University of Southern Queensland

EXPLORING THE NEED FOR ASSISTIVE TECHNOLOGIES THROUGH ANALYSES OF A LONGITUDINAL DATABASE OF OLDER PEOPLE IN CHINA

A Thesis submitted by

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ABSTRACT

This research matched older people's needs to 25 types of assistive technologies by analysing the newest wave of the longitudinal CHARLS Database, which included 10,818 older people participants. Informed by the Sociotechnical Theory, the research identified the unmet needs and urgent unmet needs for 8 assistive technologies that have users' statistics in the CHARLS Database, along with the total needs and urgent total needs for 17 assistive technologies that do not have users' statistics in the CHARLS Database, as well as the gender and age group differentiation with respect to users and users' needs (both unmet needs and total needs) by investigating older people's general health, disease and illness, functional limitation, assistive technology use, and personal and social activities. This research found that hearing aids have the highest level of unmet needs and urgent unmet needs. Catheters and urine collecting bags, electric wheelchairs, and travel devices have relatively high unmet needs but low urgent unmet needs. Walking sticks, corrective lenses and glasses, toilet series, and manual wheelchairs have relatively low unmet needs and urgent unmet needs. The highest total needs were found in alarm signallers with light/sound/vibration. Relatively high total needs have been found in grasping tools or reach extenders, personal emergency response systems, handrails and grab bars, watches (talking/touching), electrotherapy devices for pain, time management products and smart/white canes. Moderate levels of total needs were found for shower chairs, smart pillbox/pill organisers, pressure relief mattresses, therapeutic footwear, glucometers, talking blood pressure monitors, braille writing equipment/braillers and portable ramps. Overall, women generally have higher needs for assistive technology than man; Needs for most of the assistive technologies increased in higher age groups.

CERTIFICATION OF THESIS

I, Lei Yu, declare that the PhD Thesis entitled "Exploring the Need for Assistive Technologies Through Analyses of a Longitudinal Database of Older People in China" is not more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references, and footnotes. The thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AAATE - Association for the Advancement of Assistive Technology in Europe

ADL - Activities of Daily Living

AT – Assistive Technology

CAT - Comprehensive Assistive Technology

CCPIT - China Council for the Promotion of International Trade

CDC - United States Centres for Disease Control and Prevention

CHARLS - The China Health and Retirement Longitudinal Study

CNY - Chinese Yuan (Renminbi)

ELSA - English Longitudinal Survey of Aging

GPS - The Global Positioning System

HAAT - Human Activity Assistive Technology

HREC - Human Research Ethics Committee

HRS - United States Health and Retirement Study

ICF - International Classification of Functioning, Disability and Health

IFLS - The Indonesia Family Life Survey

IRB - Institutional Review Board

ISTIC - Institute of Scientific and Technical Information of China

JSTAR - Japanese Study of Aging and Retirement

KLoSA - Korean Longitudinal Survey of Aging

LASI - The Longitudinal Aging Survey of India

MPT - Matching Person and Technology

PDA - Personal Digital Assistant

PhD - Doctor of Philosophy

PRISMA - The Preferred Reporting Items for Systematic Reviews and Meta-Analyses

QoL - Quality of Life

SHARE - The Survey of Health, Aging and Retirement in Europe

TGs - Triglycerides

UNs - User Needs

USA - The United States of America

USD - The United States dollar

WHO - The World Health Organization

CHAPTER 1 : BACKGROUND, INTRODUCTION AND SCOPE OF THE RESEARCH

Opportunities for aged care products and assistive technologies have a strong connection with the growing number of older people, the awareness of disease, illness and functional limitations, the awareness of what assistive technologies are available and benefits for older people, their carers and their communities, as well as addressing the fiscal constraints of the healthcare system. The following sections discuss the growing number of older people and the low provision but growing interest in assistive technologies. Furthermore, this section illustrates health issues and functional limitations that are problematic to older people and assistive technologies that help address these challenges. Based on this background information, the remaining part of the chapter explains the purpose and the significance of this research.

1.1 BACKGROUND TO THE PROBLEM

Global life expectancy rose from 64.2 years in 1990 to 72.6 years in 2019 (United Nations 2019). By 2050, the global population of older persons is projected to more than double its 2015 size, reaching nearly 2.1 billion (United Nations 2017).

The growing number of older people can be explained by the demographic transition theory (Mirkin & Weinberger 2000). The demographic transition is the change in the human condition from high mortality and high fertility to low mortality and low fertility. Most people are experiencing greater longevity. The total fertility rate is reducing and is less than two births in most economically advanced countries, which is insufficient to replenish national populations (Caldwell 2006). This demographic transition process happened rapidly in China: China’s fertility rate decreased sharply

from 6.385 in 1965 to 1.690 in 2018 (The World Bank 2019b). While the life expectancy of Chinese people soared from 49.549 in 1965 to 76.704 in 2018 (The World Bank 2019a). As a result, in 2020, 18.7% of the Chinese population were aged 60 years and over, and 13.5% of the Chinese population were aged 65 years and over (State Council of the People's Republic of China 2021). From 2010 to 2040, it is predicted that the proportion of people aged 60 years plus in China will more than double - increasing from 12.4% (168 million) to 28% (402 million).

China's population has been ageing more rapidly than other countries. People aged 65 years and over in China were predicted to grow from 7% to 14 % in a period of 26 years, compared to Australia which took 73 years, and the USA which took 69 years to achieve this growth (Thomas et al. 2020). This increased ageing of the Chinese population presents a number of challenges and opportunities influencing health and business strategies, workforce planning, and health and disability support planning, at both the government and individual enterprise levels (Chand & Tung 2014).

Growing numbers of older people indicated opportunities for assistive technologies - by the end of 2018, nearly 200 million of the Chinese population needed assistive technology (Li, Wu & Liu 2019). Those who need assistive technologies are not only older people but also people with disabilities. There were 85.02 million people living with disability in China. Among them, there were 12.63 million people with a vision disability, 20.54 million people with a hearing disability, 1.3 million people with a speaking disability, 24.72 million people with a physical disability, 5.68 million people with an intellectual disability, 6.29 million people with mental disability and 13.86 million people with multi types of disabilities (China Disabled Persons' Federation 2012). They were the people who may be the most in need of assistive technologies.

Throughout the world, many people who need assistive technology do not have access to it: 200 million people with low vision did not have access to assistive products for low vision. 466 million people globally experienced hearing loss but the hearing aid production merely met less than 10% of the global need (World Health Organazation 2021b). There are significant workforce shortages associated with assistive technology. Over 75% of low-income countries had no prosthetic and orthotics training programmes. Sadly, countries with the highest prevalence of disability-related health conditions tend to be those with the lowest supply of health workers skilled in the provision of assistive technology - as low as two professionals per 10,000 citizens (Smith et al. 2018). In many countries, the access to assistive technology in the public sector was weak or did not exist at all. Even in high-income countries, assistive products were often rationed or not included in health and welfare schemes, leading to high out-of-pocket payments by users and their families (World Health Organazation 2021b).

The need for assistive technologies is high, but the supply is low, especially in developing and less developed countries - this mismatch presents a challenge to improving access, and is the result of many factors, such as a widespread lack of awareness among potential beneficiaries and their caregivers, among health-care providers and trained personnel (Tangcharoensathien et al. 2018).

While some older people in China enjoyed the convenience of "smart home" and assistive technologies, most have not yet had the opportunity to consider adopting these. China is a typical example of many countries, in that the assistive products market and related industries are relatively new and awaiting further development, which could not only serve to meet the local demand at an affordable cost but also provide opportunities for job creation

through enhancing local technical capability and innovation (MacLachlan et al. 2018). There is growing interest in assistive technologies. For example, more than 36,000 people and 295 companies attended the annual Jiangsu International Senior Care Services Expo and Forum in 2018 in Nanjing, Jiangsu Province, China (See Picture 1). The Expo and Forum were organized by Jiangsu International Expo & Exhibition Co. Ltd. and Jiangsu Intelligent Assistant Equipment Research Association for the Elderly, sponsored by the China Council for the Promotion of International Trade, Jiangsu Sub-council and the Department of Civil Affairs of Jiangsu Province (The Committee of Jiangsu International Senior Care Services Expo and Forum 2019). Technologies focusing on modification of the home environment to support independence in everyday activities are of the utmost importance (Löfqvist et al. 2016). People regard technology features such as ease of use, security, safety, reliability and ease of use as important characteristics (Mattie et al. 2016). There is still a need for greater awareness of what smart home and assistive technologies are available.

Picture 1 - Stalls Fully Engaged in 2018 Jiangsu International Senior Care Services Expo

Source of the picture: (Jiangsu CCPIT International Conference & Exhibition Co. Ltd 2018)

Older people in China are placing increasing demands on healthcare products and services (Zhang, Li & Wu 2020). Common needs include professional assistance, high-quality health and medical consultation, property management, as well as entertainment and study (Mu, 2000). Regulations related to healthcare provisions need to be better enacted (Fu & Han, 2015). In some rural areas in China, older people depend on themselves for aged care more than depending on their children and relatives (Chen & Fang, 2014), which puts further stress on the need for assistive technologies. China's aged care network has still not taken full advantage of advanced information technologies and other improvements related to aged care products and service sharing (Gu, Wu & Cao, 2017).

Compared to China, Australia has advanced healthcare and illness treatment technologies as well as high-quality medical research outcomes and highly qualified medical professionals (Australian Government Department of Health 2019). The healthcare sector in Australia uses creative solutions for complex problems and uses professional remote telecommunications. Examples of innovative technologies include the handheld ultrasound scanner made by Signostics, which actively recognizes the 3D contours of the bladder and provides real-time ultrasound imaging of the kidneys, pelvic floor, prostate and gallbladder, with built-in Wi-Fi and Bluetooth which works with Android Operating System (Signostics Ltd, 2016). Within the aged-care service field, Australia does well in professional nursing (Masters 2018), end-of-life caring and aged care community service provision (Thomas, Lobo & Detering 2017). Another example is Tunstall Healthcare, which is a provider of connected care and connected health solutions and services (Tunstall Healthcare 2021c). The following paragraphs discuss the "Vibby fall detector", and the "Emfit epileptic seizure alarm" as examples.

"Vibby fall detector" is an intelligent fall pendant that is a small, lightweight device which can automatically detect if the wearer has fallen and raised an alarm call for help. Within the Tunstall monitoring system, the fall pendant also provides the wearer with an option of manually calling for help from anywhere in their home 24 hours a day (Tunstall Healthcare 2021a). The "Vibby fall detector" is a wearable fall detection device, used by individuals to support independent living. It detects hard falls and raises an automatic alert and allows users to manually call for help (Tunstall Healthcare 2018b). The "Vibby fall detector" is shown in Picture 2.

Picture 2 - The “Vibby fall detector”

Source of the picture: (Tunstall Australasia Pty Ltd 2018b)

The “Emfit epileptic seizure alarm” is an epilepsy sensor which monitors the user's vital signs including heart rate and breathing patterns to detect a range of epileptic seizures. The sensor reduces the need for carers to make physical checks, promoting independence and dignity (Tunstall Healthcare 2021b). The “Emfit epileptic seizure alarm” monitors people with epilepsy while they sleep. The sensor technology detects all a person’s movement in bed and can differentiate normal movements from epileptic seizures. It consists of a sensor, a control unit and a radio transmitter. The bed sensor is thin and contains no embedded wires or switches.

An alarm can be raised through a local audible alarm if there is a carer nearby (Tunstall Healthcare 2018a). The “Emfit sensor” is shown in Picture 3.

Picture 3 - The "Emfit epileptic seizure alarm"

Source of the picture: (Tunstall Australasia Pty Ltd 2018a)

1.2 STATEMENT OF RESEARCH QUESTIONS

Research questions that the thesis aims to address are stated below. They are generated from the literature review that identified knowledge gaps (illustrated in Chapter 2).

Research Question 1:

What theoretical framework provides a method to best explore the user needs identified in the CHARLS data?

Research Question 2:

2.1 What are older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities?

2.2 What are the unmet needs and urgent unmet needs for assistive technologies that can be identified from the CHARLS Database?

2.3 What are the total needs and urgent total needs for assistive technologies that can be identified from the CHARLS Database?

2.4 What differentiation exists with respect to users and users' needs (both unmet needs and total needs) between gender and age?

Research Question 3:

What opportunities exist for assistive technologies to assist older people with healthcare and independent living?

1.3 PURPOSE OF THE STUDY

The purpose of this study was to identify the level of needs and unmet needs, urgent unmet needs of assistive technology products as well as the gender and age group differentiation of the above needs. Needs detection is processed by analysing a longitudinal database (CHARLS Database, introduced in Chapter 2) that contains older people's profiles of health conditions, diseases and illnesses and daily activities of 10,818 Chinese older people. Needs, unmet needs and urgent unmet needs came from the condition of use of assistive technologies and older people's access to assistive technologies. The research also aimed to examine and find a framework that is suitable for the data characteristics of CHARLS Database to systematically detect the needs and the condition of use of assistive technologies. This research aimed to build a framework as a guideline to identify the needs and the gap of provision of assistive technologies. The research aimed to inform the aged care industry and lead to many social benefits and assist the researcher to engage with the industry. The results of the research are expected to enhance the researcher's capability to advise Australian businesses on assisting China about the challenges of an ageing society.

1.4 DELIMITATION OF THE STUDY

This research proposed to match older people's needs to assistive technologies, thus the delimitation should be about the scope of older people, the assistive technology and the relationship between older people and the assistive technology.

This research was focused on Chinese older people, not people of other ages and in other countries. The WHO defines people aged 60 years and older as older people (World Health Organazation 2021e) while the United Nations suggests that the "old-age" stood for persons aged 65 years or over (United Nations 2020). In different countries, there are different definitions of older ages. "Older population" refers to those who are aged 65 years and above in the USA (United States Census Bureau 2019). Australia's older generation refers to those who are aged 65 and over (Australian Institute of Health and Welfare 2021). In China, the definition is different from the USA and Australia. "The elderly" in China referred to citizens at or above the age of 60 (Standing Committee of the National People's Congress 2018).

This research is restricted to exploring the needs for assistive technologies, not other products. In the recent literature review of relevant research, there were 11 definitions provided for assistive Technologies. They were: A). Assistive technology is a technology that is adapted or specially designed to improve the functioning of people with disabilities (Borg, Lindstrom & Larsson 2011); B). Assistive devices and technologies are those whose primary purpose is to maintain or improve an individual's functioning and independence to facilitate participation and enhance overall well-being. They can also help prevent impairments and secondary health conditions (World Health Organazation 2019); C). "Assistive

technology" is an umbrella term referring to specialized technology used by people to adapt how specific tasks are performed (Blackman et al. 2016); D). "Assistive technology" refers to the use of an array of electronic devices incorporated into everyday objects to monitor the users' status and assist as needed, such as feedback, guidance or warning (Bruno & Sebastien 2017); E). "Assistive technology and devices" are defined as any item, piece of equipment, software program, or product system that is used to increase, maintain, or improve the access to the internet for persons with deaf or blindness (Perfect, Jaiswal & Davies 2019); F). "Assistive technology" is defined as electrical or mechanical devices designed to help people recover movement by offering direct assistance to the movement of the upper extremity (Van Ommeren et al. 2018); G). The assistive technology device is defined as any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities (Laughlin et al. 2018; Olsson et al. 2018; van Niekerk et al. 2018; Durocher et al. 2019); H). Assistive technology may be defined as a commercially acquired tool or product which is modified or adjusted to enhance, maintain, or improve the functional capability of individuals with disabilities (Putri, Ramadhani & Akbar 2018); I). An "Assistive technology" is a term used for items that can enable a person to counteract the difficulties they experience from living with certain conditions and enable them to navigate their world (Devlin, Nolan & Turner 2019); J). Assistive technology can be generically defined as the use of resources and/or services that ensure the autonomy and independence of people with disabilities (Sardenberg & Maia 2019); K). Assistive technology is an umbrella term covering the systems and services related to the delivery of assistive products and services (World Health Organazation 2021b).

The above 11 definitions were similar however not fully aligned. Their common points included: assistive technologies referred to devices and the related provision, services and supporting systems and technical issues; assistive technologies aimed to improve people's independence, health status and functional performance; assistive technology enhanced the chance for people to participate in personal and social activities, meanwhile, relieved the burden to their caregivers and family members. Among the above definitions, this research followed "B", which comprehensively demonstrated the advantages of the assistive technology in addressing functional limitations and disabilities, diseases and illnesses, and personal and social activities. It also stressed that assistive technology had evolved with and emerged from information technology, passing from detecting and reporting problems, to preventing them (Alexandru & Ianculescu 2017).

The relationship between older people and the assistive technology can be explained in two aspects: assistive technology providers' decision/provision/innovation according to older people's profiles, status and conditions, and older people's decision/attitude/adoption towards assistive technologies. This research is restricted to detecting older people's needs and indicating opportunities according to their needs. This research is not designed to present assistive technologies to older people and examine their attitudes and adoption.

1.5 SIGNIFICANCE OF THE STUDY

The significance of the research refers to the potential contribution to older people, to the assistive technology industry, the cooperation with the government policy and to the researcher's future connection with the assistive technology industry. The following sections illustrated these aspects.

1.5.1 ASSISTIVE TECHNOLOGIES CAN BE SIGNIFICANT IN OPTIMISING OLDER PEOPLE'S QUALITY OF LIFE

Assistive technologies can have a positive impact on the health and well-being of a person and their family, as well as broader socioeconomic benefits. Assistive technologies have helped people with a healthy, productive, independent, and dignified life, and reduced the need for formal health and support services, long-term care and the work of caregivers (World Health Organazation 2021b).

The increasing number of older people and rapid innovations in household devices means that technology has become more familiar in the everyday life of the older person (Matlabi, Parker & McKee 2011). Assistive technologies and residential facilities appropriately designed and supplied have potential benefits for older people, including physical and mental health, improving their quality of life, improved care, housing, and social services (McKee, Matlabi & Parker 2012). They lead to the creation of more inclusive and desirable living environments that are suitable for those who required some assistance in activities of daily living, in monitoring and security (Horgas & Abowd 2004), or more generally, for everyone, regardless of age or ability (Croucher 2008). Technological solutions have promoted independence levels and allowed older people to remain at home by addressing age-related difficulties such as falls, isolation, medication management, sensory impairment, and diminished mobility (McKee, Matlabi & Parker 2012).

1.5.2 ASSISTIVE TECHNOLOGIES CAN BE SIGNIFICANT FOR AGED CARE SERVICES PROVIDERS AND GOVERNMENT POLICY

One billion people need assistive products today and more than two billion people around the world, at some time in their life, are expected to need at least one assistive product by 2030 (World Health Organazation 2021b). The assistive products industry is currently limited and specialized, primarily serving high-income markets (World Health Organazation 2021b). Apart from very few countries that have a national assistive technology policy or programme, most countries in the world lack funding, nationwide service delivery systems, user-centred research and development, procurement systems, quality and safety standards, and context-appropriate product design (World Health Organazation 2021b). By 2050, more than 2 billion people will need at least one assistive product with many elderly needing two or more (Parra et al. 2017). In China, there were communities largely populated by older people placing growing demands for support on local services, whilst the changing demographics produced negative economic outcomes including funds available to provide services (Zhang & Wang 2010). This is both a challenge and an opportunity for China and its trading partners. China offers a large potential market for researchers, innovators and suppliers of solutions to assist with the increasing demands of an ageing population including dementia and chronic illness support (Fang et al. 2020). Even a modest percentage of the population in China could translate into a large number of people needing assistive technologies and a sustainable market.

This research is closely aligned to both the Australian National Science and Research Priorities (Australian Government Department of Industry Science Energy and Resources 2015;

Australian Institute of Health and Welfare 2018) and the Development Guidance of the Assistive Technology published by the State Council of the People's Republic of China (The State Council of the People's Republic of China 2016). The Australian Government requires departments and agencies to give priority to research that will lead to improved prediction, identification, tracking, prevention and management of health threats, and for the development and deployment of effective technologies for individuals to better manage their own health care (Australian Government Department of Industry Science Energy and Resources 2015; Australian Research Council 2019). The State Council of the People's Republic of China highlighted several key milestones in the development of assistive technology: China aimed to significantly enhance the innovation ability of assistive technology from 2020; the industry size of assistive technology in China should exceed 700,000,000,000 CNY (around 107 billion USD) in 2020 and keep rapidly growing after 2020 (The State Council of the People's Republic of China 2016).

1.6 JUSTIFICATION OF THE RESEARCH

The justification of the research explains the reason why the study should be conducted. The following paragraphs justify this research by illustrating knowledge and theoretical framework gaps from the literature review, explaining the data availability, and showing potential benefits for both older people and the aged care industry.

Previous studies (Cook & Hussey 2002; Scherer & Craddock 2002; World Health Organization 2002a; Hersh & Johnson 2007, 2008; Giesbrecht 2013; World Health Organization 2013; Nauha et al. 2018) showed that few theoretical frameworks provide an adequate methodology to explore how assistive technologies (ATs) can be used to address users' needs and this is particularly the

case in China. As a result, this research develops a comprehensive innovative and theoretical framework to detect users' needs so that other knowledge can be analysed, investigated, and applied to solve the user health needs of older people in China. The framework will provide the means for all relevant health professionals to be able to better use the existing data of the CHARLS Database to help solve the health needs of older people in China.

The research utilised the CHARLS Database, which is a comprehensive database that collates Chinese older people's demographic backgrounds, family, health status and functioning, assistive technology use, health care and insurance, work, retirement and pension, income, expenditure and assets as well as housing characteristics. The availability, scope and broad range of data are enough for the researcher to detect older people's needs for assistive technologies according to their profiles.

Older people's awareness of needs and access to assistive technology is drawn from difficulties in undertaking everyday activities of daily living (ADLs), either by the result of ageing or by illnesses, diseases or disabilities. A physical disability is a physical condition that affects a person's mobility, physical capacity, stamina, or dexterity, which results from the interaction between individuals with a health condition such as cerebral palsy and depression as well as personal and environmental factors including negative attitudes (World Health Organazation 2021c). Physical disabilities may affect, either temporarily or permanently, a person's physical capacity and/or mobility (Achieve Australia 2019) which directly influences a person's abilities to undertake ADLs. These disabilities can include mobility impairment, visual impairment, hearing loss, chronic fatigue or pain and seizures. Just as types of physical abilities and how they impact a person's ADLs

are all different, causes of physical disabilities also vary - physical disabilities can be caused by either hereditary, congenital or acquired reasons (Carehome United Kingdom 2021). People with disability do not often receive the healthcare services they needed. Evidence suggests that half of all people with a disability cannot afford healthcare (World Health Organazation 2021c). People with disability were also more than twice as likely to find healthcare providers' skills inadequate (World Health Organazation 2021c). A chronic illness is a long-term health condition that may not have a cure (United States National Library of Medicine 2021). It not only adds challenges to undertaking ADLs but can also challenge mental health, which is likely to furthermore compound physical conditions (National Institutes of Health 2021). Addressing the challenges caused by older people’s disability and disease by enhancing the provision of assistive technologies can directly impact health outcomes and quality of life.

1.7 CHAPTER STRUCTURE

There are six chapters in this thesis.

Chapter one introduces the background of the research and some related knowledge such as older people’s health issues and functional limitations, as well as the definition, classification, growing demand and interest in assistive technologies. This chapter states the purpose and the significance of the research that it aims to identify the level of needs and unmet needs, urgent unmet needs of assistive technology products as well as the gender and age group differentiation of the above needs, and that the research is significant in optimising older people's quality of life and informing assistive technology providers.

Chapter two reports on the literature review related to older people's needs for assistive technologies, as well as the provision and access of technologies; it found few research study findings that explored how assistive technologies can be applied to address older people's needs within China. This chapter then introduces the CHARLS Database and its data characteristics, together with several theoretical frameworks. It was found that there is no suitable assistive technology theoretical framework that explores how the CHARLS Database item constructs can be analysed, investigated, and applied to solve user-health needs.

Chapter three states the research questions aimed to address the knowledge gaps and the methodology used to conduct this research. The entire methodology includes seven steps including data description, assistive technology selection, studying the condition of use of assistive technologies, determining factors based on sociotechnical theory, determining unmet needs and total needs of assistive technologies, statistical tests of data and finally experts' interview for results' interpretation.

Chapter four is a data description chapter, which shows the profiles of older people in China in the survey with respect to general health, functional limitation, and personal and social activities. The described data was then used for total needs, urgent needs, unmet needs and urgent unmet needs detection.

Chapter five presents the calculation results that included users' statistics, the mean, standard deviation, median, interquartile range and bivariate correlations for ordinal variables, normality tests for ordinal variables, the bivariate correlation information, Wilcoxon signed rank test, Mann Whitney U and Kruskal Wallis test for ordinal variables. The Chapter then lists the calculation data of unmet needs and urgent unmet needs for 8 assistive technologies with users' statistics in the CHARLS database, and total needs and

urgent needs for 17 assistive technologies without users' statistics in the CHARLS database.

Chapter six provides the discussion and interpretation of the calculation results. The discussion and interpretation cover older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, and older people's unmet needs, urgent unmet needs, total needs and urgent total needs for specific assistive technologies, as well as the differentiation existing for users and users' needs (both unmet needs and total needs) between different gender and age groups. Finally, this chapter combines the outcomes from all research questions and presents them as the conclusion of the research.

1.8 LIMITATIONS OF THE STUDY

1.8.1 MAPPING WORK ONLY BASED ON CHARLS DATABASE

Many ways can be used for mapping older people's needs with assistive technologies, including but not limited to directly interviewing older people, investigating older people's daily activities and searching the data from many other databases. However, this research chose to do so by mapping work only based on the CHARLS Database. Questions included in the CHARLS database reflect important dimensions of needs but not a comprehensive stereotype. Moreover, questions in the database might interfere with each other. Older people with many functional limitations and at the same time, participate in social activities frequently, are usually defined as those who urgently need assistive technologies. People may have stopped engaging in activities due to impairments. Thus, there may be more older people urgently needing some assistive technologies than reflected in this database.

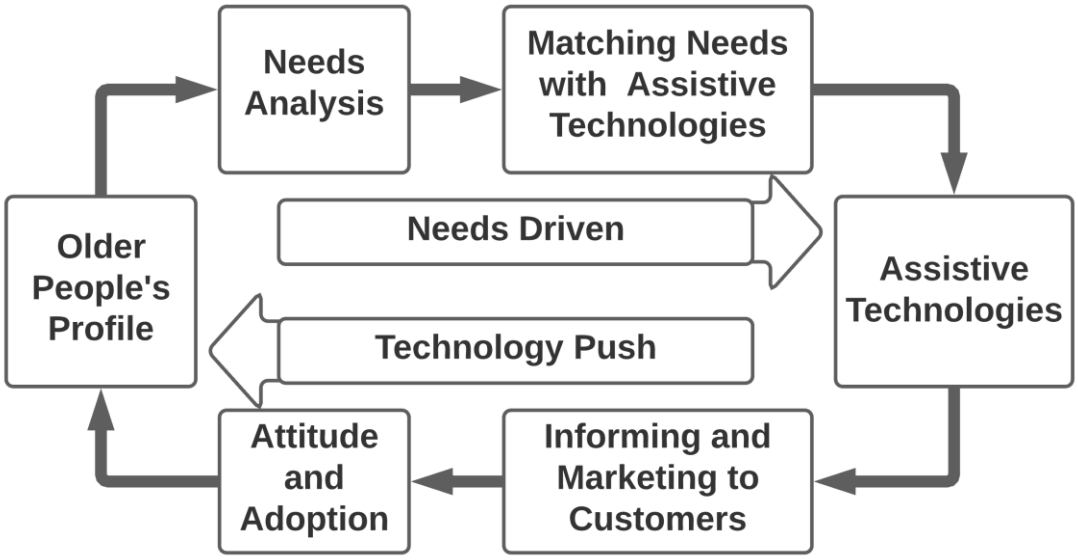
1.8.2 DEALING WITH LIMITED ASSISTIVE TECHNOLOGIES

Although there are various assistive technologies, covering a broad range of older people's ADLs, with continuous innovation and the release of new products, the research cannot include all types of assistive technologies. The main reason for this is that CHARLS Database has limited information about older people's profiles, including limited questions about functional limitations and limited questions about health status and disease. The research can only take advantage of the available questions and data provided in CHARLS Database Questionnaire.

1.8.3 FOCUSING ON "NEEDS DRIVEN", NOT "TECHNOLOGY PUSH"

As illustrated in Figure 1, the relationship between older people and assistive technologies is more complex than what is studied in this research. This research starts from the access to CHARLS Database and is driven by older people's needs. Older people's attitudes towards assistive technologies and their adoption affect the users' statistics in CHARLS Database, and this information is discussed in Chapter six. This research does not systematically analyse the exact percentage of adoption and does not provide a comprehensive framework of how older people's attitudes affect the adoption of assistive technologies.

Figure 1 - "Needs Driven" and "Technology Push" between Older People and ATs



1.9 CONCLUSION OF THIS CHAPTER

This chapter presented the foundations and general structure of this thesis. It initially explained its objective to identify the level of needs and unmet needs, urgent unmet needs of assistive technology products as well as the gender and age group differentiation of the above needs by analysing a longitudinal database (the CHARLS Database). Three research questions were identified. Justification for the research was given by illustrating knowledge and theoretical frameworks gaps from the literature review, explaining data availability, and showing potential benefits for both older people and the aged care industry. The delimitations were given by defining the scope of older people and the assistive technology, and by clarifying the relationship between older people and the assistive technology. Limitations of the research were discussed. The chapter arrangement of this thesis was also outlined.

CHAPTER 2 : LITERATURE REVIEW

2.1 INTRODUCTION AND OVERALL LOGIC OF LITERATURE REVIEW

This thesis reports on research that examines the CHARLS Database to find opportunities for providing assistive technologies for older people in China, by analysing the total needs, unmet needs and urgent unmet needs of 25 selected assistive technologies. Before the calculation and analysis, the literature review firstly focuses on older people's needs for assistive technologies and identifies the knowledge gap. These have guided the project in the selection of appropriate assistive technologies for research. The literature review then examines the provision and access of assistive technologies in different countries and throughout the globe. It introduces the CHARLS Database and details its contents and data characteristics. The feasibility of existing assistive technology frameworks is discussed regarding data characteristics and available variables of the CHARLS Database. This review also reports on the research outcomes generated by the CHARLS Database to determine whether there are any similar research designs to this thesis. The review concludes by identifying knowledge gaps and presenting the research questions.

In the theoretical aspect, the research discussed several theories related to older people's quality of life and independence including their health, social involvement, connection with families and activities participation. This research aims to identify needs and unmet needs for several types of assistive technologies. There is a need to systematically derive accurate information from the database based on its data characteristics. The literature review also examines several existing possible frameworks related to

assistive technology design, provision, assessment and needs analysis. These frameworks suggest that older people's needs for assistive technologies can be detected in multiple systematic ways. Their advantages, disadvantages, and the possibility to meet needs identified in the CHARLS Database are also discussed. This information contributes to mapping older people's exact needs to specific technologies.

Databases searched for this literature review included but were not limited to:

A) Academic Search Ultimate;

B) American Hospital Formulary Service Consumer Medication Information;

C) Anthropology Plus;

D) Applied Science & Technology Source Ultimate;

E) Business Source Ultimate;

F) Cumulative Index of Nursing and Allied Health Literature with Full Text;

G) Health Business Elite;

H) Health Source - Consumer Edition;

I) Health Source: Nursing/Academic Edition;

J) Humanities Source Ultimate;

K) Mental Measurements Yearbook with Tests in Print;

L) Psychology and Behavioural Sciences Collection;

M) Sociology Source Ultimate;

N) Website;

O) Social Media;

P) Information received from consultation with aged care and assistive technology industry experts.

2.2 OLDER PEOPLE'S NEEDS FOR ASSISTIVE TECHNOLOGIES

Detecting older people's needs in multiple approaches is the critical step before analysing unmet needs and opportunities for assistive technologies. This section reviews older people's assistive technology needs in various categories. Selected papers in this section were sourced from resources beginning with A to M as outlined. The search used keywords of "older people", "elderly", "old aged people", "assistive technologies" and "smart home technologies". The selection criteria included:

A), the result must focus on older people; while other groups such as teenagers can be involved, results pertaining to the other groups must be separately demonstrated in the conclusion of the research;

B), the research should be based on empirical evidence, observed and calculated from data, questionnaires or interviews, and not be derived from theory directly;

C), the research should discuss older people's needs that are significantly beneficial to quality of life (QoL), including independent living skills, ADL's, satisfaction of living, mental status, social involvement, selection of aged care mode and relationship with relatives;

D), The factors discussed in the research positively link to and enhance the opportunities of assistive technologies which help older people with QoL;

E), The results should be published in or after 2015;

F), The papers should be published in English.

According to the keywords and exclusion criteria presented above, the review found 923 studies. After excluding the duplications, which were 386 studies, the review then had 537 studies screened based on the title and abstract. There were 271 studies excluded on selection criteria, as a result, 266 studies were left and screened based on the complete text. After the complete text screening, 232 studies were excluded on selection criteria leaving 34 studies for further analysis. In the analysis, the literature identified that older people's assistive technology needs were distributed across six main categories: independent living, safety, health, leisure, communication, family relationship and social involvement (Lee, Lim & Lee 2015). In the published research, the "independent living" category had the highest priority, followed by "safety". The literature selection and culling process is shown as a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) Flow in Appendix 8.15.

2.2.1 OLDER PEOPLE'S ASSISTIVE TECHNOLOGY NEEDS IN MULTIPLE CATEGORIES

The following paragraphs illustrated several research findings related to older people's assistive technologies needs in different categories. These needs are then concluded and listed in Appendix 8.2.

Almost half the studies identified in this review investigated older people's Assistive Technologies (AT) needs in relation to independent living with many discussing the potential of assistive technologies. In the project "Home and Health in the Third Age", data collected from 371 people aged between 67-70 suggested that assistive technologies and modification of the home environment to

support independence in ADLs were of the utmost importance (Löfqvist et al. 2016). An interview from six focus groups gained deeper insight into the most important practical problems preventing people with dementia from living at home, which emphasized automatic control technology for home appliances, smart cooking/kitchen technology, toilet use assistance, cleaning and laundry assistance, dressing assistance, walking and mobility assistance, eating reminders and an item-locating system to be the focus of needs (Thoma-Lürken et al. 2018). Abdi et al. explored the potential of emerging technologies to meet the care and support needs of older people and found that voice-activated devices, artificial intelligence-enabled apps and wearables and the internet of things showed potential to support basic self-care/ADLs and access to healthcare needs of older people (Abdi, Witte & Hawley 2021). Researchers found that technology-based services such as home automation and advanced telecare, telemonitoring and telematics intervention were of great concern based on business case and model, technological barriers and components, training, policies and assurance of service (Carretero & Kucsera 2015) supported independent living and met the needs of the older person.

Safety was a critical aspect for older people's activities, both indoor and outdoor. Based on a review of assistive technology, and a questionnaire regarding the needs of the older people and their views on technology, researchers found that technology for emergency responses, warning about potential hazards and a gas leakage detector were most needed by older people (Jännes et al. 2015). Many researchers found that reminders for declining memories were of great significance in meeting older people's needs (Saracchini, Catalina & Bordoni 2015; Kamilaris, Kondepudi & Danial 2016; Bedaf et al. 2018; Meristö 2018; Orellano-Colon et

al. 2018; Thoma-Lürken et al. 2018). Safety assistive technologies were required to remind older people about turning off home equipment, closing windows, locking the door and providing an appropriate response when older people became lost (Boman, Persson & Bartfai 2016; Egan & Pot 2016; Thoma-Lürken et al. 2018). When hazards occurred, for example, a gas leakage (Jännes et al. 2015; Lee, Lim & Lee 2015), assistive technologies were critically needed to provide emergency warnings and responses (Doughty & Williams 2016; Jiancaro, Jaglal & Mihailidis 2017; Callari et al. 2019; D'Onofrio et al. 2019; Mayer, GÜLdenpfennig & Panek 2019). Older people also needed transportation assistance to keep them safe when travelling (Egan & Pot 2016; Peek et al. 2016).

Assistive technology needs related to health identified in the literature review included sight/vision assistive technology, medication reminders/treatment and general health monitoring technology. While older people required sight and vision assistance technology as their main self-reported functional goals (Casten, Rovner & Fontenot 2016), only a few of them had received formal low vision services, despite using low vision resources and reporting low to moderate difficulty in using them. In an interview with 14 participants either in the hospital or in the participants' homes (Boman, Persson & Bartfai 2016), sight and vision assistance technology was one need with high significance. Recent research using a telephone survey with older people with low vision suggested that older adults with low vision failed to obtain the full range of all health information and services to meet their specific needs; they shared various concerns in accessing, understanding, and using health information, care services, and multimedia technologies (Kim 2019). Burrows et al. (2015) introduced empirically derived attributes that could help designers to build a

more detailed understanding of the potential users of home healthcare systems, which pointed out that long term pain management was of great significance among the interviewees. Klimova (2018) focused on those with mental health disorders and discussed the use of computer-based programs as suitable intervention tools for older people and found that computer-based programs designed for older people with depression may be beneficial as non-invasive treatments, as they can be tailored-made and cost-effective.

Communication, family relationships and social involvement played an important role in older people's mental health. Assistance in the form of social contacts with family members and companionship technology/robots were noted by many researchers (Löfqvist et al. 2016; Chu et al. 2017; Chang, Lu & Yang 2018; Lin & Chen 2018; Meristö 2018; Thoma-Lürken et al. 2018; Andrews et al. 2019; D'Onofrio et al. 2019; Kim 2019). In the project "Multi-Role Shadow Robotic System for Independent Living" for identifying user requirements, older people expressed the need to be reminded about appointments, the capacity for enhanced communication for people with diverse communication needs and social interaction and communication with others (García-Soler et al. 2018). A wide range of stakeholders, such as representatives from industry, government, academia, and people living with dementia from China, India, UK, Canada and Japan expressed similar needs for innovative assistive health technologies for people with dementia related to overcoming social isolation and improving social activities, including contacts with the social network of families, peers, and other important persons (Egan & Pot 2016). Lanne et al. (2019) completed the research based on interviews of 10 companies and an online survey data of 13 companies and highlighted the potential and barriers in the care robot business,

including care robot for older people (Lanne et al. 2019). Another systematic review also found there was a requirement for communication technologies (Pedrozo Campos Antunes et al. 2019).

The need for leisure identified in the literature suggested that tailored games and technology for playing musical instruments attracted most of the research focus. Besides general and unspecified needs for leisure assistive technologies (Nguyen et al. 2015; Casten, Rovner & Fontenot 2016), in addition to activities associated with ADLs, stroke survivors also expressed higher needs such as opportunities related to playing musical instruments and games in a home visit (Nasr et al. 2016). Similar research also suggested that in order to benefit their mood and overall mental health, older people required assistive technologies for playing music (Andrews et al. 2019). Here, the mobile augmented reality of assistive technology such as a music player was highlighted (Saracchini, Catalina & Bordoni 2015). Older people might still have a requirement for sports (Boman, Persson & Bartfai 2016). Sports assistive technologies helped them to increase participation, autonomy, safety and self-efficacy (Orellano-Colón et al. 2017). Those general indoor leisure technologies such as television, radio (Peek et al. 2016; Kim 2019) and education technologies (Kim 2019) had also been noted by studies of older people's needs.

2.2.2 COMMENTS AND CONCLUSION OF RELATED PAPERS

Previous papers (Casten, Rovner & Fontenot 2016) investigated older people's expectations (Burrows, Gooberman-Hill & Coyle 2015; Nasr et al. 2016; Thoma-Lürken et al. 2018) towards assistive technology or identified the features of a specific type of assistive technology (García-Soler et al. 2018) but did not include a comprehensive review of assistive technologies. Previous research

focused more on the motivation (Smaerup et al. 2017; Andrews et al. 2019), barriers (Egan & Pot 2016) and effectiveness (Shishehgar, Kerr & Blake 2019) of smart home and assistive technologies. Some focused more on assistive technology adoption than needs (Lee, Lim & Lee 2015; Doughty & Williams 2016; Orellano-Colon et al. 2018). There was also extant research based on senior citizens' current situations, but not on the future problems of a large demand-driven push towards providing better healthcare services and the technological nature of this demand (Chan et al. 2009). Looking at the range of assistive technologies mentioned in extant research, some research was sufficiently broad but not specific and mentioned the whole range of assistive technology (Jiancaro, Jaglal & Mihailidis 2017; Orellano-Colón et al. 2017; Meristö 2018; O'Connell et al. 2018) or technology used in a very broad field (Nguyen et al. 2015; Boman, Persson & Bartfai 2016; Löfqvist et al. 2016; Karlsen et al. 2017; D'Onofrio et al. 2019; Mayer, GÜLdenpfennig & Panek 2019). Much of the previous research did not help to guide technology developers to map their detailed products to older people's needs. Similarly, some researchers focused on specific assistive technologies (Saracchini, Catalina & Bordoni 2015; Mattie et al. 2016; Chu et al. 2017; Bedaf et al. 2018; Chang, Lu & Yang 2018; Ku 2018; Callari et al. 2019), with only one or two specific technologies introduced, but not matched to older people's needs.

There were three main ways to link older people with assistive technologies or smart home technologies. The first was to develop and innovate technologies as the initial activity, and to promote the technologies to older people by evaluating the result of the impact. Technologies that were acquired in ways that were not congruent with seniors' personal needs and circumstances ran a higher risk of proving to be ineffective or inappropriate (Peek et al. 2017). The

second way was to focus on older people's attitudes towards the adoption of assistive technologies - to optimize user acceptance of products by identifying and eliminating the barriers to adoption. This included research that looked at user attitudes and acceptance and examines social factors which appropriately support the relationship between users and service providers (Halloran 2017). The third way was to detect older people's needs and to develop and optimize the technologies in a specific orientation. Needs for assistive technology could be detected in many ways, including direct ways and indirect ways.

Much existing research noted above had been completed mostly by interviews, telephone conversations, home visits or observation within a project. Although these methods were direct, reliable and accurate, they were less efficient than directly interacting with older people, who might not be able to express their needs well because of inadequate awareness of technology or chronic disease that hindered their ability to communicate. A few of the above research outcomes were detected by analysing older people's health status, disease or daily activities. Another way to link older people's needs with technologies was to apply a technology push to older people and check its effectiveness and adoption, which might then identify a misfit between older adults' needs and available technology. Because some older adults experienced a misfit between technology and needs, they must see the value of a device to use it (Karlsen et al. 2017).

A better way was required to explore the opportunities for assistive technologies avoiding a direct interviewing approach of older people. That was, given that there was a priority to explore older people's needs and a requirement to understand the market demand for assistive technologies, a better understanding of older people's needs was required. According to 34 studies included in

the literature review, older people's needs can be summarised in the categories in Appendix 8.2.

In conclusion, the health industry more generally required an effective way to analyse and detect older people's needs that can be matched with available assistive technologies. Multiple methods such as direct interviews, telephone consultations, indirect analysing of health problems and participation in activities, evaluating assistive technology outcomes and barriers to adoption, and pushing technological innovations to users, were most effective if they were integrated and interdependent.

The literature review of older people's needs for assistive technologies illustrated above was also published as:

Soar J., Yu L., Al-Hakim L. (2020) Older People's Needs and Opportunities for Assistive Technologies. In: Jmaiel M., Mokhtari M., Abdulrazak B., Aloulou H., Kallel S. (eds) The Impact of Digital Technologies on Public Health in Developed and Developing Countries. ICOST 2020. Lecture Notes in Computer Science, vol 12157. Springer, Cham. https://doi.org/10.1007/978-3-030-51517-1_37

2.3 THE PROVISION OF ASSISTIVE TECHNOLOGIES

Assistive devices and technologies can maintain or improve an individual's functioning and independence to facilitate participation and enhance overall wellbeing - they benefit not only the individual users, but also family members, carers, employers, teachers, and other community members who interact with AT users (World Health Organization 2018). Assistive technologies help older people to remain living independently in the community and decrease their dependency and need for support in undertaking ADLs as well as the cost for families and communities and they can also help

prevent impairments and secondary health conditions (World Health Organization 2021). With appropriate and relevant access, adoption and application, assistive technology can provide individuals with opportunities to participate in community life (Nayar et al. 2021).

