still face specific resistance and/or barriers during adoption. Even though these barriers are well-documented in the literature, there is a lack of comprehensive review.

There are several reasons for choosing a systematic literature review over other methods. First, this method helps in a complete synthesis and critical review of existing literature, enabling researchers to identify gaps. Second, management and digital healthcare research is multidisciplinary in nature (Parris and Peachey 2013). Thus, it is necessary to undertake a systematic literature review to better understand the domain without the limitations of being restricted to a set of journals and authors. This study aims to explore the evolving barriers to the adoption of digital health technologies among older people. The scope of this review is threefold: (i) to review the existing literature and identify key barriers, (ii) to examine the training and educational needs required to overcome these barriers, and (iii) to synthesize the policy and regulatory frameworks that support the widespread adoption of digital health technologies among older populations.

2.2 Methodology

This study adopted a systematic literature review approach to explore the adoption of digital health technologies among older adults. The study aims to synthesize the barriers, training needs, and policy frameworks that impact the widespread adoption of these technologies. The systematic literature review method offers several advantages over traditional approaches, as it enables a systematic, transparent, and reproducible synthesis of the literature (Tranfield, Denyer, and Smart 2003). Previous research has supported using systematic reviews to minimize bias, reduce chance effects, and enhance data analysis's reliability (Reim, Parida, and Örtqvist 2015). These are rational motivations for undertaking this study in the current format and add credibility to the study's findings (Reim, Parida, and Örtqvist 2015; Tranfield, Denyer, and Smart 2003). While different authors have proposed various methods for conducting systematic reviews, three main steps are generally shared across all approaches.

2.2.1 Search Strategy

A systematic search was conducted to identify peer-reviewed journal articles published between 2010 and 2024 that focused on digital healthcare technologies for elder care. The search included studies that examined barriers to the adoption of such technologies and the related training and educational needs, as well as policy and regulatory frameworks. The search was performed using the Scopus database, applying the following query: TITLE-ABS-KEY (digital AND healthcare

AND technologies) OR TITLE-ABS-KEY (technologies AND for AND elderly AND care) AND TITLE-ABS-KEY (elderly AND people) OR TITLE-ABS-KEY (senior AND citizens) AND TITLE-ABS-KEY (barriers AND to AND adoption) OR TITLE-ABS-KEY (training AND education AND needs) OR TITLE-ABS-KEY (policy AND regulatory AND frameworks). The query targeted publications from 2010 to 2024, limited to journal articles published in English, to capture a broad range of studies related to the adoption of healthcare technologies by older adults.

2.2.2 Inclusion Criteria

For the study, we used six inclusion criteria: (i) studies must focus on the barriers, training needs, and/or policy frameworks related to the adoption of digital healthcare technologies where the context of the study is on the older population, (ii) studies published between a fixed timeline, between 2010 and 2024 (including those accepted for upcoming publication), (iii) studies published in the English language, (iv) only peer-reviewed journal articles were included, (v) the barriers, training needs, or policy frameworks must be empirically examined, and (vi) the title, abstract, keywords, and occasionally the introduction were also reviewed to ensure that the focus was on the older population's adoption of digital healthcare technologies.

2.2.3 Exclusion Criteria

The exclusion criteria were as follows: (i) non-journal articles, such as conference papers or book chapters, (ii) studies focusing on general healthcare technologies without specific emphasis on elder care, and (iii) articles that were not available in full text or did not directly address the themes of barriers, training, or policy frameworks related to the adoption of digital healthcare technologies by older people.

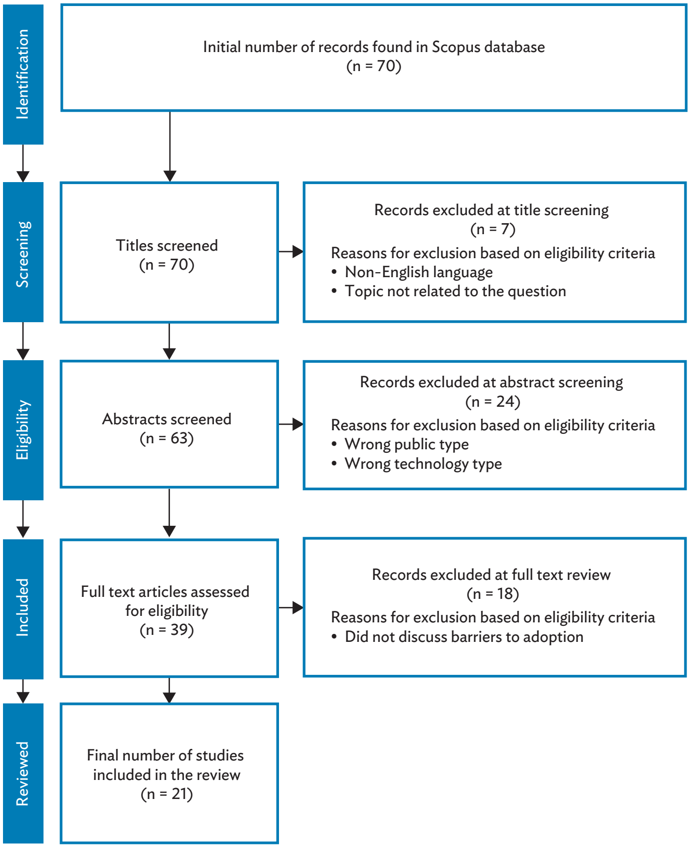
2.2.4 Data Extraction

For each included study, data were extracted using a standardized form, capturing the following information: (i) author(s), year of publication, and journal, (ii) study design and methodology, (iii) target population (older individuals or healthcare providers), (iv) focus of the study (barriers, training needs, or policy frameworks), and (v) key findings related to the barriers and solutions for the adoption of digital healthcare technologies.

2.2.5 Review Protocol and Outcomes

This initial search yielded a total of 70 potential studies. Each of these studies was then assessed based on the inclusion and exclusion criteria outlined for the review. Following this assessment, 39 studies were deemed relevant and included for further analysis. While all 39 studies contributed to the identification of barriers, training needs, and policy frameworks, only 21 studies were found to empirically examine the relationships between these barriers, training interventions, and the adoption of digital healthcare technologies among older people. The article selection process is detailed in Figure 2.1.

Figure 2.1: PRISMA Flow Diagram



PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Source: Authors.

Data Synthesis

The findings were synthesized by identifying common barriers to digital healthcare adoption, including digital literacy gaps, cost concerns, and technophobia. Solutions such as educational programs, policy interventions, and user-friendly interface designs were analyzed. The study also reviewed policy and regulatory frameworks that support the adoption of digital technologies. The synthesized results are presented in supplemented tables to highlight the key findings of the study.

2.3 Barriers to the Adoption of Digital Healthcare Solutions for Older People

Closely studying the synthesized results, we have identified several key barriers that affect digital healthcare adoption among older people. We have identified several benefits to adopting digital solutions into the care of older people. It is important to understand how these factors act as a barrier to adoption among older adults. The primary barriers identified include technological literacy gaps, financial constraints, and concerns about privacy and security.

2.3.1 Technology Anxiety

Technology anxiety denotes the negative evocation characterized by anxiety or distress when thinking about or using technology (Hasan and Ahmed 2010). This anxiety arises when individuals face the possibility of using technology and social cognitive theory roots as noted in Bandura (1986). People who perceive themselves as lacking technological proficiency often experience stress and impaired performance due to their focus on personal shortcomings and fear of failure (Deng, Mo, and Liu 2014). Older adults possess fewer technological skills, and they have lower technological assurance compared to young adults (Czaja et al. 2013). Additionally, their declining physical and cognitive abilities lead to advanced levels of anxiety, thus reducing their use of new technologies (Talukder et al. 2020a). This heightened anxiety may be attributed to factors such as hearing and optical impairments (Almulhem 2023; Frishammar et al. 2023).

Prior research has shown that older users exhibit increased levels of technological anxiety than younger users (Anderberg, Eivazzadeh, and Berglund 2019; Huang 2011; Talukder et al. 2021; Talukder et al. 2020b). For instance, Keidser, Matthews, and Convery (2019) identified that older adults feel uncertain and anxious about using app-controlled hearing aids, primarily due to their lack of self-efficacy and fear of making mistakes. Technology anxiety significantly affects behavioral intentions to use wearable healthcare technologies (Talukder et al. 2021). In Saudia Arabia, the older population avoids using mobile health technology due to fear of making mistakes and poor digital literacy (Almulhem 2023). When it comes to adapting to innovation, older people experience technological anxiety (Hoque and Sorwar 2017; Meng et al. 2022; Talukder et al. 2020a).

2.3.2 Financial Constraints

When it comes to older people, financial barriers are a crucial factor that can affect the adoption of digital technologies (Frishammar et al. 2023; Tangcharoensathien et al. 2018). Devices like hearing aids, telecare systems, or lifestyle monitoring technologies often come with high initial costs, which are prohibitive for many older users (Braspenning et al. 2022). Modifying the devices for their use is expensive because it entails purchasing digital devices, including smartphones, tablets, and wearable health monitors that constantly stream information to them from these under a monitored setup (Bujnowska-Fedak and Pirogowicz 2013; De San Miguel, Smith, and Lewin 2013). Furthermore, additional costs are attributed to the acquisition and procurement of systems, which may include paying for internet services, updating computer software, and maintenance costs associated with the devices (van Deursen and van Dijk 2018). Besides, some health facilities and home care services do not have enough money to continuously use the necessary infrastructure supporting digital health technologies, as Bloom, Canning, and Lubet (2015) indicated. This, in turn, adds more constraints on older adults, who cannot complete such tasks.

Additionally, there is often a lack of or limitation on insurance coverage regarding digital health tools and services, giving older people fewer resources to help pay for the technology. Thus, the inability to receive reimbursement from insurance companies for telehealth services and for digital health devices delivered can be a significant turn-off in terms of incentives perceived by patients or healthcare professionals (Frishammar et al. 2023). Financial constraints not only limit the initial access to these technologies but also restrict long-term engagement and participation in digital healthcare systems (Ho and Merchant 2022). Therefore, the initial cost of purchasing digital healthcare technologies, continuously using those technologies, and supporting materials (i.e., broadband connection) becomes expensive for the majority of older people.

2.3.3 Resistance to Change

The continuity theory states that older people typically continue engaging in the same activities and behaviors they have always practiced (Atchley 1989). Older people often show a preference for healthcare practices and tools they are familiar with rather than embracing new, digital alternatives. Having been born 60 years or more years ago, when digital healthcare technologies were not common in developing economies like India and the People's Republic of China, older individuals received professional healthcare services primarily through face-to-face interactions rather than through information technology channels (Greene et al. 2024). Heart and Kalderon (2013) reported that a lack of interest or the perception that the technology does not significantly improve their quality of life contributed to resistance among older adults to adopting health-related information and communication technology. Despite the availability of innovative technologies in the care of older people, they tend to stay on their previous behaviors and repel-altering medical routines (Talukder et al. 2020b). Since new technologies require lifestyle changes, their reaction to these changes influences their willingness to adopt new technologies (Hoque and Sorwar 2017). Keidser, Matthews, and Convery (2019) noted that older adults feared losing control over their own healthcare decisions when using user-driven and app-controlled technologies like hearing aids, which made them more resistant to adopting these tools. Similarly, Hoque and Sorwar (2017) identified a significant negative effect of resistance to change on the communicative intention of older individuals toward adopting mHealth systems. As the adoption of innovative digital healthcare technologies requires changes in health-related behaviors, older individuals must alter their past habits to adapt to new ways of managing their health. Consequently, their opposition to change reduces their plan to adopt available healthcare technologies.

2.3.4 Privacy and Security Concerns

Privacy and security concerns are also the most concerning issues for older people in using digital health technologies (Wan, Alagar, and Oyikanmi 2017). A focus group discussion identified 70% of older adults in the United States expressed concerns over data protection and security while using digital technology (Wang et al. 2019). Misuse of data and identity are significant concerns among older people when using smart technologies or cloud-based tools (Tao and Shuijing 2016; Elavsky et al. 2024). Another study identified similar results from Japan, the Republic of Korea, and Singapore (Raghavan, Demircioglu, and

Taeihagh 2021). Furthermore, Huang (2011) noted that in the adoption of telecare services, older users were particularly worried about the security of their information, which further deterred their engagement with these systems. There is a high level of skepticism about how personal data can be used and who will get control over their ability to use that (Talukder et al. 2021). These worries are further aggravated by an inadequate understanding of digital safety protocols and the danger of being exposed as a result (Dwivedi et al. 2017).

Personal data security and technology can be a concern because the “reliability and security of this technology remains questionable” (Shareef et al. 2021). Older people may be afraid of what is occurring; the gadget breakdown or jeopardy of software bugs could impact their health monitoring or care (Steele et al. 2009). Research has shown that privacy and security issues significantly impact the adoption and utilization of novel digital healthcare technology. There has also been earlier research on this aspect (Meng et al. 2022; Shareef et al. 2021; Talukder et al. 2021; Wan et al. 2017). For example, Talukder et al. (2021) found that perceived privacy risk significantly negatively influences the intention of older individuals to use wearable healthcare devices in the context of Bangladesh. Consequently, risk perception in terms of privacy and safety appears to be a major limitation to enlisting this group for implementing digital health technologies.

2.3.5 Technological Literacy

One of the biggest obstacles to the older population adopting digital healthcare technologies is their varying levels of technological literacy. Many older adults have limited experience with digital devices and the internet, which makes it challenging for them to navigate digital health tools (Wang and Wu 2022). A Pew Research Center study found that 53% of people over 65 based in the United States use the internet but find it challenging to navigate the interfaces (Zickuhr and Madden 2012). In emerging markets, digital literacy and overall literacy are lower (Talukder et al. 2020a), making it difficult for people to embrace digital solutions (Talukder et al. 2021). In the past, studies also generated similar results in Saudia Arabia (Almulhem 2023). Huang (2011) emphasized the importance of improving users’ ease of use and educating them to aid adoption. Studies also highlighted that people in care facilities had less motivation and social interaction and thus, lower digital literacy compared to those living in the community (Zhu, Al Mahmud, and Liu 2023). Since older adults struggled with registering to use these services, the frustration while using digital tools further worsened their intention to use and adopt.

2.3.6 Lack of Infrastructure and Support

Another major concern for the adoption of digital technology among older people is the institutional void. A lack of infrastructure and support system also meant these older people did not receive the much-needed assistance to adopt. Many lived in rural areas and lacked stable internet tools (Hoque and Sorwar 2017). Even in an urban setting, well-off households were more likely to adopt due to the digital divide and income disparity, as they have access to devices and better connectivity (Yusif, Soar, and Hafeez-Baig 2016). This lack of infrastructure also meant that the service personnel lacked access to training and necessary resources (Kunonga et al. 2021; Kiaušienė and Vaznonienė 2016).

Elavsky et al. (2024) highlighted that caregivers themselves expressed concerns about their own discomfort with using smart technologies, which compounded the lack of support available to older patients. While it is true that initial training and support are essential, the other side of the coin is equally significant. Older users may quickly become tired of using digital tools without proper support and are unlikely to use them again (Marler and Hargittai 2022). Much younger. In fact, according to the Pew Research Center, 29% of older people who own one or more digital devices reported feeling confident using new devices on their own. With their increasing dependence upon technology, you would think they are able to do everything by themselves. However, this assumption falls short, as 70% of them believe they need assistance using new devices (Aaron 2014). Hence, the poor facilitating conditions and supportive resources available for older people may prove detrimental to their ability to adopt digital health innovations.

2.4 Training and Education Needs

As digital technologies become increasingly important in the care of the older population, it is crucial to provide comprehensive training and education for older people. This training will ensure their effective use of technologies, resulting in better health consequences and a better life for the older population (Wilson et al. 2021). A practical training and education program will help older people develop the necessary skills and digital literacy to engage and benefit from digital health programs throughout their lives (Bruder, Blessing, and Wandke 2007). However, for older users to leverage these technologies effectively, they must possess the necessary skills and knowledge to navigate and use them confidently (Wilson et al. 2021). Based on the literature review, we identified a number of well-validated training and educational programs tailored for older individuals to ensure that they can effectively engage with digital healthcare tools, ultimately leading to enhanced independence and better health management.

First, many older people may not be familiar with using modern digital devices such as smartphones, tablets, and computers (Wang and Wu 2022). As a result, training should begin with these basic functions first (e.g., starting and turning off power sources/charging devices, navigational understanding of home screens, touch screens, and keyboard use) (Zhou, Rau, and Salvendy 2014). Zhu, Mahmud, and Liu (2023) noted that the ability of older adults' to use digital tools is closely linked to their motivation and access to training opportunities. It is also important that the sessions be accompanied by clear instructions during hands-on practice so that confidence and competence can be built in these basic operations (Czaja et al. 2013). Moreover, an important part of digital literacy is knowing how the internet can be accessed and how many different applications can be run using it (Almulhem 2023). Furthermore, training should be about how to use Wi-Fi connections, including searching for health information through the internet and downloading and installing application software for healthcare and navigating them. Emphasizing online safety and security, such as recognizing secure websites and understanding privacy settings, is also critical to protect personal health information (Gell et al. 2015).

Second, at the same time as providing general technology literacy training, there is also a need for older people to develop practical abilities to use specific healthcare technologies. Older people could benefit to a large extent by using health monitoring devices, mainly blood pressure or glucose meters and wearable fitness trackers (Talukder et al. 2021). Sessions should cover how to function these devices, read the data acquired, and communicate it with health providers as comprehensively as possible. Visual, step-by-step instruction and repetitive practice are effective means of ensuring potential users can manage the device confidently (Mitzner et al. 2010). In addition, e-health and m-health are increasingly used in healthcare systems for older adults who live far away or have difficulty driving. Training programs mainly focus on working with and using digital healthcare platforms. This includes scheduling appointments, understanding video conferencing tools, and managing virtual consultations. With practical demonstrations and scenarios for playing a role, older people are accustomed to receiving those services independently. This will lead to active participation in healthcare through independence (Czaja et al. 2013).

Moreover, it is important for older people to open and manage their electronic heath records. Training should include logging into patient portals, checking test results, updating personal information, and communicating with their healthcare providers through different mediums (Jimison et al. 2008). This is an important point to stress as records will be kept current, and they may contain medical information that a patient may not otherwise know unless it is presented in an electronic health record, but not ideal for comparison. Equipping older adults with this knowledge can help them become more involved when taking charge of their health care.

Third, training and education programs should emphasize to older people the possibility of communicating with healthcare providers through e-mailing or messaging apps within healthcare portals securely. They should inform which can be classified as phish and safeguard their personal information from being shared by anyone professionally trained to preclude phishing attacks (Xie et al. 2022). Practical examples of staged real-life scenarios could make a big difference in turning older adults into learning skills they would use safely at various times in life (Talukder et al. 2020b).

Fourth, older adults need to have training to overcome their limitations in handling cognitive and physical problems (Deng, Mo, and Liu 2014). For their part, older people demonstrate cognitive impairments that could potentially impact the comprehension and recall of novel information (Phang et al. 2006). Hence, training programs should be prepared with those challenges kept in mind. The programs can be performed with the help of repetitive learning by dividing the information into smaller parts and steps, with written instructions and visual support (Popescu, Pitic, and Dragomir 2020). Moreover, patience, reinforcement, and positive encouragement are important to ensure that older adults continue to grasp their newly acquired knowledge and skills (Ball et al. 2002).

Moreover, some older people have physical incapacities, which can keep them from being able to use digital-tech devices. The training programs should employ the use of adaptive technologies to overcome this barrier (Ho and Merchant 2022). The technology could include voice-activated assistants, larger font sizes, and allowing individuals to adjust the settings on their screens (Rogers and Fisk 2010). Rendering functionality and training the customers' handiness with these variations should bring about growing their skills to help them (Frishammar et al. 2023). Training sessions that provide hands-on experience and clear, step-by-step instructions can significantly reduce anxiety and improve user satisfaction (Keidser, Matthews, and Convery 2019).

Fifth, the training and literacy programs should also be carried out to increase confidence levels among older people regarding using digital healthcare services while minimizing anxiety. During training, practical, real-life scenarios could be used to make older people aware of the relevance and benefits of digital healthcare technologies (Talukder et al. 2020b). For example, showing how to schedule a doctor's appointment online or using a fitness tracker to record daily activity may lend an interactive nature in training, hence facing the chance of adoption (Heart and Kalderon 2013). Developing a safe space without fear of judgment is important to minimizing anxiety and increasing the confidence level of older citizens. Trainers should be patient and encouraging and respond properly to questions (Hill, Betts, and Gardner 2015). Peer support groups are also found to be useful, as they provide a space for both experience sharing and collective solution findings (Talukder et al. 2020a). Elavsky et al. (2024) found that caregivers themselves often lack the skills and confidence to use smart technologies, which limits the support they can provide to older users. By extending training programs to include caregivers and family members, the overall support network for individuals can be strengthened, improving the likelihood of sustained technology use.

Finally, all older adults should be trained to access support activities and broader involvement in ongoing learning programs. It is essential for technical support in terms of problem-solving and advice. Training programs can provide practical advice on how to reach technical support services as well, e.g., through a helpline or a local center regularly supported by tech-savvy volunteers (Talukder et al. 2020a). A robust support system can help minimize some of that frustration and promote continued use, which is crucial for long-term adoption and benefit (Wilson et al. 2021). Moreover, Sestino and D'Angelo (2024) emphasized the importance of gamification and socialization in training programs, as these elements can make learning more engaging and accessible for older individuals. However, with digital health technologies evolving so rapidly, continued (and expanded) education and support are critical. That can be delivered in various forms, from refresher courses to advanced training sessions and through resources like online tutorials and help desks (MacNeil 2019). A mechanism that provides regular updates and continuous learning opportunities where older people remain updated on these new technologies or changes in existing ones can help older individuals feel competent and confident as users (Taha, Sharit, and Czaja 2009).

In a nutshell, providing comprehensive ongoing training and education is essential to overcoming the barriers that older individuals face when adopting digital healthcare technologies. By improving digital literacy, reducing technology anxiety, and involving caregivers in the process, training programs can play a pivotal role in promoting the successful adoption and sustained use of health technologies among older adults.

2.5 Policy and Regulatory Frameworks

A well-developed policy and regulatory framework is critical for the successful adoption of digital healthcare technologies among the older population. From the literature, we find that lacking clear policies, supportive regulations, and government involvement creates big obstacles to accessing, safely using, and widely adopting health technologies. The review shows several key points about why we need strong policy and regulatory frameworks.

2.5.1 National Policy Support

Governments are crucial in promoting digital healthcare technologies through supportive national policies. Tangcharoensathien et al. (2018) emphasized the need for policy frameworks to ensure equitable access to assistive technologies in low- and middle-income countries (LMICs). The National Digital Health Mission (NDHM) aims to enhance healthcare delivery by building a robust digital ecosystem in India. However, Das and Sengar (2022) pointed out that without strong policies addressing literacy and affordability, eHealth adoption remains limited among the older population and low-income groups. Similarly, in Brazil, the absence of government subsidies and structured policies for older people hinders the widespread adoption of telemedicine and mobile health applications. Despite high demand due to aging populations, limited funding and lack of national policies in many LMICs impede the deployment of digital healthcare tools. To overcome these gaps, governments in LMICs must develop comprehensive national strategies that include technological infrastructure, subsidies, and training programs targeted at older populations.

2.5.2 Data Privacy and Security Regulations

Protecting personal health data is a significant concern for older users adopting digital healthcare technologies. Raghavan, Demircioglu, and Taeihagh (2021) highlighted the critical need for data privacy and security regulations in adopting cloud-based healthcare technologies in economies like Japan, the Republic of Korea, and Singapore. Confidentiality, truthfulness, and accessibility are important when handling older adults' information. Ethical concerns arise regarding consent and potential misuse or coercion. This underscores the need for strict rules enforcement to prevent unauthorized access and ensure technology does not violate older adults' rights or dignity (Pung et al.

2009). However, in many LMICs, regulations are absent or inadequate, exposing users to data breaches and unauthorized access. For example, in India, despite NDHM's progress in integrating digital health records, data privacy protections remain weak. No comprehensive law mandates stringent data protection, making older users vulnerable to privacy violations. In Brazil, the General Data Protection Law was implemented in 2020 to address data privacy. However, enforcement is inconsistent, and penalties are rarely applied, creating uncertainty about digital health platform security. Therefore, robust regulatory frameworks are necessary to securely manage personal health data and build trust among older users concerned about misuse. Governments can mitigate privacy fears by establishing strict data protection laws and promoting wider adoption of digital health technologies.

2.5.3 Standardization, Interoperability, and Quality Control

Ensuring the quality and reliability of digital healthcare technologies is a crucial regulatory aspect. Tangcharoensathien et al. (2018) called for policies establishing product development standards to ensure safe, high-quality technologies meet older users' specific needs. Regulatory frameworks like the Health Insurance Portability and Accountability Act in the United States and the General Data Protection Regulation in the European Union offer comprehensive guidelines on data privacy and security (European Commission 2018). These regulations set strict requirements for securing personal health information, individuals' rights to access their data, and the need for explicit consent for data processing. It also explains the obligations of data controllers and processors (Scheibner et al. 2020).

Standardization is essential for seamless health information exchange between digital health systems. To achieve interoperability, policies should promote adopting international standards like HL7, FHIR, and DICOM (Borycki and Kushniruk 2022). Regulatory bodies play a crucial role; for instance, the United States Office of the National Coordinator for Health Information Technology developed the Interoperability Standards Advisory, offering a comprehensive list of the best standards for health information interoperability (ONC 2020). These initiatives help healthcare providers and technology developers implement interoperable solutions. Regulatory frameworks should also include guidelines for ongoing quality control and evaluation to ensure technologies continue to meet the changing needs of older adults.

2.5.4 Incentive Programs and Funding

Governments can promote the adoption of digital healthcare technologies by implementing incentive programs for manufacturers and end-users. Tangcharoensathien et al. (2018) recommended creating incentive schemes to encourage the development of affordable, user-friendly products for older populations. These programs should address lower income brackets and gender disparities, as older women often face more significant financial constraints due to longer life expectancy and lower lifetime earnings. Direct subsidies or financial assistance to older end-users can reduce the economic burden of adopting health technologies. Ho and Merchant (2022) highlighted that financial subsidies can bridge the digital divide for lower-income older individuals who struggle to afford devices and services. Older women may significantly benefit from targeted financial aid, enabling them to access technologies like telemedicine, wearable devices, and mHealth services.

An example is India's Ayushman Bharat Digital Mission, which provides financial incentives to healthcare providers and developers. The mission integrates digital health solutions like telemedicine and electronic health records. These efforts are aimed at rural and lower-income groups, lower healthcare delivery costs, and make technologies more accessible to the older population. Das and Sengar (2022) emphasized the need for incentive schemes to support affordable digital health products tailored to older populations facing significant economic barriers. These incentive programs, supported by regulatory frameworks, can make digital healthcare technologies more affordable and accessible.

2.5.5 Ethical Considerations

Ensuring the ethical use of digital healthcare technologies is critical, especially for vulnerable populations like older adults. Ethical considerations include informed consent, autonomy, and equitable access. Older adults may struggle to understand how their data are used or stored. They might also lack the ability to provide meaningful consent. Chen and Chan (2013) highlighted that older individuals are particularly vulnerable to exclusion from decision making regarding their care when digital technologies are involved. So, policy frameworks must simplify informed consent processes and explain them to older users. Policies must also ensure equitable access to these technologies, preventing disparities based on socioeconomic status, as access is often limited to wealthier populations. In Brazil, the General Data Protection Law addresses some ethical concerns related to privacy and consent, but

Ho and Merchant (2022) argue that more needs to be done to ensure older users are appropriately informed about their rights and data handling.

2.5.6 Training and Capacity Building

The policy frameworks should include capacity-building initiatives to train healthcare providers, caregivers, and end-users. Elavsky et al. (2024) highlight that older adults and their caregivers often lack the skills to operate these technologies effectively. For example, Kenya launched the “Digital Literacy for Elderly Care” program with nongovernment organizations and private health tech companies. This initiative offers training workshops to improve the digital literacy of older users, focusing on mobile health apps, telemedicine, and remote monitoring devices. In India, as part of the NDHM, the government has started capacity-building programs. The program trains healthcare providers and end-users on digital health technologies. Policies promoting training programs in healthcare systems and communities can help ensure that older users and their caregivers are equipped to adopt and use digital health technologies.

2.6 Limitations and Future Research Directions

This study has several limitations. First, we only used sources from the Scopus database. This might have omitted essential studies from other databases like PubMed or Web of Science. So, the findings might not be fully comprehensive. Second, the study did not look at gender barriers, even though we mentioned the feminization of aging. This limits our understanding of how older women might face different challenges than men. Third, the study looked at general trends across LMICs, which might have missed unique conditions in individual economies. Fourth, the study did not use a theoretical framework to analyze the barriers systematically. This limits the depth of our analysis. Finally, the study is based only on existing literature, not empirical data.

Future research should address these limitations by including sources from multiple databases like PubMed and Web of Science to be more comprehensive. Researchers should conduct gender and economy-centric studies to see how older women and men in different regions face different challenges. Focusing on specific economies would help understand unique regional issues instead of general LMIC trends and help develop a theoretical framework to analyze the barriers. Finally, doing empirical research like interviews or surveys with older users and healthcare providers would offer more concrete insights into the practical challenges.

2.7 Conclusion

Digital healthcare technology adoption among older adults has a number of barriers including technology anxiety, low technology literacy, financial constraints, resistance to change, privacy concerns, and security concerns. Inadequate infrastructure, lack of support systems, and weak policy frameworks in many low- and middle-income economies are further hurdles to adoption. To promote the effective integration of digital healthcare solutions into the care of older people, governments must develop comprehensive national policies. Policies that promote data privacy provide financial incentives and ensure the ethical use of these technologies. In addition, training programs for older users and healthcare providers are critical to overcoming digital literacy barriers. The findings of this study highlight the need for multi-faceted approaches that combine policy interventions, capacity building, and supportive infrastructure.

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3

Silver Surfers and Digital Drift: The Adoption of Technology and Elder Care Amid Rising Suicide Rates

Sruti Tiwari

3.1 Introduction

The intersection of demographic shifts and technological advancements presents both profound challenges and unique opportunities for modern societies. As birth rates decline and life expectancies rise, the global socioeconomic landscape is being reshaped, particularly in relation to aging populations. Gerontologists have referred to this demographic shift as the "age quake," emphasizing the unprecedented growth in the proportion of older individuals worldwide (Miller 1991; Hooyman and Kiyak 2011; UN DESA 2015; Sabri et al. 2022). For the first time in human history, the number of individuals over 65 years old has surpassed those under 5 years old, a trend that reflects not only falling fertility rates but also remarkable increases in longevity (National Institute on Aging et al. 2011; Sabri et al. 2022). Projections suggest that by 2050, approximately 21% of the world's population will be aged 60 or older, a demographic reality that demands attention from policymakers, economists, and society at large.

This transformation is not occurring in isolation; it represents a culmination of centuries of demographic transition. The "Demographic Transition Theory" explains how societies have evolved through four distinct stages: from high fertility and mortality in pre-industrial times to low fertility and mortality in today's post-industrial world. As mortality rates began to fall in the late 18th and 19th centuries, primarily in developed economies, improvements in infant and child survival rates boosted life expectancy, setting the stage for the aging populations we observe today. Globally, average life expectancy has risen dramatically from just 47 years in 1950 to 72 years in 2020 (UN DESA 2020, signaling a radical shift in how societies are structured.

Today, many nations have completed the demographic transition and have entered what demographers call the "Second Demographic Transition," a phase characterized by very low fertility and rapidly aging populations (Lesthaeghe 2014). Economies like Japan and much of Western Europe, where fertility rates have been below replacement levels since the 1970s, are experiencing some of the most extreme cases of population aging. Japan, for example, is projected to have a median age of 52.4 years by 2035 (UN DESA 2020). This shift in the age structure is not only confined to developed economies but is spreading to regions previously considered youthful, including parts of Asia and Latin America. Economies that are newly aging face their own set of challenges, requiring innovative solutions and adaptive strategies (Dobriansky, Suzman, and Hodes 2007; Kochhar and Oates 2014).

The aging of populations presents significant economic and social implications, a phenomenon recognized by the United Nations since the mid-20th century. According to the United Nations Department of Economic and Social Affairs, an economy or region is classified as an aging society when the proportion of individuals aged 65 and above exceeds 7% of the total population. Further standards established during the First World Assembly on Ageing in Vienna in 1982 indicate that a society is considered aging when 10% or more of its population is aged 60 and older. Many nations have already surpassed this threshold, highlighting a global trend toward demographic aging. As the "age quake" continues to intensify, it underscores the need for adaptive strategies to tackle challenges in areas such as healthcare, social security, and labor dynamics.

In this context, the intersection of demographic changes and technological advancements creates both challenges and opportunities for modern societies. Declining birth rates and rising life expectancies are transforming the global socioeconomic fabric, particularly concerning aging populations. Concurrently, the proliferation of digital technologies is reshaping industries, communication platforms, and the way services are provided, leading to fundamental shifts in societal operations. As these trends unfold, it becomes critical to understand their combined impact on aging populations, particularly in light of demographic shifts, including rural-to-urban migration, as identified by Du et al. (2007), which remain pertinent in reflecting broader, ongoing changes affecting social structures and families.

While digital technologies promise to enhance the quality of life for older individuals through improved healthcare access and social connectivity, concerns persist about potential downsides, such as reduced human contact and increased social isolation. The fragmented and inconclusive nature of empirical research on digitalization's specific effects on aging populations is particularly evident when comparing developed economies and emerging market economies (EME), where disparities in digital infrastructure and economic development are pronounced (Bernstein 2002; Du et al. 2004; Herrmann 2014; Guo et al. 2024). Additionally, the societal portrayal of aging and the internalization of ageist stereotypes contribute to the vulnerability of older adults, especially concerning their mental health and risk of suicide (WHO 2021).

Suicide in later life is often viewed as a rational response to factors like physical frailty, loss of autonomy, bereavement, and loneliness. These deeply rooted in ageist views, reinforced by the media, shape not only public opinion but also healthcare approaches to older adults, often leading to underestimation of their mental health needs and inadequate care options (WHO 2021; De Leo 2022). While depression is a major risk factor for suicide among older adults, its role is often overstated, resulting in oversimplified medical interventions that fail to address the multifaceted social determinants that contribute to suicidal behavior (Bernstein 2002; WHO 2021, De Leo 2022).

This study aims to bridge these gaps by exploring the relationship between digitalization and key indicators of aging populations, including suicide rates, across developed economies and EMEs. By examining age-related factors such as healthy life expectancy, labor force participation rates, and social security systems, this research seeks to uncover how digitalization influences these indicators and, in turn, affects the well-being and vulnerability of older adults. Understanding how digitalization shapes social connectivity and access to resources is crucial for comprehending its impact on suicide rates among older individuals. By providing a comparative analysis using robust empirical methodologies, this study offers a more holistic understanding of the aging experience in diverse economic contexts and highlights the need for tailored interventions that consider both the opportunities and challenges presented by digital technologies.

With a focal point on aging, this study addresses these gaps by exploring the relationship between digitalization and key indicators of aging populations across diverse economic contexts. Through a comparative analysis using robust empirical methodologies, this research provides evidence-based insights into how digitalization influences health outcomes, labor participation, demographic trends, and social security systems among older individuals in developed economies and EMEs. Furthermore, understanding the role of digital technologies in fostering intergenerational connectivity and community engagement among older adults is crucial. Technological advancements offer opportunities for sustained social participation and active aging, although challenges related to digital exclusion among older populations persist (Laslett 1989; Gilleard and Higgs 2002; Östlund et al. 2015).

This study employs panel data to examine these dynamics across developed economies and EMEs, focusing on key aging indicators and a comprehensive digital index derived through principal component analysis (PCA) spanning infrastructure, innovation, and access.

Beyond economic metrics, the study highlights stark demographic trends, such as suicide rates among the older population. While high-income economies show declining trends due to advanced healthcare and social support, low- and middle-income economies struggle with persistent vulnerabilities exacerbated by limited access to services. Analysis of policy frameworks and resource availability reveals significant disparities. High-income economies report robust policies supporting age-friendly environments and comprehensive healthcare, contrasting starkly with low-income economies, where resources are limited, hindering effective care provision of older adults. Policy implementation varies widely, with lower-income economies demonstrating higher engagement in basic healthcare provisions but facing challenges in scaling comprehensive support systems.

These findings underscore the urgency of inclusive digital strategies that bridge global divides, promote technological literacy among older populations, and bolster social safety nets amidst demographic transitions. Effective policy interventions must address these disparities to ensure equitable access to healthcare, economic opportunities, and social support for aging populations worldwide. As digital technologies continue to reshape societal norms and practices, understanding their nuanced impacts on aging populations is essential for promoting inclusive growth and sustainable development worldwide. This study contributes to this understanding by examining the multifaceted interactions between digitalization and care of older people, ensuring that technological advancements align with the evolving needs of older populations globally.

The chapter is organized as follows: Section 3.2 establishes the empirical methodology, including variables and data sources. Section 3.3 presents the analytical framework. Section 3.4 verifies the robustness of the findings. Finally, Section 3.5 concludes.

3.2 Empirical Methodology

3.2.1 Panel Data Analysis

We employ both fixed effects and random effects models in the panel data analysis to account for unobserved heterogeneity across economies and to ensure robustness in the findings. The choice between these models is guided by the Hausman test, which helps determine whether the individual-specific effects are correlated with the independent variables.

The fixed effects model controls for time-invariant economy-specific characteristics, making it suitable when these effects are assumed to be correlated with the independent variables. On the other hand, the random effects model assumes that individual-specific effects are random and uncorrelated with the independent variables, providing efficient and consistent parameter estimates when these assumptions hold.

For developed economies, the fixed effects model was primarily selected based on the Hausman test, but random effects were also applied for robustness checks. In contrast, for emerging market economies, the random effects model was the preferred choice, with fixed effects used as a robustness check. This dual approach strengthens the reliability of the results across different model specifications.

The general form of the panel data model used for both developed economies and emerging market economies is specified as:

$$Y_{it}^{G} = \alpha^{G} + \beta^{G} X_{it} + \mu_{it}$$

Where:
Y_{it}^{G} represents the vector of dependent variables for economy i at time t within a specific group (developed economy or EME). The dependent variables in our analysis focus on various indicators of aging and labor force participation among older individuals. Specifically, these include:

(1) Healthy life expectancy at age 60
(2) Labor force participation rate by older people (65+ years) (SDG 8.5)
(3) Age dependency ratio (% of working-age population)
(4) Percentage of total population aged 60 years or over

Some important variables such as care expenditure of older adults, specific healthcare costs for the aging population, and detailed social support metrics were considered essential for a comprehensive analysis of aging and its impacts. However, due to limitations in the availability of consistent and comparable data across the selected economies, particularly for emerging and developing economies, we could not incorporate these variables into our study.

Let, $Y_{it} = [Y_{1it}, Y_{2it}, Y_{3it}, \ldots.., Y_{Kit}]$

α^G is the random effect for economy i, capturing unobserved heterogeneity.

β^G is the coefficient vector for the independent variable X_{it} i.e., digitalization. We employ Principal Component Analysis to measure the digital adoption index discussed in detail in successive sections.

μ_{it} is the error term.

Each dependent variable is modelled separately for both developed economy and EME groups using the random effects and fixed effects specification. The separate analysis for economies is based on income classification levels to explore heterogeneity.

Developed economies: Australia, Belgium, Canada, France, Germany, Israel, Italy, Japan, Netherlands, New Zealand, Singapore, Spain, Sweden, Switzerland, United Kingdom.

Emerging market economies: Brazil, People's Republic of China, India, Indonesia, Mexico, Poland, Romania, Russia, Saudi Arabia, Thailand, United Arab Emirates.

Data are sourced from the World Health Organization data portal, the World Bank, the International Labour Organization Statistics, Surveys, and Reports – Household Income and Expenditure Survey, Household Survey, Labour Force Survey, and Organisation for Economic Co-operation and Development from the year 2002 to 2023.

3.2.2 Methodology for Principal Component Analysis

This study employs the PCA to examine the dimensions of digitalization across economies. By analyzing the relationships among various digital indicators, we focus on key components such as infrastructure, adoption, innovation, and payments. This methodology provides insights into the factors influencing digital transformation.

Data preprocessing and correlation analysis

Before conducting the PCA, the dataset undergoes preprocessing to ensure data integrity and manage missing values. Missing data are addressed using mean imputation, applied independently to each variable. Following imputation, the dataset is carefully reviewed to confirm that the imputed values accurately reflect the underlying data patterns. A comprehensive correlation analysis is conducted to explore interrelationships among various digital indicators, highlighting dependencies and associations within digital economies.

Principal component analysis

By employing the PCA, we distil the primary dimensions of digital economies, including infrastructure, adoption, innovation, and payment. This dimensionality reduction technique identifies key components driving digital transformation across selected economies. In our analysis, we considered 16 variables capturing diverse aspects of digital economies, such as financial access, connectivity, and technology usage. A full list of variables is available in Table A3.1 (appendix).

Data sources

Our data is curated from databases, including the International Telecommunication Union (ITU), the United Nations Conference on Trade and Development (UNCTAD), and the Global Findex Database of the World Bank. The data spans from 2002 to 2023 with annual data frequency, ensuring a comprehensive analysis of trends in digital economy. Specifically, data on digital infrastructure is compiled from the ITU, while information on digital payments is obtained from the Global Findex Database. Additionally, research and development, digital skill adoption, information and communication technology, and e-commerce-related data are sourced from UNCTAD.

Index calculation

The normalized data are integrated into a unified index framework. PCA identified five principal components (PCs) that collectively explain a significant portion of the variance in the dataset. The first three PCs were weighted more heavily based on their variance contributions, resulting in a weighted digital index. This index provides a comparative measure of digital economy performance across economies.

As detailed in Table A3.2, the results of the PCA offer key insights into the structure of the data. The first three principal components (PC1, PC2, and PC3) together account for 74.56% of the total variance, capturing the most substantial patterns in the dataset. While the eigenvalues for the fourth (PC4: 0.9639) and fifth (PC5: 0.9190) components fall slightly below the critical threshold of 1, they are close enough to warrant inclusion, as they still explain meaningful variance. Retaining all five components ensures a more comprehensive view of the data, allowing for the identification of subtler relationships and trends in digital economy performance. This approach not only captures significant variance but also strengthens the reliability of subsequent analyses, ensuring a robust representation of the factors influencing digital transformation across economies.

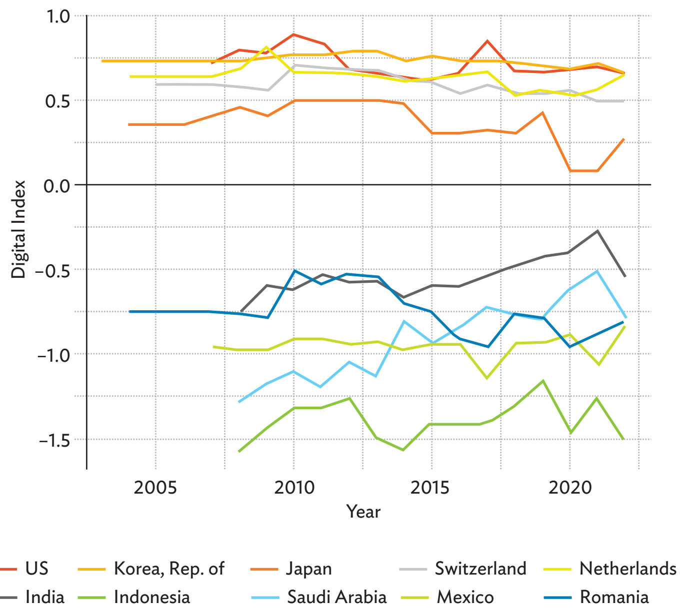
Validation and sensitivity analysis

To ensure reliability and robustness, we conduct sensitivity analyses with various data scaling methods, including:

- **Standard scaling:** Data scaled to have a mean of 0 and a standard deviation of 1.
- **Centering only:** Data centered around the mean without scaling.
- **Min-max scaling:** Data scaled to a range of [0, 1].

Comparing PCA results across these methods reinforces our findings' robustness. Finally, additional sensitivity analyses validate index results through comparisons with existing literature.

Figure 3.1: Economy-wise Digital Index Trend



US = United States.

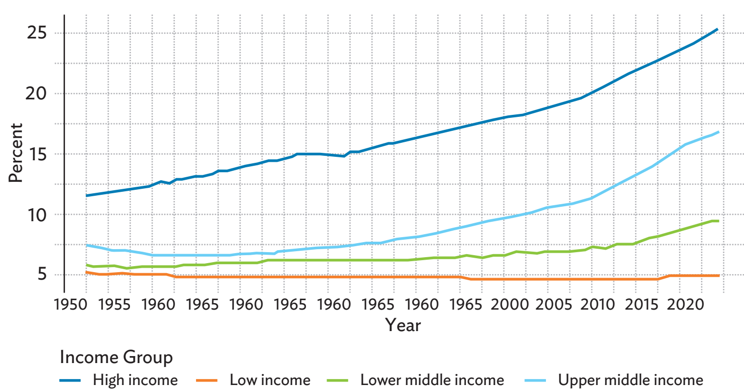
Source: Author's estimates.

3.3 Dynamics of Demographic Transition: Insights and Interpretations

Economies at the forefront of global demographic transition, such as Japan, the Republic of Korea, Germany, Italy, and the United States, are experiencing significant shifts in their population structures, trending towards an increasingly older demographic (Jarzebski 2021). This transition is driven by a myriad of factors, such as declining fertility rates, the rise of materialistic lifestyles, increased female labor force participation, elevated education levels among women, the high costs of raising children, and geographic dispersion. As a result, many nations are witnessing a close balance between birth and death rates, often resulting in growth rates that fall below the replacement level.

Figure 3.2 illustrates the percentage of the population aged 60 years and over across different income groups. The data reveal that high-income economies are aging more rapidly than their lower-income counterparts, with upper-middle-income economies following the trend closely. In contrast, lower-middle and low-income economies experience a slow but gradual increase, affording them a longer window to adapt to these demographic changes. This pronounced aging phenomenon in wealthier nations carries significant implications for their social and economic structures, including increased healthcare demands, shifts in workforce dynamics, and heightened pressures on pension systems.

Figure 3.2: Percentage of Total Population Aged 60 Years and Over

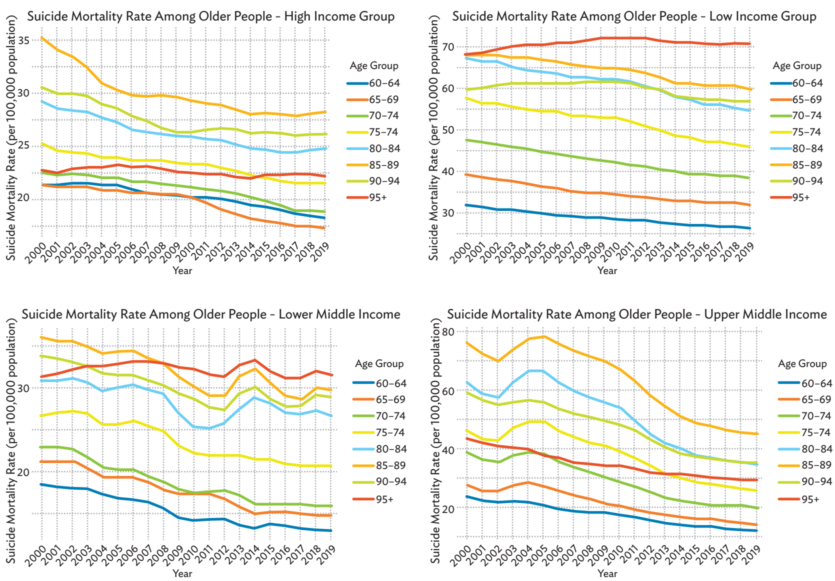


Source: UN Population Division.

3.3.1 Vulnerabilities of the Older Population

The older population represents a particularly vulnerable demographic, a reality that becomes evident when examining suicide mortality rates across different income groups. Figure 3.3 presents data on suicide mortality rates among older individuals segmented by income groups (high income, upper-middle income, lower-middle income, and low income) and age groups from 2000 to 2019. In high-income economies, while overall suicide rates among the older population have generally declined, certain age cohorts—particularly those aged 70–79 and 85–89—still exhibit significant rates. High-income economies, with their advanced technological infrastructure, have integrated digital health services, telemedicine, and digital monitoring systems, contributing to better care of the older population and reduced suicide mortality rates. However, the high suicide rates among older age groups, particularly those between 70–89 years, in high-income economies suggest that technology alone cannot replace the need for emotional and social

Figure 3.3: Suicide Mortality Rate among Older People Across Income Groups



Source: World Health Organization.

support. The more pronounced decline among younger cohorts (60–64 years) can be attributed to advancements in healthcare systems, including improved mental health services, robust social support programs, financial assistance, the development of age-friendly environments and potentially reflecting their greater adaptability to digital tools.

Conversely, data from low-income economies reveal that older age groups (80–84 and 85–89 years) experience the highest suicide mortality rates, with little improvement over time compared to their high-income counterparts. This is largely due to limited access to digital infrastructure, which exacerbates existing vulnerabilities. In these income-vulnerable economies, older populations face persistent challenges, including inadequate healthcare and heightened social isolation. The inability to leverage digital solutions for mental health support, coupled with uneven access to such technologies, further perpetuates high suicide mortality rates, particularly among those aged 80–89. Similarly, lower-middle-income economies have seen minimal declines in suicide mortality rates among the older population, especially in the 75–79 and 80–84 age groups. These elevated suicide rates are closely linked to inadequate healthcare, restricted access to mental health services, and pervasive social isolation, with economic hardships compounding the mental health challenges faced by older individuals.

Upper-middle-income economies exhibit mixed trends, with certain age groups (e.g., 70–74 years) showing substantial declines in suicide rates, while others (e.g., 80–84 years) continue to report high rates as some groups benefit from better digital resources while other do not. While digital solutions improve some aspects of care of the older population, they do not fully address the deep-rooted social isolation and mental health challenges that accompany aging. Across all income groups, the data underscore the urgent need for targeted interventions aimed at addressing social isolation and mental health issues among the older population. Developing robust social support networks and community programs can alleviate feelings of isolation and provide crucial emotional support. Policies designed to reduce economic burdens on older adults, such as comprehensive pension schemes and affordable healthcare, can significantly enhance their overall well-being.