2.3.1 ASSISTIVE TECHNOLOGIES' OVERALL PROVISION AND ACCESS THROUGHOUT THE WORLD

The percentage of people with health conditions and disabilities is higher among older people because, as people age, they become more susceptible to disease and disability (World Health Organization Regional Office for Europe 2021). People living in different countries or regions of a country, under different socio-economic conditions, and people with different impairments, genders, ages, languages, and cultures do not always have equal access to assistive devices and services (World Health Organazation 2021b). Over one billion people globally need one or more assistive devices, with a projected two billion in need by 2030; yet only 5-15% or only 1 in 10 people in need had access to assistive products (World Health Organization 2018). Based on the 2012 Canadian Survey on Disability, among the estimated 3,775,920 Canadians over 15 years with a disability (13.7% of the Canadian population), 3,579,580 of them used some form of assistive technologies, but still, among people with disability, 37% (5% of the total population) had self-reported unmet needs - the overall point estimate for unmet need was 1,002,890 people (Berardi, Smith & Miller 2021). In some less developed countries, this need, and the gender inequity of access to assistive technologies were more notable. In the Kurigram and Narsingdi region of Bangladesh, for example, 74.9% of females and 74.4% of males reported unmet needs for assistive products (Pryor et al.

2018). More surprisingly, 80.7% of people aged 60 years and older reported unmet needs for assistive products (Pryor et al. 2018). Needs and access to assistive technologies in some other less developed countries among people with disabilities (in all ages) are shown in the Table 1.

Table 1 - Needs and Access of Assistive Technologies in Some Less Developed Countries

Country Name	%*	%**	Year of Research	Gender Differentiation in Assistive Technology Use
Namibia	67.00%	12.00%	2003	Males were higher than females in AT use.
Zimbabwe	39.00%	13.00%	2015	Females were higher than males in AT use.
Malawi	31.50%	6.10%	2017	Male percentages were higher than females in AT use.
Zambia	46.00%	11.00%	2018	Males were higher than females in AT use.
Mozambique	66.00%	11.00%	2009	Males were significantly higher than females in AT use.
Swaziland	60.00%	20.00%	2011	Males were higher than females in AT use.
Lesotho	51.00%	9.00%	2010	Females were slightly higher than males in AT use
Botswana	59.00%	34.00%	2015	Males were higher than females in AT use.
Nepal	56.00%	15.00%	2016	Males were significantly higher than females in AT use.

(Eide et al. 2019; Berardi, Smith & Miller 2021)

%* The percentage of people in the specific country with disabilities needing assistive technology

%** The percentage of people with disabilities who had received or accessed such technology in the year of research shown in the table

2.3.2 PROVISION AND ACCESS TO SPECIFIC TYPES OF ASSISTIVE TECHNOLOGIES

This section reports on the literature review undertaken related to the provision and access to several specific types of assistive technologies. There are 21 types of assistive technologies identified in the literature and they are divided into three groups, including assistive technologies related to A), mobility ability, B), sensory ability, C), everyday living, safety and memory problems. Information on provision and access to assistive technologies is limited however studies have been undertaken in a range of high-income countries (i.e., Canada, USA and Germany) and middle-income countries (i.e., India, Bangladesh) and low-income countries (i.e. Syria, Cameroon). The income level is determined by the World Bank Definition. Low-income economies are defined as those with a Gross National Income (GNI) per capita of $1,045 or less in 2020; Middle-income economies are those with a GNI per capita between $1,046 and $12,695; High-income economies are those with a GNI per capita of $12,696 or more (The World Bank 2021).

Based on World Health Organization estimates, there were 75 million people globally who needed mobility-related assistive products such as a wheelchair (World Health Organazation 2022a). It was estimated that only 5-15% of the population had access to these (Boggs et al. 2019). In some countries, assistive technologies related to mobility, such as walking sticks and wheelchairs, etc, have a relatively high percentage of provision and access for those who need them. For example, in Canada, it was estimated that there were 0.22% of the whole population who needed, but did not have a scooter; 0.13% of the whole population who needed, but did not have a walker (Berardi, Smith & Miller 2021). Similarly, 87% of the need for walking sticks were met in

India and 93% of the needs for walking sticks were met in Cameroon (Mactaggart et al. 2016). In contrast, in northeast Syria, 87% of older women and 85% of older men with a mobility disability did not have any form of assistive products related to their disability, despite requesting support (Hiscock 2019). Specifically, 44% of older women with a walking disability in northeast Syria did not have any form of walking sticks related to their disability, despite requesting support; 34% of older men with a walking disability did not have any form of walking sticks related to their disability, despite requesting support (Hiscock 2019).

Globally, it has been reported that 70 million people needed a wheelchair but only 5-15% had access to one wheelchair (Tangcharoensathien et al. 2018). In Canada, there were 288,800 users aged over 15 using wheelchairs (combined manual and electric wheelchairs), which consisted of 1% of the total Canadian population (Smith et al. 2016). Although motorised wheelchairs were provided in every province and territory (Mattison. et al. 2017), still it was estimated that 0.12% of the whole population needed a motorised wheelchair but did not have one (Berardi, Smith & Miller 2021). In India, there were needs for wheelchairs for mobility impairments but only 33% of those needs were met and 33.33% of the population reported an unmet need for portable ramps in the Hubli-Dharwad region of India (Hegde et al. 2019).In Cameroon, there were needs for wheelchairs for mobility impairments but none were met (Boggs et al. 2019). Other researchers found different results concluding that 26% of the needs for wheelchairs were met in India and 41% of the needs for wheelchairs were met in Cameroon (Mactaggart et al. 2016).

Falling is a major issue for older people. In Canada, approximately 30% of people older than 65 years and, 50% of people older than 85 years living in the community had experienced a fall at least

once a year (Medical Advisory Secretariat 2008). Older people falling can cause not only physical injury such as bone fractures and traumatic brain injuries but also psychological consequences such as fear associated with falls (Schoene et al. 2019). According to United States Centres for Disease Control and Prevention, National Centre for Injury Prevention and Control, one out of four older people fell each year in the United States, making falls a public health concern, particularly among the ageing population (Centers for Disease Control and Prevention 2020). There was no data showing the percentage of usage of fall detectors. There were also a range of other AT supports for people with mobility impairments and falls risk including handrails and grab bars, however little is known about the provision and access to these. In Canada, handrails and grab bars were provided in Alberta, New Brunswick, Nova Scotia, Newfoundland and Labrador, Northwest Territories and Yukon by the government (Mattison. et al. 2017). It was mentioned that similar items were provided in other provinces and territories.

In middle- and low-income countries, there were also lots of gaps in the provision and access regarding assistive technologies related to sensory ability - there were 430 million people globally who need to address their hearing loss problems and this number could climb up to 700 million by 2050 (World Health Organazation 2021d). It was estimated that product production met only 10% of the global needs and 3% of the needs in low-income countries (Boggs et al. 2019). In India and Cameroon, only 4-6% and 7-24% of the needs for hearing aids were reported as being met (Mactaggart et al. 2016; Boggs et al. 2019). Similarly, in northeast Syria, 89% of older women with a hearing disability did not have any form of assistive products related to their disability requesting support; 77% of older men with hearing disability did not have any form of

assistive products related to their disability (Hiscock 2019). In research in Bangladesh with 285 participants with hearing impairments, 149 of them had no access to hearing aids (Borg & Ostergren 2015).

In contrast, in Canada, it was estimated that 0.86% of the population needed but did not have access to hearing aids (Berardi, Smith & Miller 2021). Hearing aids were provided in every province and territory except Saskatchewan (Mattison. et al. 2017).

Assistive technologies of vision ability aids also showed a great difference in different countries. It was estimated that 2.2 billion people globally have a near or distance vision impairment (World Health Organazation 2021a). Over 200 million people did not have access to spectacles or other low-vision devices (Boggs et al. 2019). In middle and low-income countries, a considerable proportion of the need for vision-related assistive products remained unmet. In India, 44 - 46% of the needs for glasses were met for mild vision impairments, and 87% of the needs for glasses were met for moderate vision impairments (Mactaggart et al. 2016; Boggs et al. 2019). In Cameroon, 33 - 37% of the need for glasses was met for moderate vision impairments (Mactaggart et al. 2016; Boggs et al. 2019). 75% of the needs for white canes were met in India and 33% of the needs for white canes were met in Cameroon (Mactaggart et al. 2016).

In contrast, in high-income countries, there is a higher level of provision of vision-related assistive products to meet people’s needs. In Canada, it was estimated that 0.26% of the population required but did not have corrective lenses (Berardi, Smith & Miller 2021). Braille displays are provided in Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, Newfoundland and Labrador by the government but not provided in other provinces (Mattison. et al. 2017). Braille writing equipment/braillers were provided in

Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, Newfoundland and Labrador by the government but not provided in other provinces (Mattison. et al. 2017). Deafblind communicators were provided in Alberta, Ontario in Canada by the government but not provided in other provinces (Mattison. et al. 2017). The review also checked the provision of screen readers. These were provided in Alberta, Saskatchewan and Ontario in Canada by the government. In Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador and Northwest Territories, there was mention of similar items being provided, but it was not explicitly stated that are provided (Mattison. et al. 2017).

Assistive technologies related to ADLs, safety and memory problems had limited provision and access to information in developed countries like Canada and USA. Alarm systems were provided in Alberta, Ontario, New Brunswick and Nova Scotia in Canada by the government but were not provided in other provinces and territories (Mattison. et al. 2017). In Canada, alarm signallers were provided in Alberta by the government but not provided in other provinces (Mattison. et al. 2017). Global Positioning System (GPS) Locators were provided in Alberta, Ontario, by the government but not provided in other provinces. It was mentioned that similar items were provided in New Brunswick (Mattison. et al. 2017). In Canada, these were provided in Nova Scotia by the government. There were similar items provided in Manitoba, Quebec and Prince Edward Island (Mattison. et al. 2017).

This literature review did not find the provision, access and unmet needs for time management support technologies. In a report from the USA, which involved 189 community-living individuals with faecal incontinence, an absorbent product was used to manage faecal incontinence by 45% of respondents. Among them, more

women (88%) and older people over 65 years old (44%) wore an absorbent product. People who wore an absorbent product for faecal incontinence had a higher (worse) than usual faecal incontinence (Bliss et al. 2011). Both pressure relief cushions and pressure relief mattresses were provided in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick and Nova Scotia in Canada by the government. There were similar items provided in Quebec. Pressure relief cushions were provided in Newfoundland and Labrador and Northwest Territories (Mattison. et al. 2017). Commodes were provided in all provinces in Canada (Mattison. et al. 2017).

In conclusion, the above literature review suggested that people living in different countries or regions of a country, under different socio-economic conditions, and people with different impairments, genders, ages, languages, and cultural backgrounds did not always have equal access to assistive devices and services. Access and provision information on 23 specific types of assistive technologies in some specific countries presented in previous sections are summarised in Table 2.

Table 2 - Assistive Technologies' Access & Provision in Some Countries

	High-income Countries			Middle-income		Low-income	
AT number and Name	Canada	USA	Germany	India	Bangladesh	Syria	Cameroon
1 Alarm signallers with light/sound/vibration	■	▲	▲	▲	▲	▲	▲
2 Braille displays (note takers)	■	▲	▲	▲	▲	▲	▲
3 Braille writing equipment/braillers	■	▲	▲	▲	▲	▲	▲
4 Walking sticks	▲	▲	▲	▲	▲	■	▲
5 Chairs for shower/bath/toilet	√	▲	▲	▲	▲	▲	▲
6 Closed captioning displays	■	▲	▲	▲	▲	▲	▲
7 Deafblind communicators	■	▲	▲	▲	▲	▲	▲
8 Fall detectors	▲	▲	▲	▲	▲	▲	▲
9 Global Positioning System (GPS) locators	■	▲	▲	▲	▲	▲	▲
10 Handrails/grab bars	■	▲	▲	▲	▲	▲	▲
11 Hearing aids	■	▲	▲	■	■	■	■
12 Personal emergency alarm systems	▲	■	▲	▲	▲	▲	▲
13 Corrective lenses	■	▲	▲	■	▲	▲	■
14 Personal emergency alarm systems	■	▲	▲	▲	▲	▲	▲
15 Pill organizers	■	▲	▲	▲	▲	▲	▲
16 Pressure relief products	■	▲	▲	▲	▲	▲	▲
17 Ramps, portable	▲	▲	▲	■	▲	▲	▲
18 Screen readers	■	▲	▲	▲	▲	▲	▲
19 Standing frames, adjustable	▲	▲	■	▲	▲	▲	▲
20 Time management products	▲	▲	▲	▲	▲	▲	▲
21 Mobility aids	■	▲	▲	▲	▲	■	▲
22 Wheelchairs (manual or electric)	■	▲	▲	■	▲	▲	■
23 White canes	■	▲	▲	▲	▲	▲	▲

▲No information ■Partly provided in the country √Provided in the whole country

2.3.3 ASSISTIVE TECHNOLOGY USE AND UNMET NEEDS IN CHINA

This literature review did not find any research outcome within the recent five years illustrating Chinese older people's unmet needs for a specific type of assistive technology based on their health status or social and personal participation. Papers found were about China setting up assistive technology centres across the nation to provide services for older people and people with disabilities (World Health Organization 2020), but these did not illustrate any unmet needs. The papers found were about community care (Zhou & Walker 2016), but not about assistive technologies. Papers were about awareness, access (Tangcharoensathien et al. 2018), development (Alqahtani et al. 2019), innovation (Egan & Pot 2016) of assistive technologies, designing residential buildings and promoting ageing-in-place (Gadakari et al. 2017; Gadakari et al. 2018), but not about unmet needs for specific types of products.

2.4 THE CHINA HEALTH AND RETIREMENT LONGITUDINAL STUDY DATABASE AND ITS CHARACTERISTICS

2.4.1 BASIC INFORMATION OF THE DATABASE AND ITS QUESTIONNAIRE

The China Health and Retirement Longitudinal Study (CHARLS) database was the source of data for the research undertaken in this thesis. The China Health and Retirement Longitudinal Study (CHARLS) aims to collect a high quality nationally representative sample of Chinese residents aged 45 and older, using scientific research, to serve the needs of the elderly. The baseline data collection of the CHARLS was conducted in 2011 and now includes about 10,000 households and 17,500 individuals in 150 counties/districts and 450 villages/resident committees (Zhao et al.

2013; Zhao et al. 2014). The individuals supplying the data were re-surveyed every two years. All data was made public one year after the end of data collection (Zhao et al. 2020).

Ethical approval for all the CHARLS waves was granted by the Institutional Review Board (IRB) at Peking University. The IRB approval number for the main household survey, including anthropometrics, is IRB00001052-11015; the IRB approval number for biomarker collection, is IRB00001052-11014 (Zhao et al. 2020). During the fieldwork, each respondent who agreed to participate in the survey was asked to sign two copies of the informed consent, and one copy was kept in the CHARLS office, which was also scanned and saved in PDF format (Zhao et al. 2020). Four separate consents were obtained during the data collection: one for the main fieldwork, one for the non-blood biomarkers, one for the taking of the blood samples, and another for storage of blood for future analyses (Zhao et al. 2020).

The chapter name, sub-chapter name and the content closely related to this research are shown in Table 3.

Table 3 - Contents in the CHARLS Database Questionnaire

Chapter Name	Sub-chapter Name	Variables of Concern
Demographic Backgrounds	N/A	Variables about demographic information and
Family	Parent, Children and Sibling	N/A
	Time Transfer and Transfers	N/A
Health Status and Functioning	Health Status	Variables about functional limitations, about mental and emotional status, about personal and social activities, about the information collected from the interviewee's acquaintances
	Functional Limitations and Helpers	
	Cognition & Depression	
	Informants Information	
Health Care and Insurance	Medical Insurance	Variables about health care status about medical care and insurance cost
	Health Care Costs and Utilization	
Work and Retirement	N/A	N/A
Income, Expenditures and Assets	Household Income and Expenditures	Variables about income and expenditure
	Household Assets	
	Individual Assets	
Housing Characteristics	N/A	N/A

(National School of Development of Peking University & Institute of Social Science Survey of Peking University 2020)

This research uses the data from wave four. This wave is the newest wave.

Wave four data collection was conducted in 2018; the data were published in 2020.

2.4.2 CHARACTERISTICS OF THE CHARLS DATABASE

The CHARLS database has a large number of participants with 20,866 people sampled in total (National School of Development of Peking University 2020). Out of these, there are 10,818 older people who are respondents. The data were collected in 2018 with the research defining older people as 60 years old and over, with older participants born on or before 1958.

Within the database, there are mixed and complicated questions and metrics/scales. Unlike a standard questionnaire-based research approach concentrating on one main issue with one or very few answer metrics, the CHARLS is a comprehensive database for researchers in different fields. The content of the database involves demographic backgrounds, family, health status and functioning, health care and insurance, work, retirement and pension, income, expenditures and assets as well as housing characteristics. The CHARLS Database is designed for multi-purpose use. The content can be used for demography study, economical study, aged care study and many more specific areas. Based on the comprehensive content, the database uses a number of different metrics for different types of questions. The metrics include Likert scales, numeric scales, binary options, nominal choices, and answers in text format.

There are two main challenges in manipulating the database. The first challenge was how to systematically pick information of older people's health and functional limitation, and how to map the needs of assistive technology. The second challenge concerns how to analyse different types of metrics so that different questions can be grouped to contribute to and identify functional limitations as well as the needs for specific products. The research attempted to align the CHARLS Database with four frameworks illustrated in Section 2.5.5, however it found that none of them could be properly used for analysing data in the CHARLS Database.

2.4.3 THE CHARLS DATABASE REPRESENTS CHINESE OLDER POPULATION, NOT ENTIRE POPULATION

The CHARLS Database does not represent the entire population of China. It does represent the older people throughout China: the CHARLS is the first nationally representative survey of the older population that enables the study of the health of the older population in China patterned after US Health and Retirement Study and related ageing surveys around the world such as the English Longitudinal Survey of Aging, the Survey of Health, Aging and Retirement in Europe, Japanese Study of Aging and Retirement, the Longitudinal Aging Survey of India, the Indonesia Family Life Survey and the Korean Longitudinal Survey of Aging (Zhao et al. 2020).

It can be noticed in the following Table, 4 and 5, that the number of participants in the CHARLS ranged from 17,708 to 21,095 and around half of them were older people, this is significantly different from the percentage of the older population in China calculated by Statistical Communique of the People's Republic of China on the National Economic and Social Development by National Bureau of Statistics of China. The calculation results derived from the CHARLS Database represent the older population in China but not the whole population of China.

Table 4 - The Percentage of Older People in the CHARLS Database

CHARLS Wave	Total CHARLS Participants	CHARLS Older People Participants	Percentage of CHARLS Oder People Participants
2011	17,708	7,650	43.20%
2013	18,605	8,899	47.83%
2015	21,095	9,785	46.39%
2018	20,866	10,818	51.85%

(National School of Development of Peking University 2013, 2015, 2017, 2020)

Table 5 - The Percentage of Older People in China

Report Year	China population in that year	China older people population in that	Percentage of older people in China in that
2011	1,347,350,000	184,990,000	13.73%
2013	1,360,720,000	202,430,000	14.88%
2015	1,374,620,000	222,000,000	16.15%
2018	1,395,380,000	249,490,000	17.90%

(National Bureau of Statistics of China 2012, 2014, 2016, 2019)

(The minimum counting unit used by the Statistical Communique of the People's Republic of China on the National Economic and Social Development is 10,000)

2.4.4 REAL PRACTICES USING THE CHARLS DATABASES

As illustrated in section 2.4.2, the CHARLS Database is a comprehensive database for researchers in different fields. The research searched papers with "CHARLS Database" as keywords in Google Scholar since 2015. Among the large number of papers using the CHARLS Database, the researcher found that most of the papers were about general health, mental health, medical care service and financial issues.

Some researchers used the CHARLS Database to investigate general health topics. Researchers found that the proportion of patients who received diabetes-related health education decreased significantly and the proportion of those receiving examinations and treatments remained unchanged from 2011 to 2015 (Sun et al. 2020). The relationship of health to its determinants greatly differed between Eastern and Central/Western China. Higher education, higher income level, better life satisfaction, and long-term marriage were significantly associated with better health status among Chinese people. Regional healthcare resources were positively associated with the health of residents (Liu, Xu & Yang 2018). Wang (2018) used the Probit Regression Model and found that developing the facilities for the education of the elderly improves the

family welfare of the surrounding residents. Providing a friendly and supportive environment for the social participation of "empty-nest elderly" (older people who live alone and rarely or never see their children) was found to be an important measure to promote healthy ageing (Su et al. 2020). Targeted social participation might be one of the greatest opportunities to improve the mental health of the empty-nest elderly (Su et al. 2020). Controlling the rapid growth in health expenses and reducing citizens' overuse of health services were needed to better protect residents from the economic risks of poor health (Wang et al. 2021). Individuals who were older than 55 years, male and who suffered from diabetes were associated with hypertension (Wu & Wang 2019).

Researchers also found that the length of suffering from disability was found to be significantly related to mobility impairment; mobility impairment was inversely related to social engagement and life satisfaction, and social engagement was positively related to life satisfaction (Li & Loo 2017). Childhood health recalled by the respondents was positively and significantly associated with their adult health outcomes in terms of self-reported health status, cognition, and physical function (Wang et al. 2018). Zhang et. al. (2019) found an increasing trend of prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia with ageing, based on the CHARLS Database which varied according to marital status, socioeconomic status, and geographical region. Researchers found that depression prevalence was significantly higher among malnourished older Chinese adults living in the community and highlighted the importance of malnutrition and depression screening and treatment for older Chinese community-dwelling adults, and the importance of community-based nutrition-specific programs (Wei et al. 2018).

Age was the only demographic risk factor for functional limitations. The presence of multiple chronic physical diseases, perceived pain and depression consistently influenced physical ADLs (Hu et al. 2015). The

odds ratio of premature death for smokers/drinkers was higher compared with non-smokers/non-drinkers (Hongli et al. 2021). The incidence of symptomatic knee osteoarthritis was highest among females (Ren et al. 2020). Physical activities and high education level were associated with a lower risk of incident symptomatic knee osteoarthritis, while histories of heart, kidney and digestive disease were associated with a higher risk of incident (Ren et al. 2020). Smoking was one of the primary risk factors for the high level of health expenditures caused by significant health problems, suggesting stronger interventions against smoking are needed to reduce the occurrence of health issues caused by smoking and the financial, social and health losses for individuals, families and society (Zhong et al. 2020). The research about environmental pollution's effect on health suggested that although environmental pollution in China had no significant negative impact on people's short-term health status, it could still reduce people's overall levels of "self-rated health" and "mental health" (Yuan, Li & Zhao 2020).

Regarding mental health, researchers found that working status and gender moderated the effect of caregiving time on depressive symptoms. Some adverse childhood experience such as bullying and poor relationships with the mother figure was associated with a higher prevalence of depressive symptoms in older adults in China (Fang 2019). Employed men and women caregivers who spent more hours providing care suggested fewer depression symptoms (Liu et al. 2019). Unemployed men caregivers who spent more hours providing care suggested the highest level of depressive symptoms (Liu et al. 2019). The incidence of depressive symptoms was much higher in rural areas and in women (Wen et al. 2019). Individuals who perceived their health status as excellent had a 62% lower risk of developing depressive symptoms as compared with individuals who perceived their health status as poor (Wen et al. 2019). Researchers Yi et al. (2021) innovatively found the correlation between cognitive ability and climate change: cumulative heat exposure

adversely affects verbal test scores and middle-aged women and people in rural areas who suffered from continuous heat performed low in cognitive tests.

Previous findings implied that continuing climate change effects might diminish decision-making capacity and effectiveness, to some extent (Yi et al. 2021).

It was found that increasing economic welfare was significantly associated with a lower probability of depression symptoms among Chinese older adults thus improved socioeconomic welfare systems for older adults were necessary to contribute further to reduced depression risk in China (Liu et al. 2021). Researchers found that positive change in social group engagement was associated with a reduced decline in cognitive performance over the 4-year retirement transition period (Lam et al. 2020). Researchers investigated the gender differential impact of bereavement on health outcomes and found a harmful impact of bereavement on mental health among older women in China and pointed out the need for a comprehensive policy on survivor benefits in China, particularly for rural older women (Chen et al. 2020). Regarding marriage status, People living with a spouse were less likely to experience depressive symptoms compared to people living alone (Liu et al. 2017).

Some research outcomes were related to medical care services, aged care services and systems. Chinese middle-aged and elderly patients with diabetes faced a higher economic risk of diseases, and unhealthy lifestyles increased the economic risk (Leng et al. 2020). China’s basic medical insurance system had a certain resistance to the disease’s economic risk for diabetes patients, but it could not meet the actual needs of patients (Leng et al. 2020). Based on the CHARLS Database, researchers found informal long-term care services for elderly persons with disabilities heavily depended on a family member from different health insurance groups (Chen, Zhang & Xu 2020). It was shown that integrated care systems should be concentrated on family care and community

organizations as a unit and establish elders nursing service institutes with different functions; it was vital to establish a professional service network system for older people with impairments and to make sure this care system could fulfil its functions (Shiyong & Dan 2017). The current policy design of urban and rural resident medical insurance scheme had a significant impact on the medical service utilisation of rural residents and positively affected the promotion of urban and rural equality in terms of outpatient utilisation (Su et al. 2019).

Researchers also found that overweight and obese people had significantly higher total direct health care costs as compared with the normal-weight group (Shi et al. 2017). It could be seen that heavy air pollution worsened self-rated health conditions, thus the air pollution affected the physical health of middle-aged and elderly people and negatively affected medical insurance cost (Pi, Wu & Li 2019). Functionally impaired older people's age, gender, marital status, level of disability, and their adult offspring's income and living status, were all significantly associated with their caregiving types (Zhou & Yang 2021). Statistical association analysis suggested that rural residents in China insured by the new rural cooperative medical system were more likely to seek inpatient and outpatient care than those who were not insured (Li & Wang 2017). The households that had enrolled in the new rural cooperative medical system suffered higher catastrophic health expenditure and impoverishment by medical expense than those that had not enrolled (Wang et al. 2020). The new rural cooperative medical system did not provide sufficient economic protection from catastrophic health expenditure for households with three or more chronic diseases, with inpatient service needs, or households with members aged 65 years or older (Wang et al. 2020).

There were other papers discussing socio-economic issues. It was found that the correlation between elderly income and the likelihood of living with their children proved nonlinear (Fan, Fang & Yang 2018). The

adoption of the Systolic Blood Pressure Intervention Trial treatment strategy would increase the number of Chinese adults requiring systolic blood pressure treatment intensification, but this approach had the potential to prevent cardiovascular disease, produce longevity and be cost-effective under common thresholds (Li et al. 2021). Research of income-related inequalities in chronic disease situations suggested that chronic disease prevalence among members of the population aged 45 to 59 years was greatly affected by income - prevalence ratios were highest for heart problems in 45 to 59 years middle-income males and for memory-related diseases in 45 to 59 years middle-income females (Qin, Huang & Ding 2019). Regarding fertility issues, the age of first childbirth, the childbearing period, and the number of births were significantly and positively correlated with the degree of depression among the elderly (Hu et al. 2020).

As for the labour force, the new rural insurance did not have a significant impact on the total labour supply of the rural middle-aged and elderly people, but the distribution of labour time changed significantly, non-agricultural employment time decreased, and agricultural self-employment time increased (Zhu 2021). The air pollution affected the medical expenditure: regression models suggested a robust linear association between reduced PM2.5 (particles that are 2.5 microns or less in diameter) and saved medical expenditures (Xue et al. 2021). Solid fuels (including coal, crop residue or wood-burning) use for five or more years was found to be associated with a shorter duration of sleep and higher frequencies of restless days of sleep compared with cleaner fuels (including electric, natural gas, and liquefied petroleum gas) users (Yu 2020).

As for “return migration behaviour” in mainland China, which refers to a phenomenon whereby rural people travel to metropolitan areas to work but return to their hometown after retirement, historical and socioeconomic factors affected this behaviour (Liu, Dou & Perry 2020).

These factors included a decline in health status, improved housing infrastructures and better access to community services, which called for flexible policies in China's social welfare system, comprehensive senior living facilities, and adequate support systems in rural communities (Liu, Dou & Perry 2020). Social capital improved the mental health of older adults in rural China significantly; the beneficial effect was stronger for females, people with lower income and older age (Wang et al. 2019). Social capital affected the mental health of rural older adults by raising the awareness of healthy behaviour and lowering the searching cost of health-related information (Wang et al. 2019). By investigating the patients' behaviour of giving extra money to doctors, the statistical results revealed that health insurance status in fact increased the probability of patients making informal payments to physicians while this association varied among population groups and insurance programs, particularly between social health insurance and private health insurance status (Liu, Bao & He 2020). Village farmers' intention to reallocate farmland due to changes in the village population increased when social security policies did not effectively cover the village (Huang & Tan 2018).

To search the CHARLS Database practice in the aged care industry, the research set the "CHARLS" and "needs" and "older people" or "aged care" as keywords and searched in Google Scholar. The research searched the results from 2015 to 2021 and finally found 58 results. Focusing on the aged care industry, the publications covered the field of health care and aged care provision (Li, Fang & Hu 2018; Falkingham et al. 2019; Li et al. 2019; Chen, Zhang & Xu 2020; Luo et al. 2020), mental and emotional health (Zhou, Ma & Wang 2021), care for older people with disabilities in China (Liu, Lu & Feng 2017), long-term aged care needs and cost as well as the policy design (Lu, Liu & Yang 2017; Giles et al. 2018; Xu & Chen 2019; Zeng et al. 2019; Hu, Si & Li 2020) and aged care system itself (Glinskaya & Feng 2018), poverty reduction (Wang et al. 2019) and aged

care policy targets that were related to defining vulnerable older people (Kong & Yang 2019).

The CHARLS Database was widely used for correlation analysis such as the relationship between economic status, family dependence and health outcomes (Guo, Chen & Perez 2019); the relationship between the number of offspring and the financial support to older people (Ren et al. 2015); the relationship between the variety, frequency, and type of Internet use and risk of depression in middle- and older-aged Chinese (Liao et al. 2020); the relationship among health, work and income (Mitra et al. 2020); the relationship between childhood health and social and economic variations during adulthood (Kendig et al. 2017); the relationship between cognitive performance and depressive symptoms (Zhou, Ma & Wang 2021). Some researchers tried to find associated factors in different aspects such as factors associated with healthy ageing among Chinese rural empty elderly nesters and future focus of health services (Fu, Wang & He 2020); prevalence and associated factors of self-treatment among the elderly (Gao et al. 2020).

The review did not identify any research using the CHARLS Database that is specifically related to mapping older people’s needs to assistive technologies. The research accordingly narrowed the keywords. Google Scholar was utilised for the search, using the keywords "CHARLS" and "assistive technology" and "needs" and "older" or "seniors". Literature from the year 2015 was reviewed but found that there were few papers illustrating the above topic. 22% of buildings had handicapped facilities and 12.9% of buildings had more than 25 steps to access the main entrance (Gadakari et al. 2017). The authors used this as part of the data to explain the design specifications for residential buildings for older people in China and encouraged refurbishment of homes through government funding, subsidiaries and more awareness of modern design and technologies (Gadakari et al. 2017). This research focused on the characteristic of residential places and older people’s awareness of the

potential optimisation of residential building design and the affordability of ageing-in-place. This research did not take advantage of older people's health and functional limitation information in the CHARLS Database, and did not systematically investigate older people's difficulties, disabilities, and personal activities.

The CHARLS Database was only used for part of the introduction data for a psychosocial game suite design for non-invasive cross-generational cognitive capabilities data collection (Ahmad et al. 2017). This research focused on older people's social participation and leisure activity. An extensive evaluation of the game suite was demonstrated to have high acceptability and attraction for its target users (Ahmad et al. 2017). This research had a very weak connection with the use of the CHARLS Database.

It can be concluded that though the CHARLS Database generated many research outcomes, based on its broad range of information related to health status, functional limitation, mental status, income and insurance etc, there were no researchers who organised the health and functional limitation and activity participation information to detect (this fitted the data characteristics of the CHARLS Database) older people's needs for assistive technologies. There were few outcomes discussing the needs of assistive technologies or illustrating any unmet needs and opportunities for their development and innovation.

2.5 THE THEORETICAL FRAMEWORK

This section introduces the theories related to older people, aged care and to mapping older people's needs to assistive technologies, as well as several theories that help with linking all theories together to form a macro-structure. These presented theories/frameworks are grouped into four types. Each section has its own contribution to the construction of the framework and to answering different questions in generating

research problems and questions. In the following 8 sections, theories in these sections are described first. Then, their value, connection and contribution to this research are explained.

2.5.1 THEORIES RELATED TO THE MACRO-STRUCTURE

In this section, three frameworks/models are presented, which explain why the number of older people is increasing and how this can be transformed into greater needs. These also justify that a better demographic outcome can be achieved by addressing the needs.

1. The "Proximate-Determinants Framework"

The "Proximate-Determinants Framework" has been applied extensively in the study of fertility and child survival in developing countries in study design, it can be applied in the analysis and interpretation of risk factors or intervention studies that include both biological and behavioural data, and in ecological studies. Creatively, the proposed research applies this framework to the aged care field. Key to the framework is the identification of a set of variables, called "proximate determinants," that can be influenced by changes in contextual variables or by interventions and that have a direct effect on biological mechanisms to influence health outcomes (Boerma & Weir 2005). The following figure 2 illustrates how the basic working flow of the "Proximate-Determinants Framework". In this research, this framework was used to guide a macro-structure that follows the ageing process, through the emergence of older people's needs, and finally to matching their needs to assistive technologies for better health outcomes.

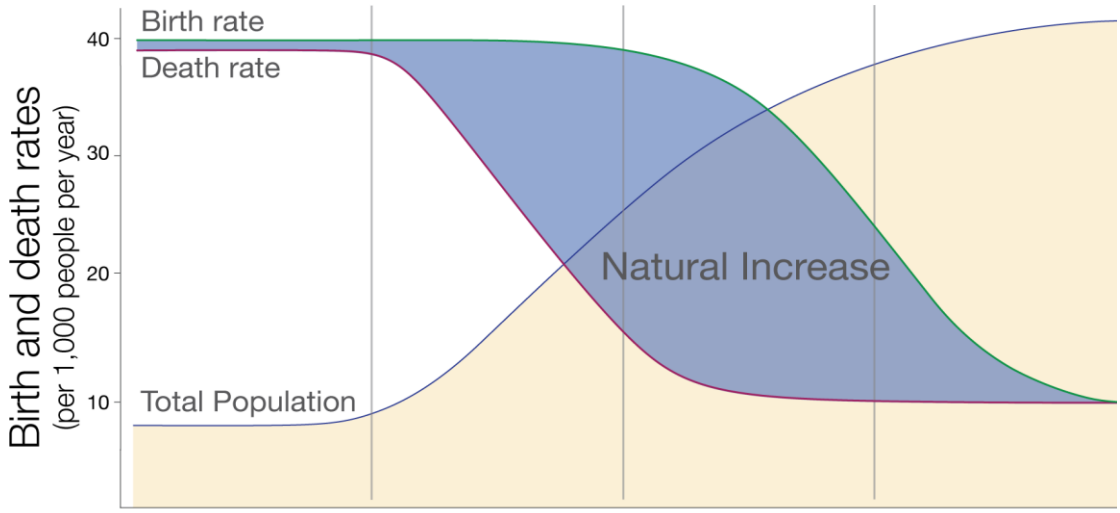
Figure 2 - General Logic of the Proximate-Determinants Framework

Source of the figure: (Boerma & Weir 2005)

2. The Demographic Transition Theory

The Demographic Transition Theory describes population change over time. It is based on the observed changes, or transitions, in birth and death rates in industrialized societies over the past two hundred years or so (Caldwell 2007). Changes in the birth and death rates can be divided into four stages. The first stage is the "High Fluctuating" stage, in which the birth rate and death rate are both high. As a result, population growth is slow and fluctuating (Montgomery 2007). The second stage is the "Early Expanding" stage, in which the birth rate remains high, but the death rate is falling. As a result, the population begins to rise steadily (Montgomery 2007). The third stage is the "Late Expanding" stage, in which the birth rate starts to fall, and the death rate continues to fall. As a result, the population is moved towards stability through a decline in the birth rate (Galor 2012). The fourth stage is the "Low Fluctuating" stage, in which the birth rate and death rate are both low, leading to a total population stable (Stolnitz 2017). Figure 3 illustrates the changes in birth rate and death rate according to the demographic transition process and the population pyramid as a result.

Figure 3 - The Demographic Transition Theory

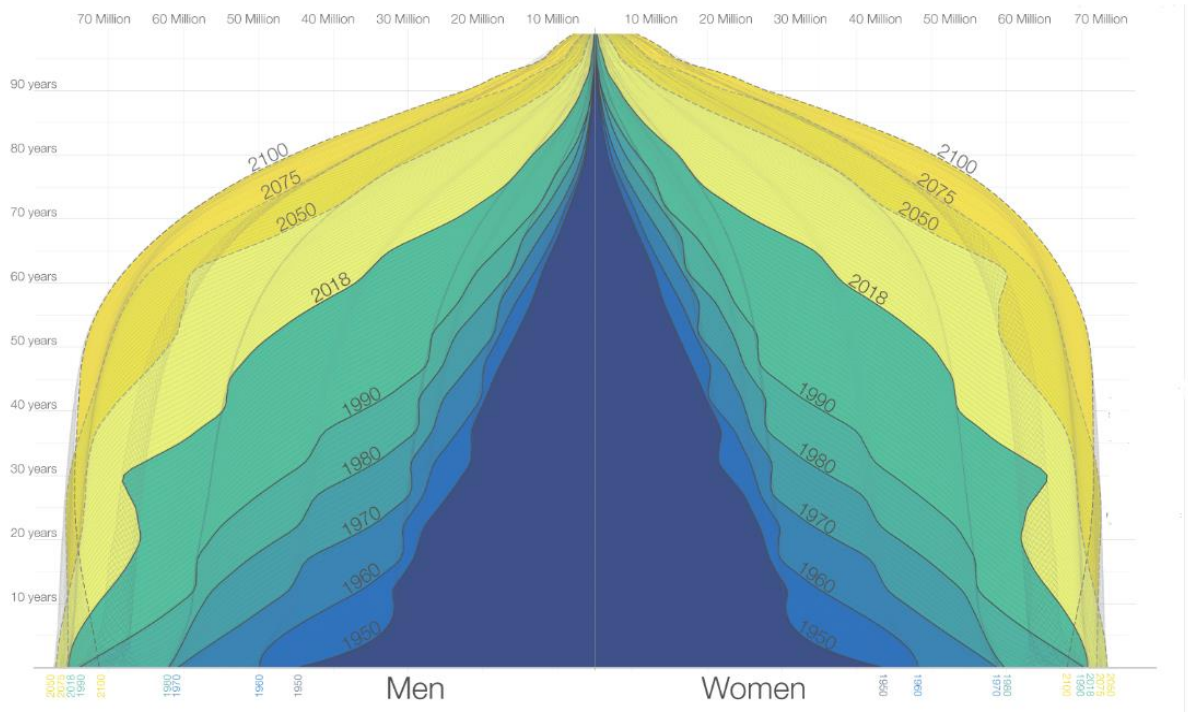


	Stage 1	Stage 2	Stage 3	Stage 4
Birth rate	High	High	Falling	Low
Death rate	High	Falls rapidly	Falls more slowly	Low
Natural increase	Stable or slow increase	Rapid increase	Increase slows down	Falling and then stable

Source of the figure: (Roser, Ritchie & Ortiz-Ospina 2013)

The Demographic Transition Theory explains why older people's demographics are expanding with the development of the country as the death rate declines earlier than the birth rate. A world population pyramid and projection shown below predict that the percentage of older people will be increasing.

Figure 4 - World Population Pyramid from 1950 to 2020



Source of the figure: (Roser, Ritchie & Ortiz-Ospina 2013)

3. Maslow's Hierarchy of Human Needs

The American psychologist, Abraham Harold Maslow, stated that "There are at least five sets of goals, which we may call basic needs. These are briefly physiological, safety, love, esteem, and self-actualization" (Maslow 1943). "These basic goals are related to each other, being arranged in a hierarchy of prepotency" (Maslow 1943). According to this theory, needs are divided into different levels (Crandall et al., 2019), with security, health and social involvement needs not in high levels that truly exist (Hale et al., 2019). Older people also have the common needs of security, health and social involvement, which assistive technologies can help. This is the basis of the research problems' existence - the need for assistive technologies do exist. Figure 5 shows the contents of each level of the Maslow's Hierarchy of Human Needs.

Figure 5 - Maslow's Hierarchy of Human Needs

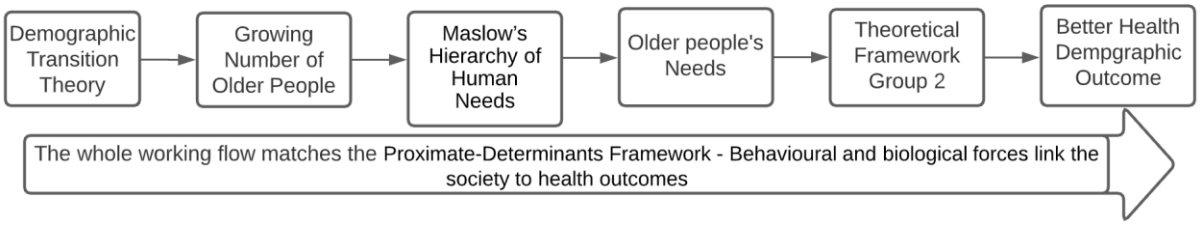
Source of the figure: (Grant 2021)

2.5.2 COMMENTS THEORIES RELATED TO THE MACRO-STRUCTURE

The value of the above-illustrated frameworks is to provide a macro-structure. The Demographic Transition Theory confirmed that the number and the percentage of older people in China will get more and more based on the current fertility rate of the Chinese people and the death rate. This is an important basis to inform the research because as the older population increases, the need to address their growing health needs and the potential for assistive technologies to do so, must be considered. The research that was undertaken in this thesis, which focuses on older people and assistive technologies to help them, promises to have a continued and sustained development, attraction and interest in the future according to the Demographic Transition theory. Maslow's Hierarchy of Human Needs contextualises the growing number of older people to foundational human needs. These included needs for personal safety, health and other physiological needs. This theory guided the researcher to focus on older people's needs providing their growing

number. Finally, the "Proximate-Determinants Framework" guided the analysis of older people's needs to the ultimate destination - reaching better health outcomes and demographic outcomes by addressing these needs. What kind of proximate determinants and biological determinants the researcher should choose and focus on, are not solved in framework group 1 shown in figure 6. They are informed in Frameworks illustrated in Section 2.5.3.

Figure 6 - The Logic of Framework Group 1



2.5.3 THEORIES RELATED TO AGED CARE, HEALTH, QUALITY OF LIFE

In this section, six frameworks/theories are presented. They are related to how older people can live a life where they can achieve their ADL goals, increase their quality of life and connect with families and communities to optimise health outcomes. At the end of the section, the common points of these six frameworks/theories are merged and concluded by the researcher.

1. The Active Aging Framework

This framework was originated by the World Health Organization. Active ageing is "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (World Health Organization 2002b). The most important parts of active ageing include the autonomy, which is the perceived ability to control, cope with and make personal decisions about how one lives on a day-to-day basis according to one's own rules and preferences, as well as the independence, which is the ability to perform functions related to daily

living (World Health Organization 2002b). Active ageing is an individual's striving for elements of wellbeing with activities as per their goals, abilities and opportunities (Rantanen et al. 2018). Active Aging is supported by three pillars, which are participation, health and security (World Health Organization 2002b). Figure 7 shows the determinants of active aging.