3.3.2 Policy Engagement and Resource Allocation

The divide between high-income and low-income economies in terms of digital access raises questions about the long-term efficacy of digitalization as a tool for the care of the older population. Figure 3.4

shows that lower-income economies engage in more traditional, non-digital interventions, such as free out-patient services and assistive devices. While these are critical, the lack of digital resources makes it challenging to scale and provide consistent care, particularly in remote areas. The engagement in human rights mechanisms and efforts to combat ageism is strong across all income groups, reflecting a global acknowledgment of the issues faced by older people. Yet, in low-income economies, the absence of digital tools to raise awareness, track data, and implement anti-ageism policies limits the reach and impact of these initiatives. Digital platforms could enhance community engagement and awareness campaigns, amplifying efforts to address ageism and human rights issues among the older population.

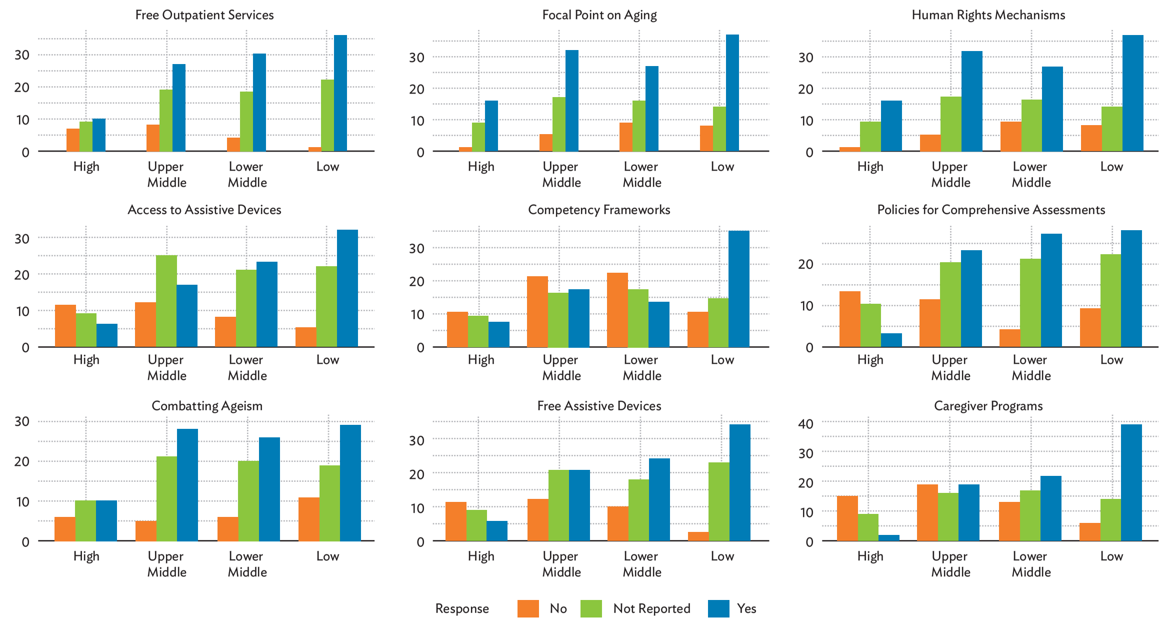
Additionally, low-income economies report more policies focused on comprehensive assessments and competency frameworks for care of the older population. While this shows a commitment to structured support systems, these frameworks remain largely manual and resource-intensive. In contrast, leveraging digital tools for data management and service delivery could make these support systems more efficient and scalable. Digital technologies could facilitate real-time monitoring, improve coordination among caregivers, and enhance the overall quality of care, thereby addressing the aging population's needs more effectively.

Figure 3.5 reveals a significant disparity in the availability of age-specific resources across different income levels. High-income economies report having adequate or substantial resources to implement actions on ageism, age-friendly environments, integrated care, and long-term care. In contrast, low-income economies predominantly report lack of resources or very limited means to support these initiatives. Middle-income economies display mixed responses, with lower middle-income economies indicating lack of resources, while upper middle-income economies demonstrate a combination of limited and substantial resources.

A key factor behind this divide is the availability of digital tools. High-income economies are far better equipped with digital systems for integrated care, long-term care applications, and age-friendly environments. Digital platforms in these nations enable comprehensive care solutions, from real-time monitoring to virtual health consultations. However, in low-income economies, even the basic infrastructure needed to implement such policies is often absent, limiting the potential of digitalization to address the needs of aging populations.

While digitalization holds immense promise, its uneven distribution across income groups highlights its limitations. In high-income economies, the use of digital platforms for care of the older population is widespread, but the reliance on technology also introduces new

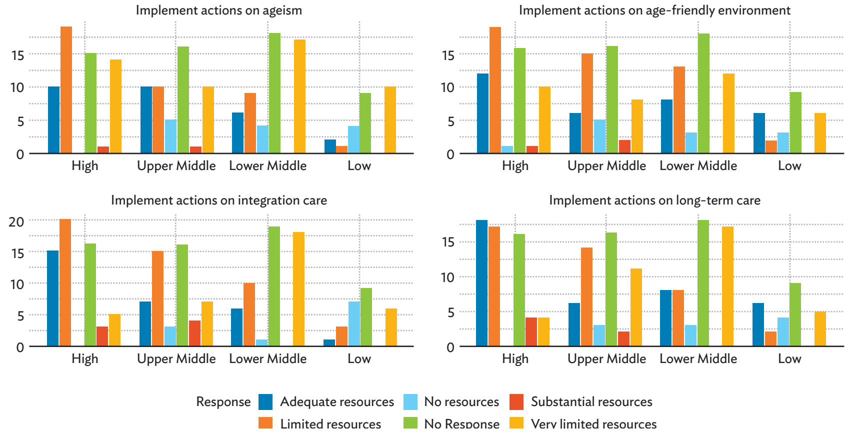
Figure 3.4: Number of Economies with Care Provisions and Policies for Older Adults across Income Groups (2023)



Source: World Health Organization.

challenges. The growing disconnection between technological assistance and human interaction suggests that addressing mental health and providing social support for older adults requires a more holistic approach—one that balances digital tools with personalized care and community support systems.

Figure 3.5: Number of Economies with Availability of Resources for the Care of Older Adults across Income Groups



Source: World Health Organization.

3.3.3 Digitalization as a Response to Declining Working-Age Population and Aging

Studies show that digitalization is a catalyst for effective service development (Meristö and Laitinen 2020). As the working-age population declines, particularly in developed economies, digitalization introduces automation that offsets the impact of labor shortages. Acemoglu and Restrepo (2020) highlight that industries reliant on middle-aged labor show notable productivity improvements when adopting digital solutions, particularly automation. These adaptations are more pronounced in economies undergoing significant demographic shifts, where automation sustains economic output even as labor market participation from older individuals declines. By reducing the need for prolonged working lives, automation alleviates pressure on social security systems, ensuring that older individuals may not need to work as long before retiring.

3.3.4 The Role of Automation in Addressing Demographic Changes

As integration of technology has gained momentum. More automation-related technologies are being created and exported from nations with rapid demographic transitions, such as Japan, Germany, and the Republic of Korea (Acemoglu and Restrepo 2021). These economies are at the forefront of a spreading effect, where innovations in automation and robotics are disseminating globally, elevating technology embodiment. This global investment in automation is forward-looking, positioning economies to handle the growing older population. These technologies—robots, e-services, and digital tools—enhance the functionality of the older population, offering new solutions in healthcare and social inclusion (Siegel and Dorner 2017). Telemedicine, wearable health devices, and artificial intelligence-driven care systems are closing the gap left by traditional healthcare, providing personalized options and improving accessibility for those in rural or underserved areas.

3.3.5 Panel Data Analysis of Digitalization and Aging Populations

In recent years, the increasing digitalization across the globe has raised significant questions about its impact on aging populations, particularly in terms of health outcomes, labor participation, and social security measures. While our preliminary analysis has provided valuable insights into these relationships, we complement our analysis by employing a more robust analytical framework to capture the complexities involved. The panel data analysis approach, will allow us to account for both cross-sectional and time-series variations in the data, offering a more comprehensive understanding of how digitalization influences aging populations. This method allows us to isolate the impact of digitalization on aging populations in both developed and emerging economies.

Table 3.1 presents the results of panel data analysis conducted on various indicators related to aging populations in developed economies, utilizing a fixed effects model. The results indicate that the digital index has significant negative coefficients for both the age dependency ratio and the percentage of the total population aged 60 years or over. The age dependency ratio suggests that as digitalization increases, the

Table 3.1: Results: Panel Data with Random Effects in Developed Economies

Dependent Variable	Coefficient	Standard Error	Significance	R-Squared
Healthy Life Expectancy at Age 60	−1.9670	1.1006	*	0.0649
Labor Force Participation Rate (65+ years)	−1.7423	2.4051		0.0026
Age Dependency Ratio (% of working-age population)	−14.1963	2.0825	***	0.1573
Percentage of Population Aged 60 Years or Over	−5.3378	1.6564	**	0.0459

Note: ***, **, * indicate statistical significance at 0.1%, 1%, and 5% level, respectively.

Source: Author's calculations.

dependency ratio decreases, implying a relative increase in the working-age population compared to the older population. The percentage of the total population aged 60 and over reinforces the notion that digitalization may be correlated with a decreasing proportion of older individuals in the demographic landscape.

However, it is essential to acknowledge that while digitalization can lead to improvements in health outcomes and extended life expectancies for healthier, more tech-savvy older people, it simultaneously exacerbates existing health inequalities. For many older individuals, barriers to accessing technology and lacking necessary digital skills can heighten their vulnerability and mortality risks. The elevated suicide rates among older adults further illustrate this disparity, particularly affecting the least advantaged older population, including those from rural areas, low-income households, or the very old.

The observed decline in the proportion of older individuals within the population does not necessarily indicate worsening conditions for older adults; rather, it reflects demographic shifts driven by migration patterns, changing birth rates, and economic factors. These dynamics can create a greater relative presence of younger cohorts, thereby obscuring the challenges faced by certain segments of the older population.

Moreover, the impact of digitalization on aging populations is highly contingent upon the institutional frameworks and healthcare systems present in developed economies. Economies with robust support structures and effective healthcare systems are likely to experience more pronounced positive effects of digitalization on older adults. In contrast, nations lacking such frameworks may see limited benefits, resulting in a heterogeneous landscape of outcomes for older populations across different contexts.

Ultimately, the benefits of digitalization are not uniformly distributed. A comprehensive understanding must consider the nuanced opportunities and challenges presented by technological advancements, ensuring that the most vulnerable groups receive the support they need to thrive in an increasingly digital world.

Table 3.2 presents the results of the panel data analysis conducted on various indicators related to aging populations in EMEs, utilizing a random effects model. The results from the analysis reveal notable trends regarding the impact of digitalization on aging populations in EMEs. Specifically, the positive coefficients for both healthy life expectancy at age 60 and labor force participation rates among older individuals (65 years and above) indicate statistically significant improvements associated with increasing digitalization. Additionally, the percentage of the total population aged 60 years or over shows a strong positive correlation, significant at the 0.1% level. These findings suggest that digitalization plays a crucial role in enhancing the well-being and economic engagement of older adults in these economies.

Table 3.2: Results: Panel Data with Random Effects in Emerging and Developing Economies

Dependent Variable	Coefficient	Standard Error	Significance	R-Squared
Healthy Life Expectancy at Age 60	1.37471	0.61133	*	0.16261
Labor Force Participation Rate (65+ years)	4.3760	2.2313	*	0.058439
Age Dependency Ratio (% of working-age population)	–2.2018	1.6651		0.009026
Percentage of Population Aged 60 Years or Over	4.3067	1.0540	***	0.082776

Note: ***, **, * indicate statistical significance at 0.1%, 1%, and 5% level, respectively.

Source: Author's calculations.

The marginal impact of digitalization on older adults in EMEs is significant due to several interrelated factors that uniquely shape the experiences of this demographic group. Unlike in more developed contexts, where many older adults may already have access to various digital tools and resources, the initial adoption of digitalization in EMEs presents unique opportunities for substantial improvements in well-being and economic engagement. In many EMEs, older adults often experience a pronounced digital divide, characterized by limited access to technology and digital skills. Digitalization serves as a powerful equalizer, providing these individuals with access to essential services that were previously out of reach. For instance, mobile health applications can facilitate remote consultations, reducing travel barriers for older people who may face mobility challenges or live in remote areas. This bridging of the digital divide means that even small increases in digital access can lead to significant improvements in health management, leading to higher life expectancies and overall well-being.

As digitalization proliferates, it opens up new economic pathways in EMEs that were previously inaccessible to older adults. Traditional job markets often marginalize older people due to age discrimination or lack of flexible roles. However, digital platforms allow them to engage in gig work, freelancing, and e-commerce, enabling retirees to pursue short-term projects or start online businesses aligned with their skills and interests.

This flexibility helps older people balance work with caregiving or health needs while also accessing broader markets. Additionally, tailored digital literacy programs empower older adults to navigate these opportunities confidently, enhancing their financial security and quality of life. Overall, digitalization significantly enhances economic engagement for older adults in EMEs, fostering independence and empowerment.

The introduction of digital literacy programs specifically aimed at older adults can further amplify the marginal impact of digitalization. In EMEs, tailored training programs can empower older people to use technology confidently, thus increasing their engagement with digital tools. This empowerment can lead to improvements in health literacy, allowing older adults to better manage their health conditions and engage with healthcare services. The marginal effect here is notable, as older individuals gain digital skills, their ability to navigate health information, seek care, and access social support networks expands dramatically, resulting in substantial improvements in their overall well-being.

Digitalization also fosters enhanced social connectivity for older adults, combating the isolation that many experience in EMEs. Social media platforms, video calling applications, and online communities can connect older people with family, friends, and support networks, improving their emotional well-being. The marginal impact is evident here, even small increments in social interaction through digital means can significantly reduce feelings of loneliness and isolation, which are prevalent among older adults. This social engagement is crucial for mental health and contributes to a higher quality of life.

Lastly, the increased marginal impact of digitalization is amplified by a feedback loop of continuous improvement. As older adults experience the benefits of digitalization—such as improved health outcomes, enhanced economic participation, and greater social connectivity—the demand for digital services and skills training grows. This demand can lead to further investments in technology infrastructure, healthcare services, and educational programs tailored for older people. In turn, this creates a more favorable environment for older adults, fostering ongoing improvements in their lives.

3.4 Robustness Check

For the **sensitivity analysis**, robustness was checked by using both fixed effects (FE) and random effects (RE) models, with model selection guided by the Hausman test.

In the analysis of **developed economies**, the FE model was primarily chosen based on the Hausman test results. This model controls for unobserved, time-invariant heterogeneity across economies, accounting for factors such as institutional structures and economy-specific policies. However, to ensure robustness, the RE model was also applied for comparison. The robustness check using the RE model confirmed that the significant negative relationship between the digital index and indicators like the age dependency ratio and the percentage of the population aged 60 years or over remained consistent across both models.

For **emerging market economies (EMEs)**, the RE model was the preferred choice, as indicated by the Hausman test. This model captured both within- and between-economy variations, reflecting differences in digital infrastructure and socioeconomic contexts across economies. To validate the robustness of the results, the FE model was also applied. The positive correlation between digitalization and indicators such as healthy life expectancy at age 60 and labor force participation among older individuals remained consistent across both FE and RE models, reinforcing the validity of the analysis.

Overall, the use of both FE and RE models for robustness checks substantiates the findings, ensuring that the conclusions are reliable and consistent across different model specifications.

3.5 Conclusion

The surge in the older population presents substantial challenges in terms of rising healthcare costs, pension systems, and overall economic sustainability. As the proportion of older dependents in economies increases, so does the need for greater public spending and resource allocation. These pressures are further compounded by the inflationary effects linked to shifting age structures (Han 2019; Bobeica and Sun 2017). Addressing the comprehensive needs of aging populations requires targeted public policies that ensure accessible and affordable care services for the older population, as well as robust safety nets to protect the most vulnerable. Policymakers must navigate complexities and uncertainties in planning for the silver population, balancing economic and social priorities (Auping, Pruyt, and Kwakkel 2015).

This study employs robust empirical methodologies to examine the intricate dynamics between digitalization and aging populations across developed economies. The findings suggest that while digital transformation offers potential benefits, its impacts on health outcomes, labor participation, and social security systems vary significantly and is contingent on several factors based on the preparedness of economies' social support structures.

In particular, the study reveals that high-income economies have made significant strides in leveraging digital technologies to create age-friendly environments, but this progress has not been uniform across all regions. The generational gap in digital literacy remains a key barrier, even in technologically advanced nations. In contrast, low and middle-income economies face pronounced challenges in building digital infrastructure and addressing economic and social vulnerabilities, which contribute to higher suicide rates and inadequate care of older people. However, given the study's focus on developed economies, we highlight that even within these economies, the adoption of digital tools by older adults remains slow due to unfamiliarity, highlighting the need for more inclusive policies. In developed economies, this includes integrating technology with personalized care and mental health support. In emerging markets, expanding digital infrastructure and literacy programs will be critical in ensuring that digitalization can serve as a tool for empowerment rather than exacerbating existing inequalities.

Digitalization is not a panacea for the challenges posed by aging populations. Policymakers must balance the deployment of digital tools with investments in traditional support systems to ensure that the most vulnerable are not left behind. This includes prioritizing digital literacy programs that equip older populations with the skills necessary to engage with new technologies, while fostering emotional and community-based support systems that complement, rather than replace, technological advances.

While digital tools can improve healthcare delivery and enhance labor participation for older individuals, they cannot fully substitute for strong social safety nets and comprehensive care systems. Policymakers must ensure that digital platforms are accessible, tailored to the needs of older users, and designed to integrate with traditional care systems to provide holistic support.

The findings underscore the importance of inclusive digital strategies that not only bridge the digital divide but also promote technological literacy and social inclusion for aging populations. By prioritizing these initiatives, governments can navigate the demographic transition in a way that fosters resilience and equity, ensuring that older adults benefit from the ongoing digital transformation.

In summary, the study highlights the need for forward-looking, inclusive policies that harness the potential of digitalization while addressing the diverse needs of aging populations. Future research should further explore how regional variations in digital adoption and socioeconomic contexts influence the long-term impacts of digitalization on aging societies, providing a foundation for more tailored interventions and strategies.

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Appendix

Table A3.1 Description of Variables Used in PCA for Forming the Digital Index

The table provides a detailed description of the variables used in the principal component analysis (PCA) to construct the digital index. These variables capture different dimensions of digital infrastructure, technological adoption, and digital literacy across developed economies. Each variable was standardized prior to PCA to ensure comparability across economies.

Category	Variable	Description
Financial Access and Inclusion	Access to finance	Percentage of the population with access to financial services
	Have a bank account	Proportion of individuals with a bank account
	Mobile money account	Usage of mobile-based financial accounts
	Digital payments using financial institution account	Frequency of using bank accounts for digital payments
	Used a debit or credit card	Proportion of individuals using payment cards
Mobile and Internet Infrastructure	Active mobile broadband subscriptions per 100 inhabitants	Number of active mobile broadband subscriptions
	Fixed broadband subscriptions per 100 inhabitants	Number of fixed-line broadband subscriptions
	Fixed telephone subscriptions per 100 inhabitants	Number of fixed telephone connections
	Own a mobile phone (%)	Percentage of individuals owning a mobile phone
	Households with internet access at home (%)	Percentage of households with home internet connections
Internet Use and ICT Skills	Individuals using the internet, total (%)	Percentage of the population using the internet
	Households with a computer at home (%)	Proportion of households that have a computer
	Access to the internet	Availability of internet access
	ICT	Level of ICT development
	Skills	Degree of digital and technological skills among the population
Research and Development	Research and development	Investment and activities in R&D related to ICT and technology

ICT = information and communication technology, R&D = research and development.

Source: Compiled from the International Telecommunication Union (ITU), United Nations Conference on Trade and Development (UNCTAD), World Bank Global Findex Database, and the Organisation for Economic Co-operation and Development (OECD).

Table A3.2 Importance of Components for PCA Results

The table summarizes the importance of each principal component (PC) identified in the principal component analysis (PCA) results. This analysis reveals the proportion of variance explained by each component, helping to understand the contribution of individual PCs to the overall digital index.

Components	Standard Deviation	Proportion of Variance	Cumulative Proportion
PC1	2.9607	0.5479	0.5479
PC2	1.4236	0.1267	0.6745
PC3	1.0667	0.0711	0.7456
PC4	0.9639	0.0581	0.8037
PC5	0.9190	0.0528	0.8565
PC6	0.7357	0.0338	0.8903
PC7	0.6706	0.0281	0.9184
PC8	0.5833	0.0213	0.9397
PC9	0.4647	0.0135	0.9532
PC10	0.4407	0.0121	0.9653
PC11	0.4055	0.0103	0.9756
PC12	0.3450	0.0074	0.9830
PC13	0.3165	0.0063	0.9893
PC14	0.2713	0.0046	0.9939
PC15	0.2464	0.0038	0.9977
PC16	0.1923	0.0023	1.0000

Notes:

- **Eigenvalue** indicates the amount of variance attributed to each component. Higher eigenvalues suggest a greater contribution to explaining the variance in the data.
- **Proportion of variance** shows the percentage of total variance that each principal component explains relative to the total variance across all components.
- **Cumulative variance** provides the cumulative percentage of variance explained by all components up to that point, highlighting how many components are necessary to explain a substantial portion of the variance.

Source: Author's calculations.

This table helps to determine the optimal number of components to retain for further analysis in the context of digitalization ensuring a robust representation of the underlying data structure.

4

Digitalization in Elder Care: Addressing Global Aging Challenges and Bridging Healthcare Gaps with Voice-Assisted Technology

Liankhankhup Guite, Aleena Chinnu Rajan, and Mayank Kumar

4.1 Introduction

The global trend of population aging is not just a demographic shift but a pressing issue with profound implications for societies and healthcare systems worldwide. This trend, driven by increased life expectancy and improved living conditions, underscores the crucial need for innovative solutions in elder care (Crimmins 2015).

Moreover, societal changes, such as declining birth rates and lower mortality rates due to improved healthcare access and disease management, contribute to the aging population phenomenon. These demographic shifts are not limited to developed economies but are a global pattern increasingly observed in low- and middle-income nations, reflecting the universality of aging populations.

Projections from the World Health Organization (WHO) paint a stark picture of the future demographic landscape. By 2050, the number of individuals aged 65 and above is expected to outnumber children under 14 years of age, marking a significant demographic milestone. Furthermore, WHO estimates a doubling of the global population aged 60 or older between 2015 and 2050, underscoring the magnitude of this demographic transition. The age distribution of the world population is given in Figure 4.1, as the United Nations estimates.

Within this broader global context, India stands out as a pertinent case study. India is experiencing a rapid surge in its older population, a trend expected to accelerate in the coming decades. Older adults constitute over 10% of India's population, accounting for roughly 104 million individuals. However, projections indicate that by 2050, this percentage could nearly double, reaching 19.5% (NITI 2024). This demographic shift brings various socioeconomic challenges (Cohen, Legault, and Fulop 2020).

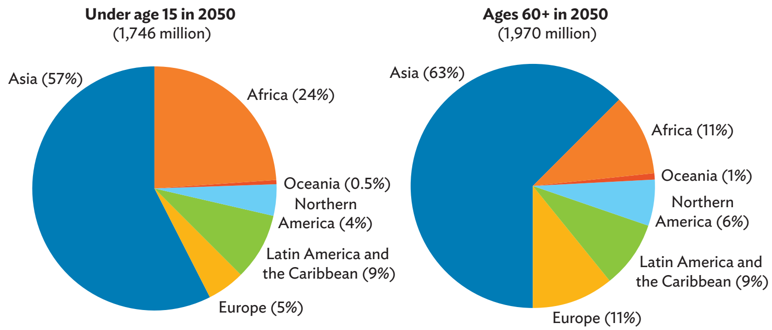
One of the most pressing challenges of population aging is the increasing demand for healthcare and well-being services for older people. As individuals age, they are more likely to experience chronic health conditions, disabilities, and other age-related ailments, placing a significant strain on healthcare systems (National Research Council 2001).

The rising cost of healthcare for older adults is a concern in India and many other economies grappling with similar demographic shifts. The per capita health expenditure has been increasing over time, which is associated with rising medical costs, medical technology, an increase in noncommunicable diseases, medical inflation, rising income, and a change in the economy's population age structure (Ministry of Health & Family Welfare Government of India 2020). The mean out-of-pocket expenditure for outpatient care during the last 30 days prior to the survey was 1,061; it is higher for those aged 60 and above (1,149) compared with older adults aged 45–59 (977). Older adults aged 45 and above from urban areas spend more than those from rural areas; similarly, older adult men (1,224) spend more on outpatient care than women (957) (Ministry of Health & Family Welfare Government of India 2020).

In light of these challenges, there is a growing recognition of the need for innovative solutions to address the evolving needs of aging populations. One promising solution is the integration of digitalization in elder care, particularly through the use of voice-assisted technology (VAT). By leveraging digital solutions, healthcare providers can deliver more accessible, efficient, and personalized care to older individuals, empowering them to age with dignity and independence.

The senior care system confronts many challenges, such as a lack of a comprehensive policy framework, infrastructure gaps, fragmented social support structures, and financial insecurities. The Longitudinal Ageing Study of India (LASI) 2021 report by the Ministry of Health & Family Welfare sheds light on significant health challenges encountered by the older population. Chronic diseases afflict a substantial 75% of older people, with 24% experiencing limitations in daily activities and 48% facing limitations in instrumental activities (LASI 2020). The National Institute of Geriatrics of the Mexican Republic underscores the impact of chronic diseases, stressing the urgency of monitoring the health conditions of older adults, particularly those at risk. Mental health issues, including depressive symptoms, are prevalent among older people, while social protection measures remain limited, with a majority lacking pension coverage.

Figure 4.1: Age Distribution of the World Population



Source: United Nations Population Division. 1998. World Population Prospects: 1998 Revision, Volume II: The Sex and Age Distribution of the World Population.

Amid these challenges, the global acceleration of aging necessitates urgent strategies to address the care needs of the older group. Older adults increasingly prefer to age in place and maintain independence in their homes, so the "smart home" concept has gained prominence. This paradigm, introduced at the Consumer Electronics Show 2016, envisages residential spaces characterized by the integration of home appliances and contents through information and communication technology (ICT) (Taylor 2015).

In this context, our research aims to comprehensively understand how digitalization, specifically VAT, can offer practical solutions to the challenges of elder care. By exploring its impact on healthcare, social engagement, accessibility, and well-being, the study aims to shed light on opportunities and hurdles in the digital revolution, particularly in low-middle-income economies like India. The novelty of this research lies in its focus on the integration of different services and unique suitability of VAT for older individuals, especially those with mobility or literacy limitations. This chapter explores the challenges and opportunities associated with adopting digital technology for older individuals, emphasizing the unique suitability of voice-enabled systems.

By identifying critical research gaps, our study seeks to contribute valuable insights for policymakers, healthcare professionals, and technology developers involved in enhancing care through digital innovation.

4.2 Literature Review

4.2.1 The Aging Population and Healthcare Challenges

The aging population in India presents significant challenges for healthcare, the economy, and societal structures. The India Ageing Report 2023 (UNFPA 2023) highlights that the southern region of India has a higher old-age dependency ratio. This suggests increased dependency on the younger generation for social, financial, and caregiving needs. In this context, the healthcare needs of the older population are becoming more complex, driven by chronic conditions like multi-morbidity, balance disorders, and increased risks of falls. These issues call for innovative, technology-driven healthcare solutions to enhance access and quality of care.

4.2.2 Digitalization in Elder Care

Digitalization has emerged as a transformative force in elder care, providing new avenues to meet these challenges. However, technology adoption among older adults lags behind younger demographics. Hanson (2010) identifies a persistent technology adoption gap, emphasizing the need to bridge this gap to utilize digital solutions in healthcare effectively. Many older adults express enthusiasm and willingness to learn how to use technology, recognizing its benefits for social engagement and healthcare. However, challenges like digital illiteracy remain significant barriers, requiring targeted interventions and digital literacy training.

4.2.3 Digital Literacy and the Age-based Digital Divide

Digital illiteracy among older adults contributes to their exclusion from the digital realm, hindering access to online services like shopping, banking, and social engagement. Contrary to stereotypes of technophobia, many older adults are eager to adopt technology if provided with adequate training and support. Age alone does not determine digital exclusion; other factors such as education, social class, and living arrangements contribute to this “age-based digital divide.” A multifaceted approach is necessary to address digital inclusion for older adults, recognizing these intersecting factors (Neves and Mead 2021).

4.2.4 Usability and Barriers in Technology Adoption

Wearable devices that provide real-time health data have gained prominence as a potential solution for elder care. However, despite their perceived benefits, the impact of wearables on healthcare outcomes remains inadequately understood (Mattison et al. 2022). Older adults' declining functional abilities and the constant need for upskilling to adapt to evolving ICT systems create barriers to adoption. These usability challenges can contribute to feelings of being out-of-touch, reducing older adults' engagement with technology. Addressing these concerns through tailored usability improvements and ongoing support is critical to ensuring that older adults can benefit from wearable technology (Gaspar and Lapão 2021).

4.2.5 Telehealth and Remote Monitoring

Telehealth interventions have the potential to revolutionize elder care, offering remote monitoring and enhanced accessibility. Artificial intelligence (AI)-driven healthcare applications, such as IBM Watson and Google's Deep Mind, are being explored for their potential to improve chronic disease management, diagnostics, and patient care. However, the success of these interventions has been mixed. Some studies suggest that remote monitoring, when combined with usual care, may not yield additional benefits. Privacy concerns and technological barriers also complicate the adoption of telehealth solutions, underscoring the need for optimized implementation strategies (Bohr and Memarzadeh 2020).

4.2.6 Addressing Loneliness and Social Isolation

Loneliness and social isolation among older adults are linked to adverse health effects such as elevated blood pressure, heart disease, and cognitive decline. The rising demand for caregivers has prompted the exploration of AI-powered socially assistive robots (SARs) as a solution to alleviate caregiver burden and improve the well-being of older adults. AI SARs have shown promise in enhancing care efficiency, providing continuous monitoring, and preventing caregiver overwork (Lee et al. 2022). To fully realize the potential of AI in elder care, understanding factors influencing technology acceptance, both pre- and post-implementation, is essential (Peek et al. 2014).

4.2.7 The Promise and Challenges of Digitalization in Elder Care

Digitalization holds significant promise in addressing the healthcare challenges faced by the aging population. Wearables, telehealth, and AI-powered robotics offer personalized, accessible, and efficient healthcare solutions that can improve the quality of life for older adults. However, realizing the full potential of digitalization requires addressing various technical, social, and regulatory challenges. A supportive ecosystem that fosters innovation, usability, and technology acceptance in care settings is vital to ensuring successful implementation and adoption (Bohr and Memarzadeh 2020).

4.3 Methodology

This chapter is based on a systematic review of existing literature, aimed at understanding the global aging challenges and the potential of digitalization in elder care. We conducted a comprehensive review of articles, policy reports, and research papers related to elder care, digital therapeutics, and voice-enabled technology. The inclusion criteria focused on studies published within the last two decades that addressed technological interventions in elder care, particularly those highlighting voice-assisted technologies and their role in bridging healthcare gaps.

We followed a structured approach, first identifying key themes—such as digital health technology, healthcare accessibility for aging populations, and the role of AI in elder care. Google Scholar and Pubmed were mostly used to get relevant articles using these themes. By synthesizing the findings, we developed a framework for evaluating how digital technologies can address the needs of the older population, offering a pathway for improving care services and overcoming the healthcare disparities that aging societies face.

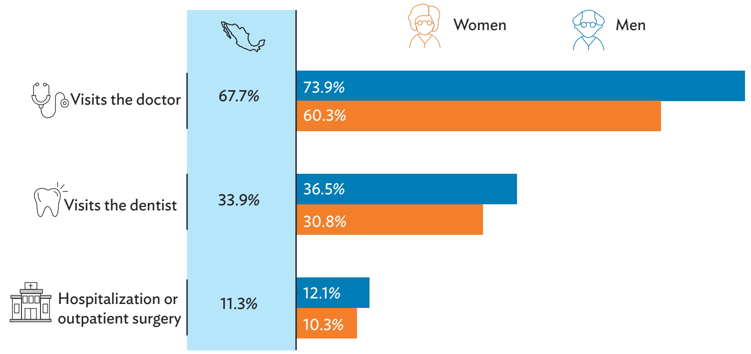
4.3.1 Demographic Changes within the Aging Population

Across the globe, populations are undergoing a significant transformation—they are graying. This phenomenon is driven by two critical demographic trends, a relatively new development in human history where populations were traditionally younger with shorter lifespans. The most evident is the increase in life expectancy, meaning people live longer than ever. However, a less obvious but equally important factor is the decline in birth rates. As birth rates fall and lifespans rise, the proportion of older individuals within a population steadily grows (National Research Council 2012) .

Economies across the globe are aging; however, the rate of population aging varies tremendously across regions and economies at different levels of development. For example, the share of older individuals grew substantially over the past 50 years in HICs and in many economies in Asia. In contrast, economies in sub-Saharan Africa experienced virtually no aging over this same period

In Mexico's *Health and Ageing Study 2021*, they estimated a population of 25.9 million persons aged 53 years and older, of whom 45.6% were men and 54.4% were women. Of these, 45.4% lived in urban localities—that is, those with 100,000 inhabitants or more—and 54.6% in localities with fewer than 100,000 inhabitants. Of the population aged 53 years and older, 67.7% reported having attended a consultation or medical visit in the past 12 months, 33.9% visited a dentist and 11.3% reported having been hospitalized or having had some outpatient surgery. Women reported receiving some type of health service more than men. Of the total population of study, 23.3% (6.0 million) did not use any of these types of health service.

Figure 4.2: Population Aged 53 Years and Older, by Gender and Type of Health Service Utilized in a Span of 12 Months in Mexico



Source: INEGI (2021).

With respect to self-reporting of previous diagnoses of chronic illnesses, the most common illnesses among the population aged 53 years and older were: hypertension (43.3%), diabetes (25.6%), and arthritis (10.7%). The self-reported prevalence of these illnesses differed by sex: women reported the main chronic-degenerative illnesses in greater percentages.

Table 4.1: Distribution of the Population Aged 53 Years and Older in Mexico by Gender, Age Group, and Principal Illness, 2018 and 2021

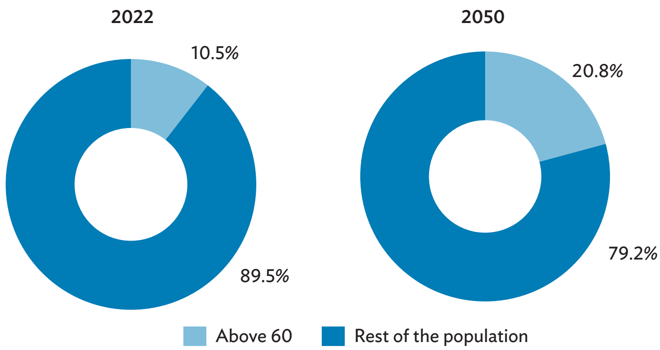
	2018				2021			
	Women		Men		Women		Men	
	53–59 yrs	60+ yrs	53–59 yrs	60+ yrs	53–59 yrs	60+ yrs	53–59 yrs	60+ yrs
Hypertension	39.8%	52.4%	28.8%	38.5%	40.9%	54.9%	29.7%	38.6%
Diabetes	23.9%	27.3%	18.6%	21.8%	26.0%	29.2%	20.5%	23.7%
Lung disease	4.1%	7.2%	2.9%	5.0%	4.8%	4.8%	2.3%	4.1%
Arthritis	10.3%	18.5%	2.7%	9.45%	10.9%	17.4%	3.2%	6.5%
Heart attack	2.6%	3.4%	2.4%	4.6%	1.2%	2.6%	3.5%	4.9%
Stroke	1.3%	3.2%	3.5%	3.5%	0.8%	3.1%	1.3%	3.3%
Cancer	2.7%	3.0%	0.7%	2.1%	2.3%	3.1%	0.8%	2.1%

Source: INEGI (2021).

Delving deeper into the population of certain economies, like the People's Republic of China, a nation experiencing a rapidly aging population, serves as a prime illustration. By the end of 2022, a staggering 280.04 million people, constituting a remarkable 19.8% of its national population, were aged 60 and above. This number is projected to continue its meteoric rise, exceeding 300 million in 2024 and reaching a peak of 524 million by 2052 (Li, Chen, and Zhang 2024). According to projections by Chen (2022), the number of people aged 65 and over is expected to follow a similar trajectory, exceeding 300 million in 2033, surpassing 400 million in 2050, and reaching a peak of 436 million in 2057 (Peng 2023).

The percentage of older citizens in India has been increasing swiftly in recent years, and this trend is likely to continue in the coming decades. According to projections, the share of the population over the age of 60 years is expected to rise from 10.5% in 2022 to a significant 20.8% in 2050 (UNFPA 2023). By the end of the century, the older population is projected to constitute 36% of the economy's population. This sharp rise in the older population is particularly evident from 2010 onwards, coinciding with a decline in the youth population (under 15 years old), highlighting the rapid pace of aging in India (Banerjee 2021).

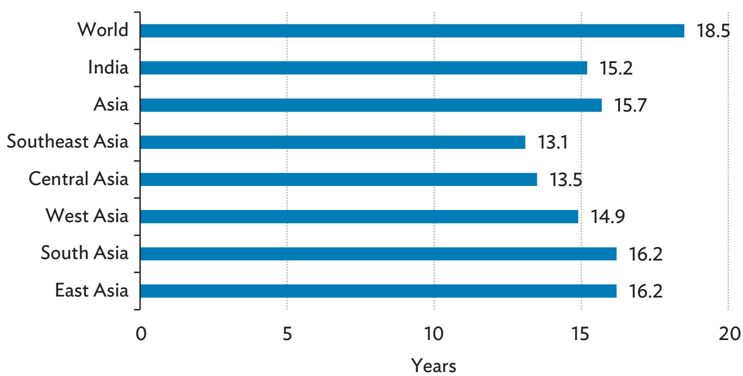
Figure 4.3: Projected Growth in India's Older Population (2022 vs. 2050)



Source: UNFPA (2023).

Reduced fertility rates and mortality rates in developing economies, including India, have also contributed to a rise in the proportion of the older population, those aged 60 years and above. As per the *Population Projections Report, 2020*, senior citizens account for 14% of the total population of India, and this number is estimated to increase to 20.8% by 2050 (UNFPA 2023). Figure 4.4 shows the annual growth rate of the older population from 2010 to 2020 for various regional groups of Asia.

Figure 4.4: Annual Growth Rate of the Older Population from 2010 to 2020 (%)



Source: UNFPA (2023).

The global demographic landscape is profoundly changing, particularly regarding the aging population. In 2022, a significant 1.1 billion individuals, accounting for 13.9% of the total global population of 7.9 billion, were aged 60 years or above (UNFPA 2023). This demographic segment is poised for remarkable growth in the coming decades, with projections indicating that over the next 30 years, the number of older persons worldwide will double to a staggering 2.1 billion by 2050, constituting approximately 22% of the total population.

This exponential increase in the number and proportion of older persons is not confined to specific regions but is anticipated to be a global phenomenon. Both developed, and less developed regions are expected to experience a substantial rise in the share of older persons within their populations. In more developed areas, the proportion of older persons is projected to surge from 26% in 2022 to 34% in 2050. Similarly, in less developed regions, this share is anticipated to climb from 11.5% to 20% during the same period. According to the United Nations Population Fund India, the absolute number of older persons in less developed regions is expected to more than double from 772 million in 2022 to a projected 1.7 billion in 2050 (UNFPA 2023).

Asia, with a population of 649 million aged 60 years and above, currently holds the largest share of the global older population (UNFPA 2023). However, the rapid aging trend is not unique to any region, as populations across continents are experiencing similar demographic shifts. These data underscore the urgent need for comprehensive strategies and policies to address the diverse needs and challenges associated with an aging population on a global scale.

Existing technology for wise aging

As the global population ages, there is a growing need for innovative technologies to support older adults living independently and maintaining their quality of life. Recent technological advancements, such as the internet of things (IoT) and ambient assisted living, which facilitates communication between connected devices and the cloud, have shown great promise in addressing aging populations' challenges (Junaid et al. 2022). The global internet of medical things market is expected reach $187.60 billion by 2028, more than four times its worth in 2020 at $41.17 billion, according to Fortune Business Insights (2025).

There are certain voice-assisted healthcare technologies in the market. Amazon Alexa has enhanced its capabilities with features complying to the Health Insurance Portability and Accountability Act, enabling healthcare providers to securely exchange private patient data. Through voice commands, Alexa assists patients in managing tasks like scheduling appointments, checking prescriptions, and monitoring chronic conditions. Similarly, Google Assistant has been integrated into healthcare, providing users with access to health information, medication reminders, and even the ability to connect with doctors. In collaboration with hospitals like the Mayo Clinic, Google offers voice-driven healthcare guidance for specific medical conditions. Orbita, a conversational AI platform, specializes in healthcare and supports voice-enabled services for remote patient monitoring, telehealth, and patient engagement. On the clinical side, Suki, a voice-powered digital assistant, aids doctors by streamlining administrative tasks, such as clinical documentation, allowing them to focus more on patient care.

One of the critical pillars of aging is the integration of smart home technologies. These systems utilize sensors, such as passive infrared sensors, to detect the presence and movements of residents within their homes. By tracking activities such as room occupancy, toilet usage, and sleep patterns, these technologies can provide valuable insights into an individual's daily routine. This information can be leveraged to enhance safety, monitor health indicators, and provide timely assistance for older people (Facchinetti et al. 2023). Moreover, external memory aids, such as digital-memory notebook mobile applications, are seamlessly integrated with smart home data, which utilize activity recognition techniques to assist users in managing daily tasks and medication schedules (Dahmen et al. 2018). Studies have shown that digital prompts and reminders can significantly improve medication adherence and overall health outcomes in older adults with chronic conditions (Alkhaldi et al. 2015).

Specific research papers have proposed some technology to aid patients with chronic diseases. Goldberg et al. (2003) describe a system called AlertNet that includes an electronic scale placed in patients' homes and an individualized symptom response system linked via a standard phone line using a toll-free telephone number to a computerized database monitored by trained cardiac nurses. Celler et al. (2014) describe devices with user-friendly interfaces able to detect a range of vital signs, allow patient video-conferencing and messaging capability, fill out clinical questionnaires specific to patient condition, and deliver educational/training material. In the dispersed healthcare landscape, fragmented infrastructure can make accessing services challenging. Unified health interfaces aim to overcome this hurdle by establishing an ecosystem that facilitates seamless communication among stakeholders across different platforms and enables the exchange of health data with patient consent, operating as an open network, thereby promoting interoperability among digital health services. Patients can discover, schedule, engage in, and pay for services offered by collaborating providers through any unified health interface-enabled application they prefer.

The convergence of AI, IoT, and telemedicine has led to the development of hybrid technologies that bridge the gap between home-based care and medical interventions. Most current studies have shown encouraging results, confirming that combining AI and IoT can help older people live more accessible and better lives (Qian et al. 2021). In addition, remote health monitoring in smart home platforms offers unobtrusive and continuous monitoring of physiological signs. Wearable devices, including indoor positioning, activity recognition, and vital sign monitoring sensors, are crucial in tracking health parameters and detecting potential emergencies such as falls (Majumder 2017). The combination of ambient intelligence and domotics can respond to older adults' desire to live independently from extensive forms of care (Meulendijk et al. 2011). These technologies ensure maximum independence for older adults and provide caregivers and family members peace of mind. Another significant development in technology in elder care is the emergence of SARs. These robots are designed to assist with daily living activities and improve the psychological well-being of older adults. From service robots aiding with household tasks to companion robots providing companionship and entertainment, SARs have the potential to enhance social engagement and reduce feelings of loneliness among older adults (Majumder et al. 2017).

The United States' health systems and hospitals are also turning to another IoT tool—remote patient monitoring technology—to improve outcomes and reduce costs. This type of patient care leverages connected devices with IoT sensors to offer providers a continuous stream of real-time health data such as heart rate, blood pressure, and glucose monitoring.

As technology advances and AI algorithms become more sophisticated, we are moving toward a predictive rather than a purely preventive approach. This entails algorithms capable of anticipating a person's susceptibility to various conditions. For instance, Google and the Massachusetts Institute of Technology have developed algorithms capable of predicting dementia at an early stage. Typically, dementia is identified after it has progressed significantly, but early detection enables potential damage to be reversed and the condition to be managed more effectively. Furthermore, emergency response systems, such as smartphone-based calling systems and smart beds embedded with vital sign sensors, offer rapid emergency assistance. These systems can automatically generate calls to emergency services or caregivers, providing accurate location information using embedded global positioning systems and facilitating timely intervention (Majumder 2017).

As we continue to witness advancements in gerontechnology, an interdisciplinary field linking existing and developing technologies to the aspirations and needs of aging and aged adults, it is essential to prioritize solutions that support the functional status of older adults and address their emotional well-being. Technologies like Amazon Echo and Alexa exemplify how voice-activated sensors can promote engagement, independence, and social inclusion among older populations, including inducing them to listen to music or to control the thermostat and reminding them of important events(Lee and Kim 2020).

Challenges in technology adoption by older adults

In the realm of technology aimed at supporting older adults, there lies a pivotal challenge in aligning the development of these innovations with the desires and preferences of the aging population. Surveys have indicated that a significant portion of older individuals, particularly those grappling with chronic illnesses, are skeptical about the benefits of smart home technologies (Tomita et al. 2007). This skepticism raises pertinent questions about the suitability and appeal of these technologies for older adults. A qualitative study by Ghorayeb, Comber, and Gooberman-Hill (2021) has shed light on the preferences of older individuals, emphasizing the importance of discreet and easily adaptable technology that grants them control and customization options.

Moreover, cognitive impairments prevalent among older adults present another obstacle to adopting smart home technologies. As the aging population continues to grow, the burden on healthcare resources escalates, necessitating cost-effective solutions to assist individuals with cognitive difficulties in their daily activities. The desire of older adults to age in place further accentuates the urgency for advancements in smart home technologies that can support them, their families, and caregivers efficiently (Facchinetti et al. 2023).

However, older adults' journey toward widespread acceptance of smart home technologies is fraught with challenges. While exposure to technology increases with time, older individuals often face cognitive, physical, and sensory limitations that hinder their ability to adapt to new technologies. Concerns regarding smart home technologies' affordability, complexity, and privacy implications further impede their adoption. Additionally, the fear of burdening their children as caregivers or compromising personal health adds to the apprehensions surrounding these technologies (Facchinetti et al. 2023). In addressing these challenges, it becomes imperative to prioritize the independence and well-being of older adults. A user centric approach that enhances the quality of life through technology is crucial. Financial accessibility must also be considered, as older adults may hesitate to invest in systems whose long-term utility remains uncertain (Gunge and Yalagi 2017).

Furthermore, while AI and gerontechnology hold promise in revolutionizing elder care, concerns linger regarding the depersonalization of care through algorithm-based standardization, the discrimination of minority groups through generalization, and the discipline of users through monitoring and surveillance (Rubeis 2020). Safeguarding privacy and ensuring safety are paramount in designing smart home technologies, promoting interoperability, and addressing the complexity of IoT systems. Efforts toward developing comprehensive smart home solutions that integrate automation, health monitoring, and environmental assessment are essential to realizing the full potential of these technologies in supporting aging-in-place(Majumder 2017).

A case for voice-assisted technology

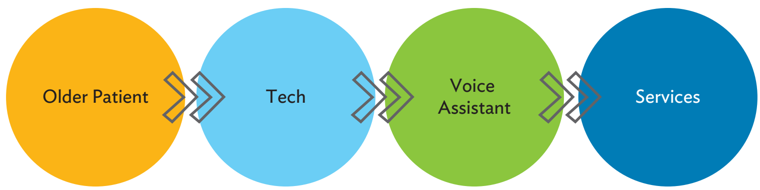
The intersection of healthcare and technology has significantly improved healthcare access and delivery in recent years. Initiatives such as the Ayushman Bharat Digital Mission (ABDM) and eSanjeevani in India have demonstrated the transformative potential of integrating technology into healthcare systems. The ABDM aims to achieve universal access to quality healthcare services leveraging IT and associated technologies. Central to this mission is eSanjeevani, the National Telemedicine Service of India, which facilitates quick access to doctors and specialists through smartphones. By overcoming geographical barriers and streamlining healthcare information, eSanjeevani has revolutionized primary healthcare services, particularly benefiting rural populations with limited access to healthcare.

In 2024, the World Health Organization (WHO) launched the Global Initiative on Digital Health (GIDH), which is a collaborative network aimed at accelerating national digital health transformation. The GIDH focuses on aligning resources and prioritizing economy-level needs to support the implementation of the Global Strategy on Digital Health 2020–2025. By fostering knowledge exchange and capacity building, the GIDH aims to facilitate sustainable digital health systems that adapt to evolving healthcare demands globally.

In the United Kingdom, the National Health Service (NHS) embraces digital innovation to improve patient care and reduce healthcare burdens. Initiatives such as AI-driven risk identification for hospitalization and providing health information through voice-assisted technology like Alexa demonstrate the transformative potential of digital solutions in healthcare. By leveraging advanced technology, the NHS aims to enhance patient outcomes, reduce healthcare costs, and improve healthcare delivery. AI technologies like ChatGPT are transforming mental healthcare for older adults by providing personalized conversation and emotional support. By understanding the unique needs of each user, ChatGPT fosters social connections and alleviates feelings of loneliness among older adults. ChatGPT enables older adults to maintain a sense of connectedness and belonging through virtual chat groups and customized interactions, addressing this demographic's critical mental health challenges.

The collaboration between the NHS and Amazon to provide reliable health information through voice-assisted technology underscores the importance of digital innovation in healthcare delivery. By making healthcare information more accessible through voice commands, this initiative aims to empower patients, particularly those with limited access to traditional devices or internet connectivity. This partnership represents a significant step towards democratizing healthcare information and improving patient engagement.

Figure 4.5: Flow Chart of Voice-Assisted Technology Services



Source: Authors.