Figure 7 - The Active Aging Framework

Source of the figure: (World Health Organization 2002b)

2. The Ageing in Place Theory

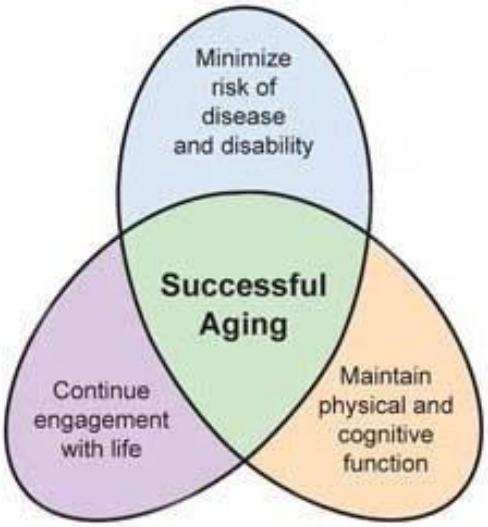
The ageing in place theory is about being able to continue to live in one's own home or neighbourhood and adapt to changing needs and conditions. It is of high concern due to the increasing number of old and very old people in all societies and challenges researchers, practitioners, and policymakers in many social and scientific areas and disciplines (Fänge, Oswald & Clemson 2012). The ageing in place theory used to refer to individuals growing old in their own homes, however lately the theory has broadened to remaining in the current community and living in the residence of one's choice (Vanleerberghe et al. 2017). Ageing in place can be achieved if the person has made preparations, the home is safe and

accessible, and there is a good support network in place; all of these factors can be greatly enhanced by early and comprehensive planning (Lee & Dey 2014). The above information suggests that assistive technologies and smart homes can play an important role in helping older people with ageing in place.

3. The Successful Aging Theory

This Successful Aging Theory consists of different ideas, and designs from different researchers. The theory has become an important concept to describe the quality of ageing that focuses on how to expand functional years in a later life span (Medeiros, Jackson & Perkinson 2016). The concept has developed from a biomedical approach to a wider understanding of social and psychological adaptation (Urtamo, Jyvakorpi & Strandberg 2019) processes in later life. One of the most important contribution to the theory is the Baltes' Model of successful aging (Baltes & Baltes 1990), which refers to the multidimensional avoidance of disease and disability, the maintenance of high physical and cognitive function, and sustained engagement in social and productive activities (Donnellan, 2015). Rowe and Kahn (1997) defined the avoidance of disease and disability, the engagement with life and high cognitive and physical function as three keys to a successful aging. Figure 8 shows the successful factors found by Rowe and Kahn (1997).

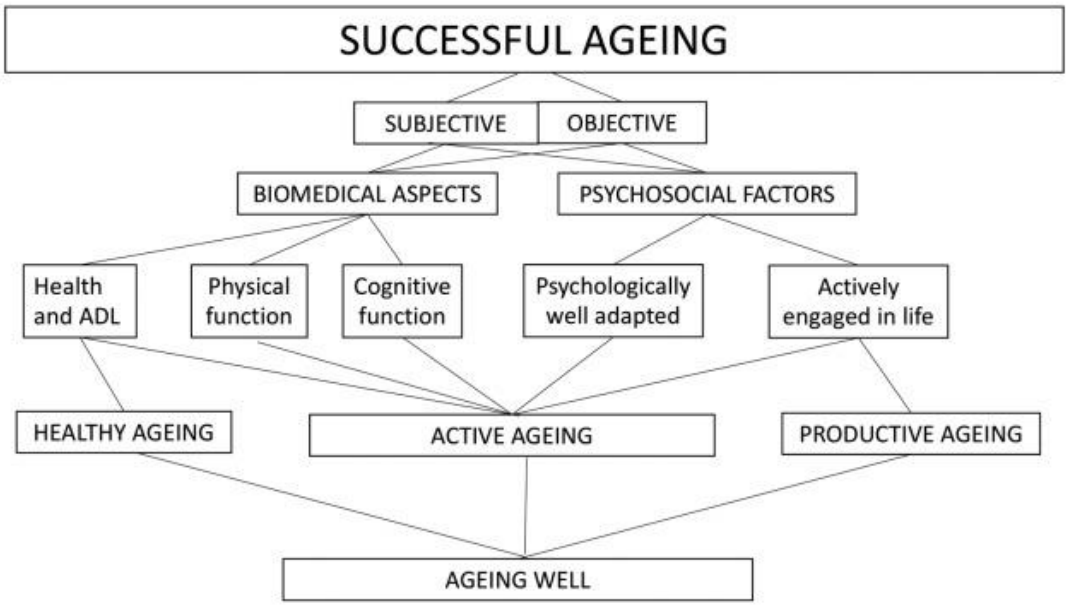
Figure 8 - Factors related to Successful Aging



Source of the figure: (Rowe & Kahn 1997)

Urtamo, Jyvakorpi and Strandberg studied the successful aging in biomedical aspects and psychosocial factors (Urtamo, Jyvakorpi & Strandberg 2019), which is shown in Figure 9. This is very similar to the foundation provided by sociotechnical theory illustrated above.

Figure 9 - Biomedical Aspects and Psychosocial Factors related to Successful Aging



Source of the figure: (Urtamo, Jyvakorpi & Strandberg 2019)

The goal of successful ageing is pertinent in today's ageing society. It focuses more on effective interventions to control and reduce disability and health risks and increase the ability to undertake ADLs. The theory now is suitable to be applied across the life span, improving older people's adaptively by maximizing their potential gains and minimizing losses (Donnellan, 2015).

4. The Continuity Theory

The continuity theory of normal ageing, as developed by Robert Atchley (Atchley 1999), states that older adults will usually maintain the same activities, behaviours, and relationships as they did in their earlier years of life, in other words, people attempt to maintain stability in attitudes and activities developed over the life course as part of the adaptation to growing older (Rowson & Phillipson 2020). According to the continuity theory, people who carry positive health habits, preferences, lifestyles and relationships from mid to later life age most successfully. On the other hand, inadequate social support and connection are associated with an increase in mortality and morbidity and a decrease in overall health and well-being. In addition, positive cumulative social experiences and emotional support are also associated with lower biological risk for morbidity and mortality (Skelton & Dinan-Young 2008).

5. The Social Model of Disability

The Social Model of Disability was developed by people with a disability to identify and take action against oppression and exclusion. It was developed as a direct challenge to the prevailing models of disability that viewed disability as an individual, medical problem that needed to be prevented, cured or contained, and as a charitable issue that viewed people with a disability as unfortunate who needed to be pitied and catered for by segregated, charitable services (Watson & Vehmas 2019). The Social Model of Disability is a radically different model from the medical and charitable approach to disability. It states that people have

impairments but that the oppression, exclusion and discrimination that people with impairments face is not an inevitable consequence of having an impairment but is caused instead by the way society is run and organised. The Social Model of Disability holds that people with impairments are 'disabled' by the barriers operating in a society that excludes and discriminates against them (Shakespeare 2006). Figure 10 illustrates the logic of the social model of disability.

Figure 10 - The Social Model of Disability

Source of the figure: (Inclusion London 2021)

6. The Activity Theory

The activity theory, also known as the implicit theory of ageing, normal theory of ageing, and lay theory of ageing, proposes that successful ageing occurs when older adults stay active and maintain social interactions (Schulz et al. 2006). The Activity theory is built around four major concepts: activity, equilibrium, adaption to role loss, and life satisfaction (Silverstein et al. 2008). It takes the view that the ageing

process is delayed, and the quality of life is enhanced when ageing people remain socially active - there is a positive relationship between a person's level of activity and life satisfaction, which in turn increases the self-concept and improves adjustments in later life. The activity theory rose in opposing response to the disengagement theory (Silverstein et al. 2008) which postulates that older people disengage themselves from the roles they occupied not only in relation to work roles but also in relation to families and social interactions.

2.5.4 COMMENTS ON THEORIES RELATED TO AGED CARE, HEALTH, QUALITY OF LIFE

The value of above-illustrated frameworks and theories is to guide the researcher of what aspects and dimensions to focus on the research. Interestingly, these frameworks and theories showed some common points: It can be concluded that all items mentioned in group two are related to and can be categorized into two aspects: technical aspect and social aspect. The technical aspect can be minimising the impact of diseases and disabilities, optimizing their safety and the overall quality of life. The social aspect can be building better connections and interactions between older people and family members and/or the community. Table 6 shows the specific technical and social aspect statement in each theory related to aged care, health and quality of life.

Table 6 - Technical and Social Statement in Each Theory

Theory Name	Social/Technical Aspect	Statement
Active Aging Framework	Social Aspect	Participation, wellbeing with activities
	Technical Aspect	Health and security
Aging in Place Theory	Social Aspect	Community environment and involvement, Activities of daily living, recreation
	Technical Aspect	Home modification, presentative healthcare, medical care,
The Successful Aging Theory	Social Aspect	Continue engagement with life
	Technical Aspect	Minimise the risk of disease and disability, Maintain physical and cognitive function
The Theory of Gerotranscendence	Social Aspect	Redefinition of the self and of relationships, more selective and active in social interaction
	Technical Aspect	Not mentioned
The Continuity Theory	Social Aspect	To maintain the same activities, behaviours, relationships
	Technical Aspect	Overall health and well-being
Social Model of Disability	Social Aspect	Families' isolation prevention, discrimination prevention
	Technical Aspect	Better building design, mobility assists to prevent medical problem
The Activity Theory	Social Aspect	To stay active and maintain social interactions
	Technical Aspect	Not mentioned

The above theories focus either on the technical aspect, including healthcare, medical care, security, living environment modification, disease and disability, physical and cognitive function, or on the other hand, the social aspect, including activities of daily living, recreation,

social interaction, involvement and behaviours, as well as relationships with families.

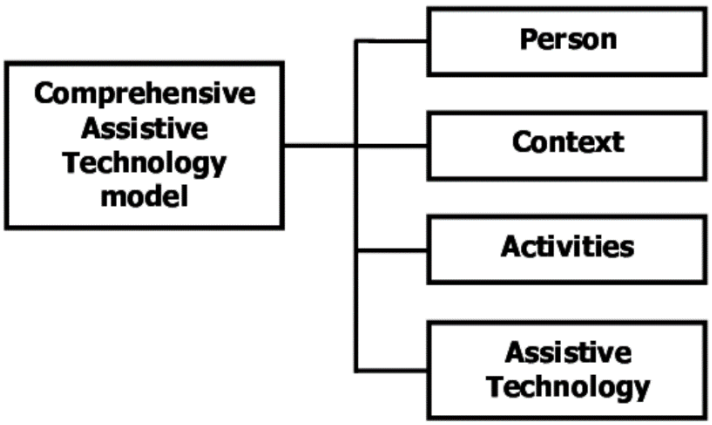
2.5.5 FRAMEWORKS USED FOR ASSISTIVE TECHNOLOGIES

The use of assistive technology is one of the solutions for enhancing older people's quality of life and successful ageing. The uses, needs, designs, developments and outcomes of assistive technologies can be assessed and detected in several systematic ways. These ways are called the models and frameworks used for assistive technologies. This research aimed to map older people's needs for assistive technologies and develop a practical framework that links older people's profiles and specific products. This section accordingly reported four frameworks related to assistive technology, functioning, disability, and health, as well as access and provision of assistive technologies. The research examined if the framework could help to detect assistive technology needs for older people and if any one of them can fit the data characteristics of the CHARLS Database when doing needs detection.

1. The Comprehensive Assistive Technology Model

The Comprehensive Assistive Technology (CAT) Model (Hersh & Johnson 2008) is a hierarchically structured model, with the four components of the person, the context, the activities, and the assistive technology at the top level and subdivisions of these components at the second and third levels (Nauha et al. 2018). The CAT aims to give a comprehensive description of an assistive or other technology system in terms of the characteristics of the person using it, the activities they are carrying out, the technical, end-user and other specifications of the technology and the context in which the technology is being used (Hersh & Johnson 2007). Figure 11 suggests the structure of the Comprehensive Assistive Technology Model.

Figure 11 - Comprehensive Assistive Technology (CAT) Model



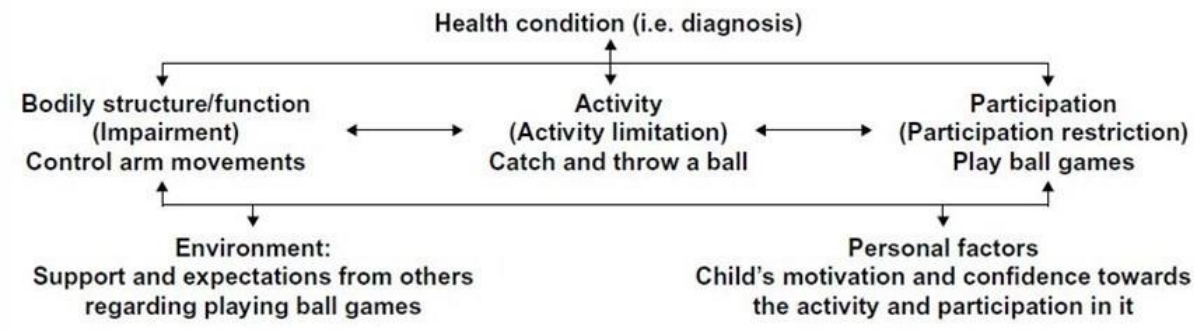
Source of the figure: (Hersh & Johnson 2010)

The Comprehensive Assistive Technology (CAT) Model is good to use for exploring the condition of use for each type of assistive technology. This framework focuses on product design specifications. It can be noted that the "person" aspect and "assistive technology" aspects are on the same hierarchical level. It is very difficult for this model to explore the opportunity for assistive technologies by checking older people's profiles, such as health status and activities participation. This framework is not suitable for detecting older people's needs.

2. International Classification of Functioning, Disability and Health

The International Classification of Functioning, Disability and Health (ICF) is a framework for organising and documenting information on functioning and disability (World Health Organization 2002a). It conceptualises functioning as a "dynamic interaction between a person's health condition, environmental factors and personal factors" (World Health Organization 2013). Figure 12 suggests the structure of the International Classification of Functioning, Disability and Health.

Figure 12 - The ICF Framework



Source of the figure: (World Health Organization 2013)

A Practical Manual of Using the International Classification of Functioning, Disability and Health (ICF) Exposure Draft for Comment. Geneva: 18. (World Health Organization 2013)

The ICF framework is the one that is the most related to this research. It includes health condition, functional impairment, and activity participation. As it is named, this framework is used for assessing human functioning and disability. This framework, as shown in figure 12, illustrates how the health condition and personal/environmental factors mutually affect each other. Health condition can be connected directly with assistive technology use and needs. On the other hand, the health condition is moderated and affected by bodily structure, activity and participation in this framework (World Health Organization 2013). The ICF Framework has provided all the correct elements that should be used in analysis using CHARLS Database. But it does not provide the correct logic when using the CHARLS Database. In this framework, health condition is either an independent variable that affects body function, activity and participation, or a dependent variable indexed by the condition of body function, the ability of activity and participation. The CHARLS Database in this research is used for providing older people's profiles, which are then further matched with the condition of use for assistive technologies. This research is not a mutual correlation analysis. To sum up, the ICF

Framework is of great value for reference, but a framework with more accurate logic is needed.

3. The Matching Person and Technology Model

The Matching Person and Technology (MPT) Model (Scherer & Craddock 2002) includes a set of questionnaires developed to identify the assistive technology that best matches a given person's needs, taking into account their skills, preferences and lifestyle. The process allows for organizing many influences which impact the use of assistive, educational, workplace, and healthcare technologies. These influencing factors include personal and social factors, the potential device user's motivation and readiness for technology use, as well as expectations of use, etc (Scherer & Craddock 2002). Figure 13 suggests the structure of the fundamentals of Matching Person and Technology Model.

Figure 13 - The Matching Person and Technology Model

Source of the figure: (García, T. P., et al. 2019)

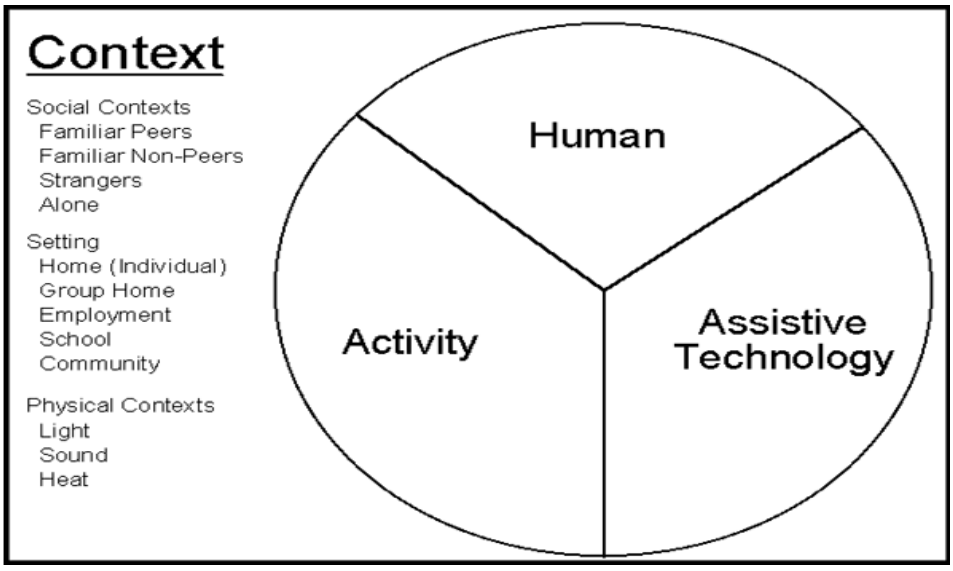
The Fundamentals of Matching Person and Technology Model look very comprehensive with around 20 aspects to accurately detect a person's

exact needs towards assistive technology. The data collecting process will be very complicated and time consuming thus this is only conductible with very few people. It is almost impossible to collect all the above factors among thousands of people and ensure the reliability and accuracy of each factor for each interviewee. Whilst this research aimed to map the needs of a large group of older people (older people in China) with assistive technologies, it cannot conduct this Matching Person and Technology Model.

4. Human Activity Assistive Technology (HAAT) Model

Four core concepts of the Human Activity Assistive Technology (HAAT) Model (Cook & Hussey 2002) influence successful engagement in meaningful occupation: the human; the activity; the assistive technology and the context - physical, social, cultural and environmental (Giesbrecht. 2013). There is a dynamic interaction between the initial three factors of the human, the activity, the assistive technology and a pervasive influence of the context on them, both individually and collectively (Giesbrecht. 2013). Figure 14 suggests the structure of the Human Activity Assistive Technology Model.

Figure 14 - The Human Activity Assistive Technology Model



Source of the figure: (Cook & Hussey 2002)

The Human Activity Assistive Technology Model suggests the interactions between the activity, the human, the context, and the assistive technology (Elsahar et al. 2019). The elements in this model look comprehensive and reasonable. This framework is mainly used to describe a process for prescribing an assistive technology or a solution, optimally suited for a person with a disability; it was also designed to guide assessment and evaluate the result (Giesbrecht 2013). This framework is still an assistive technology provision model, though it does identify that the assistive technology need is determined by human and the activity. It is better to be used for a technology provision or prescription research, but not needs-driven research. This research was driven by older people's needs detected from older people's profiles stored in the CHARLS Database. Thus, the HAAT model was not suitable to use for this research.

2.5.6 COMMENTS ON FRAMEWORKS USED FOR ASSISTIVE TECHNOLOGIES

All frameworks in this section are theories, models and frameworks that can help to explain people's assistive technology needs and how to optimise the provision and use of assistive technologies. A user's health status, attitudes and preferences, knowledge, financial status, personal and social activities participation, all have effects on the needs for and outcomes of assistive technologies. It is critical for researchers to see what information and data are available and the characteristics of data before choosing a suitable, reasonable and accurate model related to assistive technology (Watts, O'Brian & Wojcik 2003). A framework that is suitable to be used for this research should meet the following criteria at the same time: it provides the correct elements to focus on; the provided elements suit the data availability and characteristics of the CHARLS Database, and it provides a proper instruction to systematically filter the information from the database. As it is commented after each illustration

of the framework, all these four frameworks failed to suit the CHARLS Database which was extensively used in this thesis. As a result, this research needed an innovative adoption and smart use of a framework that helps to detect older people's needs for assistive technologies from the CHARLS Database – the Sociotechnical Theory. This framework is illustrated in Section 2.5.7.

2.5.7 THE SOCIOTECHNICAL THEORY AND THE GROUNDED THEORY

All frameworks illustrated in Section 2.5.5 were not considered to be suitable to be used against the CHARLS Database – they were either not suitable for needs-driven research or not feasible to the CHARLS Database characteristics. Theories related to older people, aged care, health, quality of life in Section 2.5.3 showed two common aspects in use - technical aspect and social aspect. Based on this, the research introduced the sociotechnical theory for analysing and matching older people's needs with assistive technologies in two aspects: the technical aspect and the social aspect. The model chosen for this research needs to be highly applicable to the characteristics of the CHARLS Database. The tool selected must fit the database. To justify the starting from the access to the database, this section explains the use of grounded theory which allows a research design to cooperate with the data availability.

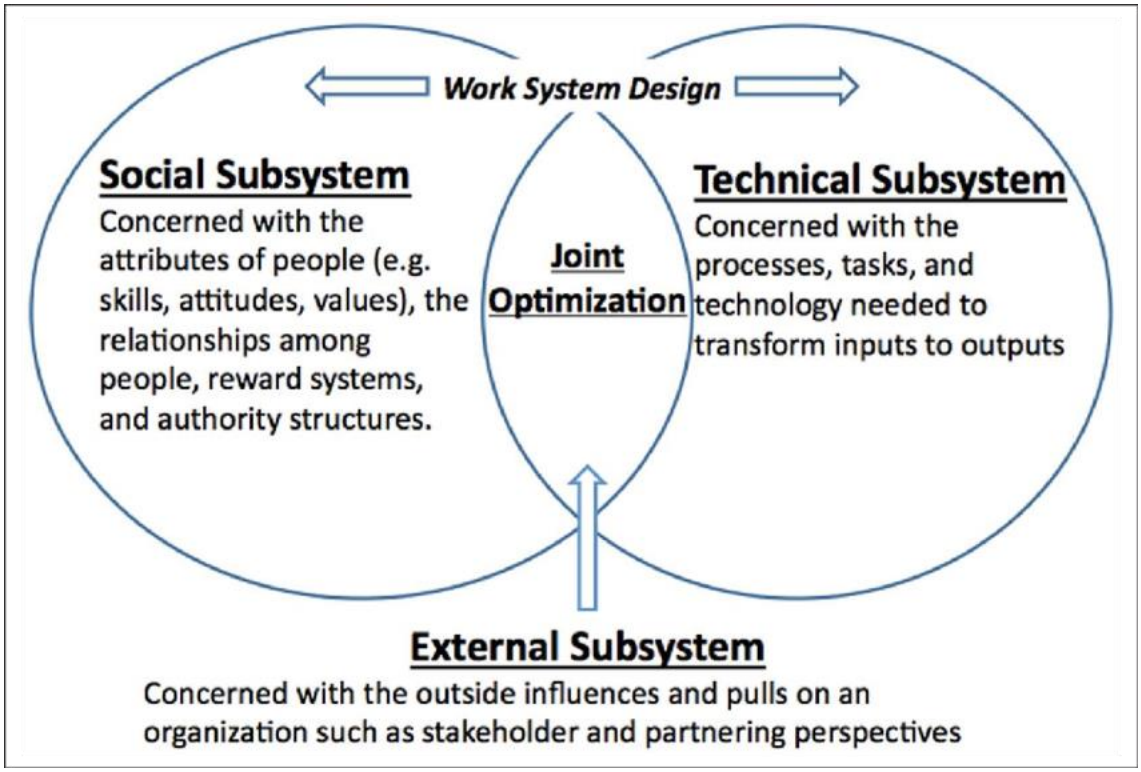
1. Sociotechnical theory

Sociotechnical theory views an organization as a work system with two interrelated subsystems: the technical system and the social system (Bostrom & Heinen 1977). Sociotechnical theory involves three main factors: people, technology, and task (Lu et al. 2011). The technical system is concerned with the processes, tasks, and technology needed to transform inputs such as raw materials to outputs such as products; the social system is concerned with the relationships among people and their

attitudes, skills, and values. The outputs of a work system are a result of the joint interaction between these two subsystems (Xiang, Archer & Detlor 2014).

Sociotechnical theory was first used for joint optimization, with a shared emphasis on the achievement of both excellence in technical performance and quality in people's work lives (Bostrom & Heinen 1977). Sociotechnical theory, as distinct from sociotechnical systems, proposes a number of different ways of achieving joint optimisation (Bostrom & Heinen 1977). They are usually based on designing different kinds of organisations, ones in which the relationships between social and technical elements lead to the emergence of productivity and wellbeing (Tetiana & Yuliya 2019). Figure 15 illustrates the cooperation of social subsystem and technical subsystem in sociotechnical theory to reach joint optimization.

Figure 15 - Sociotechnical Theory's Original Logic



Source of figure: (Militello et al. 2014)

There are four values of sociotechnical theory that are supportive of this thesis:

A. Technology as a tool to assist humans.

The aim of technology should be to promote human adaptability and learning, rather than requiring the person to adapt to it (Eason 2014). This value aims to avoid the common scenario where a technical solution is implemented as a panacea to a problem, with little or no consideration of the goals of people's work or the social system required to make the technology work within an open system (Eason 2014).

B. To promote quality of life.

Instead of humans being allocated those tasks that cannot be performed by technology, humans should only be allocated those tasks that justify the use of humans and utilises human skills and judgement. Technology should be designed to fulfil the remaining functions (Norros 2014).

C. To respect individual differences

People have different needs and preferences. Access to assistive technologies should aim to achieve a flexible outcome that incorporates different preferences, acknowledging that meeting all needs may not always be possible (Read et al. 2015).

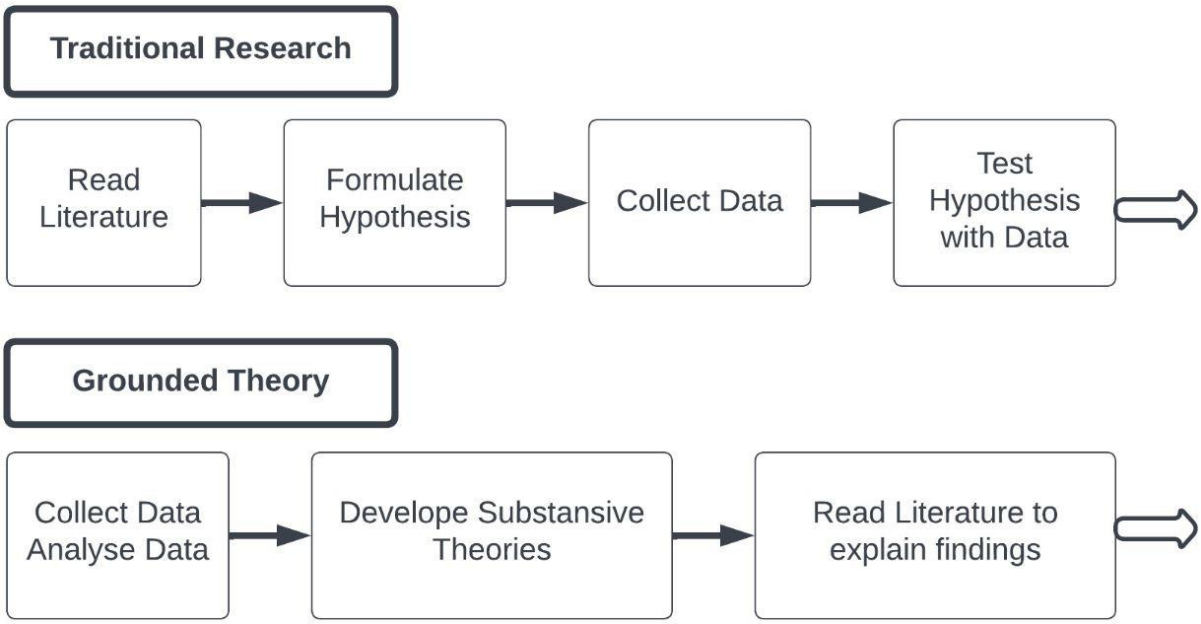
D. To consider humans as assets

Rather than characterising humans as "unpredictable, error-prone and the cause of problems in an otherwise well-designed technological system", sociotechnical systems theory acknowledges that no technical system is perfect and that people are assets as they are capable of identifying the need for change and of learning and adapting, making them effective problem-solvers (Hendrick 1995; Clegg 2000).

2. Grounded Theory

Grounded theory sets out to discover or construct theory from data, systematically obtained and analysed using comparative analysis (Lambert 2019). While grounded theory is inherently flexible, it is a complex methodology (Chun Tie, Birks & Francis 2019). The following Figure 16 shows the differences between traditional research theory and grounded theory.

Figure 16 - Differences between Traditional Research Theory and Grounded Theory



Source of figure: (Mediani, H. 2017)

2.5.8 USING SOCIOTECHNICAL THEORY AND THE GROUNDED THEORY

The Sociotechnical Theory has two contributions to this research: Firstly, it is a suitable framework to indirectly and systematically detect older people's needs for assistive technologies from the CHARLS Database. Secondly, it algins to and concludes the guidance of theories in Section 2.5.3. As mentioned in Section 2.4, the CHARLS questionnaire provided various questions related to different aspects of older people's conditions including their general health status, functional limitation, illness and

diseases as well as activities participation. Information in the CHARLS Database was in various metrics and needed to be organised systematically. Frameworks in 2.5.5 reviewed several frameworks for assistive technology analysis and assessment but none of them were considered suitable for the characteristics of the CHARLS Database. Therefore, there is a need to adopt a new theory that not only helps to analyse older people's needs for assistive technologies but also fits the data characteristics of the CHARLS Database, at the same time, it should also be in accordance with the theories in the section 2.5.3.

In this situation, this section introduces an innovative adoption and practice of sociotechnical theory to derive information from the CHARLS Database systematically and map older people's disability, disease and illness, personal and social activities to assistive technologies. According to the selected assistive technologies and the condition of use for each one of them, the adoption of sociotechnical framework scans and chooses related questions in the CHARLS Database in five steps: first, to divide the condition of use into two aspects, social aspect and technical aspect; second, to divide the social aspect into personal activities and social activities, to divide technical aspects into disabilities and diseases & illnesses; third, to list the detailed condition of use in each sub-aspect (the thesis calls the detailed condition of use as "explanation of the factor"); fourth, to determine what primary factors are and what secondary factors are; fifth, to link each factor in each sub-aspect with related questions in the CHARLS questionnaire.

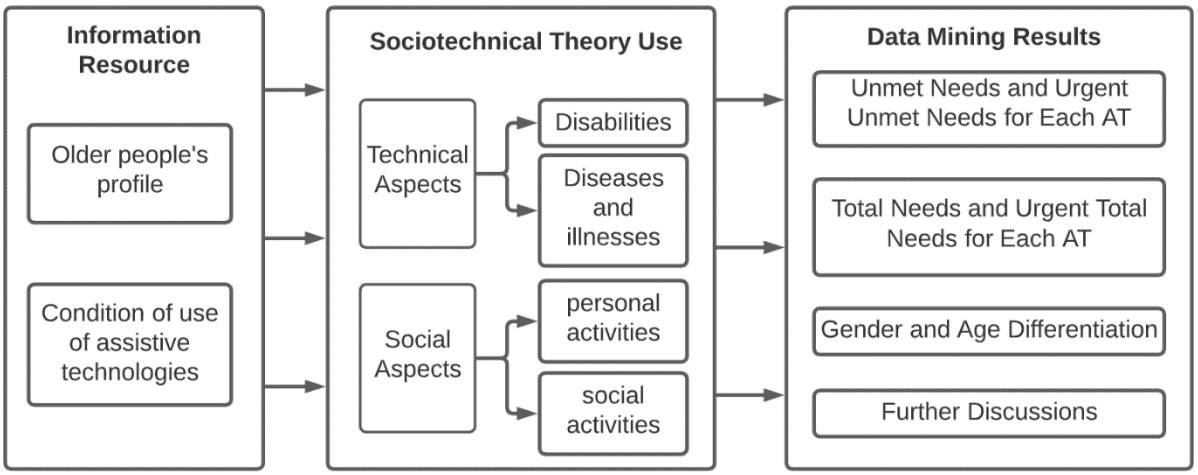
The Grounded Theory fitted the reported research in the following way.

The research data were accessed through the CHARLS Database. The research carefully checked what data was available and what metrics and characteristics are available with the data. The findings could be concluded as A), The content of the database involves a broad range of issues related to older people including demographic backgrounds, family, health status and functioning, health care and insurance, work, retirement

and pension, income, expenditures and assets as well as housing characteristics; B), Within the database, there are mixed and complicated metrics/scales of answers to questions including numeric variable, 5-point and 4-point Likert scale, binary option ("yes" or "no"), multiple choices, etc. This referred to the first step in the Grounded Theory Working Flow shown in Figure 16.

The research then reported the literature review work and found the knowledge gaps. The knowledge gaps were that few research study findings specifically suggested the needs, unmet needs, and urgent unmet needs of various priority assistive technologies in China. Moreover, there was no suitable assistive technology conceptual framework existed for the CHARLS Database. After finding five unsuitable frameworks, this research found that an innovative adoption of Sociotechnical Theory could help fill the gaps by coding and categorizing questions and information in the CHARLS Database into older people's diseases and illnesses, and disabilities (functional limitations), personal and social activities participation. Mapping these coded and categorized information with the condition of use of selected assistive technologies (condition of use of selected assistive technologies came from the literature review) could fill the knowledge gap of needs, unmet needs and urgent unmet needs of assistive technologies. The operational flow of using Sociotechnical Theory to detect the needs, unmet needs and urgent unmet needs of assistive technologies is shown Figure 17.

Figure 17 - Working Flow of this Research Based on Sociotechnical Theory



2.5.9 SUMMARY OF THEORETICAL FRAMEWORK

The section on theoretical frameworks provided four groups of theories, models and frameworks. Group one, which includes the "Proximate-Determinants Framework", demographic transition theory and Maslow's Hierarchy of Human Needs, illustrated the trend of a growing number of older people and their growing needs and identified a research orientation that addressing older people's needs will generate better biological and social outcomes. Group two, which includes several theories related to aged care, older people's health and quality of life, provided ample information on what contributes to a successful ageing and high quality of life for older people. Group two theories informed the technical and social aspects of the socio-technical approach. Group three, which included several models and frameworks used for assistive technologies, were examined for their suitability to use against the CHARLS Database. Though not all of them are designed for assistive technology needs analysis, these models and frameworks provided comprehensive elements and factors to consider when matching older people's needs to assistive technologies. Considering the data characteristics and questions design of the CHARLS Database and its questionnaire, none of the above-illustrated models provided a suitable instruction to explore and extract information

theoretically from the database. Informed by the technical and social aspects that emerged from group two, group four, the sociotechnical theory and the grounded theory, provided the basis by which to extract information related to older people's needs for assistive technologies from the CHARLS Database for this thesis. The socio-technical approach helped to petition data so that it could be analysed on the basis of social and technical perspectives. Figure 18 shows the antecedents, moderators, mediators and outcomes of this research.

Figure 18 - Antecedents, Mediators, Moderators and Outcomes

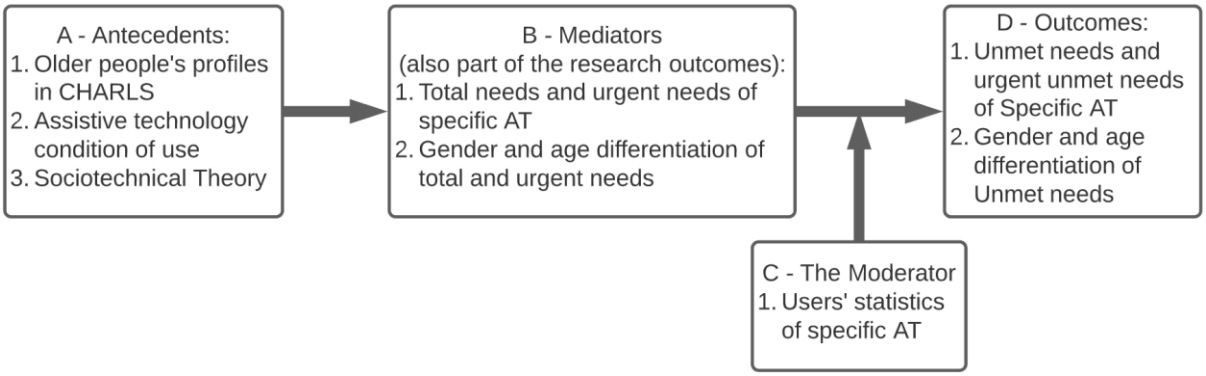


Figure 18 shows antecedents (box A), mediators (box B), moderators (box C) and outcomes (box D) of the research conduction process. Box A shows that the research starts with the access to the CHARLS Database which provides older people’s profiles. Together with the information on the condition of use of selected assistive technologies, the sociotechnical theory can provide ideas to systematically match older people's profiles with the condition of use of selected assistive technologies. Box B shows mediators that are generated from antecedents. Total needs and urgent needs of specific assistive technology as well as the gender and age differentiation of total and urgent needs are calculated by matching older people’s profiles with the condition of use of assistive technologies. The matching process is guided by the Sociotechnical Theory. Box D shows outcomes, which are unmet needs and urgent unmet needs of specific assistive technology as well as the gender and age differentiation of unmet needs. These outcomes are moderated by users’ statistics

information, which is shown in box C. Total needs for assistive technology include users (refer to met needs) and non-users (refer to unmet needs). When there are more users, there are fewer unmet needs.

2.6 SUMMARY OF FINDINGS AND KNOWLEDGE GAPS

The following table briefly concludes the literature review findings, gaps and limitations in the above sections. Accordingly, Table 7 suggests their influence on framework development and design.

Table 7 - Literature Review Findings, Gaps and the Indication for Research Design

Literature review findings, gaps and limitations	Influence on framework development and design
Hierarchy of needs **Findings:** Guided researchers about what needs shall be included in the research. Physiological needs, safety needs, love and belonging needs are in the most basic, second basic and middle layer of People's hierarchy of needs (Maslow 1943; Crandall et al. 2019; Hale et al. 2019) **Gaps:** This is purely a theory illustrating human needs. Researchers should map these needs to their research interests.	Both the needs and assistive technologies in the mapping framework should include the needs related to older people's health, safety, friendship, family, and sense of connection.
Older people's needs **Findings:** Older people's needs for assistive technologies are related to health, leisure, living, safety, communication, family relationship and social involvement (Lee, Lim & Lee 2015). **Gaps:** Technology-push research outcomes are much more than needs-driven research outcomes. No needs-driven research indicated the accurate unmet needs of various specific priority assistive technologies in China.	The frameworks must focus on older people's profiles related to their needs to help with identifying the unmet needs for several specific assistive technologies.

The detection of older people's needs **Findings:** Older people's needs can be detected in several ways, both direct and indirect. These ways can be face to face interviews (Burrows, Gooberman-Hill & Coyle 2015; Boman, Persson & Bartfai 2016; Egan & Pot 2016; Kamilaris, Kondepudi & Danial 2016; Smaerup et al. 2017; Bedaf et al. 2018; Meristö 2018; Thoma-Lürken et al. 2018; Callari et al. 2019), telephone consultation (O'Connell et al. 2018; Kim 2019), home visits (Löfqvist et al. 2016; Nasr et al. 2016) or observation within a project (Casten, Rovner & Fontenot 2016; Chu et al. 2017; García-Soler et al. 2018). **Gaps:** Older people have limited awareness of available assistive technologies. Direct communication with them sometimes cannot get accurate information relate to their needs.	The framework must guide the research to detect older people's needs in an indirect way, which is analysing a database. Older people's profiles such as health status, functional limitations and everyday activities suggest ample information for data analysis, which can be more reliable and accurate than older people's own expression of needs.
CHARLS Database and its data characteristics **Findings:** The CHARLS Database questionnaire is not a standard questionnaire which concentrates on one main issue with one or very few answer metrics. Instead, it is a comprehensive database for researchers in different fields. There are mixed and complicated questions and metrics/scales in it (National School of Development of Peking University & Institute of Social Science Survey of Peking University 2020; Zhao et al. 2020). **Gaps:** None of the existing frameworks specifically designed for assistive technology study suit the data characteristics of the CHARLS Database regarding assistive technology research.	The framework must fit the data characteristics of the CHARLS Database in order to explore older people's needs to assistive technologies. That means the framework should be applicable to many questions in different fields and in different metrics and should be able to guide the research to systematically pick and cull related questions in the CHARLS Database for analysing the need for different kinds of assistive technologies.

Research outcomes generated by using the CHARLS Database **Findings**: Outcomes were about general health topics (Liu, Xu & Yang 2018; Wang 2018; Wu & Wang 2019; Su et al. 2020; Sun et al. 2020; Wang et al. 2021), mental health (Fang 2019; Liu et al. 2019; Wen et al. 2019; Lam et al. 2020; Yi et al. 2021), medical care services (Shi et al. 2017; Shiyong & Dan 2017; Chen, Zhang & Xu 2020; Leng et al. 2020), aged care service and system (Li & Wang 2017; Pi, Wu & Li 2019; Zhou & Yang 2021), and socio-economic issues (Fan, Fang & Yang 2018; Qin, Huang & Ding 2019; Yu 2020; Li et al. 2021; Xue et al. 2021). **Gaps:** No research outcomes generated by the CHARLS Database specifically suggested the needs, unmet needs and urgent unmet needs of various priority assistive technologies in China.	The research framework should start with the access to the CHARLS Database and the awareness of what data are available in the CHARLS Database. Then, a working flow can be grounded in the analysis of unmet needs or provision gaps of assistive technologies based on the study of data. This thought strongly indicated that the Grounded Theory should be applied.
Theories related to older people and successful aging **Findings:** Successful ageing includes healthcare, medical care, security, living environment modification, prevention of disease and disability, optimization of physical and cognitive function, activities of daily living, recreation, social interaction, relationship with families, etc (Baltes & Baltes 1990; Rowe & Kahn 1997; Atchley 1999; World Health Organization 2002b; Schulz et al. 2006; Shakespeare 2006; Silverstein et al. 2008; Lee & Dey 2014; Donnellan 2015; Vanleerberghe et al. 2017; Watson & Vehmas 2019; Rowson & Phillipson 2020). **Gaps:** These factors need to be systematically concluded into a framework that can be used against the CHARLS Database.	A useful framework to map people's needs to assistive technologies from the CHARLS Database should not only perfectly fit and include all factors mentioned in theories related to older people and successful ageing but also fit the data characteristics of the CHARLS Database.

Frameworks related to assistive technologies **Findings:** There are several frameworks related to assistive technology, functioning, disability, and health, as well as access and provision of assistive technologies (Cook & Hussey 2002; Scherer & Craddock 2002; World Health Organization 2002a; Hersh & Johnson 2007, 2008; Giesbrecht. 2013; World Health Organization 2013). **Gaps:** All the reviewed frameworks failed to suit the data characteristics of the CHARLS Database.	The research does on data analysing on the CHARLS Database thus the framework must fit the data characteristics of the CHARLS Database in order to explore older people's needs for assistive technologies. Any theory that is not originally designed for data analysing but is still related to older people's health status, functional limitations and everyday activities can be innovatively adopted as long as it fits the data characteristics of the CHARLS Database.

In relation to Table 7, various knowledge gaps emerged from each of the theoretical findings with some similarities and overlaps. Those gaps can be merged into two main knowledge gaps in relation to ascertaining opportunities for assistive technologies according to older people's needs based on the data analysis of the CHARLS Database.

Knowledge gap 1: There was no suitable assistive technology theoretical framework that explores how the CHARLS Database item constructs can be analysed, investigated, and applied to solve user-health needs. As stated in Section 2.4.2, the characteristics of the CHARLS Database suggest that the database is designed for extensive use in several fields. It is not specifically designed to identify User Needs (UNs) which are defined in this thesis as total users' unmet needs and highly/urgent unmet needs. There was no current method related to how assistive technologies (ATs) inform and solve problems related to UNs. Few research frameworks provided an adequate framework by which older people's needs can be matched to ATs. Accordingly, the existing frameworks used for assistive technology stated in extant research (World Health Organization 2001; Cook & Hussey 2002; Fuhrer et al. 2003; Scherer et al. 2007; Hersh & Johnson 2010; World Health Organization

2013; García et al. 2019; Menich 2019), although valuable within different health/need contexts, cannot be used as measures of UNs. This is the first gap to be explored in this thesis.

Knowledge gap 2: Few research study findings explored how ATs can be applied to address UNs within China. Chapter 2 discussed how most studies exploring the relationship between ATs and UNs have been conducted in high-income countries such as the USA (Rubenstein 2006; Bliss et al. 2011), Germany (Fujak et al. 2010), Canada (Medical Advisory Secretariat 2008; Mattison et al. 2017; Berardi, Smith & Miller 2021) and Switzerland (Eide et al. 2019). Some studies have been conducted in middle- and low-income countries such as India (Hegde et al. 2019), Bangladesh (Borg & Ostergren 2015), Nepal, Botswana (Eide et al. 2019), and some underdeveloped countries such as Cameroon (Smith et al. 2016; Tangcharoensathien et al. 2018; Boggs et al. 2019), Syria (Hiscock 2019), and Lesotho, Zambia, Namibia, Malawi and Mozambique (Eide et al. 2019). Given the high population of China compared with the USA, Europe and other countries, it was very surprising that there had been very limited research on China compared with their western counterparts. This thesis explored this second gap.