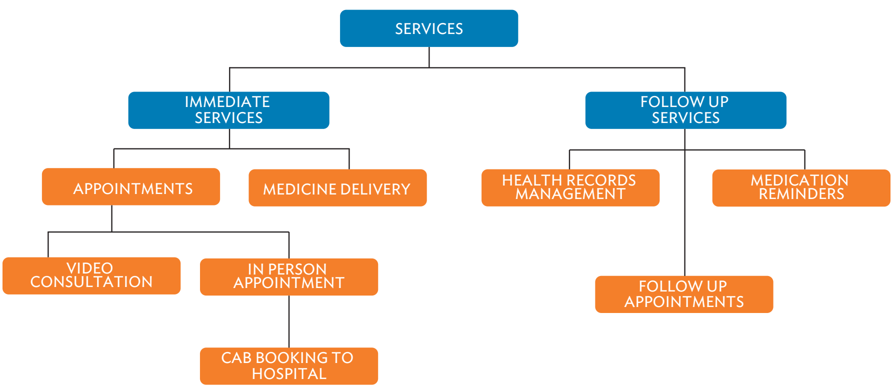
Despite the advancements in digital healthcare, there exists a crucial need to address the specific healthcare needs of the older population. Voice-assisted technology presents a unique opportunity to address these needs by offering personalized and accessible healthcare services. Integrating voice-assisted technology, such as Alexa, with AI can provide customized health solutions based on daily requirements and preferences. Figure 4.3 presents the components of voice-assisted technology that can aid older people in healthcare services. There can be two cases of the technology as follows:

Case 1 If an older individual experiences a headache, they can ask the VAT, "Hey XYZ, my head is aching," and receive suggestions for home remedies. If the discomfort persists, the technology can advise booking an appointment with a doctor. Further, the internet-connected VAT can facilitate seamless appointment booking by providing a list of nearby hospitals and recommending the most suitable doctor based on their experience. Additionally, the design can extend to assisting older individuals in booking a cab (integrated with ride-hailing apps) for their hospital appointments, streamlining the entire healthcare process through voice commands.

Case 2 If an older individual feels unwell and, for various reasons such as an emergency or discomfort, prefers not to visit the hospital, they might say, “Hey XYZ, I’m experiencing a headache and would like to consult a doctor via video call.” Subsequently, the technology would inquire about basic details such as age and duration of the headache. Based on the responses, it would suggest nearby hospitals and recommend the most suitable doctor for the specific ailment. Following this, the voice assistant would schedule a video call appointment with the doctor. When the appointment time arrives, the older person would instruct the voice assistant to connect them to the doctor via video call. At that point, the technology would activate the TV or laptop and establish a connection with the doctor. Following the consultation, if the doctor recommends any medication, the voice-assisted technology, with the consent of the older individual, will proceed to order the prescribed medicine. The medication will be delivered directly to the individual’s doorstep for their convenience.

Figure 4.6 captures the flow chart of the services that VAT can provide to an older individual for healthcare. VAT can serve as a helpful reminder for older individuals to schedule follow-up appointments with their doctor. For instance, if the doctor advises a follow-up visit

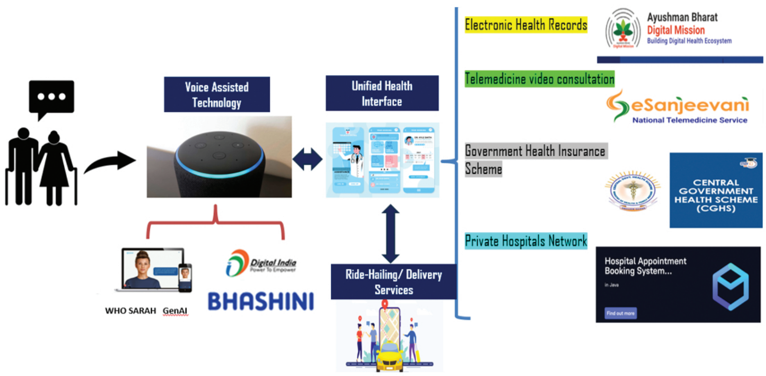
Figure 4.6: Chart illustrating the Services Provided by Voice-Assisted Technology in Healthcare



Source: Authors.

in 20 days, the technology will prompt the individual to schedule the appointment, ensuring they see the same doctor. Additionally, if transportation assistance is needed, the technology can even arrange a cab to take them to the hospital. It can also remind the older adult to take their medication at the specific times prescribed by the doctor. For instance, it may say, “It’s time to take your medication. Please take it with lukewarm water and avoid eating anything for the next half-hour.” This feature ensures that the individual adheres to their medication schedule and follows any specific instructions their healthcare provider provides.

Figure 4.7: Integration of Different Services and Voice-Assisted Technology



Source: Authors.

Figure 4.7 illustrates how VAT integrates with various healthcare platforms to enhance the healthcare experience for older users. At the core of the system is VAT (such as Amazon’s Alexa or other AI-driven voice interfaces like WHO’s SARAH and India’s Bhashini platform). This technology serves as a bridge for older individuals, enabling them to interact with healthcare services through voice commands. The flowchart connects the VAT to multiple healthcare components:

Unified health interface: Through VAT, users can access a unified health interface that offers a comprehensive view of various healthcare services. This interface can connect to:

- Electronic health records, providing users access to their medical histories, prescriptions, and other personal health data.

- Telemedicine video consultations via platforms such as eSanjeevani, India's national telemedicine service, allowing older patients to consult doctors remotely.
- Government health insurance schemes like Ayushman Bharat and the Central Government Health Scheme, giving access to insurance benefits and coverage information.
- Private hospitals network and hospital appointment booking systems, allowing users to schedule hospital visits efficiently.

Ride-hailing and delivery services: VAT also connects to ride-hailing and delivery services, which can be used to arrange transportation to medical appointments or to deliver medications and other healthcare essentials.

Furthermore, VAT can help users securely store and access their health records. This enables seamless sharing of pertinent information with healthcare providers during consultations. Should the individual wish to consult another doctor, they need not worry about carrying physical reports or remembering specific health details. The voice assistant can effortlessly share the necessary information with the new doctor, streamlining the consultation process and ensuring continuity of care. This streamlined approach empowers older adults to take control of their health and well-being, reducing dependence on caregivers and improving overall quality of life. Additionally, voice-assisted technology can help overcome barriers such as limited mobility, vision impairment, or cognitive decline, making healthcare services more accessible to older adults with diverse needs.

4.4 Conclusion

In conclusion, as the population of older adults is growing, there is an urgent need for innovative solutions to address their diverse healthcare needs effectively. In this context, the integration of voice-assisted technology emerges as a promising avenue for transforming elder care and bridging healthcare gaps.

Voice-assisted technology offers personalized, accessible, and efficient healthcare services tailored to older adults' unique needs and preferences. By leveraging artificial intelligence and voice commands, this technology enables seamless access to healthcare information, appointment booking, medication management, and remote consultations. Moreover, it fosters social engagement, independence, and empowerment among older individuals, enhancing their overall quality of life. The potential of voice-assisted technology in elder care is underscored by its ability to overcome barriers such as limited mobility, vision impairment, and cognitive decline, making healthcare services more inclusive and accessible. Through innovative features like medication reminders, appointment scheduling, and health record management, voice-assisted technology empowers older adults to take control of their health and well-being while reducing dependence on caregivers.

In light of the challenges posed by population aging, it is imperative to prioritize developing and implementing voice-assisted technology in healthcare systems worldwide. By embracing digital innovation and leveraging the transformative potential of voice-enabled solutions, we can address the evolving healthcare needs of the aging population, promote healthy aging, and enhance the quality of life for older adults globally. As we navigate the complexities of aging demographics and healthcare delivery, we must adopt a holistic approach that prioritizes the dignity, autonomy, and well-being of older individuals. Voice-assisted technology represents a significant step towards realizing this vision, offering a pathway to a more inclusive, accessible, and personalized healthcare experience for older adults in the digital age. Through collaborative efforts among policymakers, healthcare professionals, technology developers, and community stakeholders, we can harness the full potential of voice-assisted technology to build a more age-friendly and supportive healthcare ecosystem for generations to come.

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PART II

Regional Insights into Digital Healthcare for Older People

5

Use of Telemedicine in the Care of Older Patients During the COVID-19 Pandemic: Case Studies of Singapore and Hong Kong, China

Sabrina Ching Yuen Luk and Agnes Xue Lishan

5.1 Introduction

Traditionally, a patient attends a face-to-face consultation at a clinic or a hospital where a doctor thoroughly assesses the patient's condition by observing, palpating, evaluating vital signs, and conducting hands-on tests (Alpert 2024). While traditional, face-to-face consultations have the advantages of higher diagnostic accuracy, enabling immediate intervention and addressing patients' psychological and emotional needs (Alpert 2024), their disadvantages include longer wait times and bringing inconvenience to patients who have mobility issues or live in remote areas. "The advent of telemedicine has heralded a new era in healthcare delivery, offering myriad possibilities to enhance patient outcomes and expand access to care" (Ezeamii et al. 2024). Telemedicine refers to the use of information and communications technology (ICT) by licensed healthcare professionals to remotely diagnose, treat, and communicate with patients in a real-time manner, manage patients' chronic conditions, monitor patients' vital signs or recovery progress after surgery, deliver rehabilitative care or therapy sessions to patients, and allow rapid transmission of medical data and images for review. It serves as an adjunct modality to traditional, face-to-face consultations and is best used for non-urgent cases, routine check-ups, outpatient follow-up, post-discharge care, preventive care, and patients with mobility issues. It "has a significant role in more than 13 major areas of health and treatment" (Jafarzadeh et al. 2022, 879), including teleconsultation, remote imaging, telepathology, remote patient monitoring, remote surgery, patient care in emergencies, teledermatology, and remote psychotherapy (Jafarzadeh et al. 2022). The 2019 coronavirus disease (COVID-19) pandemic caused by the global spread of an infectious respiratory disease accelerated the adoption of telemedicine across the globe to reduce healthcare professionals' and patients' risk of virus infection and transmission, conserve personal protective equipment (PPE) during severe shortages, and reduce strain on overwhelmed healthcare facilities. Consequently, the global telemedicine market was valued at $107.5 billion in 2024 and is projected to reach around $432 billion by 2032, expanding at a compound annual growth rate of 19% during the forecast period (Pawar 2024).

According to the World Health Organization, older adults are more vulnerable to COVID-19 infection and are more likely to have severe effects from the disease because they have weakened immune systems and multiple chronic diseases (WHO 2020). Both Singapore and Hong Kong, China face a rapidly aging population due to declining fertility rates and longer life expectancy. Both economies used telemedicine to care for older patients during the COVID-19 pandemic, and this study examines how they did so. It looks at the benefits and barriers to using telemedicine in caring for older adults and considers critical factors for the use and growth of telemedicine in future.

5.2 Case Study of Hong Kong, China

5.2.1 The Use of Telemedicine Before the COVID-19 Pandemic

The use of telemedicine in Hong Kong, China began in 1998 when the Hospital Authority, which develops and manages all public hospitals in the city, leveraged video conferencing technology to enable healthcare professionals to remotely provide medical consultations for some residents living in residential care homes for older adults (Cheng 2021). In 2003, the Telephone Nursing Consultation Service (TNCS) was introduced in the East Cluster (Yam 2010).[1] The TNCS was a pilot scheme enabling trained nurses to leverage an advanced telephone support system and the clinical management system of the Hospital

[1] The East Cluster is one of the seven hospital clusters managed by the Hospital Authority.

Authority to provide consultation and one-stop support for high-risk older patients discharged from public hospitals (Ho 2006; Yam 2010). Under the scheme, a nurse makes a proactive outbound call to an older patient within 48 hours of hospital discharge (Kwong 2018) to assess the patient's health condition based on telephone triage protocols, give the patient prompt advice on drug and diseases management, home care and medical appointments, or refer the patient to the community nursing service, allied health services, volunteer service, or a District Elderly Community Centre, if necessary (Ho 2006). A follow-up call would be made by the nurse within 24 to 48 hours to the patient to see if the advice was effective in improving the patient's health condition (Ho 2006). Alternatively, the patient could call the service hotline if they needed the TNCS although the service was not available on Sundays and public holidays (Ho 2006). A study found that the TNCS could reduce older patients' attendance to the Accident and Emergency Department by 36.5% and their emergency admission by 35.8% (Ho 2006). It also found that older patients and their caregivers were highly satisfied with the TNCS because the service helped them reduce their worry (100%), improve their health knowledge (100%), get referrals for an appropriate health service (100%), and self-manage their diseases (about 95.6%) (Ho 2006).

The Community Health Call Centre, which was established by the Hospital Authority in April 2009, enables trained nurses to leverage the Call Logging System to provide consultation and one-stop support for high-risk discharged older patients, diabetic patients, and patients with mental illness over the phone (Hospital Authority 2014; Kwong 2018). The call logging system integrates the clinical management system, supports short message, paging, and web fax services, uses algorithms to aid decision making and generates call records, reports, and management statistics for resource planning (Hospital Authority 2014). The Community Health Call Centre runs all year round and its service is available on Sundays and public holidays (Hospital Authority 2014).

The Hospital Authority (HA) Go mobile application, which was launched in December 2019, supports teleconsultation via embedded Zoom (Yeung et al. 2022). Patients who are in a stable condition and require no physical examination would be invited by healthcare staff to attend teleconsultation sessions (Hospital Authority n.d.). To attend the teleconsultation sessions, patients must first register for HA Go and activate their HA Go account (Hospital Authority n.d.). Besides, they must be in Hong Kong, China on the day of the teleconsultation. They must sign into their HA Go account to register and make an electronic payment within 2 hours before their scheduled appointment time (Hospital Authority n.d.) and give consent to attend the teleconsultation session. They would enter the teleconsultation room after clicking the push notification sent by the staff around the appointment time and then begin the session after identity verification (TeleHealth App Introduction 2023). HA Go also enables eligible patients to watch rehabilitation exercise videos prescribed by healthcare professionals after assessment so that they can exercise in the comfort of their homes (Government of the Hong Kong Special Administrative Region 2019). In 2022–2023, about 8,700 attendances were recorded for HA Go teleconsultation services, enabling patients to remotely receive dietetic service, physiotherapy, occupational therapy, speech therapy, and clinical psychology services (Hospital Authority 2023).

5.2.2 The Use of Telemedicine During the COVID-19 Pandemic

On 23 January 2020, Hong Kong, China recorded the first confirmed case of COVID-19 (Leung et al. 2021). The case-patient was a person from the People's Republic of China traveling to Hong Kong, China from Wuhan by high-speed rail (Leung et al. 2021). Since January 2020, Hong Kong, China has experienced six waves of COVID-19 (Yang et al. 2024). During the first four waves (i.e., January 2020 to April 2021), the government contained the spread of the virus through non-pharmaceutical interventions, which included strict border-control measures, quarantine of close contacts, school closures, work-from-home arrangements and mandatory wearing of face masks (Yang et al. 2024). No community outbreaks were reported from 1 May 2021 to 30 December 2021 (Wong et al. 2022). Before the start of the fifth wave, Hong Kong, China logged a total of 12,636 confirmed cases of COVID-19 and 213 COVID-19 deaths (Wong et al. 2022). The start of the fifth wave was due to the spread of the Omicron variant by two flight attendants who violated COVID-19 home quarantine rules when they went back to Hong Kong, China (Li 2022). During the fifth wave (31 December 2021 to 31 May 2022) (Wong et al. 2022), there was vertical airborne transmission of Omicron subvariant BA.2 in high-rise residential buildings through faulty sewage drains or shared lightwells (Cheng 2022). Omicron subvariant BA.2, which was 4.2 times more contagious than the Delta variant (Chen and Wei 2022) and 17 times more capable than the Delta variant to escape existing vaccines (Chen and Wei 2022), led to over 1.2 million confirmed cases of COVID-19 and 9,318 COVID-19 deaths in Hong Kong, China (Wong et al. 2022). The sixth wave began on 1 June 2022 when there was the spread of Omicron subvariant BA.5 (Wong et al. 2022). From 1 June to 25 September 2022, Hong Kong, China logged a total of 532,801 confirmed cases of COVID-19 and 585 COVID-19 deaths

(Wong et al. 2022). In 2022, Hong Kong, China logged 9,291 COVID-19 deaths (Centre for Health Protection of the Department of Health and Hospital Authority 2023). Among these recorded COVID-19 deaths, 74.2% were among adults aged 80 years or over, followed by those aged between 70 and 79 years (15.4%), those aged between 60 and 69 years (7.3%), those aged between 40 and 59 years (2.7%), and those aged 39 years and below (0.4%) (Centre for Health Protection of the Department of Health and Hospital Authority 2023). Meanwhile, 70% of COVID-19 deaths were unvaccinated persons (Centre for Health Protection of the Department of Health and Hospital Authority 2023). The majority of them (75%) were adults aged 80 years or over (Centre for Health Protection of the Department of Health and Hospital Authority 2023). This indicated that unvaccinated older adults aged 80 years or over were most vulnerable to COVID-19.

The outbreak of COVID-19 severely disrupted the delivery of rehabilitation services to Hospital Authority patients in late January 2020, leading to a 50% decrease in attendance (Ku et al. 2021). For this reason, 1,112 physiotherapists, occupational therapists, and speech therapists in the Hospital Authority leveraged a telerehabilitation platform to prescribe musculoskeletal, pulmonary, and swallowing training videos to patients who could access the training videos through the rehabilitation app (Ku et al. 2021). This resulted in a drastic increase in the total number of patients prescribed from 1,057 in December 2019 to 9,101 in late July 2020 (Ku et al. 2021). Patients aged between 51 and 60 years had the highest prescription rate (about 29%), followed by those aged between 61 and 70 years (about 25%) (Ku et al. 2021). A total number of training videos prescribed reached 131,995 by the end of July 2020, with the overall adherence rate of almost 82% (Ku et al. 2021).

From April to December 2022, the Community Geriatric Assessment Teams of the Hospital Authority leveraged telehealth to provide medical and nursing care to residents living in residential aged care (Government of the Hong Kong Special Administrative Region 2023). It recorded about 47,000 attendances of the telehealth service (Government of the Hong Kong Special Administrative Region 2023a). From July 2022 to late January 2023, the Hospital Authority allowed patients with COVID-19 to use the HA Go app to make and attend their medical appointments via teleconsultation (Hospital Authority 2023). Patients with COVID-19 could also place medication delivery orders via HA Go so that prescription medicines could be directly delivered to their homes (Hospital Authority 2023). Over 214,900 attendances were recorded for HA Go teleconsultation, of which about 42,100 attendances (about 19.6%) were adults aged 70 years or over (Government of the Hong Kong Special Administrative Region 2023b). Teleconsultation services for patient with COVID-19 were terminated on 30 January 2023 when the health officer stopped issuing compulsory isolation orders to patients with COVID-19 on the same day (Government of the Hong Kong Special Administrative Region 2023b).

From March 2022 to March 2023, the "Fight the Virus Together – Chinese Medicine Telemedicine Scheme", which was supported by the Chinese Medicine Development Fund, was introduced by the government to subsidize Chinese medicine practitioners to have teleconsultations with COVID-19 patients via WhatsApp video calls and deliver Chinese medicines to patients (Government of the Hong Kong Special Administrative Region 2022). Close to 35,000 patients had benefited from the scheme (Chinese Medicine Development Fund n.d.).

5.2.3 Benefits and Barriers to Using Telemedicine for Older Patients during the COVID-19 Pandemic

Before the COVID-19 pandemic, the Hospital Authority provided telemedicine services for older patients and other patients via different technology tools. Telemedicine enabled patients to have timely access to medical care, empower them to self-manage their health conditions, and facilitate continuity of care remotely. It brought convenience to older patients with mobility issue or those living in remote areas. It helped save travel and consultation wait time as well as travel expenses for patients. It also helped reduce the cost of medical escort and transport for nursing homes (Hui et al. 2001).

During the COVID-19 pandemic, teleconsultation helped reduce doctors' and patients' risk of virus infection and transmission and enabled doctors to provide caregivers prompt advice on caring for patients at home. A study reported that a geriatrician's use of videocalls and WhatsApp messages allowed two severely frail geriatric patients with COVID-19 to be treated at home and recover fully (Kong 2022). Geriatric telemedicine enabled the geriatrician to properly guide family caregivers and helpers to attend to the frailty syndromes (i.e., falls, delirium) of the patients by following their advice on medication, health monitoring, oxygen support, and fluid and nutrition management (Kong 2022). It enabled patients to receive personalized and holistic care at home with the presence of family members, avoiding damage from social isolation which was prevalent during the COVID-19 pandemic (Kong 2022).

Meanwhile, telerehabilitation made therapies more accessible, steadily improving patients' functional capacity and brought peace of mind to patients who declined to visit the Hospital Authority for fear of virus infection although it increased the workload of therapists.

A study that examined patients' and therapists' views on the use of the rehabilitation app during COVID-19 found that the overall satisfaction score of 2,623 patients for the rehabilitation app was high, with an average rating of 4.2 out of 5 (Ku et al. 2021). Patients praised the app for being easy to use, improving their participation in the home rehabilitation program and helpful for their rehabilitation (Ku et al. 2021). For therapists, the rehabilitation app facilitated home-based rehabilitation (Ku et al. 2021), but their workload increased because much time was spent on instructing and helping patients to install the app on their smartphones (Ku et al. 2021). This indicates that digital literacy skills of patients and support for users of the app need to be strengthened.

Older patients encountered barriers to using telemedicine during COVID-19. A survey that examined 600 Hong Kong, China residents' use of digital tools and services found that residents aged between 60 and 69 years had the lowest take-up rate of telemedicine services (12.7%) and the highest rate of never using telemedicine services (78.7%) compared to other age groups (Economic Impact 2022). Residents of this age group reported that lack of trust in digital services (38.7%), lack of digital know-how (18.7%), and absence of human touch (16%) were the top three barriers to using digital services (Economic Impact 2022). They lacked trust in digital services "for fear of privacy breaches, fraud and other cybersecurity threats" (Economic Impact 2022, 11), especially those who lived in communities for older people or only lived with domestic helpers or professional caregivers (Economic Impact 2022).

Another study that offered online primary care services to 429 older patients with multimorbidity during COVID-19 found that online services which had a higher number of attendance were pain management (460), sessions for sarcopenia and frailty (434), sessions for anxiety (329), and sessions for mindfulness (311) (Xu et al. 2023). For those who used online services, encountering technical issues with smartphones or Zoom, unstable internet connection, poor memory, and poor concentration were the top three factors interfering with their use of online services (Xu et al. 2023). They preferred online services more when there were fewer internet connection issues and a higher level of self-efficacy on mobile applications (Xu et al. 2023). Those who did not use online services (n=67) were older, lived alone, had lower income, received social security assistance, were less depressed, and had greater cognitive decline ($p < 0.05$) (Xu et al. 2023). These indicate that they may not have sufficient financial means to afford smartphones or broadband plan, not cognitively competent enough to use telemedicine services or not have family members to help them cope with technical issues arising from the use of telemedicine services.

Telemedicine is supposed to breakdown geographic barriers and enabled patients to access medical care remotely. However, the HA Go teleconsultation service that requires patients to be physically present in Hong Kong, China could not be provided to cross-border older adults residing in Fujian and Guangdong. During the COVID-19 pandemic, most of the cross-border older adults who had chronic illnesses could not return to Hong Kong, China for scheduled medical appointments due to strict border control measures and hence faced drug shortages (Huang, Ma, and Peng 2021). To address the problem, the government from February 2020 introduced a 9-month special support scheme to deliver prescription medications to these cross-border older adults with the assistance of the Hong Kong Federation of Trade Unions (Huang, Ma, and Peng 2021; Government of the Hong Kong Special Administrative Region 2020).

Another barrier to using telemedicine is that no legislation has been promulgated to regulate telemedicine. Ethical Guidelines on Practice of Telemedicine, which were issued by the Medical Council of Hong Kong in December 2019, only set out some general principles (e.g., due diligence) and standards on evaluating and treating patients, informed consent, drug prescription, keeping medical record and privacy that should be followed by doctors when practicing telemedicine (Medical Council of Hong Kong 2019). Doctors who contravene the ethical guidelines may be subject to disciplinary proceedings (Medical Council of Hong Kong 2019). Since the guidelines do not clearly lay down specific standards and requirements for practicing telemedicine, the medical sector adopts a prudent approach to telemedicine (Government of the Hong Kong Special Administrative Region 2022). Hence, telemedicine has not been widely used by doctors to provide consultation services for older patients and other patients.

5.3 The Case Study of Singapore

5.3.1 The Use of Telemedicine before the COVID-19 Pandemic

Telemedicine has grown in importance in Singapore over the past 10 years due to its potential to remotely provide personalized and continuous care for patients in a convenient and cost-effective manner. In 2014, the Singaporean government inaugurated the Smart Nation initiatives, with the objective of strategically leveraging information technology to enhance economic productivity, improve the convenience and sustainability of citizens' lives, and foster a more interconnected and responsive society (Lee 2014). It prioritized the use of information technology to transform health, education, transportation, finance, and solve urban problems (Smart Nation and Digital Government Office 2018). National Telemedicine Guidelines, which were issued by the Ministry of Health (MOH) in 2015, facilitated the use of telemedicine by setting out best practices in the areas of organizational readiness and accountability, human resources, technology and equipment, clinical standards, and outcomes (Ministry of Health 2015). It is the most comprehensive telemedicine guideline in Southeast Asia and comparable to other telemedicine guidelines overseas (Intan Sabrina and Defi 2021).

In 2016, the pilot launch of a mobile application called Health Marketplace SG, enabled discharged patients, especially those with limited mobility, to connect nurses from KK Women's and Children's Hospital and Singapore General Hospital to obtain home nursing services such as wound care and catheter management (Luk 2018). About 75 patients benefited from the use of this mobile application by late May 2017 (Luk 2018).

In 2017, three telehealth systems were launched in Singapore: Smart Health Video Consultation (SHVC), Smart Health TeleRehab, and the Vital Signs Monitoring system (Luk 2018). SHVC enables several healthcare institutions such as KK Women's and Children's Hospital and Singapore General Hospital to leverage video conferencing technology to remotely provide consultations, speech therapy, cancer patient care, and other services for post-discharged patients and those with mobility constraints (Bhunia 2017a). SHVC, accessible via computer or smartphone, ensured security through two-factor authentication and end-to-end encryption (Luk 2018). Smart Health TeleRehab enables therapists to "customise the level of difficulty of each exercise" (Ang Mo Kio Thye Hua Kwan Hospital 2017), use videoconferencing to immediately provide feedback to patients who wore sensors to perform rehabilitation exercises demonstrated by videos and use smart dashboards to asynchronously review patients' progress (Bhunia 2017b). The Vital Signs Monitoring system enables healthcare personnel to remotely monitor patients' vital signs such as blood glucose and blood pressure and give patients prompt advice on managing their health conditions without visiting hospitals (MOH 2017). In April 2018, the MOH launched the new Licensing Experimentation and Adaptation Programme, which was a regulatory sandbox to support the development of telemedicine (MOH 2018).

5.3.2 The Use of Telemedicine during the COVID-19 Pandemic

On 23 January 2020, Singapore recorded the first confirmed case of COVID-19. The case-patient was a Wuhan resident traveling to Singapore with nine companions (Goh and Toh 2021). In April 2020, the emergence of infection clusters in foreign worker dormitories, a drastic increase in the number of local unlinked cases, and greater community transmission led the government to impose an 8-week partial lockdown called a "circuit breaker" (Luk and Preston 2021). From 2 June 2020, economic and other essential activities were resumed safely and gradually following a three-phased approach (Government of Singapore 2020). From December 2020, Singapore launched the national vaccination program against COVID-19. From April 2021, Singapore had experienced a drastic increase in confirmed cases caused by the Delta variant. In 2022, Singapore experienced three waves of COVID-19 caused by the Omicron variant and sub-variants (Channel NewsAsia 2022). But Singapore's high vaccination rate enabled residents to "weather successive waves of COVID-19 infections" (MOH 2023). In February 2023, Singapore exited the acute phase of pandemic (MOH 2023), with the vast majority of COVID-19 restrictions lifted (Mohan and Lim 2023; Lim 2023). In 2024, the wave of COVID-19, which was the combined proportion of KP.1 and KP.2 variants, accounted for over two-thirds of confirmed cases in Singapore (MOH 2024a). As of 5 May 2024, Singapore had an estimated 3.1 million confirmed cases and 2,024 deaths (Mathieu et al. n.d.).

During the COVID-19 pandemic, the MOH suggested the use of telemedicine to deliver non-essential healthcare services such as outpatient therapy services (MOH 2020). Different healthcare providers accelerated the use of telemedicine to provide consultation and other services for patients. Migrant workers infected with COVID-19 could seek medical consultation through tele-kiosks in dormitories or their mobile phones (MOM 2020). The Community Care Facility Expo, which housed low-risk patients with COVID-19, provided urgent after-hour consultations for patients via videoconference on live streaming (Chia et al. 2021). SingHealth polyclinics (SHPs), which served over 1.3 million Singapore residents (Tan et al. 2023), leveraged the Zoom Video Conference platform, sanctioned by the Integrated Health Information Systems (Lee, Kang, and Tan 2021), to provide teleconsultation services to patients with chronic diseases. As of January 2021, over 1,000 video consultations had been conducted by SHP doctors (Lee, Kang, and Tan 2021). Besides, nurses at SHPs remotely conducted wound reviews via video consultations (Lee, Kang, and Tan 2021). Two of the SHPs also collaborated with community nurses to provide video consultation services for patients at senior activity centers or patients' homes (Lee, Kang, and Tan 2021).

Meanwhile, a geriatric center enabled nurses, dieticians, therapists, psychologists, social workers, and case managers to provide continuity of care for older patients via teleconsultation (Tan et al. 2020). A tertiary cancer center at the National University Cancer Institute, Singapore adopted a hybrid model to provide geriatric oncology services for patients via physical and video consultations (Chen et al. 2022). A restructured hospital used Zoom as a telepractice platform to provide outpatient communication and swallowing services to patients (Chua et al. 2022). It experienced a drastic increase in the percentage of patients receiving telepractice service from 48% in April 2020 to 89% in May 2020 (Chua et al. 2022). In January 2020, only 407 video consultations were offered by 53 public healthcare institutions in Singapore (Teo 2021). From October 2020 to January 2021, the number of video consultations offered by 125 public healthcare institutions increased from 6,718 to over 7,500 (Teo 2021). During the same period, the number of patients who sought medical help through video consultation in Singapore increased from 24,227 to over 36,000 (Teo 2021).

The Telemedicine Allocation and Reconciliation System (TMARS), which was "a unified, centrally managed cloud-based system with data privacy measures in place" (Kok et al 2022), triaged and managed COVID-19 patients in the community during the Omicron waves (Kok et al. 2022). It allowed doctors to remotely diagnose patients, input medical consultation notes, and prescribe medications via this platform (Kok et al. 2022). High-risk patients would be flagged by the TMARS to the MOH's COVID-19 operations team to get urgent medical services or escalation of care (Kok et al. 2022). From 3 January to 10 April 2022, the TMARS managed 179,230 cases, of which 55,774 were geriatric patients aged 70 years and over (Kok et al. 2022).

5.3.3 Benefits and Barriers to Using Telemedicine for Older Patients during the COVID-19 Pandemic

The use of telemedicine during the COVID-19 pandemic had brought several benefits to older patients. It reduced patients risks of virus infection, reduced patients unnecessary travel to clinics, and unnecessary admissions to hospital, while allowing patients to continuously receive the care they need in the comfort of their homes (Tan et al. 2020). Some older patients thought that telemedicine allowed them to have consultation safely at home, helped them save time from traveling to and waiting at clinics, and saved the trouble of taking leave from work (Tan et al. 2023).

SHP patients who had teleconsultations with doctors reported that their experience in having teleconsultations was comparable to that of an in-person consultation (92.8%) (Lee, Kang, and Tan 2021). They found that teleconsultation was easy to use (95.5%), felt at ease when talking to the doctor (97.6%) ,and were highly satisfied with the quality of their interaction with doctors (94.5%) (Lee, Kang, and Tan 2021). They thought that their medical condition was adequately accessed by the doctor (95.9%) and their privacy was respected (97.6%) (Lee, Kang, and Tan 2021).

With older cancer patients, the use of a hybrid teleconsultation model to provide interventions enabled them to reduce the average amount of time spent in the hospital per visit from 4 hours to 2.5 hours (Chen et al. 2022), "with an average of three interventions on the same day versus one intervention previously in the one-stop clinic" (Chen et al. 2022). It also helped over 80% of older cancer patients receiving interventions maintain or improve their quality of life (Chen et al. 2022).

The TMARS could handle over 5,000 cases via teleconsultation in a single day, which "demonstrates the scalability of a centrally managed telemedicine platform" (Kok et al. 2022). It triaged high-risk patients to healthcare institutions to receive proper care and helped preserve medical resources at tertiary care for high-risk and vulnerable patients (Kok et al. 2022).

Nevertheless, there are several barriers of using telemedicine in older patients. A survey conducted by the Singapore Eye Research Institute found that 58.3% of 523 older patients were uncomfortable with automated software or artificial intelligence interpreting their medical tests and providing medical advice to them (Teo 2021). Older patients with higher income were more receptive to use telemedicine services if the COVID-19 pandemic continued (Teo et al. 2021). The head of audiology at Ng Teng Fong General Hospital said that patients aged 60 years and over were seven times less likely to have tele-audiology sessions because they lacked the knowledge and skills to use tele-audiology and preferred in-person consultations (Begum 2021). However, live demonstrations of the use of tele-audiology at clinics or hospitals and the technical support from caregivers helped make older patients feel more comfortable with using tele-audiology (Begum 2021).

A study that examined the awareness and attitudes of 78 older adults aged 60 years and over toward telehealth services during the COVID-19 pandemic through interviews found that over 51% of the older adults "had not heard of telehealth before" (Man et al. 2023). Only about 19% of older adults reported the use of teleconsultation for stroke rehabilitation and emergency situation while about 16.6% of older adults used telehealth for home medication delivery (Man et al. 2023). Those who used telehealth or teleconsultation services reported that doctors were proactive in providing follow-up sessions for them and the attitudes of medication delivery personnel were personable (Man et al. 2023). Older adults interviewed thought that telehealth services could reduce their risks of virus infection, save traveling time and costs, maintain their independence (Man et al. 2023), and enable them to "have greater control over their own safety (e.g., not having to travel in bad weather or when unwell)" (Man et al. 2023). But the perceived lack of human touch, the absence of physical examination, potential misdiagnosis due to the lack of access to medical records by doctors and self-obtained clinical measures (e.g., blood pressure), miscommunication between doctors and patients, high costs of telemedicine-capable devices, and poor digital literacy were barriers to using telemedicine (Man et al. 2023). Another study found that barriers to using teleconsultation among older patients include unstable internet connectivity at home, the lack of knowledge and skills to use teleconsultation or computers, and patients' concern about suboptimal care due to the absence of physical examinations (Tan et al. 2023).

Also, a study which examined caregivers' views on telepractice found that technological and logistical issues encountered by older patients, clinicians and caregivers were barriers to using telepractice (Chua et al. 2022). Caregivers from nursing homes reported that they would discontinue telepractice due to patients' difficulty in hearing well through digital means, clinicians' inability to see well from the video, and caregivers having insufficient time to set up and troubleshoot (Chua et al. 2022).

5.4 Comparative Analysis on the Use of Telemedicine in Singapore and Hong Kong, China

By comparing the findings of the use of telemedicine in Singapore and Hong Kong, China, this study finds that Hong Kong, China introduced telemedicine to patients 18 years earlier than Singapore. Before the COVID-19 pandemic, telemedicine in Hong Kong, China was first provided to older patients living in residential care homes and high-risk discharged older patients. Then, it was also provided to diabetic patients, patients with mental illness, and those who were stable and required no physical examination. In Singapore, telemedicine was used to deliver home nursing services, consultations, rehabilitation, speech therapy, and other services to post-discharged patients, patients with mobility issues, and cancer patients without targeting older patients. During the COVID-19 pandemic, telemedicine in Hong Kong, China was used to deliver medical and nursing care, rehabilitation services to older patients, make and attend medical appointments, and place medication delivery orders. In Singapore, telemedicine was used to provide consultations and telepractice (i.e., outpatient communication and swallowing services) to older patients and triage and manage geriatric patients with COVID-19. A hybrid model that consisted of physical and video consultations was adopted by a tertiary cancer center in Singapore to provide geriatric oncology services for older patients. However, the hybrid model was not adopted to provide consultation service for older patients in Hong Kong, China.

In both places, the use of telemedicine in the care of older patients during the COVID-19 pandemic helped reduce healthcare professionals' and older patients' risk of virus infection and transmission, conserve PPE during severe shortages, reduce strain on overwhelmed healthcare facilities, ensure older patients' timely access to medical care, save travel and consultation wait time and travel expenses, and ensure continuity of care for older patients. However, the lack of digital literacy, the perceived lack of human touch, the lack of financial means, and unstable internet connectivity at home were key barriers to the use of telemedicine in older patients in both economies.

5.5 Critical Factors for the Use and Growth of Telemedicine

The COVID-19 pandemic has accelerated the use of telemedicine by healthcare professionals to diagnose, treat, monitor, and communicate with patients in real time. This allows healthcare professionals to "provide easier delivery of care where, when and how patients need it" (Siwicki 2024). The World Health Organization officially announced in early May 2023 that COVID-19 was no longer a public health emergency of international concern (WHO 2023). But many economies are still facing "periodic surges in COVID-19 infections" (National Center for Disease Control and Prevention 2024). Telemedicine will continue to be an important tool to deliver consultation and other services to patients. Its adoption is expected to increase, especially in Asia where the rapid aging of the population induces greater demand for healthcare (Luk 2020). Based on the case studies of Singapore and Hong Kong, China, this study identifies four factors which are critical for the use, growth, and sustainability of telemedicine in Asia and other economies: infrastructure, legislation, digital literacy training, and social influence.

Infrastructure: To expand and sustain the use of telemedicine in the long run requires the establishment of a highly integrated, interoperable, scalable, and secure telemedicine system (Márquez, Astudillo, and Taramasco 2020). An integrated and interoperable telemedicine system allows for efficient data access, sharing and retrieval, thereby offering a seamless experience for healthcare professionals and patients, avoiding manual data entry errors and supporting continuity of care. Telemedicine systems that involve transmission and storage of extensive sensitive patient data are susceptible to security and privacy threats such as illegal network access, malicious code, and data leakage (Márquez, Astudillo, and Taramasco 2020; Kim, Choi, and Han 2020). Security measures, including access control, user identity authentication, data encryption, and regular software updates, have to be carried out to protect telemedicine systems and patient data. Other features which are critical to the development of telemedicine infrastructure include "user-friendly design, intuitive system navigation, and easy-to-use interfaces" (do Nascimento et al. 2023, 161). Telemedicine platforms that only support the English language would hinder the use of such platforms by non-English-speaking patients. A telemedicine platform that supports multilingual user interfaces helps remove language barriers and expand the reach of healthcare services to non-English-speaking patients (Dsouza 2024), which is particularly important in many Asian economies.

Legislation: It is important to promulgate legislation to regulate the use of telemedicine to ensure the accountability of healthcare professionals in delivering telemedicine services, patient safety, data privacy, and security (Al-Alawy and Moonesar 2023). In Singapore, for example, Phase 2 of the Healthcare Service Act 2020, which took effect on 26 June 2023, regulates the licensing of telemedicine providers (MOH 2024b). It requires independent doctors and dentists who offer teleconsultation services themselves and clinics that employ or engage doctors or dentists to "hold an Outpatient Medical Service or Outpatient Dental Service license with approval for the remote mode of service delivery (MOSD)" (MOH 2024b). Any doctors, dentists, or clinics offering teleconsultation services without the relevant license and the MOSD approval shall be guilty of an offence under Section 8 of the Healthcare Service Act (MOH 2024b) and be liable for a fine up to S$10,000 and/or imprisonment of up to 2 years if they have no previous qualifying conviction (Singapore Legal Advice 2023). Currently, there is no uniform approach to telemedicine legislation (Al-Alawy and Moonesar 2023). Nevertheless, telemedicine legislation should be promulgated to ensure proper delivery of medical care to patients via telemedicine devices without stifling the use and growth of telemedicine by healthcare professionals and healthcare institutions.

Digital literacy training: Digital literacy can facilitate healthcare professionals', caregivers' and older patients' acceptance and adoption of telemedicine devices. Proper training helps healthcare professionals, caregivers, and patients understand what telemedicine devices are, dispel skepticism, and develop greater confidence in using telemedicine systems or devices. It also helps healthcare professionals, caregivers, and patients acquire knowledge and skills necessary for using telemedicine systems or devices. Training courses, workshops, or continuing education programs should be "appropriately tailored to healthcare professionals' needs and coverage of deficient abilities" (do Nascimento et al. 2023, 161). The provision of real-time technical support and coaching helps reduce healthcare professionals' implementation fear (do Nascimento et al. 2023) and boost their confidence in using telemedicine. Digital health topics such as telemedicine and digital doctor–patient communication should be integrated into medical school curriculums so that medical students can be well prepared for the use of telemedicine or other digital tools to diagnose and treat patients in future (Chan 2022; Kuhn et al. 2020). For caregivers and older patients, training can be offered to them via short videos and live demonstrations of the use of telemedicine devices such as mobile apps by volunteers at hospitals, clinics, or nursing homes.

Social influence: Social influence refers to the process by which individuals change their beliefs, opinions, or behavior as a result of their interactions with significant others (Moussaïd et al. 2013; Venkatesh et al. 2003) can affect older adults' use of telemedicine. A study found that spouses, children, and grandchildren could stimulate older adults' acceptance of digital devices by their enthusiasm or by helping older adults get to know the possibility of or appealing functions of digital devices, imparting knowledge and skills to them, helping them and advising them on the use of digital devices when necessary (Luijkx, Peek, and Wouters et 2015). Older patients' acceptance and use of telemedicine can increase if their family members or grandchildren can demonstrate the use of teleconsultation or telemedicine mobile applications or provide technical support for older adults when necessary.

5.6 Conclusion

To conclude, the use of telemedicine by healthcare professionals during the COVID-19 pandemic helps reduce healthcare professionals' and older patients' risk of virus infection and transmission, conserve PPE during severe shortages, reduce strain on overwhelmed healthcare facilities, and ensure continuity of care for older patients. It is expected that the use of telemedicine will continue to increase globally due to the threats posed by COVID-19 or other public health crises. Asia is expected to have greater use of telemedicine so as to meet the greater demand for healthcare caused by the rapid aging of the population. Infrastructure, legislation, digital literacy training, and social influence are four factors critical for the use, growth, and sustainability of telemedicine in the long run.

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6

Smart Platforms for Elder Care: A Case Study of Taiyuan, People's Republic of China*

Yixin Yao, Xia Chen, and Subhasis Bera

6.1 The Concept of Smart Elder Care

Smart elder care (first introduced by Unit Trust UK) provides services by adopting information communication and technology (ICT) and intelligent control technology (Chen and Wu 2018). The core concept of smart elder care is to build a technological network for service participants, including government, communities, healthcare institutions, and healthcare professionals (Zuo 2019). The scope of research on smart elder care contains multidimensional perspectives from distinctive disciplines ranging from information engineering to public management to health and medical care.

As per the United Nations Department of Economic and Social Affairs (UNDESA 1956), an economy or region is classified as an aging society when the proportion of the population aged 65 and above exceeds 7% of the total population. At the United Nations World Assembly on

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Aging held in Vienna in 1982, it was noted that if the proportion of the population aged over 60 and over exceeds 10% of the total population, the society is recognized as an aging society.

Currently, the People's Republic of China (PRC) is experiencing a significant increase in its older population, with a projection that 39.80% of the population will be aged 60 and above by 2050 (National Bureau of Statistics of China 2020). This rapid aging presents enormous challenges for healthcare and social services, making innovative solutions like smart care platforms crucial. A study by Chen and Shao (2021) estimated that the healthcare expenditure for older adults in the PRC is expected to increase from 2.1% of gross domestic product (GDP) in 2015 to 5.1% by 2050, which will create huge pressure on the economy. Moreover, The number of internet users aged 60 and above in the PRC reached 119 million by June 2020, accounting for 10.3% of the total internet population (CNNIC 2020), indicating the need for a framework to provide digital healthcare facilities. Understanding the smart elder care platform helps address the growing demand for high-quality elder care services.

Although a considerable amount of published literature reviewed the technologies adopted in smart elder care in the form of eHealth technologies (Marques 2020), mHealth technologies (Kong et al. 2022), artificial intelligence (AI), and the internet of things (IoT) (Shaikh, Dar, and Sofi 2022), The extensive literature on smart elder care covers various academic areas but remains disorganized. Considering this gap, this study focuses on comprehending the challenges of using smart elder care in the PRC.

6.2 Challenges of Use of Smart Technologies for the Care of Older People in Developing Economies

Smart elder care technologies have gained traction in developed economies, demonstrating efficacy in improving health outcomes and reducing the burden on caregivers (Zhang et al. 2020). However, studies highlight significant disparities in technology adoption between developed and developing regions (Pick and Nishida 2015). The implementation of such systems in developing economies is fraught with difficulties due to economic, infrastructural, social, and regulatory barriers (Kamel Boulos et al. 2011; Tun, Madanian, and Mirza 2021).

6.2.1 Economic Constraints

Developing economies often face significant economic limitations that hinder the adoption of advanced technologies. The high initial costs of smart care systems, including hardware, software, and maintenance, are prohibitive for both governments and individuals (WHO 2015; United Nations 2020). Furthermore, limited healthcare budgets prioritize immediate healthcare needs over long-term investments in technology (World Bank 2019). Additionally, the ongoing costs associated with training, support, and updates further strain limited financial resources (Granja, Jansen, and Johansen 2018).

6.2.2 Technological Infrastructure

Effective smart solutions for elder care rely on robust infrastructure, including reliable electricity, internet connectivity, and healthcare facilities. Many developing economies struggle with inadequate infrastructure, particularly in rural and remote areas (Heeks 2018). The lack of reliable power (ITU 2020) and internet access hampers the deployment and operation of smart technologies, limiting their reach and effectiveness (Mothobi and Gillwald 2018). Additionally, there is a shortage of technical experts to maintain and troubleshoot advanced medical devices (Cohen et al. 2021).

6.2.3 Technological Literacy

The successful adoption of smart technologies requires a certain level of technological literacy among both older adults and their caregivers. In many developing economies, low levels of education and digital literacy pose significant barriers. Older adults, in particular, can find it challenging to adapt to new technologies, which can lead to resistance and underutilization of available resources (Ghafurian et al. 2023).

6.2.4 Social and Cultural Factors

Social and cultural attitudes toward aging and technology adoption also present substantial challenges. In many developing economies, traditional family-based care models dominate, and there may be resistance to replacing human care with technology-driven solutions (Chou et al. 2013, Hoque and Sarwar 2017). Moreover, low levels of digital literacy among the older population can impede the effective use of smart care devices (Hilbert 2016). Additionally, privacy and data security concerns can deter adoption, as individuals may be wary of surveillance and data misuse (Al-Rahmi, Othman, and Yusuf 2021).

6.2.5 Regulatory and Policy Issues

The regulatory environment in many developing economies is often underdeveloped with respect to technology and healthcare. Inconsistent or unclear regulations regarding the use of smart technologies in healthcare can create uncertainty and hinder adoption (Heeks 2018). Furthermore, the lack of standardized guidelines and policies for integrating these technologies into existing healthcare systems poses additional challenges (WHO 2015). The regulatory and policy frameworks in developing economies often lag behind technological advancements, leading to issues related to data privacy, cybersecurity, and standardization (ITU 2020). Additionally, bureaucratic hurdles further complicate the situation, delaying the approval and deployment of new technologies.

Addressing these barriers requires a multifaceted approach. Investment in technological infrastructure (such as expanding broadband access and training technical personnel) is crucial. Economic strategies should focus on reducing costs through subsidies, public–private partnerships, and international aid. Culturally sensitive approaches to technology adoption must be developed, including community engagement and education initiatives. Finally, robust policy frameworks are needed to ensure safe, effective, and equitable implementation of smart solutions for elder care. Culturally sensitive approaches that respect traditional family roles and address privacy concerns can also enhance the acceptance and utilization of these technologies.

While the potential benefits of smart technologies are significant, their adoption in developing economies is fraught with challenges. Overcoming these barriers necessitates coordinated efforts from governments, international organizations, and the private sector.

6.3 Smart Elder Care in the People's Republic of China

6.3.1 The PRC's Aging Population Situation

The PRC's Fifth National Population Census in 2000 indicated that the proportion of the population aged 60 and above accounted for 13.26% of the total population and the proportion of the population aged 65 and above accounted for 6.96%[1] of the population, indicating that the PRC had become an aging society. As time goes by, the PRC's aging problem has become increasingly prominent. In addition, the Seventh National Population Census in 2020 noted that the proportion of the total population aged 60 and above had reached 18.70% and the proportion aged 65 and above had reached 13.50%,[2] indicating an acceleration in the aging of society. According to data collected by the National Bureau of Statistics in 2023, the proportion of the population aged 60 and above accounted for 21.10% of the total population and the proportion of the population aged 65 and above accounted for 15.40%[3] (Figure 6.1), indicating the growing severity of societal aging. A joint forecast by the United Nations Population Fund China and the China Population and Development Research Center in 2022 shows that by 2050 the population in the PRC aged 60 and above will account for 39.80% of the total population and the population aged 65 and above would account for 30.80% (UNFPA 2022), predicting that the aging problem will become grave. At the same time, according to data from the National Bureau of Statistics of China, the PRC's total population and number of births began declining in 2022. The PRC's total population in 2022 was 1,411.75 million, decreasing 850,000 from 2021, and the number of births in 2022 was 9.56 million, decreasing 1.06 million from 2021.[4] In 2023, the PRC's total population was 1,409.67 million, a 2.08 million decrease from 2022, and the total number of births was 9.02 million, a 540,000 decrease from 2022.[5] Because of these changes, the PRC is facing increasingly prominent issues regarding elder care. The burden of family care is constantly increasing and the contradiction between traditional care services and the growing demand for high-quality care is becoming increasingly apparent. Therefore, there is an urgent demand to explore new care models to better meet the needs of older adults.