In conclusion, few theoretical frameworks provided an adequate methodology to explore how ATs could be used to address UNs and this is particularly the case in China. As a result, this research developed a comprehensive innovative and theoretical framework to address gaps one and two such that UNs and other knowledge could be analysed, investigated, and applied to solve the user-health needs of older people in China. The framework is expected to provide a means for health professionals to be able to better use the existing data of the CHARLS Database to help solve the health needs of older people in China.

2.7 IDENTIFYING RESEARCH PROBLEMS AND QUESTIONS

2.7.1 THE STATEMENT OF RESEARCH PROBLEMS

What are the opportunities for assistive technologies in relation to Chinese older people's health needs and independent living? How can these opportunities be identified and detected from the CHARLS database?

2.7.2 THE STATEMENT OF DETAILED RESEARCH QUESTIONS

The research questions are based on the knowledge gaps and research problems stated in Section 2.6 and 2.7.1.

Research Question 1:

What theoretical framework provides a method to best explore the user needs identified in the CHARLS data?

Research Question 2:

2.1 What are older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities?

2.2 What are the unmet needs and urgent unmet needs for assistive technologies that can be identified from the CHARLS Database?

2.3 What are the total needs and urgent total needs for assistive technologies that can be identified from the CHARLS Database?

2.4 What differentiation exists with respect to users and users' needs (both unmet needs and total needs) between gender and age?

Research Question 3:

What opportunities exist for assistive technologies to assist older people with healthcare and independent living?

CHAPTER 3 : RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This research aimed to match older people's needs with assistive technologies. The previous chapter identified the knowledge gap from the literature review. This chapter first proposes the research questions to try to address the gap. Based on the identified research question, this chapter introduces how the research was undertaken. The chapter introduces the research paradigm that includes ontology, epistemology and the philosophical orientation of this research. This chapter then explains the qualitative approach used in this research. Subsequently, the chapter presents the reason for selecting the CHARLS Database, how the CHARLS Database provides the variables required for the research questions and the process of accessing and obtaining the data. The chapter then explains the method used to systematically choose questions from the database, the method to analyse the chosen data in order to detect older people's assistive technology needs based on sociotechnical theory, and the method to describe and test the data. This chapter also explains the strategy to recruit aged care experts for data interpretation after the analysis results were generated. Finally, the validity, reliability and the limitations of the research are explained.

The process of methodology design received assistance and guidance from Adjunct Associate Professor Latif Al-Hakim (University of Southern Queensland) from Aug 2020 to March 2021.

3.2 RESEARCH PARADIGMS

This section discusses the ontology and epistemology, and the philosophical orientation of this research. The ontology leads to the

epistemology, and the epistemology leads to the philosophical orientation. These three elements together guide the researcher to choose an appropriate methodology for this thesis. This section not only describes this orientation but also explains the reasons for choosing them and the connections between the philosophical orientation and the research.

3.2.1 ONTOLOGY, EPISTEMOLOGY AND PHILOSOPHICAL ORIENTATION OF THIS RESEARCH

Ontology seeks to provide a definitive description of entities (Liamputtong 2019). There are several types of ontological approaches. Starting from the spectrum of "one reality exists" and ending up with "multiple realities exist", then the referred ontology goes from realism, which indicates that one reality exists and reality can be understood using appropriate methods (Moon & Blackman 2014), to relativism, which means there are multiple realities existing as intangible mental constructions (Moon & Blackman 2014). This research is based on realism ontology.

Epistemology refers to how an individual understands knowledge, how a researcher understands the thinking process and how a researcher can examine or detect the reality. Epistemology focuses on the nature, limitations, and justification of human knowledge (Hathcoat, Meixner & Nicholas 2019). Typical epistemology approaches include objectivism, which means an objective reality exists in an object independent of the subject; constructionism, which means that the truth is created from the interplay between the subject and object; and subjectivism, which means the subject imposes the meaning of an object (Moon & Blackman 2014). This research is based on objectivism epistemology.

Ontology and epistemology together contribute to the research philosophical orientation, which gives a holistic view of the value of knowledge to a researcher. Common philosophical orientation ranges from positivism, which suggests that knowledge can be measured and

positively applied to assist human progress (Cruickshank 2012), to constructivism, which suggests that knowledge needs to be interpreted to discover the underlying meaning (Keaton & Bodie 2011), and to pragmatism, which suggests that reality is constantly negotiated, and debated (Keaton & Bodie 2011). This research is based on the positivism philosophical orientation in social research. It is proposed that scientific knowledge and principles can be derived from logical proof or mathematical calculation.

3.2.2 THE CONNECTION BETWEEN THE CHOICE OF PARADIGMS AND THIS RESEARCH

The "truth" in this research refers to older people's needs and unmet needs for assistive technologies. These needs and unmet needs always exist according to older people's challenges in everyday life, the provision and unequal access to assistive technologies, and the awareness of what is available and what is still needed from a personal and social perspective.

Since there is the truth of existing needs, unmet needs and the opportunities of assistive technologies, the truth can be detected in systematic ways, by logical proof or mathematical calculation. Many tools, such as information relating to older people's health, illness, participation in personal and social activities, their financial status, their awareness and attitudes towards assistive technologies and the barriers to adoption of assistive technologies, are available to systematically detect the truth from an objective perspective.

The research studied the condition of use of several types of assistive technologies, and then adopted a systematic methodology to match the condition of use to older people's health and illness, and personal and social activities participate to judge how many older people in China are in need of any one or more assistive technologies. This study process, in

other words, this approach for detecting the reality, is repeatable for any other researchers who aim to study any other types of assistive technologies that are not included in this research or to study similar related topics such as smart home technology software. Answers to research questions in this thesis exist and can be discovered, systematically studied and interpreted, and can be repeated with the same research methodology to generate the same results. This research draws upon realist ontology, objectivist epistemology, and the positivist philosophical orientation in social research.

3.3 EXPLANATION OF QUALITATIVE APPROACH

A qualitative approach is used to understand concepts, thoughts or experiences; it focuses on exploring ideas, analysing by summarizing, categorizing and interpreting, as qualitative studies address the social aspect of research (Choy 2014). A qualitative research approach is often employed when the problem is not well understood and there is an existing desire to explore the problem thoroughly (Mohajan 2018). Typically, the researcher uses a rich narrative from the participant and provides analysis to answer the research question (Polit & Beck 2020). Open-ended questions and interviews can be used to uncover the problem and address it comprehensively (Rutberg & Bouikidis 2018). Types of qualitative research include ethnography, phenomenology, grounded theory, historical research, and case studies (Cibangu 2012).

This research, though, generated several tables illustrating numbers and percentages of older people's needs, urgent needs, unmet needs and urgent unmet needs for assistive technologies, the research mainly follows a qualitative approach. The research questions focus on generating a systematic way to extract information from the CHARLS Database, to examine older people's profiles in the database related to health, diseases, disabilities, personal and social activities, and exploring the needs and unmet needs, whether met or unmet, for assistive

technology by analysing this database. The calculation outcomes (tables with numbers and percentages) must go through several interviews with aged care experts. This will help with thorough interpretations of what the outcomes mean to research questions, and what deeper thoughts can emerge from the outcomes.

In analysis step seven, the interview with experts, the researcher managed, concluded the information collected from the interview by thematic analysis method. The thematic analysis refers to a method for identifying, analysing, organizing, describing, and reporting themes found within a data set (Braun & Clarke 2006) The Thematic Analysis can be done in six phases, which are: familiarizing with your data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, producing the report (Nowell et al. 2017).

This research conducted Thematic Analysis by saturating experts' expressions. A rigorous thematic analysis can produce trustworthy and insightful findings (Braun & Clarke 2006). Using the thematic analysis method strengthened the research by providing trustworthy, relatively precise, consistent discussions of assistive technologies - discussions are based on an exhaustive approach including recording, systematizing, and disclosing the expressions from aged care experts with enough detail to enable that the process is credible (Nowell et al. 2017). By using the thematic analysis method, the quality of the discussion derived from aged care experts is ensured: experts' ideas, expressions and comments are categorised systematically. Their commonly expressed suggestions indicated the truth of assistive technology demand and factors related to demand.

The researcher first conducted the interview with six aged care experts and watched the video recordings of the interview many times. This refers to the first step (familiarizing with your data) of the thematic review conduction. The research then saturated experts' expressions and concluded topics in common. For this research, the common topics that

emerged from the discussion should be the causes of specific calculations results related to some assistive technologies, and the factors related to older people's attitudes, and adoption of assistive technologies which might cause some differences from the calculated results to the real demand. This process refers to steps of generating initial codes and searching for themes. After this, the researcher categorised the issues mentioned in common and list them in a table of emerging themes (Table 34). This refers to steps of reviewing themes, and defining and naming themes. Finally, the researcher explained these themes in Chapter 6, the discussion chapter. This refers to the step of producing the report.

3.4 THE CONNECTION BETWEEN RESEARCH QUESTIONS AND THE FOLLOWING ANALYSIS STEPS

3.4.1 THE LOGIC OF RESEARCH QUESTIONS

The following research questions introduced in Chapter two are now restated:

Research Question 1:

What theoretical framework provides a method to best explore the user needs identified in the CHARLS data?

Research Question 2:

2.1 What are older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities?

2.2 What are the unmet needs and urgent unmet needs for assistive technologies that can be identified from the CHARLS Database?

2.3 What are the total needs and urgent total needs for assistive technologies that can be identified from the CHARLS Database?

2.4 What differentiation exists with respect to users and users' needs (both unmet needs and total needs) between gender and age?

Research Question 3:

What opportunities exist for assistive technologies to assist older people with healthcare and independent living?

The research started with access to the CHARLS Database. Research question one is related to finding a way to extract information from the database. Research question two is related to using the way found in research question one to calculate older people's needs and unmet needs for assistive technologies. Research question three is related to the interpretation of the results generated from Question Two. Research question one provides a tool for Question Two. Research Question Two provides materials for research Question Three. Research Question Three is necessary, as it was mentioned in the explanation of the qualitative approach, "a qualitative approach is used to understand concepts, thoughts or experiences; it focuses on exploring ideas, analysing by summarizing, categorizing and interpreting" (Choy 2014). Research Question Three as the interpretation helps with deeper understanding and insights of the answers to Research Question Two.

3.4.2 HOW THE DATA AND ANALYSIS METHODS INTENDED TO ANSWER THE RESEARCH QUESTIONS

Detecting older people's needs for assistive technologies is the core of this research (research questions 2.2 and 2.3). To do this, the methodology conducted a counting process to check how many older people's profiles met the condition of use of selected assistive technology - these older people were counted in the total needs of assistive technology. Among them, older people who did not have access to specific assistive technology were those counted in the unmet needs of assistive technologies. This process was provided by analysis step five (in section

3.10). To do this detecting work, the research needs a logical and systematic method to extract information from the data resource (the CHARLS Database), in other words, the research needs to first decide what data (the answer to the question in the CHARLS Database) should be included in the analysis for each selected assistive technology, and why (refers to research question 1 and 2.1). For example, why vision ability should be included to determine the need for corrective lenses, but not for pressure relief mattresses. These issues need to be resolved before any analysis can be conducted. Resolving this issue includes initially showing the basic information of all included data (analysis step one, section 3.6) and selecting assistive technologies (analysis step two, section 3.7), studying the condition of use of selected assistive technologies (analysis step three, section 3.8), showing a comprehensive list of what data are included for the analysis for each type of assistive technology (analysis step four, Section 3.9 and in Appendix 8.4). After finishing the detecting job, the results need further testing and interpretation in order to develop deeper insight for answering the research question and informing the aged care industry. Testing jobs were undertaken in the analysis step six, shown in section 3.11. Interpretation was completed in the Analysis Step Seven, shown in Section 3.12.

3.5 SELECTING, ACCESSING THE CHARLS DATABASE

3.5.1 REASON FOR SELECTING THE CHARLS DATABASE

This research selected the CHARLS Database for three reasons related to its quality, the volume of participants and the contents of the data. First, the CHARLS Database is a national survey involving more than 10,000 households in 150 counties/districts and 450 villages/resident committees in China (Zhao et al. 2013; Zhao et al. 2014). It is the first nationally representative survey of the older population that enables the study of

the health of the older population in China (Zhao et al. 2020). Second, the CHARLS Database provides reliable data with high quality and a large volume of respondents. The CHARLS project is a collaborative effort of many scholars in different countries. The data collection was conducted and supervised under prevailing organisations including the National School of Development (China Centre for Economic Research) at Peking University, the University of Southern California, the Chinese Academy of Medical Sciences/Peking Union Medical University, the University of California at Los Angeles, Hong Kong University of Science and Technology, Tsinghua University and the Central University of Finance and Economics (Zhao et al. 2020). The newest wave of the CHARLS Database has 20,866 participants, including 10,818 older people aged 60 years and older, that covers multiple provinces in China (National School of Development of Peking University 2020). Third, the CHARLS Database provides ample information regarding older people's profiles, including general health status, chronic disease, cancer, functional limitation, sensory problems, personal and social activities participation, education level, etc. All this information is closely related to detecting older people's needs for assistive technologies.

3.5.2 ACCESSING THE CHARLS DATABASE

All data in the CHARLS Database was made public one year after the end of data collection (Zhao et al. 2020). To access the data, the researcher registered and applied for the data online on CHARLS official site at http://charls.pku.edu.cn. This official site has both an English version and a Chinese version. To request data from this site, the researcher first signed up for an account (by clicking the "sign up" button on the website). During the signing up process, the researcher was first asked to sign an agreement online to promise that the researcher uses the CHARLS Database with goodwill and a reasonable purpose. The terms of the agreement include that: 1). The user must only use the CHARLS data for

academic study, any use for a commercial purpose is prohibited; 2). The user must not publish original microdata in any form; all data will be used to generate statistics or analytical results that cannot be linked to any individual respondent; 3). The user must not disclose, release, sell, rent, lease, loan, or otherwise grant access to the data covered to any person; 4). The user must provide real personal information to register CHARLS website (Peking University 2020).

After signing the agreement, the researcher was redirected to the next step and was asked to fill in some personal details and academic backgrounds before finalising the signing up process, which include the full name, profession, field of study, country, state, city and telephone number, etc. The signing up process succeeded after this step. Then the researcher logged in and clicked the pane of "Data" on the website http://charls.pku.edu.cn. Then the researcher clicked "2018 CHARLS Wave 4" and clicked "All Dataset in one Zip file" to download the data. The data was downloaded as ".dta" files. This format is suitable for Stata Software. To operate the data in SPSS software, the format was changed from ".dta" into ".sav".

The following 7 sections (from Section 3.6 to Section 3.12) illustrated how to use the tool (Sociotechnical theory) to extract information from the CHARLS Database, how to use the tool to calculate the answer to the research question and how to enrol experts for interpretation of the calculation results.

3.6 ANALYSIS STEP ONE - DATA DESCRIPTION

Before mapping older people's needs for assistive technologies, the research first provided descriptive data for preliminary statistical analysis of older people's profiles. This computation included measures to describe sample characteristics such as proportion, mean, standard deviation, median, and quartiles. In total, the CHARLS Database provided 41

variables related to older people's demographic information and general health, mobility functional limitations, mental and emotional status. Variables of each aspect were listed in the following sections. Each variable was statistically described in chapter four.

3.6.1 HOW THE CHARLS DATABASE PROVIDED THE VARIABLES REQUIRED FOR RESEARCH QUESTIONS

Aiming to match older people's needs with several types of assistive technologies, the research needed information that links older people's profiles with the conditions of use of assistive technologies. The information needed, guided by socio-technical theory, was related to older people's health status, functional limitation, personal and social activities. The CHARLS Database includes a broad range of information related to them. In practice, each question in the CHARLS Database questionnaire was scanned and determined if the question should be included for analysis according to the condition of use of the selected assistive technology. The answers to the selected questions act as useful data in answering research questions. All the included questions are listed in the following sections.

3.6.2 VARIABLES RELATED TO DEMOGRAPHIC INFORMATION AND GENERAL HEALTH

There are 20 variables related to demographic information and the general health of older people's profiles. Their description and metrics are listed in the following Table 8.

Table 8 - Variables Related to Demographic Information and General Health

Number	Variables	Metrics
1	Age	Numeric Variable
2	Gender	Male or Female
3	Specific types of disabilities	Binary option (yes or no)
4	Chronic disease diagnoses	Binary option (yes or no)
5	Type of cancer	Multiple choices about cancer
6	Eyesight for things up close	5-point Likert scale
7	Eyesight for things at a distance	5-point Likert scale
8	Glaucoma diagnosis	Binary option (yes or no)
9	Hearing ability	5-point Likert scale
10	Hearing aid use	Binary option (yes or no)
11	Teeth remaining	Binary option (yes or no)
12	Body pain	Multiple choices about body
13	Health status during childhood	5-point Likert scale
14	Length of sleeping at night	Numeric Variable (Hours)
15	Length of the nap after lunch	Numeric Variable (Minutes)
16	Frequency of doing high/moderate/low intensity	Numeric Variable (Days per week)
17	Type of social activities participant	Multiple choices about activities
18	Assistive technology use	Multiple choices about auxiliary
19	Self-reported Overall Health Status	5-point Likert scale
20	Education Level	Multiple choices about

3.6.3 VARIABLES RELATED TO MOBILITY FUNCTIONAL LIMITATIONS

There are 21 variables related to mobility functional limitations. Their description and metrics are listed in the following Table 9.

Table 9 - Variables Related to Mobility Functional Limitations

Number	Variables	Metrics
1	Any difficulty with running or jogging about 1 km	4-point Likert
2	Any difficulty with walking 1 km	4-point Likert
3	Any difficulty with walking 100 metres	4-point Likert
4	Any difficulty with getting up from a chair after sitting for a long period	4-point Likert scale
5	Any difficulty with climbing several flights of stairs without resting	4-point Likert scale
6	Any difficulty with stooping, kneeling, or crouching	4-point Likert
7	Any difficulty with reaching or extending your arms above shoulder level	4-point Likert scale
8	Any difficulty with lifting or carrying weights over	4-point Likert
9	Any difficulty with picking up a small coin from a	4-point Likert
10	Any difficulty with dressing because health and memory problems	4-point Likert scale
11	Any difficulty with bathing or showering	4-point Likert
12	Any difficulty with eating	4-point Likert
13	Any difficulty with getting into or out of bed	4-point Likert
14	Any difficulty with using the toilet	4-point Likert
15	Any difficulty with controlling urination and	4-point Likert
16	Any difficulty with doing household chores	4-point Likert
17	Any difficulty with preparing hot meals	4-point Likert
18	Any difficulty with shopping for groceries	4-point Likert
19	Any difficulty with managing money	4-point Likert
20	Any difficulty with taking medications	4-point Likert
21	Any difficulty with making phone calls	4-point Likert

3.6.4 WAYS TO DEAL WITH MISSING DATA

There are some missing data in the CHARLS Database. To address this missing data, the research checked the mechanisms of missing data and several ways to deal with missing data. It finally chose an appropriate way to deal with missing data in the CHARLS Database.

There are three typical mechanisms for missing data. First, the data are missing completely at random, which means the missingness mechanism does not depend on the variable of interest or any other variable collected in the dataset. In this case, the complete cases are representative of all the original cases without causing any bias (Little et al. 2012) though they caused enlarged standard errors due to the reduced sample size (Jakobsen et al. 2017). Second, the data are missing at random, which means that any systematic difference between the missing values and the observed values can be explained by differences in observed data (Donders et al. 2006). For example, missing blood pressure measurements may be lower than measured blood pressures but only because younger people may be more likely to have missing blood pressure measurements (Sterne et al. 2009). Third, the data are not missing at random, which means that the likelihood of missing data depends on the actual value of unobserved data (Dziura et al. 2013), in other words, the data are informatively missing - even after the observed data are taken into account, systematic differences remain between the missing values and the observed values (Sterne et al. 2009).

Based on the above mechanisms, the research discussed how the selected data from the CHARLS Database were missed. After screening the variable listed from Section 3.6.2 to 3.6.3, it can be concluded that missing data can be categorized into the following two situations.

First, the data were missing because of human factors. These human factors can be: the interviewer forgot to ask the question; the interviewer asked the question but the interviewee refused to give an answer; the interviewer asked the question but the interviewee could not give a proper answer (the answer did not fit the content of the question or the answer was apparently a false answer) due to challenges for the interviewee; the interviewer asked the question, received an answer but did not record or register the answer into the system. In this situation, the mechanisms of missing data can be either missing at random or not

missing at random. Second, the answer was missing because of a mixture of logic reasons and human factors mentioned in the first situation. Logic reasons mean that the question of interest acts as a consequence of previous questions, in other words, these questions were conditionally asked only of eligible interviewees. For example, the question DB003 asked about older people's difficulties in walking 100 metres. Older people were asked this question only when they answered that they could not walk for 1 km to the previous question (DB002). In this situation, the data were missing either because of the human factors mentioned in the first situation, or because the interviewee was not needed or qualified to answer this question. In this situation, the mechanisms of missing data are not missing at random. Table 10 shows the missing data that fit the second situation, along with the explanation. All the rest of the variables are categorised into the first situation.

Table 10 - Missing Data Because of a Mixture of Logic Reasons and Human Factors

Item Code	Explanation of Logic Reasons
DA008_W2_1	This question asks about the way of diagnosing of chronic disease. This question is only asked of older people who are confirmed to have at least one chronic disease
DA018_W4	This question asks about the treatment for cancer. This question is only asked of older people who are confirmed to have at least one cancer
DA025	This question asks about hip fracture. This question is only asked of older people who ever severely fell
DA037_W2	This question asks about the treatment for glaucoma. This question is only asked of older people who are confirmed to have glaucoma
DA042	This question asks about the part of the body feeling painful. This question is only asked of older people who are confirmed to have body pain
DA042_W2_1	This question asks about the treatment for body pain. This question is only asked of older people who are confirmed to have body pain
DB002	This question asks about difficulties in walking 1 km. This question is only asked of older people who cannot jog 1 km
DB003	This question asks about difficulties in walking 100 metres. This question is only asked of older people who cannot walk 1 km
DC028_W4_1	This question asks the interviewer about why older people cannot do the reading test. This question is only asked when older people cannot read the provided content in previous questions.
DC039_W4_1	This question asks the interviewer about why older people cannot do the speaking test. This question is only asked when older people
DC043_W3	This question asks about the satisfaction with marriage. This question is only asked of married older people
DC044_W3	This question asks about the relationship with children. This question is only asked of older people who have children
DD008_W4 DD009_W4 DD010_W4 DD011_W4 DD040_W4	These questions are asked of older people's relatives, carers and acquaintances about their knowledge related to the interviewed older people's health. These questions aim to fill the information gaps that older people fail to provide or intentionally hide. These questions are asked only when older people are able to nominate any informants.

Knowing the potential reason and mechanism of missing data, the researcher then attempted to find a suitable solution to address the missing data. There are five principal ways to address missing data. The first one is the complete case analysis. This method is to include only individuals with complete information on all variables in the dataset (White & Carlin 2010). The second one is the missing indicator method. In this method, for categorical variables, missing values are grouped into a "missing" category. For continuous variables, missing values are set to a fixed value (usually zero), and an extra indicator or dummy (normally it should be 0 or 1) variable is added to the main analytic model to indicate whether the value for that variable is missing. In this method, each participant can still be included in the analysis, reducing the loss of statistical power (Groenwold et al. 2012). The third one is the single value imputation method, which replaces missing values with a single value, for example, the mean score of the observed values or the most recently observed value for a given variable (Shaharudin 2020). The fourth one is the sensitivity analyses with worst- and best-case scenarios. In this method, missing data values are replaced with the highest or lowest value observed in the dataset (Pedersen et al. 2017). The fifth one is the multiple imputation method, in which missing data values are imputed based on the distribution of other variables in the dataset (Cro et al. 2020). Table 11 listed different missing data handling approaches and the assumption to achieve unbiased estimates under each approach.

Table 11 - Different Missing Data Handling Approaches and the Assumption

Solution/Approach	The Assumption to Achieve Unbiased Estimates
Complete Case Analysis	Missing completely at random
Missing Indicator Method	None
Single Value Imputation Method	Missing completely at random only when estimating mean
The Sensitivity Analyses with Worst- and Best-Case Scenarios	Missing completely at random
Multiple Imputation Method	Missing at random

(Pedersen et al. 2017)

As was discussed in the above paragraph, the missing data in the CHARLS Database was caused for various of reasons and could be concluded into a hybrid of "missing at random" and "not missing at random". After matching this information with the assumption of each method listed above, the only suitable method is the missing indicator method. The metrics of selected questions in the CHARLS Database were listed in Sections 3.6.2 and 3.6.3. Table 12 concluded these metrics and shows how the missing data were solved for each metric.

Table 12 - Category of the Metric Type and Its Missing Data Solution

Metric Type	Metric Sub-Type	Missing Data Solution for this Metric Type
Continuous variables	Numeric Variable	Missing values were fixed to zero, and an extra indicator was set to show that the variable is missing.
Categorical variables	Binary option	Missing values are grouped into an extra "missing" category.
	Multiple choices	
	4- or 5- point Likert scale	

3.7 ANALYSIS STEP TWO - ASSISTIVE TECHNOLOGIES SELECTION

There are hundreds of assistive technologies. Due to the time limit of the research and the content of accessible data, only a few of them were chosen for analysis. This section explains how the assistive technologies' terminologies were resourced, chosen and combined. After the exclusion process, there were 25 assistive technologies left for further calculation.

3.7.1 RESOURCES OF ASSISTIVE TECHNOLOGY SELECTION

The assistive technologies terminology used in this thesis comes from two resources: first, terminologies used in CHARLS Database Questionnaire that are within the questions investigating older people's assistive technology use (it is also called "auxiliary use" in CHARLS Questionnaire); second, terminologies used in the Priority Assistive Products List published by the World Health Organization (2016). The following paragraphs explain each of the resources.

Firstly, there were 50 assistive technologies' terminologies provided from the World Health Organization's Priority Assistive Products List. The Priority Assistive Products List was developed through an extensive global consultation with experts, including users and their caregivers, which involved first selecting key assistive devices and then prioritizing them down to 50 (World Health Organization 2016). They were listed in Appendix 8.3. Secondly, there were 8 assistive technology terminologies provided in the CHARLS Database (wave four). They were: "walking sticks", "travel devices", "manual wheelchairs", "electric wheelchairs", "catheter and urine collecting bags", "toilet series", "corrective lenses and glasses" and "hearing aids". Regarding the CHARLS Database Questionnaire, two languages were used: Chinese and English. The Chinese language is used for the initial development of the questionnaire and English is used as an official foreign language translation. When the English translation caused any confusion or potential misunderstanding,

the researcher could always clarify by reading the original Chinese version. The questions and choices listed in the attachment are the official English translation of the CHARLS Database Questionnaire. Some of the above terminologies from the CHARLS Database, for example, "toilet series" and "travel devices", translated by Chinese researchers, are not clear enough. Thus, there is a glossary at the end of the thesis for further explanation and definition.

In total, there were 58 terminologies resourced for selection. 50 of them were from the World Health Organization's Priority Assistive Products List (2016). 8 of them were from the CHARLS Database Questionnaire.

3.7.2 FILTERING ASSISTIVE TECHNOLOGY TERMINOLOGIES ACCORDING TO DATA AVAILABILITY

Among the 58 assistive technologies listed in the previous section, some of them needed to be culled for three reasons. Firstly, the function of the technology can be easily substituted by a smartphone, which is very easy to get in China. In this situation, the potential needs of the technology are hard to predict because the smartphone can meet a considerable number of their total needs. These assistive technologies included: Audio players with DAISY capability, closed captioning displays, communication boards/books/cards, communication software, personal digital assistants, video communication devices, recorders, screen readers, and simplified mobile phones. Secondly, the analysis of assistive technology is of very low value to inform the industry in a modern society. These assistive technologies included communication boards/books/cards, recorders, magnifiers (digital hand-held), magnifiers (optical), and simplified mobile phones. Communication boards/books/cards are printed goods with very low technology levels and seldom have unmet needs. Magnifiers have ample productivity. Recorders are broadly used by many people in multiple occupations and can be easily purchased at any time. Simplified mobile phones, though, are needed by some older people who are not

willing/able to learn and use smartphones. There is no longer a significant need for these largely obsolete devices. Thirdly, there is little information in the CHARLS Database related to the condition of use of the assistive technology. These include gesture to voice technology, keyboard and mouse emulation software, orthoses (lower limb), orthoses (spinal), orthoses (upper limb), prostheses (lower limb), standing frames (adjustable), and club foot braces.

After this process, 19 assistive technologies were excluded, with 39 for further combination. In the combination, similar assistive technologies were combined because their functions were similar; thus, it was hard to use the CHARLS Database to tell the small difference between their unmet needs. For example, personal emergency alarm systems, global positioning system (GPS) locators, and fall detectors, were combined as personal emergency response systems. Finally, there were 25 assistive technologies for further calculation.

3.7.3 THE GLOSSARY OF EACH SELECTED ASSISTIVE TECHNOLOGY

This thesis included 25 types of assistive technology. To avoid any confusion or potential misunderstanding, a glossary was provided in Appendix 8.14.

3.8 ANALYSIS STEP THREE - STUDYING THE CONDITIONS OF USE OF 25 SELECTED ASSISTIVE TECHNOLOGIES

In accordance with the glossary of selected assistive technologies illustrated in Appendix 8.14, there were 25 types of assistive technologies (discussed next) illustrated with their conditions of use. It should be noted that the conditions of use of manual wheelchairs and electric wheelchairs are combined in the illustration.

1 Alarm Signallers with Light/Sound/Vibration

Lighting alarm systems are increasingly popular for elderly care and assisted living solutions for those who suffered from hearing impairment (Dhanjal & Singh 2019). A sound alert with light and vibration (Olaosun & Ogundiran 2013) can be helpful for older people with hearing loss (Mielke & Brück 2016; Tebbutt et al. 2016). These alarms with light, sound and voice reminders about which tasks to do can be of great significance for people with acquired brain injury (Gómez et al. 2012). Many different types of visual, sound, and vibrating alarms are useful for older people with disabilities (Dove 2012).

2 Braille Writing Equipment/Braillers

Braille writing equipment is used for older people with vision impairment (Vik & Lassen 2010; Frediani, Busfield & Carpi 2018; World Health Organization 2019) that hinders their communication ability (Mills et al. 2017; Argyropoulos et al. 2020) or for deaf and blind people (Pal, Vallauri & Tsaran 2011). Braille writing equipment still requires older people to have at least some basic literacy.

3 Walking Sticks

Walking sticks are cheap and easy to buy. They can help older people who have limited walking ability, body pain or risk of falling (Cruz et al. 2019). The walking stick can be used to reduce vertical joint reactive forces on the knee by promoting a flexed position at the joints (Haddas, Villarreal & Lieberman 2020) and improve postural stability and decrease the load on the weak side of the lower extremities (Dogru et al. 2016). The elderly often start using a walking stick because of balance and postural disorders and to prevent falling (Laufer 2003). Walking sticks are helpful with speed and comfort in walking for stroke survivors (Polese et al. 2012).

4 Toilet Series

Older people with lower limb amputation and spinal cord injuries (World Health Organization 2019) and those who are at risk of falls and have an

unsteady gait may have difficulties using the toilet (Friesen, Theodoros & Russell 2016). These people with limited mobility can benefit from commode seats.

5 Deafblind Communicators

Deaf blind communicators can assist older people with combined vision (Casten, Rovner & Fontenot 2016) and hearing impairment (Pal, Vallauri & Tsaran 2011) of such severity that it is hard for the impaired senses to compensate for each other (Cantin, de Abreu Cybis & Durocher 2022).

6 Shower Chairs

A shower chair can assist with personal hygiene tasks by allowing the user to safely wash while reducing the risk of slips or falls (Cheng & Hao 2021). They are ideal for people who have difficulty standing for long periods or who experience dizziness when undertaking some tasks in the shower. A shower chair enables a person who has decreased balance, physical strength or mobility to shower safely and independently while sitting (Cheng & Hao 2021). Shower chairs are useful for people who find it difficult to stand in the shower for long periods. A shower chair is often used in conjunction with grab rails (Cheng & Hao 2021).

7 Electrotherapy Device for Pain

Electrotherapy is a common therapeutic treatment used to provide pain relief (Chen et al. 2022). The device delivers a mild level of electric current via electrodes positioned on the skin to interfere with the pain signal and stimulate the release of the body’s own natural painkiller to reduce the pain (Liu et al. 2020). Electrotherapy for pain includes a range of devices with treatments using electrical current to reduce pain, improve circulation, repair tissues, strengthen muscles, and promote bone growth, leading to improvements in physical functioning. While a large number of people find electrotherapy helpful, others do not. The medical literature on electrotherapy's effectiveness has been mixed, and not all electrotherapy treatments are supported by research (Veritas Health

2021). Electrotherapy is typically used in conjunction with other treatments, rather than by itself - for people undergoing physical therapy, electrotherapy may alleviate pain sufficiently for an individual to participate more actively in targeted exercises. Electrotherapy is among pain relief options gaining attention as the potential risks and side effects of opioid (narcotic) medications have become more apparent (Veritas Health 2021).

8 Handrails/Grab Bars

Handrails can significantly improve the ability of people who are inactive due to functional limitations (Verma et al. 2016). Handrails can help these people with recovering from balance loss (Maki, Perry & McIlroy 1998) that leads to the cause of unintentional injury (Billette & Janz 2011) and avoid a fall. By grasping a handrail, a person can anchor their body and apply substantial forces and moments to stabilize their centre of mass (Maki & McIlroy 1997). The condition of use of handrails and grab bars is similar to fall detectors. They are of great use to older people who are vulnerable to falling (Komisar et al. 2019).

9 Hearing Aids

Hearing aids, Frequency Modulation Systems and Audio Loop Systems can significantly assist people with hearing disorders (Olaosun & Ogundiran 2013). Hearing aids can be useful for mild hearing loss, moderate hearing loss, moderately severe hearing loss, severe hearing loss, profound hearing loss and complete hearing loss (World Health Organization 2019).

10 Catheters and Urine Collecting Bags

Incontinence products and absorbents can help people with urinary or faecal incontinence (Bliss et al. 2011). They are also used for people with spinal cord injuries (World Health Organization 2019) that pose challenges for toileting.

11 Corrective Lenses

Corrective lenses have broad conditions of use including presbyopia, moderate vision loss, and severe vision loss (World Health Organization 2019).

12 Personal Emergency Response System

Older people with mobility impairment need to be monitored in case of an emergency (García-Soler et al. 2018), particularly in bathrooms. Older people with difficulties in using the toilet can use these systems (Jännes et al. 2015). These systems can assist older people with dementia or other memory-related problems (Egan & Pot 2016).

The Global Positioning System (GPS system) can increase mobility, safety and autonomy (Røhne, Boysen & Ausen 2017), but only for users who are already active (Topfer 2016). Users stop benefitting from GPS systems when they are no longer capable of going outdoors - in general, GPS systems increase freedom of movement and experience of freedom; GPS systems further contribute to faster positioning and retrieval of the users when they trigger an alarm or they are missing (Øderud et al. 2015)..

People experiencing reduced mobility, in particular the elderly, can greatly benefit from having a fall and mobility sensor for several reasons (Velázquez 2010). Common risk factors include problems with balance and stability, arthritis, muscle weakness, multiple medications therapy, depressive symptoms, cardiac disorders, stroke, impairment in cognition and vision (Fuller 2000; Weir & Culmer 2004). Typically, fall detectors are for older people with poor eyesight, difficulties in using the toilet and bathroom and difficulties in walking and stepping up or down a few stairs (Kamei et al. 2015). Older people with mobility impairment need monitoring in case of emergency (García-Soler et al. 2018).

13 Pill Organizers

The intelligent pillbox can help with elderly people’s basic medication schedules and decrease health disorders. Because of brain diseases and brain tissue deterioration, it is common that older people fail to remember

taking medications (Parra et al. 2017) and this is when pill organizers can increase medication compliance.

14 Pressure Relief Mattresses

Pressure relief products are useful for older people with spinal cord injuries and low mobility (World Health Organization 2019) which is associated with an increased risk of developing such as pressure ulcers and skin breakdown (Beeckman et al. 2019).

15 Ramps, Portable

Portable ramps can be used by wheelchair users, providing a temporary way to increase accessibility in their daily lives (Kumtepe et al. 2020).

16 Time Management Products

Time management products are useful for people with an intellectual disability (Green, Hughes & Ryan 2011). By enhancing the ability to self-regulate and organise their personal scheduling, independent living can be improved (Davies, Stock & Wehmeyer 2002) as well as the autonomy (Smith et al. 2007).

17 Travel Device

Mobility aids, for example, scooters and tricycles, can assist with mobility, provide a seat for resting and a basket for shopping items (Scott et al. 2018). Mobility items such as quad canes are frequently recommended to assist patients who cannot walk unaided due to arthritis or other mobility problems (Menz 2021).

18 Watches, Talking/Touching

Touching and talking watches help to improve accessibility, usability, and understandability that help older people with vision problems (Kim 2019). Wearable devices to assist with vision ability are one of the main emerging trends for visually impaired older people (Bhowmick & Hazarika 2017).

19 Wheelchairs (manual or electrical)

Wheelchairs allow people with a mobility disability to travel longer distances (Scott et al. 2018) including older people with lower limb amputation or other disabilities (World Health Organization 2019). An electric wheelchair provides increased independence due to its ease-of-use and the ability to travel without experiencing fatigue. A wheelchair can be used in conjunction with other mobility aids or forms of transport.

20 White Canes

White canes are for older people with severe vision impairment (World Health Organization 2019) or for legally blind people (Mills et al. 2017). A white cane helps to navigate and avoid obstacles on the road for vision-impaired people.

21 Therapeutic Footwear

Therapeutic footwear has become the first line of treatment in the prevention of diabetic foot ulcers and future complications of diabetes. Ulcers have been associated with 84% of diabetes-related amputations (Maciejewski et al. 2004). Previous studies and the International Working Group on the Diabetic Foot described therapeutic footwear as a protective factor to reduce the risk of re-ulceration (Lopez-Moral et al. 2019).

22 Glucometer

A glucometer is a medical device for determining the approximate concentration of glucose in the blood. It can also be a strip of glucose paper dipped into blood and measured on the glucose chart. It is a key element of home blood glucose monitoring by people with diabetes mellitus or hypoglycaemia (Mian, Hermayer & Jenkins 2019). Regular blood glucose monitoring is an essential tool to increase the self-management of diabetes. By identifying and recording changes in blood sugar levels, people have more information about how food, exercise,

stress, and other factors affect diabetes and blood sugar levels (Krans 2018).

23 Grasping Tool or Reach Extender

A grasping tool or reach extender is used to increase the range of the user's reach when grabbing objects. The tool can reach high shelves and low floors easily, preventing older people from requiring ladders or constant bending and stretching.

24 Talking Blood-pressure Monitor

A blood-pressure monitor helps patients with hypertension and other symptoms of disease to track their blood pressure and other fundamental physiological signals by the correct estimation of blood pressure in a non-invasive setting (Hwang et al. 2019). Non-mercury blood-pressure monitors, for example aneroid and more recently, digital ones have largely replaced the use of traditional ones (Shahbabu et al. 2016).

It can be concluded that different health conditions require different assistive technologies, which lead to multiple questions to choose from the CHARLS Database. For each selected assistive technology, the question choice and the way to determine total needs, urgent needs, unmet needs and urgent unmet needs are stated in Sections 3.9 and 3.10.

3.9 ANALYSIS STEP FOUR - DETERMINING FACTORS BASED ON SOCIOTECHNICAL THEORY

This section relates to setting up factors and descriptions in order to match the condition of use of assistive technologies to the question selecting process from the CHARLS Database. Every selected assistive technology should be put in the template as in the following Table 13.

Table 13 - Template of Factors Related to the Use of Selected Technology

Technology	Factor	Description	CHARLS' Items	Comments
Name of the Selected Assistive Technology	Body disability	Specified disability related to this assistive technology	The code of Selected questions from CHARLS Database Questionnaire	To provide more explanation
	Disease and illness	Specified disease related to this assistive technology	The code of Selected questions from CHARLS Database Questionnaire	To provide more explanation
	Personal activities	Specified personal activity related to this assistive technology	The code of Selected questions from CHARLS Database Questionnaire	To provide more explanation
	Social activities	Specified social activity related to this assistive technology	The code of Selected questions from CHARLS Database Questionnaire	To provide more explanation

According to sociotechnical theory (Bostrom & Heinen 1977), the condition of use of each assistive technology should be classified into social aspects and technical aspects. The social aspects were further divided into personal activities and social activities. The technical aspects were further divided into body disability and disease and illness. A description was provided for each personal activity, social activity, body disability, disease and illness. Then, according to each description, the research scanned relevant questions from the CHARLS Database. The codes of the questions were listed in the column of "CHARLS' Items". Finally, the comments column provided more information about listed

factors and item codes. The full-length table was attached in Appendix 8.4.

3.10 ANALYSIS STEP FIVE - DETERMINING UNMET NEEDS, TOTAL NEEDS AND URGENT NEEDS

There were 25 types of assistive technologies included in this research (the glossary was provided in Appendix 8.14). For each one of them, there was a unique way to determine the choice of the question from the CHARLS database and a unique way to organise the data to decide what should be counted as total needs, urgent needs, unmet needs and urgent unmet needs. This section first illustrated how to identify users' statistics from the CHARLS Database. It subsequently explained 25 different ways of selecting questions from the CHARLS Database, together with 25 types of solutions for determining needs and unmet needs for 25 different assistive technologies.

3.10.1 USERS' STATISTICS INFORMATION

Older people's needs for each type of technology were divided into "met needs" and "unmet needs". "Met needs" refer to older people who need specific technology and currently use it. "Unmet needs" refer to older people who need the technology but currently do not have it. Technology users were excluded before determining unmet needs. In the CHARLS Database, questions asking older people about assistive technology use were distributed in different chapters, in different ways of expression. Among the 25 selected assistive technologies in this thesis, 8 of them had users' statistics in the CHARLS Database. Users' statistics of each assistive technology were located according to the following Table 14.

Table 14 - Location of Users' Statistics in the CHARLS Database

Name of Assistive Technology	Location of Users' Statistics
Walking Stick	Choice Number 1 of the Question DB029
Travel Device	Choice Number 2 of the Question DB029
Manual Wheelchair	Choice Number 3 of the Question DB029
Electric Wheelchair	Choice Number 4 of the Question DB029
Catheter and Urine Collecting Bags	Choice Number 5 of the Question DB029
Toilet Series	Choice Number 6 of the Question DB029
Corrective Lenses and Glasses	Choice Number 1 of the Question DA032
Hearing Aids	Choice Number 1 of the Question DA038_W4

User information included not only the number of users but also several percentages. These percentages were: The percentage related to the total number of older people in the CHARLS database (10,818 respondents); The percentage related to total users in the CHARLS database; The percentage related to the number of older people in a specific age or gender group; The percentage related to total older people users in the CHARLS database.

3.10.2 TO DETERMINE UNMET NEEDS, URGENT UNMET NEEDS, TOTAL NEEDS AND URGENT NEEDS

This is the core of this research conduct. This section explains the detailed methods about how unmet needs (only if there are users' statistics in the CHARLS Database), total needs, and urgent needs for each included assistive technology were determined. Appendix 8.4 provided a comprehensive list of the factor description, and question code from the CHARLS Database Questionnaire for each of the following assistive technologies.

1. Walking Sticks:

Statistics on the use of walking sticks are available in the CHARLS Database. Assessment of the unmet needs for walking sticks is based on the number of older people who indicated a need but did not have a walking stick. Older respondents who did not answer "walking stick" to question DB029 were referred to as non-users of walking sticks. Among non-users, the respondents who answered "Yes, I have difficulty and need help" or "I cannot do it" to at least one question among DB003, DD005, DB006 and DB013 refer to those who have difficulty in one or more of walking 100 metres, climbing stairs, stooping, kneeling, crouching and getting out of bed. They were defined as people in the "Total Unmet Need" of a walking stick. Respondents who chose at least 2 items among choices of 8/10/11/12/13/14 for nominal question DA042 were defined as those who have slight or severe body pain related to walking stick use. Respondents who answered "1" to question DA007_13_ were defined as those who have arthritis or rheumatism. Among older people within the "Total Unmet Need" of a walking stick, those who have slight or severe body pain, or who have arthritis or rheumatism, or both, were defined as having high unmet needs for walking sticks. Questions I011 and I013 were also included in the consideration (shown in Appendix 8.4), but they were considered only for those older people who already suffered from physical disabilities, diseases and illnesses listed in the walking stick's factor description in Appendix 8.4. In other words, I011 and I013 were taken into consideration but do not affect the calculation result.

2. Travel Devices

Statistics on the use of travel devices are available in the CHARLS Database. Assessment of unmet needs of travel devices is based on the number of older people who indicated a need but did not have them. Older person respondents who did not answer "travel device" to question DB029 refer to non-users of travel devices. A travel device requires "good" or "fair" vision for seeing things up close or far away. This refers to the respondents who answered "excellent", "very good", "good" or

"fair" to both questions DA033 and DA034, and at the same time, answered "no" in DA005[3] ("No" to being blind). A travel device excludes older people with severe body pain. Respondents who chose less than 2 items among choices of 8/10/11/12/13/14 for nominal question DA042 refer to those who do not have severe body pain. Based on these selection criteria, among non-users, respondents who answered "Yes, I have difficulty and need help" or "I cannot do it" to question DB018 at the same time answered "Yes, I have difficulty and need help" or "I cannot do it" to question DB003 or DB008 or both, refer to older people with difficulties in everyday shopping at the same time with difficulties in walking and carrying items. These respondents were regarded in the total unmet needs of travel devices. Among them, respondents who chose at least one item in question DA056 refer to those who also participate in social activities. They are the ones with urgent unmet needs for travel devices.

3. Manual Wheelchairs

Statistics on the use of manual wheelchairs are available in the CHARLS Database. Assessment of unmet needs of manual wheelchairs is based on the number of older people who indicated a need but did not have them. Older people respondents who did not answer "manual wheelchair" to question DB029 refer to non-users of the manual wheelchair. It must be noted that a few of the manual wheelchair non-users were electric wheelchair users. These electric wheelchair users should also be excluded to promise the accuracy of the calculation. It is reasonable that some older people who need a manual wheelchair are using the more expensive, luxury, superior products, say, electric wheelchairs. Among non-users, older people who answered "Yes, I have difficulty and need help" or "I cannot do it" to at least two questions among questions DB003, DB004, DB006 (mobility impairment), at the same time, who answered "No, I don't have any difficulty" or "I have difficulty but can still do it" for both question DB007 and DB009 (enough arm and hand

strength) were defined as having the total needs of a manual wheelchair. These people were counted as having the total unmet needs of a manual wheelchair. Among the total unmet needs, older people who chose at least two items among 11/12/13/14 of question DA042, were defined as having the urgent unmet need for a manual wheelchair as they have at least moderate body pain.

4. Electric Wheelchairs

Statistics on the use of electric wheelchairs were available in the CHARLS Database. Assessment of unmet needs of electric wheelchairs is based on the number of older people who indicated a need but did not have one. Older respondents who did not answer "electric wheelchair" to question DB029 refer to non-users of the electric wheelchair. Still, it can be noted that a few of the electric wheelchair non-users were manual wheelchair users. These people cannot be deducted from the non-users as the manual wheelchair cannot take place of the electric wheelchair, especially when older people do not have enough arm and hand strength. Among non-users, older people who answered "Yes, I have difficulty and need help" or "I cannot do it" to all three questions of DB003, DB004, DB006 (severe mobility impairment), at the same time, who answered "Yes, I have difficulty and need help" or "I cannot do it" for both question DB007 and DB009 (not enough arm and hand strength) were defined as having the total unmet needs of an electric wheelchair. Among them, older people who chose all four items of 11/12/13/14 of question DA042, were defined as having the urgent unmet need for an electric wheelchair as they have severe body pain.

5. Catheters and Urine Collecting Bags

Statistics on the use of catheters and urine collecting bags were available in the CHARLS Database. Assessment of the unmet needs of catheters and urine collecting bags is based on the number of older people who indicated a need but did not have them. Older respondents who did not

answer “catheters and urine collecting bags” to question DB029 refer to non-users of catheters and urine collecting bags. Non-user older people with difficulties in controlling urination and defecation or suffered from cancer that was related to urinating and defecating such as bladder cancer, colon cancer, rectal cancer, kidney cancer and prostate cancer, were regarded as total unmet needs. Older people who answered “Yes, I have difficulty and need help” or “I cannot do it” to question DB015, or answered “frequent incontinence, or needs much assistance” or “Little or no control” to question DD040_W4 were regarded as people with difficulties in controlling urination and defecation. Older people who chose at least one item among 12/13/18/19 of question DA017 were regarded as those who suffered from cancer that was related to urinating and defecating. All people illustrated above are regarded to have the total unmet needs for a catheter and urine collecting bags. Among them, older people who answered “I cannot do it” to question DB015 or answered “Little or no control” to question DD040_W4 were regarded as people with severe problems in controlling urination and defecation. They were counted as having an urgent need for catheters and urine collecting bags.

6. Toilet Series

Statistics on the use of the toilet series are available in the CHARLS Database. Assessment of the unmet needs of the toilet series is based on the number of older people who indicated a need but did not have them. Older respondents who did not answer “toilet series” to question DB029 refer to non-users of toilet series. Among these non-users, older people who answered “yes” to question DA005[1] were defined as people with physical disabilities. Older people who answered “Yes, I have difficulty and need help” or “I cannot do it” to question DB014 are defined as people with difficulties using toilets. People who have physical disabilities or have difficulties using toilets are regarded in the total unmet needs of the toilet series. Older people who chose at least two items of 8/10/11/12/13/14 of question DA042 are defined as those who have

moderate to severe body pain related to toilet use. Older people who chose at least one item among 12/13/18/19 of question DA017 were regarded as those who suffered from cancer related to toilet use. Among older people in total unmet needs, those who have moderate to severe body pain related to toilet use, or suffer from cancer related to toilet use, are regarded as in urgent unmet needs of the toilet series. Similar to the factors' determining the need for a walking stick, question I013 (distance to the nearest toilet) was considered as a factor, but not affecting calculation results.

7. Corrective Lenses and Glasses

Statistics on the use of corrective lenses and glasses are available in the CHARLS Database. Assessment of unmet needs for corrective lenses and glasses is based on the number of older people who indicated a need but did not have them. Older respondents who answered "no" to question DA032 refer to non-users of corrective lenses and glasses. Among these non-users, older people who answered "fair" or "poor" to at least one question of DA033 and DA034 are defined as those who have vision problems, seeing things either up close or far away. Older people who answered "poor eyesight" to question DC068_W4 were defined as those who have an overall vision problem. Older people with an overall vision problem or a specific problem such as seeing things up close and far away are regarded in the total needs for corrective lenses and glasses. Among them, older people who answered "yes" to question DA037 or DA037_W2 refer to a glaucoma diagnosis. These respondents were counted in the high unmet needs because glaucoma worsens vision ability.

8. Hearing Aids

Statistics on the use of hearing aids are available in the CHARLS Database. Assessment of unmet needs for hearing aids is based on the number of older people who indicated a need but did not have them. Older respondents who answered "no" to question DA038_W4 refer to

non-users of hearing aids. Among these non-users, older people who answered "yes" to question DA005[4], or answered "fair" or "poor" to question DA039, or answered "deaf or poor hearing" to question DC028_W4_1, or answered "deaf or poor hearing" to question DC039_W4_1, or answered "Poor hearing without hearing-aid" to question DC068_W4, were defined as having hearing problems. These older people are regarded in the total unmet needs for hearing aids. Among them, respondents who chose at least two items in question DA056 refer to those who also participate frequently in social activities. They are the ones with high unmet needs for hearing aids.

9. Braille Writing Equipment/Braillers

There are no users' statistics for braille writing equipment/braillers available from the CHARLS Database thus this research only looks into their total needs and urgent needs. Braille writing equipment/braillers require users to be literate, or say, to have basic primary education. Braille writing equipment/braillers can be hard to use late in life, thus the older people aged 75 years and older are not considered in this calculation. The other older respondents who answered "no formal education (illiterate)" to BD001_W2_4 at the same time, answered "none" to question BD007_W2_1 or BD007_W4_1, are regarded as illiterate people who attended neither primary education nor adult literacy training courses. After excluding illiterate people, the rest of the respondents who answered "yes" to question DA005[3] or answered "legally blind" to question DA032, were defined as blind people. Literate but blind people were regarded as having the total need for braille writing equipment/braillers. Among them, older people who chose at least two items in question DA056 refer to those who also participate frequently in social activities. They are the ones with high unmet needs for braille writing equipment/braillers.

10. Smart/White Canes

There is no users' statistic of smart/white canes available from the CHARLS Database; thus, this research only looks into their total needs and urgent needs. Being able to walk is the basic requirement of white canes, thus the calculation first excludes older people who cannot walk. Older people who answered "I cannot do it" to the question DB003 refer to those who cannot walk even for a very short distance. These people are excluded. The rest older people who answered "yes" to question DA005[3] or answered "legally blind" to question DA032, were defined as blind people. Non-blind people who answered "poor" to both questions DA033 and DA034 were defined as those who have low vision ability. Together, blind people plus people with low vision ability, were regarded as with the total needs of smart/white canes. Among them, blind people are the ones with high unmet needs of smart/white canes.

11. Electrotherapy Device for Pain

There is no set of user statistics for the use of electrotherapy devices for pain available from the CHARLS Database, thus this research only examines their total needs. Older people who chose at least 3 items among choices of 1/2/3/4/5/6/8/9/10/11/12/13/14/15 for the nominal question DA042 were defined as having moderate to severe body pain which can be treated with electrotherapy devices for pain. As mentioned, electrotherapy devices for pain are typically used in conjunction with other treatments rather than by themselves. Older people who chose at least one answer from the choices 1/2/3/4/5/6 for the nominal question DA018_W4, or chose at least one answer from the choices 1/2/3/4/5 for the nominal question DA042_W2_1, already had some other types of treatment against pain (caused by any reason, including cancer). Among them, older people who answered "Quite a bit" or "Very" to the question DA041_W4 were regarded as being in the group comprising the total needs of electrotherapy devices for pain. Older people who answered "Very" to the question DA041_W4 were regarded as having an urgent need for an electrotherapy device for pain.

12. Pressure Relief Mattresses

There are no user statistics for the use of pressure relief mattresses available from the CHARLS Database thus this research only examines its total needs and urgent needs. Older people who answered "yes" to question DA005[1] or answered more than 12 hours (including 12 hours) were defined as people who either have physical disabilities or spend a long time in bed every day. These people were defined as being in total need of a pressure relief mattress. Among total needs, older people who answered "yes" to question DA007_13_ or DA007_8 or answered "Quite a bit" or "Very" to the question DA041_W4, or chose at least 3 items among choices of 1/2/3/4/5/6/8/9/10/11/12/13/14/15 for the nominal question DA042 are judged as having a stroke, arthritis or rheumatism, or severe and frequent body pain. These people are regarded as being in urgent need of pressure relief mattresses.

13. Therapeutic Footwear

There are no user statistics for the therapeutic footwear available from the CHARLS Database, thus this research only examines its total needs and urgent needs. Older people who answered "yes" to question DA007_3_ refer to those who were diagnosed with diabetes or high blood sugar by a doctor. They were regarded as being in total need of therapeutic footwear. Among these people, those who answered "Physical examination after had Diabetes attack" or "Physical examination after had been ill" to question DA008_W2_1 were defined as people who have already been attacked by diabetes symptoms. These people were regarded as being in urgent need of therapeutic footwear.

14. Smart Pillbox/Pill Organiser

There are no user statistics for the smart pillbox and pill organiser available from the CHARLS Database; thus, this research only examines their total needs and urgent needs. Older people who answered "Yes, I have difficulty and need help" or "I cannot do it" to question DB013 were

defined as people who have difficulties in taking medicines because of health and memory problems. These are the people in total need for the smart pillbox and pill organiser. Among them, respondents who answered "yes" to question DA007_12_or question DD010_W4, or question DD011_W4, were judged as people with Alzheimer's disease or other memory-related disease diagnosed by a doctor. These people have difficulty in taking medicine and at the same time, have been attacked by memory-related diseases. They are in urgent need of the smart pillbox and pill organiser. Older people in total need who answered "poor" or "very poor" to the question DA002 refer to older people with bad overall health conditions at the same time as having difficulties in taking medicines. They were also in urgent need of the smart pillbox and pill organiser.

15. Handrail and Grab Bar

There is no users' statistic of the handrail and grab bar available from the CHARLS Database; thus this research only examines their total needs and urgent needs. Older people who answered "Yes, I have difficulty and need help" or "I cannot do it" to at least one question among DB003, DB004, DB006 and DB014 were regarded as those with limited ability to move and to keep their balance while navigating in rooms, toilets and other facilities. These people are in the total need of the handrail and grab bar. Among them, older people who answered "yes" to one of the questions of DA007_8_, DA007_12_, DD009_W4 and DD010_W4 were regarded as those who have suffered from stroke, Parkinson's disease, dementia, Alzheimer's disease or brain atrophy. These people were regarded as in urgent need of the handrail and grab bar.

16. Ramps, Portable

There are no user statistics for portable ramps in the CHARLS Database thus this research only looks into their total needs and urgent needs. Older people who chose "manual wheelchair" or "electric wheelchair" in

question DB029 were regarded as wheelchair users no matter what type it is. Wheelchair users were regarded as within the total need for portable ramps. Among total needs, older people who frequently participate in social activities, which require people to go across different buildings and facilities, are with urgent need for portable ramps. Older people who chose at least one among items "interacted with friends", "Played Ma-Jong, played chess, played cards, or went to community club" and "Took part in a community-related organization" in the question DA056 were regarded as those who frequently interact in social activities and enter different buildings and facilities.

17. Watches, Talking/Touching

There are no user statistics for talking and touching watches available from the CHARLS Database thus this research only examines their total needs and urgent needs. Watches, talking/touching, are a useful form of assistive technology for visually impaired people. It has been noted that people must be able to hear before using this assistive technology. Older people who answered "No" to the question DA005[4] are those who can hear. Among these respondents with fair hearing ability, those who answered "yes" to the question DA005[3] or answered "legally blind" to the question DA032 are defined as blind. Older people who answered "poor" to the question DA034 are defined as those who hardly can see things up close. People with difficulties seeing things up close are regarded as of total need for watches, talking/touching. Among them, blind people were in urgent need of these watches.

18. Glucometer

There is no users' statistic of a glucometer available from the CHARLS Database; thus this research only looks into its total needs and urgent needs. Older people who answered "yes" to question DA007_3_ refer to those who have been diagnosed with Diabetes or high blood sugar by a doctor. They were regarded within the total need for a glucometer.

Among these people, the ones who answered “physical examination after had diabetes attack” or “physical examination after had ill” to question DA008_W2_1 were defined as people who have already experienced the complications of diabetes. These people are regarded in urgent need of a glucometer.

19. Talking Blood-pressure Monitor

There are no user statistics for talking blood-pressure monitor available from the CHARLS Database thus this research only examines its total needs and urgent needs. Older people who answered “yes” to question DA007_1_ refer to those who were diagnosed with hypertension by a doctor. Older people who answered “Legally Blind” to the question DA032 or answered “Yes” to the question DA005 or answered “Poor” to the question DA034 refer to those who are blind or at least have severe vision problems when seeing things up close. Together, these hypertension patients with low vision ability were regarded in the total need of a talking Blood-pressure Monitor. Among these people, those who answered “Physical examination after had Diabetes attack” or “Physical examination after had ill” to question DA008_W2_1 were defined as people who have already experienced complications because of hypertension symptoms. These people are considered to be in urgent need of a talking Blood-pressure Monitor.

20. Alarm Signallers with Light/Sound/Vibration

There is no users’ statistic of alarm signallers with light/sound/vibration available from the CHARLS Database thus this research only examines their total needs and urgent needs. Older people who answered “yes” to at least one question among DA007_12, DD010_W4, DD011_W4 and DA005[2] were defined as those who have suffered from memory-related disease, especially Parkinson’s disease, dementia, Alzheimer’s disease or brain atrophy and damage. Older people who answered “poor” to the question DA039 are those who have poor hearing ability. Older people

who answered “Yes, I have difficulty and need help” or “I cannot do it” to the question DB017 were those with difficulties in cooking, preparing meals and using the kitchen. The above conditions together, are regarded in the total needs of alarm signallers with light/sound/vibration. Among them, respondents who answered “yes” to either question DA005[1] or question DA005[4] refer to those who are deaf of have other physical disabilities. These people were regarded in the urgent needs for alarm signallers with light/sound/vibration.

21. Deafblind communicators

There are no user statistics for deafblind communicators available from the CHARLS Database; thus this research only examines their total needs and urgent needs. Deafblind people face great challenges in communicating with each other; thus every one of them is in both the total needs and the urgent needs of deafblind communicators. Deafblind communicators require users to be literate or to have basic primary education. Deafblind communicators can be hard to use late in life, thus people aged 75 years and older are not considered in this calculation. The rest of the older respondents who answered “no formal education (illiterate)” to BD001_W2_4 at the same time, answered “none” to question BD007_W2_1 or BD007_W4_1, were regarded as illiterate people who attended neither primary education nor adult literacy training course. After excluding illiterate people, the rest of the older people who answered “yes” to the question DA005[4] are deaf. Older people who answered “yes” to the question DA005[3] or answered “legally blind” to the question DA032 are blind. Those who meet these two criteria at the same time are deafblind people. They were counted as both total and urgent needs of deafblind communicators.

22. Shower chairs

There are no user statistics for shower chairs available from the CHARLS Database; thus this research only examines their total needs and urgent

needs. Older people who answered "Yes, I have difficulty and need help" or "I cannot do it" to the question DB011 were regarded as those who have difficulties in taking a bath or shower. They were counted in the total needs for shower chairs. Among them, respondents who chose at least 3 items among choices of 2/3/4/6/8/9/10/11/12/13 for nominal question DA042 are defined as those who have moderate to severe body pain related to shower chair use. These people were counted as being in urgent need for shower chairs.

23. Personal emergency response system

There are no user statistics for personal emergency response systems available from the CHARLS Database; thus, this research only examines its total needs. The personal emergency response system is adopted by many questions in the CHARLS Questionnaire. Older people who answered "Yes, I have difficulty and need help" or "I cannot do it" to at least one question among DB003, DB011, DB014, DB018, and DB035 were defined as in the total need of a personal emergency response system. Among them, urgent needs include several conditions. First, older people who answered "yes" to the question DA005[3] or answered "legally blind" to the question DA032 are referred to as blind people. Second, older people who answered "poor" to both questions DA033 and DA034 or answered "poor eyesight" to the question DC068_W4, were defined as having poor vision ability. Third, older people who answered "yes" to either the question DA005[1] or DA005[2], refer to people either with a physical or mental disability. Fourth, older people who answered "yes" to any one of the questions DA007_1_, DA007_7_, DA007_8_, DA007_11_, DA007_12_, DD010_W4 and DD011_W4 refer to those who have chronic diseases (that can be either physical or mental) related to personal emergency response system use. Fifth, older people who chose at least 3 items among choices of 1/2/3/4/5/6/8/9/10/11/12/13/14/15 for the nominal question DA042 were defined as having moderate to severe body pain. Sixth, older people who answered "yes" to either question DA023 or

DA023_W4, or answered "yes" to either question DA025 or DA025_W4, refer to the people who ever fell down in the past year or fractured the hip, which might cause more severe accidents if they fall down again. Seventh, older people who chose at least one item in question DA056 refer to those who also participate in social activities. Within the total needs for a personal emergency response system, older people who meet any one of the above seven conditions were counted in the urgent needs of a personal emergency response system.

24. Grasping tool or reach extender

There are no user statistics for grasping tools or reach extenders available from the CHARLS Database; thus this research only examines their total needs. Older people who answered "Yes, I have difficulty and need help" or "I cannot do it" to at least one question among DB006, DB007 and DB009 were regarded as those who have difficulties in reaching the floor, reaching upper shelves or picking up items. They were regarded as having a total need of grasping tools or reach extenders. Among them, older people who answered "Yes" to the question DA007_13_, or who chose at least 3 items among choices of 2/3/4/8/9/11/12/13/15 for nominal question DA042 were defined as those who either have arthritis/rheumatism or have moderate to severe body pain necessitating the use of grasping tools or reach extenders. These people were counted as in urgent need of grasping tools or reach extenders.

25. Time management products

There is no users' statistic of time management products available from the CHARLS Database; thus this research only examines their total needs. There are no urgent needs for time management products. Olde people who answered "yes" to at least one question among DA007_12, DD010_W4, DD011_W4 and DA005[2] were defined as those who suffered from memory-related disease, especially Parkinson's disease,

dementia, Alzheimer's disease or brain atrophy and damage. These people are regarded as in the total need for time management products.

According to the above statement, the research counted the number of older people who meet the criteria of being in total need, total urgent need, unmet need and urgent unmet need. After determining the number of older people who are in need, there are also three percentages to be calculated: percentage related to the total number of unmet needs of each specific assistive technology, percentage related to the total number of older people in the database, and percentage related to total older users in specific gender or age groups.

3.11 ANALYSIS STEP SIX - STATISTICAL TESTS FOR DATA

Statistical tests in this research aimed to check if the answers included in response to ordinal question have a significant difference from responses to other questions, or between males and females, or among different age groups. Before this, chosen ordinal questions will go through a normality test to see if the answer is well-modelled by a normal distribution. A normality test was necessary because the test result leads to the choice of further test methodology. If the answer data are modelled by a normal distribution, then the T-test would be used. If the answer data fail in the normality test, then non-parametric test would be issued.

The T-test is a type of inferential statistic used to determine if there is a significant statistical difference between the means of two groups, which may be related to certain features. Calculating a t-test requires three key data values. These are the difference between the mean values from each data set (called the mean difference), the standard deviation of each group, and the number of data values of each group (Delacre, Lakens & Leys 2017). T-test requires the single variable to be measured at the interval or ratio level, rather than the ordinal level, and to be normally distributed (Weiner & Craighead 2010).

When data do not meet the parametric assumptions of the T-Test, the Wilcoxon Signed Rank Test tends to be more appropriate. This is a nonparametric test procedure for the analysis of matched - pair data, based on differences, or for a single sample. The test statistic is the sum of the ranks for either the positive or the negative values (Taheri & Hesamian 2012).

3.11.1 TESTING DIFFERENCES BETWEEN DIFFERENT GENDERS

Differences between different genders include the difference of overall health status, vision ability, hearing ability and functional performance. The code of the question from the CHARLS Database related to the above categories is shown at the end of this section.

The research used the Mann-Whitney U Test to explore if there is a significant difference in functional performance and limitation between males and females. The Mann-Whitney U Test, which is also known as the Wilcoxon rank sum test, tests for differences between two groups on a single, ordinal variable with no specific distribution (Divine et al. 2013). Researchers accordingly refer to the Mann-Whitney U Test as the nonparametric version of the parametric t - test. Both tests require two independently sampled groups. The two tests differ in the assumed distribution. A nonparametric test assumes no specific distribution, whereas a parametric test assumes a specific distribution (Weiner & Craighead 2010). The functional performance difference between males and females is one issue between the two populations. The answer from the database never promises to obey a specific distribution, thus the Mann-Whitney U Test is the appropriate way to test responses based on gender.

The answer data of the following question codes (shown in Table 15) were put into Mann-Whitney U Test to see if there was any significant

difference between different gender regarding older people's overall health status, vision ability, hearing ability and functional performance.

Table 15 - Items to Go through Mann-Whitney U Test

Category	Code of the Question
Overall Health Status	DA002
Vision Ability	DA033, DA034
Hearing Ability	DA039
Functional Performance	DB003, DB004, DB005, DB006, DB007, DB008, DB009, DB011, DB013, DB014, DB015, DB017, DB018, DB020, DB035, DD040_W4

3.11.2 TESTING DIFFERENCES AMONG DIFFERENT AGE GROUPS

Differences among different age groups include the difference in overall health status, vision ability, hearing ability and functional performance. The code of the questions from the CHARLS Database related to the above categories is shown at the end of this section.

As for responses difference among different age groups, the research uses the Kruskal Wallis Test. The Kruskal Wallis Test is a nonparametric statistical test that assesses the differences among three or more independently sampled groups on a single, non-normally distributed continuous variable (McKight; & Najab 2010). This research divided participants into four age groups: 60 - 64 years old; 64 - 69 years old; 70 - 74 years old; 75 years old and over. Different age groups include independent samples and there are more than three groups in age, thus Kruskal Wallis Test is a proper way to test responses based on different age groups.

The answer data of the following question codes (shown in Table 16) were put into the Kruskal Wallis Test to see if there was any significant difference among different age groups regarding older people's overall health status, vision ability, and hearing ability and functional performance.

Table 16 - Items to Go through Kruskal Wallis Test

Category	Code of the Question
Overall Health Status	DA002
Vision Ability	DA033, DA034
Hearing Ability	DA039
Functional Performance	DB003, DB004, DB005, DB006, DB007, DB008, DB009, DB011, DB013, DB014, DB015, DB017, DB018, DB020, DB035, DD040_W4

3.12 ANALYSIS STEP SEVEN – INTERVIEW OF EXPERTS FOR INTERPRETATION OF RESULTS

Tables of calculation results are not the end of the research, as there is a need for high-quality data interpretation. The researcher recruited several experts in the aged care industry to engage in a 60-minute-interview to make sure the researcher interprets the results in a fair and appropriate way and avoids any potential misunderstandings.

3.12.1 EXPERTS' SELECTION CRITERIA

The experts selected for the interpretation of the results must meet the following criteria. The expert must:

A), have more than 10 years of experience in assistive technology industry or as a health professional.

B), have more than 10 years of experience providing information and advice on assistive technology or prescribing assistive technology.

C), must provide assistive technology service to older adults (over 60 years old).

3.12.2 EXPERTS' SELECTION PROCESS

Aged care experts who were identified by the research team as having expertise relevant to the findings were selected from universities and research centres, private practice and services, and other entities. First, aged care experts were contacted by email with information about the research and participation requirements. Second, experts who expressed an interest were asked to fill in a one-page-questionnaire detailing their professional background and experience related to the research The questionnaire requested information about their years of experience in the assistive technology industry or as a health professional, years of providing information and advice on or prescribing assistive technology, professional qualification, sectors that they work in, the main client groups that they provide assistive technology services to, field(s) of assistive technology that they are most experienced in. From this information, it was possible to determine their eligibility to participate according to the selection criteria illustrated in Section 3.12.1. Third, the researcher negotiated a mutually suitable time for the video-interview with the eligible experts. Topics discussed during the interview are detailed in the following section.

Recruiting aged care experts, the informed consent process, interview and recording, their contributions as part of the discussion, were approved by the Human Research Ethics Committee of the University of Southern Queensland. The ethics approval number is H18REA259 (v2).

3.12.3 EXPERTS' INTERVIEW CONDUCT

Step five involved generating several tables (shown in Appendices 8.12 and 8.13) illustrating the numbers and percentages of older people needing different kinds of assistive technologies, needs, and unmet needs to be shared with the experts during the interview. In step six, data was generated regarding the gender and age group differences in older people's needs, and unmet needs for assistive technologies. This

information was initially interpreted into several statements of findings and then discussed with the experts.

During the interview, data and interpretations were presented to the expert by sharing PowerPoint slides. Topics discussed in the interview included:

1. Issues related to Older People's Needs and Unmet Needs for Assistive Technologies

    (a). Percentage of older people's unmet needs compared with recorded older people users

    (b). Percentage of older people with the need for specific assistive technologies

2. Gender and Age Differentiation regarding Users:

    (a). Assistive technologies that have significant gender differentiation

    (b). Assistive technologies that are abnormal regarding users in different age groups

3. Gender and Age Differentiation regarding Needs and Unmet Needs of Assistive Technologies

4. Gender and Age Differentiation and some other less important issues regarding Older People's Profile (Ordinal Questions)

    (a). The comparison of the calculated results with expert's knowledge - is there any result ground-breaking and might attract providers' and the industry's interest?

    (b). What opportunities exist for assistive technologies according to the calculation results? According to the calculation results, what kind of assistive technology should be put in the priority place from providers' perspective?

(c). Are there any difficulties or functional limitations that the current available assistive technologies are not able to assist with, or are able to assist with in a limited way?

(d). What sort of innovation or optimisation to the current available assistive technologies do you suggest or expect, or do you think older people might expect?

In the interview, aged care industry experts were asked to answer two types of questions in relation to the information presented. They were:

Question 1 - What is the possible cause for this result/phenomenon? (Hint: the cause can be related to the provision of the assistive technology, older people's attitudes of adoption, the quality of the data…)

Question 2 - What would you comment/discuss more about this result/phenomenon? (Hint: The comment/discussion can be related to the opportunities of any assistive technology, any needs for increasing the provision and access of assistive technology, any need for technological innovation that helps older people with health problems and functional limitations more and better than current available assistive technologies do…)

3.12.4 PRIVACY PROTECTION AND ANY SOLUTION TO AVOID RISKS AND DISADVANTAGES

According to the National Statement on Ethical Conduct in Human Research 2007 (National Health and Medical Research Council et al. 2007), the risk of research refers to potential for harm, discomfort or inconvenience. This interview presented no harm to the experts. The time imposition might have been a potential discomfort or inconvenience for experts because the interview consumed their time. To minimise the discomfort or inconvenience of time imposition, the interview was kept to the suggested timeframe of 60 minutes. The interview started only when the expert felt they knew what the research was about; what was

required and was totally happy with the intended interview process. As for privacy, any information obtained in connection with this research project that could identify the expert remained confidential. It will be disclosed only with the expert's permission, or as required by law.

3.13 VALIDITY AND RELIABILITY

Reliability and validity are two key aspects of all research (Cypress 2017). Researchers assert that the rigour of qualitative research equates to the concepts of reliability and validity and both are necessary components of quality (Tappen 2016).

Research reliability is the degree to which a research method produces stable and consistent results - that refers to the extent to which results are consistent over time and an accurate representation of the total population under study and if the results of a study can be reproduced under a similar methodology (Golafshani 2003). Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are (Leung 2015). The validity of a research study refers to how well the results among the study participants represent true findings among similar individuals outside the study (Golafshani 2003).

Based on sociotechnical theory, the social and technical aspect chosen by this research clearly represents the focus to match older people's needs for assistive technologies. Moreover, section 3.10.2 provided very detailed instruction on what questions from the CHARLS Database were chosen and how older people's needs and unmet needs for assistive technologies were calculated. Once the question choosing is fixed, the logic of determining needs and unmet needs is fixed, and the database is fixed, the research can always generate the same result no matter who conducts the calculation process.

3.14 ETHICS APPROVAL

The ethics approval of this research has been gained through the University of Southern Queensland Human Research Ethics Committee: approval ID H18REA259 (V2).

3.15 CHAPTER SUMMARY

As demonstrated in Chapter one, with the rapidly increasing population of older people, and the growing need for independent living and active ageing, older people are demonstrating increased need for assistive technologies that improve their independence, support their ADL and relieve the burden on their families and communities. Addressing these needs has great value for older people's health outcomes and informing the future of the aged care industry. Chapter two examined several ways to detect older people's needs, directly or indirectly, but none of them is suitable to use as a framework to analyse the CHARLS Database. Chapter two also found that the assistive technologies' needs in China have not yet been clearly detected in an appropriate way. This information led to the research problem of "What are the opportunities of assistive technologies in relation to Chinese older people's health needs and independent living? How can these opportunities be identified and detected from the CHARLS database?" Chapter three resolved the above-stated problems by detecting older people's total needs, urgent needs, unmet needs and urgent unmet needs under the guidance of sociotechnical theory and by interpreting the above-stated calculation results. Based on the research problem, the research proposed research question one that "what theoretical framework provides a method to best explore the user needs identified in the CHARLS data according to its available information and data characteristics?" To answer this question, this chapter explained the innovative use of the sociotechnical theory framework that analyses conditions of assistive technology use from social aspects which included personal activities and social activities, and

technical aspects which included disabilities and diseases & illnesses. These sub-aspects are further linked with detailed questions from the CHARLS Database Questionnaire. Data description was provided before further data analysis. This data description answers the Research Question 2.1 that "what are older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities?". In the further data analysis process, total needs and urgent needs for 17 assistive technologies that do not have users' statistics were analysed by calculating the population that meets the conditions of use of each type of assistive technology. This information answers the research question 2.3 that "what are the total needs and urgent total needs for assistive technologies that do not have users' statistics in the CHARLS Database?" Unmet needs and urgent unmet needs for 8 assistive technologies that had users' statistics were analysed by calculating the population that met the condition of use of each assistive technology but did not have the access to it. This information answered the Research Question 2.2 that "what are the unmet needs and urgent unmet needs for assistive technologies that have users' statistics in the CHARLS Database?" Profile differences between males and females, and among different age groups, were tested by either the Mann-Whitney U Test or the Kruskal Wallis Test. This information answered the research question 2.4 that "what differentiation exists with respect to users and users' needs (both unmet needs and total needs) between gender and age?" The above information included interviews and discussions with aged care industry experts for data interpretation to find out how the calculation outcomes addressed research questions, what deeper thoughts could emerge from the outcomes, and how the calculation results could inform aged care and assistive technology industries. These intended interpretation contents helped to answer research question three "what opportunities exist for assistive technologies to assist older people with healthcare and independent living?"

This research drew upon realist ontology, objectivist epistemology, and the positivist philosophical orientation in social research. That means that reality and truth exist and can be detected and studied. Older people's total needs, unmet needs for assistive technologies, as well as the opportunities for assistive technologies indicated by total needs and unmet needs are the existing truth that this research intends to enclose. This chapter provided a step-by-step guide on how to find the truth and what the truth indicated and informed. Unmet needs, total needs and urgent needs of each type of assistive technology not only can map older people's needs for proper technologies, but also can show great opportunities for various forms of assistive technologies. This is of great significance not only to older people, but also to the assistive technology industry, especially to developers and providers.

CHAPTER 4 : AGED POPULATION IN CHINA - DATA DESCRIPTION

The previous chapter (Chapter 3) presented the steps that were followed to conduct this research. This chapter presents the data description which shows the profile of older people in China in the survey with respect to general health, functional limitation, and personal and social activities. These comprise the total needs, urgent total needs, unmet needs and urgent unmet needs. The data interpretation provides deeper insights into the opportunities provided by assistive technologies' needs.

The research aims to identify the level of needs and unmet needs, urgent unmet needs of assistive technology products as well as the gender and age group differentiation of the above needs in China. The work of matching older people's needs was based on analysing the answers to the questions from the CHARLS Database. There were 25 types of assistive technologies selected in this research. For each of them, there were related questions for analysis from the CHARLS Database and for determining older people's needs for assistance. These 25 unique solutions, together, involved 41 questions from the CHARLS Database, including 21 ordinal questions. The preliminary description of the answers to these questions was presented in this chapter.

This chapter describes 41 variables that were related to older people's demographic information and general health, functional limitation, and personal and social activities. These variables are described for two reasons: first, to show the profile of older people in China in respect to general health, functional limitation, and personal and social activities; second, they were further used in the calculation of needs, unmet needs and urgent unmet needs for assistive technologies. There was a need for an overview of older people's demographic information, general health, and mobility functional limitations in the CHARLS Database before putting the information into data analysing.

4.1 THE CONNECTION BETWEEN THIS CHAPTER AND THE RESEARCH QUESTION

The research questions introduced in chapter two are:

Research Question 1:

What theoretical framework provides a method to best explore the user needs identified in the CHARLS data?

Research Question 2:

2.1 What are older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities?

2.2 What are the unmet needs and urgent unmet needs for assistive technologies that can be identified from the CHARLS Database?

2.3 What are the total needs and urgent total needs for assistive technologies that can be identified from the CHARLS Database?

2.4 What differentiation exists with respect to users and users' needs (both unmet needs and total needs) between gender and age?

Research Question 3:

What opportunities exist for assistive technologies to assist older people with healthcare and independent living?

This chapter presented a response to research question 2.1. Older people's profiles, which were shown as the answer data to the questions regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities in the CHARLS Database Questionnaire, needed to be presented and described. This chapter discussed the questions that were included in the further data analysis (older people's assistive technology needs detection). The answers to other research questions were shown in other chapters.

Chapter 3 discussed research question one by illustrating an innovative use of the sociotechnical theory framework that analysed conditions of assistive technology use from social aspects which included personal activities and social activities, and technical aspects which included disabilities and diseases and illnesses, in order to detect older people's total needs, urgent needs, unmet needs and urgent unmet needs for assistive technologies. Chapters five and six together explored research questions 2.2, 2.3 and 2.4. Chapter five presented the analysis results of research questions 2.2, 2.3 and 2.4. Chapter six provided the interpretation and explanation of the above three research questions. Chapter six also answered the research questions 3.1 and 3.2, which focused on the deeper thoughts and insights that can emerge from the outcomes.

4.2 VARIABLE RELATED TO DEMOGRAPHIC INFORMATION AND GENERAL HEALTH

In this section, 15 pieces of variable data description about older people's demographic information and general health were presented.

4.2.1 AGE AND GENDER

There were 20,866 participants in the CHARLS Databases Wave 4 (National School of Development of Peking University 2020). Among them, 19,494 participants had their birth year recorded. Among these participants, 10,818 participants were born in 1958 or before. Since the survey was conducted in 2018, these 10,818 participants were aged 60 years and over while they participated in the survey. Among older people in this wave, there were 5,306 males comprising 49.05% of the total number of older participants. There were 5,512 females comprising 50.95% of the older participants. The gender distribution of older people in the CHARLS Database was illustrated in Table 17.

Table 17 - The Number and Percentage of Male and Female in the CHARLS Database

Gender	Number of Older People Participants	Percentage
Male	5,306	49.05%
Female	5,512	50.95%

According to China's Statistical Yearbook, males consisted 48.25% of the older people population (National Bureau of Statistics of China 2021). This percentage is very similar to the percentage of male older people participants (49.05%) in the CHARLS Database. Females consisted 51.75% of the older people population (National Bureau of Statistics of China 2021) in China's Statistical Yearbook. This percentage is very similar to the percentage of female older people participants (50.95%) in the CHARLS Database. It can be seen from these figures and numbers that the gender percentage and ratio of the CHARLS Database accords with the gender ratio and percentage of the Chinese population. The number and percentage of the male and female population in China recorded in the Statistical Yearbook was shown in the following Table 18.

Table 18 - The Number and Percentage of Male and Female in China

Gender	Population of Older People	Percentage
Male	127,381,486	48.25%
Female	136,636,732	51.75%

(National Bureau of Statistics of China 2021)

In the calculation in Chapter 5, older respondents' ages were divided into four groups shown in Table 19.

Table 19 - Samples' Age Group Distribution in the CHARLS Database

Age Group	Number of Participants	Percentage
60 - 64 Years Old	3,340	30.87%
65 - 69 Years Old	3,132	28.95%
70 - 74 Years Old	1,931	17.86%
75 Years Old and Over	2,415	22.32%

Compared with the percentage of the entire Chinese older people recorded in China's Statistical Yearbook in the same age group (shown in the Table 20), samples in the CHARLS Database had similar age group distribution.

Table 20 - Chinese Older People's Age Group Distribution

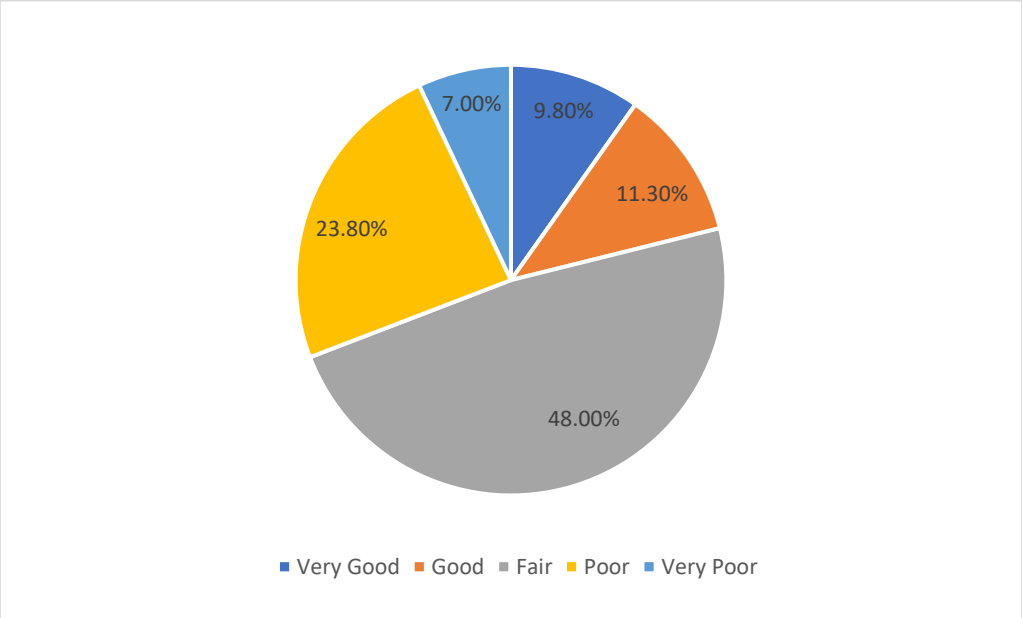
Age Group	Number	Percentage
60 - 64 Years Old	73,382,938	27.29%
65 - 69 Years Old	74,005,560	28.03%
70 - 74 Years Old	49,590,036	18.79%
75 Years Old and Over	67,039,684	25.39%

(National Bureau of Statistics of China 2021)

4.2.2 SELF-REPORTED OVERALL HEALTH STATUS

Self-reported overall health status was shown in question DA002 of the CHARLS Database Questionnaire. Among 10,818 older participants, 9897 (91.50%) responded to the self-reported health status. The percentage of answers was shown in Figure 20. Among these respondents, 9.80% of older people reported very good health status and 11.30% reported good health status. Almost half (48.00%) of the older people reported fair health status. Almost one-fourth (23.80%) of older people reported poor health status and 7.00% reported very poor health status. Overall, older participants in the CHARLS Database did not show optimism about their health condition. The concern for their health indicated the need for assistive technologies as a tool to address their health needs.

Figure 19 - Percentage of Answers of Self-reported Health Status



*The percentage of older people who responded to self-reported health status (9897 older people)

4.2.3 SPECIFIC TYPES OF DISABILITIES

Disability status was shown in questions DA005[1], DA005[2], DA005[3], DA005[4], DA005[5] of the CHARLS Database Questionnaire. There were five types of disabilities listed in the CHARLS Database: physical disabilities, brain damage/intellectual disabilities, vision problems, hearing problems, and speech impediments. The number and percentage of respondents with a specific type of disability were listed in Table 21. Sensory disabilities occurred with the highest incidence. Among them, hearing problems ranked the highest, followed by vision problems. Intellectual disabilities exceeded physical disabilities. Speech impediment had the lowest occurrence.

Table 21 - The Number and Percentage of Each Type of Disability

Type of Disability	Number	Percentage*	Percentage**
Hearing Problems	696	8.20%	6.43%
Vision Problems	505	5.48%	4.67%
Brain Damages/Intellectual Disabilities	428	4.29%	3.96%
Physical disabilities	368	3.74%	3.40%
Speech impediment	89	0.84%	0.82%

Percentage* related to the total respondents who responded to specific type of disability.

Percentage** related to the total older people in the CHARLS Database (10818 older people), including those who did not answer the specific question.