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1 National Bureau of Statistics. 2011. https://www.stats.gov.cn/sj/zxfb/202303/t20230301_1919256.html (in Chinese)

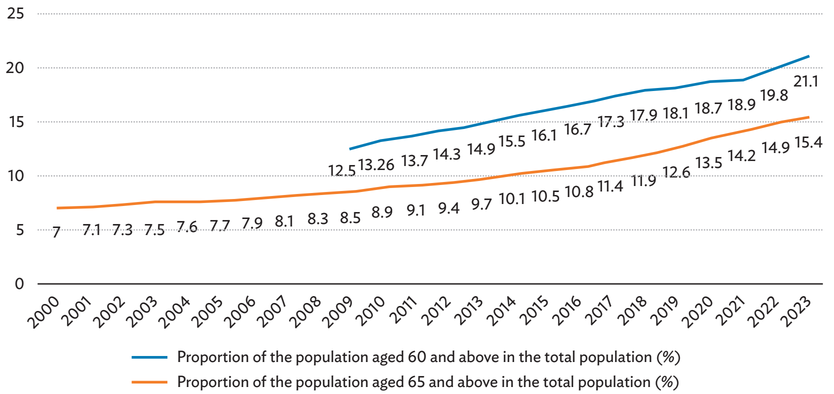
2 National Bureau of Statistics. 2021. https://www.stats.gov.cn/zt_18555/zdtjgz/zgrkpc/dqcrkpc/ggl/202302/t20230215_1904001.html (in Chinese)

3 National Bureau of Statistics. 2024. https://www.stats.gov.cn/xxgk/jd/sjjd2020/202401/t20240118_1946711.html (in Chinese)

4 National Bureau of Statistics. 2023. https://www.stats.gov.cn/xxgk/jd/sjjd2020/202301/t20230118_1892285.html (in Chinese)

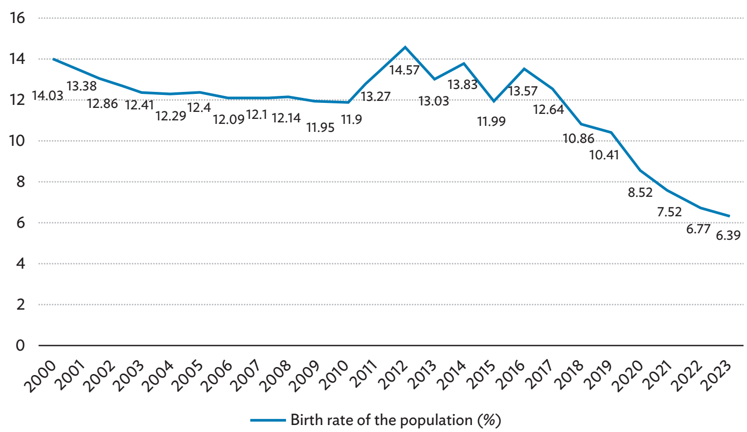
5 National Bureau of Statistics. 2024. https://www.stats.gov.cn/xxgk/jd/sjjd2020/202401/t20240118_1946711.html (in Chinese)

Figure 6.1: Changes in the Proportion of the Older Population in the People's Republic of China (2000–2023)



Source: National Bureau of Statistics. *Annual Report on the Development of the National Aging Affairs (2000–2023)*.

Figure 6.2: Birth Rate in the People's Republic of China (2000–2023)



Source: National Bureau of Statistics.

In recent years, the PRC has been actively promoting the construction of Digital China, with a significant focus on using digital technology to support older people (Zhang and Han 2017; Zhu 2016). Several companies are developing electronic products and launching more digital products and application software specifically to meet the needs of the older population (Geng and Wang 2017). For example, Tencent News launched an age-friendly “Care Edition” and in response to older people’s shift in needs from “seeing” to “listening”, Tencent News developed AI voice technology and other functions to enable “one-click listening to news” and allow voice input to post comments.

6.3.2 The PRC’s Smart Elder Care Platform: Construction in Decades

All provinces (autonomous regions and municipalities) in the PRC are actively developing smart elder care platforms, although the names vary. Some areas refer to the platform as a “smart elder care service platform” or a “smart elder care network platform”, while other areas call it a “smart health and elder care service comprehensive information system platform”, among other names. For simplicity, this chapter collectively refers to them as smart elder care platforms. The smart elder care platform mainly refers to the use of information technologies such as the IoT, the internet, mobile internet technology, intelligent calling, cloud technology, and GPS positioning technology to create a smart service model of “system + service + elder + terminal”. This model encompasses various forms of care, such as institutional care of older adults, home care, and community daycare, enabling older adults to enjoy professional and intelligent services at home. The smart care platform aims to provide superior care services by effectively monitoring older people’s physical condition, safety, and daily activities. It is designed to fully meet their needs in areas such as life, health, safety, and entertainment, thereby enhancing their overall quality of life.

Organizational Structure

At the central government level, according to the State Council’s institutional setup, the Ministry of Civil Affairs is primarily responsible for national aging work and its two related responsibilities. The specific expectations are listed as follows: Undertake the specific work of the National Committee on Aging. Organize the formulation and coordination of the implementation of policies and measures to actively respond to population aging. Guide and coordinate the work of protecting the rights and interests of the older population. Organize the formulation of policies for the social participation of older people and organize their implementation. Additionally, the Ministry of Civil Affairs is expected to organize the formulation and coordination of the implementation of policies and measures to promote the development of the elder care industry. Coordinate the promotion, supervision, and guidance of elder care services, formulate plans, policies, and standards for the construction of the elder care service system and organize their implementation, and undertake the welfare of older people and the assistance of older adults with special difficulties.[6] The Ministry of Civil Affairs also receives assistance and cooperation from the National Development and Reform Commission, the Ministry of Human Resources and Social Security, the Ministry of Education, the Ministry of Industry and Information Technology, the Ministry of Finance, the National Health Commission and other departments in carrying out relevant work on aging. At the local government level, the Civil Affairs Bureau or Department of Civil Affairs of each province (autonomous region, municipality directly under the central government) is mainly responsible for aging work, and they are supported by the other bureaus or departments.

Policy and Regulations

At the central government level (Table A6.1, Appendix), the State Council, the National Development and Reform Commission, the Ministry of Human Resources and Social Security, the Ministry of Education, the Ministry of Industry and Information Technology, the Ministry of Finance, the Ministry of Housing and Urban-Rural Development, the National Health Commission and other departments have successively issued Guiding Opinions on Actively Promoting the Internet+Action, Smart Elder Care and Health Industry Development Action Plan (2021–2025), Work Plan for Promoting the High-quality Development of Digital Technology for Older People, and other policies to support the development of smart care and related industries. Among them, the Ministry of Civil Affairs, the Ministry of Finance, the National Development and Reform Commission, and 10 other ministries issued the Implementation Opinions on Encouraging Private Capital to Participate in the Development of the Elder Care Service Industry as early as 2015 regarding the participation of private capital in the development of the smart care industry, supporting private capital to use the internet, the IoT, cloud computing, and other technical means to connect the service needs of older adults with the service supply of various social entities. In 2021, the Ministry of Civil Affairs and the China Development

6 Ministry of Civil Affairs. https://www.mca.gov.cn/n158/index.html

Bank issued the Notice on Using Development Finance to Support the Construction of the Elder Care Service System during the 14th Five-Year Plan Period, proposing to use special development finance loans to support the construction of the elder care service system, including smart elder care services.

At the local government level (see Table A6.2), 31 provinces (autonomous regions and municipalities) across the country have also issued policies to support smart elder care and platform construction to ensure the intelligence, convenience, and efficiency of care services. Some provinces and cities have explored the establishment of smart care service platforms, such as Zhejiang's Zheliyang Smart Care Service Platform and Guangxi's Huikangyang Smart Care Service Platform. Older adults can enjoy the various services provided by smart elder care platforms through mobile apps, mini-programs, and portal websites.

6.4 The Practice of the Smart Elder Care Platform: A Case Study of Taiyuan, Shanxi Province

All provinces (autonomous regions and municipalities) across the PRC are constructing smart elder care platforms. In 2016 and 2019, Taiyuan, Shanxi Province, was selected as one of the first pilot cities for a home and community-based elder care service reform in the country and a national demonstration city for smart and healthy elder care, which has continued to explore platforms and is committed to addressing aging issues. Shanxi province has become a model city for the country, demonstrating its capabilities to solve elder care problems, empower the care industry, and drive the care economy through information platforms.

6.4.1 The Smart Elder Care Platform in Taiyuan

According to the Major Data Bulletin of the 2023 Population Change Survey in Shanxi Province [7] by the Shanxi Provincial Bureau of Statistics, at the end of 2023, the resident population of the province included 5.27 million people aged 65 and above, accounting for 15.20% of the total. The population aged 60 and above was 7.50 million, representing 21.64% of the total resident population. In terms of natural population growth, the number of births in the province in 2023 was 213,100, a decrease of

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7 The People's Government of Jiaocheng County. 2024. www.sx-jc.gov.cn/xxgk/jjsj/sjjd/202402/t20240223_1844027.html (in Chinese)

22,000 compared to the previous year, while the number of deaths was 291,100, an increase of 22,000 compared to the previous year. The natural population growth rate was –2.25‰, indicating a worsening aging issue. As the only city in Shanxi Province with a resident population exceeding 5 million, Taiyuan has reported from the 2024 Taiyuan Municipal Aging Work Committee's (expanded) meeting that the city's older population has reached 878,000, accounting for 21.91% of the total registered population. The city has entered a stage of moderately aging.[8]

Accurately Identifying Service Recipients

The Taiyuan Smart Elder Care Platform uses data on the population over 60 years old collected by the Taiyuan Civil Affairs Bureau. The data are subdivided into different categories, such as empty-nest older adults, older adults living alone, older adults without self-care ability, and older adults enjoying old-age allowance, with relevant statistical data updated in real-time. This enables civil affairs bureaus, communities, nursing homes, and other service providers to promptly understand the needs of older people, accurately identify service recipients, and meet the needs of different groups. Currently, the platform has collected data on about 529,000 empty-nest older adults, 128,000 older people living alone, 153,000 older people living with their children, 40,000 older people living with other relatives, and millions of sensor monitoring data points.

Covering All Scenarios of Smart Elder Care

The Taiyuan Smart Elder Care Platform has multiple sub-platforms, including family care bed management, home care services, call services, and smart supervision of community canteens to build an "online + offline" service model (order online and enjoy services offline). By linking various resources for care services such as communities, service providers, and volunteer teams, a lot of services (including dining, cleaning, bathing, walking, medical, and emergency assistance) are provided. This allows older people to obtain real-time, safe, convenient, efficient, and low-cost intelligent care services, thereby improving their quality of life.

Full Cloud Supervision

The Taiyuan Smart Elder Care Platform has realized important tracking and supervision functions. First, it can provide 24-hour monitoring for older adults to ensure their safety. Through smart bracelets, flood alarms, combustible gas alarms, and other equipment, the platform

8 According to the United Nations' classification standards, an economy is considered to have entered "moderately aging" if the proportion of its population aged 60 and above exceeds 20% or if the proportion of those aged 65 and above exceeds 14%.

can monitor safety hazards such as smoke, gas, and water leakage to reduce the life risks of older people living alone. At the same time, it can monitor when an older person living alone leaves their home, and after 24 hours it will automatically alert support to ensure the safety of older people; the platform can also use real-time monitoring of distress information to ensure that they can get timely help in an emergency. Second, it supervises home-based elder care services. The platform has established a supervision and follow-up mechanism, which enables the supervision of market service resources through dispatching orders, supervising, and following up, thereby improving the transparency and quality of services. Third, the platform supports real-time viewing on mobile phones. Older adults' family members and relevant staff can watch the dynamics of the older person in real-time through their mobile phones and understand their conditions at any time. Fourth, the platform provides one-stop closed-loop services to community canteens online, including government subsidy supervision, institutional service supervision, and meal assistance for older adults, to achieve standardized and high-quality care services.

6.4.2 Achievements of the Smart Elder Care Platform in Taiyuan

The Taiyuan smart elder care platform has effectively integrated AI, IoT sensing technology, big data, and other advanced technologies to achieve significant results, creating a comprehensive three-dimensional elder care service system.

First is all-inclusive data analysis. The platform aggregates various data on daily electricity, water, and gas use of older people living alone, among other key older groups. By modeling and monitoring usage patterns, it can predict abnormalities promptly and issue early warnings to ensure the safety of older people.

Second is all-round process safety monitoring. The platform equips older adults with IoT intelligent sensing terminals. Through intelligent monitoring and early warning, it establishes a linkage mechanism with hospitals and communities to detect and solve problems as soon as possible, providing full-process safety monitoring.

Third is all-encompassing health management. The platform analyses health data and medication usage through the chronic disease management system, promptly grasping and confirming the current health status of the older person to prevent accidents.

Fourth is all-integrated intelligent services. To address the barriers older people face in using intelligent systems, the platform has a built-in voice service interface, connecting various related phone applications for safety, health, and consumption. When older people make a phone call, AI recognizes their needs and invokes the corresponding services.

The Taiyuan smart elder care platform has centralized upstream and downstream service providers in the care industry into a unified service system, integrating, co-building, sharing, and interconnecting various service resources to the maximum extent possible to meet the needs of older people for convenient services in Taiyuan. The platform has so far integrated more than 500 community home-based elder care service providers across the city, established 2,461 service points for older adults, and formed 760 service teams, providing age-friendly equipment to 3,076 households. Each year, the platform serves over 12,000 older people, completing more than 210,000 meal assistance services, nearly 200,000 cleaning and bathing assistance services, over 100,000 walking assistance services, and more than 200,000 medical assistance services. In total, the six major assistance services exceed 1 million orders annually, with a total service value close to CNY100 million. These data and service statistics indicate that the Taiyuan smart elder care platform has played a significant role in integrating resources, providing convenient services, and promoting the development of the elder care industry, offering valuable reference for smart elder care services in other regions.

6.4.3 Challenges Faced by the Smart Elder Care Platform in Taiyuan

Funding supply issues

The construction of the platform requires enhanced financial support. The Taiyuan smart elder care platform, led by the Taiyuan Municipal Civil Affairs Bureau, was developed and maintained by China Science TopChance Waking Information Technology Co. Ltd., which invested approximately CNY24 million in platform construction. Meanwhile, the Taiyuan Municipal Finance Bureau and Civil Affairs Bureau have provided around CNY10 million in project-based funding support. To meet the growing market demand for elder care services, an additional CNY20 million is expected to be needed for the further improvement of the platform.[9] Smart care services require significant investment. As technology companies are involved in the construction of smart care services, they need to cover costs related to technology application, function design, labor, platform development, testing, operation,

9 The data are from China Science TopChance Waking Information Technology Co. Ltd.

and training to support platform construction. Therefore, ensuring sustainable funding support for platform construction is indispensable.

Shortage of technical personnel

The construction of the Smart Elder Care Service Platform requires the infusion of technical talent. In developing and operating of the platform, China Science TopChance Waking Information Technology Co. Ltd. has already gathered a full-cycle technical team including project managers, user interface designers, front-end developers, engineers, database administrators, test engineers, and operations engineers. With digitalization as the foundational driving force, increasingly intelligent elder care facilities present widespread applications of large language models and AI technologies in the smart care industry. However, current enterprises lack sufficient investment in building and training technical teams, leading to a deficiency in professional and sustainable technical support. From a technical perspective, the continuous construction of the platform requires more specialized technical talent, such as AI engineers, data governance engineers, and data management professionals.

Insufficient platform promotion

The usage rate of the Smart Elder Care Platform needs to be further improved. Despite providing more convenient and precise services for older people, the platform's usage rate remains low. In Taiyuan, for example, only about 7% of the older population aged 60 and above have registered on the platform, with only about 32% of registered users using the platform monthly, and an average monthly usage rate of 0.7 times per user.[10] This situation is particularly pronounced among older adults who are not familiar with using smartphones, making it more difficult for them to access the services they need. This issue is especially significant among older groups who urgently need care services, as they may lack understanding and proficiency in smartphone and digital technology, leading to weak awareness and willingness to use the smart platform. Additionally, some individuals may have memory decline or cognitive impairments, making it challenging for them to understand or remember how to use the platform. Furthermore, some older people and their families may worry about privacy leaks or financial losses when entering personal information or conducting online transactions on the smart platform, causing apprehension and resistance to using it.

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10 The data are from China Science TopChance Waking Information Technology Co. Ltd.

Lack of unified standards for smart elder care platforms

There are significant differences among regions in terms of technical standards for the interface design, main functionality, and data security protection of smart elder care platforms, leading to varying quality in platform construction across different areas. This disparity also hampers the replication and promotion of successful practices in platform development. For instance, differences in functionality may result in some platforms inadequately meeting the needs of older users. Some platforms may lack emergency call features or health monitoring modules, while others may excel in these areas. This inconsistency means that older people in different regions cannot receive uniform services, impacting their daily convenience. Additionally, in terms of data security protection, the security measures and standards adopted by various platforms differ significantly, lacking unified regulations. This could lead to the leakage and misuse of personal information belonging to users. Such issues not only threaten the privacy and safety of individuals but may also trigger a crisis of trust, causing apprehension among older people regarding the use of these platforms.

6.5 Policy Implications

With the support of relevant national policies, the construction of the PRC's smart elder care platforms is currently in a rapid development stage. Some provinces and cities have established platforms, providing older people with "six assistance" smart services such as real-time health status monitoring and telemedicine. However, they also face challenges and need further improvement.

6.5.1 Exploring Diverse Investment and Financing Methods to Support Smart Elder Care Platforms

A tripartite investment model involving "government + financial institutions + enterprises" can be established to fully leverage resources and advantages from various sectors and secure more funding for the construction of smart elder care platforms. As the primary leader and regulator, the government can support these platforms by providing financial subsidies, tax incentives, or establishing special funds, while also implementing policies that encourage financial institutions, social organizations, and enterprises to participate actively. Financial institutions can explore innovative financing models, such as issuing care service bonds or attracting social investment funds to provide financial support for the construction of smart elder care platforms. Meanwhile, enterprises can engage in this initiative by collaborating with the government or financial institutions, or by adopting franchising models. This diversified investment and financing approach not only helps to mitigate risks but also promotes resource sharing and collaborative development, thereby achieving sustainable growth for platforms.

6.5.2 Establishing a Diversified Talent System to Support Smart Elder Care Platforms

In an era of rapid digital technological advancement, it is essential to establish a diversified talent development system to better leverage digital technology for elder care services. First, training centers for smart care technology and services should be established, along with a comprehensive training plan and curriculum to cultivate more interdisciplinary talents in smart care. Second, universities and vocational schools should be encouraged to offer courses related to smart care technology and services, providing pathways and support for training more specialized professionals. Third, efforts should be made to actively recruit foreign experts in the field of smart care. Finally, existing technical staff should undergo regular training and participate in knowledge exchange programs to stay updated on the latest developments in digital technology.

6.5.3 Enhancing the Usage Rate of Smart Elder Care Platforms

To effectively enhance the usage rate of smart platforms among older individuals, a collaborative effort is required from the government, communities, businesses, and the families of the older people. At the government level, efforts should be intensified to promote smart elder care platforms through various media channels, such as newspapers and television. At the community level, community digital learning centers can be established, equipped with professional instructors or volunteers to provide regular training courses on using smart platforms for older people. Additionally, volunteers can offer home assistance services to guide those who have difficulty going out, and regular competitions can be organized to encourage participation, with awards set up to motivate learning among older individuals. From the business perspective, companies could design customized smart devices specifically for older adults, thereby lowering the barriers for older individuals to learn how to use these technologies. On the family side, relatives should actively assist older individuals in learning to use the smart elder care platform, providing patient guidance and addressing any issues they encounter during the process.

6.5.4 Establishing Unified Standards for the Construction of Smart Elder Care Platforms

To further improve the quality of smart elder care platform construction, the following measures should be implemented. First, it is essential to establish unified technical standards and regulations that clearly define the interface design, functionality, and data security requirements for the platforms, ensuring they are developed in various regions and meet the same standards. Second, there should be strengthened supervision, management, and evaluation of the construction of the platforms, with corrective actions taken for those that do not meet the established standards. Third, it is important to enhance data security protection by developing unified data encryption and privacy protection standards to ensure the safety and privacy of older individuals' personal information.

6.5.5 Enhancing International Cooperation and Knowledge Sharing in Smart Technology for Elder Care

To further promote the construction of smart elder care platforms, the PRC should actively cooperate and exchange in the field of smart technology for the care of older people. Learning from the experience of European economies, the United States, Japan, and other economies in the formulation of smart technology standards, fund support mechanisms, and talent training models, will accelerate the pace of construction. At the same time, the PRC collaborates with international organizations like the Asian Development Bank, which is actively carrying out project cooperation in the field of elder care. The construction of the PRC's smart elder care platforms should take advantage of the rich experience and resources accumulated by these institutions in this field along with their financial support, technical guidance, and policy research to jointly explore innovative models and best practices for smart care services. This will promote the in-depth application of smart care concepts on a global scale.

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Appendix

Table A6.1: Policies on Smart Elder Care issued by the Central Government of the PRC

Issuing Date		
17 September 2011	Issuing Department	State Council of the People's Republic of China
	Document Name	12th Five-Year Plan for the Development of the People's Republic of China's Aging Affairs
	Contents Related to Smart Elder Care	Accelerate the construction of home-based elder care service information systems, and conduct pilot projects for home-based elder care service information platforms; establish a collaborative mechanism for the informatization of elder affairs, set up platforms for aging information collection and data analysis, and improve the monitoring system for tracking the living conditions of older people in urban and rural areas.
13 September 2013	Issuing Department	State Council of the People's Republic of China
	Document Name	Several Opinions on Accelerating the Development of Elderly Care Service Industry
	Contents Related to Smart Elder Care	Develop home-based network information services. Local governments should support enterprises and institutions in using technologies such as the Internet and the Internet of Things to innovate home-based elder care service models, develop electronic commerce for older people, build home service network platforms, and provide services suitable for older people, such as emergency calls, housekeeping appointments, health consultations, purchase of goods on behalf, and service payments.
3 February 2015	Issuing Department	Ministry of Civil Affairs, Ministry of Finance, National Development and Reform Commission, among 10 ministries
	Document Name	Implementation Opinions on Encouraging Private Capital to Participate in the Development of Elderly Care Service Industry

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Table A6.1 *continued*

Issuing Date		
	Contents Related to Smart Elder Care	Advance the informatization of care services of older people, and gradually implement dynamic management of information. Support private capital in using technologies such as the internet, the internet of things, and cloud computing to meet the service needs of older people and the service supply of various social entities. Develop remote medical services for care institutions for older people, develop electronic commerce for older people, and provide services such as emergency calls, housekeeping appointments, health consultations, purchase of goods on behalf, and service payments. In areas where conditions permit, electronic calling devices such as "one-touch" can be provided free of charge to older individuals living at home.
1 July 2015	Issuing Department	State Council of the People's Republic of China
	Document Name	Guiding Opinions on Actively Promoting the "Internet+" Action
	Contents Related to Smart Elder Care	Promote the development of the smart health and care industry of older adults. Support innovation and application of smart health products and promote a new comprehensive quantified healthy living style. Encourage health service institutions to use technologies such as cloud computing and big data to build public information platforms, providing long-term tracking, forecasting, and personalized health management services. Develop third-party online health market research, consulting evaluation, and preventive management application services, and enhance the standardization and professionalism of operations. Relying on existing internet resources and social forces, and based in communities, build a care information service network platform, providing home-based care services such as nursing, health management, and rehabilitation care. Encourage care service institutions to use mobile internet-based portable physical examination, emergency call monitoring, and other devices to improve the level of care services.
28 February 2017	Issuing Department	State Council of the People's Republic of China
	Document Name	13th Five-Year Plan for the Development of Aging Affairs and Construction of the Elderly Care System

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Table A6.1 *continued*

Issuing Date		
	Contents Related to Smart Elder Care	Implement the "Internet+ Elder Care" project. Support communities, care service institutions, social organizations, and enterprises in utilizing information technologies such as the internet of things, mobile internet, cloud computing, and big data. Develop applications for smart terminals and intelligent platforms for home and community care services for older adults, information systems, apps, WeChat public accounts, etc., with a focus on expanding functions such as remote reminders and control, automatic alarms and handling, dynamic monitoring, and recording. Standardize data interfaces and build virtual care homes for older people.
6 February 2017	Issuing Department	Ministry of Industry and Information Technology, Ministry of Civil Affairs, National Health and Family Planning Commission
	Document Name	Action Plan for the Development of the Smart Elderly Care Health Industry (2017–2020)
	Contents Related to Smart Elder Care	Develop health and care data management and service systems. Utilize information technology such as the internet, the internet of things, and big data to advance the integration of smart health and care application systems, connect with medical institutions at all levels and care service resources, establish dynamic monitoring mechanisms for health, integrate information resources, and provide smart health and care services for the older population.
27 July 2017	Issuing Department	Ministry of Industry and Information Technology, Ministry of Civil Affairs, National Health and Family Planning Commission
	Document Name	Notification on Conducting Pilot Demonstrations for Smart Health Elderly Care Applications
	Contents Related to Smart Elder Care	Support the construction of several demonstration enterprises, including those that can provide mature smart health elder care products, services, system platforms, or comprehensive solutions. Support the construction of several demonstration streets (townships), including the application of various types of smart health care products to provide smart health care services to older residents within the jurisdiction. Support the construction of several demonstration bases, including promoting smart health care products and services, forming industry agglomeration effects, and demonstrating leading effects in prefectural or county-level administrative regions.

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Table A6.1 *continued*

Issuing Date		
19 April 2019	Issuing Department	State Council of the People's Republic of China
	Document Name	Opinions on Promoting the Development of Elderly Care Services
	Contents Related to Smart Elder Care	Implement the "Internet+ Elderly Care" initiative. Continuously promote the development of the smart health elder care industry, expand the application of information technology in the field of the care of older adults, establish a catalog for promoting smart health care products and services, and conduct pilot demonstrations of smart health care applications. Promote the in-depth application of new-generation information technologies such as artificial intelligence, the internet of things, cloud computing, big data, and intelligent hardware products in the field of elder care services. Construct several "smart elder care homes" nationwide, promote the internet of things and remote intelligent security monitoring technologies, achieve 24-hour automatic security monitoring, reduce accidental risks for older people, and improve service experiences. Utilize the internet and biometric technologies to explore the establishment of a remote declaration and review mechanism for subsidies for older people. Accelerate the construction of the national care service management information system, and advance integration with civil registration, medical care, social insurance, and social assistance information resources. Strengthen the protection of older people's identity and biometric information security.
12 March 2021	Issuing Department	Central Committee of the Communist Party of China
	Document Name	Outline of the Fourteenth Five-Year Plan for the National Economic and Social Development of the People's Republic of China and the Long-Range Objectives Through the Year 2035
	Contents Related to Smart Elder Care	Develop the silver economy, develop aging-appropriate technologies and products, and cultivate new business forms such as smart care for older people.
20 October 2021	Issuing Department	Ministry of Industry and Information Technology, Ministry of Civil Affairs, National Health and Family Planning Commission

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Table A6.1 *continued*

Issuing Date		
	Document Name	Action Plan for the Development of Smart Elderly Care Health Industry (2021–2025)
	Contents Related to Smart Elder Care	Promote the research and development of new technologies for smart health elder care; expand the supply of smart health care products; strengthen smart health care software system platforms; and enrich smart health services.
26 November 2021	Issuing Department	Ministry of Civil Affairs, China Development Bank
	Document Name	Notification on Using Developmental Finance to Support the Construction of the Elderly Care Service System During the "14th Five-Year Plan" Period
	Contents Related to Smart Elder Care	Support the application of technologies such as the internet, big data, the internet of things, cloud computing, artificial intelligence, and blockchain in care service management, build community-based care service information platforms, and guide care institutions to rely on emerging technological means to construct "Internet+ elder care services" and smart care models. Support the research, development, promotion, and application of smart care products, and develop aging-appropriate technologies and products, focusing on aging-appropriate rehabilitation aids, smart wearable devices, service robots, and accessible technology products.
21 February 2022	Issuing Department	The State Council of the People's Republic of China
	Document Name	The 14th Five-Year National Plan for the Development of Aging Affairs and Elderly Care Service System
	Contents Related to Smart Elder Care	Advance "internet+ medical health," "internet+ nursing services," and "internet+ rehabilitation services," and develop smart medical and care services aimed at homes, communities, and institutions. Promote the application of smart health and are products.
19 December 2023	Issuing Department	Ministry of Industry and Information Technology
	Document Name	Work Plan for Promoting High-Quality Development of Aging-Appropriate Digital Technology

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Table A6.1 *continued*

Issuing Date		
	Contents Related to Smart Elder Care	Enhance the quality of supply for aging-appropriate digital technology products and services; deepen the aging-appropriate and accessibility transformation of internet applications; strengthen the innovative application capability of aging-appropriate digital technologies.
15 January 2024	Issuing Department	State Council of the People's Republic of China
	Document Name	Opinions on Developing the Silver Economy to Enhance the Welfare of Older People
	Contents Related to Smart Elder Care	Create new business forms in smart health and care of the older population. Perfect the promotion catalog of smart health and care products and services, advance the integrated application of new generation information technologies, mobile terminals, wearable devices, service robots, and other smart devices in care settings such as homes, communities, and institutions. Develop smart products for health management, care monitoring, and psychological comfort, and promote the application of smart nursing robots, home service robots, smart anti-wandering terminals, and other smart devices. Encourage the use of virtual reality and other technologies to conduct exhibitions and experiences of products and services.

Source: Authors.

Table A6.2: Policies Related to Smart Elder Care Issued by Local Governments in the PRC's 31 Provinces (autonomous regions, municipalities)

Issuing Date		
1 November 2023	Province (autonomous region, municipality)	Beijing
	Issuing Department	The People's Government of Beijing Municipality
	Document Name	Implementation Opinions on Improving Beijing's Elderly Care Service System
	Contents Related to Smart Elder Care	Establish a Comprehensive Elder Service Platform
14 October 2022	Province (autonomous region, municipality)	Tianjin
	Issuing Department	Tianjin Municipal Civil Affairs Bureau
	Document Name	The 14th Five-Year Elderly Care Service System Development Plan and Long-term Goals for 2035
	Contents Related to Smart Elder Care	Integrate the existing elder care service systems (platforms) of the city and districts, connect with the Ministry of Civil Affairs "Jinmin" project, construct a citywide smart elder care service platform, introduce information technology into all areas of care services, achieve broad participation, information interconnectivity, resource sharing, and system integration, enabling one platform to manage the city's care services, one set of data to control the situation of care services, one map to display care resource information, and one smartphone to handle all care service matters.
15 April 2022	Province (autonomous region, municipality)	Hebei
	Issuing Department	The People's Government of Hebei Province

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Table A6.2 *continued*

Issuing Date		
	Document Name	The 14th Five-Year Plan for the Construction of the Elderly Care Service System in Hebei Province
	Contents Related to Smart Elder Care	Actively cultivate new business forms in smart elder care and promote the deep integration of the internet with care services. Improve traditional service methods, advance intelligent services to adapt to older people and build a smart society that takes into account the needs of the older population.
13 April 2022	Province (autonomous region, municipality)	Shanxi
	Issuing Department	The People's Government of Shanxi Province
	Document Name	Implementation Plan for Promoting the Healthy Development of Elderly Care and Childcare Services
	Contents Related to Smart Elder Care	Explore the construction of smart elder care service platforms
1 January 2022	Province (autonomous region, municipality)	Inner Mongolia
	Issuing Department	Inner Mongolia Autonomous Region's 13th NPC Standing Committee, 31st Meeting
	Document Name	Inner Mongolia Autonomous Region Elderly Care Service Regulations
	Contents Related to Smart Elder Care	Promote the construction of urban and rural home-based elder care service information platforms, integrate various care services resources such as medical, catering, domestic service, property management, and transportation, and provide services for home-based older people such as emergency calls, health consultation, proxy shopping, housekeeping appointments, and fee payment.
13 June 2022	Province (autonomous region, municipality)	Liaoning
	Issuing Department	The People's Government of Liaoning Province

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Table A6.2 *continued*

Issuing Date		
	Document Name	The 14th Five-Year Plan for Promoting the Healthy Development of Elderly Care and Childcare Services in Liaoning Province
	Contents Related to Smart Elder Care	Utilize resources such as the internet, the internet of things, mobile terminals, information platforms, and public services to provide smart care services such as emergency calls, safety monitoring, remote medical care, wireless positioning, housekeeping appointments, and service referrals.
22 February 2023	Province (autonomous region, municipality)	Jilin
	Issuing Department	Jilin Province Civil Affairs Department, Jilin Province Justice Department, Jilin Province Finance Department, Jilin Province Culture and Tourism Department, Jilin Province Health Commission, Jilin Province Sports Bureau, Jilin Province Medical Insurance Bureau
	Document Name	Jilin Province Community-based Home Care Service Reform Pilot Work Plan
	Contents Related to Smart Elder Care	Develop and improve the "smart elder care platform," incorporating home-based care services, intelligent monitoring, "tri-bed linkage," and aging-appropriate modifications into the platform management.
29 April 2022	Province (autonomous region, municipality)	Heilongjiang
	Issuing Department	Heilongjiang Province Civil Affairs Department
	Document Name	Heilongjiang Province Action Plan for Enhancing Basic Elderly Care Services in Home and Community Settings (2022–2024)
	Contents Related to Smart Elder Care	At the city (prefecture) level, construct a home and community smart elder care network platform.
6 December 2022	Province (autonomous region, municipality)	Shanghai
	Issuing Department	Shanghai Municipal Civil Affairs Bureau

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Table A6.2 *continued*

Issuing Date		
	Document Name	Shanghai Three-Year Action Plan for Advancing Smart Elderly Care Home Construction (2023–2025)
	Contents Related to Smart Elder Care	Utilize various intelligent care devices and information application platforms to provide services such as daily living, cleaning, position shifting, and smart elder care. Encourage and support multiple elder care institutions, chain operation organizations, and districts to integrate resources, and develop and construct a unified and efficient smart management information platform.
3 September 2021	Province (autonomous region, municipality)	Jiangsu
	Issuing Department	The People's Government of Jiangsu Province
	Document Name	Jiangsu Province's 14th Five-Year Elderly Care Services Development Plan
	Contents Related to Smart Elder Care	During the "14th Five-Year" period, the entire province will have built a three-level smart elder care service platform accessible by all regions at the provincial, city, and county levels, realizing the joint construction and sharing of basic information about the older population, information about care institutions, home and community care service organization information, and care service credit information across the province.
28 April 2021	Province (autonomous region, municipality)	Zhejiang
	Issuing Department	Zhejiang Provincial Civil Affairs Department
	Document Name	Zhejiang Province Elderly Care Services Development "14th Five-Year" Plan
	Contents Related to Smart Elder Care	Utilize the internet of things, big data, and artificial intelligence technologies to build a unified provincial "Zhejiang Elderly Care" smart care service platform following the "1+5+N" general framework.

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Table A6.2 *continued*

Issuing Date		
28 May 2020	Province (autonomous region, municipality)	Anhui
	Issuing Department	Anhui Province Department of Economy and Information Technology, Anhui Provincial Civil Affairs Department, Anhui Provincial Health Commission, Anhui Province Department of Science and Technology
	Document Name	Anhui Province Smart Health and Elderly Care Industry Development Plan (2020–2025)
	Contents Related to Smart Elder Care	Accelerate the construction of the comprehensive information system platform for smart health and elder care services across the province.
8 August 2022	Province (autonomous region, municipality)	Fujian
	Issuing Department	The People's Government of Fujian Province
	Document Name	Fujian Province "14th Five-Year" Plan for Elderly Affairs and Elderly Care Service System Development
	Contents Related to Smart Elder Care	Expand the application of information technology in the field of elder care, continuously improving the construction and application promotion of the provincial are service information platform.
1 January 2022	Province (autonomous region, municipality)	Jiangxi
	Issuing Department	Jiangxi Provincial People's Congress Standing Committee
	Document Name	Jiangxi Province Elderly Care Services Regulations
	Contents Related to Smart Elder Care	Support social forces in developing and promoting smart elder care service platforms, utilizing the internet, IoT, cloud computing, and big data technologies to integrate market and social resources, facilitate supply-demand matchmaking, and provide services for older people such as emergency rescue, health management, service booking, and safety monitoring.

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Table A6.2 *continued*

Issuing Date		
30 December 2023	Province (autonomous region, municipality)	Shandong
	Issuing Department	The People's Government of Shandong Province
	Document Name	Shandong Province High-Quality Development Action Plan for Elderly Care Services (2024–2026)
	Contents Related to Smart Elder Care	Establish a comprehensive smart elder care service platform, strengthen the matching of service supply and demand, and create a service scenario where the older people have support, healthcare, activities, education, and joy.
21 January 2022	Province (autonomous region, municipality)	Henan
	Issuing Department	The People's Government of Henan Province
	Document Name	Henan Province "14th Five-Year" Plan for Elderly Care Service System and Healthy Aging Industry Development
	Contents Related to Smart Elder Care	Optimize home-based care service models for older adults, supported by a smart care service platform to timely and accurately grasp the needs of the older person. Through an offline resource integration platform, provide services such as meal assistance, bathing assistance, cleaning assistance, medical assistance, emergency assistance, and mobility assistance.
30 January 2022	Province (autonomous region, municipality)	Hubei
	Issuing Department	The People's Government of Hubei Province
	Document Name	Hubei Province "14th Five-Year" Plan for the Construction of the Elderly Care Service System
	Contents Related to Smart Elder Care	Advance the construction of smart elder care information platforms, aggregating online and offline elder care services, medical health, domestic nursing, and emergency rescue resources, precisely matching demands with supply, and providing older people with "menu-style" nearby convenient elder care services.

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Table A6.2 *continued*

Issuing Date		
15 July 2022	Province (autonomous region, municipality)	Hunan
	Issuing Department	Hunan Province Health Commission, Hunan Provincial Development and Reform Commission, Hunan Provincial Civil Affairs Department
	Document Name	Hunan Province "14th Five-Year" Plan for the Development of Aging Affairs and Elderly Care Service System
	Contents Related to Smart Elder Care	Combine provincial medical care integration service platform construction and application promotion, and innovate smart medical care integration models for the new era.
23 October 2023	Province (autonomous region, municipality)	Guangdong
	Issuing Department	General Office of the CPC Guangdong Provincial Committee, The People's Government of Guangdong Province
	Document Name	Implementation Opinions on Promoting the Construction of the Basic Elderly Care Service System
	Contents Related to Smart Elder Care	Strengthen accessibility in information technology, rely on platforms like "Yue Province Matters" to optimize online service models, focus on high-frequency matters and service scenarios involving older people to optimize public services, government services, and lifestyle services, effectively solve the difficulties older people face in using digital technologies, and provide convenience for people to access basic elder care services.
31 October 2022	Province (autonomous region, municipality)	Guangxi
	Issuing Department	The People's Government of Guangxi Zhuang Autonomous Region
	Document Name	Guangxi Zhuang Autonomous Region "14th Five-Year" Elderly Care Service System Plan
	Contents Related to Smart Elder Care	By the end of 2025, fully establish the Guangxi smart elder care service platform, integrating the older population information database, care resource database, demand matching, and industry supervision.

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Table A6.2 *continued*

Issuing Date		
31 December 2022	Province (autonomous region, municipality)	Hainan
	Issuing Department	The People's Government of Hainan Province
	Document Name	Hainan Province Three-Year Action Plan for the Development of Aging Affairs and Elderly Care Service System (2023—2025)
	Contents Related to Smart Elder Care	Encourage various enterprises to develop comprehensive service platforms that integrate information systems, professional services, and smart elder care products.
2 March 2022	Province (autonomous region, municipality)	Chongqing
	Issuing Department	The People's Government of Chongqing Municipality
	Document Name	Chongqing "14th Five-Year" Plan for the Construction of the Elderly Care Service System (2021—2025)
	Contents Related to Smart Elder Care	Leverage the advantages of smart elder care information platforms, integrate various elder care service resources, enhance the collection, analysis, and utilization of big data, achieve precise matching of elder care service demand and supply, and promote the rational allocation and efficient use of elder care resources.
14 March 2019	Province (autonomous region, municipality)	Sichuan
	Issuing Department	Sichuan Province Economic and Information Technology Department, Sichuan Provincial Civil Affairs Department, Provincial Health Commission
	Document Name	Sichuan Province Smart Health Elderly Care Industry Development Action Plan (2019—2022)
	Contents Related to Smart Elder Care	Encourage and support social forces to use cloud computing and big data technologies to build elder care information service platforms.

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Table A6.2 *continued*

Issuing Date		
11 December 2023	Province (autonomous region, municipality)	Guizhou
	Issuing Department	The People's Government of Guizhou Province
	Document Name	Guizhou Province Implementation Plan for Promoting the Construction of the Basic Elderly Care Service System
	Contents Related to Smart Elder Care	Build the Guizhou smart elder care service platform by 2025, enhance data collection, sharing, and comparison among departments, and promote precise identification and dynamic management of older people with special difficulties, such as those who live alone, are empty nesters, are left behind, have disabilities, have severe disabilities, or are from families with special family planning issues (hereinafter collectively referred to as older people with special difficulties).
18 February 2024	Province (autonomous region, municipality)	Yunnan
	Issuing Department	The People's Government of Yunnan Province
	Document Name	Yunnan Province Three-Year Action Plan for Promoting High-Quality Development of Elderly Care Services (2024–2026)
	Contents Related to Smart Elder Care	Accelerate the construction of the "internet+" smart health elder care service platform.
June 2022	Province (autonomous region, municipality)	Tibet Autonomous Region
	Issuing Department	The People's Government of the Tibet Autonomous Region
	Document Name	Several Measures for Promoting the High-Quality Development of Elderly Care Services
	Contents Related to Smart Elder Care	Advance smart elder care services and strengthen the construction of the elder care service talent team.

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Table A6.2 *continued*

Issuing Date		
22 July 2019	Province (autonomous region, municipality)	Shaanxi
	Issuing Department	Shaanxi Province Department of Industry and Information Technology, Shaanxi Provincial Civil Affairs Department, Shaanxi Provincial Health Commission
	Document Name	Shaanxi Province Smart Health Elderly Care Industry Development Implementation Plan
	Contents Related to Smart Elder Care	Build a smart health elder care information service platform.
23 November 2022	Province (autonomous region, municipality)	Gansu
	Issuing Department	The People's Government of Gansu Province
	Document Name	Gansu Province "14th Five-Year" Plan for the Development of Aging Affairs and Elderly Care Service System
	Contents Related to Smart Elder Care	Construct a service management platform for the integration of care resources for older people, providing online service functions such as housekeeping appointments, shopping and medicine purchasing, health management, medical appointment registration, and green referrals.
29 April 2020	Province (autonomous region, municipality)	Qinghai
	Issuing Department	The People's Government of Qinghai Province
	Document Name	Several Measures for Promoting the Development of Elderly Care Services in Qinghai Province
	Contents Related to Smart Elder Care	Build an information-sharing, interconnected care service management and publicity platform.

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Table A6.2 *continued*

Issuing Date		
27 June 2023	Province (autonomous region, municipality)	Ningxia
	Issuing Department	Party Committee of Ningxia Hui Autonomous Region, The People's Government of the Ningxia Hui Autonomous Region
	Document Name	Implementation Plan for Promoting the Construction of the Basic Elderly Care Service System
	Contents Related to Smart Elder Care	Integrate data related to older people from departments such as civil affairs, human resources and social security, health, and the Disabled Persons' Federation to form a data resource library for the older population in the entire region and improve the smart care information platform.
15 August 2023	Province (autonomous region, municipality)	Xinjiang
	Issuing Department	The People's Government of the Xinjiang Uygur Autonomous Region
	Document Name	Implementation Plan for Accelerating the Construction of the Basic Elderly Care Service System
	Contents Related to Smart Elder Care	Promote the construction of a smart elder care service platform and integrate it with the region's integrated government service platform. Facilitate the precise matching of basic care services with basic care service recipients, providing "menu-style" nearby convenient services for older people, gradually transitioning from "people seeking services" to "services seeking people."

Source: Authors.

7

Assessing the Potential for Digital Transformation in Elder Care in the Rural Sector: The Case of Sri Lanka

N. P. Dammika Padmakanthi and Jie Mi

7.1 Introduction

Population aging has become a significant global challenge, with profound implications for various aspects of society and the economy. As healthcare conditions improve and life expectancy increases, the proportion of older adults is growing rapidly, exacerbating the aging issue. According to the World Health Organization, the number of individuals aged 60 years and older surpassed the number of children under the age of 5 for the first time in 2020 (WHO 2022). Moreover, the global share of people aged 60 and above is expected to rise from 12% in 2015 to 22% by 2050. Although this demographic transition initially began in high-income economies, it is now low- and middle-income nations that are experiencing the more pronounced shifts. By mid-century, it is estimated that 80% of the world's older population will reside in these regions (WHO 2022).

Sri Lanka is experiencing one of the fastest rates of population aging in South Asia. The working-age population, those between 15 to 64 years, is anticipated to peak in 2027, while the population aged 65 and older is projected to double by 2040 compared to 2015 (ADB 2019). Moreover, the old-age dependency ratio is expected to increase more rapidly than the child dependency ratio by mid-century (UN DESA 2023). In rural areas, the challenges are particularly acute due to limited access to healthcare services and specialized care facilities for older adults. Older individuals in these regions often rely heavily on family support, which is increasingly strained by the migration of younger family members to urban areas and the transition from extended to nuclear family systems. Consequently, older adults in rural Sri Lanka are with inadequate healthcare, social isolation, and a lack of supportive infrastructure. These issues underscore the urgent need for targeted interventions to improve elder care, particularly in rural communities where traditional support systems are under pressure.

Digital tools have increasingly been recognized as effective means of enhancing healthcare accessibility and enabling older adults to maintain independence (Lee, Chen, and Hewitt 2011; Turja et al. 2018; Sabbagh et al. 2012; Czaja and Lee 2007; Lutz, Sanderson, and Scherbov 2008; Bloom et al. 2015). The adoption of digital technologies among older adults has been extensively studied, revealing both significant opportunities and challenges. Although digital tools, such as smartphones, tablets, and internet-based services, have the potential to significantly enhance the quality of life for older adults, various barriers hinder their widespread adoption (Czaja and Lee 2007; Peek et al. 2016; Qazi et al. 2021). Age-related factors, such as declining cognitive and physical abilities, often contribute to difficulties in learning and using new technologies (Chopik 2016). Additionally, a lack of digital literacy and limited familiarity with technological devices are major obstacles, particularly among older individuals in low- and middle-income economies (Zillien and Hargittai 2009; Rains and Tsetsi 2017; Hargittai and Micheli 2019; Dimaggio et al. 2004). Social and motivational factors also play a role, with some older adults showing reluctance or anxiety toward adopting digital technologies due to perceived complexity and a lack of trust in digital systems (Venkatesh et al. 2012; Selwyn 2004). Nevertheless, studies have demonstrated that with adequate support, training, and user-centered design, older adults can successfully adopt and benefit from digital technologies. Tailored interventions, such as simplified interfaces and age-friendly designs, have been shown to facilitate technology adoption among older adults (Gallistl et al. 2020).

While the literature on the adoption of digital technologies by older adults is extensive, research focused specifically on rural older populations is limited, particularly in low-and middle-income economies. This study investigates the potential of digital technologies to enhance the care of older people in rural Sri Lanka, offering a distinct perspective and significant practical implications. Differing from previous research, which mainly focused on urban areas or specific occupational groups, this study addresses the digital literacy of rural older individuals—a particularly marginalized group. By analyzing two age cohorts, those in their 50s and those aged 60 and above, this study sheds light on differences in their digital literacy levels and identifies the key determinants that influence these competencies, thereby addressing the gap in the existing literature. The findings may yield relevant insights for formulating targeted policy interventions to promote digital inclusion and improve the quality of life for rural older populations in Sri Lanka.

The rest of the chapter is organized as follows. Section 7.2 reviews the relevant literature. Section 7.3 describes the data and methodology. Section 7.4 presents the descriptive and empirical results, while Section 7.5 concludes with policy implications.

7.2 Literature Review

Numerous studies have shown that digital technologies have significantly improved healthcare access, enabling timely interventions, remote consultations, and enhanced patient outcomes by bridging geographical barriers (Bond et al. 2010; Slegers van Boxtel, and Jolles 2008; Shapira, Barak, and Gal 2007; Bloom et al. 2015; Prendergast and Grattini 2015). Leveraging digitization in care of older adults can provide cost-effective solutions by reducing labor requirements (Vandemeulebroucke, de Casterle, and Gastmans 2018; Prendergast and Grattini 2015; Mort, Roberts, and Callen 2013). Beyond healthcare, digital technologies also serve as tools for entertainment, social connection, and information gathering, which collectively enhance the well-being of older adults (Kuoppamäki 2018; Pirhonen et al. 2020; Genoe, Liechty, and Marston 2018; De Schutter, Brown, and Abeele 2015; Wherton et al. 2015). Telemedicine has proven particularly effective in expanding healthcare access in rural areas by bridging the distance between patients and healthcare providers (Kruse et al. 2018). Mobile health applications have effectively managed chronic diseases and promoted healthy behaviors among older populations (Guo et al. 2020). Additionally, remote monitoring systems have demonstrated their capability to provide real-time health data, facilitating early intervention and reducing hospital admissions (Yang et al. 2019). Familiarity with these technologies is becoming essential as daily activities increasingly rely on digital solutions, thus mitigating risks associated with the inability to adapt to digitization (Pirhonen et al. 2020). Moreover, the adoption of these technologies has been linked to improved health management, enhanced social connectivity, and greater independence, which collectively contribute to overall well-being (Heart and Kalderon 2013; Gell et al. 2015). Therefore, addressing the barriers and providing targeted support are crucial for promoting digital inclusion among the older population, ensuring that they can fully reap the benefits of technological advancements.

The benefits of digital technologies are contingent upon the availability of necessary infrastructure and the level of digital literacy

(Aker and Blumenstock 2014; Wheeler et al. 2022; and Dodson, Sterling, and Bennett 2013). Disparities in digital literacy are evident between older and younger populations, with older adults facing additional barriers to adopting digital tools. Limited digital proficiency and infrequent use of technology heighten the risk of exclusion for older individuals (Chopik 2016; Peek et al. 2016; Fox and Connolly 2018; Stafford 2015; Haight, Quan-Haase, and Corbett 2014; Fang et al. 2019; Levy, Janke, and Langa 2015; Kuoppamäki 2018). The existing literature on digital literacy is rich in definitions and classifications. Gilster (1997) proposed the term digital literacy describing it as the ability to derive meaningful information from diverse sources on the internet. Subsequent researchers expanded on this concept, such as Eshet (2004), who argued that digital literacy encompasses more than the ability to operate digital devices; it involves cognitive, motor, social, and emotional competencies essential for navigating digital environments. He defined digital literacy as a critical survival skill in the digital age, involving a system of skills and strategies needed for effective learning and functioning in digital contexts. More recently, Chan, Churchill, and Chiu (2017) introduced another perspective, defining digital literacy as the ability to understand and use information in multiple formats, emphasizing the importance of critical thinking rather than solely on information and communication technology (ICT) skills.