4.2.4 CHRONIC DISEASE DIAGNOSIS

Chronic disease diagnoses were shown from the answers to questions DA007_1_ to DA007_14_ of the CHARLS Database Questionnaire. There

were 14 types of chronic disease listed in the CHARLS Database Questionnaire: 1) hypertension, 2) dyslipidaemia, 3) diabetes or high blood sugar, 4) cancer or malignant tumour (excluding minor skin cancers), 5) chronic lung diseases such as chronic bronchitis and emphysema, 6) liver disease (except fatty liver, tumours, and cancer), 7) heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems, 8) stroke, 9) kidney disease (except for tumour or cancer), 10) digestive diseases (except for tumour or cancer), 11) emotional, nervous, or psychiatric problems, 12) memory-related disease (such as dementia, brain atrophy, and Parkinson's disease), 13) arthritis or rheumatism, 14) asthma. The number and percentage of respondents with specific types of chronic disease were listed in Table 22. Hypertension, dyslipidaemia, arthritis or rheumatism were the most common (around or higher than 10% of older people) chronic diseases for older people. Digestive diseases, heart attack, stroke, chronic lung disease and diabetes were also of great concern (around 5% to 10% of older people). Kidney diseases, memory-related diseases, liver diseases, asthma, cancer, emotional or nervous problems had a relatively low percentage (lower than 5% of older people). But considering the large population of Chinese older people, the total number of respondents with any chronic disease was still high.

Table 22 - The Number and Percentage of Each Chronic Disease

Type of Chronic Disease	Number	Percentage*	Percentage**
Hypertension	1305	18.37%	12.06%
Dyslipidaemia	1080	11.74%	9.98%
Arthritis or rheumatism	782	11.54%	7.23%
Digestive diseases	805	9.86%	7.44%
Heart attack	863	9.62%	7.98%
Stroke	747	7.15%	6.91%
Chronic lung diseases	631	6.67%	5.83%
Diabetes or high blood sugar	644	6.60%	5.95%
Kidney diseases	471	4.71%	4.35%
Memory-related disease	370	3.52%	3.42%
Liver diseases	364	3.52%	3.36%
Asthma	284	2.78%	2.63%
Cancer	171	1.60%	1.58%
Emotional or nervous problems	144	1.36%	1.33%

Percentage* related to the total respondents who responded to specific type of chronic disease.

Percentage** related to the total older people in the CHARLS Database (10818 older people), including those who did not answer the specific question.

4.2.5 TYPE OF CANCER

The type of cancer was shown in question DA017 of the CHARLS Database Questionnaire. There were 22 types of cancer plus an "other type" listed in the Questionnaire: 1) brain, 2) oral cavity, 3) larynx, 4) other pharynx, 5) thyroid, 6) lung, 7) breast, 8) oesophagus, 9) stomach, 10) liver, 11) pancreas, 12) kidney, 13) prostate, 14) testicle, 15) ovary, 16) cervix, 17) endometrium, 18) colon or rectum, 19) bladder, 20) skin, 21) non-Hodgkin's lymphoma, 22) leukaemia, 23) other organ. The number and percentage of respondents with specific types of cancer were listed in Table 23. Because there are various types of cancer and the CHARLS

Questionnaire can include only limited types, the “other organ” was the most selected. Among the listed type of cancer, lung cancer, colon or rectum cancer and breast cancer occurred most commonly. Liver, cervix, endometrium, brain, oesophagus, thyroid, bladder, kidney, larynx, ovary, non-Hodgkin’s lymphoma and prostate cancer had a medium level percentage of the occurrence. Oral cavity, other pharynx, skin, leukaemia, and pancreas cancer had a relatively low percentage of occurrence. No participants reported testicle cancer, but this did not mean that there was no testicle cancer patient in China. Testicle cancer is gender-specific (for males only) and has a low prevalence.

Table 23 - The Number and Percentage of Each Type of Cancer

Type of Chronic Disease	Number	Percentage*	Percentage**
Other organ	40	15.94%	0.37%
Lung	29	11.55%	0.27%
Colon or rectum	28	11.16%	0.26%
Stomach	28	11.16%	0.26%
Breast	26	10.36%	0.24%
Liver	17	6.77%	0.16%
Cervix	17	6.77%	0.16%
Endometrium	16	6.37%	0.15%
Brain	15	5.98%	0.14%
Oesophagus	12	4.78%	0.11%
Thyroid	11	4.38%	0.10%
Bladder	10	3.98%	0.09%
Kidney	9	3.59%	0.08%
Larynx	8	3.19%	0.07%
Ovary	6	2.39%	0.06%
Non-Hodgkin lymphoma	6	2.39%	0.06%
Prostate	5	1.99%	0.05%
Oral cavity	4	1.59%	0.04%
Other pharynx	4	1.59%	0.04%
Skin	2	0.80%	0.02%
Leukaemia	2	0.80%	0.02%
Pancreas	1	0.40%	0.01%
Testicle	0	0.00%	0.00%

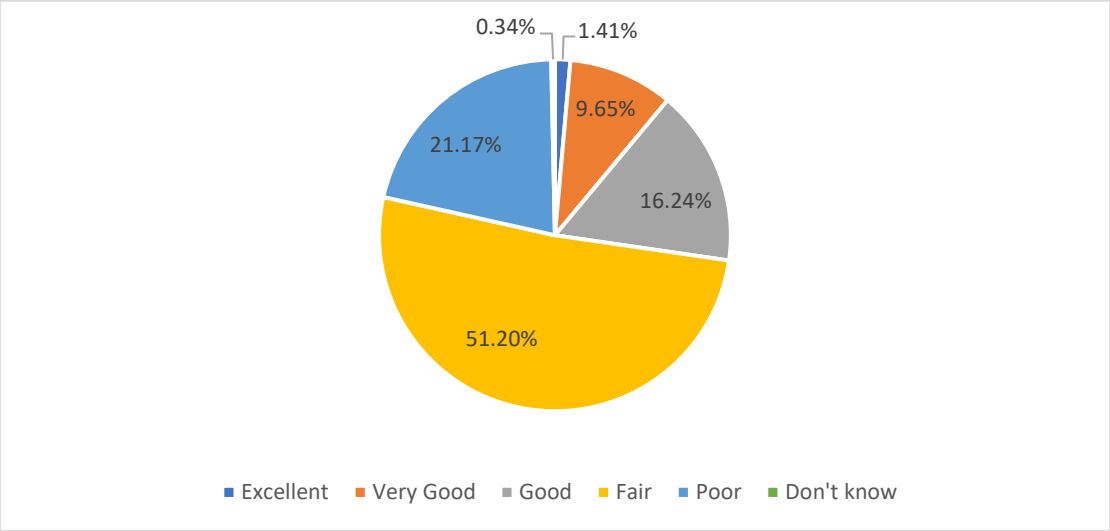
Percentage* related to the total respondents who responded to specific type of cancer.

Percentage** is the percentage related to the total older people in the CHARLS Database (10818 older people), including those who did not answer the specific question.

4.2.6 EYESIGHT FOR OBJECTS UP CLOSE AND AT A DISTANCE

Eyesight for objects up close and at a distance was shown in the questions DA033 and DA034 of the CHARLS Database Questionnaire. 10727 older people answered the question of eyesight for objects up close and at a distance, that was 91.00% of the total older people in the CHARLS Database. The percentage of respondents reporting problems with near vision was shown in Figure 21. Most of the older people in the database (51.20%) reported they had reasonable close vision. More than one out of five older people (21.17%) reported poor close vision. Similarly, regarding the issues with distance vision, more than half (50.41%) of the older people reported fair eyesight and one in every four older people (25.41%) reported poor eyesight. Overall, the eyesight of many older people was poor.

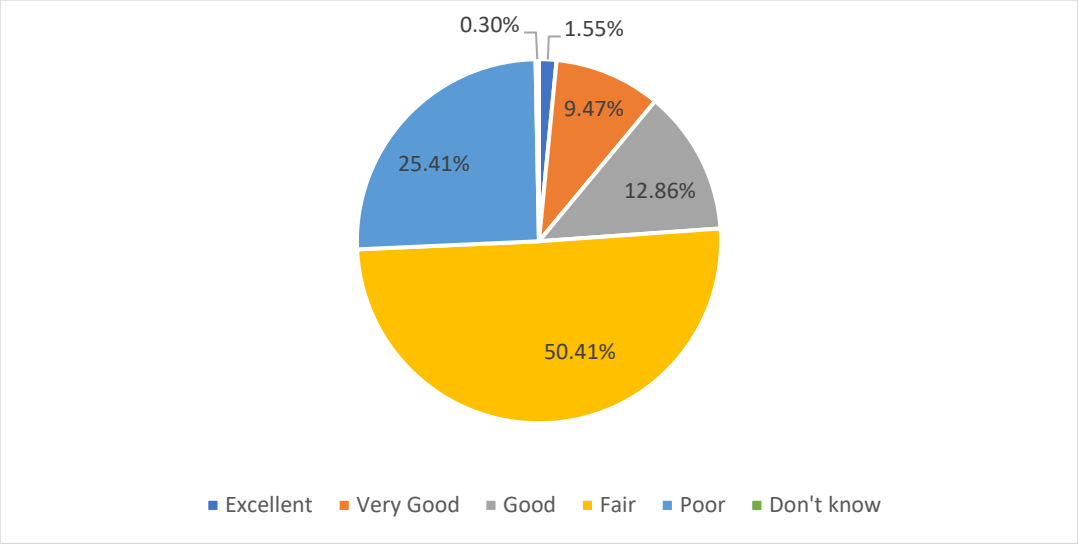
Figure 20 - Eyesight for Things Up Close



*The percentage related to older people who responded to eyesight for things up close (10727 older people)

The percentage of respondents regarding eyesight for things at a distance is shown in Figure 22.

Figure 21 - Eyesight for Things at a Distance



*The percentage related to older people who have a rating of eyesight for things at a distance (10727 older people)

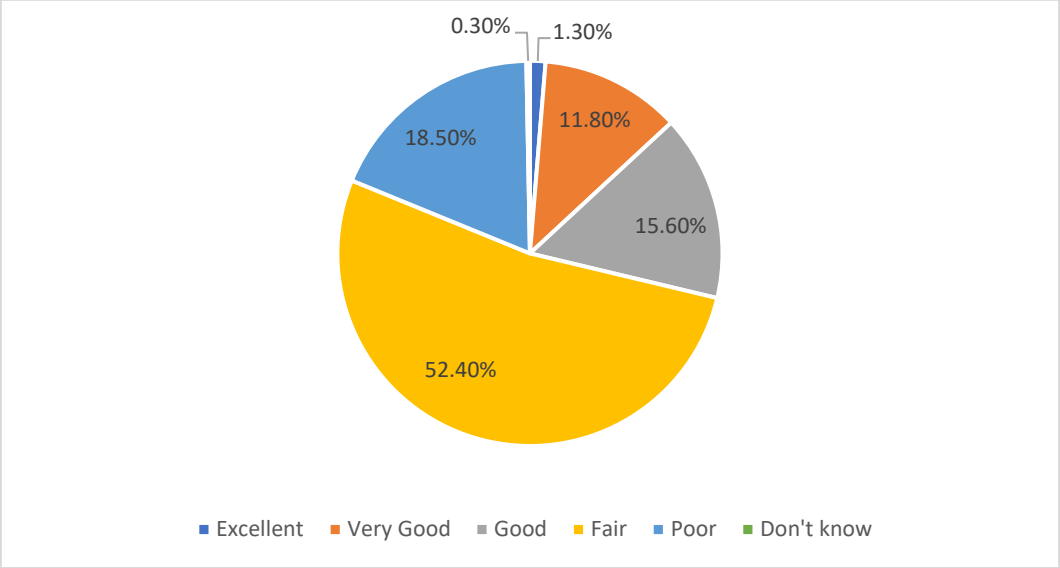
4.2.7 GLAUCOMA DIAGNOSIS

Glaucoma diagnosis was shown in questions DA037 and DA037_W2 of the CHARLS Database Questionnaire. Of those surveyed, 238 older people, or 2.20% of the total older participants responded that they had Glaucoma.

4.2.8 HEARING ABILITY

Hearing ability was shown in question DA039 of the CHARLS Database Questionnaire. There were 10,773 older people who answered about their hearing ability, which was 99.58% of the total older people in the CHARLS Database. The percentage of respondents regarding hearing ability was shown in Figure 23. Most of the older people in the database (52.40%) reported fair hearing ability. Almost one out of five older people (18.50%) reported a poor hearing ability. Together with the eyesight condition illustrated in Section 4.2.6, it can be concluded that sensory problems were of great concern for older people.

Figure 22 - Hearing Ability



*The percentage related to older people who responded to the question about their level of hearing ability (10773 older people)

4.2.9 TEETH REMAINING AND DENTURE USE

Teeth remaining data was shown in the question DA040, DA040_W4_1 and DA040_W4_2. Among 10818 older people in the database, there were 8797 people who answered the question about teeth remaining, that was 81.32% of the total older people in the CHARLS Database. 717 older people, or 8.15% of the total respondents, answered that they had lost all their teeth. 3212 older people, or 36.51% of the total respondents, answered that they wore denture.

4.2.10 BODY PAIN

Body pain problems were shown in the question DA042. In the database, 6694 older people, or 61.9% of the total older people in the CHARLS Database responded to questions about body pain. There were 16 types

of pain listed in the question. The number and percentage of respondents with body pain were listed in Table 24. The waist, knees, legs shoulder and head were the five parts most likely to be painful for older people. Arm, back, neck, stomach, fingers, ankle, wrist, chest, toes and buttock pain were also of relatively high percentage among older people. Overall, the percentage of body pain is rather high. This situation indicated that pain management was of great concern.

Table 24 - Participants Number and Percentage of Body Pain

Body Part	Number	Percentage*	Percentage**
Waist	4127	61.65%	38.15%
Knees	3455	51.61%	31.94%
Leg	3150	47.06%	29.12%
Shoulder	2892	43.20%	26.73%
Head	2738	40.90%	25.31%
Arm	2255	33.69%	20.84%
Back	2226	33.25%	20.58%
Neck	1960	29.28%	18.12%
Stomach	1834	27.40%	16.95%
Fingers	1705	25.47%	15.76%
Ankle	1687	25.20%	15.59%
Wrist	1532	22.89%	14.26%
Chest	1263	18.87%	11.67%
Toes	1213	18.12%	11.21%
Buttocks	1167	17.43%	10.79%
Other	677	10.11%	6.26%

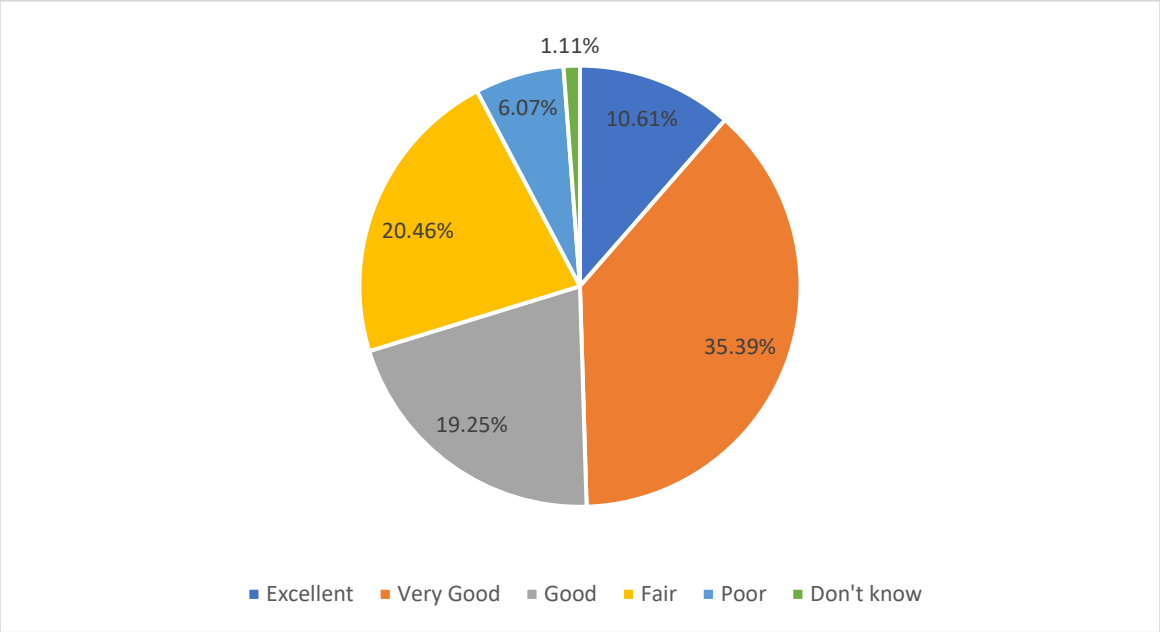
Percentage* of older people who responded to body pain in the CHARLS Database (6694 older people)

Percentage** of older people in the CHARLS Database (10818 older people), including those who did not answer the specific question.

4.2.11 HEALTH STATUS IN CHILDHOOD

Health status in childhood was shown in the question DA048. In the database, 10050 older people, or 92.90% of the total older people, responded to questions about their health status in childhood. Most of the older people in the database reported good health during their childhood (more than 65% of them had excellent, good or very good health status). Around 20% of older people had fair health status during childhood and less than 10% of respondents had poor health status during childhood or could not remember their health status. The percentage of respondents regarding health status in childhood was shown in Figure 24.

Figure 23- Health Status in Childhood



*The percentage related to older people who responded the question relating to their health status in childhood (10050 older people)

4.2.12 LENGTH OF SLEEP

Length of sleep was shown in the question DA049 and DA050. Length of sleep included length of sleeping at night and length of the nap after lunch. 10070 older people, or 93.09% of the total older people,

responded to questions about the length of sleep. According to the answers from older people, the mean length of sleep at night was 6.14 hours; the mean length of the nap after lunch was 44.15 minutes. The median length of sleep at night was 6 hours; the median length of the nap after lunch was 30 minutes

4.2.13 PHYSICAL ACTIVITY PARTICIPATION

The frequency of physical exercises was shown in the question DA051, DA052, DA053, DA054, DA055, and DA051_1. Physical exercises in the CHARLS Database were divided into three categories: vigorous-intensity activities, moderate activities and mild activities. According to the explanation in the CHARLS Database Questionnaire, vigorous activities can cause shortness of breath. Examples of vigorous-intensity activities included carrying heavy loads, digging, hoeing, aerobic workout, bicycling at a fast speed, riding a cargo bike/motorcycle (National School of Development of Peking University & Institute of Social Science Survey of Peking University 2020). Moderate activities can make people breathe more quickly than usual. Examples of moderate activities included carrying light loads, bicycling at a normal speed, mopping, Tai-Chi, and speed walking (National School of Development of Peking University & Institute of Social Science Survey of Peking University 2020). Mild activities are of low intensity such as walking from one place to another place at a workplace or home and taking a walk for leisure, sports, exercise or entertainment (National School of Development of Peking University & Institute of Social Science Survey of Peking University 2020). The CHARLS Database defined "doing the activity" as "taking part in for at least 10 minutes every time in a week" (National School of Development of Peking University & Institute of Social Science Survey of Peking University 2020).

10770 older people, or 99.56% of the total older people in the CHARLS Database, responded to the question related to physical exercise. Most of the older people in the database participated in mild activities (around 80%). Around 40% of older people participated in moderate activities and around 25% of older people participated in vigorous-intensity activities. Overall, older people were still active in physical activities. The number and percentage of respondents regarding each type of physical activity were listed in Table 25.

Table 25 - The Number and Percentage of Physical Activity Participation

Type of Physical Activities	Number	Percentage*
Vigorous-intensity Activities	2779	25.69%
Moderate Activities	4606	42.58%
Mild Activities	8656	80.37%

*The percentage of older people who responded to physical exercise (10770 older people)

The CHARLS Database also investigated the purpose for undertaking these physical activities, including entertainment, job demands and exercise. Older people do vigorous-intensity activities mostly for entertainment, followed by the desire for exercise. Other purposes were very low in number. Almost half of older people undertook moderate and mild activities for entertainment, followed by the desire to exercise. The response to "purpose of job demand" and other purposes was relatively low in numbers. The number and percentage of the purpose for vigorous-intensity activities were listed in Table 26.

Table 26 - The Number and Percentage of the Purpose for Vigorous-Intensity Activities

Purpose of Vigorous-intensity Activities	Number	Percentage*
Entertainment	2193	78.91%
Exercise	337	12.13%
Other	195	7.02%
Job Demand	54	1.94%

*The percentage of older people who responded to taking part in the vigorous-intensity activities (2779 older people)

The number and percentage of the purpose for moderate activities were listed in Table 27.

Table 27 - The Number and Percentage of the Purpose for Moderate Activities

Purpose of Moderate Activities	Number	Percentage*
Entertainment	2238	48.59%
Other	1316	28.57%
Exercise	927	20.13%
Job Demand	125	2.71%

*The percentage of older people who responded to taking part in the moderate activities (4606 older people)

The number and percentage of the purpose for mild activities were listed in Table 28.

Table 28 - The Number and Percentage of the Purpose for Mild Activities

Purpose of Mild Activities	Number	Percentage*
Entertainment	2850	48.59%
Exercise	3810	44.02%
Other	1119	12.93%
Job Demand	877	10.13%

*The percentage of older people who responded to taking part in the mild activities (8656 older people)

4.2.14 SOCIAL ACTIVITIES PARTICIPATION

Participation in social activities was shown in the question DA056. 10769 older people, or 99.55% of the total older people in the CHARLS Database, responded to the question related to social activities participation. There were 10 types of specified social activities listed in the CHARLS Database Questionnaire. The number and percentage of each type of social activity participation were listed in Table 29. Interacting with friends was the most popular social activity for older people. Playing Ma-Jong, chess, cards, going to a community club, providing help to family, friends, or neighbours, using the internet, going to a sport, social, or another kind of club also had considerable levels of participation.

Taking part in a community-related organization, doing voluntary or charity work, caring for the sick or disabled, attending an educational or training course, stock investment and other activities had a low percentage of participation. There was still a considerable percentage of older people who did not engage in social activities.

Table 29 - The Number and Percentage of Each Type of Social Activities Participation

Type of Social Activities Participation	Number	Percentage*
Interacted with friends	3241	31.10%
Played Ma-Jong, chess, cards, or went to a community club	1747	16.22%
Provided help to family, friends, or neighbours	1095	10.17%
Used the Internet	668	6.20%
Went to a sport, social, or other kind of club	578	5.37%
Took part in a community-related organization	244	2.27%
Cared for a sick or disabled adult who does not live with you	204	1.89%
Other	154	1.43%
Done voluntary or charity work	131	1.22%
Stock investment	40	0.37%
Attended an educational or training course	38	0.35%
None of these	5650	52.47%

*The percentage of older people who responded to social activities participation (10769 older people)

4.2.15 EDUCATION LEVEL

Education level is shown in the question DD003_W4 in the CHARLS Database. There were 9,906 older people who answered the question about education level, making up 91.57% of the total older people in the CHARLS Database. The education level ranged from "no formal education (illiterate)" to "doctoral degree/PhD". Most of the older people surveyed did not go beyond middle school. Almost half of older people finished

elementary school or middle school. Around 30% of them did not finish primary school or just had no formal education. The number and percentage of each education level are listed in Table 30.

Table 30 - The Number and Percentage of Each Education Level

Education Level	Number	Percentage*
No Formal Education (illiterate)	1906	19.24%
Did not Finish Primary School	1393	14.06%
Sishu/home School	9	0.09%
Elementary School	2150	21.70%
Middle School	2440	24.63%
High School	923	9.32%
Vocational School	452	4.56%
Two-/Three-Year College/Associate Degree	355	3.58%
Four-Year College/Bachelor's Degree	257	2.59%
Master's Degree	16	0.16%
Doctoral degree/PhD	5	0.05%

*The percentage of older people who responded to education level (9,906 older people)

4.3 VARIABLE RELATED TO FUNCTIONAL LIMITATIONS

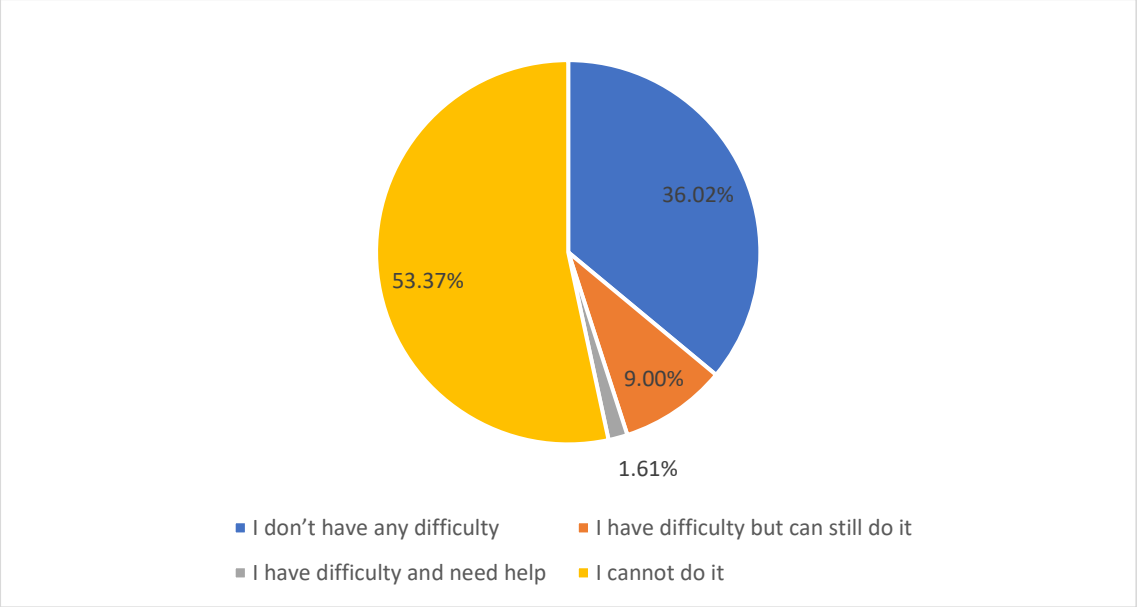
In this section, 21 pieces of data description about older people's functional limitations were presented.

4.3.1 ANY DIFFICULTY WITH RUNNING OR JOGGING ABOUT 1 KM

The difficulty with running or jogging about 1 km was shown in question DB001 in the CHARLS Database. 10,765 older people, which was 99.51% of the total older people in the CHARLS Database, answered the question of difficulty with running or jogging about 1 km. Running or jogging about 1 km was a significant challenge for many older people. 53.37% of the older people who answered the question could not do this. 1.61% of the older people had difficulty and needed help to run or jog. 9.00% of the older people had difficulty but still could run or jog and 36.02% of the older people could run or jog without difficulties. The percentage of the

difficulty with running or jogging about 1 km was listed in Figure 25.

Figure 24 - Any difficulty with running or jogging about 1 km

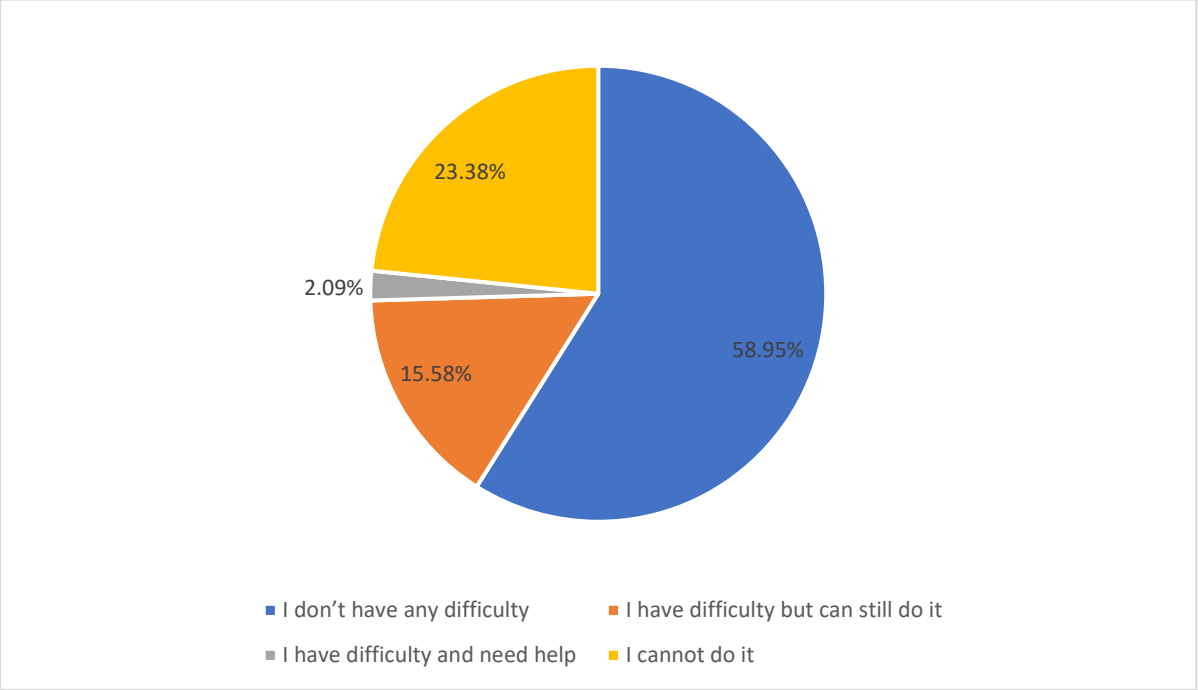


*The percentage of older people who responded to difficulty of running or jogging about 1 km (10765 older people)

4.3.2 ANY DIFFICULTY WITH WALKING 1 KM

The difficulty with walking 1 km was shown in question DB002 in the CHARLS Database. 2827 older people, which was 26.13% of the total older people in the CHARLS Database, answered the question of difficulty with walking 1 km. 23.38% of the older people reported that they could not do it. 2.09% of the older people had difficulty and needed help to do it. 15.58% of the older people had difficulty but could still do it and 58.95% of older people could do it without difficulties. The percentage of the difficulty with walking 1 km was shown in Figure 26.

Figure 25 - Any Difficulty with Walking 1 km

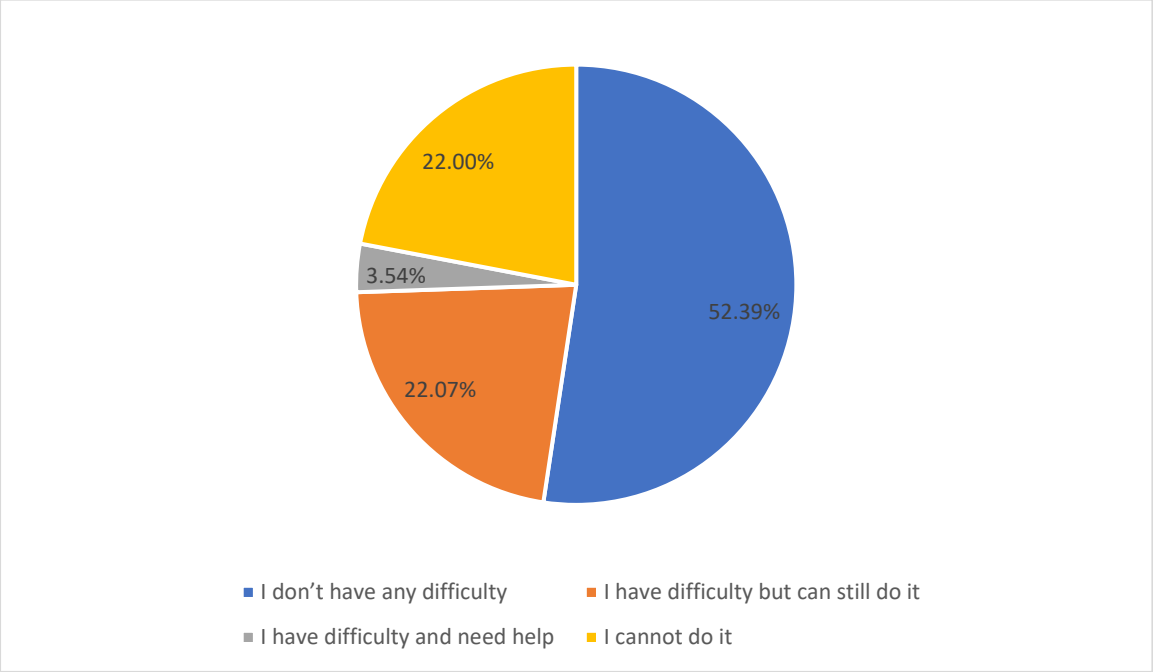


*The percentage of older people who responded to the difficulty of walking 1 km (2827 older people)

4.3.3 ANY DIFFICULTY WITH WALKING 100 METRES

The difficulty with walking 100 metres was shown in question DB003 in the CHARLS Database. 2827 older people, which was 26.13% of the total older people in the CHARLS Database, answered the question of difficulty with walking 100 metres. 23.38% of the older people could not undertake this activity. 22.00% of the older people had difficulty and needed help with walking that distance. 3.54% of the older people had difficulty but could do it and 52.39% of the older people could complete the walk without difficulties. The percentage of the difficulty with walking 100 metres was shown in Figure 27.

Figure 26 - Any Difficulty with Walking 100 Metres

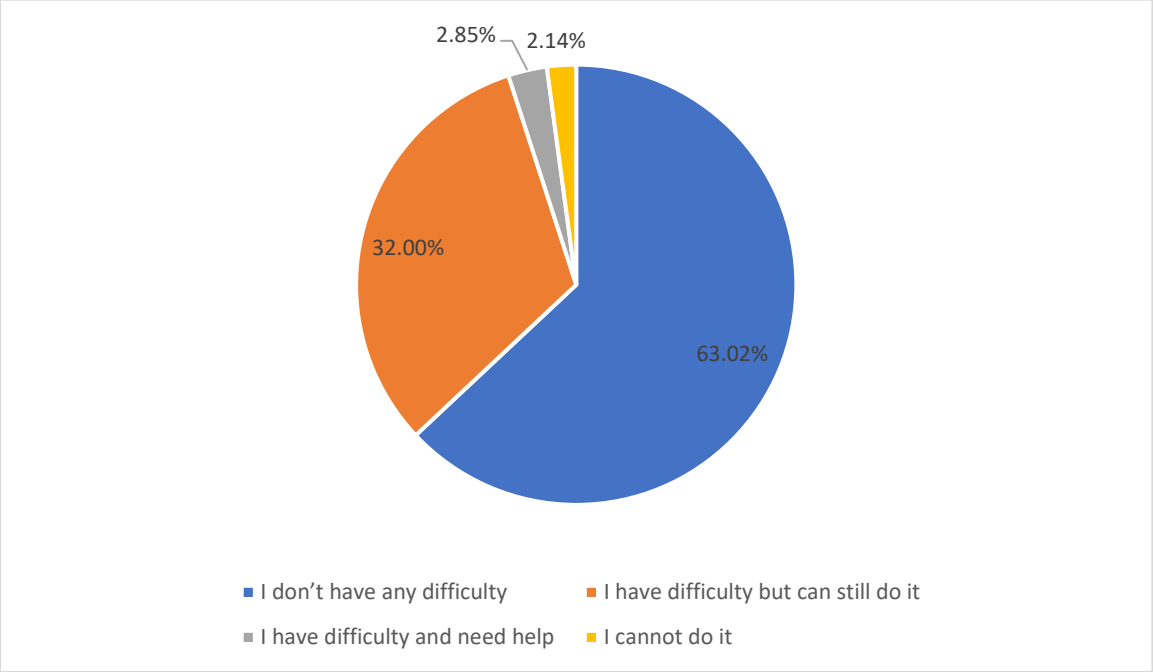


*The percentage related to older people who answered the question about the difficulty with walking 100 metres (2827 older people)

4.3.4 ANY DIFFICULTY WITH RISING FROM A CHAIR AFTER SITTING FOR A LONG PERIOD

The difficulty with rising from a chair after sitting for a long period was shown in question DB004 in the CHARLS Database. 10764 older people, which was 99.50% of the total older people in the CHARLS Database, answered the question of difficulty with rising from a chair. 2.14% of the older people could not do it. 2.85% of the older people had difficulty performing the task and needed help to do it. 32.00% of the older people rose from the chair after sitting for a long period with difficulty but still could undertake this activity and 63.02% of the older people rose from the chair without difficulty. The percentage of the difficulty with getting up from a chair was shown in Figure 28.

Figure 27 - Any Difficulty with Getting Up from a Chair

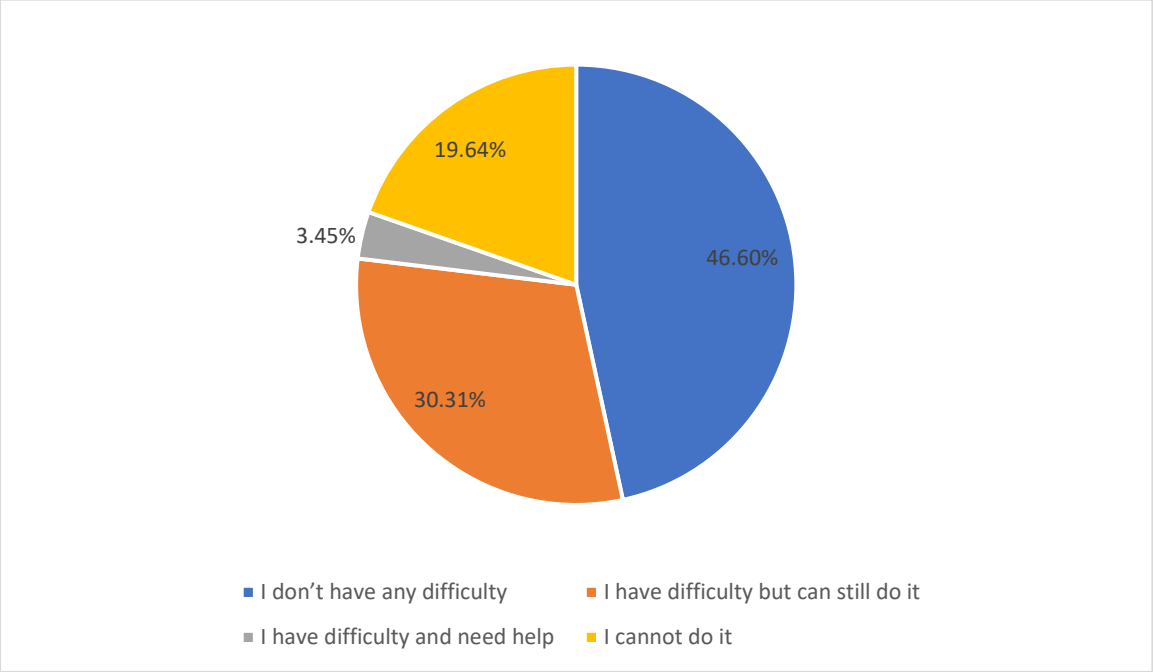


*The percentage of older people who responded to difficulty with getting up from a chair after sitting for a long period (10764 older people)

4.3.5 ANY DIFFICULTY WITH CLIMBING SEVERAL FLIGHTS OF STAIRS WITHOUT RESTING

The difficulty with climbing several flights of stairs was shown in question DB005 in the CHARLS Database. 10764 older people, which was 99.50% of the total older people in the CHARLS Database, answered the question of difficulty with climbing several flights of stairs. This was another challenge for older people. 19.64% of the older people could not climb several stairs without resting. 3.45% of the older people had difficulty and needed help to do it. 30.31% of the older people had difficulty but could still manage the task and 46.6% of the older people climbed stairs without difficulty. The percentage of difficulty with climbing several flights of stairs was shown in Figure 29.

Figure 28 - Any Difficulty with Climbing Several Flights of Stairs

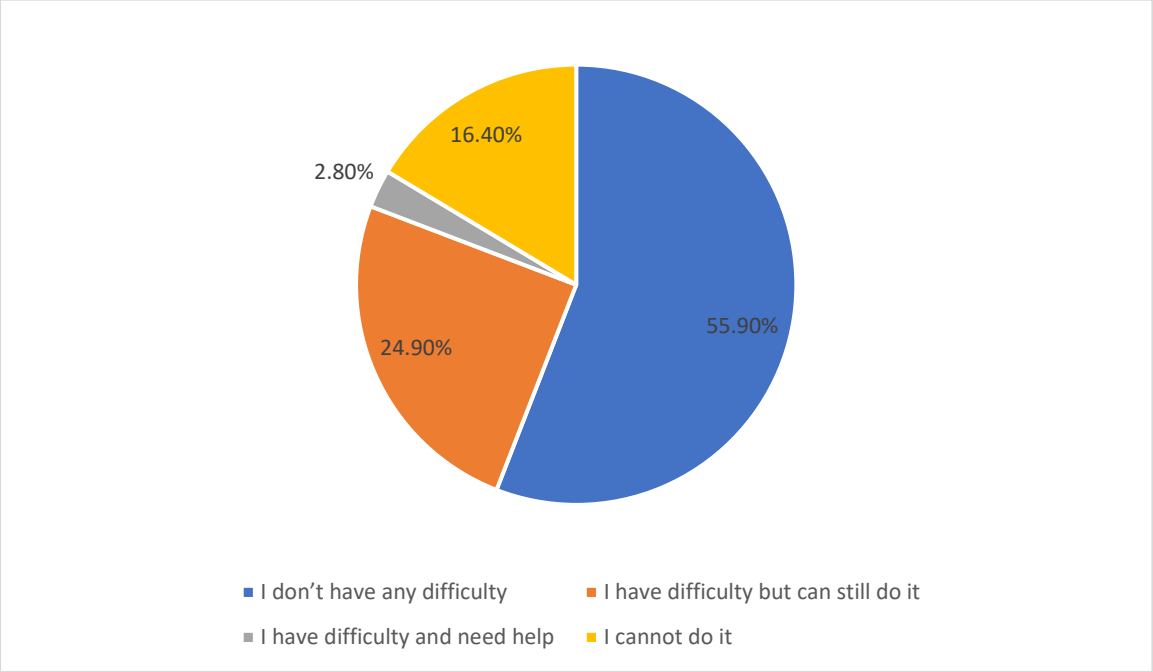


*The percentage of older people who responded to difficulty with climbing several flights of stairs (10764 older people)

4.3.6 ANY DIFFICULTY WITH STOOPING, KNEELING, OR CROUCHING

The difficulty with stooping, kneeling, or crouching was shown in question DB006 in the CHARLS Database. 10,764 of older people, which was 99.50% of the total older people in the CHARLS Database, answered the question of difficulty with stooping, kneeling, or crouching. Older people showed a considerable percentage of difficulties in undertaking these movements. 16.40% of the older people could not carry out these movements. 2.80% of the older people had difficulty and needed help. 24.90% of the older people had difficulty but could still complete these tasks and 55.90% of the older people could do these without difficulties. The percentage of difficulty with stooping, kneeling, or crouching was shown in Figure 30.

Figure 29 - Any Difficulty with Stooping, Kneeling, or Crouching

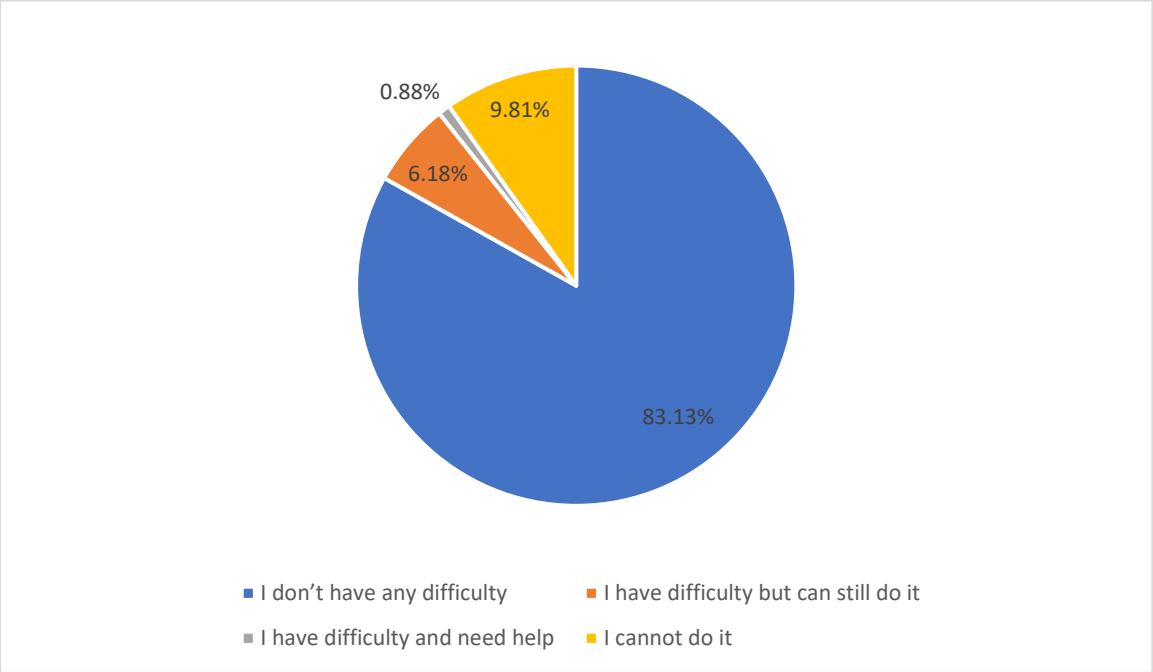


*The percentage related to older people who answered about the difficulty with stooping, kneeling, or crouching (10,764 older people)

4.3.7 ANY DIFFICULTY WITH REACHING OR EXTENDING ARMS ABOVE SHOULDER LEVEL

The difficulty with reaching or extending the arms above shoulder level was shown in question DB007 in the CHARLS Database. 10764 older people, which was 99.50% of the total older people in the CHARLS Database, answered the question of difficulty with reaching or extending arms above shoulder level. This was easily attainable for older people. Only 9.81% of the older people could not undertake this activity. 0.88% of the older people had difficulty and needed help to complete this. 6.18% of the older people had difficulty but could still do it and 83.13% of the older people could do it without difficulties. The percentage of the difficulty with reaching or extending arms above shoulder level was shown in Figure 31.