Despite the growing importance of digital literacy, research in the Sri Lankan context remains limited, particularly concerning marginalized groups. The existing studies predominantly assess the digital literacy of specific demographic groups, focusing on how individuals utilize digital tools for personal or professional purposes. Musfira et al. (2002), for instance, examined the ICT literacy of school teachers, exploring their willingness, readiness, and ability to use ICT, as well as their overall digital competence in the education sector. Their findings revealed that while some teachers demonstrated significant proficiency, others exhibited lower levels of knowledge in certain areas. Similarly, Ranaweera, Kumara, and Samaradiwakara (2014) assessed the digital literacy of postgraduate students at two Sri Lankan universities through a sociocultural lens, discovering relatively high levels of digital competence. Their research underscored the importance of enhancing infrastructure and offering comprehensive training programs to improve digital literacy further. Thilina, Guruge, and Nanayakkara (2020) conducted a descriptive analysis of the digital behaviors of young adults in Sri Lanka, focusing on patterns of internet and digital device use. Kommalage (2009) explored the use of the internet by patients and their guardians in Sri Lanka to access health-related information, finding a notably low uptake of the internet for this purpose. De Silva et al. (2014)

examined computer literacy and internet exposure among Sri Lankan youth aged 15–29 years. However, there is a distinct lack of research on the digital literacy of marginalized communities in Sri Lanka, with Galagedara et al. (2014) being a rare exception. Their study investigated barriers to internet adoption in rural communities, particularly focusing on 400 respondents from the rural areas aged between 18 and 41. Using correlation analysis, they identified key factors such as affordability, access to information, and economic and technological constraints that significantly influenced internet usage in these communities. The study highlighted the overall low adoption rates of the internet. However, it did not specifically focus on the older population, a group likely to face unique challenges due to age-related factors. Moreover, the study did not attempt to measure the digital literacy levels of rural inhabitants.

In light of these gaps, the objectives of this study are to: first, assess the digital literacy levels of older adults and those in the immediately preceding age group in the rural sector; second, investigate the awareness, affordability, and accessibility of digital facilities among these age groups, and third, examine the factors influencing digital literacy within this demographic.

7.3 Data and Methodology

7.3.1 Data Collection

Primary data were collected in two Grama Niladhari divisions in rural areas of the Badulla district in Sri Lanka. A sample of 400 individuals was selected, evenly divided into two age cohorts: 200 participants in their 50s and 200 participants aged 60 years or older. Due to insufficient information, 13 respondents from the younger and 16 from the older cohorts were excluded and the data from the remaining participants were employed to examine the objectives of the study. Inclusion of both age groups is crucial for devising sustainable solutions for elder care. The sampling process employed purposive sampling techniques to select the districts and villages, ensuring the inclusion of rural areas. Within selected areas, respondents were chosen using convenient sampling methods. The sample size determination followed the guidelines provided by Roscoe (1975). Sample representatives for people in their 50s is 11.86%, and for people aged 60 years or older is 20.04% (author's calculation based on the primary data). For this study, only smartphones and tablets were considered digital equipment, recognizing that adults generally do not use computers for daily activities. Data was collected using a structured questionnaire for one month, starting November 2023.

The inclusion of both age groups is crucial for devising sustainable solutions for elder care. Older adults are defined as people 60 years old (UNHCR 2024). Two age groups are considered because people in their 50s are the immediate cohort who will enter the older adult category in the near future. Therefore, it is essential to examine their ability to adapt the transformation of digital care facilities for older adults to make this implementation sustainable. If the socioeconomic backgrounds of these two age groups are significantly different, it is necessary to implement policies for the two categories separately since these differences may impact the digital literacy level. However, similar implementations are valid if the socioeconomic background does not differ significantly. Hence, it is worth considering these two age groups separately to calculate the digital literacy level. Table 7.1 illustrates the summary statistics of the sample data and highlights the statistical significance of the differences between the two age groups.

Table 7.1: Summary Statistics of Sample Data and Statistical Significance of Differences Between Two Age Groups

		Mean	Maximum	Minimum	t-value
50–59 years	Age (years)	53.5	59	50	--
	Income (SLRs)	29,483	62,000	10,000	--
	Education (years)	11	17	0	--
60 years and above	Age (years)	63.3	60	81	2.93*
	Income (SLRs)	24,624	58,000	8,000	1.03
	Education (years)	11	17	0	0.92

Notes:* represents statistically significant difference. T-test is to detect statistical difference between the two groups.

Source: Authors' calculations.

The mean, maximum, and minimum values are calculated separately for two age groups considering key socioeconomic characteristics. Monthly income was used as income, while years of formal education were considered as education. A t-test was conducted to examine the statistical significance of differences in the main socio-economic characteristics of the two age groups. According to the t-value, only age is statistically different, while income and education are not statistically different between the two age groups.

7.3.2 Methodology

Assessment of Digital Literacy Level

In the context of digital literacy, technology refers to the tools, systems, and resources that enable the creation, access, management, and communication of information through digital means. It includes devices such as computers, smartphones, and tablets, as well as software, applications, and platforms like the internet, social media, and cloud services. Digital literacy involves the ability to effectively and critically use these technologies for tasks such as accessing information, communicating, problem-solving, and participating in digital environments.

The study assessed basic and advanced digital literacy levels among adults aged 50–59 and those aged 60 and above in rural Sri Lanka to determine their proficiency in using digital devices (smartphones and tablets) and the internet for a range of daily tasks. The assessment tool measured digital literacy across a spectrum of competencies, ranging from fundamental activities such as browsing and email use to more sophisticated tasks involving online purchases and digital security using technology.

Basic digital literacy encompasses the foundational skills required to effectively use digital technologies, such as tablets, smartphones, and the internet. It was assessed through six questions related to essential smartphone tasks and basic internet use: (1) Can you charge your smartphone independently? (2) Are you able to receive calls on a smartphone? (3) Can you send and receive text messages on a smartphone? (4) Are you able to connect your phone to the internet? (5) Can you use messaging apps like WhatsApp and Viber, and access social media? (6) Are you able to make online reservations or purchases? For each question, a positive response (Yes) was scored as 1, while a negative response (No) was scored as 0. The overall digital literacy level was calculated by summing all responses, resulting in a possible score range from 0 to 6. Advanced digital literacy reflects a high level of competency in using digital technologies for various complex tasks. This involves the ability to critically evaluate, create, and manage digital content, use specialized software, understand data privacy and security, issues, and apply problem-solving and analytical thinking to digital environments. In this study, advanced digital literacy was measured using nine questions: (1) Can you insert and replace a SIM card? (2) Are you able to install apps? (3) Can you adjust your phone's settings as needed? (4) Do you know how to troubleshoot technical issues on your phone? (5) Are you able to create strong, secure passwords? (6) Can you search for information using different web browsers? (7) Are you able to identify fake news or misinformation online? (8) Do you know how to protect your personal information on the internet? (9) Do you know whom to contact if you encounter internet-related issues? Scores ranged from 0 to 9 and were classified into three benchmark categories: Zero (0), Low (1–4), and High (5–9), as outlined in Table 7.2.

Table 7.2: Benchmark Values of the Digital Literacy Levels

	Benchmark Values		
Literacy Level	Zero	Low	High
Basic	0	1–3	4–6
Advanced	0	1–4	5–9

Source: Authors' calculations.

Awareness, Affordability, and Accessibility of Digital Equipment and Internet Services

Awareness of available digital equipment and internet services is crucial for effective and economical utilization. This study measures awareness through a set of 15 questions designed to gauge a spectrum of knowledge from basic to advanced aspects of internet services and digital equipment. The questions cover the following dimensions: (1) awareness of device types and functions, including understanding different digital devices, such as smartphones and tablets, their capabilities, compatibility, and specific uses, as well as the ability to compare their qualities and costs; (2) familiarity with internet services and providers, including knowledge of various types of internet services (e.g., broadband, mobile data) and their associated packages, speeds, and costs; (3) knowledge of digital tools and applications, assessing understanding of commonly used software, such as productivity tools (e.g., Microsoft Office, Google Workspace) and communication apps (e.g., Zoom, Viber, WhatsApp), including those used for finance, healthcare, or government services; (4) awareness of internet accessibility in public spaces, focusing on knowledge of public internet access points, such as free Wi-Fi in libraries, cafes, and schools; (5) awareness of repair services and the lifespan of digital devices, assessing individuals' understanding of maintaining and extending the utility of their digital equipment. The benchmark values of the awareness levels are shown in Table 7.3.

Table 7.3: Benchmark Values of the Awareness Levels

Level of Awareness	Benchmark Value
Zero	0
Low	1–7
High	8–5

Source: Authors' calculations.

The affordability of digital equipment and internet services is a crucial factor determining the extent to which individuals can access and benefit from the digital economy. Affordability is a multifaceted concept encompassing the initial purchase price of digital equipment and the ongoing costs associated with internet connectivity. This affordability is influenced by the price of digital devices, such as smartphones and tablets, and the cost of internet services, including broadband and mobile data plans. For older adults living on limited incomes, the financial burden of maintaining access to digital services can be significant. Therefore, evaluating the affordability of these services involves considering both the one-time expense of acquiring digital devices and the recurring charges for internet access. Ensuring affordable access to digital services is essential for promoting digital inclusion and enabling older individuals to participate fully in the digital economy. The affordability of digital equipment and internet facilities was measured according to the percentage of monthly income spent on digital equipment and related services and internet services. If the rate is 5% or less, it is considered affordable. This is verified by double-checking people who say current facilities are affordable. The cost of digital devices and the initial fixed cost for internet and related services are divided by 24, assuming people can use their mobile phones for at least 2 years.

Accessibility was evaluated based on internet coverage and the availability of institutions providing internet facilities and shops offering digital equipment and related services. If respondents reported easy access to these facilities (particularly if they were available within a 2 kilometer radius) and good internet coverage (as directly assessed based on their responses), they were considered to have no accessibility issues.

Determinants of Digital Literacy Level

Digital literacy determinants are crucially and urgently understood, particularly for implementing innovative methods in digitalizing elder care. A multiple regression model was used to determine the key factors that could affect the digital literacy level of the people. In this study, generally, the dependent variable and independent variables are rarely equal to zero at the same time. In other words, the fitted line, representing the relationship between them, would not perfectly go through the coordinates original point. Furthermore, the multiple linear regression without intercept term tends to be biased, and their statistical indicator, such as R^2, make no sense statistically. Hence, considering these two points, we adopt a multiple linear regression with an intercept term in this study.

The dependent variable (total digital literacy level) is derived from the combined basic and advanced digital literacy levels. A dummy variable was used to measure the gender of the respondents by assigning 1 for male and 0 for female respondents. The number of years spent on formal education was used to measure the education level of the respondents. The current or preretirement occupation was measured using a dummy variable that assigned 1 for the respondents who worked or are working in the formal sector and 0 for other respondents. The total monthly income from the monetary term (SLR) was used to measure the monthly income. Availability of smartphones or tablets was measured using a dummy variable in which 1 was assigned for those with their own smartphone or tablet and 0 for others. The ability to use a phone or tablet was measured according to the respondent's positive or negative answer by assigning 1 for the positive answer and 0 for a negative answer. A similar procedure was used to measure the availability of good internet coverage by assigning 1 for the respondents who are able to access good internet coverage and 0 for others. The convenience of access to digital equipment and internet services was measured by assigning 1 for the respondents who could easily access these facilities and 0 for others. Monthly charges for digital services were measured according to the monthly payments for those services. The affordability of digital equipment and internet facilities was measured according to the percentage of monthly income spent on digital equipment and related services and internet services. If the rate is 5% or less, it is deemed affordable and 1 was assigned. For others 0 was assigned. The dummy variables, with 1 for positive response and 0 for negative response, were used to measure the variables such as getting support from family members for handling digital equipment, participating in the training program, availability of electricity facilities, and availability of services that can be obtained using the internet.

Based on the selected variables, the regression models could be expressed as follows:

$$y_i = aX_i + c + \varepsilon_i \qquad (1)$$

where y_i represents the variable, namely digital literacy level, of the observation i, X_i represents a vector of independent variables as listed above of the observation i, a and c are the coefficients and intercept term to be estimated, and ε_i represents the error term for the observation i. Examining these variables through a multiple regression analysis can identify which factors have the most strong impact on digital literacy. This understanding is essential for developing strategies that can effectively enhance digital skills among the older population, ultimately improving their quality of life and access to essential services. Table 7.4 outlines the dependent and independent variables considered in this study.

Table 7.4: Variables of the Multiple Regression Model

Variables	Measurement
Dependent Variable	
Digital literacy level	Total digital literacy score
Independent variables	
Age	Number of years
Gender	1-Male; 0-Otherwise
Education level	Years of formal education
Current occupation or occupation before retired	1-Formal; 0- Otherwise
Monthly income	Monthly income (SLR)
Availability of smartphone/tablet	1-Yes ; 0-Otherwise
Ability to use a smartphone/tablet	1-Yes; 0-Otherwise
Availability of good internet coverage	1-Available; 0-Otherwise
Availability of digital equipment and internet service nearby	1-Available; 0-Otherwise
Monthly charges for digital services	Monthly bill (SLR)
Affordability of digital equipment and charges for internet services	1-Affordable; 0-Otherwise
Support from family members for handling digital equipment	1-Support; 0-Otherwise
Participated in the training program	1-Yes; 0-Otherwise
Availability of electricity	1-Available; 0-Otherwise
Availability of services that can be obtained using the internet	1-Available; 0-Otherwise

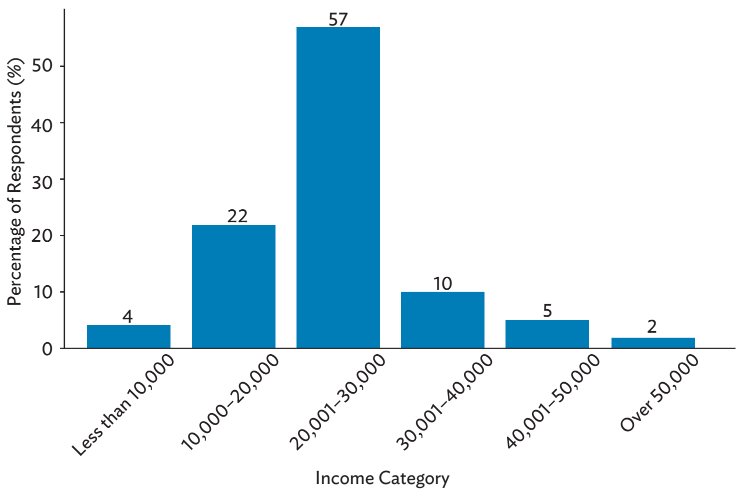
Source: Authors.

7.4 Results and Discussion

7.4.1 Socioeconomic Background of the Respondents

Regarding the socioeconomic characteristics of the respondents, we summarize information on income, living arrangements, and educational background. Figure 7.1 presents the percentage of respondents across various income categories, while Figure 7.3 outlines the primary sources of income.

Figure 7.1: Monthly Income Distribution of Respondents

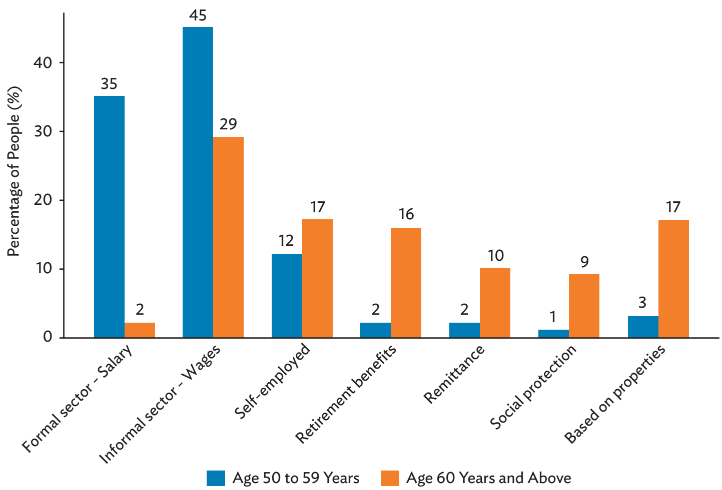


Source: Authors' calculations.

The majority of the population in the rural sector relies on the informal sector for their livelihood, resulting in moderately low-income levels. According to the survey, the highest concentration of respondents (57%) falls within the income range of SLR20,001 to SLR30,000. A smaller segment of respondents (4%) earns less than SLR10,000. Notably, all individuals within this income bracket are over 70 years old and rely on remittances from relatives and social protection benefits. This demographic is particularly vulnerable and may face significant challenges accessing digital services. Conversely, only 2% of the respondents have an income exceeding SLR50,000. This group primarily comprises self-employed individuals or those who possess properties that generate income.

The disparity in income distribution highlights the economic challenges faced by the majority of the respondents in rural Sri Lanka. Individuals with stable and regular income sources are generally better positioned to manage financial needs than those reliant on irregular income streams. Figure 7.2 provides a breakdown of the main income sources. It illustrates a notable shift in the primary income source as individuals transition from the 50 to 59 age group to the 60 years and over cohort. Notably, the 50–59 age group shows a significant reliance on wages from the informal sector (45%), whereas the reliance shifts as individuals transition into older age. For those aged 60 years and above, self-employment (17%) and property-based income (17%) become more prominent income sources, highlighting a shift away from wage employment towards more independent and passive income channels. Moreover, retirement benefits play a more critical role for older adults, with 16% of individuals aged 60 years and above receiving such benefits, compared to only 2% in the younger cohort.

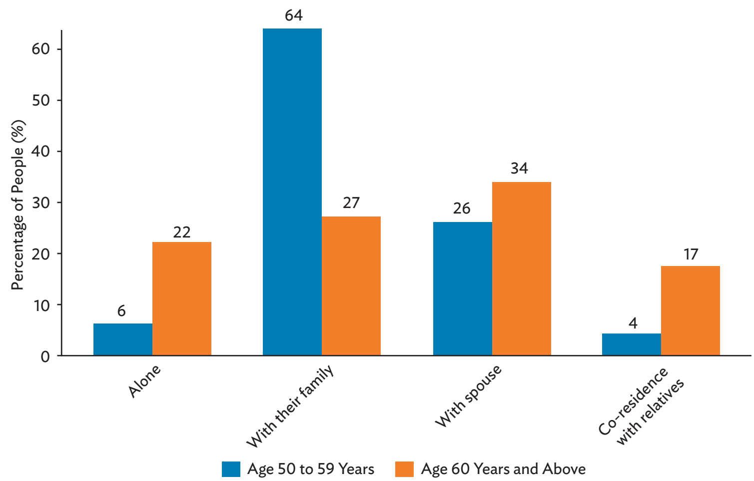
Figure 7.2: Main Income Sources by Age Group



Source: Authors' calculations.

Living arrangements are crucial in implementing care facilities for older adults, particularly in determining the demand for digital facilities among the older population since those living with family members or relatives can receive their assistance. Figure 7.3 shows the living arrangements of respondents divided into two age groups: 50 to 59 years and 60 years and above.

Figure 7.3: Living Arrangements by Age Group

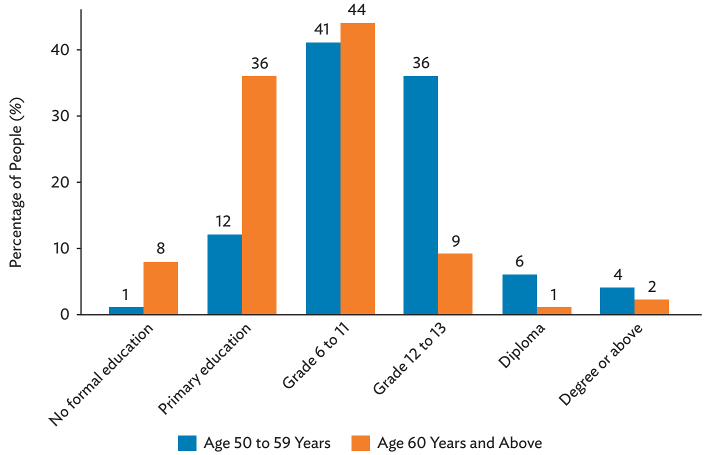


Source: Authors' calculations.

The results reveals distinct differences in living patterns between the two groups. The majority of individuals aged 50 to 59 live with their family (64%), while this proportion decreases significantly to 27% for those aged 60 and over. This decline can be attributed to various factors such as marriage or occupational commitments of children, which limit their opportunity to live with parents. In some families, children migrate locally or internationally for work or education or because of marriage. Conversely, the older age group shows a higher tendency to live alone (22%) compared to the younger group (6%) or co-reside with relatives (17%) compared to the younger group (4%). Furthermore, the percentage of respondents living with a spouse is higher among the 60 and above group (34%) compared to those aged 50 to 59 (26%).

The educational background of individuals is crucial in implementing policies targeted at older people, as these innovations should be aligned with their educational levels. Figure 7.4 presents the educational background of the respondents.

Figure 7.4: Educational Background of Respondents by Age Group



Source: Authors' calculations.

The education level of those residing in rural areas is relatively low regardless of age. Only 4% of respondents in their 50s and 2% of those aged 60 or older have attained a degree-level education. In contrast, 1% of individuals in their 50s and 8% of those aged 60 or older did not have formal education. Furthermore, 36% of respondents in their 50s have completed formal school education, compared to only 9% of those in the older age group. A significant proportion of individuals over 60 have only primary school education. This variation in education levels reflects the need for custom-oriented digital innovation approaches in elder care.

7.4.2 Digital Literacy Level

The basic and advanced digital literacy levels of individuals in their 50s and over were measured by gathering information on their proficiency in using smartphones and tablets to search and use information in digital space. Table 7.5 presents the digital literacy levels of respondents across different categories: zero, basic, and advanced.

Table 7.5: Digital Literacy Level of the Respondents (%)

	Zero	Basic		Advanced	
Age category	Zero	Low	High	Low	High
50–59	12	46	42	70	18
60 and above	29	49	22	64	05

Source: Authors' calculations.

The results indicate that a significant portion of respondents lacks digital skills entirely, with 12% of those aged between 50 and 59 and 29% of individuals aged 60 and above classified as having no digital literacy. In terms of basic literacy, nearly half of each age group is categorized as having low levels of basic literacy (46% for those aged between 50 and 59 and 49% for those aged 60 and above). High proficiency in basic digital literacy is notably lower in the older group, at only 22%, compared to 42% in the group aged between 50 and 59. Regarding advanced digital literacy, merely 18% of respondents aged between 50 and 59, and only 5% of those aged 60 and above, achieving high levels of advanced skills. These findings underscore significant digital skill gaps, especially among older individuals. This is consistent with studies showing that adults generally have lower levels of digital literacy compared to younger cohorts (Friemel 2014; Baker et al. 2017). The majority of respondents reported insufficient internet services as a barrier to internet use, while a significant portion cited unaffordable charges as a hindrance. Additionally, a considerable number of older people indicated that they do not see the need for using the internet or lack the awareness required to understand its benefits. These results highlight the need for improved infrastructure facilities and training programs to enhance the digital literacy of older people to integrate them more effectively into the digital world.

7.4.3 Discussion on Awareness, Affordability, and Accessibility of Digital Equipment and Internet Services Among Older Adults

The awareness of digital services was assessed through a series of questions concerning the knowledge of available digital equipment, various internet and calling plans, and existing facilities within the digital space. Table 7.6 summarizes the levels of awareness regarding digital services and equipment among respondents in two age groups.

Table 7.6: Awareness of Digital Services and Equipment (%)

	Awareness Level		
Age category	Zero	Low	High
50–59	3	63	34
60 and above	11	76	13

Source: Authors' calculations.

Table 7.6 indicates that among individuals aged between 50 and 59 years, only 3% have no awareness, while 63% are categorized as having low awareness, and 34% demonstrate high awareness. In contrast, for those aged 60 years and above, 11% have no awareness, and 76% are categorized as having low awareness. Compared to people in their 50s with 34% having high level of awareness, only 13% of older adults display a high level of awareness.

Table 7.7: Affordability of Digital Equipment and Internet Services (%)

	Age 50–59 Years		Aged 60 Years and Above	
	Affordable	Not affordable	Affordable	Not affordable
Monthly internet bill	22	78	13	87
Monthly phone bill	45	55	24	76
Price digital equipment	21	79	12	88
Repairing	24	76	19	81
Initial payment for internet	23	77	13	87

Source: Authors' calculations.

Affordability is a significant barrier to digital inclusion, impacting individuals' ability to participate fully in the digital economy. Table 7.7 summarizes the respondents' views regarding the affordability of digital equipment and internet services.

The results reveal that respondents aged 60 years and above consistently reported lower affordability compared to those aged 50–59 across all assessed aspects. For instance, only 13% of the older group found the monthly internet bill affordable, compared to 22% in the younger group. Similarly, affordability of digital equipment, repair costs, and initial internet setup costs was substantially lower among individuals aged 60 and above. Even the monthly phone bill, which showed relatively higher affordability, was manageable for only 24% of older adults, compared to 45% in the younger group. These findings underscore the financial barriers faced by older adults in accessing digital services. Moreover, the cost of digital services and equipment is rapidly increasing in Sri Lanka following the economic crisis that originated due to the coronavirus disease (COVID-19) pandemic, making it difficult for individuals to afford digital facilities. Economic policies that restrict imports and revise taxes have significantly contributed to the rising costs in this sector. Therefore, targeted policy interventions are needed to alleviate these financial barriers and facilitate the effective implementation of digital technologies for elder care in rural Sri Lanka.

Accessibility to digital equipment and internet services in rural areas is vital for digitalizing elder care, as this sector often faces significant healthcare and connectivity challenges. The survey data highlights that accessing reliable internet services is significant challenges in rural areas. Approximately, 73% of the sample population reported that the quality of their internet service was very poor, while 22% indicated they had moderately good internet service. Accordingly, 18% of respondents do not have internet access entirely. A minority of respondents utilized wireless internet services, with the majority relying on card connections for internet access. Table 7.8 summarizes the most highlighted reasons regarding the accessibility of digital equipment and internet service.

Table 7.8: Accessibility to Digital Facilities in Rural Areas (%)

Information on Accessibility	Respondents (%)
Availability of shops with digital equipment within a reasonable distance	23
Availability of institutes that provide internet services	12
Availability of shops that provide repair services for digital equipment	4

Source: Authors' calculations.

The results in Table 7.8 indicate that accessibility to digital facilities for respondents is notably constrained. Specifically, 23% of respondents reported access to shops selling digital equipment within a reasonable distance, 12% indicated access to institutions providing internet services, and only 4% have access to shops for digital equipment repair. This limited accessibility is primarily due to inadequate infrastructure and the reluctance of the private sector to invest in nonprofitable rural areas. The scarcity of internet service providers and the absence of retail outlets selling digital equipment and related services in remote areas impede internet usage. This issue is particularly pronounced among older adults, who often face difficulties traveling long distances to access these services. Phuong et al. (2023), Cullinan et al. (2021). Duzenli, Felekoglu, and Tasan (2020), Ayim et al. (2022), and Parajuli et al. (2022) have also indicated that poor accessibility of digital services hinders the adoption of new innovations by examining the situation in other economies. Therefore, it is imperative to enhance the availability of digital services in remote regions prior to implementing digital innovations aimed at elder care.

7.4.4 Determinants of Digital and Internet Literacy

Examining the determinants of digital literacy among the older population in remote areas is crucial for addressing the unique challenges they face and tailoring effective interventions. Table 7.9 presents the results of the multiple regression analysis evaluating the determinants of digital literacy among respondents. The dependent variable, digital literacy level, was derived from the cumulative score of fifteen questions, with higher scores indicating greater proficiency in using smartphones and/or tablets, and the internet.

The regression results reveal several significant factors influencing the digital literacy level of respondents aged 50 and above in rural Sri Lanka. As for the demographic and socioeconomic characteristics,

Table 7.9: Results of the Multiple Regression Model

Variables	Coefficient	Standard Deviation	T value	P-value
Intercept	10.13	0.85	11.90	0.00***
Age	−0.59	0.04	−13.76	6.95 E-13***
Gender	0.01	0.013	1.20	0.24
Education level	0.18	0.055	3.27	0.00***
Current occupation or occupation before retired	0.23	0.708	0.328	0.74
Monthly income	0.87	0.42	2.07	0.05**
Availability of smartphone/tablet	0.45	0.028	15.60	2.22 E-13***
Ability to use a smartphone/tablet	0.35	0.032	11.12	5.94 E-07***
Availability of good internet coverage	1.81	0.358	5.072	0.00***
Availability of digital equipment and internet service nearby	3.85	1.042	3.70	0.00***
Monthly internet bill	−0.048	0.016	−3	0.00***
Affordability of digital equipment and charges for internet services	2.17	0.606	3.58	0.00***
Support from family members for handling digital equipment	0.01	0.003	4.47	0.00***
Training to use the internet and digital equipment	0.36	0.129	2.79	0.01***
Availability of electricity	0.33	0.041	8.21	2.1 E-16***
Availability of services that can be obtained using the internet	0.48	0.052	9.33	1.48 E-9***

Notes: In scientific notation, E stands for "exponent" and is used to represent very large or very small numbers in a more compact form. It is shorthand for powers of 10. ** $p < 0.01$, *** $p < 0.001$.

Source: Authors' calculations.

age is negatively correlated with digital literacy (coefficient = −0.59, p <0.001), indicating that older individuals in rural Sri Lanka tend to report lower level of digital literacy. This finding is consistent with the literature, which suggests that young people are more capable than adults in using computers, internet, telephone and videocassette (Rogers et al. 1996; Czaja et al. 2001; Sharit et al. 2003; Czaja et al. 2006; Xie et al. 2009; and Helsper and Reisdorf 2013). Moreover, education level is positively associated with the digital literacy level of residents aged 50 and above in rural Sri Lanka (coefficient = 0.18, $p < 0.001$). It implies that higher levels of education may provide individuals with essential skills and knowledge, enabling them to navigate digital platforms more proficiently, which is in line with findings by DiMaggio et al. (2004). Furthermore, monthly income is positively correlated with the digital literacy level of respondents. (coefficient = 0.87, $p = 0.05$), since financial stability contributes to improved access to digital resources and training, which in turn can boost digital competencies (Deursen and Dijk 2014).

Regarding other influencing factors, firstly, the availability of resources is critical for enhancing the digital literacy level of rural older residents in Sri Lanka. The availability of smartphones or tablets (coefficient = 0.45, $p < 0.001$), good internet coverage (coefficient = 1.81, $p < 0.001$), digital equipment and internet services nearby (coefficient = 3.85, $p<0.001$), electricity (coefficient = 0.33, $p<0.001$) and the service for internet use (coefficient = 0.48, $p<0.001$) demonstrate a positive correlation with level of digital literacy. These results are consistent with previous studies. For instance, Selwyn (2004) also highlighted that local availability of digital resources and services reduces barriers to access and promotes digital inclusion. The importance of a reliable electricity supply for utilizing digital technologies has been documented by Aker and Mbiti (2010), Blair, Pons, and Krumdieck (2019), and Salat et al. (2021). Moreover, respondents who participated in training programs (coefficient = 0.36, $p<0.01$) and received support from family members in handling digital equipment (coefficient = 0.01, $p<0.001$) tend to have greater proficiency in using smartphones, tablets, and the internet. Structured training programs may provide a formal learning environment where respondents can gain both foundational skills and more advanced competencies, helping them overcome barriers related to the use of digital tools. Family support often serves as an informal, social learning mechanism in building digital skills. It may come in the form of hands-on assistance, sharing knowledge, or troubleshooting technical issues, which encourages older individuals to engage more frequently with digital technologies (Livingstone and Helsper 2007; Xiong and Zuo 2019; Taipale 2019; Deursen and Helsper 2015). In addition, the affordability of digital equipment and internet services is positively correlated with digital literacy (coefficient = 2.17, $p<0.001$), as it may reduce financial barriers to accessing devices (such as smartphones, tablets, or computers), services, and training needed to develop digital skills. This effect is particularly crucial in rural areas, where limited income often constrains individuals‘ ability to purchase digital devices and access costly digital services. If digital devices, internet subscriptions, or training programs are affordable, people are more likely to invest in and use these resources regularly, allowing them to build familiarity and competence with digital tools (Warschauer 2004; Kadylak et al. 2018; Kobayashi, Taka, and Suzuki 2021). By contrast, the monthly internet bill has a significantly negative impact on respondents' digital literacy levels, suggesting that service costs may pose a barrier to digital adoption, particularly for individuals with limited income in rural Sri Lanka.

7.5 Conclusions and Policy Implications

7.5.1 Conclusions

With the rapid acceleration of population aging and digital transformation worldwide, digital literacy has emerged as a key ability for older adults to integrate into society and access essential services. However, in less developed economies, particularly in rural areas, older populations face multiple barriers in accessing digital resources and developing digital skills, which significantly limit their ability to benefit from digital technologies. Therefore, identifying and understanding the factors that influence digital literacy among rural older populations is crucial for designing effective policies aimed at bridging the digital divide and promoting the use of digital technologies in elder care. Against this backdrop, we focused on Sri Lanka to assess the digital literacy levels of older residents in rural areas and to explore the key determinants influencing their digital literacy.

Based on survey data collected in 2023 from 400 rural Sri Lankan residents divided into two age groups (50–59 years and 60 years and above), this research assesses the proficiency of respondents in using smartphones, tablets, and the internet, as well as their awareness, affordability, and accessibility of these digital devices and internet services. Moreover, the study also investigates the key factors influencing the competencies in using these digital devices and internet services.

The results from the descriptive analysis highlight that a substantial proportion of respondents have zero digital literacy, with 12% of respondents aged 50–59 years, and 29% of those aged 60 years and above reporting no digital literacy skills. Respondents aged 60 and above demonstrated lower performance compared to the younger group, both in terms of basic and advanced levels of digital literacy. Furthermore, regarding the evaluation of awareness, affordability, and accessibility of digital equipment and internet services, over half of the respondents in both age groups were categorized as having low levels of awareness and reported being unable to afford digital equipment and internet services.

Additionally, respondents' access to digital facilities was significantly constrained. Specifically, 23% of respondents reported having access to shops selling digital equipment within a reasonable distance, 12% reported access to institutions providing internet services, and only 4% could access shops offering digital equipment repair.

The multiple regression results further reveal that age has a significant negative impact on digital literacy levels, indicating that older individuals tend to exhibit lower digital literacy. Moreover, the availability of resources and affordability are critical for enhancing digital literacy level of rural older residents in Sri Lanka. In particular, the availability of digital devices and internet services nearby, along with the affordability of digital equipment and internet costs, are among the most critical factors enhancing the levels of digital literacy. The results imply that improving access to affordable digital devices and reliable internet services may substantially increase digital literacy among the rural older population.

7.5.2 Policy Implications

The findings of this study have several important implications for policymakers, healthcare providers, and technology developers. To foster the adoption of digital innovations for care of older adults in rural Sri Lanka, the following recommendations are proposed.

Enhanced digital literacy programs: Implement comprehensive digital literacy training programs tailored to the needs of older adults. These programs should focus on basic digital skills, internet use, and the benefits of digital health services. Appoint digital ambassadors, launch targeted awareness campaigns, organize workshops and training programs that teach digital literacy skills and age-specific training, and establish ongoing support systems, such as help desks or call centers, where older adults can receive assistance with digital issues and integration with existing services such as health care integration are recommended.

Affordable digital services: Develop initiatives to subsidize the cost of digital equipment and internet services for older people in rural areas. Financial support, affordable pricing plans, and subsidized devices, government voucher programs, grants and subsidies for low-income people, tax intensives, recycling, and donation programs can be introduced.

Infrastructure development: Invest in improving digital infrastructure in rural regions, including expanding internet coverage and ensuring reliable connectivity. Collaboration between government and the private sector is crucial in this endeavor. Necessary action should be taken to expand broadband, public Wi-Fi, and mobile internet solutions such as 4G or 5G.

Policy and regulatory support: Formulate and implement comprehensive digital inclusion policies at both national and local levels, ensuring a coordinated approach to improving digital literacy and access. Allocate funding and grants specifically for initiatives aimed at enhancing digital literacy and access in rural areas.

By implementing these policy measures, the digital literacy of older adults and people in their 50s in rural areas can be significantly enhanced by improving access, affordability, and awareness of digital services. This, in turn, can foster greater social inclusion, economic opportunities, and quality of life for these populations.

These findings collectively emphasize the multifaceted nature of internet and digital literacy, influenced by factors ranging from individual characteristics to environmental resources and support systems.

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PART III

Technology's Impact on Elder Care and Well-Being

8

Global Trends and Opportunities of Healthcare Driven by Generative Artificial Intelligence and Behavioral Attitude of Older People in Bangladesh

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8.1 Introduction

Healthcare is a fundamental necessity required for people of all ages. However, its necessity and endurance are more critical for older individuals. Unfortunately, the world is facing serious challenges in this aspect, particularly developing economies, which are striving to ensure the availability of healthcare for older adults (Acampora et al. 2013; Bloss 2011). Healthcare facilities and support are gradually decreasing in Asian economies (Shareef et al. 2023). Nowadays, in the perspective of economic solvency, it is difficult for middle- to lower-income people to access adequate health support, which is essential for older individuals. Even at the end of the 20th century, many developing economies in Asia had enough family support to provide essential healthcare to older people (Unifor 2020). Both males and female family members were used to taking care of older people. Nevertheless, previously, due to family composition and employment pattern in Bangladesh (or any developing economy), women were more engaged in family affairs due to their less scope in employment (Shareef et al. 2023). However, due to dramatic changes in professional engagement, women empowerment, and digitalization, people, particularly women, are increasingly engaging in earning opportunities. As a result, there is a change in the composition of required human support for taking care of older family members, making it challenging for family members to provide care for the older population (Shareef et al. 2023).

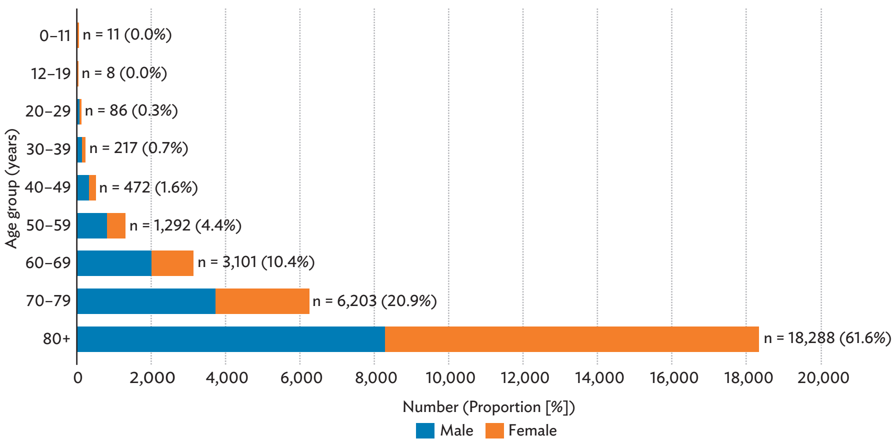
Throughout the world, the cost of healthcare support is growing tremendously. For the last few years and particularly since 1990, it has been almost out of reach for most low-earning people (Schneider and Kummert 2021). They cannot afford to seek regular healthcare support from local health facilities. Heuristically and obviously, continuous daily life support for older people is almost rare. Digitization, driven by ambient intelligence and machine autonomy, can be an excellent alternative for future healthcare support for older people (Rantanen et al. 2017). There are many different kinds of generative artificial intelligence (GAI)-driven autonomous tools and facilities that can provide continuous daily life support to older individuals, and they are assumed to be cost-effective and efficient (Nasr et al. 2021).

Elder healthcare is a significant problem due to an aging population and a shortage of caregivers. Solutions need to be implemented to remedy this situation. This research focuses on one of the most plausible solutions: ambient intelligence and homecare automation systems for older people and people with disabilities as an alternative source of human support. The research also investigates the design of automation systems and the acceptance of machine intelligence by older people, considering their trust and behavioral attitude.

While research has started on home automation for elder care, it is still in its early stages (Shareef et al. 2023). Researchers remain skeptical about the essential technical features of autonomous systems for healthcare support for older people and the quality dimensions required for the acceptance of this autonomous system as an alternative to traditional human support (Nasr et al. 2021). Since healthcare, including daily support for older people, is an urgent and potentially significant issue, without sufficient research on this matter, it is challenging to establish conclusive guidelines (Lee et al 2023). Therefore, more research still needs to be conducted to understand GAI, machine autonomy, and their essential features (Aguiar Noury et al. 2019). More importantly, in this regard, it is essential to understand older people's behavior to foster their positive attitude toward adopting this system with trust and willingness (Lee et al. 2023).

Since life expectancy is growing, the increasing number of older people has led to a significant rise in lifetime healthcare costs for this demographic. This trend was particularly pronounced during the coronavirus disease (COVID-19) pandemic, as older people are more susceptible to diseases due to weaker immune systems compared to healthy younger adults. The findings of this research have the potential to contribute to the existing knowledge of GAI, ambient intelligence, machine autonomy, and their application in healthcare for the older population.

Figure 8.1: Number of Deceased Based on Various Ages from COVID-19



COVID-19 = coronavirus disease.

Source: Public Health Agency of Canada (n.d.).

As can be seen from Figure 8.1, diseases such as COVID-19 pose a much greater risk to older people, leading to a surge in their healthcare costs due to high demand. This figure represents a Canadian sample; however the global trend is similar. Therefore, alternative sources for healthcare of older adults need to be explored to alleviate these financial burdens.

Given the aforementioned understanding, this study has two main objectives:

- Identifying the features, scope, and future global trends of applying machine autonomy for regular healthcare and daily family support for older people through a review of scholarly studies.

- Understanding the behavioral patterns of older people in adopting GAI-driven machine autonomy through qualitative study in Bangladesh.

The next section discusses the literature review on machine autonomy and healthcare for older people, followed by the research methodology. Subsequently, the findings and discussions of this study are presented. Section 8.4 outlines the future trends of autonomous systems and the implications of this study. The limitations of the study are then identified, along with future research guidelines. Finally, the conclusion of this study is summarized in Section 8.6.

8.2 Literature Review

Based on literature reviews of smart home devices (Edwards et al. 2019; Garza 2012; Marchant and Lindor 2012; Shareef et al. 2021) a homecare autonomous system has been defined as "any integrated and interconnected process or product that can act independently, making appropriate contextual decisions within a changing environment and without any human intervention."

The number of older individuals worldwide is dramatically increasing. According to Shareef et al. (2021), the proportion of the population aged over 65 in Europe was 19.2%, while it was 16% in North America. Although this trend is slightly slower in developing economies, such as those in South Asia, and familial support is still available, the availability of family support is gradually diminishing due to dramatic changes in women's empowerment and family composition (Lee et al. 2023). It is believed that there will be more than 1 billion older people worldwide by 2030. This is due to scientific and medical breakthroughs that have extended the human life cycle. Consequently, healthcare costs and requirement of facilities is growing. As a result, an aging population is a problem for the healthcare system of any economy (Shareef et al. 2023). The aging population is growing faster than the young population that can support them. Majumder et al. (2017) suggested that the demand for healthcare is continuously rising. This has led governments to invest huge amounts of money in the healthcare sector due to increasing demand. To address this Majumder et al. (2017) discussed using automated technology for the care of older people. However, the undeniable question in this context is whether older people are psychologically and behaviorally ready to accept the use of automation systems in their lives for healthcare support. Researchers in human psychology, technology, and healthcare systems have argued that acceptance behavior depends on complex multidimensional factors that need to be extensively investigated based on technology and trust models (Schaefer et al. 2016).

Typically, people from different economies in Asia have significantly different attitudes toward older individuals due to specific characteristics of family composition (Jafree et al. 2020). Due to factors such as employment scope, the impact of religion, and the dominance of masculinity, women are comparatively more engaged in household work and in taking care of older individuals (Osamor and Grady 2016). However, this trend has been changing rapidly in Asia over the last couple of decades (Hamiduzzaman et al. 2022). Most of the developing economies in the region are promoting women's employment, and as a result, the traditional role of women in caring for the older adults is experiencing a severe crisis (Chakraborty et al. 2003; Hamiduzzaman et al. 2022). Pragmatically, a recent phenomenon is that older people in developing economies in this region also require technology-driven autonomous systems to supplement human support for their healthcare (Jafree, Zakar, and Anwar 2020).

Due to the fast advancement of GAI, the idea and function of a homecare autonomous system, which can provide excellent supporting, supplementary, or even primary assistance, are changing rapidly (Dwivedi et al. 2016; Gao, Li, and Luo 2015). It is believed and predicted that in the future, the features and scope of machine autonomy, i.e., smart home appliances, will be so versatile that older people can receive assistive support to manage their daily lives without being accompanied by internal family members or external healthcare service providers (Di Vaio et al. 2020; Körber, Baseler, and Bengler 2018).

In this regard, it is worthwhile to explain and understand that the degree of innovation, flexibility, novelty, and robustness of any autonomous system varies significantly (Shareef et al. 2021). The concept of an autonomous system controlled by ambient intelligence largely depends on the creative power of GAI, which is the primary driving force for the design of smart home appliances (Gao et al. 2015). Among many parameters, the most important controlling criteria of the level of autonomy include users' requirements, operating cost, necessity, adaptability, ability to control, skill, scope of use, and moreover, the behavioral attitude of the service receivers (de Visser et al. 2020).

At present, smart homecare systems driven by ambient intelligence available to support human tasks include several partial or complete machine autonomy such as automated vehicles, automated vacuum cleaners, washing machines, alarm clocks, robots, etc. (Shareef et al. 2023). However, researchers predict that in the near future, this list of autonomous systems that can be used to assist older people, both in developed and developing economies, will be longer and soon, human support can be entirely replaced by GAI-driven autonomous systems (Lee et al. 2023). These GAI-driven smart homecare machine autonomies can provide all the essential supports that an older person might need to manage their daily activities (Lee et al. 2023).

8.3 Research Methodology

This research has two objectives. To unveil the answer to the first objective, this study investigated secondary data through a literature review. Thus, the features, scope, and future trends of the application of machine autonomy for regular healthcare and daily life support of older people have been postulated from secondary information revealed in the literature review. The research gathered, examined, and reviewed secondary information to understand the essential daily functions and activities of older people that can be accomplished through machine autonomy driven by GAI. The second objective was achieved through interviews with older people in Bangladesh. This was done to understand the behavioral patterns of older people in adopting this GAI-driven machine autonomy.

8.3.1 Experiment

In many economies, particularly in developing ones, older individuals lack experience in using autonomous systems driven by ambient intelligence, capturing their perceptions regarding the acceptance of autonomous systems replacing physical assistance provided by family or acquaintances requires practical demonstrations.

To address this, digital media and computer and system engineering students from both a private and a public university designed a short informative documentary video of approximately 45 minutes to showcase the application of certain autonomous systems assisting with daily activities. Primarily, it was designed to provide experiences of how autonomous home appliances controlled by ambient intelligence can aid in performing daily activities for older individuals recruited for the qualitative study.

The video begins with a narrative about the application of autonomous systems, followed by a demonstration of an automatic vacuum cleaner. Subsequently, a self-controlled robot is shown performing various daily healthcare activities such as reminding to take medicine and assisting with it, accompanying on morning walks, and cleaning houses.

8.3.2 Qualitative Study

A qualitative study was conducted among older individuals selected randomly from the eight major cities in Bangladesh: Barishal, Chattogram, Dhaka, Khulna, Rajshahi, Rangpur, Mymensingh, and Sylhet. Fifteen older people were randomly selected from each city, resulting in a total of 120 samples for the interview process.

The researchers, assisted by two research assistants, visited the addresses of these respondents physically to conduct interviews about their perceptions toward accepting machine autonomy as a replacement for traditional human support in caregiving. Before obtaining their statements of perceptions, the video was shown to demonstrate the potential reality of assistance that could be offered by machine autonomy.

After viewing the video, each respondent was asked to express their thoughts about autonomous systems, the current level of support from family members and healthcare professionals, and their interest in accepting this alternative support to perform their daily activities, including emergency healthcare. Each interview lasted approximately 30 minutes.

8.3.3 Findings and Discussions

This study, as the first objective, primarily aimed to reveal the global status of using machine autonomy in healthcare of older people. However, this global status fundamentally represents healthcare for older people in developed economies. Very few scholarly studies have performed investigations to understand adoption behavior of machine autonomy of older people in developing economies, particularly in Asia (Shareef et al. 2023). As the second objective, the researchers investigated behavioral attitudes of older people in Bangladesh.

To understand the future trend and prospects of autonomous systems in assisting daily activities and healthcare of older people, it is imperative to reveal the features and prospects of future autonomous systems controlled by GAI (Table 8.1).

Table 8.1: Autonomous Systems for Elder Support: Present Status and Future Trends

Healthcare Functions and Daily Activities	Description	Autonomous Systems	Source
Room cleaning	Controlled and operated by GAI, robot vacuum cleaners can clean an entire space to help older people	Robot vacuums	Körber, Baseler, and Bengler 2018; Lewis, Sycara, and Walker 2018; Lu and Sarter 2019; Satterfield et al. 2017; Schaefer et al. 2016; Shareef et al. 2023
Washing and drying clothes	Clothes can be washed and dried through automatic washing machines and dryers. It can be done almost independently with barely any need of human assistance.	Automatic washing machines and dryers	Chen et al. 2021; Martinez-Martin et al. 2020; Nasr et al. 2021; Na, Jung, and Kim 2023
Turning on lights, fans, air conditioners, setting room temperature, and locking the door	Smart home devices including lights, switches, outlets, and thermostats can be operated automatically through verbal instructions. The room temperature can be set by an older person lying in bed. Smart door locks can also be used to lock and unlock the door remotely.	Google Assistant	Aguiar Noury et al. 2019; Lee et al. 2023
Managing medication	Medication times and dosages can be managed so that the correct intake of medication is ensured.	Automated pill dispensers	Guerrero et al. 2019; Kumar, Sharma, and Karnwal 2024
Managing finances	Using mobile applications and other devices, finances can become a lot easier to manage. This can be done by tracking expenses, providing reminders for payments, budgeting and monitoring suspicious activity.	Mobile apps	Skuza and Lizak 2023; Vesna 2021
Assistance in taking care of pets	There are various technologies available to assist older people in taking care of their pets, if they have any. One of the most widely used of these technologies are automatic pet feeders and waterers. These devices allow people to fill up food and water once, and the machine will provide the required amount of food and water to the pets at the correct times. The machines only need to be refilled every now and then, providing convenience and ensuring that the pets are properly fed and hydrated even when their owners may have difficulty doing so themselves.	Automatic pet feeder and waterer	Kamat and Nasnodkar 2018; Ma et al. 2023; Porkodi and Kesavaraja 2021
Emergency response systems	There are many robots and devices that are programmed to respond to emergencies such as sudden illnesses or falling. They can respond by contacting emergency services or alerting family members nearby.	Robots designed as safety alert systems	Aguiar Noury et al. 2019; Edwards et al. 2019; Shareef et al. 2023
Assisting daily activities including interactive accompaniment	As an alternative support system for older people, an autonomous robot operated by GAI can be used to provide assistance for daily routine life	Healthcare robots	Belpaeme et al. 2018; Chen et al. 2021; Martinez-Martin et al. 2020; Na et al. 2023; Schneider and Kummert 2021

GAI = generative artificial intelligence.

Source: Authors.

8.3.4 Findings from the Interviews

In the beginning, a demographic analysis was conducted to get a synergistic picture about the respondents of the interviews (Table 8.2).

Table 8.2: Demographic Information

Traits	Response
Average age (year)	69.5
Gender	46:54 (male:female)
Dependent on family members to perform daily activities (average length of time)	4.75 years
Average education	College degree
Average family income (yearly)	$18,320
Children	3
Smart phone usage experience	79%
Computer usage experience	42%

Source: Authors.

Three university professors who have experience in conducting qualitative studies in multidisciplinary business fields formed the focus group. The focus group, along with the researchers, deliberated over the long answers and identified keywords from each interview. Then, extensive content analysis was conducted on the lengthy transcripts, along with keywords and themes related to behavioral intention toward autonomous systems. The fundamental idea of this content analysis was to select keywords and themes and reveal similarities. Initially similarities among keywords were identified through conceptual analysis. Then to understand the exact meaning, relational analysis was done. These key concepts were then categorized based on the principles of matrix thinking (Patton 2002). Finally, a thematic analysis was conducted to identify the key concepts of behavioral attitude using a software named NVivo.

Older people have shown immense pleasure and interest in several types of autonomous systems, enabling them to execute their daily tasks and address health issues without human assistance. Mostly, their behavioral intention is positive; however, they exhibit certain resistance toward accepting autonomous systems replacing scarce human support due to their lack of trust in modern technology. One of the most significant reasons for this lack of trust in technology is the older person's uncertainty about their ability to use it. Shareef et al. (2021) explained that older adults' "perception about their ability to use and achieve control is not just about their physical abilities. Rather, it is much more complicated, compounded by psychological ability." There are many factors such as emotional attachment, beliefs, scope of interactions, belongingness, cost, and user-friendliness, etc., that affect their positive motivation to adopt these ambient intelligence-driven autonomous systems. The summary of the findings depicting the key attributes they require from autonomous systems is shown in Table 8.3. In this context, following the recommendations of focus group members and at the discretion of the researchers, only those attributes are listed here that received at least a 50% response.

Table 8.3: Factors Pursuing Positive Attitude Toward Autonomous Systems Driven by GAI

Key Attributes	Percentage of Response
Trust	100
Empathy	98.5
Self-control	97.75
Price-value	92
Facilitating conditions	67
Effort-value	67
Hedonic motivation	51

GAI = generative artificial intelligence.

Source: Authors.

Trust

Almost all older people who participated in the interview conceptualized trust as confidence in autonomous systems being reliable. Since an autonomous system driven by ambient intelligence is proposed to provide continuous assistance in performing daily activities for older people, currently carried out by family members or paid human beings, it should, according to the expectations of the older person, include the following elements to generate trust:

- Physical confidence
- Psychological confidence or emotional reliability

This trust comprises accuracy in executing tasks, intellectual ability to make correct decisions in a timely manner, psychological ability to instill confidence in its reliable performance, availability when needed, and functions to assist properly and continuously. Several researchers working on technology adoption behaviors (de Visser et al. 2020; Shareef et al. 2024) have asserted that trust is a generic and essential requirement for any user to develop a positive behavioral intention towards adopting any new complex technological systems. Scholarly articles on GAI, ambient intelligence, and homecare autonomous systems have also emphasized the importance of trust and reliability (de Visser et al. 2020).

Considering the mental status, familiarity, and experience of older people, along with this completely new trend of technology-based human assistance controlled by GAI, it is heuristically revealed that developing trust is the primary concern of older people to encourage their acceptance of autonomous systems Martinez-Martin, Escalona, and Cazorla 2020; Na, Jung, and Kim 2023; Schneider and Kummert 2021; Shareef et al. 2021). Technological uncertainty presents a significant challenge in this aspect (Shareef et al. 2023).

Empathy

While using any technology-driven autonomous systems to perform daily activities, replacing human companionship, the absence of lively two-way communication is a serious concern for human beings (Shareef et al. 2023). Mayo's human relations theory also asserts that the scope of live attention, belongingness, emotional attachment, and social interaction is an eternal urge of human beings (Belpaeme et al. 2018; Chen et al. 2021). Particularly for older people, it is imperative that they receive certain priorities and keen attention from younger family members (Nasr et al. 2021).

As a result, the absence of proper attention and empathy triggers eagerness for belonging and affection. They eagerly yearn for the lost sense of belongingness from their family members. This issue is described as the expectation of the older person to be accompanied by any automated systems that can give them the impression and feeling of emotional attachment. The system must provide cordial and social interaction. This is the second most important behavioral issue for older people when considering their attitude toward using a new autonomous system, replacing the urge for human company.

Self-control

Literature on technology adoption behavior, as well as behavioral theorists, have clearly indicated that user-friendliness is a common and important issue for anyone to embrace a new technological system. Adoption models such as the Technology Adoption Model (Davis 1989), Government Adoption Model (Shareef et al. 2011), Diffusion of Innovation Theory (Rogers 1995), Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) (Venkatesh, Thong, and Xu 2012) model, and Mobile Health Adoption Model (Dwivedi et al. 2016) have confirmed that since a new technological system is sometimes difficult to operate, ease of use is a potential factor for consumers to adopt a new system. Although different theorists have used different names to reflect this idea, the central concept denoted by the construct "self-control" is the degree to which older people perceive any autonomous systems driven by ambient intelligence as easy to learn, manage, control, and use without difficulties.

The Social Learning Theory of Bandura (1986) postulated clear guidelines that perception of control over any system is a motivation for a person to adopt it. Since older people are not always familiar with recent trends and the dramatic changes in technology, autonomous systems controlled by GAI pose a serious challenge for them to use and obtain the expected benefits from (Guerrero et al. 2019). The demand for self-control is the third essential factor for older people to adopt any autonomous healthcare systems as an alternative to human assistance.

Price-value

Williamson's transaction cost analysis (1989) provided the idea that while comparing two systems, the value obtained in exchange for the price is an important cognitive component for human beings. Prospect theory (Kai-Ineman and Tversky 1979) articulates this generic attitude of human beings that they want to evaluate the benefits of any system in exchange for the price they spend to finalize their selection. In mobile-health adoption, Dwivedi et al. (2016) revealed that technology-assisted any mode, assumed to replace traditional physical support provided by human beings, has always been comparatively evaluated by users to select the best alternative.

The experiment displayed to the older people clearly demonstrated that autonomous systems can assist them in performing many daily routine tasks without human support. However, the degree of autonomy and perfection of execution depends on the price they are willing and able to spend. One important reason for the application of GAI-oriented autonomous systems to replace human support is the growing high price of human support and its scarcity. Older people want to understand the benefits they can gain by using an autonomous system to perform a specific task that can be done with human assistance. Therefore, price-value is a comparative judgment of investment.

Facilitating conditions

The UTAUT model, summarizing several adoption behavior theoretical frameworks, suggests that a new complex technological system requires support from multiple sources. As such, facilitating conditions are a prerequisite factor for human beings to be encouraged to adopt a system. They need to know whether the new technological system can provide essential support if they face any challenges and hurdles (de Visser et al. 2020; Shareef et al. 2024). According to social learning theory, people will try to observe (as the older people observed the video), model, and imitate a new system and develop a positive attitude to adopt that system if they find that the system has adequate resources to support them.

Both self-determination theory (Deci and Ryan 2012) and control theory (Reckless 1973) have affirmed that the necessity of assurance that, in case of any difficulties, the system has adequate external resources to provide support is a prerequisite condition for people to adopt the autonomous system. In this study, older people have a strong recommendation in favor of this construct.

Effort-value

Older people have suggested a new factor: the time, skill, and labor they need to seek the same benefits they could get from services provided by human beings. The UTAUT model has a primary construct named effort expectancy, which describes the essential criteria needed to execute a job, similar to the self-control concept. However, this idea recommended by the participant older people is more focused on the relation between how much effort they need to put forth to avail how many benefits. Therefore, it primarily indicates the evaluation between the two alternatives: support and nursing provided by the direct presence of human beings and autonomous systems. It is a new concept not directly covered by existing consumer behavior models as an independent construct.

However, the central idea is articulated by several behavioral and economics theories. Psychodynamic theory (Ahles 2004; Bateman, Brown, and Pedder 2010) explicitly reflects this phenomenon by articulating that human beings are logically controlled by their urge for benefits. Rationally, when they have two alternatives to adopt for their betterment, one is very traditional and the other is a new option, they attempt to evaluate the two alternatives based on the effort and the benefits earned (Adamovic 2022).

Hedonic motivation

Sociocultural theory (Vygotsky 1962) postulated that interest in embracing a new innovative system is substantially dominated and pursued by intrinsic motivation, which is further controlled by enjoyment. The urge for hedonic motivation is proposed by the extended UTAUT2 model (Venkatesh et al. 2012) and is supported by many researchers (Oshagbemi 2003; Pinder 1984; Shareef et al. 2024), suggesting that adopting a new technological system can be accelerated if that system has the ability to provide fun and enjoyment in addition to utilitarian benefits. Nevertheless, several scholarly articles (Dwivedi et al. 2016; Ye et al. 2020) did not find its relevance in adopting a new complex system.

In this qualitative study, older people have recommended the need for hedonic motivation, as the degree of enjoyment they might get by using nonliving equipment dominated by ambient intelligence, which is supposed to be an alternative to human presence. However, as a qualifying construct (if at least 50% of older people recommended), it barely achieved a significant score. Since an autonomous system governed by GAI is proposed to replace traditional socially interactive human beings who have all kinds of expressible feelings and emotions, the urge for hedonic motivation from the use of that autonomous homecare support is understandable.

8.4 Future Trends and Implications

Based on the findings from Table 8.1, it can be inferred that in the future, several daily activities and special healthcare support can be provided to older people by introducing machine autonomy driven by GAI. Gradually, this list of support must be increased; however, at present, it can be safely claimed that the introduction of autonomous systems can gradually reduce the need for human support in providing assistance for the healthcare of older people.

Still, this trend is in an emerging stage and requires enough experimentation to consider abandoning human support for older people provided by family members or healthcare professionals. However, the future trend of the prospective application of GAI in designing smart home appliances that can provide continuous assistance like a human being is in progress (Schneider and Kummert 2021). Several researchers are optimistic that this trend can supplement, if not obsolete, healthcare support for older people at a lower cost with equivalent efficiency (Nikou et al. 2020; Pires et al. 2016; Shareef et al. 2023). Since the cost of healthcare for nursing older people—whether provided by health professionals or family members—is growing worldwide due to a shortage of service providers and an increase in demand, researchers anticipate that AI-driven autonomous systems might be much cheaper compared to human support.

Now, researchers and practitioners can take an extensive look at the summary shown in Table 8.3 and deliberate over the recommended factors for their adoption.

From the interviews, it is observed that there are multiple factors that affect the behavioral attitude to adopt an autonomous system in the near future. This can range from the older person's ability to use automated technology to other, more emotional beliefs. Most older people do not have much experience in using technology except phones and the internet, which causes them to feel uncomfortable switching to automated technology. Since the older person's lack of ability to use automated technology is a big reason why they lack trust in it, trust can be developed by teaching them how to use the machines.

In 2017, Brooks et al. (2017) suggested that "building relationships with healthcare providers, auxiliary staff members (e.g., transport and catering staff), and other falls clinic attendees appeared to relax participants, improve their mood, and instill in them confidence that staff members were acting in their best interests" (p. 3). For the older person to be receptive to teachings in the facility, they must be willing to learn from the workers, which would only be possible through gaining the trust of older people. However, it also depends on their cognitive and affective attitude toward autonomous systems. Nymberg et al. (2019) suggested that older people who have more experience in using modern technology in their life are more focused and interested in adopting autonomous systems. Older people who did not have positive experiences with digital tools instead displayed distrust in their ability to learn to use the technology. In this regard, Nymberg et al. (2019) suggested that receiving tailored information for older adults and counseling on how to find and use digital tools was crucial.

A facility built to teach older adults about technology would be a great way to build trust, reliability, and emotional attachment between the older person and any automated healthcare systems they would be using. The facility needs to ensure it creates personal connections with older people so that they are more likely to trust what they have been told. This will help better teach them about the technology, while also possibly addressing some of the more emotional reasons for not being able to trust technology. The facility also needs to tailor the information properly for older people. This has to be done so that the older person with negative experiences with technology are also able and willing to learn to trust in the automated machines.

Another way to help teach the older person would be simply to teach more children about automated technology in schools. Children could learn about the topic and later share what they learned with their relatives, helping them understand the technology. Grandparents would love to learn stuff from their grandchildren, and they might be more willing to try it. While this would not directly teach the older person about the technology, it might serve as a sense of motivation to try to learn.

In summary, the essential paradigms of the grounded theory of adopting autonomous systems by older people are:

- Reliability: Older people are concerned about the reliability of any new technology-driven autonomous systems proposed to assist them in performing daily activities and healthcare independently without any necessity of human support. They must have confidence in its performance.
- Emotional support: Since these systems are assumed to replace human support, older people need emotional support from this system. It must fulfill their eternal desire for emotional and physical companionship, demonstrating benevolence and belongingness.
- User-friendliness: Given that older people may not have high skill levels in handling modern technology, user-friendliness is an important issue for future prospective usage of autonomous systems.
- Facilitating resources: Adequate resources must be there to support them in case of any problems.
- Comparison with human support: Older people evaluate and compare the benefits they gain in exchange for the price and effort of using autonomous systems versus human support.
- Social interaction and enjoyment: When the proposed system is removing the necessity of human presence and support, the autonomous system must be socially interactive to create a certain amount of enjoyment, which can motivate them intrinsically to use the systems.

8.4.1 Theoretical and Managerial Implications

In theoretical terms, this research will contribute significantly to future prospective literature on smart homecare autonomous systems driven by ambient intelligence. It will also make contributions to human behavior, psychology, and healthcare literature.

In practical terms, this report will provide valuable insights for public and private policymakers involved in supporting older adults, offering them a deeper understanding of automated technology. Additionally, organizations developing automation technology for older people will gain insights into the attributes the technology needs to ensure comfortable use by the older person.

8.5 Limitations and Future Research Guidelines

As an exploratory study, this research has several limitations that should be considered when interpreting the findings. Although the experiment demonstrated in front of older people before the interview was an attempt to provide some sort of familiarity, it can be assumed that older people provided their opinions mostly based on expectations rather than real perceptions. This could introduce bias. Depending on the level of autonomy, adoption behavior might vary. However, in this study, while doing the interviews, the autonomous systems were explained to identify their adoption behavior; the levels of autonomy were not categorized. This is a limitation of this study, and future researchers can replicate this study considering a particular autonomous system.

Loyalty is also a criterion that cannot be properly evaluated, as it would require a longitudinal study. Cultural and demographic diversity may be an issue, with factors such as gender, income, and level of education potentially having moderating effects. Sampling from only one economy is a serious challenge for claiming generalizability. Future researchers could try to better test loyalty and interview a larger and more varied group.

8.6 Conclusions

With healthcare prices increasing, automated healthcare systems might offer a potential solution to circumvent this problem. The lack of interest in automated technology due to the absence of human interaction and the inability to use this technology are significant issues, but they can be addressed by helping older adults understand the technology itself. By creating facilities to properly teach older people and help them understand and trust in automated healthcare systems, the usage of machine autonomy can be rapidly increased.

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9

Nexus Between Smartphone Use and Objective and Subjective Well-Being Outcomes: Insights from Older Residents in Rural Areas of the People's Republic of China*

Junpeng Li and Wanglin Ma

9.1 Introduction

In an era of information explosion, smartphones have become an indispensable part of human society. Smartphone use is playing a significant role in easing people's daily life (Colbert, Thornton, and Richmond 2020; García-Milon, Olarte-Pascual, and Juaneda-Ayensa 2021), improving labor productivity (Ma, Grafton, and Renwick 2020), and enhancing human well-being (Nuñez and Radtke 2024; Zhuo et al. 2023). Notably, the advantages conferred are especially evident among marginal groups in underdeveloped regions, like older rural residents (Hossain et al. 2020; Zheng, Zhou, and Rahut 2023). Nevertheless, the penetration of smartphones among older rural residents in developing economies remains unacceptably low (He, Li, and Wang 2022). For instance, the smartphone penetration rate among older rural populations in sub-Saharan Africa was around 33% in 2023 (Mukhopadhyay, Bagchi, and Udo 2023). Thus, further exploitation of the efficiency of smartphone use among marginal groups in such areas is reasonably warranted.

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According to the Justice Theory proposed by John Rawls in 1971, justice lies in whether the welfare of the least advantaged people is improved (Amartya 2018). It is widely agreed that older rural residents are marginalized in well-being worldwide. For instance, multiple shreds of evidence from previous studies suggest that older rural residents are exposed to a lower level of income, health conditions, and psychological status (e.g., Chen 2022; Cheng et al. 2018b; Das, Kundu, and Hossain 2023). Therefore, improving older rural residents' well-being is central to social justice realization.

Especially for economies like the People's Republic of China (PRC) and Japan, which are facing rapid aging, improving the well-being of the older rural population is critically important for harnessing the demographic dividend and sustaining economic growth (Chen and Powell 2012). Therefore, it is pivotal to enhance older rural residents' well-being. Nevertheless, older rural residents tend to be information-poor, entertainment-deprived, consumption-limited, and socially disconnected, which hinders them from a higher level of well-being (Busch et al. 2021; Liu et al. 2020). Therefore, strategies targeted to overcome these obstacles are regarded as urgently needed to improve older rural residents' well-being.

Our study investigates the association between older rural residents' smartphone use and their objective and subjective well-being in the PRC. Smartphone use enlarges older rural residents' access to information, online shopping, entertainment items, and social connections (Wilson et al. 2022), which can potentially determine their well-being. We apply the inverse probability weighted regression adjustment (IPWRA) model, which possesses a double-robust nature, to analyze the 2020 the Rural Revitalization Survey (RRS) data gathered in the PRC.

Our study expands the scope of the literature in the field from two aspects. First, the study provides the first attempt to investigate the impact of smartphone use on well-being regarding the case of older rural residents. As mentioned above, improving older rural residents' objective and subjective well-being is the benchmark for evaluating social fairness and rural development. Our study pioneeringly expands the understanding of smartphone use's role in determining older rural residents' well-being. Second, we disaggregate the impact of smartphone use on objective and subjective well-being by older rural residents' gender and living arrangements (i.e., whether the respondent lives with other household members). This can deepen our perception of the association between older rural residents' smartphone use and their objective and subjective well-being. It can also lend suggestive support to design context-specific policy instruments.

The rest of the chapter is arranged as follows. Section 9.2 introduces the background and reviews the related literature, followed by the introduction of a conceptual framework in Section 9.3. Section 9.4 presents the details of materials and methods used for empirical analysis. Section 9.5 discusses our empirical results. Section 9.6 concludes the chapter, proposes the policy recommendations derived from our empirical findings, and clarifies the research limitations of our study.

9.2 Background and Literature Review

9.2.1 Background

The PRC provides a typically interesting case study of unlocking the association between older rural residents' smartphone use and their well-being. On the one hand, the PRC is massively building a digital countryside to improve agricultural productivity and rural residents' quality of life. Data from the China Internet Network Information Center suggest that over 90% of rural households owned at least one smartphone at the end of 2023 (CINNIC 2024). However, the smartphone penetration rate among individuals in rural areas only exceeded 30% in the same year (CINNIC 2024), highlighting considerable room for popularizing smartphone use among rural residents in the PRC (Zheng, Zhou, and Rahut 2023). Besides, the PRC is progressing toward an aged society, and older rural residents' underdevelopment in objective and subjective well-being has become an undeniable impediment to rural development for the country. For instance, the proportion of people aged 65 and above in the population is expected to increase from 12.6% in 2020 to 27.9% in 2050 (Fang et al. 2023).

Meanwhile, declining health, income generation, and family companionship expose older rural residents to low objective and subjective well-being (Fang et al. 2023). Strikingly, the suicide rate among older rural residents is four to five times higher than the rate among the nation's total population (Fang et al. 2023). The PRC's urgent and challenging task is to enhance older rural residents' objective and subjective well-being. To sum up, exploration focusing on the PRC can properly realize the role of smartphone use in determining older rural residents' objective and subjective well-being.

9.2.2 Literature Review

A considerable body of literature has emerged to investigate the effects of smartphone use on people's well-being. Generally, the literature can be disintegrated into four strands. The first strand documents the impact of smartphone use on human capital accumulation (Lin et al. 2021; Ryu, Jang, and Oh 2022; Zhou et al. 2022). Due to its informative and internet-connected attributes, smartphone use helps increase undergraduate students' comprehension of courses in the PRC (Lin et al. 2021). However, problematic smartphone use, such as smartphone addiction, distracts students and lowers their school performance (Zhou et al. 2022). Moreover, prolonged smartphone use reduces middle- and high-school students' intake of healthy food like fruits and vegetables and increases their dietary risk (Ryu, Jang, and Oh 2022).

The second strand of literature is about the association between people's smartphone use and their consumption (Colbert, Thornton and Richmond 2020; García-Milon, Olarte-Pascual, and Juaneda-Ayensa 2021). Smartphone use links individuals to multiple online markets and eases payment, which makes it valid for people's purchases. For instance, García-Milon, Olarte-Pascual, and Juaneda-Ayensa (2021) found that smartphone use promoted people's tourism expenditure during the coronavirus disease pandemic in Spain. Zhao, Wu and Gao (2022) found that mobile smartphone payments can significantly increase rural households' durable goods consumption and entertainment consumption in the PRC.

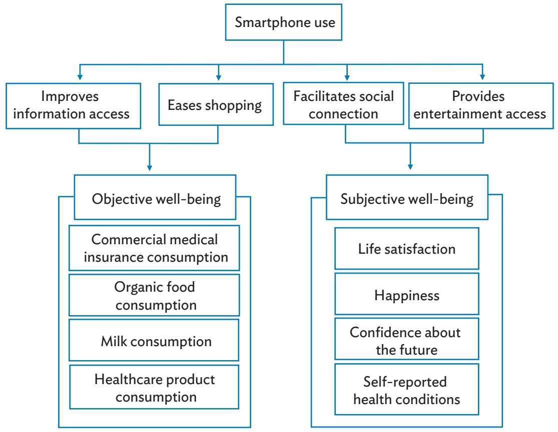
Smartphones connect people to the internet, providing necessary labor and product market information and knowledge. This can increase people's employment opportunities and income earning. Thus, the third strand of literature focuses on the impact of smartphone use on people's economic performance (Emileva et al. 2023; Ma, Grafton, and Renwick 2020; Zheng, Zhou, and Rahut 2023; Zhuo et al. 2023). For instance, Ma, Grafton, and Renwick (2020) found that smartphone use increases rural households' farm income by CNY569 per capita and off-farm income by CNY3,342 per capita. Emileva et al. (2023) documented that the acquisition of smartphone-based weather information facilitates farmers' adaptation to climate changes in the Kyrgyz Republic, Mongolia, and Uzbekistan. The fourth literature strand looks at the impact of smartphone use on people's subjective well-being (Ma et al. 2023; Nie, Ma, and Sousa-Poza 2020; Nuñez and Radtke 2024). Nie, Ma, and Sousa-Poza (2020) suggested that smartphone use significantly increases rural residents' happiness and life satisfaction in the PRC by enhancing household income. However, problematic smartphone use can induce disorders (e.g., chaotic daily routines and mental disorders) in people's lives (Kheirinejad et al. 2023), which is detrimental to their subjective well-being. Nuñez and Radtke (2024) found that excessive smartphone use is associated with depression and relationship dissatisfaction by conducting a systematic meta-analytic review.

The literature discussed above analyzes the impact of smartphone use on well-being indicators regarding young people (e.g., middle- and high-school students) or people in a general sense, neglecting people in marginal groups in less developed areas like older rural residents. Given the great significance of older rural residents' well-being in achieving social development, exploring the impact of smartphone use on their well-being is of paramount importance.

9.3 Conceptual Framework

Relative to conventional ways (e.g., face-to-face chats and newspapers), smartphone use provides older rural residents a powerful way to reach the world regardless of spatial and temporal constraints (Nie, Ma, and Sousa-Poza 2020; Wilson et al. 2022). In particular, smartphone use not only provides older rural residents with abundant information but also connects them to other individuals and multiple markets (Wilson et al. 2022). This can further influence older rural residents' social capital accumulation, lifestyle modification, and household resource allocation (Busch et al. 2021; Wilson et al. 2022). Therefore, smartphone use is expected to play a decisive role in older rural residents' objective and subjective well-being. Relying upon related theories and studies (e.g., Amez and Baert 2020; Busch et al. 2021; Nie, Ma, and Sousa-Poza 2020; Wilson et al. 2022), we comb potential pathways linking older rural residents' smartphone use and their objective and subjective well-being and visualize them in Figure 9.1.

Figure 9.1: Relationship Between Older Rural Residents' Smartphone Use and Their Objective and Subjective Well-being Outcomes



Source: Authors.

People's economic conditions are directly linked to their objective well-being. According to the theories of information economics, information asymmetry impedes individuals from deeply participating in labor markets (Autor 2001). Therefore, devices or practices that promote people's labor market information access possess the potential to improve people's objective well-being. As an internet-connected device, smartphones can provide older rural residents with enormous amounts of employment information (Zheng, Zhou, and Rahut 2023). With such information access, older rural residents can quickly obtain off-farm work opportunities (Balgobin and Dubus 2022), increasing their economic status and objective well-being.

People's objective well-being is also reflected by consumption (Li et al. 2023). A diversifying consumption of high-quality goods and services implies a higher level of objective well-being. However, people's consumption is hindered by limited information access and temporal and spatial constraints (Jun and Park 2016). Internet-connected smartphones link older rural residents to abundant consumption market information (Colbert, Thornton, and Richmond 2020). Accessing consumption market information grants older rural residents more reasonable choices (Zhao, Wu, and Gao 2022). This can lead to two consequences. First, older rural residents obtain the chance to diversify their consumption. For instance, with smartphone use, older rural residents who allocate a significant proportion of their budgets on necessities could increase their consumption of organic food and healthcare products. Second, older rural residents can optimize their consumption by replacing low-quality products with high-quality ones. Smartphone use can uplift older rural residents' objective well-being by improving information access.

Smartphone use mainly manifests as using specific applications (apps). Apps in terms of online shopping platforms (e.g., Amazon, eBay, and JD) and online payment platforms (e.g., Alipay and PayPal) release people's consumption from temporal and spatial constraints (Zhao, Wu, and Gao 2022). More importantly, online shopping platforms open people's access to a massive number of products that people never reach in physical stores (Chiu et al. 2019; Zheng and Ma 2021). Thus, people can compare prices and choose from various products. As a result, older rural residents can enjoy more high-quality products at reasonable prices. Accordingly, smartphone use can relax older rural residents' shopping, improving their objective well-being.

Smartphone use can also be connected to people's subjective well-being through its impact on shopping. According to the classic utility theory, more and better consumption can directly increase people's utility in terms of subjective well-being (Deaton 2012; Zheng and Ma 2021).

For instance, consuming more health-beneficial goods can make older rural residents happier and more satisfied with their lives. Moreover, a high evaluation of current life can enhance people's confidence about their future. However, online shopping using smartphones is trailed by an unshakeable dark side. The social comparison theory suggests that people define their social status by excessive consumption (Gao et al. 2024). The convenience of consumption generated by smartphone use can foster this process, which induces impulse purchases and conspicuous consumption among older rural residents (Leong, Jaafar, and Ainin 2018; Wu et al. 2021). As a result, smartphone use as a shopping assistant can leave older rural residents with a heavy economic burden and negative consequences of subjective well-being. For instance, dead-weight debt induced by online shopping is supposed to harm people's life satisfaction and happiness (Zheng and Ma 2021).

One of the typical labels of older rural residents is loneliness (Fang et al. 2023; Liu et al. 2020). As their children depart and their partners pass away, older individuals gradually lose their social connections, which can send them into isolation and loneliness (Fang et al. 2023). As a result, older adults are more likely to be trapped in low subjective well-being. Social capital theory indicates that information exchange constitutes the foundation of people's social networks (Gannon and Roberts 2020). Therefore, enhancing older rural residents' information access can help reshape and consolidate their social networks, which power up their integration into society (Gil-Clavel, Zagheni, and Bordone 2022). Smartphone use helps improve older rural residents' access to information, which can enhance their connection with society, and thus mitigate older rural residents' sense of isolation.

Moreover, smartphone chat apps like WhatsApp and WeChat give older rural residents channels to share joys and confide in grievances with their household members, relatives, friends, and even strangers online. This can effectively release older rural residents' loneliness and other negative feelings (Busch et al. 2021). Therefore, smartphone use can effectively link older rural residents to improved subjective well-being via its efficiency in facilitating social connection. Meanwhile, smartphones can be entertainment for online and offline game playing, short video watching, and music appreciation (Kheirinejad et al. 2023). Thus, smartphone users are more likely to access diverse entertainment items, which are essential for saving them from the loneliness and tribulations of daily lives and increasing their subjective well-being. Accordingly, by improving older rural residents' entertainment access, smartphone use is expected to increase their subjective well-being.

According to behavioral economics, individuals prefer immediate rewards over delayed ones, known as hyperbolic discounting (Hepburn, Duncan, and Papachristodoulou 2010). Smartphone use in terms of social connection and entertainment is characterized as addictive for humans as it provides continuous and motivating content (Kheirinejad et al. 2023; Merikivi, Tuunainen, and Nguyen 2017). For instance, online games are designed with various difficulty levels and corresponding rewards to lock-in people as players (Merikivi, Tuunainen, and Nguyen 2017). Thus, people can remain addicted to smartphones even though some are disciplined. This phenomenon could be even worse among older rural residents because they live alone and nobody can monitor their smartphone use regularly (Fang et al. 2023). Intensive smartphone use can isolate older rural residents from the real world, rendering them unversed in interpersonal communication and deepening their loneliness (Al-Kandari and Al-Sejari 2021). Meanwhile, prolonged immersive smartphone use disrupts older rural residents' regular diet and rest habits, inducing malnutrition, insomnia, memory decline, and multiple mental disorders (e.g., irritation and depression) (Elhai, Tiamiyu, and Weeks 2018). Accordingly, smartphone use can simultaneously be toxic to older rural residents' subjective well-being.

Smartphone use can promote older rural residents' objective well-being regarding health-beneficial product consumption. However, its impact on subjective well-being is theoretically undecided as it is recognized to have dual impacts on subjective well-being: positive or negative. In what follows, we will use a suitable empirical method to rigorously investigate the effect of older rural residents' smartphone use on their objective and subjective well-being.

9.4 Materials and Methods

9.4.1 Materials

Data

The data analyzed in this study is refined from the 2020 RRS dataset. The Chinese Academy of Social Science sponsored and conducted the survey. Multiple information on rural household characteristics, village management, and rural industrialization were gathered to comprehensively portray and understand the PRC's rural development. Notably, the dataset of the 2020 RRS entails rich information on rural residents' smartphone use and objective and subjective well-being. This enables the dataset to back up the investigation on the relationship between older rural residents' smartphone use and objective and subjective well-being.

Using a probability proportional to size sampling procedure, the RRS generated samples in five steps. In the first step, three provinces from eastern PRC (Zhejiang, Shandong, and Guangdong), three provinces from central PRC (Heilongjiang, Anhui, and Henan), and four provinces from western PRC (Sichuan, Guizhou, Shaanxi, and Ningxia) were randomly selected. Next, five counties from each selected province were sampled based on the county-level per capita gross domestic product (GDP). In the following two steps, three to four towns within each county and two villages within each town were randomly selected. In the last step, 10–15 households and the corresponding household members were sequentially and randomly chosen, and face-to-face interviews were conducted from each sampled village. The 2020 RRS contains a total sample of 3,738 households and 15,919 individuals.

Multiple steps were used to concentrate the data on the topic of our study. First, we retained the sampled individuals aged 65 and above by excluding 11,115 samples aged under 65 years. Second, 265 samples containing missing and abnormal values in dependent variables reflecting older rural residents' objective and subjective well-being were deleted. Third, 2,426 samples reporting missing and abnormal values in control variables were dropped. Finally, 2,113 older rural residents were analyzed in the present study.

Selection of objective well-being outcomes

Objective well-being refers to the objective evaluation of an individual's quality of life (He, Li, and Wang 2022; Li, Vatsa, and Ma 2023; Tesfaye and Tirivayi 2020), which is a collective term for individuals' economic conditions, health, job opportunities, living environment, safety, and political status (Voukelatou et al. 2021). In light of this, we apply multiple indicators to capture older rural residents' objective well-being comprehensively. As labor market retirees, older rural residents have lower aspirations for job opportunities and economic condition development. In contrast, older rural residents in the PRC show an excellent desire for health and improved quality of life (Du et al. 2023). Meanwhile, information on the living environment, safety, and political status is absent in the 2020 RRS data. Therefore, we mainly focus on the dimensions of consumption and healthcare of older rural residents' objective well-being. In particular, we use commercial medical insurance ownership and healthcare product consumption status (e.g., multivitamin multimineral supplement consumption status) to reflect older rural residents' objective well-being from the perspective of healthcare.

Meanwhile, we use organic food consumption status and milk consumption to capture the consumption dimension of older rural residents' objective well-being. The indicators of commercial medical insurance ownership, organic food consumption status, and healthcare product consumption status are measured by a dummy. In particular, a specific indicator is assigned the value of one if the respondent has purchased the corresponding goods and/or services, like organic food and healthcare products and zero otherwise. The variable for milk consumption is measured at grams per capita per day.

Selection of subjective well-being outcomes

Subjective well-being reflects people's subjective evaluation of their lives (Cheng et al. 2018a; Oishi, Diener, and Lucas 2016), which manifests as their feelings, motivations, and aspirations. Generally speaking, previous studies use happiness and life satisfaction as measures (e.g., Kanji et al. 2024; Tauseef 2022). A study by Li, Ma, and Gong (2023) expanded the scope of subjective well-being by involving the dimension of people's confidence about the future as it determines their performance. According to earlier literature, older rural residents' subjective well-being, in our case, was reflected by a vector of classical indicators.

First, as with most prior literature, we use older rural residents' life satisfaction and happiness to reflect their overall and instant evaluation of subjective well-being, respectively. Second, we follow Li, Ma, and Gong (2023) and include the variable reflecting older rural residents' confidence about the future as a dependent variable of interest. Third, regarding health deterioration faced by most older rural residents, we also use self-reported health conditions to measure subjective well-being. Among these variables, life satisfaction, happiness, and confidence about the future are measured by a 5-point Likert scale from 1=very unsatisfied/unhappy/unconfident to 5=very satisfied/happy/confident. Self-reported health conditions are measured by a 3-point Likert scale from 1=poor to 3=good.

Older rural residents' smartphone use is recognized as our treatment variable. Regarding a person's decision on using smartphones or not following a dichotomous manner, we use a dummy to measure our treatment variable. In particular, the treatment variable equals one if the respondent uses a smartphone and zero otherwise. This definition is consistent with the work of Gerosa, Gui, and Büchi (2022) on Italy and Zheng, Zhou, and Rahut (2023) on the PRC.

We also select a vector of indicators as control variables by leaning upon related literature (e.g., Al-Kandari and Al-Sejari 2021; Zheng, Zhou, and Rahut 2023; Zhuo et al. 2023). Variables for older rural residents' age, gender, education, marital status, household size, and youth dependency ratio are used to capture households' demographic characteristics. The asset ownership variable representing whether a rural household owns a computer is used to reflect rural households' economic conditions. Variables for farm size and proximity to the plot were included to capture the impact of agricultural production. A variable representing negative shocks (e.g., household member death and disasters) was included because rural residents' daily lives and welfare tend to be disturbed by unpredictable risks. To control the impacts of unobserved spatial disparities, we also included three location dummies (i.e., eastern, central, and western regions of the PRC) in our control variables.

Descriptive statistics

Table 9.1 presents the definitions and descriptive statistics of the selected variables. Approximately 10%, 29%, and 17% of older adults in our sample had purchased commercial medical insurance, organic food, and healthcare products, respectively. The average milk consumed by sampled older rural residents was 33.86 grams per capita per day. The average values of life satisfaction, happiness, and confidence about the future were 4.14, 4.22, and 4.22, respectively, suggesting that older rural residents in the PRC tend to enjoy a relatively high subjective well-being. On average, our sample's level of self-reported health condition was approximately 1.79, ranging between poor and fair, highlighting the urgency of improving older rural residents' physical conditions. Table 9.1 reports that approximately 61% of the sampled older rural residents used a smartphone. This statistic reflects the reality that the PRC is currently heading toward constructing a digitalized countryside.

Table 9.1: Variable Definitions and Descriptive Statistics

Variables	Definitions	Mean	SD
Objective well-being outcomes			
Commercial medical insurance ownership	1 if a respondent has purchased commercial medical insurance, 0 otherwise	0.10	0.30
Organic food consumption status	1 if a respondent has purchased organic food, 0 otherwise	0.29	0.46
Milk consumption	Milk consumed by a respondent (grams/capita/day)	33.86	70.07
Healthcare product consumption status	1 if a respondent has consumed healthcare products (e.g., multivitamin multimineral supplements), 0 otherwise	0.17	0.38
Subjective well-being outcomes			
Life satisfaction	Self-reported life satisfaction: 1=very unsatisfied to 5=very satisfied	4.14	0.81
Happiness	Self-reported happiness: 1=very unhappy to 5=very happy	4.22	0.78
Confidence about the future	Self-reported confidence about the future: 1=very unconfident to 5=very confident	4.22	0.77

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Table 9.1 *continued*

Variables	Definitions	Mean	SD
Self-reported health condition	Self-reported physical health condition: 1=poor, 2=fair, and 3=good	1.79	0.62
Key explanatory variable			
Smartphone use	1 if a respondent aged 65 and above uses a smartphone, 0 otherwise	0.61	0.49
Control variables			
Age	Age of the respondent (years)	72.31	6.56
Gender	1 if a respondent is male, 0 otherwise	0.52	0.50
Education	Educational level of the respondent: 1=no formal education (illiterate), 2=primary school, 3=elementary school, and 4=high school or above	1.32	0.62
Marital status	1 if a respondent is married, 0 otherwise	0.82	0.39
Household size	Number of people residing in a household (persons)	3.16	1.72
Youth dependency ratio	Ratio of the number of residents aged 0–14 years to the number of household members aged 15-64	0.18	0.43
Asset ownership	1 if a household owns a computer, 0 otherwise	0.19	0.39
Farm size	Total farmland area of a household (mu)a	12.60	38.20
Proximity to plot	Proximity of household to the largest plot: 1=close (distance0.5 km), 2=medium (0.5 kmdistance1.0 km); 3=remote (distance1.0 km)	1.58	0.72
Negative shocks	1 if a household experienced negative shocks (e.g., member death and disasters) in the previous year, 0 otherwise	0.22	0.41
Eastern region	1 if the respondent is in the eastern region of the PRC, 0 otherwise	0.46	0.50
Central region	1 if the respondent is in the central region of the PRC, 0 otherwise	0.28	0.45
Western region	1 if the respondent is in the western region of the PRC, 0 otherwise	0.46	0.50
Sample size		2,113	

SD = standard deviation.

Note: a 1 mu=1/15 hectare.

Source: Authors.

The descriptive statistics illustrated in Table 9.1 also suggest that poorly educated and married old rural residents dominated our sample. On average, our respondents were 72.31 years old, and almost half were male. The average size of households was 3.16, 18% of which were members under 15. Asset ownership was observed in 19% of the sampled households and negative shocks in 22% of households. The average scale of farmland rural households cultivated was approximately 12.60 mu, equivalent to 0.84 hectares. Most sampled households were close to their largest plots with a mean value of 1.58 ranging between 1=close and 2=medium.

Table 9.2 reports the mean values of the selected variables regarding older adult smartphone users and nonusers and the mean differences between the two cohorts. Regarding variables measuring older rural residents' objective well-being, smartphone users are more likely to have commercial medical insurance and consume organic food than nonusers. Relative to nonusers, smartphone users tend to consume more milk per day. Smartphone users tend to obtain lower life satisfaction and happiness for subjective well-being outcomes than their nonuser counterparts. In contrast, the former reported a higher health condition than the latter. The statistics shown in Table 9.2 also suggest that smartphones are prone to be used by older, female, better-educated, and unmarried older rural residents. Meanwhile, smartphone users tend to reside in large households with a larger farm size compared with nonusers. The mean differences in the location dummies suggest that smartphone users are more likely to locate in the western PRC, whereas nonusers tend to locate in the eastern parts of the PRC.

Table 9.2: Mean Differences in Selected Variables Between Older Rural Smartphone Users and Nonusers

Variables	Smartphone Use Status: Users	Smartphone Use Status: Nonusers	Mean difference	*t* statistics
Objective well-being outcomes				
Commercial medical insurance ownership	0.122	0.067	0.056 (0.013)***	4.165
Organic food consumption status	0.372	0.172	0.201 (0.020)***	10.120
Milk consumption	35.619	31.126	4.493 (3.123)*	1.439
Healthcare product consumption status	0.177	0.167	0.010 (0.017)	0.618
Subjective well-being outcomes				
Life satisfaction	4.082	4.235	−0.153 (0.036)***	−4.261
Happiness	4.170	4.311	−0.141 (0.035)***	−4.088
Confidence about the future	4.240	4.201	0.040 (0.034)	1.147
Self-reported health condition	1.803	1.759	0.044 (0.028)*	1.589
Control variables				
Age	72.609	71.840	0.768 (0.292)***	2.631
Gender	0.502	0.556	−0.055 (0.022)***	−2.458
Education	1.351	1.274	0.077 (0.028)***	2.779
Marital status	0.780	0.872	−0.092 (0.017)***	−5.353
Household size	3.477	2.659	0.818 (0.075)***	10.970
Youth dependency ratio	0.216	0.135	0.082 (0.019)***	4.266
Asset ownership	0.256	0.077	0.178 (0.017)***	10.552
Farm size	14.360	9.859	4.501 (1.700)***	2.648
Proximity to plot	1.572	1.601	−0.029 (0.032)	−0.891
Negative shocks	0.210	0.225	−0.015 (0.018)	−0.815
Eastern region	0.219	0.325	−0.107 (0.019)***	−5.495
Central region	0.294	0.268	0.025 (0.020)	1.268
Western region	0.488	0.406	0.081 (0.022)***	3.671
Sample size	1,286	827	2,113	

Notes: Standard errors are in parentheses. Commercial medical insurance ownership, organic food consumption status, and healthcare product consumption status are measured by dummies. Milk consumption is measured at grams per capita per day. Life satisfaction, happiness, confidence about the future, and self-reported health condition are measured by categorical variables. ***<0.01 and *<0.10.

Source: Authors. v

The results illustrated in Table 9.2 clearly state the systematical differences in objective and subjective well-being between older rural smartphone users and nonusers. One should note that these differences cannot be referred to as the impacts of older rural residents' smartphone use on their objective and subjective well-being as they neglect control variables' compound impacts. In this case, we will use a suitable mathematical method to assess the association between older rural residents' smartphone use and their objective and subjective well-being.

9.5 Empirical Methods

In the scenario of a dichotomous treatment variable, empirical methods like the propensity score matching (PSM) model (Overall et al. 2023; Shen et al. 2024), the inverse probability weights (IPW) estimator, and the IPWRA model (Chigusiwa, Kembo, and Kairiza 2022; Ma et al. 2024) are widely used to address the selection bias associated with the treatment variable and estimate its impact on the outcomes. These three models contain two estimation stages: the first stage regresses the treatment model to estimate the treatment variable's determinants using a probit model. The second stage, named the outcome model, estimates the treatment variable's impact on the outcome. It is worth noting that the PSM model and the IPW estimator demonstrate efficacy in generating consistent treatment effect estimation primarily deepen on the appropriate specification of the treatment model (Pak, Cotter, and Thorson 2022; Shen et al. 2024). In contrast, the IPWRA model can generate unbiased estimates when its outcome or treatment model is properly set. Therefore, the IPWRA model possesses a double-robust property over the PSM and IPW approaches (Chigusiwa, Kembo, and Kairiza 2022). Accordingly, our study uses the IPWRA model as the primary empirical method to estimate the association between older rural residents' smartphone use and their objective and subjective well-being. As suggested by Wossen et al. (2017) and Ma et al. (2024), the estimation framework of the IPWRA model can be specified as follows:

$$\text{Treatment model:} \quad P(X) = Pr(T_{i=1}) = f(Z_i; \alpha) + \varepsilon_i \tag{1}$$

$$\text{Outcome model:} \quad Y_i = f(X_i; \beta) + \mu_i \tag{2}$$

where $P(X)$ refers to the probability of older rural resident i using a smartphone. T_i is the treatment variable ($T_{i=1}$ for smartphone users and $T_{i=0}$ for nonusers). Y_i indicates a specific outcome variable (e.g., commercial medical insurance ownership, milk consumption, and happiness). Z_i and X_i refers to the covariates determining the treatment variable and outcome variables, respectively. The IPWRA model allows an overlap between Z_i and X_i.

Utilizing the inverse-probability weights derived from the treatment model, the IPWRA model queries the impact of older rural residents' smartphone use on a specific outcome variable by calculating the average treatment effect (ATE). The calculation of ATE can be specified as the following equation.

$$ATE_{IPWRA} = E(Y_{i1} - Y_{i0}) \tag{3}$$

where Y_{i1} and Y_{i0} refer to a specific outcome variable of smartphone users and nonusers, respectively. $E(Y_{i1} - Y_{i0})$ measures the expectation of a specific outcome variable difference between smartphone users and nonusers.

9.5.1 Results and Discussion

Determinants of older rural residents' smartphone use

Table 9.3 presents the estimates of variables determining older rural residents' smartphone use. Since the coefficients of a probit model cannot be directly interpreted as effect magnitude, we also calculated the corresponding marginal effects and presented them in column 3 of Table 9.3. The gender variable has a negative and significant impact on older rural residents' smartphone use, suggesting old females are more likely to use smartphones than males. In particular, the odds of old females using smartphones tend to be 5.5% higher than males. Compared with males, females are vulnerable in social networks, which leads them to be socially isolated (Calvi 2020; Tran et al. 2020). Thus, older rural females tend to be keen to reach out to the world when they can access things such as smartphones. The variable for respondents' education is found to be positively and significantly associated with smartphone use, suggesting better educational performance increases smartphone penetration. This is because good knowledge allows older rural residents to realize the necessity of using smartphones to improve their quality of life and equips them with the skills for smartphone use (Ma, Grafton, and Renwick 2020). The coefficient of the marital status variable is negative and significant, suggesting older married people are less likely to use smartphones. This can be explained by the fact that a major part of older rural residents choose to use smartphones to relieve loneliness. Marriage is an alternative strategy for loneliness mitigation (Štípková 2021), which can frustrate older rural residents' enthusiasm to use smartphones.

Table 9.3: Predictors of Older Rural Residents' Smartphone Use: Probit Model

	Smartphone Use	
Variables	**Coefficients**	**Marginal effects**
Age	−0.002 (0.005)	−0.001 (0.002)
Gender	−0.159 (0.061)***	−0.055 (0.021)***
Education	0.204 (0.054)***	0.070 (0.018)***
Marital status	−0.450 (0.082)***	−0.156 (0.028)***
Household size	0.157 (0.025)***	0.054 (0.008)***
Youth dependency ratio	−0.005 (0.077)	−0.002 (0.027)
Asset ownership	0.632 (0.087)***	0.219 (0.029)***
Farm size (ln)	0.035 (0.024)	0.012 (0.008)
Proximity to plot	0.011 (0.042)	0.004 (0.015)
Negative shocks	−0.098 (0.071)	v0.034 (0.025)
Eastern region	0.432 (0.072)***	0.149 (0.024)***
Central region	0.315 (0.082)***	0.109 (0.028)***
Constant	−0.321 (0.405)	
Wald (12)	212.07, p>=0.000	
Log-likelihood	−1,278.658	
Sample size	2,113	2,113

Notes: Standard errors are in parenthesis. The reference region is the western region of the PRC. ***<0.01.

Source: Authors.

Household size positively and significantly impacts older rural residents' smartphone use. In particular, an additional household member can increase older rural residents' likelihood to use smartphones by 5.4 percentage points. This finding echoes that large families lend older rural residents enough financial support to purchase and use smartphones (Fortes, Broilo, and de M. Lisboa 2021). Owning assets significantly increases older rural residents' smartphone use by 21.9%. This finding coincides with intuition and classical theories. Asset ownership indicates households have good economic conditions, enabling them to afford the cost of purchasing and using smartphones (Lim et al. 2020). This finding is evidenced by the work of Ma, Grafton, and Renwick (2020) on the PRC. The coefficients of our location dummies are positive and significant, suggesting older rural residents in the eastern and central PRC are more likely to use smartphones than those in the western PRC. This spatial disparity is understandable as the central and eastern PRC are advanced in labor market development, rural residents' economic conditions, and rural development compared with the western PRC.

Treatment effects of smartphone use

Table 9.4 presents the estimates of smartphone use ATEs on objective and subjective well-being. For objective well-being outcomes, our results suggest older rural residents' smartphone use has a positive and statistically significant impact on their commercial medical insurance ownership, organic food consumption status, and milk consumption. In particular, older rural residents' smartphone use tends to yield a 5.7% and 14.5% increase in their likelihood of purchasing commercial medical insurance and organic food, respectively. Meanwhile, smartphone users among older rural residents consume 6.034 grams per capita per day more milk than nonusers, representing a 19.80% increase compared to

Table 9.4: ATE Estimates

Variables	ATE	*z*-value	Percentage change (%)	*z*-value
Objective well-being outcomes				
Commercial medical insurance ownership	0.057 (0.013)***	4.51	92.31	3.00
Organic food consumption status	0.145 (0.020)***	7.17	75.32	4.82
Milk consumption	6.034 (3.299)*	1.83	19.80	1.66
Healthcare product consumption status	0.022 (0.018)	1.22	13.49	1.13
Subjective well-being outcomes				
Life satisfaction	−0.153 (0.036)***	−4.20	−3.59	−4.30
Happiness	−0.130 (0.037)***	−3.51	−3.00	−3.58
Confidence about the future	0.033 (0.038)	0.86	0.78	0.85
Self-reported health condition	0.051 (0.031)	1.64	2.89	1.60

ATE = average treatment effect.

Notes: Standard errors are in parenthesis. Commercial medical insurance ownership, organic food consumption status, and healthcare product consumption status are measured by dummies. Milk consumption is measured at gram per capita per day. Life satisfaction, happiness, confidence about the future, and self-reported health condition are measured by categorical variables. ***<0.01 and *<0.10.

Source: Authors.

nonusers. In sum, our results suggest older rural residents' smartphone use is beneficial to their objective well-being improvement. This finding evidences the inference concluded from our conceptual framework that smartphone use improves older rural residents' market information access and eases access to online shopping (Colbert, Thornton, and Richmond 2020; Vassilakopoulou and Hustad 2023). These efficiencies of smartphones help to diversify older rural residents' consumption by offering lower prices and higher quality, thereby promoting their objective well-being (Chiu et al. 2019; Yang, Chen, and Gao 2024).