Figure 30 - Any Difficulty with Reaching or Extending Arms Above Shoulder Level

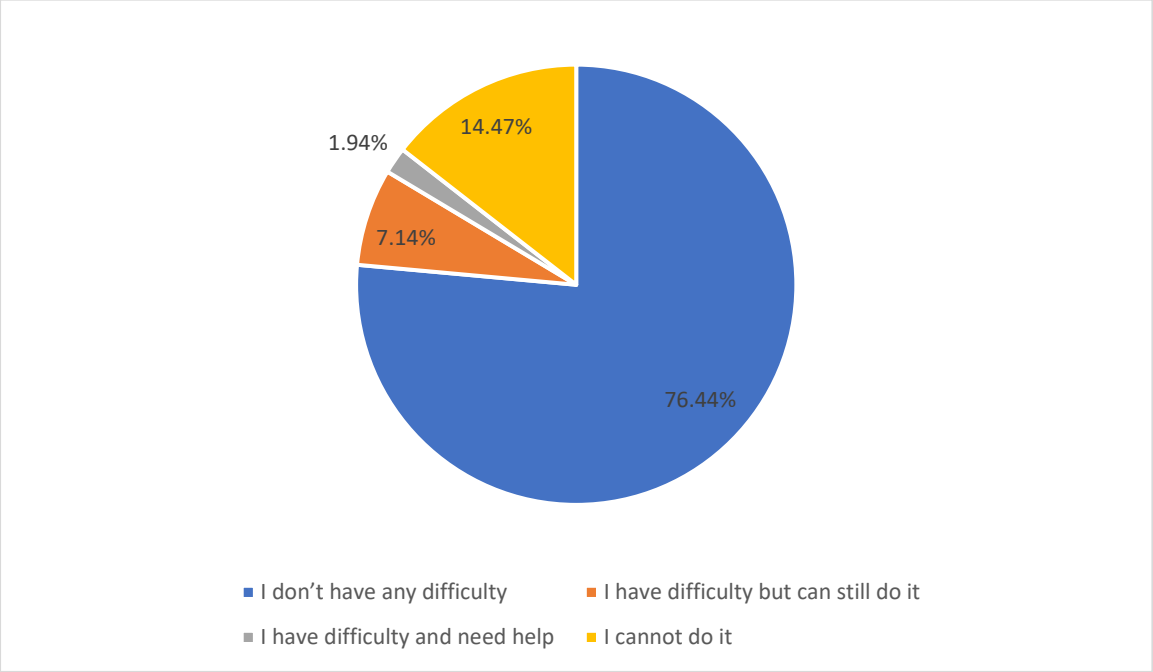


*The percentage of older people who answered about the difficulty with reaching or extending arms above shoulder level (10764 older people)

4.3.8 ANY DIFFICULTY WITH LIFTING OR CARRYING WEIGHTS OVER 5KG

The difficulty with lifting or carrying weights over 5kg was shown in question DB008 in the CHARLS Database. 10765 older people, that was 99.51% of the total older people in the CHARLS Database, answered the question of difficulty with lifting or carrying weights over 5kg. 14.47% of the older people could not carry weights over 5kg. 1.94% of the older people had difficulty and needed help to undertake this activity. 7.14% of the older people had difficulty but could still carry weights and 76.44% of the older people could do this without difficulty. The percentage of difficulty with lifting or carrying weights over 5kg was shown in Figure 32.

Figure 31- Any Difficulty with Lifting or Carrying Weights Over 5kg

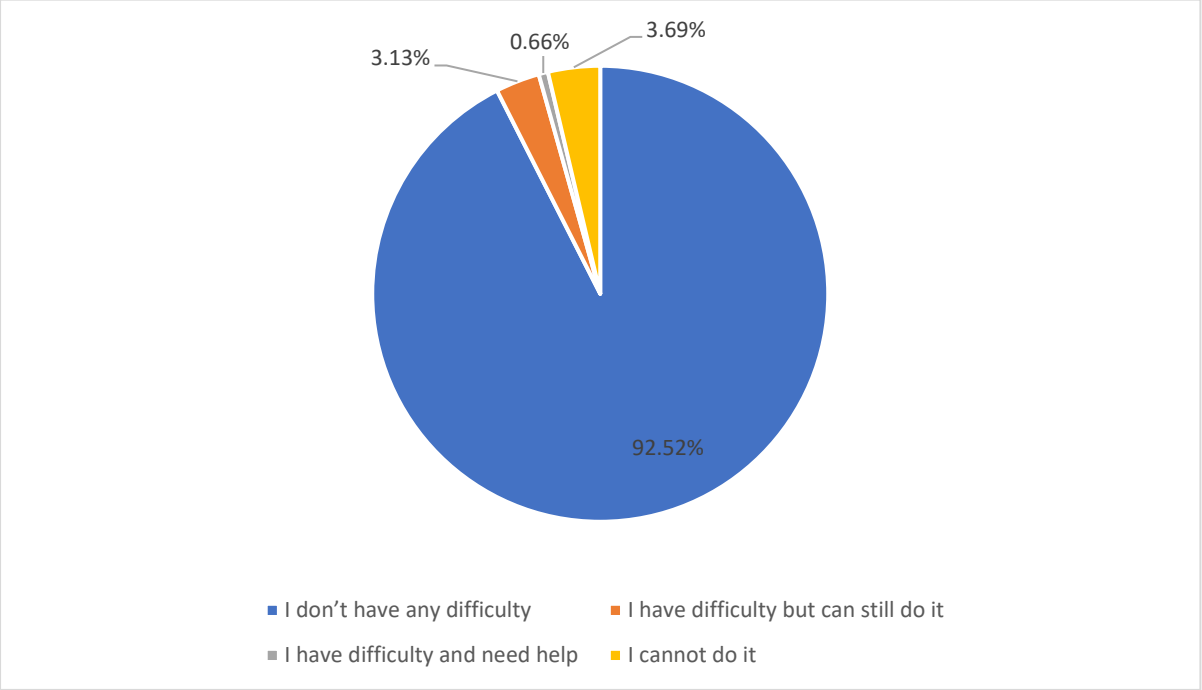


*The percentage of older people who responded to the difficulty with lifting or carrying weights over 5kg (10765 older people)

4.3.9 ANY DIFFICULTY WITH PICKING UP A SMALL COIN FROM A TABLE

The difficulty with picking up a small coin from a table was shown in question DB009 in the CHARLS Database. 10764 older people, which was 99.50% of the total older people in the CHARLS Database, answered the question of difficulty with picking up a small coin from a table. This seems relatively attainable for older people. Only 3.69% of the older people could not do it. 0.66% of the older people had difficulty and needed help to do it. 3.13% of the older people had difficulty but could still do it and 92.52% of the older people could undertake this activity without difficulties. The percentage of the difficulty with picking up a small coin from a table was shown in Figure 33.

Figure 32 - Any Difficulty with Picking Up a Small Coin from a Table

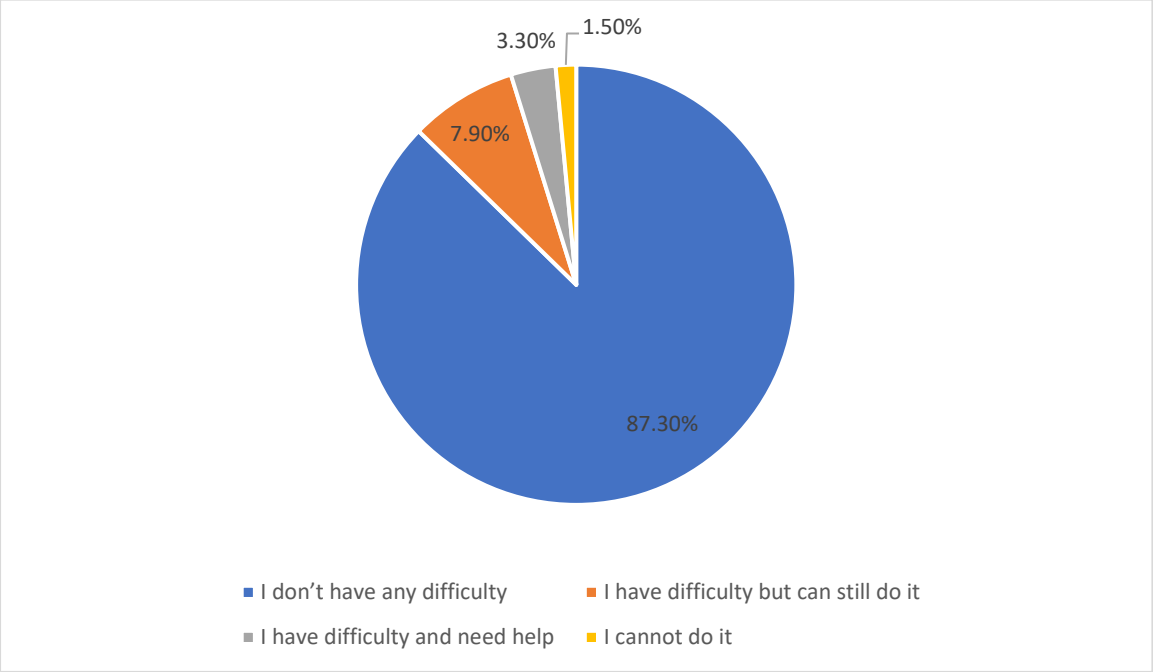


*The percentage related to older people who responded to difficulty with picking up a small coin from a table (10764 older people)

4.3.10 ANY DIFFICULTY WITH DRESSING BECAUSE OF HEALTH AND MEMORY PROBLEMS

The difficulty with dressing because of health and memory problems was shown in question DB010 in the CHARLS Database. 8469 older people, which was 78.29% of the total older people in the CHARLS Database, answered the question of difficulty with dressing. 1.50% of the older people could not dress themselves. 3.30% of the older people had difficulty and needed help to dress. 7.90% of the older people had difficulty but could still dress themselves and 87.30% of the older people could dress without difficulties. The percentage of the difficulty with dressing was shown in Figure 34.

Figure 33 - Any Difficulty with Dressing

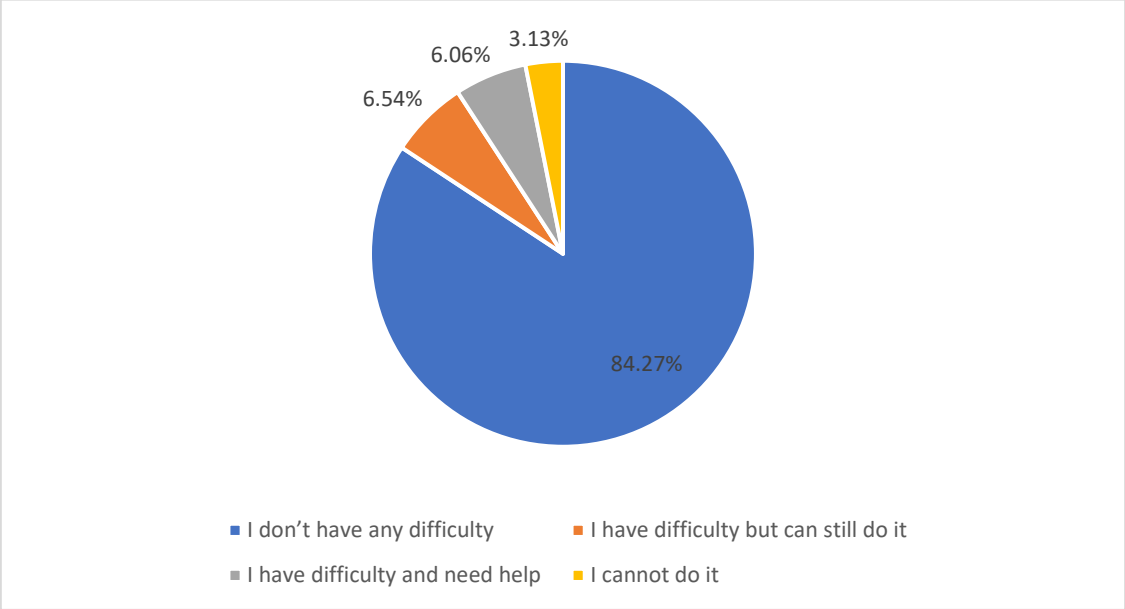


*The percentage of older people who responded to difficulty with dressing (8469 older people)

4.3.11 ANY DIFFICULTY WITH BATHING OR SHOWERING

The difficulty with bathing or showering was shown in question DB011 in the CHARLS Database. 10765 older people, which was 99.51% of the total older people in the CHARLS Database, answered the question of difficulty with bathing or showering. 3.13% of the older people could not bathe or shower by themselves. 6.06% of the older people had difficulty in completing these tasks. 6.54% of the older people had difficulty but could still bathe or shower by themselves and 84.27% of the older people could do these tasks without difficulties. The percentage of difficulty with bathing or showering was shown in Figure 35.

Figure 34 - Any Difficulty with Bathing or Showering

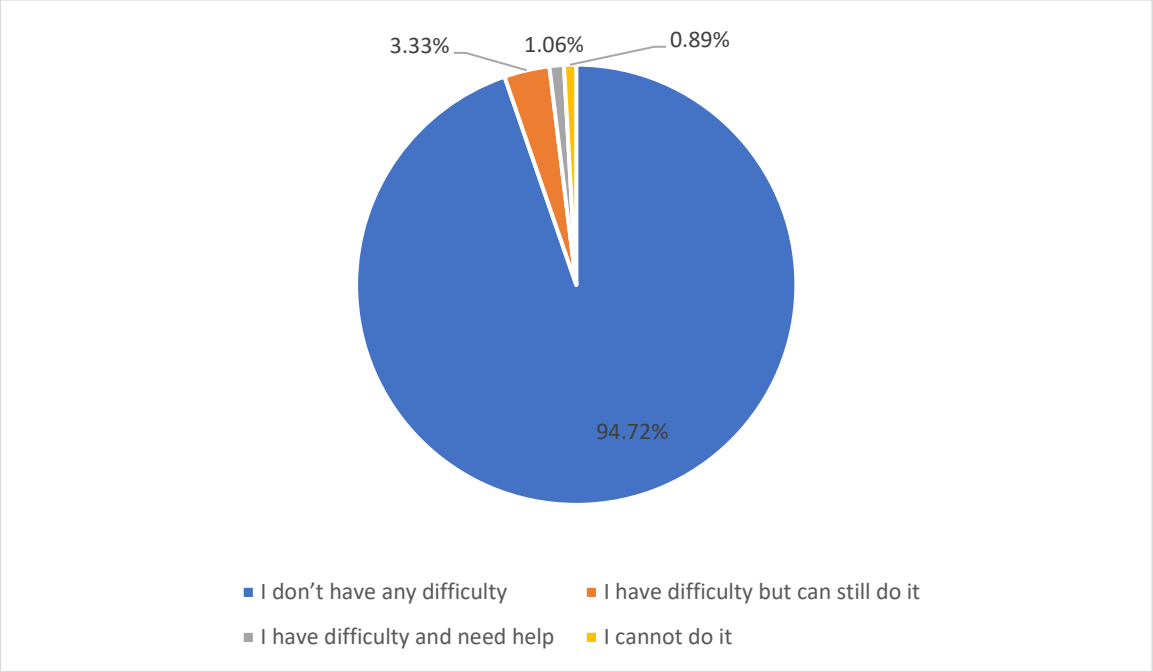


*The percentage of older people who responded to difficulty with bathing or showering (10,765 older people)

4.3.12 ANY DIFFICULTY WITH EATING

The difficulty with eating (eating means eating food by oneself when it is ready) was shown in question DB012 in the CHARLS Database. 8468 older people, which was 78.28% of the total older people in the CHARLS Database, answered the question of difficulty with eating. Only 0.89% of the older people could not eat independently. Of the respondents, 1.06% of the older people had difficulty and needed to eat. 3.33% of older people had difficulty but still could eat and 94.72% of the older people could eat without difficulty. The percentage of the difficulty with eating was shown in Figure 36.

Figure 35 - Any Difficulty with Eating

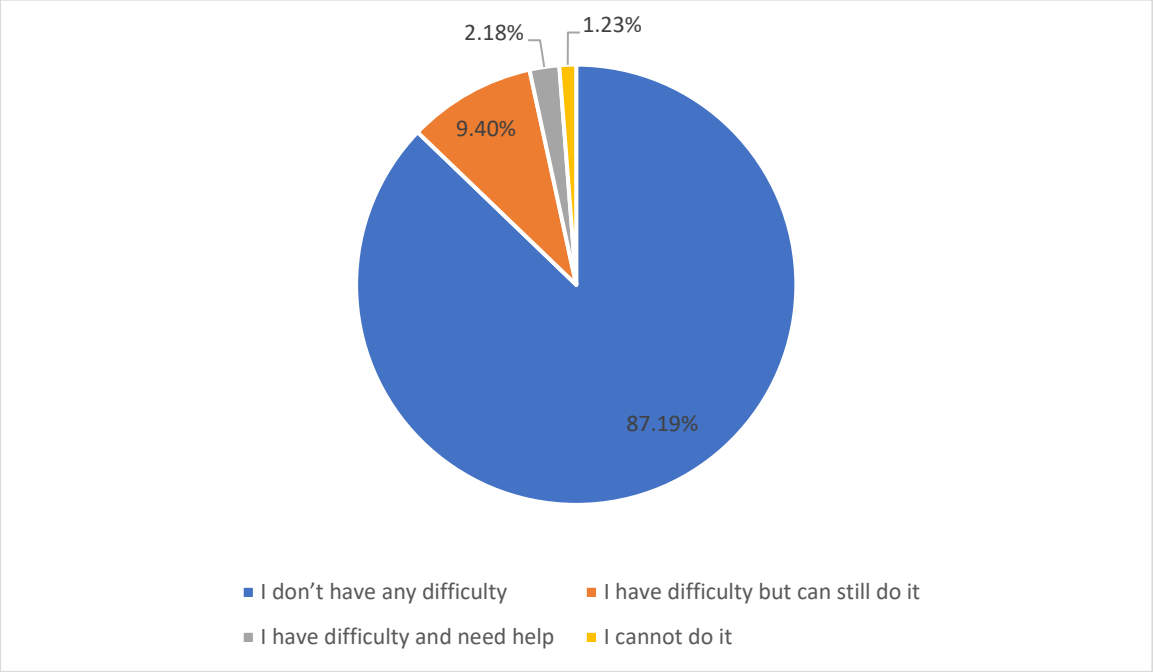


*The percentage of older people who responded to difficulty with eating (8468 older people)

4.3.13 ANY DIFFICULTY WITH GETTING INTO OR OUT OF BED

The difficulty with getting into or out of bed was shown in question DB013 in the CHARLS Database. 8468 older people, which was 78.28% of the total older people in the CHARLS Database responded to the question of difficulty with getting into or out of bed. 1.23% of the older people could not do this. 2.18% of the older people had difficulty and needed help. 9.40% of the older people had difficulty but could still get in or out of bed and 87.19% of the older people could do this without difficulties. The percentage of the difficulty with getting into or out of bed was shown in Figure 37.

Figure 36 - Any Difficulty with Getting into or out of Bed

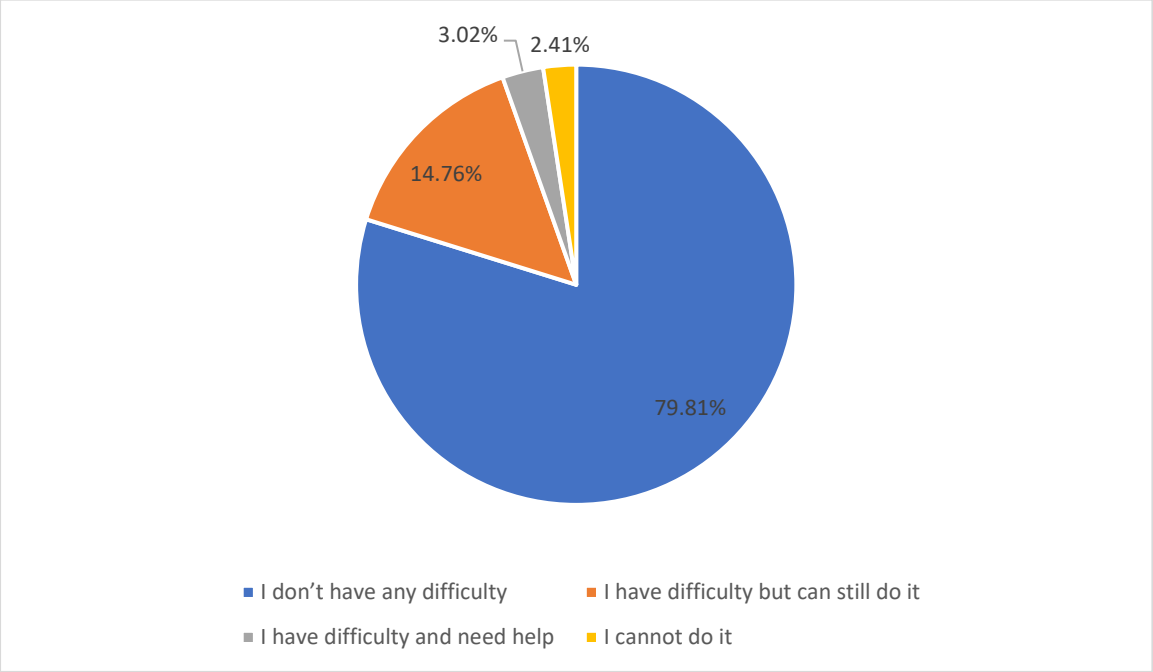


*The percentage of older people who responded to difficulty with getting into or out of bed (8468 older people)

4.3.14 ANY DIFFICULTY WITH USING THE TOILET

The difficulty with using the toilet was shown in question DB014 in the CHARLS Database. 8468 older people, which was 78.28% of the total older people in the CHARLS Database, answered the question of difficulty with using the toilet. 2.41% of the older people could not use the toilet by themselves. 3.02% of the older people had difficulty and needed help in completing this task. 14.76% of the older people had difficulty but could still use the toilet by themselves and 79.81% of the older people could do this task without difficulties. The percentage of difficulty with using the toilet was shown in Figure 38.

Figure 37 - Any Difficulty with Using the Toilet

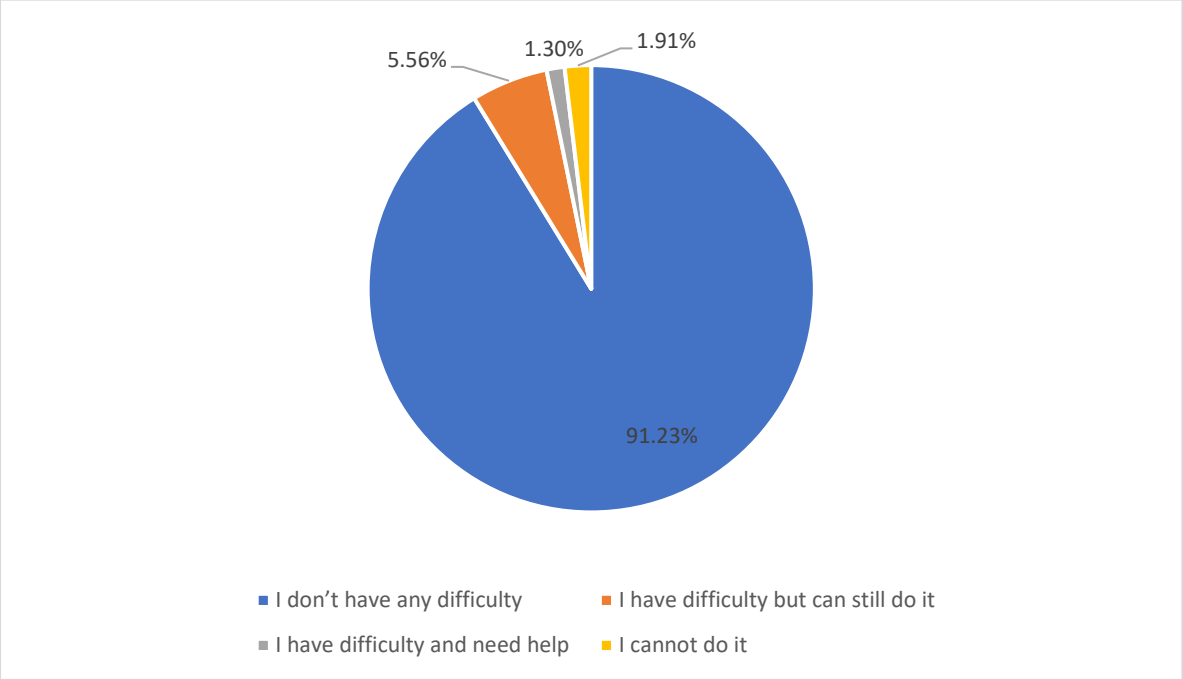


*This was the percentage related to older people who answered about the difficulty with using the toilet (8,468 older people)

4.3.15 ANY DIFFICULTY WITH CONTROLLING URINATION AND DEFECATION

The difficulty with controlling urination and defecation was shown in question DB015 in the CHARLS Database. 8468 older people, which was 78.28% of the total older people in the CHARLS Database, answered the question of difficulty with controlling urination and defecation. 1.91% of the older people could not control urination and defecation. 1.30% of the older people had difficulty in it. 5.56% of the older people had difficulty but could still control urination and defecation and 91.23% of the older people could do this without difficulties. The percentage of difficulty with controlling urination and defecation was shown in Figure 39.

Figure 38 - Any Difficulty with Controlling Urination and Defecation

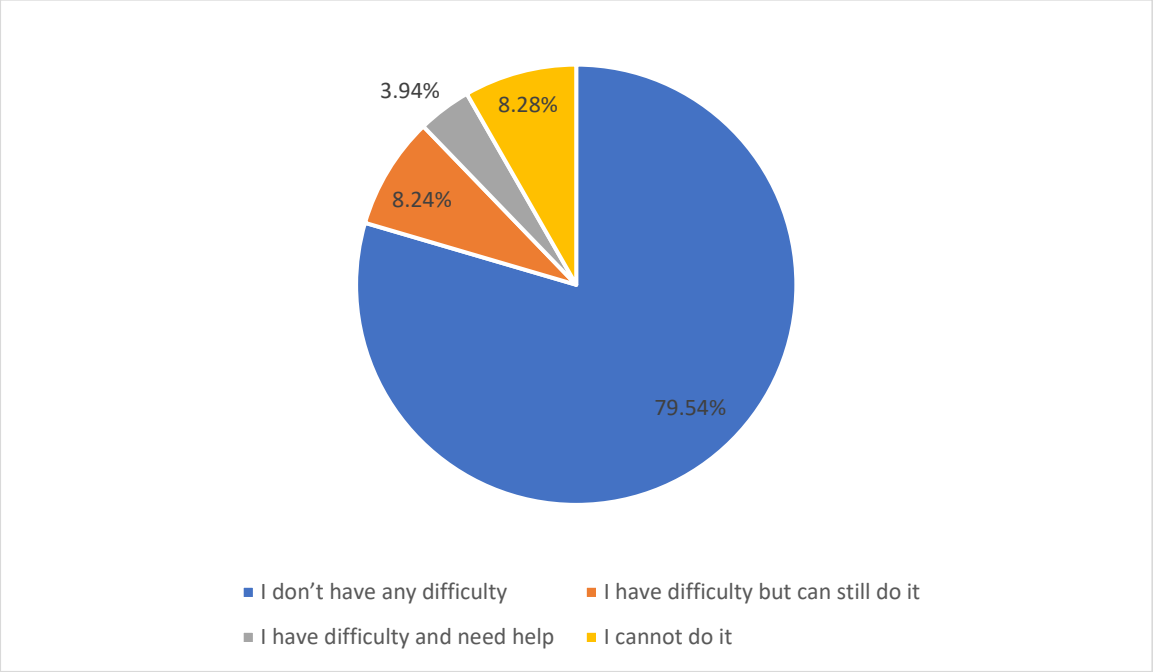


*The percentage of older people who responded to difficulty with controlling urination and defecation (8468 older people)

4.3.16 ANY DIFFICULTY WITH DOING HOUSEHOLD CHORES

The difficulty with doing household chores (doing household chores means house cleaning, doing dishes, making the bed arranging the house) was shown in question DB016 in the CHARLS Database. 10763 older people, which was 99.49% of the total older people in the CHARLS Database, answered the question of difficulty with doing household chores. 8.18% of the older people could not do chores. 3.94% of the older people had difficulty and needed help in completing these tasks. 8.24% of the older people had difficulty but could still do chores and 79.54% of the older people could do these tasks without difficulties. The percentage of difficulty with doing household chores was shown in Figure 40.

Figure 39 - Any Difficulty with Doing Household Chores

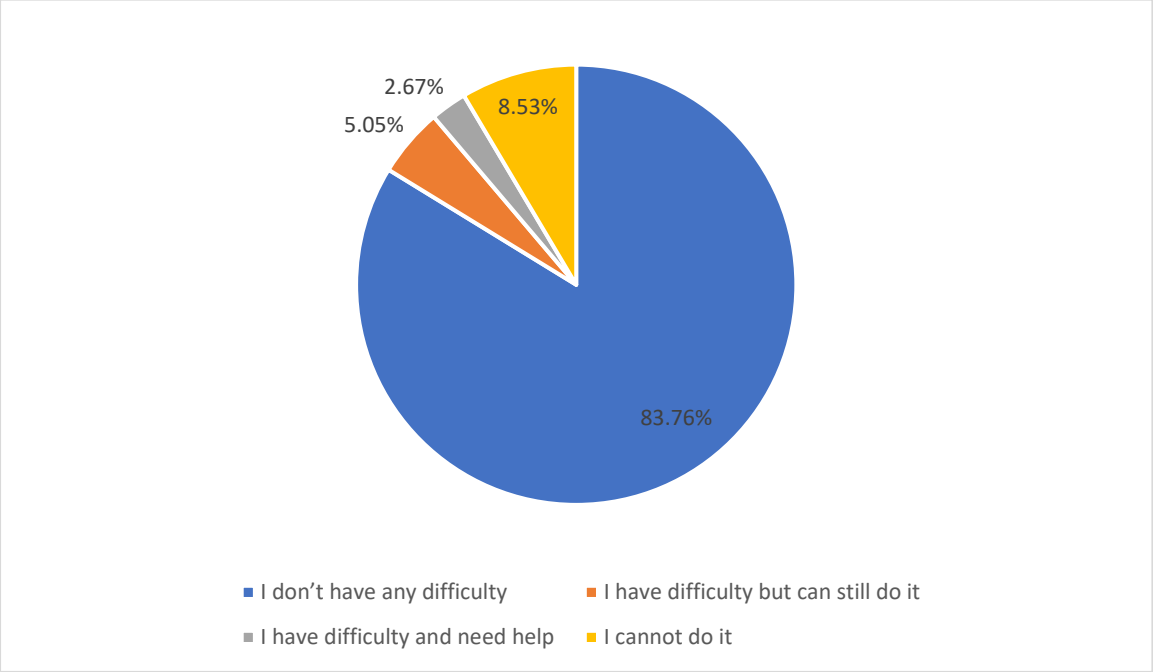


*The percentage of older people responded to difficulty with doing household chores (10,763 older people)

4.3.17 ANY DIFFICULTY WITH PREPARING HOT MEALS

The difficulty with preparing hot meals was shown in question DB017 in the CHARLS Database. 10763 older people, which was 99.49% of the total older people in the CHARLS Database, answered the question of difficulty with preparing hot meals. 8.53% of the older people could not prepare hot meals. 2.67% of the older people had difficulty and needed help in completing this task. 5.05% of the older people had difficulty but could still prepare hot meals and 83.76% of the older people could do these tasks without difficulties. The percentage of the difficulty with preparing hot meals was shown in Figure 41.

Figure 40 - Any Difficulty with Preparing Hot Meals

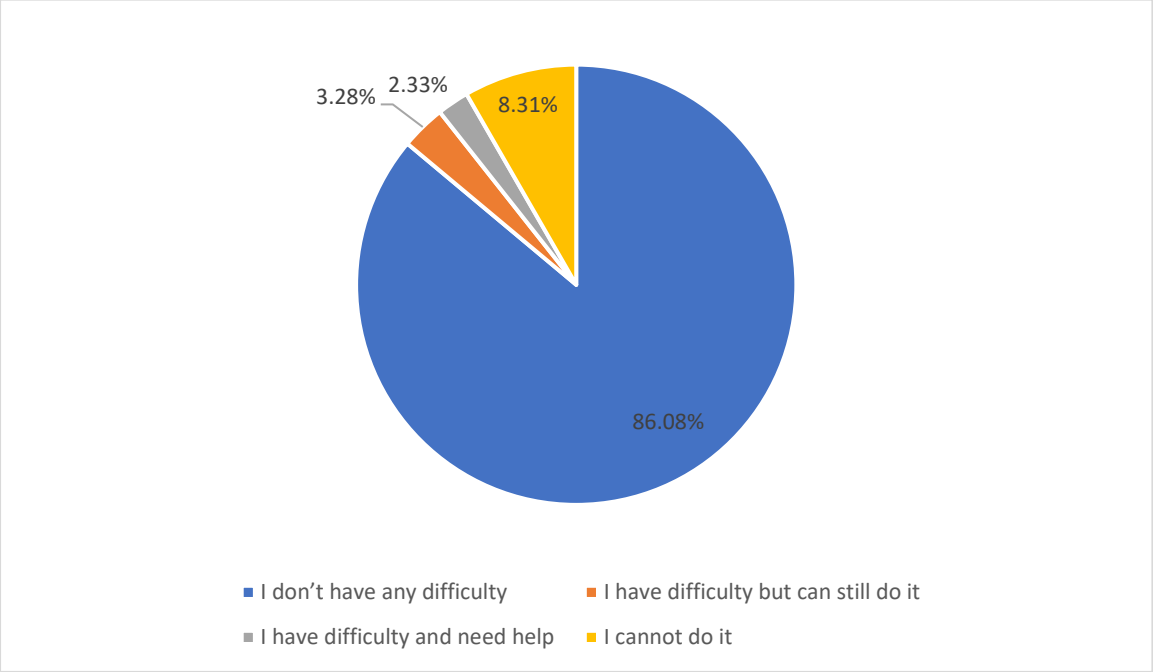


*The percentage of older people who responded to difficulty with preparing hot meals (10,763 older people)

4.3.18 ANY DIFFICULTY WITH SHOPPING FOR GROCERIES

The difficulty with shopping for groceries was shown in question DB018 in the CHARLS Database. 10763 older people, which was 99.49% of the total older people in the CHARLS Database, answered the question of difficulty with shopping for groceries. 8.31% of the older people could not shop for groceries. 2.33% of the older people had difficulty and needed help in completing this task. 3.28% of the older people had difficulty but could still shop for groceries and 86.08% of the older people could do this task without difficulties. The percentage of the difficulty with shopping for groceries was shown in Figure 42.

Figure 41 - Any Difficulty with Shopping for Groceries

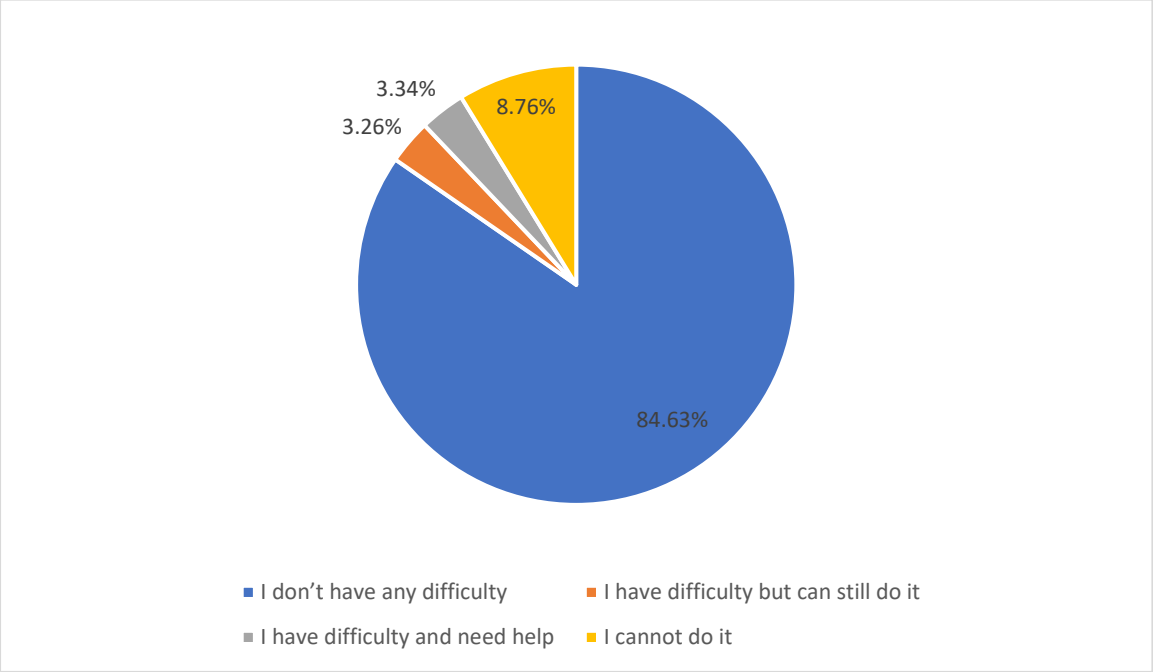


*The percentage of older people who responded to difficulty with shopping for groceries (10,763 older people)

4.3.19 ANY DIFFICULTY WITH MANAGING MONEY

The difficulty with managing money was shown in question DB019 in the CHARLS Database. 10763 older people, which was 99.49% of the total older people in the CHARLS Database, responded to the question of difficulty with managing money. 8.76% of the older people could not manage money. 3.34% of the older people had difficulty and needed help in managing money. 3.26% of the older people had difficulty but could still manage money and 84.63% of the older people could do this task without difficulties. The percentage of the difficulty with managing money was shown in Figure 43.

Figure 42 - Any Difficulty with Managing Money

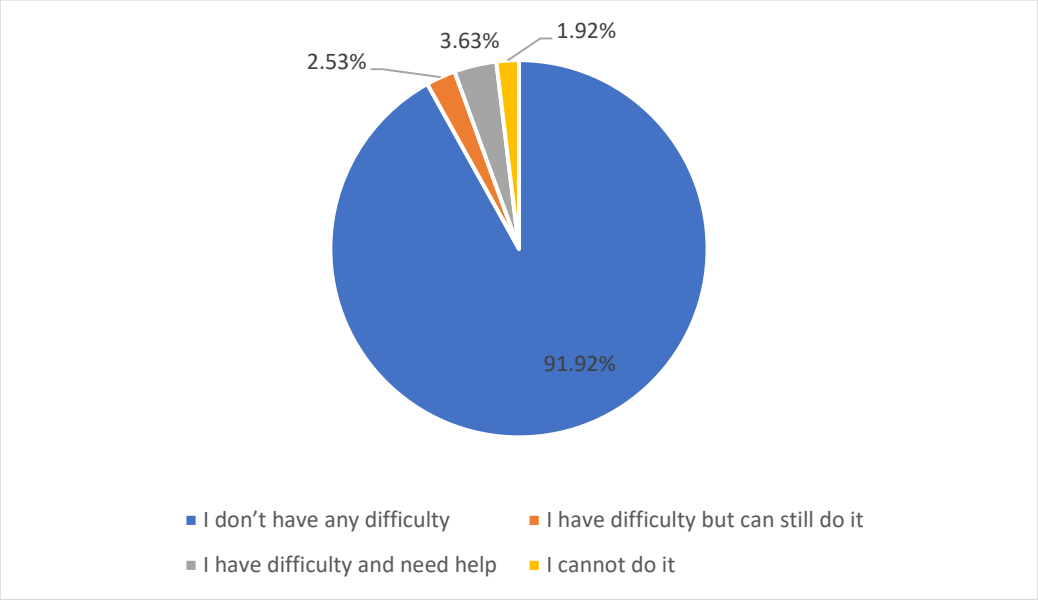


*The percentage of older people who responded to difficulty with managing money (10,763 older people)

4.3.20 ANY DIFFICULTY WITH TAKING MEDICATIONS

The difficulty with taking medications because of health and memory problems was shown in the question DB020 in the CHARLS Database. 10763 older people, which was 99.49% of the total older people in the CHARLS Database, answered the question of difficulty with taking medications. 1.92% of the older people could not take medications because of health and memory problems. 3.63% of the older people had difficulty and needed help in completing this task. 2.53% of the older people had difficulty but could still take medications and 91.92% of the older people could do this task without difficulties. The percentage of the difficulty with taking medications was shown in Figure 44.

Figure 43 - Any Difficulty with Taking Medications

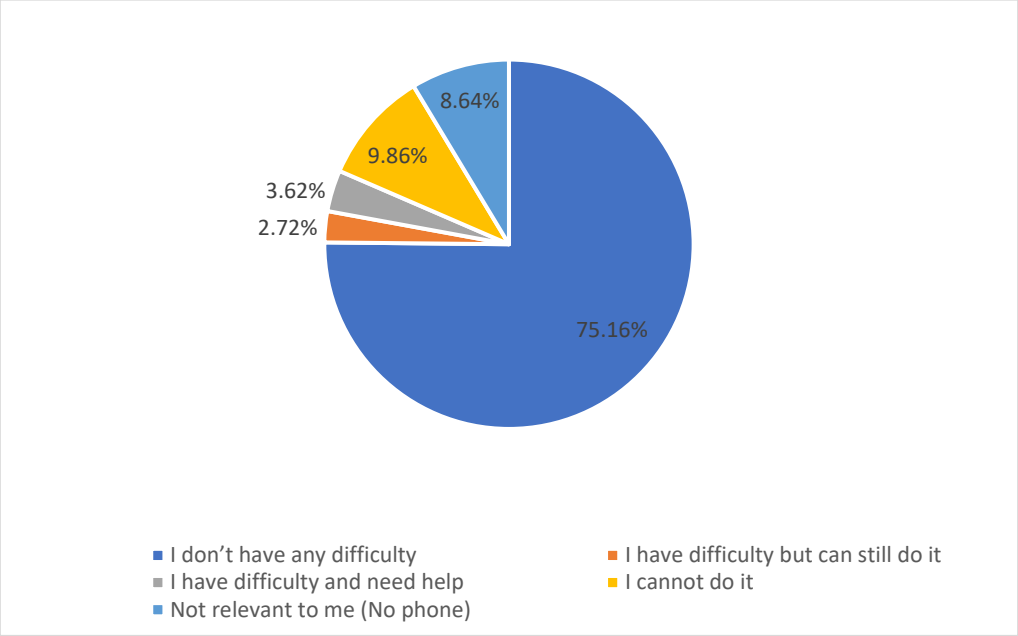


*The percentage of older people who responded to difficulty with taking medications (10,763 older people)

4.3.21 ANY DIFFICULTY WITH MAKING PHONE CALLS

The difficulty with making phone calls because of health and memory problems was shown in the question DB035 in the CHARLS Database. 10763 older people, which was 99.49% of the total older people in the CHARLS Database, answered the question of difficulty with making phone calls. 9.86% of the older people could not make phone calls because of health and memory problems. 3.62% of the older people had difficulty and needed help in completing this task. 2.72% of the older people had difficulty but could still make phone calls and 75.16% of the older people could do this task without difficulties. The remaining older people did not need to make phone calls (thus this question was not applicable to them). The percentage of the difficulty with making phone calls was shown in Figure 45.