Table 9.4 also reports smartphone use ATEs on subjective well-being outcomes in the lower panel. As can be seen, older rural residents' smartphone use is negatively and significantly associated with their life satisfaction and happiness. In particular, smartphone use reduces older rural residents' life satisfaction by 0.153 points and happiness by 0.130 points out of 5, representing a 3.59% and 3.00% reduction compared with nonusers. This finding confirms the negative association of older rural residents' smartphone use with their subjective well-being, documented in our conceptual framework. Overuse of smartphones can disrupt older rural residents' daily routines, induces family conflicts, degrades their mental and physical health, and exacerbates their loneliness (Elhai, Tiamiyu, and Weeks 2018; Liu et al. 2024), resulting in lower subjective well-being.

Disaggregated Analyses

Older rural residents' technology adoption (e.g., smartphone use) and objective and subjective well-being vary with their gender and living arrangements (e.g., whether they live with other household members. For instance, females have less access to social capital and income-earning chances than males (Calvi 2020; Ji et al. 2017), making their objective and subjective well-being more sensitive to lifestyle changes (e.g., smartphone use) (Blanchflower and Bryson 2024). These variations contain valuable policy implications as they clarify specific scenarios for policy application. Therefore, we disaggregated smartphone use's impacts on objective and subjective well-being based on respondents' gender and whether they live with other household members.

By gender

Table 9.5 presents the ATEs of smartphone use on objective and subjective well-being outcomes disaggregated by respondents' gender. For objective well-being outcomes, smartphone use is positively and significantly associated with male and female older adults' commercial medical insurance ownership and organic food consumption status.

Table 9.5: Disaggregated by Gender

Variables	Males				Females			
	ATE	*z*-value	Percentage change (%)	*z*-value	ATE	*z*-value	Percentage change (%)	*z*-value
Objective well-being outcomes								
Commercial medical insurance ownership	0.054 (0.018)***	3.04	79.64	2.17	0.065 (0.018)***	3.58	122.78	2.09
Organic food consumption status	0.122 (0.028)***	4.44	59.20	3.27	0.177 (0.030)***	5.86	100.39	3.47
Milk consumption	10.299 (4.739)**	2.17	34.48	1.91	3.222 (4.689)	0.69	10.78	0.64
Healthcare product consumption status	0.027 (0.025)	1.08	15.77	0.99	0.025 (0.025)	1.00	17.09	0.91
Subjective well-being outcomes								
Life satisfaction	−0.107 (0.051)**	−2.11	−2.54	−2.14	−0.210 (0.054)***	−3.86	−4.87	−3.99
Happiness	−0.066 (0.053)	−1.24	−1.55	−1.25	−0.218 (0.050)***	−4.32	−4.96	−4.46
Confidence about the future	0.010 (0.050)	0.21	0.25	0.21	0.056 (0.059)	0.95	1.33	0.94
Self-reported health condition	0.046 (0.040)	1.14	2.61	1.12	0.043 (0.047)	0.92	2.41	0.90

ATE = average treatment effect.

Notes: Standard errors are in parenthesis. Commercial medical insurance ownership, organic food consumption status, and healthcare product consumption status are measured by dummies. Milk consumption is measured at grams/capita/day. Life satisfaction, happiness, confidence about the future, and self-reported health condition are measured by categorical variables. ***<0.01, **<0.05, and *<0.10.

Source: Authors.

More specifically, the effect magnitudes of smartphone use on these two outcomes of females are larger than those of males. Smartphone use makes older females 6.5% more likely to consume commercial medical insurance and 17.7% more likely to consume organic food. In contrast, the estimates for older males are 5.4% for medical insurance and 12.2% for organic food. These differences are primarily due to females prioritizing health more than males (Zhou and Turvey 2018). However, the use of smartphones impact on milk consumption is heterogeneous across older rural residents' genders. Specifically, smartphone use has a positive and significant impact on older males' milk consumption, while it has no significant impact on that of older females. Compared with commercial medical insurance and organic food, milk is more necessary for daily life, with milk consumption occupying more of the household budget than the other two items. Females tend to earn less than males (Marinelli, Zhang, and Ying 2023), making their milk consumption less likely to be influenced by smartphone use compared to males.

For subjective well-being outcomes, older male smartphone users experience lower life satisfaction than nonusers. This phenomenon is also observed among older female smartphone users and is even more pronounced. Smartphone use has a negative and significant impact on older females' happiness, while its impact on that of the older male is insignificant. The results shown in the lower part of Table 9.5 suggest that females undertake more subjective well-being degradation than males by using smartphones. This finding can be explained by the following logic. First, reality tells us that females have fewer job opportunities than males (Chen, Fu, and Chang 2022), leading to older females owning less capital. This makes older females subjective well-being more fragile to external shocks than males. Second, older females have a longer lifespan than males (Patwardhan et al. 2024). Thus, older females face a high probability of loneliness as their partners often do not live as long. This exposes older females more to the negative effects of smartphone overuse than their male counterparts.

By living arrangements

Table 9.6 reports the disaggregated ATEs by whether respondents live with other household members. For objective well-being outcomes, smartphone use positively and significantly impacts all four selected indicators of older rural residents living with other household members. By contrast, smartphone use only significantly increases the odds of older rural residents who live alone having commercial medical insurance and consuming organic food. This finding highlights that older rural residents living with other household members can benefit more from using smartphones regarding objective well-being than those living alone. Having the companionship of other household members gives older rural residents more chances to receive care and monetary support from their families (Fang et al. 2023; Wu 2022), leading older rural residents to a higher level of objective well-being. Meanwhile, living with other household members helps achieve the economies of scale of household consumption and encourages older rural residents to consume more healthcare products and services (Li et al. 2023). Accordingly, living with other household members can amplify an improvement in people's objective well-being.

Table 9.6 also shows that older rural residents living with other household members receive 0.197 points reduction in life satisfaction and 0.209 points reduction in their happiness, from being smartphone users. By comparison, smartphone use reduces life satisfaction by 0.118 points for older rural residents living alone. As can be seen, older residents living with other household members tend to have a lower level of subjective well-being from using smartphones than those living alone. This finding goes against our common sense as family companionship helps release older residents' loneliness and life-stress and makes them happier and satisfied, which can offset the negative impact of smartphone use on subjective well-being. However, smartphone users can neglect their household members to some extent, as the overuse of smartphones can block out genuine communication among them (Elhai, Tiamiyu, and Weeks 2018; Neophytou, Manwell, and Eikelboom 2019; Nuñez and Radtke 2024). Meanwhile, other household members usually monitor the older members' smartphone use, which makes older residents feel their privacy is invaded and induces family conflicts (Fox and Connolly 2018; Zhang and He 2022). Thus, smartphone use is recognized as more hazardous for the subjective well-being of older rural residents living with other household members.

Table 9.6: Disaggregated by Living Arrangements

	Living Alone				Living with Other Household Members			
Variables	**ATE**	**z-value**	**Percentage change (%)**	**z-value**	**ATE**	**z-value**	**Percentage change (%)**	**z-value**
Objective well-being outcomes								
Commercial medical insurance ownership	0.056 (0.020)***	2.80	75.22	2.14	0.067 (0.017)***	3.92	156.31	1.86
Organic food consumption status	0.109 (0.026)***	4.21	76.27	3.12	0.150 (0.033)***	4.57	58.56	3.13
Milk consumption	9.944 (6.419)	1.55	29.60	1.43	9.061 (3.636)**	2.49	37.41	1.95
Healthcare product consumption status	0.026 (0.026)	0.99	14.46	0.93	0.040 (0.023)*	1.78	32.23	1.45
Subjective well-being outcomes								
Life satisfaction	−0.118 (0.049)**	−2.39	−2.73	−2.42	−0.197 (0.056)***	−3.51	−4.69	−3.64
Happiness	−0.071 (0.049)	−1.45	−1.63	−1.46	−0.209 (0.059)***	−3.51	−4.84	−3.64
Confidence about the future	−0.039 (0.054)	−0.72	−0.93	−0.72	0.005 (0.057)	0.08	0.11	0.08
Self-reported health condition	0.044 (0.041)	1.06	2.50	1.05	0.032 (0.051)	0.63	1.81	0.62

ATE = average treatment effect.

Notes: Standard errors are in parenthesis. Commercial medical insurance ownership, organic food consumption status, and healthcare product consumption status are measured by dummies. Milk consumption is measured at grams/capita/day. Life satisfaction, happiness, confidence about the future, and self-reported health condition are measured by categorical variables. ***<0.01, **<0.05, and *<010.

Source: Authors.

9.6 Conclusions, Policy Recommendations, and Limitations

9.6.1 Conclusions

Smartphones offer older rural residents the chance to overcome obstacles as they can enhance their information access, ease online shopping and entertainment, and solidify their social networks. These make smartphone use an effective strategy to uplift older rural residents' well-being, which is of particular significance for developing nations like the PRC confronting an increasingly aging population. Accordingly, investigating the association between older rural residents' smartphone use and their objective and subjective well-being can help open viable pathways to leverage the care of older rural people in the PRC and other developing nations confronting similar situations. This constitutes the original motivation of our study.

Utilizing the IPWRA model to analyze the data of 2,113 older rural residents derived from the 2020 RRS, this study systematically studied the impact of older rural residents' smartphone use on their objective and subjective well-being. Meanwhile, this study also investigated the factors driving older rural residents to use this device.

Empirical results suggest that older rural residents' smartphone use improves their objective well-being captured by their consumption of commercial medical insurance, organic food, and milk. However, smartphone use is detrimental to older rural residents' life satisfaction and happiness. Disaggregated analyses reveal that older women obtain a larger portion of their objective well-being from smartphones than their male counterparts. In addition, the positive effects are more pronounced for those living with other household members than those living alone. However, older rural females who live with other household members are more vulnerable to a lower level of subjective well-being from using smartphones than their counterparts.

9.6.2 Policy Recommendations

Leveraging the empirical findings, this study can help identify effective strategies to achieve older rural residents' reasonable smartphone use and improved well-being. Older rural residents' smartphone use is beneficial to their objective well-being in terms of commercial medical insurance ownership, organic food consumption status, and milk consumption. This suggests that policymakers should devote more effort to penetrating smartphone use among older rural residents. Providing older rural residents with purchase subsidies for smartphones should be fully considered.

The positive impact of education and asset ownership on older rural residents' smartphone use highlights the importance of increasing the provision of smartphone use-targeted training and enhancing older rural residents' asset-based income. The former can help lower the threshold of smartphone use for older rural residents, while the latter reinforces their affordability for the device and related services. However, the negative association between older rural residents' smartphone use and their subjective well-being regarding life satisfaction and happiness alerts the government to be cautious in penetrating this device. In particular, the government should intensify advocacy for the detriment of the overuse of smartphones to promote older rural residents' prudent and rational use of the device. More importantly, official and nongovernment organizations (e.g., farmers' self-help organizations) can be relied upon to mitigate the weakness of older rural smartphone users who are female and living with other household members in subjective well-being.

Besides, our results also show that older rural residents residing in western areas of the PRC are less likely to use smartphones compared to those in eastern and central areas of the PRC. Thus, policy instruments should be regionally targeted to ensure more political support is devoted to western areas of the PRC. In particular, regarding western PRC's vulnerabilities in economic development and internet infrastructure, more smartphone purchase subsidies and fiscal outlays for infrastructure construction should be allocated to this area.

9.6.3 Research Limitations

Before concluding, it is necessary to highlight the limitations of the present study. First, due to the absence of panel data, the cross-sectional data analyzed in our study cannot capture spatial and temporal variance in the association of older residents' smartphone use with their well-being. Therefore, future studies are needed to collect suitable panel data and understand the association more deeply. Second, since the primary research objective of our study is to investigate the impact of older rural residents' smartphone use on their well-being, the association between objective and subjective well-being remains unexplored. Accordingly, empirical efforts should be devoted to exploring this association.

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10

Enhancing Elder Care Through Technology: Empirical Insights from Older Urban Women in India

Ishita Bera and Sunetra Maitra Paul

10.1 Introduction

The global demographic landscape is undergoing a significant transformation with an increasing proportion of older individuals, often referred to as the "aging population" (UN DESA 2024). This shift is driven by declining fertility rates (WEF 2022) and increasing life expectancy (WEF 2023). While population aging poses challenges such as providing adequate healthcare and financial security for older people, it also offers opportunities like a more experienced workforce and increased demand for products and services tailored to the older population. Older people play an important societal role through their wisdom, experience, and contributions to cultural heritage (Viscogliosi et al. 2020). As the population ages, there is a growing focus on improving the quality of life, with active aging gaining interest among researchers and policymakers. By 2050, Asia's older population is expected to double to 1.3 billion (ESCAP 2023). With the increasing aging population, there is a need to connect them and provide enhanced care of the older population. In this regard, adopting digital technologies is crucial for improving care, as it can help overcome current disadvantages, such as limited access to information and healthcare services. Digital tools can enhance the autonomy and well-being of older people, enabling them to stay connected and manage their health more effectively (Trafton 2020). Despite various initiatives, there remains a noticeable gap in their digital inclusion, especially compared to the younger generation. This disparity is evident in the context of rapidly evolving digital technology.

Technological barriers (Gunnes, Løe, and Kalseth 2024), social isolation risks, and cultural differences (Dmello and Hussain 2023) can hinder effective communication and engagement with older populations. Bridging these gaps requires creating inclusive environments and fostering understanding across generations. One significant aspect of this demographic shift is the "feminization of aging," where women constitute a higher proportion of the older population (CEPELLOS 2021). This trend has profound social and economic implications, particularly in digital technology adoption. Digitalization can address challenges older individuals face, including social isolation and access to services (Welch et al. 2022). However, information and communication technology access disparities can lead to digital divides (Bera et al. 2024) across demographics, presenting challenges in online social interactions and information acquisition. Encountering this digital divide for the older population presents challenges in online social interactions, acquiring information, and maintaining offline social participation.

Empirical evidence addressing the digital technological adoption rate among older women remains scarce. A study by (Cirera et al. 2024) highlights that the adoption of sophisticated digital technologies by firms is a crucial factor in reducing the productivity gap between firms managed by female managers and those managed by male managers. This gap is influenced by external factors such as social norms, market conditions, and access to resources. Social norms, in particular, have led to restrictions on the roles of female managers, limiting their access to information and financial resources. Adopting technology helps level the playing field by providing female top managers with tools that enhance their decision-making capabilities and operational efficiency. Specifically, the study measures productivity using labor productivity, profit margins, and operational efficiency indicators. Further, it was concluded that by leveraging these technologies, female managers could overcome barriers related to information access and financial resources, bridging the divide in their roles and contributing to improved firm performance.

Consequently, this underscores the need to investigate technology adoption intentions across genders, particularly older females. The GSMA "Mobile Gender Gap Report 2021" (Carboni et al. 2021) highlights the gender gap in mobile internet use, noting that older women in low- and middle-income economies are less likely to own smartphones and use mobile internet. Eurostat data (Eurostat 2021) show that in the European Union (EU), only 46% of women aged 55–74 used the internet, compared to 58% of men in the same age group. (Pangestu and Granryd 2020) report that this gender gap is more pronounced among older populations globally. This divide is even more significant in rural areas due to affordability, inadequate device availability, and lack of infrastructure and skills (Barbier 2023). Studies have shown that the gender gap in accessing digital technology is influenced by affordability, infrastructure, and education. Urban women typically have better access to these resources (Signé 2023), making them suitable for studying digital behavior. Understanding the factors influencing digital technology adoption among older urban women is crucial for developing targeted interventions to enhance digital inclusion and improve overall well-being. Understanding these factors may help leverage and promote broader technology adoption within the older population. This, in turn, may enhance the quality of care of older people through targeted interventions and policy measures. Despite significant progress through Indian government initiatives to bridge the digital divide, substantial challenges still hinder the full realization of last-mile connectivity in rural India (Hassan and Rather 2020). Furthermore, the affordability of digital devices and services in rural India limits access to digital technologies (Reddick et al. 2020). Therefore, rural India is not a suitable area of study for understanding the adoption of digital technology by older people, especially for women, as these barriers could skew the study outcome.

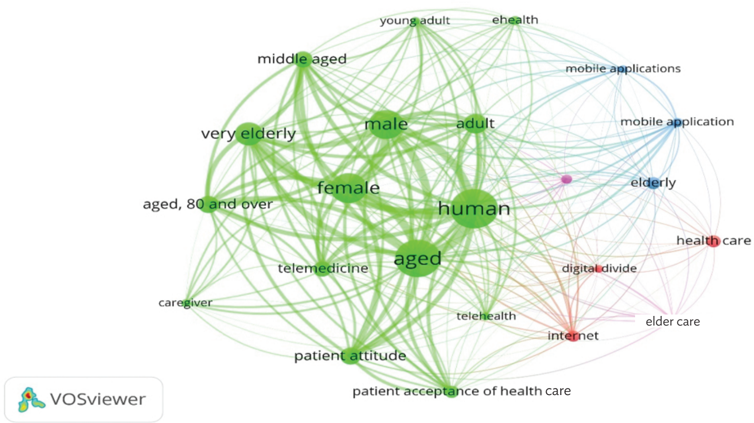
The structure of the study is as follows. Section 10.2 reviews the existing literature and theoretical frameworks. Section 10.3 presents the proposed conceptual framework and hypothesis statements based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model. Section 10.4 details the study design and demographics. Section 10.5 examines the measurement model's reliability and validity. Section 10.6 discusses the results of hypothesis testing. Section 10.7 concludes the findings and their implications.

10.2 Literature Review

Under the "Decade of Healthy Aging" initiative (WHO 2020), the UN called for collaboration among researchers, policymakers, service providers, and organizational leaders to improve the lives of older people. This global effort aims to promote healthy aging and create age-friendly environments through stakeholder cooperation. Recent Information Systems (IS) research has highlighted the adoption of technology by the older population as crucial for enhancing their quality of life (Faverio 2022).

To understand how digital technology can enhance care of the older population, we conducted a bibliographic analysis of Scopus-indexed articles using VOSviewer software. As shown in Figure 10.1, we identified four key clusters in this domain.

Figure 10.1: Bibliographic Analysis of Studies on Elder Care Using Digital Technology

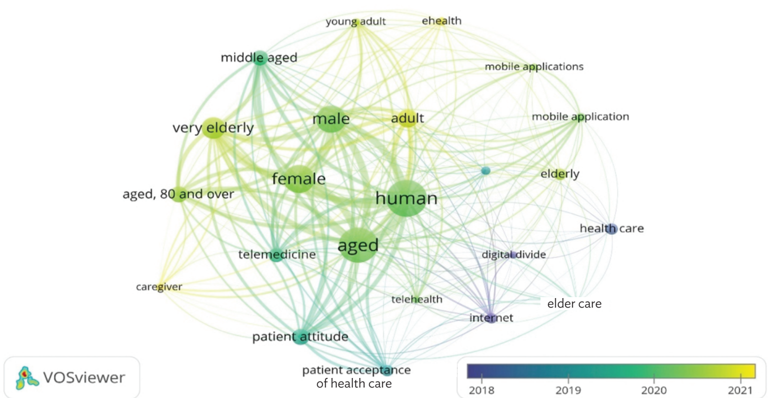


Source: Authors' calculations.

Cluster 1 focuses on demographics and healthcare attitudes including terms such as adult, aged, caregiver, and telemedicine, emphasizing the importance of patient acceptance in improving the care of older people. Cluster 2 addresses the digital divide and internet access, highlighting barriers that impact the adoption of digital technologies in healthcare among the older population. Cluster 3 centers on eHealth solutions for the care of older people, underscoring the implementation and benefits of these technologies in providing efficient and accessible care. Cluster 4 examines mobile applications and technology acceptance, exploring how mobile apps and telehealth services facilitate independent living and improve overall well-being among older individuals. The findings from our cluster analysis align with the literature review conducted using Scopus-indexed journals. Several studies underscore the importance of technological advancements in supporting independent living, facilitating social participation, and reducing isolation among older people (Keohane, Swarbrick, and Helal 2022; Fong et al. 2022; Luoma-Halkola and Häikiö 2022; Sen, Prybutok, and Prybutok 2022; Kleinman et al. 2021). Therefore, it highlights the critical role of technology in enhancing care of older people and the need for targeted interventions to address the digital divide and promote technology acceptance among the older population.

Additionally, technology can enhance the overall quality of life for older people by providing access to information, services, and entertainment, promoting well-being and a sense of fulfilment (Aggarwal, Xiong, and Schroeder-Butterfill 2020). The use of the internet by older people has been linked to several positive outcomes, including decreased loneliness and depression, enhanced social connectedness, self-esteem, and cognitive functioning (Aggarwal, Xiong, and Schroeder-Butterfill 2020; Lei et al. 2024). It has also been associated with well-being, self-efficacy, self-control, self-determination, social interaction, education, and skills development among older people (Farmer, Xu, and Dupre 2021).

Figure 10.2: Year-wise Bibliographic Analysis of Studies



Source: Authors' calculations.

Furthermore, a bibliographic analysis with VOSviewer, as depicted in Figure 10.2, explains the trends in Scopus-indexed journals related to the study's topic during 2018–2023.

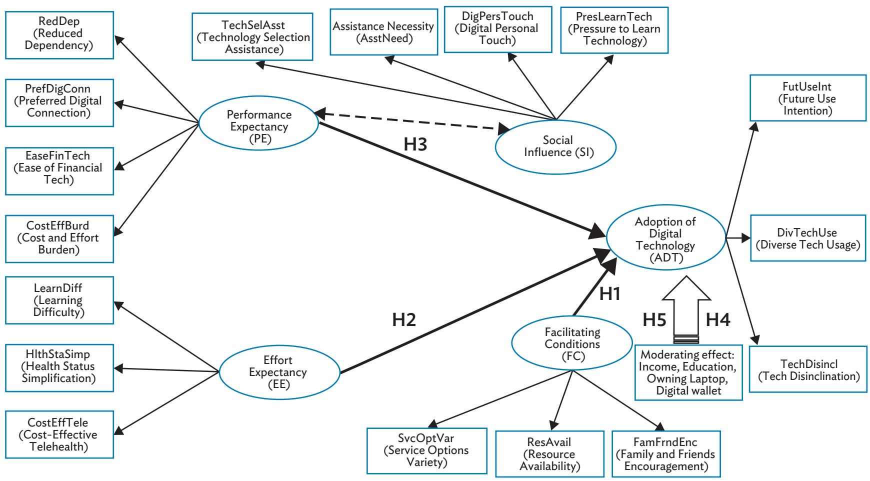
As per the analysis, over the years, topics such as eHealth, caregiver support, care of older people, telemedicine, and patient acceptance of digital healthcare have become increasingly prominent. This progression exhibits the increasing importance of digital technology in addressing the healthcare needs of older people, particularly in bridging the digital divide and enhancing access to healthcare services. However, the study of technology adoption among older women in India remains underexplored. Understanding biopsychosocial factors instrumental in technology adoption can inform inclusive digital platform design. This study analyses the determinants of acceptance of digital technology among Indian urban older women.

10.3 Proposed Conceptual Framework and Hypothesis Statements

The UTAUT model (Venkatesh et al. 2003) posits that technology use is determined by behavioral intention, influenced by performance expectancy, effort expectancy, social influence, and facilitating conditions, moderated by age, gender, experience, and voluntariness. UTAUT2 (Venkatesh, Thong, and Xu 2012) adds hedonic motivation, price value, and habit. However, hedonic motivation is less relevant for older people, who prioritize practical and functional benefits (Lee and Coughlin 2015).

This study proposes a framework based on the UTAUT theory, as depicted in Figure 10.3. The proposed framework includes performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC) as independent variables, with the adoption of digital technology (ADT) as the dependent variable. Like other developing economies, in India, older females often face unequal social status, making it crucial to understand their intentions to adopt technology. The choice of technology is a multidimensional problem of balancing technology, society, the environment, and civilization (Bera and Rahut 2024). This multidimensional approach prioritizes benefits like communication, access to services, and health monitoring.

Figure 10.3: Conceptual Framework Based on UTAUT Model



UTAUT = Unified Theory of Acceptance and Use of Technology.

Source: Authors.

Based on the proposed framework, the structural model below specifies the relationships between the latent variables in equation 1.

$$ADT = \beta_1 (PE * SI) + \beta_2 EE + \beta_3 FC + \beta_4 (OwnLaptop * DigiWalet) + \beta_5 Edu + \varepsilon \quad (1)$$

Where ADT is Adoption of digital technology, PE is performance expectancy, SI is social influence, EE is effort expectancy, FC is facilitating conditions, $OwnLaptop$ is whether an individual owns a laptop, $Digiwalet$ is individual owning a digital wallet, Edu is the level of education, and β_is are the path coefficients and the term $(PE * SI)$ and $(OwnLaptop * DigiWalet)$ represent an interaction between PE and SI and between $OwnLaptop$ and $DigiWalet$, and ε is the error term.

The measurement models of latent variables are represented as

$$ADT = \alpha_1 \cdot FutUseInt + \alpha_2 \cdot DivTechUse + \alpha_3 \cdot TechDisincl \quad (2)$$
$$PE = \alpha_4 \cdot PrefDigConn + \alpha_5 \cdot EaseFinTech + \alpha_6 \cdot RedDep \quad (3)$$
$$EE = \alpha_7 \cdot LearnDiff + \alpha_8 \cdot HlthStsSimp + \alpha_9 \cdot CostEffTele \quad (4)$$
$$SI = \alpha_{10} \cdot PresLearnTech + \alpha_{11} \cdot DigPersTouch + \alpha_{12} \cdot TechSelAsst \quad (5)$$
$$FC = \alpha_{13} \cdot SvcOptVar + \alpha_{14} \cdot ResAvail + \alpha_{15} \cdot FamFrndEnc \quad (6)$$

where, α_{is} are factor loadings

After structuring the model, the study further derives the hypothesis statements from the constructs used in the conceptual framework, which are:

Facilitating conditions

Research indicates that facilitating conditions, such as technology availability, social support, and senior-friendly device design, play a crucial role in technology adoption among older people (Bertolazzi, Quaglia, and Bongelli 2024; Man et al. 2022). Addressing these facilitators can promote independent living and enhance technology utilization among the aging population.

H1: Facilitating conditions increase the adoption of digital technologies among the older population.

Effort expectancy

Effort expectancy refers to an individual's perception of the ease of technology use. This perception significantly influences long-term adoption among older people (Zhang and Boot 2023). A study suggests that males are more willing to explore and adopt technology than females (AAUW 2021). Social norms and expectations can influence this perception.

H2: Effort expectancy is positively related to adopting digital technology among the older population.

Performance expectancy and social influence and their interaction

Performance expectancy (PE) is the belief that technology will help achieve benefits in performing activities. It is influenced by perceived usefulness and extrinsic motivation (Venkatesh et al.,2003) and is key in mobile service adoption (Allil and Khan 2016; Park and Kim 2014). Social Influence (SI) refers to the impact of interactions with others on an individual's behavior and plays a significant role in technology adoption. Social support from family can encourage older people to adopt digital tools.

H3: Performance expectancy and social influence increase the adoption of digital technologies among the older population.

Familiarity with digital tech and laptops and their interaction

Familiarity with digital technology increases its adoption for various activities. As older people become familiar with digital payment methods (e.g., UPI, mobile wallets) (The Aging 2024), they can participate in the digital economy. Owning a laptop provides access to services and information online. Digital technology allows access to telehealth services and streaming platforms, promoting holistic well-being. Aligning laptop ownership with active digital wallet use empowers older individuals in India to participate fully in the digital ecosystem (Choudrie, Zamani, and Obuekwe 2022).

H4: The interaction effect of laptop ownership and digital wallet use positively influences the adoption of digital technology among older individuals.

Education

Education plays a pivotal role in shaping technology adoption among the older population. Generally, individuals with higher education adapt to new technology more easily. However, the generation gap can create barriers to learning from the younger generation. Furthermore, educated older individuals may approach digital technology with curiosity, skepticism, and security concerns (Bansal and Choudhary 2023). Their experiences and values shape their perspective, sometimes leading them to avoid certain aspects of the digital ecosystem.

H5: Education level positively influences the adoption of digital technology among older individuals.

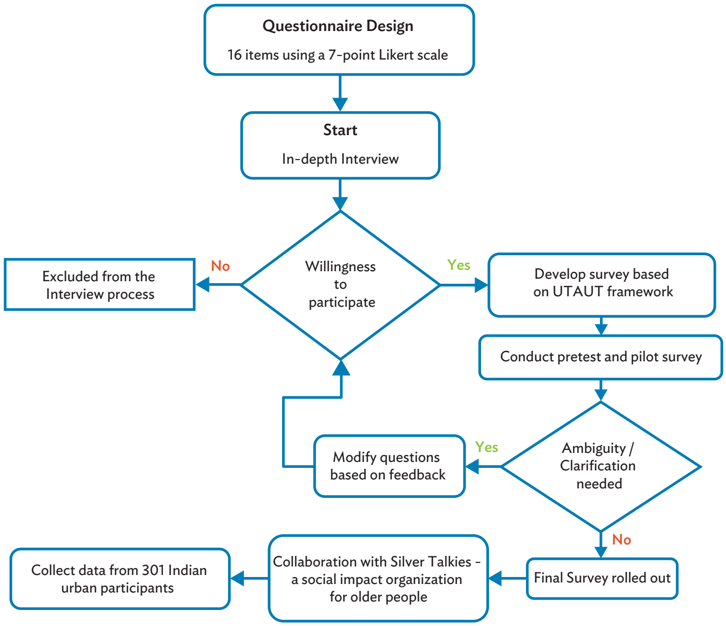
10.4 Study Design and Demographics

10.4.1 Study Design

The study followed a structured process to ensure comprehensive data collection and analysis. Initially, in-depth interviews were conducted with selected older citizens to gauge their willingness to adopt digital technology.

For a detailed understanding, Figure 10.4 depicts the entire process in the flowchart.

Figure 10.4: Flowchart of the Study Design



UTAUT = Unified Theory of Acceptance and Use of Technology.

Source: Authors.

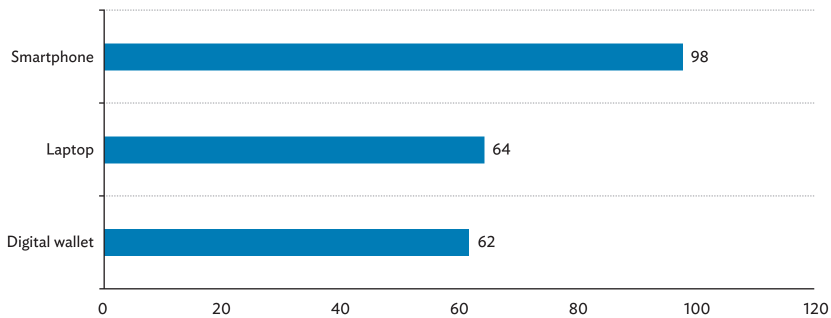
Based on these insights, a survey was developed using the UTAUT framework and refined through a pilot survey to address any ambiguities. The final survey was conducted online and in person, targeting urban older participants. We collaborated with Silver Talkies, a social impact organization, to collect 87 responses, while the remaining 214 were gathered through a primary survey conducted by volunteers. This approach allowed for a diverse and balanced sample, reflective of different segments within the older population. For a detailed understanding, Figure 10.4 depicts the entire process in the flowchart.

10.4.2 Demographics of the Respondents

Technical device ownership

As per the report Help Age India report (2023b) findings, around 60% of older women have never used digital devices. Therefore, it is essential to consider the availability and access to these devices among the study participants. To provide a balanced perspective, the study included data on device ownership among the survey respondents. Figure 10.5 illustrates the percentage of participants who own smartphones, laptops, and digital wallets, which are key tools for engaging with today's digital landscape.

Figure 10.5: Percentage of Respondents Owning Technical Devices



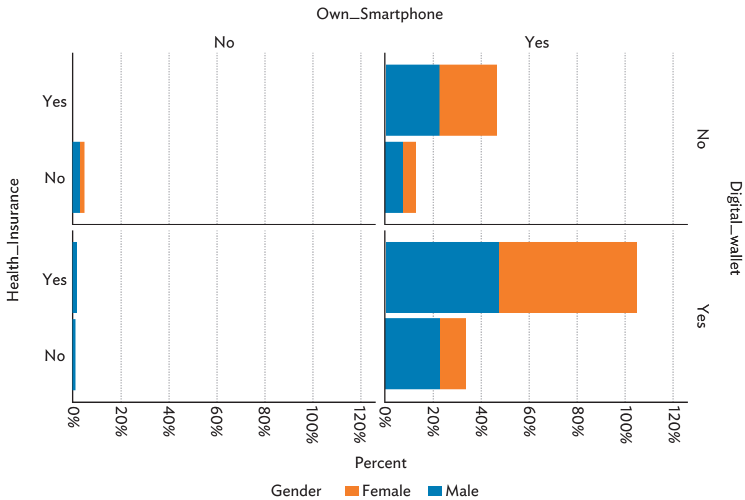
Source: Authors.

Figure 10.5 shows that the majority of respondents own digital devices such as smartphones, laptops, and fintech tools like digital wallets. Since we know they own these devices and tools, we will check their willingness to use the technology or their acceptance of it. Merely owning a device does not guarantee its use by the older population. Therefore, assessing their willingness and acceptance is crucial to understanding the adoption and utilization of digital technologies among the older population.

Other key demographics

To ensure that demographics are suitable for the study, the study presents five figures, starting with Figure 10.6, a gender-wise clustered bar chart comparing health insurance, smartphone ownership, and digital wallet ownership.

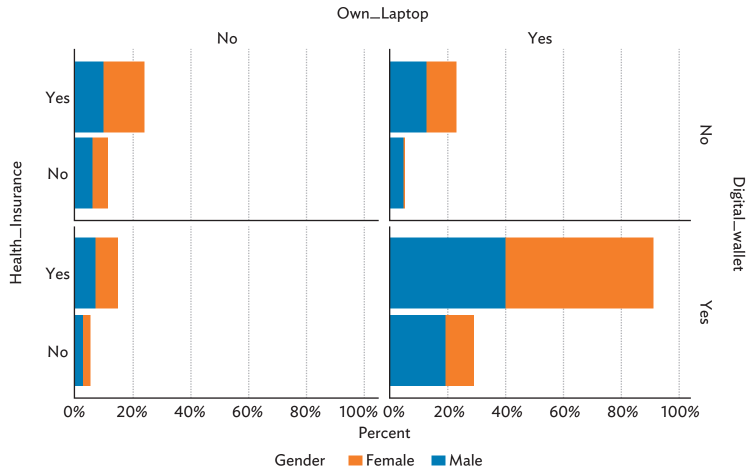
Figure 10.6: Gender-wise Cluster of Health Insurance, Smartphone Ownership, and Digital Wallet



Source: Authors.

Figure 10.6 compares male and female respondents' health insurance, smartphone, and digital wallet ownership, highlighting access differences. Males have higher smartphone ownership and digital wallet use than females. Respondents with health insurance are more likely to own smartphones and use digital wallets. In contrast, respondents without health insurance show a lower percentage of smartphone ownership and digital wallet use for both genders. The data suggest a strong correlation between health insurance, smartphone ownership, and digital wallet use.

Figure 10.7: Gender-wise Cluster of Health Insurance, Laptop Ownership, and Digital Wallet

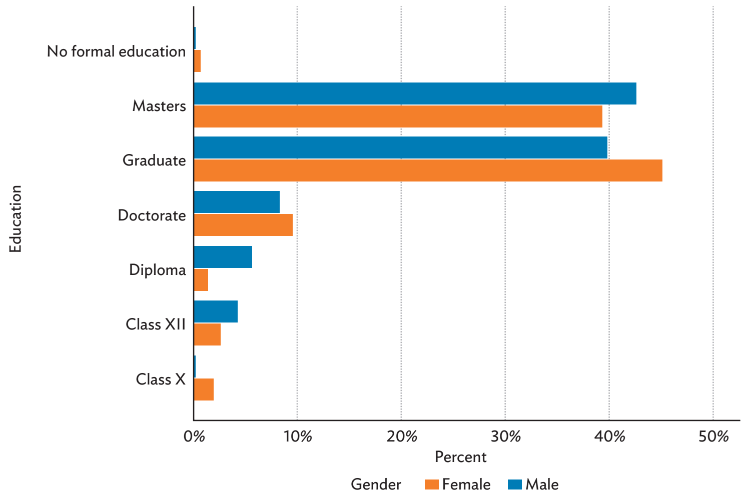


Source: Authors.

Figure 10.7 reveals a higher percentage of health insurance and digital wallet use among laptop owners than among non-laptop owners, with males showing higher figures in both categories. This suggests that individuals with laptops are more likely to have health insurance and use digital wallets, indicating a correlation between digital access and financial and health security. It highlights the differences in access to these essential tools, which are crucial for understanding the digital divide and gender bias in technology adoption among the older population. The data shows significant ownership of these devices, underscoring the importance of evaluating their willingness and acceptance to use them.

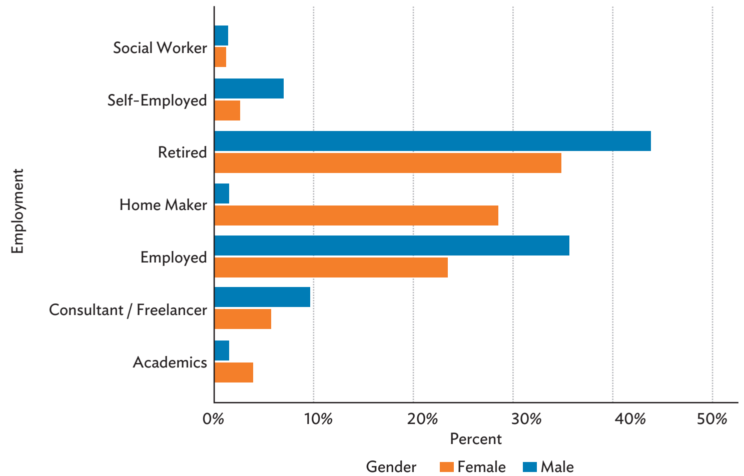
Figure10. 8 shows that the majority of respondents are highly educated, with most falling into the categories of graduates or masters. This high level of education is significant as it can influence their ability to adopt and effectively use digital technologies.

Figure 10.8: Gender-wise Cluster of Education of Respondents



Source: Authors.

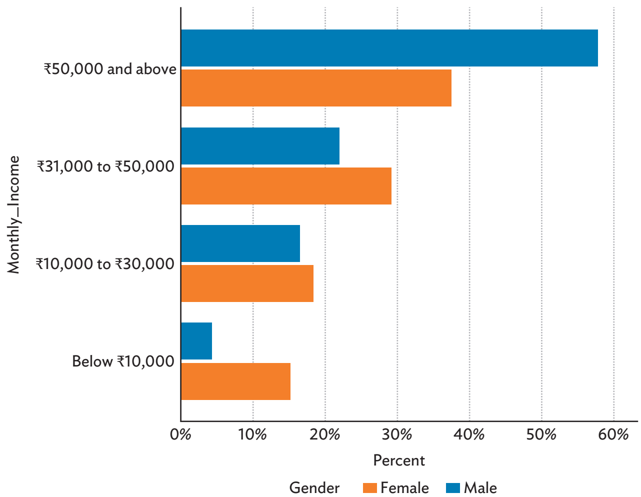
Figure 10.9: Gender-wise Cluster of Occupation of Respondents



Source: Authors.

Figure 10.9 shows that the majority of respondents are either retired, with males predominantly employed or retired and females mainly retired or homemakers. This highlights that there is gender disparity in the current occupations of the respondents aged above 60 years.

Figure 10.10: Gender-wise Cluster of Monthly Income of Respondents



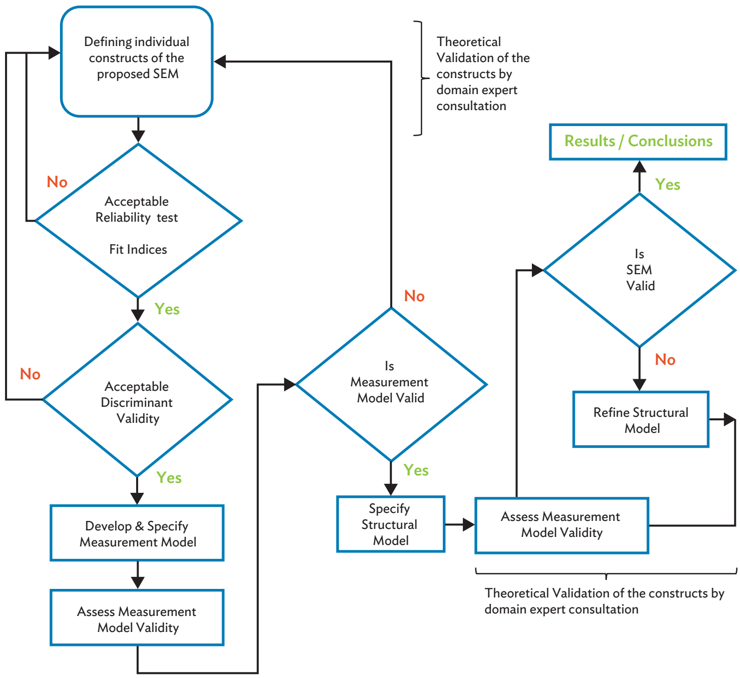
Source: Authors.

Figure 10.10 reveals a notable gender disparity in earnings among the respondents. A significantly higher proportion of male respondents fall into the highest income bracket (₹50,000 and above). In contrast, female respondents are more represented in the lower income brackets (below ₹10,000 and ₹10,000 to ₹30,000). Both genders have relatively similar representation in the middle-income bracket (₹31,000 to ₹50,000). This income divide suggests that male respondents generally have higher earnings, which could influence their affordability and adoption of technology for care of the older population. Conversely, female respondents, being more represented in lower income brackets, might face more financial constraints in adopting such technologies.

10.5 Measurement Model: Reliability and Validity

We assessed the constructs' validity and reliability before proceeding with Structural Equation Modeling (SEM). This involved checking composite reliability, convergent validity, and discriminant validity. The flowchart in Figure 10.11 depicts the detailed process we followed to ensure the constructs' validity and reliability.

Figure 10.11: Flowchart of the Measurement Design of the SEM



AVE = average variance extracted, CR = composite reliability, SEM = structural equation modeling.

Source: Authors.

Table 10.1: Cronbach's Alpha, AVE, and CR scores of all Constructs PE, EE, SI, FC, and ADT

Construct	Cronbach's Alpha	AVE	CR
Performance Expectancy (PE)	0.7	0.4	0.6
Effort Expectancy (EE)	0.7	0.4	0.7
Social Influence (SI)	0.6	0.4	0.7
Facilitating Conditions (FC)	0.6	0.6	0.8
Adoption of Digital Technology (ADT)	0.7	0.6	0.8

AVE = average variance extracted, CR = composite reliability.

Source: Authors' calculations.

Tables 10.1 demonstrates the reliability and validity of the data. Cronbach's alpha scores indicate acceptable internal consistency, with most constructs scoring around 0.7. The AVE and CR scores further support the constructs' validity, indicating robust measurement properties. These scores affirm the data's reliability and validity for further analysis.

Table 10.2: Divergent Validity Analysis (using Heterotrait-Monotrait ratio)

Construct Pair	HTMT Value
ADT vs PE	0.784
ADT vs EE	0.773
ADT vs SI	0.340
ADT vs FC	0.756
PE vs EE	0.752
PE vs SI	0.116
PE vs FC	0.743

HTMT = Heterotrait-Monotrait ratio, ADT = adoption of digital technology, PE = performance expectancy, EE = effort expectancy, SI = social influence, FC = facilitating conditions.

Source: Authors' calculations.

The Heterotrait-Monotrait ratio (HTMT) values in Table 10.2 indicate adequate divergent validity, as most construct pairs fall below the 0.85 threshold. Constructs ADT vs PE, ADT vs EE, and PE vs EE show acceptable validity. Very low values for ADT vs SI and PE vs SI indicate strong divergent validity. Overall, the data supports the validity of the measurement model, and hence we proceed for SEM analysis.

10.6 Hypothesis Testing

Before discussing the results of hypothesis testing, we introduce Table 10.3 to provide the fit indexes for these models, indicating the comparative fit index (CFI), Tucker-Lewis index (TLI), p-value for root mean square area of approximation (RMSEA), and standardized root mean square residual (SRMR). For a detailed visual representation, the SEM diagrams of all three models can be referred to in the Appendix.

Table 10.3: Fit Indexes of the Three SEM Models (all gender, male, female)

	Fit Indexes			
Evaluation Metrics	**Critical value**	**Model 1 (Overall: All Gender)**	**Model 2 (Only Male)**	**Model 3 (Only Female)**
Comparative Fit Index (CFI)	>0.9	0.8 (Reasonable Fit)	0.8 (Reasonable Fit)	0.8 (Reasonable Fit)
Tucker-Lewis Index (TLI)	>0.9	0.8 (Reasonable Fit)	0.7 (Reasonable Fit)	0.8 (Reasonable Fit)
P-value (RMSEA <=0.05)	<0.05	0.000 (Good Fit)	0.000 (Good Fit)	0.000 (Good Fit)
Standardized Root Mean Square Residual (SRMR)	<0.08	0.1 (Reasonable Fit)	0.1 (Reasonable Fit)	0.1 (Reasonable Fit)

RMSEA = root mean square area of approximation, SEM = structural equation modeling.

Source: Authors' calculations.

The fit indices for the three SEM models (Table 10.3) indicate that they each have a reasonable overall fit. The CFI values are at 0.8, indicating a reasonable fit across all gender groups. The TLI also shows a reasonable fit with values of 0.8 for Model 1, 0.7 for Model 2, and 0.8 for Model 3. The p-value for RMSEA is 0.000 in all models, suggesting a good fit. However, the SRMR is 0.1 for all models, which is slightly above the desired threshold but still indicates a reasonable fit.

From the result above, we have the following conclusions from the hypothesis testing from the SEM.

H1: Facilitating conditions increase the adoption of digital technologies among the older population.

Table 10.4: H1 Hypothesis Testing Metrics of the Three SEM Models (all gender, male female)

Hypothesis Testing 1: Facilitating Conditions (FC) ADT → FC (H3)				
Hypothesis Statement	**Critical Value**	**Model 1 (Overall: All Gender)**	**Model 2 (Only Male)**	**Model 3 (Only Female)**
Standardized Loadings (Std.lv)	>0.4	0.28	0.58	0.18
p-value	<0.05	0.01	0.001	0.23
Significance	NA	Marginally Significant	Highly Significant	Not Significant

ADT = adoption of digital technology, NA = not available, SEM = structural equation modeling.

Source: Authors' calculations.

Table 10.4 demonstrates that facilitating conditions—such as access to resources, support, and infrastructure—positively and significantly influence digital technology adoption for older males, with a factor loading of 0.58. However, for older females, the factor loading is only 0.18, and the p-value is 0.23, meaning the influence is not statistically significant. This suggests that social and cultural barriers may limit the impact of facilitating conditions on digital technology adoption among older females, highlighting a gender-specific disparity.

To bridge the gender gap in digital technology adoption among older women in India, it is crucial to promote awareness and provide accessible resources. To enhance digital literacy and inclusion, the Indian government has initiated several programs, such as the Pradhan Mantri Gramin Digital Saksharta Abhiyan (Ministry of Electronics and Information Technology 2017). Additionally, institutions like Indian Institutes of Technology and Indian Institutes of Management (IIM) and start-ups can be pivotal in building gender-sensitive training programs as part of their social responsibility or environmental, social, and governance initiatives. For instance, IIM Bangalore's Women Startup Program (NSRCEL IIM Bangalore 2020) supports women entrepreneurs by providing essential business knowledge and mentoring.

To empower older women with digital technologies, institutions could consider partnering with local community centers, nongovernment organizations (NGOs), and educational institutions to conduct tailored workshops. By leveraging government initiatives, enhancing urban digital literacy programs, and expanding rural training with cultural sensitivity, we can enhance access to essential services. Future research might explore the regional impact of these efforts. Managers and policymakers could collaborate to promote digital inclusion and bridge the digital divide comprehensively.

H2: Effort expectancy is positively related to adopting digital technology among the older population.

Table 10.5: H2 Hypothesis Testing Metrics of the Three SEM Models (all gender, male, female)

Hypothesis Testing 2: Effort Expectancy (EE) ADT → EE (H2)				
Hypothesis Statement	**Critical Value**	**Model 1 (Overall: All Gender)**	**Model 2 (Only Male)**	**Model 3 (Only Female)**
Standardized Loadings (Std.lv)	> 0.4	0.51	0.47	0.56
p-value	< 0.05	0.000	0.01	0.001
Significance	NA	Highly Significant	Marginally Significant	Highly Significant

ADT = adoption of digital technology, NA = not available, SEM = structural equation modeling.

Source: Authors' calculation.

For the H2 hypothesis, we observe a standardized factor loading of 0.5 for all genders in Table 10.5, indicating a moderate positive relationship between perceived effort expectancy and technology adoption, thus supporting the original hypothesis. This suggests that when older individuals find technology easy to use, they are more likely to adopt it. The perceived effort expectancy is highly significant for older females (p-value 0.001) and older males (p-value 0.01), with females showing a higher standardized loading of 0.56 compared to males at 0.47. This indicates that older females in India are particularly inclined to adopt digital technology when perceived as effortless, even more so than their male counterparts.

As per the *India Inequality Report 2022* (Institute for Competitiveness 2022), 61.0% of men have a mobile phone compared to 31.0% of women. Older males may prioritize ease of use but also assess technology adoption for practical benefits such as healthcare access or financial management. In contrast, older females may view digital tools as a means to achieve independence and social connectedness. The Agewell Foundation (2019) highlighted that 87.2% of older women faced gender-based discrimination, and 66% experienced abuse, suggesting that technology could potentially empower them and improve the quality of life (Singla 2020).

Effort expectancy is closely associated with digital literacy, and educated older individuals may find digital technology easier to adopt due to familiarity. The Indian government has implemented several initiatives to support the adoption of digital technology among the older population; programs like the Ayushman Bharat Digital Mission[1] and the CoWIN app[2] have made healthcare services more accessible through digital platforms.

Several organizations and NGOs are actively working to promote digital literacy among older women in India (Sharma et al. 2023). For instance, the Digital Empowerment Foundation (Kumari 2024) focuses on bridging the digital divide through digital literacy and tools, bringing government services within reach of marginalized communities. With support from Google, HelpAge India has launched initiatives to empower older people with digital safety knowledge (Help Age India 2023a). The NIIT Foundation also runs programs to enhance older citizens' digital literacy (NIIT Foundation 2024).

To enhance effort expectancy, youth and educational institutions can initiate intergenerational programs where students assist older individuals in using digital technologies. Student-led digital literacy drives and mentorship programs can boost older women's confidence with digital tools. Future research should explore the impact of these conditions on technology adoption among older women across regions. Collaboration among managers, policymakers, and younger generations can create a supportive environment for digital inclusion, bridging the digital divide.

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1 https://abdm.gov.in/

2 https://www.cowin.gov.in/

H3: Performance expectancy and social influence increase the adoption of digital technologies among the older population.

Table 10.6: H3 Hypothesis Testing Metrics of the Three SEM Models (all gender, male, female)

Hypothesis Testing 3 : Performance Expectancy (PE) ADT → PE*SI (H3)				
Hypothesis Statement	**Critical Value**	**Model 1 (Overall: All Gender)**	**Model 2 (Only Male)**	**Model 3 (Only Female)**
Standardized Loadings (Std.lv)	>0.4	−0.21	−0.27	−0.24
p-value	<0.05	0.001	0.02	0.003
Significance	NA	Highly Significant	Marginally Significant	Highly Significant

ADT = adoption of digital technology, NA = not available, SEM = structural equation modeling.

Source: Authors' calculations.

The H3 hypothesis (Table 10.6) revealed a negative loading of −0.2 across all three models, contrary to the expected positive loading. This suggests that as performance expectancy (PE) and social influence (SI) increase, digital technology adoption decreases among individuals of all genders. For older males, the p-value is 0.02 with a loading of −0.27, while for older females, the p-value is 0.003 with a loading of −0.24. The negative relationship between PE and SI with digital technology adoption may indicate that increased expectations and social pressures may overwhelm older people, leading to lower adoption rates due to the perceived effort outweighing the benefits.

In India's cultural context, which emphasizes family bonds and intergenerational relationships, older individuals, particularly women, often rely on younger family members for technology-related decisions (Verma, Bhattacharya, and Singh 2024). According to the "HelpAge India Report"[3] (Help Age India 2023b: 38), around 60% of older women have never used digital devices, indicating a pronounced digital divide and gender bias. Unfavorable attitudes toward digital technology and fear and anxiety can significantly hinder adoption, even when perceived performance benefits are high.

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3 https://www.helpageindia.org/documents/research/reports-journals/research-reports

In India, where older individuals, especially women, rely on younger family members for technology decisions, tailored training programs and community-based initiatives can enhance digital literacy and support adoption by emphasizing practical benefits like healthcare access and financial management. Organizations like Silver Talkies (Venkateswaran 2022), the JOY community (Malhotra 2018), and Samvedna Senior Care (Mathew 2021) can play a crucial role in mitigating distrust toward digital technology by offering platforms for older individuals to engage with peers and learn about digital tools in a supportive environment. Collaborating with private sector companies and NGOs can expand the reach of these programs. For example, the Digital Empowerment Foundation[4] works to bridge the digital divide by providing digital literacy and tools to marginalized communities. By leveraging the enthusiasm and knowledge of younger generations, we can create a supportive environment that enhances the acceptance and use of digital technologies among the older population.

H4: The interaction effect of laptop ownership and digital wallet use positively influences the adoption of digital technology among older individuals.

Table 10.7: H4 Hypothesis Testing Metrics of the Three SEM Models (all gender, male, female)

Hypothesis Testing 4 : Own Laptop (OwnL) ADT → OwnLptp (H4)				
Hypothesis Statement	**Critical Value**	**Model 1 (Overall: All Gender)**	**Model 2 (Only Male)**	**Model 3 (Only Female)**
Standardized Loadings (Std.lv)	>0.4	0.47	0.61	0.39
p-value	< 0.05	0.000	0.001	0.001
Significance	NA	Significant	Highly Significant	Highly Significant
Hypothesis Testing 4 : Digital Wallet (DigWllt) ADT → DigWllt (H4)				
Standardized Loadings (Std.lv)	>0.4	0.47	0.61	0.39
p-value	<0.05	0.000	0.001	0.001
Significance	NA	Significant	Highly Significant	Highly Significant

ADT = adoption of digital technology, NA = not available, SEM = structural equation modeling.

Source: Authors' calculations.

[4] https://www.defindia.org/

For the H4 hypothesis (Table 10.7), we observe that laptop and digital wallet device ownership positively influences the adoption of digital technology across all genders. The standardized loadings indicate significant positive relationships for both laptops and digital wallets, with loadings of 0.61 for males and 0.39 for females. In India, owning a laptop is often associated with educational and professional purposes. It enables tasks such as online learning, work-from-home, and accessing government services. Older males in India may have greater exposure to technology due to historical roles (e.g., working professionals and early technology adopters). At the same time, women's adoption decisions are often influenced by family needs (e.g., caregiving and household management).

The interaction effect of laptop ownership and digital wallet usage positively influences the adoption of digital technology among older individuals. This study implies that to bridge the gender gap in the adoption of digital technology, gender-sensitive digital literacy initiatives need to be initiated. For instance, the Agewell Foundation has been conducting a digital literacy program[5] for older persons since 2016, which includes training on e-wallets like Paytm and the practical use of laptops and smartphones. This program aims to empower older individuals by making them computer literate and helping them adjust to modern life.

Additionally, the Reliance Foundation's Women in the Digital Economy Fund (WiDEF)[6] focuses on closing the gender digital divide by providing up to $10 million to support women's participation in the digital economy. This initiative includes funding projects that enhance digital literacy and financial inclusion for women, including older women.

H5: Education level positively influences the adoption of digital technology among older individuals.

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5 Agewell Digital Literacy Program for Older Persons. agewellfoundation.org

6 Reliance Foundation. https://reliancefoundation.org/women-in-the-digital-economy-fund

Table 10.8: H5 Hypothesis Testing Metrics of the Three SEM Models (all gender, male, female)

Hypothesis Testing 5 : ADT → Edu (H5)				
Hypothesis Statement	**Critical Value**	**Model 1 (Overall: All Gender)**	**Model 2 (Only Male)**	**Model 3 (Only Female)**
Standardized Loadings (Std.lv)	>0.4	−0.03	0.01	−0.005
p-value	<0.05	0.6	0.88	0.32
Significance	NA	Not Significant	Not Significant	Not Significant

ADT = adoption of digital technology, NA = not available, SEM = structural equation modeling.

Source: Authors' calculations.

Table 10.8 illustrates that education level does not significantly influence digital technology adoption, as indicated by the nonsignificant p-values across all models. This may be attributed to most respondents being already well-educated, making education less of a differentiating factor in digital adoption in the study.

It is important to note that this study focuses on urban respondents, and the study of rural respondents is beyond its scope. Therefore, we emphasize the implications of digital literacy initiatives and suggest further research to understand the implications of education on digital technology adoption further. The National Education Policy 2020 (Ministry of Human Resource Development 2020) emphasizes adult education and lifelong learning, aiming to enhance digital literacy among all age groups, including the older population. Programs under this policy can be tailored to address the specific needs of older women, ensuring they have the skills and confidence to use digital technologies.

The Aajibaichi Shala (WEF 2017), or grandmother's school, is another example of an initiative where older women are taught to read, write, and use basic arithmetic5. Such initiatives can be expanded to include digital literacy components, helping older women become more comfortable with technology.

By leveraging these programs and expanding their reach, we can enhance the acceptance and use of digital technologies among the older population.

10.7 Conclusions

This study highlights the significant factors influencing the adoption of digital technology among older urban women in India. The findings indicate that facilitating conditions, effort expectancy, and the interaction of laptop ownership and digital wallet usage play crucial roles in technology adoption. Facilitating conditions positively influence digital technology adoption among older males but have a less significant effect on older females. Effort expectancy is a significant factor in digital technology adoption among the older population, particularly for females. Ownership of laptops and digital wallets positively influences digital technology adoption among older individuals, with a stronger impact on males.

However, performance expectancy and social influence show a negative relationship with adoption, suggesting that increased expectations and social pressures may overwhelm older individuals, leading to lower adoption rates. Education level does not significantly influence digital technology adoption among older individuals in the urban context studied.

There are existing policies and programs to support older individuals in India, focusing on general welfare, legal support, and digital literacy. Various institutions and governments have adopted numerous efforts to bridge the digital divide. The details of these initiatives are presented in Tables A10.1, A10.2, and A10.3 in the Appendix. However, these programs can be improved by using gender-sensitive approaches, comprehensive digital literacy programs for older women, and intergenerational programs; and tackling variability in policy implementation and enforcement and limited healthcare access awareness (details are in Table A10.4 in the Appendix).

Although the Indian government has implemented awareness programs like the National Programme for Healthcare of the Elderly,[7] hotlines such as Elder Line (14567),[8] and medical support through Ayushman Bharat Pradhan Mantri Jan Arogya Yojana,[9] the Longitudinal Ageing Study in India (UNFPA 2023) reveals that only one-quarter of older people seek outpatient care from public health facilities, and nearly two-thirds opt for private healthcare due to perceived quality and accessibility issues. Therefore, there is a need for a nationwide

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7 https://mohfw.gov.in/?q=major-programmes/Non-Communicable-Diseases/Non-Communicable-Diseases-1

8 http://elderline.dosje.gov.in/index.php/about-us/

9 https://nha.gov.in/PM-JAY

awareness campaign to increase awareness among older women about available helplines and healthcare services, ensuring that these resources are effectively utilized and reach those in need.

Furthermore, along with the awareness, there is a need to enhance effort expectancy through intergenerational support, which can provide assistance to improve digital technology adoption rates. Engaging youth and educational institutions in intergenerational programs can help bridge the digital divide for the older population. Some schools in India, such as the Intergenerational Learning Centre)[10] and organizations like Healthy Aging India in Delhi and Uttar Pradesh run intergenerational awareness programs. However, such efforts are mostly local but not operating at the national level. In this regard, a mandatory intergenerational awareness program can be introduced in schools to enhance understanding and reduce the technology use gap across age groups. This program can also be extended to include activities promoting community service projects, mentorship programs, and joint educational activities to reduce the gap, enhance care of the older population and promote their well-being and digital inclusion.

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10 https://healthyagingindia.org/iglc/

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Appendix

Table A10.1: State-wise Key Policies and Programs and Gaps

Year	Policy/Program	Focus Area	Description	State-wise Implications	Gaps/Implications
1999	National Policy on Older Persons	General Welfare	Envisages state support for financial and food security, healthcare, shelter, and protection against exploitation.	Varies by state; some states have a robust implementation, while others lag due to financial constraints.	More gender-sensitive approaches and specific programs for older women are needed.
2007	Maintenance and Welfare of Parents and Senior Citizens Act	Legal Support	Mandates care, maintenance, and well-being of parents by their children; provides for old age homes and medical facilities.	Implementation varies; it is stronger in states like Kerala and Tamil Nadu and weaker in others.	Requires stronger enforcement and awareness campaigns.
2011	National Policy for Senior Citizens	General Welfare	Focuses on financial security, healthcare, and a life of dignity for older citizens.	Effective in states with better healthcare infrastructure like Maharashtra and Karnataka.	Needs updates to address the digital divide and specific needs of older women.
2016	Agewell Foundation Digital Literacy Program	Digital Literacy	Provides training on e-wallets like Paytm and practical use of laptops and smartphones for older individuals.	Active in urban areas; needs expansion to rural regions.	Needs more gender-sensitive training modules.
2020	National Action Plan for the Welfare of Senior Citizens	Holistic Welfare	Addresses financial security, food, healthcare, and dignity for older citizens.	Implementation varies; better in states with strong social welfare systems.	Needs specific initiatives for digital literacy and inclusion of older women.
2020	National Education Policy (NEP) 2020	Education	Emphasizes adult education and lifelong learning, including digital literacy for all age groups.	Effective in states with strong educational institutions like Delhi and West Bengal.	Requires tailored programs for older women to enhance digital skills and confidence.
Ongoing	Pradhan Mantri Gramin Digital Saksharta Abhiyan	Digital Literacy	Aims to bridge the digital divide by providing digital literacy training in rural areas.	Varies by state; more effective in states with strong rural outreach programs.	Needs more focus on older women and culturally sensitive training methods.
Ongoing	Ayushman Bharat Digital Mission	Healthcare Access	Enhances healthcare services through digital platforms like the CoWIN app.	Effective in states with better digital infrastructure like Gujarat and Andhra Pradesh.	Needs targeted awareness campaigns to ensure older women can access and use these services.
Ongoing	Reliance Foundation's Women in the Digital Economy Fund (WiDEF)	Digital Economy	Provides funding to support women's participation in the digital economy, including older women.	Active in states with strong corporate presence like Maharashtra and Karnataka.	Needs broader outreach and integration with government programs for greater impact.

Source: Authors.

Table A10.2: Summary of Key Education and Training Programs for Older Citizens and Women: Digital and Business Skills

Organization/Institution	Program	Description
IIT Bombay	Digital Literacy Workshops	Conducts workshops on digital literacy for older citizens, focusing on basic computer skills, internet use, and online safety.
IIM Bangalore	Women Startup Program	Supports women entrepreneurs by providing essential business knowledge and mentoring.
NIIT Foundation	Digital Literacy for Seniors	Runs digital literacy programs for older people, including training on basic computer skills, internet use, and online safety.
Agewell Foundation	Digital Literacy Program	Provides training on e-wallets like Paytm and practical use of laptops and smartphones for older individuals.
Reliance Foundation	Women in the Digital Economy Fund	Supports projects that enhance digital literacy and financial inclusion for women, including older women.
Aajibaichi Shala	Grandmothers' School	Teaches older women to read, write, and use basic arithmetic, with potential for digital literacy components.
Ministry of Skill Development & Entrepreneurship	Vocational Training Programme for Women	Provides skill training to women, including older women, through National Skill Training Institutes (NSTIs) for women.
SEWA Bharat	Skill Development Program	Enhances the lives of disadvantaged women through various livelihood initiatives, including digital literacy.
UN Women	Second Chance Education and Vocational Learning Programme	Enables women to re-enter formal education, access vocational training, learn entrepreneurial skills, and connect to employment opportunities.

Source: Authors.

Table A10.3: Key Organizations Supporting Older People in India: Focus Areas and Services

Organization	Focus Area	Description
HelpAge India	Healthcare, Livelihood, Advocacy	Provides healthcare services, livelihood programs, and advocates for the rights of older people.
Agewell Foundation	Welfare, Empowerment	Works for the welfare and empowerment of older persons, providing healthcare, food, and social support.
Manavlok	Women's Empowerment, Community Support	Focuses on women's empowerment, community kitchens, and support for older villagers.
Abhoy Mission	Multidimensional Services	Provides services to disadvantaged groups, including destitute older citizens and persons with disabilities.
Silver Talkies	Social Engagement, Digital Literacy	Offers platforms for older individuals to engage with peers and learn about digital tools in a supportive environment.
JOY Community	Social Support, Community Engagement	Provides social support and community engagement opportunities for older people.
Samvedna Senior Care	Healthcare, Social Support	Offers healthcare services and social support to older citizens.
Dada-Dadi	Social Support, Advocacy	Focuses on social support and advocacy for the rights of older individuals.
Shraddhanand Mahilashram	Shelter, Welfare	Provides shelter and welfare services for older women.

Source: Authors.

Table A10.4: Identified Gaps and Implications for Elder Care

Gap	Description	Implications
Gender-Sensitive Approaches	Many policies lack specific provisions for older women.	Gender-sensitive training programs and initiatives are needed.
Digital Literacy	Comprehensive digital literacy programs tailored to older women are lacking.	More targeted and culturally sensitive training methods are required.
Implementation and Enforcement	Variability in the implementation of policies like the Maintenance and Welfare of Parents and Senior Citizens Act.	Stronger enforcement and awareness campaigns are necessary.
Healthcare Access	Programs like the Ayushman Bharat Digital Mission need targeted awareness campaigns.	Ensure older women can access and use digital healthcare services.
Intergenerational Programs	Lack of involvement of youth and educational institutions in intergenerational programs.	Enhance effort expectancy and provide practical support to older women.

Source: Authors.

Table A10.5: Questionnaire for Survey Conducted among Older Urban Individuals

Variable Name	Abbreviation	Questions asked in the Survey
Health Status Simplification	HlthStsSimp	Utilizing health monitoring applications simplifies tracking wellness metrics and can diminish the frequency of doctor visits for emergency prevention.
Cost-Effective Telehealth	CostEffTele	Using digital health monitoring services is more cost-effective than in-person consultations at a doctor's office or hospital.
Reduced Dependency	RedDep	Digital technology has helped me reduce my dependency on others.
Preferred Digital Connection	PrefDigConn	Digital platforms are a preferred choice to stay connected with family and friends.
Ease of Financial Tech	EaseFinTech	Digital technology is easy to use for financial transactions, banking, and payments.
Cost and Effort Burden	CostEffBurd	The cost and effort of using digital technology or services is burdensome.
Learning Difficulty	LearnDiff	It is difficult for me to learn a new digital technology by myself.
Assistance Necessity	AsstNeed	I need others to help me to use digital technologies.
Technology Selection Assistance	TechSelAsst	I need help to choose the appropriate technology that can help me live better.
Health Status Simplification	HlthStsSimp	Utilizing health monitoring applications simplifies tracking wellness metrics and can diminish the frequency of doctor visits for emergency prevention.
Family and Friends Encouragement	FamFrndEnc	My friends and family actively use and encourage me to use digital technology.
Online vs Physical Social Circle	OnlPhySocCirc	My online social circle is bigger than the physical social circle.
Pressure to Learn Technology	PresLearnTech	I am not willing to use digital technologies but I feel pressured by my circle to learn digital technology.

continued on next page

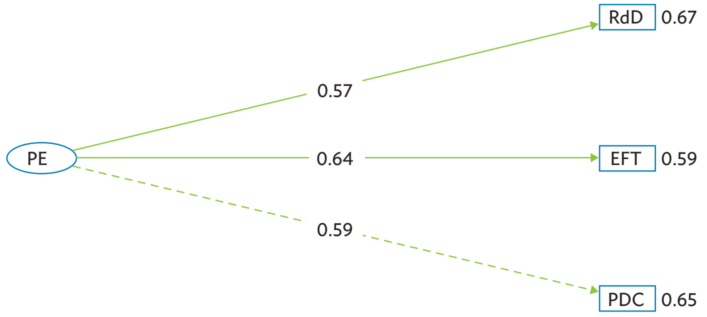
Table A10.5 *continued*

Variable Name	Abbreviation	Questions asked in the Survey
Digital Personal Touch	DigPersTouch	I feel that digital technology cannot help me feel the personal touch of the closed one.
Service Options Variety	SvcOptVar	I have multiple options to choose services provided by service providers for online transactions.
Resource Availability	ResAvail	I have the necessary resources to use digital technology (e.g., mobile, laptop, smart TV, internet access).
Assistance Availability	AsstAvail	I have people at home or a friend circle who can help me use these technologies.
Setup Confidence	SetupConf	I have people at home or friend circle who can help me using these technologies.
Tech Variety Familiarity	TechVarFam	I am familiar with using a variety of digital technology.
Feature Exploration	FeatExplor	I often explore new features and functionalities of digital technology.
Communication Tech Use	CommTechUse	I know how to use digital technology for communication and connecting with new people.
Well-being Tech Use	WellbTechUse	I am using digital technology for my well-being.
Eating Tech Use	EatTechUse	I am using digital technology for shopping and eating.
Medicine Tech Use	MedTechUse	I am using digital technology for medicines.
Future Use Intention	FutUseInt	I intend to continue using digital technology in the future.
Diverse Tech Usage	DivTechUse	I do not like using digital technology.
Tech Disinclination:	TechDisincl	I do not like using digital technology.
Privacy and Safety Concerns	PrivSafeCon	Data privacy, safety, and reliability of test results is a concern when using online digital apps or services.
Digital Over Physical Preference	DigOverPhysPref	I prefer using digital technology than face-to-face contact.

Note: The survey questions are thematic and intended only for reference. To maintain the appropriateness of the research study, specific names of companies and detailed examples are not included.

Source: Authors.

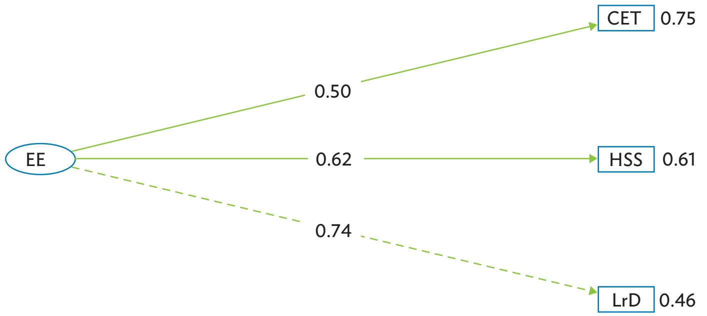
Figure A10.1: SEM Path Diagram of the Construct Performance Expectancy (PE)



SEM = structural equation modeling.

Source: Authors' calculations.

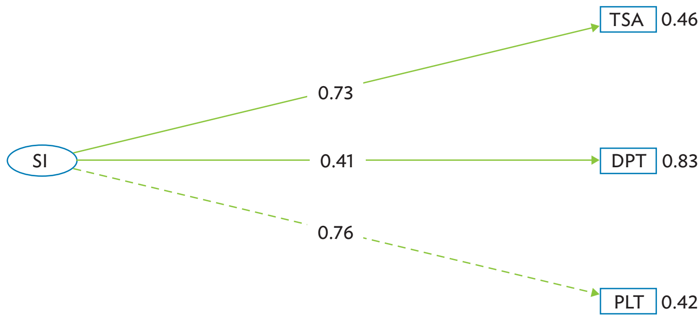
Figure A10.2: SEM Path Diagram of the Construct Effort Expectancy (EE)



SEM = structural equation modeling.

Source: Authors' calculations.

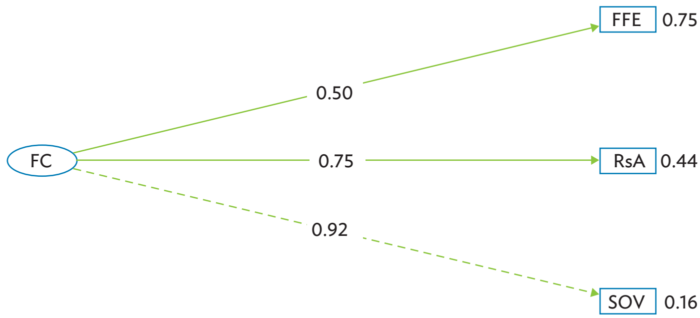
Figure A10.3: SEM Path Diagram of the Construct Social Influence (SI)



SEM = structural equation modeling.

Source: Authors' calculations.

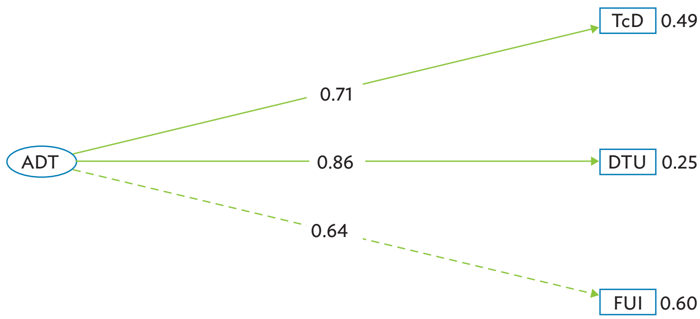
Figure A10.4: SEM Path Diagram of the Construct Facilitating Conditions (FC)



SEM = structural equation modeling.

Source: Authors' calculations.

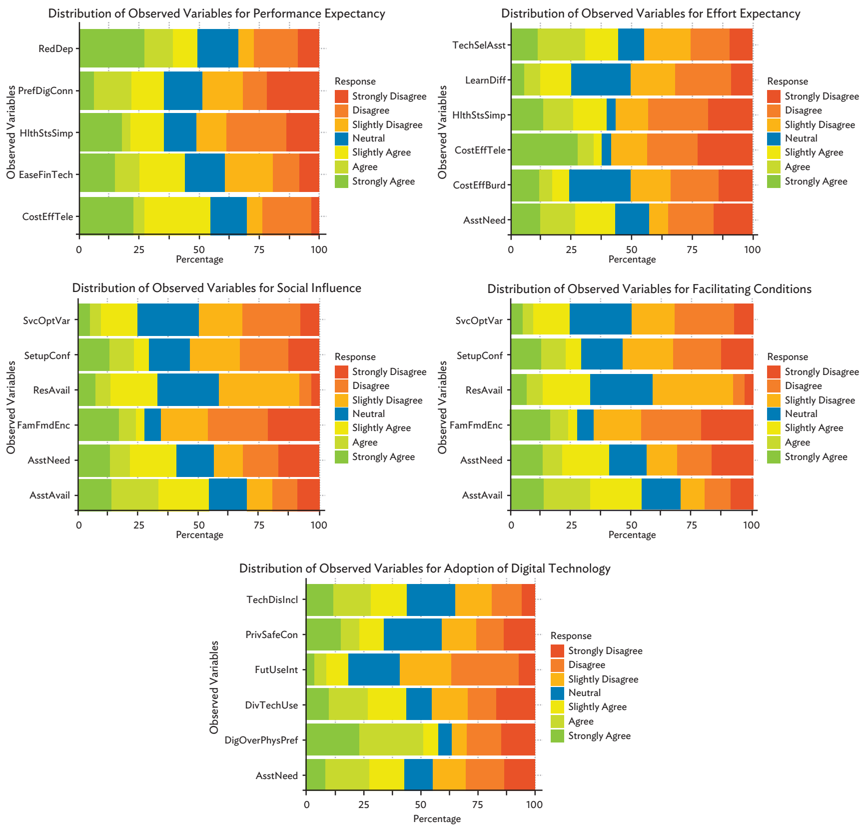
Figure A10.5: SEM Path Diagram of the Construct Adoption of Digital Technology (ADT)



SEM = structural equation modeling.

Source: Authors' calculations.

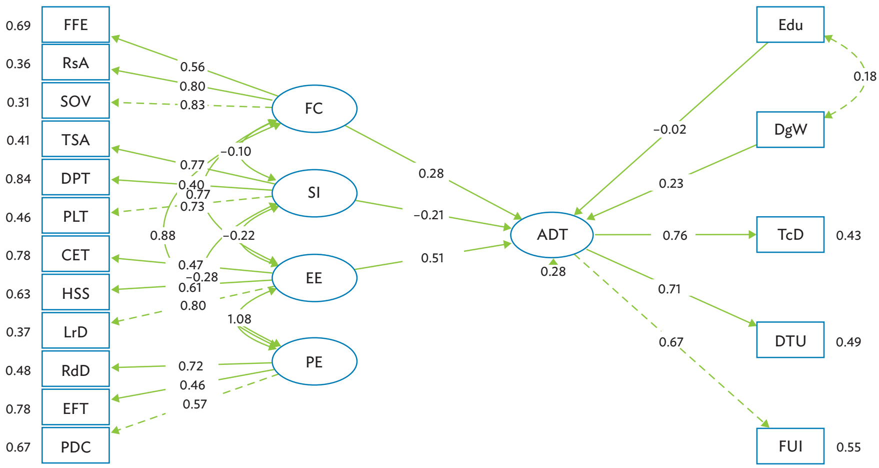
Figure A10.6: Distribution of Observed Variables for Constructs PE, EE, FC, SI, and ADT



ADT = adoption of digital technology, EE = effort expectancy, FC = facilitating decisions, PE = performance expectancy, SI = social influence.

Source: Authors' calculations.

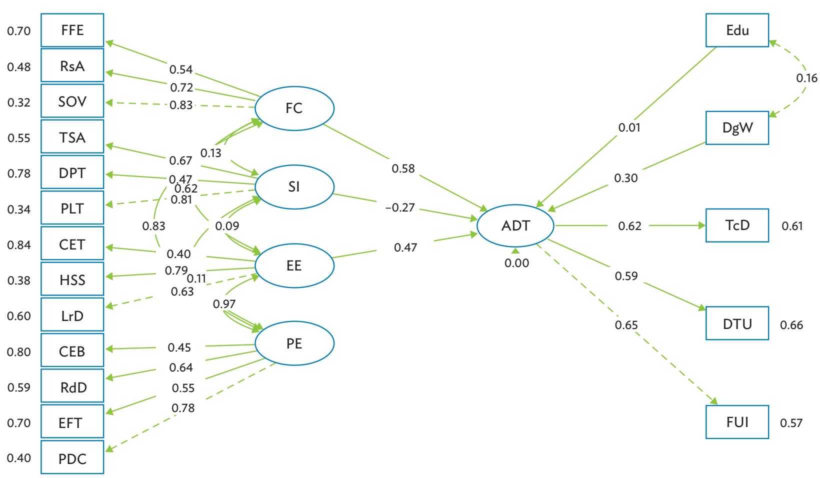
Figure A10.7: SEM Path Diagram of Model 1 – All Genders



SEM = structural equation modeling.

Source: Authors' calculations.

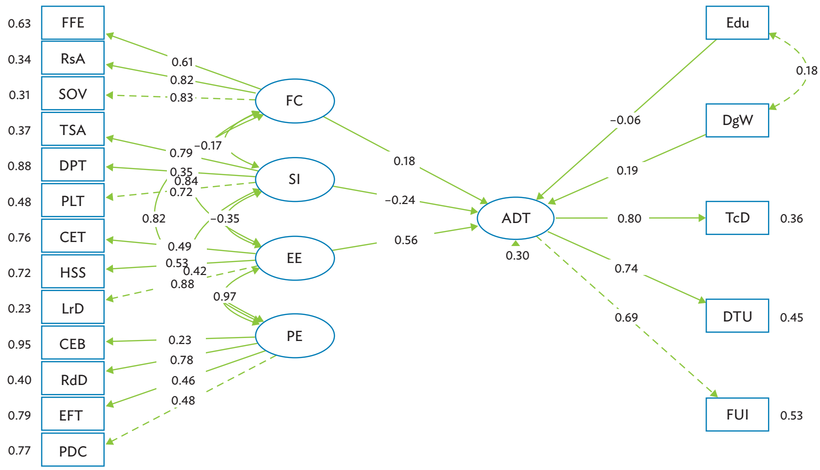
Figure A10.8: SEM Path Diagram of Model 2 – All Male



SEM = structural equation modeling.

Source: Authors' calculations.

Figure A10.9: SEM Path Diagram of Model 3 – All Female



SEM = structural equation modeling.

Source: Authors' calculations.

Conclusion

11

The Future of Digital Healthcare: Policy Options

Subhasis Bera, Dil B Rahut, Shu Tian, Yixin Yao, and Donghyun Park

11.1 Introduction

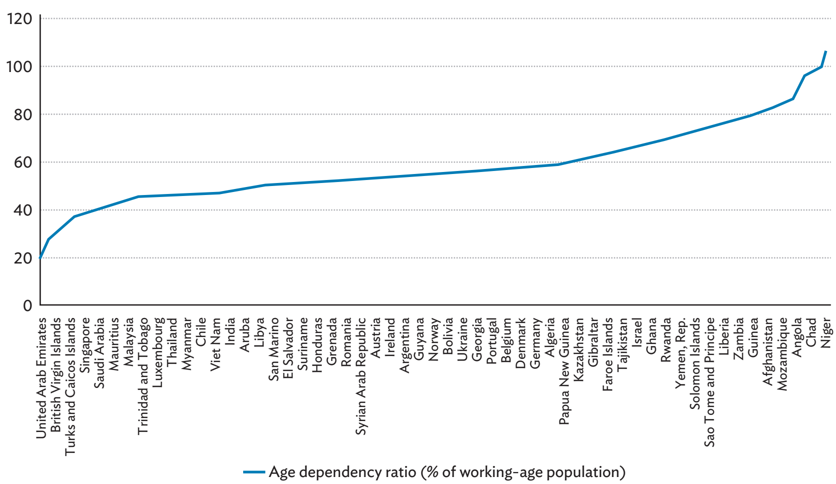
Increasing use of technology solutions brings new challenges while solving existing ones. While improved healthcare facilities lead to a decline in child mortality, they are often followed by a rise in the proportion of aging populations. Advancements in artificial intelligence (AI), robotics, and remote sensing promise to resolve various challenges faced by the older population, but a fall in cognitive flexibility due to aging poses a challenge to adopting those technologies. Subsequently, societal change leading towards a smaller family structure alters the family composition and results in a shortage of people to take care of older family members. Moreover, national and international migration due to the change in the global work environment alters the composition of human resources at home to care for older members. As a result, older individuals are at risk of social isolation, which can negatively impact their mental and physical health (Butler 2022). Furthermore, older individuals often have complex health needs that require specialized care and resources. However, institutional care costs are high, and many families are not financially prepared to handle these expenses (Butler 2024). These changes confront the traditional healthcare system, and policy formulation needs to incorporate the new challenges

The healthcare sector is experiencing a fundamental transformation driven by digital technologies, including AI, telemedicine, wearable devices, and electronic health records. This digital revolution promises improved patient outcomes, reduced costs, and enhanced healthcare accessibility. However, it also presents significant policy challenges that require careful consideration and innovative solutions. Therefore, it is crucial to understand the conundrum of digital healthcare for the older population. This chapter aims to find a pathway to digitalization for the care of older people.

11.2 Age Dependency Ratio and Healthcare Status

The increasing older population alters the human resource composition of an economy. As the proportion of older individuals rises relative to the working-age population, which is called the age dependency ratio, pressure on public finances to support pensions, healthcare, and social services increases. Figure 11.1 shows that many developed and developing economies have high age dependency ratios, so there is pressure on the economy. Due to these demographic shifts, the need for long-term care services intensifies, straining existing healthcare infrastructure.

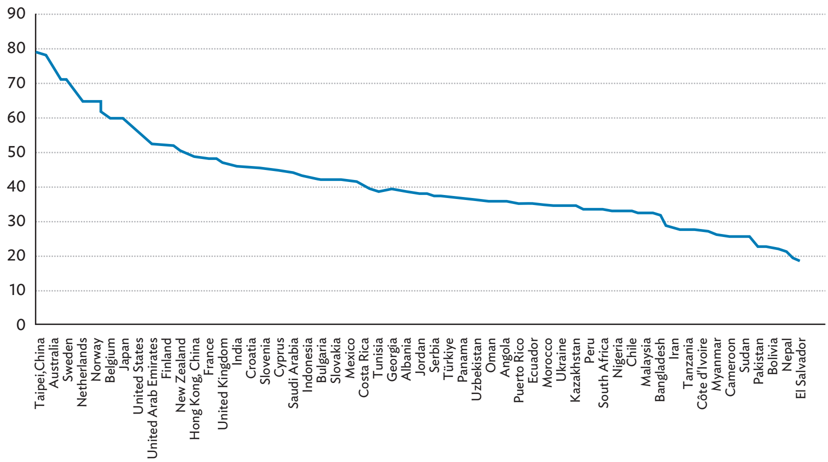
Figure 11.1: Global Age Dependency Ratios, 2023



Source: Authors' calculation from World Bank data (accessed 19 December 2024).

Increasing age dependency increases the demand for healthcare for the older population as well. Although there is a trend in institutionalizing elder care and providing professional services, statistics on the status of elder care are difficult to collect. However, the status of the healthcare of an economy can provide an idea of whether the economy is capable of meeting the demand for elder care. A report by CEOWorld (2024) lists the top economies with the highest healthcare facilities. Data collected for 110 economies show that many economies still need to enhance their healthcare systems to provide quality healthcare for all citizens. Therefore, providing access to health care is the most crucial aspect to consider. Scientists and researchers argue that digitalization can help mitigate this problem.

Figure 11.2: Healthcare Index of Top 110 Economies



Source: Authors' creation from CEOWorld Data.

11.3 Current State of Digital Healthcare

The current state of healthcare is increasingly dependent on digital technologies. The incorporation of telemedicine, AI-powered diagnostic tools, the internet of medical things (IoMT), mobile health applications, cloud-based health information systems, and blockchain for health data management in the healthcare system, on the one hand, provides more efficient, organized, enhanced healthcare facilities for a larger population, while on the other stimulates inequality of access due to lack of infrastructure, skills and training. Each of these technologies posits unique challenges depending on the economy's structure.

Telemedicine: Telemedicine has revolutionized healthcare delivery by incorporating a wide range of practices and technologies (Haleem et al. 2021), including virtual consultations, remote patient monitoring, and mobile health applications. The People's Republic of China (PRC), India, Singapore, and other economies worldwide have adopted telemedicine to provide healthcare services to remote areas, especially after the coronavirus disease (COVID-19) pandemic. Subsequently, telemedicine also reduces the chances of infection spread and the time required to receive consultations.

AI-powered Diagnostic Tools: AI-powered diagnostic tools use machine learning algorithms, natural language processing, and computer vision to analyze medical data, including patient records, medical imaging, and clinical notes, to enhance the accuracy and efficiency of medical diagnostics (Dorocka 2024). AI-powered diagnostic tools have the potential to revolutionize healthcare by providing faster, more accurate diagnoses and personalized treatment plans. However, most AI algorithms are designed to be assistive technologies—augmenting, not replacing, clinicians' decision making. The AI diagnostic tools are still imperfect and suffer from automation bias. Therefore, there is a need for a cautious approach to adopting AI-powered diagnostic tools. Although the current AI landscape in the diagnostic process is limited, a few economies, including the PRC, India, Japan, the Republic of Korea, Singapore and Viet Nam, have adopted AI-powered diagnostic tools. Among these economies, India, the PRC, Singapore, and Viet Nam have national AI policies that provide guidelines and monitor AI-powered diagnostic tools in healthcare.

Effective use of AI requires it to complement human expertise and be trained on diverse data to mitigate these risks.

Internet of Medical Things: For effective healthcare, there is a need for technology that enables real-time monitoring, remote patient management, and personalized treatments. The IoMT interconnects medical devices, sensors, and applications that collect, transmit, and analyze health data to improve patient care and healthcare outcomes (Mahfuz 2020). The IoMT promises to enhance the decision-making capabilities through comprehensive data analysis. The IoMT also promises to provide customized personal care crucial for older members at home. Considering the potential of the IoMT, the United States, the PRC, India, Singapore, and a few other economies have implemented it to enhance care of older adults and healthcare to address various healthcare challenges, including remote diagnostics and patient monitoring.

However, adopting the IoMT is not free from challenges. The IoMT requires seamless communication and data exchange between diverse medical devices and systems from different manufacturers.

Therefore, communication among the stakeholders is crucial as, other than technical aspects, they need to protect sensitive patient data from cyber threats and unauthorized access to information. Moreover, Asian economies lack adequate infrastructure as interconnectedness requires reliable and secure network connectivity, which Asian economies lack, especially in rural and remote areas. In this regard, the market mechanism fails to provide services in sparely populated areas due to smaller returns on investment.

Furthermore, the IoMT connects multiple devices and requires the accuracy and reliability of medical devices and sensors to provide efficient services. Therefore, the government needs to formulate policies to ensure the accuracy and reliability of the devices used in healthcare. The challenges in formulating policy are multidimensional. The government is required to develop and enforce stringent data privacy regulations to protect patient information, establish clear standards and certification processes for the IoMT devices, and address ethical concerns related to data usage, informed consent, and algorithmic bias.

There are challenges in adopting the IoMT from the users' perspective as well. There is a need for adequate digital literacy to effectively use the IoMT devices and systems, while a significant proportion of the older population finds it as difficult to adopt digital technologies. Cost and accessibility are other issues, as these advanced technologies are not affordable to low-income-group people. Subsequently, cultural and linguistic differences in design create a barrier to adopting the IoMT.

This multidimensional aspect implies that adopting digital technologies for healthcare as well as elder care, is complex and requires systematic analysis before adopting it.

Mobile Health Applications

The problems of the size and movability of AI-powered diagnostic tools and the IoMT can be solved using mobile health applications. Mobile health (mHealth) applications have the potential to revolutionize healthcare delivery by leveraging the power of smartphones and mobile networks. These applications offer a wide range of services, including remote monitoring, telemedicine consultations, health education, and disease management. Therefore, mobile health applications can reach a wider population with real-time monitoring, personalized health plans, and reminders to increase patient engagement and adherence to treatment plans. Mobile health applications can potentially challenge the traditional method of elder care. The PRC has invested heavily in digital health, and mHealth apps are widely used for telemedicine, health monitoring, and disease prevention. The Republic of Korea has a well-developed healthcare system, and mHealth apps are being used to improve patient outcomes and reduce healthcare costs. A large population, especially in rural India, has driven the adoption of mHealth apps. Despite the benefits, many Asian economies have yet to adopt mobile health applications and formulate policies to regulate their use to reduce the associated risks.

Cloud-based Health Information System

The digitalization of healthcare technologies mainly relies on data and information systems. Healthcare information systems are mostly cloud-based. Cloud-based health information systems (HIEs) are transformative technology, revolutionizing healthcare delivery by enabling secure and efficient sharing of patient data across diverse settings. By leveraging cloud computing, HIEs provide numerous benefits, including improved patient care, enhanced interoperability, and reduced administrative burdens. Economies like the United States, the United Kingdom, and Australia have made significant strides in adopting cloud-based HIEs. However, the implementation of such systems is not without challenges. Key policy challenges include high cost, ensuring data privacy and security, developing robust interoperability standards, and addressing potential technological access disparities. Moreover, healthcare providers and patients may face concerns related to data breaches, system reliability, and the potential for unintended consequences of widespread data sharing.

11.4 Sustainability of Elder Care and the Role of Digitalization

A rapid change in social structure and technological innovation makes it more challenging for the care of older adults. Therefore, there is a need to develop a system or framework for long-term care for the aging population without compromising the capacity of future generations to meet their own needs. This long-term care is known as sustainable care. As the global population ages, ensuring the sustainability of care of the older population becomes increasingly critical.

The challenges of providing sustainable care with an aging population and a shrinking workforce cannot be addressed within the boundaries of a single organization due to its multi-level, multi-actor and multi-sectoral challenges (Bianchi 2015). These dynamic complexities stem from diverging stakeholder views, uncertain future developments, and systemic complexity arising from the delays in the feedback mechanisms within the system (Auping, Pruyt, and Kwakke 2015). The aging of the population and its consequences for care services cannot be solved within a single policy sector (Auping, Pruyt, and Kwakke 2015). This study considers sustainable elder care from the perspective of implementation of digital technologies.

Complexities of elder care and the role of technology in mitigating the challenges, this book focuses on the sociotechnical transitions. The sociotechnical transition highlights the connectedness of technological, social, cultural, and political dimensions and their respective mutual adjustment (Smith, Voss and Grin 2010; Bugge et al. 2017). Adopting new technologies into society and fostering technological innovations require a transition that entails the simultaneous development (co-evolution) of technologies, service operations and existing practices and mindsets of the people (e.g., Geels 2002, 2005; Truffer and Coenen 2012). Therefore, it is crucial to enhance the awareness among the people. Since digital technologies improve connectivity and provide mobile and easy access, they have the potential to mitigate multisector and multi-actor challenges.

Despite its potential, this transition faces significant challenges. Technological adoption among the older population can be hindered by digital literacy gaps, resistance to change, and accessibility barriers. Social systems, such as family and community networks, often struggle to adapt to new care models due to resource constraints or lack of coordination.

11.5 Proposed Policy Formulation

The rapid advancement of digital technologies exhibits considerable potential for enhancing care of the older population. Japan, the Republic of Korea, Singapore, and Thailand have already made significant progress in employing digitalization to enhance the care of older people through well-designed national ICT and health promotion policies. India and the PRC also have made pathways to use digital technologies for elder care. However, unequal access and lack of digital literacy are grappling in many Asian economies, hindering the enhancement process of care of older people. Considering the present status of digitalization and healthcare of older people, we propose the following strategies.

Infrastructure and Accessibility

A precondition for the enhancement of elder care in Asia through digitalization is infrastructure accessibility (Mubarak and Suomi 2022; Schröder et al. 2023). Asian economies grapple with reaching the last mile and older individuals due to the paucity of infrastructure caused by market failure. This market failure is caused by the absence of senior-friendly devices with a simplified interface, lack of digital literacy, high cost of data and demand-supply gap. The government requires a private–public partnership to provide a digital platform through infrastructure development and an incentive to design devices with a simplified interface and digital literacy program to address these challenges. Furthermore, for servitization, the advancement of digital technologies requires a high-speed internet connection. Therefore, initiatives need to invest in high-speed internet connectivity in rural and urban areas to ensure widespread access.

Telehealth and Remote Monitoring

Many Asian economies endure a shortage of healthcare centers and personnel due to high population pressure (WHO 2020), which results in a problem with timely consultation and real-time monitoring. Therefore, there is a need for a user-friendly telemedicine consultation system. After introducing the telemedicine consultation system, in the second stage, there is a need for integrated health platforms with multilingual support. These integrated health platforms can help monitor older patients in real-time. Initiatives to develop wearable technologies can further enhance the quality of services. In this regard, voice-enabled technologies can also solve the problem of digital literacy by integrating the healthcare system. Therefore, the government requires investment in research and development of digital healthcare technologies that support multilingual users. Integrated systems can also provide a large amount of data for health predictive analysis using AI. Therefore, the government is required to prioritize the building of an integrated healthcare system.

Data Privacy and Cybersecurity

The integration of healthcare systems through digitalization enables the sharing of a large volume of personal and medical information across stakeholders. Therefore, there is a need for comprehensive data protection regulations specific to digital services for older people and robust cybersecurity frameworks protecting the older individual's personal and medical information. Furthermore, there is a need for national ethics guidelines for technologies for elder and user-consent mechanisms with clear and simplified language as it may differ from other uses. In this regard, Li, Rho, and Kobsa (2020) pointed out the cultural differences across economies and focused on the tailored privacy protocols for vulnerable populations.

Social Connectivity and Mental Well-Being

Changing family structure and physical burdens limit the social connectivity of the older population, resulting in declining mental well-being. Considering the challenges that the older population faces, there is a need to create virtual interaction spaces for older individuals. However, platforms and devices need to be age-friendly so that people can access and participate in social interaction. Therefore, economies need to create and improve digital mental health support systems.

Financial Technology and Support

The older population depends mainly on their savings or pensions. As per the report (ITU 2022), older people are often targets for financial scams, and their limited understanding of digital security measures increases their vulnerability. Improvement of security measures requires complex password requirements, and the need for biometric verification can frustrate older users, leading to blocked access and increased anxiety about managing their finances online. Moreover, the intricacy of modern financial products can overwhelm older adults, who may find it difficult to understand investment options or the functionalities of banking apps. Therefore, Asian economies need to develop an age-friendly digital financial system similar to SilverBills, an online bill management platform that ensures timely payment and helps detect errors, fraud, and unjustified billing. Its varied customer base primarily consists of older adults or their caregivers.

Robotics and AI for Elder Care

Although robotics and AI show the potential to enhance elder care, there is a need for improvement of the required infrastructure to integrate with the existing healthcare system. Given the context and prevailing attitudes and preconditions about robotics, introducing robotics and AI in elder care needs policies for ethical considerations and the consent process to enhance data security to make it an integral part of daily care and assist older people and caregivers.

Table 11.1 lists proposed policies to ensure the care of older adults through digitalization.

Table 11.1: Proposed Policies for Elder Care Through Digitalization

Priority	Area of Policy	Description
High	Infrastructure and Accessibility	Infrastructure development for digital networks, high cost of digital access, user-friendly devices and digital literacy training.
High	Telehealth and Remote Monitoring	Prioritizing the building of an integrated healthcare system.
High	Data Privacy and Cybersecurity	Formulate protection regulations specific to digital services for older people and robust cybersecurity frameworks.
High	Financial Technology and Support	Develop a senior-friendly digital financial system or digital bill management system.
Medium High	Social Connectivity and Mental Well-Being	Create and improve digital mental health support systems.
Medium High	Robotics and Artificial Intelligence for Elder Care	Incorporate ethical considerations and the consent process.

Source: Authors.

11.6 Conclusion

As life expectancy increases, the demand for healthcare, social services, and financial security for older adults also grows exponentially. This burdens the economy, especially in developing economies, where the proportion of the aging population is increasing rapidly, posing significant challenges to care systems for older adults. The shift from traditional extended family structures to nuclear families due to urbanization has implications for elder care. Family-based care, the primary support system in many developing regions, is declining as younger generations migrate to cities for economic opportunities (Aboderin and Beard 2015).

While inadequate infrastructure and resources to support elder care is a primary problem in developing economies, there is a lack of specialized geriatric care facilities, skilled and trained healthcare professionals, and adequate social security issues. These challenges result in a heavy burden on society as well as on the economy.

Moreover, the increasing prevalence of age-related chronic diseases such as diabetes, heart disease, and dementia brings another set of challenges as developing economies lack capacities to provide adequate treatments. Furthermore, the economic implications of an aging population are substantial. As the proportion of older individuals increases, the workforce shrinks, potentially affecting economic growth.

Subsequently, the rising costs of healthcare and social services for the older population also strain government budgets.

Elder care also requires focusing on the financial aspects of the older population. Although digitalization helps them to manage their saving and finances without traveling to nearby outlets or banks, adopting new technology is challenging for the older population. Therefore, developing economies need to implement comprehensive strategies to strengthen the healthcare system by providing adequate pensions and social benefits to support the care of older people. Investment in geriatric care, training healthcare professionals, and improving access to affordable digital healthcare can foster the implementation of digitalization to enhance elder care.

One of the major challenges of providing digital healthcare to citizens is the high cost of the devices. Therefore, the benefits of these technologies can be achieved through healthcare service providers. Moreover, to increase awareness and enhance the ability to use technology, there is a need for digital community involvement and support for older adults, including home-based care and volunteer services.

The future of elder care in developing economies requires addressing several intersecting challenges. The complexity of care is entangled with demographic changes, healthcare infrastructure deficits, insufficient social protection systems, evolving family dynamics, and the urban–rural divide. Addressing these challenges will necessitate policy innovation, investment in healthcare and social protection, and an emphasis on community-based and family-oriented care models. Through such concerted efforts, developing economies can meet the growing demand for elder care and improve the quality of life for their aging populations.

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Digitalization for Improving Elder Care

As economies face the growing challenge of supporting aging populations, traditional care systems often struggle due to gaps in infrastructure, trained personnel, and accessible healthcare. In this context, digital technologies are increasingly recognized as transformative tools for elder care. This book examines how digital solutions such as robotics and telemedicine can help address the needs of aging populations, enhance care quality, and support inclusive development.

The discussions explore both the opportunities and challenges of the digital transformation in terms of social inclusion for elder care. Through diverse case studies, the book highlights the importance of involving older people as active participants in the digital economy rather than passive recipients—an essential step in bridging the digital divide. With practical recommendations for policymakers and practitioners, it is a vital resource for advancing efficient, dignified, and high-quality elder care in the digital age.

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