Figure 44 - Any Difficulty with Making Phone Calls

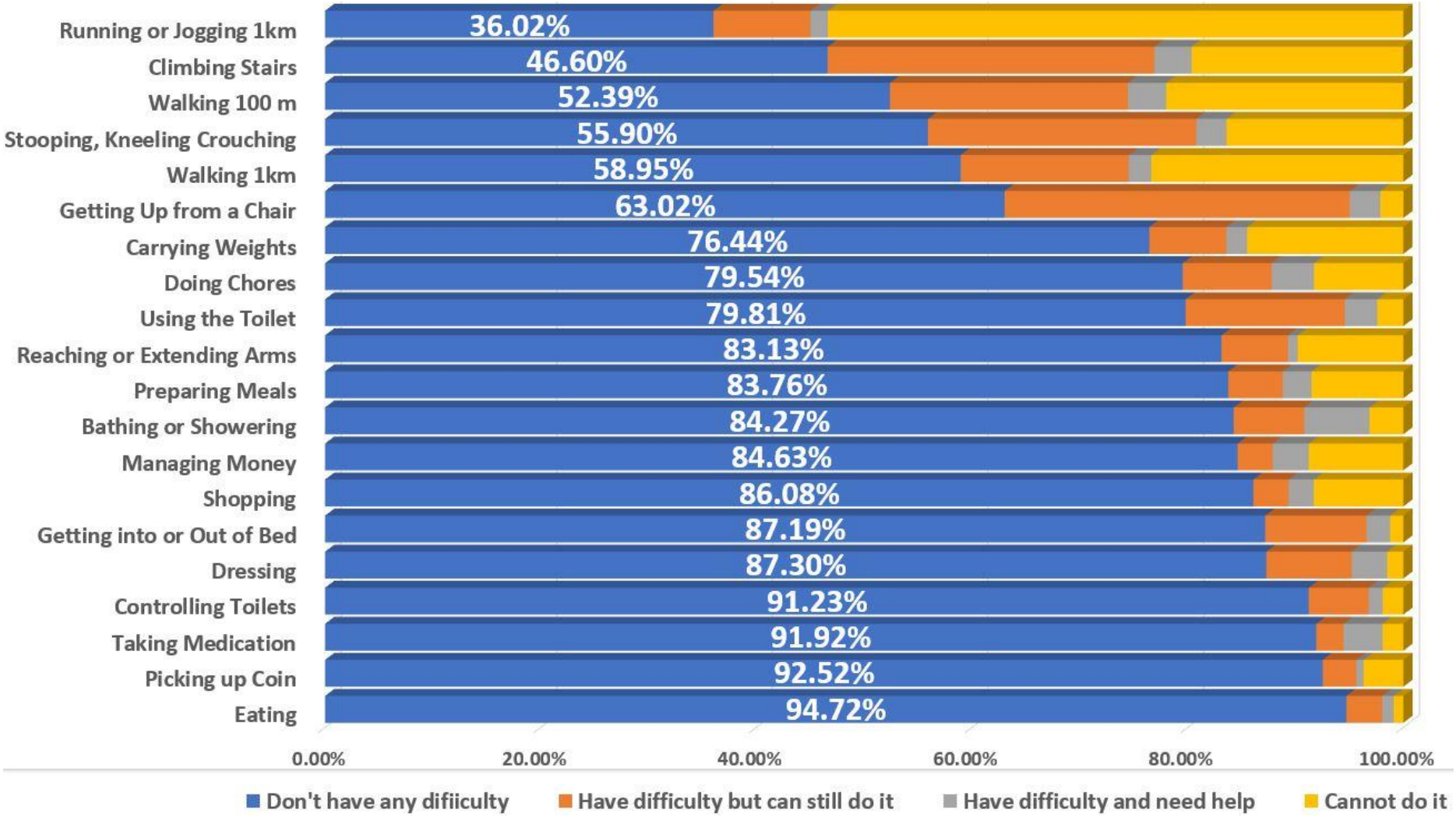


*The percentage of older people who responded to difficulty with making phone calls (10,763 older people)

4.3.22 THE RANKING OF OLDER PEOPLE'S FUNCTIONAL LIMITATIONS

Older people's functional limitations in different activities, ranking by the proportion of "having no difficulties", were comprehensively shown in Figure 46.

Figure 45 - Older People's Functional Limitation in Different Activities



4.4 SELECTED 8 ASSISTIVE TECHNOLOGIES' USERS' STATISTICS

The CHARLS Database Collected the users' statistics for 8 types of assistive technologies: "walking sticks", "travel devices", "manual wheelchairs", "electric wheelchairs", "catheter and urine collecting bags", "toilet series", "corrective lenses and glasses", "hearing aids". The glossary for each of the terminologies used above can be viewed in the appendix. Table 31 showed the total user numbers of 8 assistive technologies in all age groups in the CHARLS Database, which gave an overview of assistive technology use. Appendix 8.7 showed the number of older people users regarding 8 assistive technologies. The numbers were divided into different genders and different age groups. The number of users in each gender and age group was shown with four percentages. The first one was the percentage of older people users in the total older people in the CHARLS Database (10818 older people). The second one was the percentage of older people users in the total users of each type of assistive technology in the database (the number of total users of each selected assistive technology can be found in Table 31). The third one was the percentage of older people users in the total older people recorded in the CHARLS Database in different genders and age groups regarding each type of assistive technology. The fourth one was the percentage of gender distribution and age group distribution within the recorded older people users in the CHARLS Database.

Table 31 - Users' Statistics of 8 Assistive technologies Illustrated in the CHARLS Database

Technology	Total Users in the CHARLS
Walking Stick	1245
Travel Device	70
Manual Wheelchair	238
Electric Wheelchair	24
Catheter and Urine Collecting Bags	62
Toilet Series	362
Corrective Lenses and Glasses	5091
Hearing Aids	132

There were 8 assistive technologies in CHARLS Database provided with users' statistics. Among them, corrective lenses and glasses have the most users, which comprised 27.9% of total older people. This was followed by walling stick users, which comprised 9.87% of total older people, and toilet series users, which comprised 2.85% of total older people. Other assistive technology users' numbers were not high in percentage. Manual wheelchair users comprised 1.77% of total older people; hearing aids users comprised 0.89% of total older people; travel device users comprised 0.51% of total older people; catheter and urine collecting bags users comprised 0.50% of total older people; electric wheelchair users comprised 0.17% of total older people. Apart from the total number and the percentage related to total older participants in the database, another important index was the percentage of older people users related to total users in the database. This index could help people to know if most of the assistive technology users were older people. Regarding this, catheter and urine collecting bags had the highest index - 87.09% of users were older people users. Followed by walking stick users, in which 85.79% users were people aged 60 years and older. The toilet series had a similar index in that 85.08% of the users were older people users. 80.67% of the manual wheelchair users were older people. 78.57% of the travel device users were older people. 75.00% of the electric wheelchair users were older people. 73.48% of the hearing aid

users were older people. While corrective lenses and glasses users were likely to distribute evenly between older people and younger people, in which 59.28% of users were people aged 60 years and older. Referring to the condition of use of walking sticks, travel devices, toilet series, catheters and urine collecting bags, it could be found that mobility problems and incontinence problems were more likely to be addressed in people's old age.

4.5 SUMMARY OF THE DATA DESCRIPTION

This chapter explored research question 2.1, which asked "According to the CHARLS Database, what are older people's profiles regarding general health, disease and illness, functional limitations, assistive technology use, personal and social activities?"

First, regarding general health, disease and illness, it was found that older Chinese people's health status faces some challenges. Hypertension, Dyslipidaemia, Arthritis or Rheumatism were the most common chronic diseases. Sensory disabilities, such as vision and hearing problems, were the most common disabilities. The occurrence of intellectual disabilities was higher than physical disabilities. Lung cancer, stomach cancer, colon or rectum cancer had the highest occurrence. The majority of older people had a fair or poor vision and hearing ability. A few of the older people had lost all their teeth. Many older people suffered from body pain. Specifically, knee pain and waist pain were the most common. Some of the older people in China suffered from functional limitations, especially the limitation of mobility, including running, walking and climbing.

Second, regarding functional limitations, and personal and social activities, it was found that older people's functional limitations vary in different types of daily activities. Eating was the activity with the lowest difficulties for older people. Picking up little items, taking medications, controlling toileting, dressing, getting into or out of bed and going

shopping all showed a small percentage of difficulties among older people. As for managing money, bathing or showering, preparing meals, reaching or extending arms, using the toilet, doing chores and carrying groceries, older people showed some difficulties but still not too many. As for walking 1 km, stooping, kneeling and crouching, walking 100 meters, climbing stairs and running 1km, older people showed medium to high level of difficulties. It could be concluded that older people's difficulties mostly appeared in mobility ability - they were more likely to have some problems in walking, climbing or running.

Third, regarding assistive technology uses, it was found that corrective lenses and glasses had the most users which comprised almost half of older people. Walking sticks were the second highest, followed by toilet series, meal wheelchair and hearing aids. travel device, electric wheelchair and catheter and urine collecting bags did not have many users.

The above demographic information, health status, functional limitation, personal and social activities information were likely to indicate the need for assistance and support from assistive technologies, which could enhance older people's health and independence, and reduce the burden on their families and communities. Research questions 2.2 and 2.3 that "what are the unmet needs and urgent unmet needs for assistive technologies that have users' statistics in the CHARLS Database?" and "what are the total needs and urgent total needs for assistive technologies that do not have users' statistics in the CHARLS Database?" were answered in Chapter five which provided the numbers and percentages of older people who needed a specific type of assistive technology, and who were in need but do not have access to a specific type of assistive technology. The answer to the research questions 2.2 and 2.3 is further interpreted in Chapter six about what the outcomes meant to research questions, what deeper thoughts could emerge from the outcomes, and how the calculation results could inform aged care and

assistive technology industries. Research question 3 that “what opportunities exist for assistive technologies to assist older people with healthcare and independent living” was answered in Chapter six as deeper interpretation that was collected from discussions with aged care industry experts.

CHAPTER 5 : DATA ANALYSIS AND MATCHING NEEDS WITH ASSISTIVE TECHNOLOGIES

The previous chapter (Chapter 4) presented the data description that showed the profile of older people in China with respect to general health, functional limitation, personal and social activities. In this chapter, the described data in the previous chapter were systematically organized and tested. For each one of the selected assistive technologies, some of the questions from the CHARLS Database relating to the condition of use of the assistive technology were chosen for analysis. There was a unique way to determine if the older people's profile met the condition of use for each one of the selected assistive technologies (this was illustrated in section 3.10.2). The number of older people who meet the condition of use of each selected assistive technology was counted as its total needs. The number of older people who met the condition of use of each selected assistive technology but did not have access to it was counted as the unmet needs. This was the core of the calculation of this research.

5.1 THE CONNECTION BETWEEN THIS CHAPTER AND THE RESEARCH QUESTION

The following research questions introduced in chapter two are now restated:

Research Question 1:

What theoretical framework provides a method to best explore the user needs identified in the CHARLS data?

Research Question 2:

2.1 What are older people’s profiles regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities?

2.2 What are the unmet needs and urgent unmet needs for assistive technologies that can be identified from the CHARLS Database?

2.3 What are the total needs and urgent total needs for assistive technologies that can be identified from the CHARLS Database?

2.4 What differentiation exists with respect to users and users' needs (both unmet needs and total needs) between gender and age?

Research Question 3:

What opportunities exist for assistive technologies to assist older people with healthcare and independent living?

This chapter contributed to answers to research questions 2.2, 2.3 and 2.4. According to the calculation process introduced in Chapter 3, this chapter showed the calculation result of the users' statistics, needs, unmet needs and urgent unmet needs. This chapter first listed the users' statistics of 8 assistive technologies where users' data was available in the database. It then illustrated the unmet needs and urgent unmet needs of 8 assistive technologies with users' statistics, and the total needs and urgent needs for another 17 assistive technologies without users' statistics. Subsequently, it explored the age and gender differentiation of users, unmet needs, urgent unmet needs, total needs, and urgent total needs of assistive technologies. Finally, the answer to research question 3, which provided deeper insights and interpretation to research question 2.2, 2.3 and 2.4, was provided in Chapter 6.

5.2 THE MEAN, STANDARD DEVIATION, MEDIAN, INTERQUARTILE RANGE AND BIVARIATE CORRELATIONS FOR ORDINAL VARIABLES

According to Sociotechnical Theory, questions in the CHARLS Database were systematically selected for detecting older people's needs to 25 types of assistive technologies. Among the selected questions, there were 20 ordinal questions. Their item code, mean, standard deviation, median

and interquartile range were listed in Table 32. The mean is the mathematical average value of a set of data. The mean can be calculated using the summation of the observations divided by the number of observations. The standard deviation is a measure of how spread out values are from the mean value (Mishra et al. 2019). The calculation of the standard deviation is shown in the following formula, where X_i is the individual value, and $\bar{X}$ is the mean value. If the sample size is smaller than 30, the calculation uses "n-1" in the denominator, if the sample size is bigger than 30, the calculation uses "n" in the denominator (Mishra et al. 2019).

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x - \bar{x})^2}{n - 1}}$$

The median, which is also called the "positional average" is defined as the middle most observation if data are arranged either in increasing or decreasing order of magnitude. Thus, it is one of the observations, which occupies the central place in the data distribution (Mishra et al. 2019). The quartiles are the three points that divide the data set into four equal groups, each group comprising a quarter of the data, for a set of data values which are arranged in either ascending or descending order. Based on this, the interquartile range is a measure of variability, also called the "middle 50%", which is a measure of statistical dispersion, being equal to the difference between 75th (Q3 or third quartile) and 25th (Q1 or first quartile) percentiles (Mishra et al. 2019).

Table 32 - The Mean, Standard Deviation, Median, Interquartile Range and Bivariate Correlations for Ordinal Variables

Number	Item Code	Mean	Standard	Median	Interquartile
1	DA002	2.17	.838	2.00	1
2	DA033	2.90	.904	3.00	1
3	DA034	2.83	.889	3.00	1
4	DA039	2.77	.902	3.00	1
5	DB003	1.95	1.199	1.00	2
6	DB004	1.44	.657	1.00	1
7	DB005	1.96	1.133	2.00	1
8	DB006	1.80	1.096	1.00	1
9	DB007	1.37	.917	1.00	0
10	DB008	1.54	1.075	1.00	0
11	DB009	1.16	.605	1.00	0
12	DB011	1.28	.715	1.00	0
13	DB013	1.17	.511	1.00	0
14	DB014	1.28	.638	1.00	0
15	DB015	1.14	.510	1.00	0
16	DB017	1.36	.892	1.00	0
17	DB018	1.33	.875	1.00	0
18	DB020	1.16	.565	1.00	0
19	DB035	1.43	.986	1.00	0
20	DD040_W4	1.06	.335	1.00	0

(Note: As for missing values: Exclude cases pairwise)

5.3 NORMALITY TESTS FOR ORDINAL VARIABLES

An assessment of the normality of data is a prerequisite for many statistical tests because normal data is an underlying assumption in parametric testing. The two well-known tests of normality, the Kolmogorov-Smirnov test and the Shapiro-Wilk test are the most widely used methods to test the normality of the data (Mishra et al. 2019). The Kolmogorov-Smirnov test is an empirical distribution function in which the theoretical cumulative distribution function of the test distribution is contrasted with the empirical distribution function of the data (Öztuna, Elhan & Tüccar 2006). The Shapiro-Wilk test computes the similarity percentage that the observed data distribution overlaps with its superimposed normal curve - this test is based on the correlation between the data and the corresponding normal scores (Ghasemi & Zahediasl 2012). The null hypothesis of a normality test is that "the sample distribution is normal". If the test is significant (sig. < 0.05), the variable does not follow a normal distribution. Appendix 8.8 illustrates the normality test results of 20 ordinal variables used in the further data analysis.

As demonstrated in Appendix 8.8, all 20 ordinal variables used in the data analysis failed in the normality test, indicating that all 20 ordinal variables used in the data analysis do not obey a normal distribution. In the following tests and analyses, any calculation method that requires and assumes variables to be normally distributed could not be used. Instead, the non-parametric method or any method that had no specific requirement on normality distribution could be used.

5.4 THE BIVARIATE CORRELATION INFORMATION

The bivariate correlation information shows the degree of relationship between two ordinal variables. There are two main types of correlation calculation: Pearson's r correlation and Spearman's rank correlation. When there is a normal distribution of the data or the data are

"parametric," Pearson's correlation "r" is used (Yadav 2018). When the variable fails in the normality test, the Spearman's rank correlation can be used. Spearman's rank correlation is a nonparametric test used to measure the degree of association between two variables. Spearman's rank correlation test does not carry any assumptions about the distribution of the data and is used best when the variables are measured on a scale that is at least ordinal and the scores on one variable are monotonically related to the other variable (Yadav 2018). Spearman's rank correlation is calculated using the following formula:

$$r = 1 - \frac{6 \sum {d_i}^2}{n(n^2 - 1)}$$

r = Spearman's rank correlation

di = the difference between the ranks of corresponding variables

n = number of observations

As explained in section 5.3, the answers' data of all 20 ordinal variables used in the data analysis were not normally distributed. The bivariate correlation calculation of all 20 ordinal variables used Spearman's rank correlation. Appendix 8.9 illustrated their bivariate correlation information using Spearman's rank correlation.

5.5 WILCOXON SIGNED RANK TEST, MANN-WHITNEY U AND KRUSKAL WALLIS TEST

The Wilcoxon signed-rank test is a non-parametric statistical test used to compare two sets of scores that come from the same participants. The Wilcoxon signed-rank test used in this section was to assess whether the mean ranks differed between 2 ordinal variables included in the question selection for each type of assistive technology. For example, there were 4 ordinal questions included for detecting the need for a walking stick,

which were DB003, DB005, DB006, DB013. Thus, there were 6 variable pairs for Wilcoxon signed-rank test to compare, which were DB013 & DB003, DB006 & DB003, DB005 & DB003, DB013 & DB005, DB006 & DB005, DB013 & DB006. The Wilcoxon signed-rank test assessed whether the mean ranks differed in each pair listed above. Appendix 8.10 showed the Wilcoxon Signed rank test results for all included ordinal questions regarding 25 types of assistive technologies included in this research.

The Mann-Whitney U test is a nonparametric test that tests for differences between two groups on a single, ordinal variable with no specific distribution (Weiner & Craighead 2010). The Mann-Whitney U test here was to explore if there was any significant difference in the answer to a variable between males and females. The Kruskal Wallis test is a nonparametric statistical test that assesses the differences among three or more independently sampled groups on a single, non-normally distributed variable (McKight; & Najab 2010). The Kruskal Wallis Test here was used to test if there was any significant difference in the answer to a variable among different age groups. Appendix 8.11 presented the calculation results of Mann-Whitney U Test and Kruskal-Wallis Test to show if there was any significant difference between different genders and among different age groups.

5.6 UNMET NEEDS AND URGENT UNMET NEEDS FOR 8 ASSISTIVE TECHNOLOGIES WITH USERS' STATISTICS IN THE CHARLS DATABASE

Appendix 8.12 showed a comprehensive table of unmet needs and urgent unmet needs for the 8 assistive technologies with users' statistics in the CHARLS Database. The numbers of unmet and urgent unmet needs were shown in different genders and different aged groups. Numbers were provided with 3 types of percentages. The first percentage was related to the total number of unmet needs/urgent unmet needs of each specific assistive technology. In this percentage, males and females added up to

100%; different aged groups added up to 100%. The second percentage was related to the total number of older people in the CHARLS database (10818 older people). The third percentage was related to the number of older people in specific gender or age group. The third percentage could not be added up because the number of older people of different genders or age groups was different. The following sections provided narratives of unmet needs and urgent unmet needs for each one of the 8 assistive technologies with users' statistics in the CHARLS Database. Besides narratives, there were column charts provided to show the percentage of unmet needs and urgent unmet needs in different genders or age groups related to the total number of older people in the database. The following sections chose column charts but not pie charts because each pair of columns could show both unmet needs and urgent unmet needs together and could clearly show the volume comparison between different genders and among different age groups.

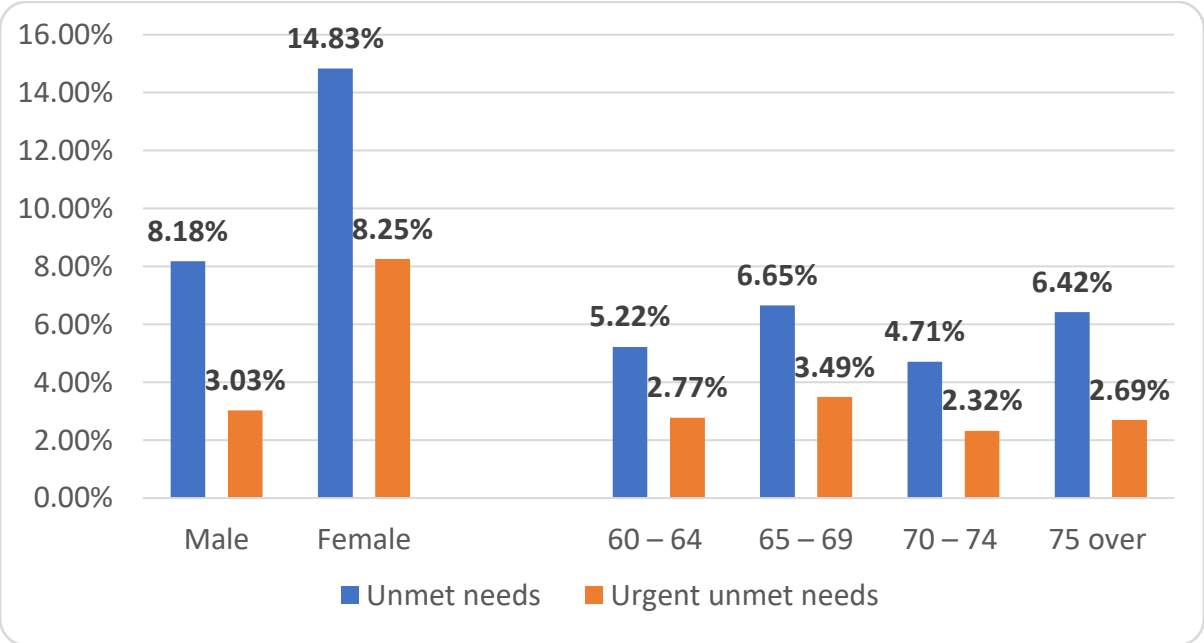
5.6.1 UNMET NEEDS AND URGENT UNMET NEEDS FOR WALKING STICK

Unmet needs for walking sticks comprised 23.01% of the total older people in the CHARLS Database. Within the unmet needs, 35.56% were men (16.68% of the male older people and 8.18% of the total older people), 64.44% were women (29.10% of the female older people and 14.83% of the total older people). As for age group differentiation, 22.70% were older people aged between 60 - 64 years old (16.92% of the older people in this age group and 5.22% of the total older people), 28.89% were older people aged between 65 - 69 years old (22.96% of the older people in this age group and 6.65% of the total older people). In higher age groups, 20.49% were older people aged between 70 - 74 years old (26.41% of the older people in this age group and 4.71% of the total older people), 27.92% were older people aged 75 years and over

(28.78% of the older people in this age group and 6.42% of the total older people).

Urgent unmet needs for walking sticks comprised 11.28% of the total older people in the CHARLS Database. Within the urgent unmet needs, 26.89% were men (6.18% of the male older people and 3.03% of the total older people), 73.11% were women (16.18% of the female older people and 8.25% of the total older people). As for age group differentiation, 24.59% were older people aged between 60 - 64 years old (8.98% of the older people in this age group and 2.77% of the total older people), 30.98% were older people aged between 65 - 69 years old (12.07% of the older people in this age group and 3.49% of the total older people). In higher age groups, 20.57% were older people aged between 70 - 74 years old (13.00% of the older people in this age group and 2.32% of the total older people), 23.85% were older people aged 75 years and over (12.05% of the older people in this age group and 2.69% of the total older people). Figure 47 showed the percentage of unmet needs and urgent unmet needs for walking sticks in different genders or age groups related to the total number of older people in the database.

Figure 46 - Unmet / Urgent Unmet Needs for Walking Sticks



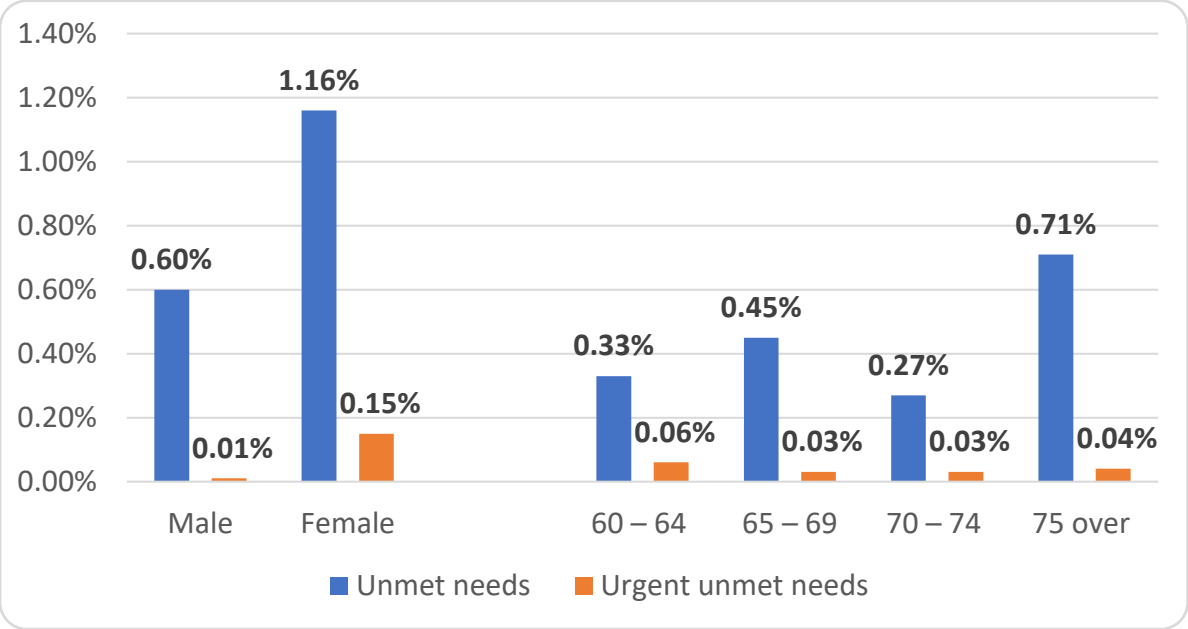
5.6.2 UNMET NEEDS AND URGENT UNMET NEEDS FOR TRAVEL DEVICES

Unmet needs for travel devices comprised 1.77% of the total older people in the CHARLS Database. Within the unmet needs, 34.03% were men (1.23% of the male older people and 0.60% of the total older people), and 65.97% were women (2.29% of the female older people and 1.16% of the total older people). As for age group differentiation, 18.85% were older people aged between 60 - 64 years old (1.08% of the older people in this age group and 0.33% of the total older people), 25.65% were older people aged between 65 - 69 years old (1.56% of the older people in this age group and 0.45% of the total older people). In higher age groups, 15.18% were older people aged between 70 - 74 years old (1.50% of the older people in this age group and 0.27% of the total older people), 40.31% were older people aged 75 years and over (3.19% of the older people in this age group and 0.71% of the total older people).

Urgent unmet needs for travel devices comprised 0.16% of the total older people in the CHARLS Database. Within the urgent unmet needs, 6.25% were men (0.02% of the male older people and 0.01% of the total older people), 93.75% were women (0.27% of the female older people and 0.15% of the total older people). As for age group differentiation, 37.50% were older people aged between 60 - 64 years old (0.18% of the older people in this age group and 0.06% of the total older people), 18.75% were older people aged between 65 - 69 years old (0.10% of the older people in this age group and 0.03% of the total older people). In higher age groups, 18.75% were older people aged between 70 - 74 years old (0.01% of the older people in this age group and 0.03% of the total older people), 25.00% were older people aged 75 years and over (0.17% of the older people in this age group and 0.04% of the total older people). Figure 48 showed the percentage of unmet needs and urgent unmet

needs for travel devices in different genders or age groups related to the total number of older people in the database.

Figure 47 - Unmet / Urgent Unmet Needs for Walking Sticks

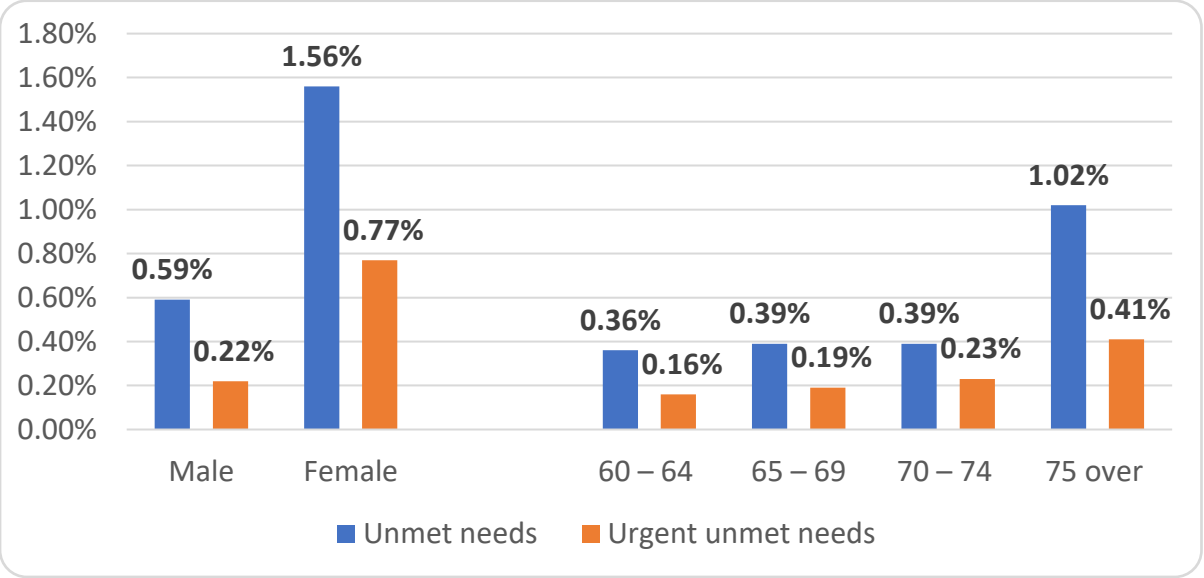


5.6.3 UNMET NEEDS AND URGENT UNMET NEEDS FOR MANUAL WHEELCHAIRS

Unmet needs for manual wheelchairs comprised 2.15% of the total older people in the CHARLS Database. Within the unmet needs, 27.47% were men (1.21% of the male older people and 0.59% of the total older people), and 72.53% were women (3.07% of the female older people and 1.56% of the total older people). As for age group differentiation, 16.74% were older people aged between 60 - 64 years old (1.17% of the older people in this age group and 0.36% of the total older people), 18.03% were older people aged between 65 - 69 years old (1.34% of the older people in this age group and 0.39% of the total older people). In higher age groups, 18.03% were older people aged between 70 - 74 years old (2.18% of the older people in this age group and 0.39% of the total older people), 47.21% were older people aged 75 years and over (4.55% of the older people in this age group and 1.02% of the total older people).

Urgent unmet needs for manual wheelchairs comprised 0.99% of the total older people in the CHARLS Database. Within the urgent unmet needs, 22.43% were men (0.45% of the male older people and 0.22% of the total older people), 77.57% were women (1.51% of the female older people and 0.77% of the total older people). As for age group differentiation, 15.89% were older people aged between 60 - 64 years old (0.51% of the older people in this age group and 0.16% of the total older people), 19.63% were older people aged between 65 - 69 years old (0.67% of the older people in this age group and 0.19% of the total older people). In higher age groups, 23.36% were older people aged between 70 - 74 years old (1.29% of the older people in this age group and 0.23% of the total older people), 41.12% were older people aged 75 years and over (1.82% of the older people in this age group and 0.41% of the total older people). Figure 49 showed the percentage of unmet needs and urgent unmet needs for manual wheelchairs in different genders or age groups related to the total number of older people in the database.

Figure 48 - Unmet / Urgent Unmet Needs for Manual Wheelchairs

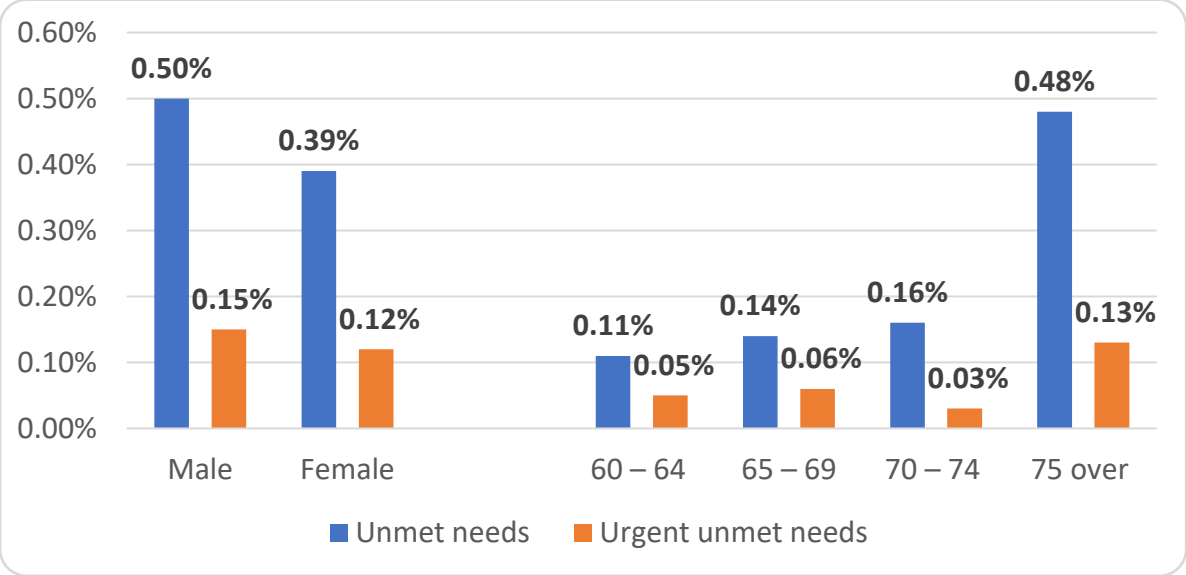


5.6.4 UNMET NEEDS AND URGENT UNMET NEEDS FOR ELECTRIC WHEELCHAIRS

Unmet needs for electric wheelchairs comprised 0.89% of the total older people in the CHARLS Database. Within the unmet needs, 56.25% were men (1.02% of the male older people and 0.50% of the total older people), 43.75% were women (0.76% of the female older people and 0.39% of the total older people). As for age group differentiation, 12.50% were older people aged between 60 - 64 years old (0.36% of the older people in this age group and 0.11% of the total older people), 15.63% were older people aged between 65 - 69 years old (0.48% of the older people in this age group and 0.14% of the total older people). In higher age groups, 17.71% were older people aged between 70 - 74 years old (0.88% of the older people in this age group and 0.16% of the total older people), 54.17% were older people aged 75 years and over (2.15% of the older people in this age group and 0.48% of the total older people).

Urgent unmet needs for electric wheelchairs comprised 0.27% of the total older people in the CHARLS Database. Within the urgent unmet needs, 55.17% were men (0.30% of the male older people and 0.15% of the total older people), 44.83% were women (0.24% of the female older people and 0.12% of the total older people). As for age group differentiation, 17.24% were older people aged between 60 - 64 years old (0.15% of the older people in this age group and 0.05% of the total older people), 24.14% were older people aged between 65 - 69 years old (0.22% of the older people in this age group and 0.06% of the total older people). In higher age groups, 10.34% were older people aged between 70 - 74 years old (0.16% of the older people in this age group and 0.03% of the total older people), 48.28% were older people aged 75 years and over (0.58% of the older people in this age group and 0.13% of the total older people). Figure 50 showed the percentage of unmet needs and urgent unmet needs for electric wheelchairs in different genders or age groups related to the total number of older people in the database.

Figure 49 - Unmet / Urgent Unmet Needs for Electric Wheelchair



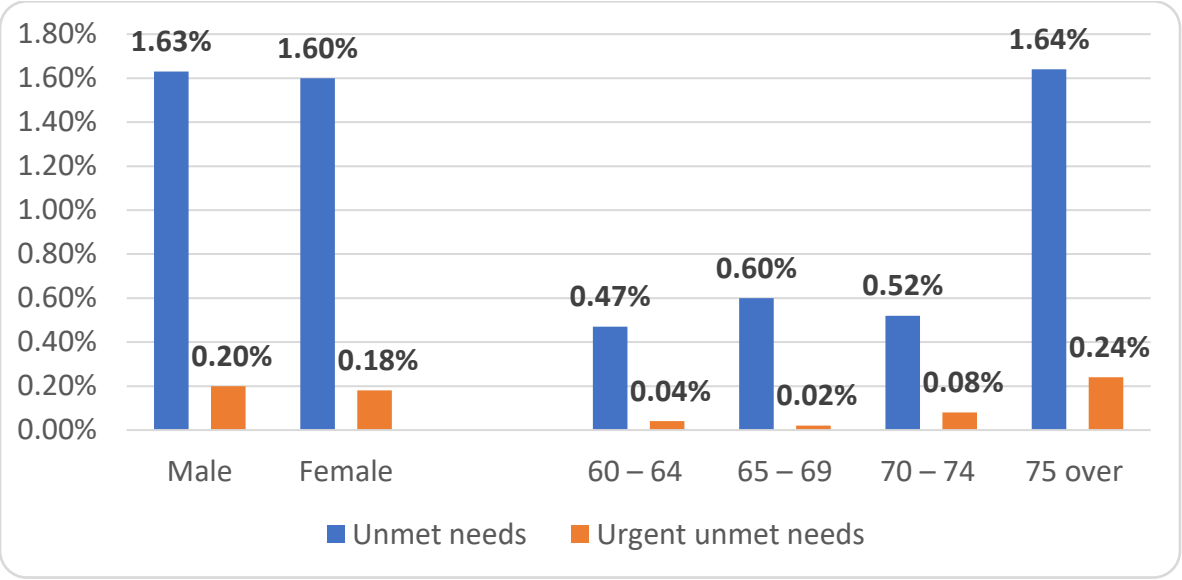
5.6.5 UNMET NEEDS AND URGENT UNMET NEEDS FOR CATHETER AND URINE COLLECTING BAGS

Unmet needs for catheter and urine collecting bags comprised 3.23% of the total older people in the CHARLS Database. Within the unmet needs, 50.43% were men (3.32% of the male older people and 1.63% of the total older people), and 49.57% were women (3.14% of the female older people and 1.60% of the total older people). As for age group differentiation, 14.61% were older people aged between 60 - 64 years old (1.53% of the older people in this age group and 0.47% of the total older people), 18.62% were older people aged between 65 - 69 years old (2.08% of the older people in this age group and 0.60% of the total older people). In higher age groups, 16.05% were older people aged between 70 - 74 years old (2.90% of the older people in this age group and 0.52% of the total older people), and 50.72% were older people aged 75 years and over (7.33% of the older people in this age group and 1.64% of the total older people).

Urgent unmet needs for catheter and urine collecting bags comprised 0.38% of the total older people in the CHARLS Database. Within the

urgent unmet needs, 53.66% were men (0.41% of the male older people and 0.20% of the total older people), 46.34% were women (0.34% of the female older people and 0.18% of the total older people). As for age group differentiation, 9.76% were older people aged between 60 - 64 years old (0.12% of the older people in this age group and 0.04% of the total older people), 4.88% were older people aged between 65 - 69 years old (0.06% of the older people in this age group and 0.02% of the total older people). In higher age groups, 21.95% were older people aged between 70 - 74 years old (0.47% of the older people in this age group and 0.08% of the total older people), 63.41% were older people aged 75 years and over (1.08% of the older people in this age group and 0.24% of the total older people). Figure 51 showed the percentage of unmet needs and urgent unmet needs for catheter and urine collecting bags in different genders or age groups related to the total number of older people in the database.

Figure 50 - Unmet / Urgent Unmet Needs for Catheter and Urine Collecting Bags

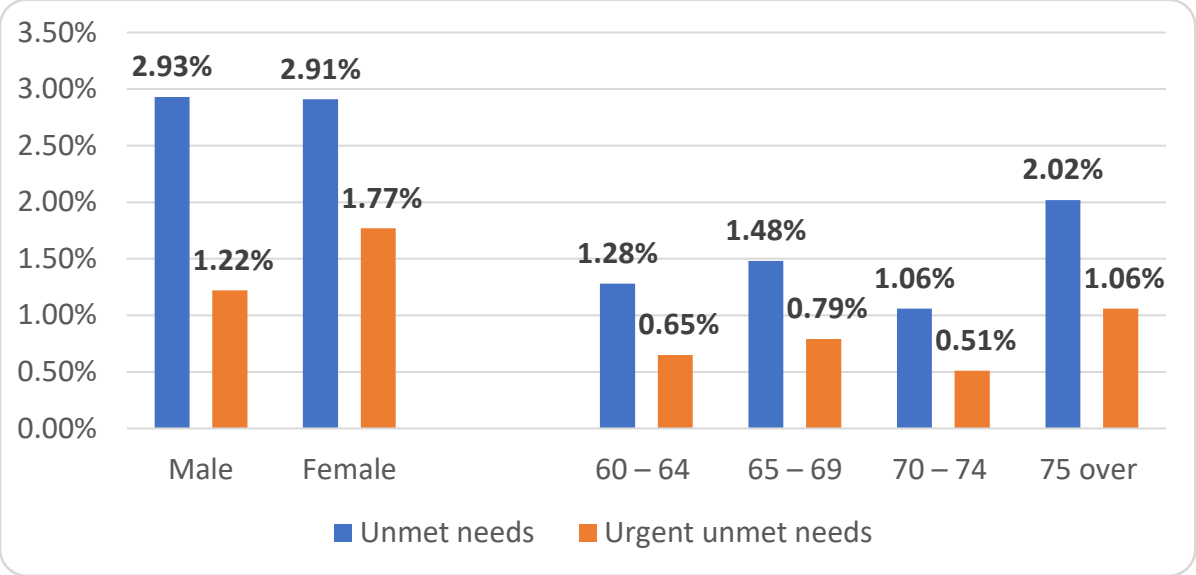


5.6.6 UNMET NEEDS AND URGENT UNMET NEEDS FOR TOILET SERIES (COMMODES)

Unmet needs for toilet series (Commodes) comprised 5.84% of the total older people in the CHARLS Database. Within the unmet needs, 50.16% were men (5.97% of the male older people and 2.93% of the total older people), and 49.84% were women (5.61% of the female older people and 2.91% of the total older people). As for age group differentiation, 21.99% were older people aged between 60 - 64 years old (4.16% of the older people in this age group and 1.28% of the total older people), 25.32% were older people aged between 65 - 69 years old (5.11% of the older people in this age group and 1.48% of the total older people). In higher age groups, 18.20% were older people aged between 70 - 74 years old (5.96% of the older people in this age group and 1.06% of the total older people), 34.49% were older people aged 75 years and over (9.03% of the older people in this age group and 2.02% of the total older people).

Urgent unmet needs for toilet series comprised 3.00% of the total older people in the CHARLS Database. Within the urgent unmet needs, 40.62% were men (2.49% of the male older people and 1.22% of the total older people), 59.38% were women (3.50% of the female older people and 1.77% of the total older people). As for age group differentiation, 21.54% were older people aged between 60 - 64 years old (2.10% of the older people in this age group and 0.65% of the total older people), 26.15% were older people aged between 65 - 69 years old (2.71% of the older people in this age group and 0.79% of the total older people). In higher age groups, 16.92% were older people aged between 70 - 74 years old (2.85% of the older people in this age group and 0.51% of the total older people), 35.38% were older people aged 75 years and over (4.76% of the older people in this age group and 1.06% of the total older people). Figure 52 showed the percentage of unmet needs and urgent unmet needs for toilet series (commodes) in different genders or age groups related to the total number of older people in the database.

Figure 51 - Unmet / Urgent Unmet Needs for Toilet Series



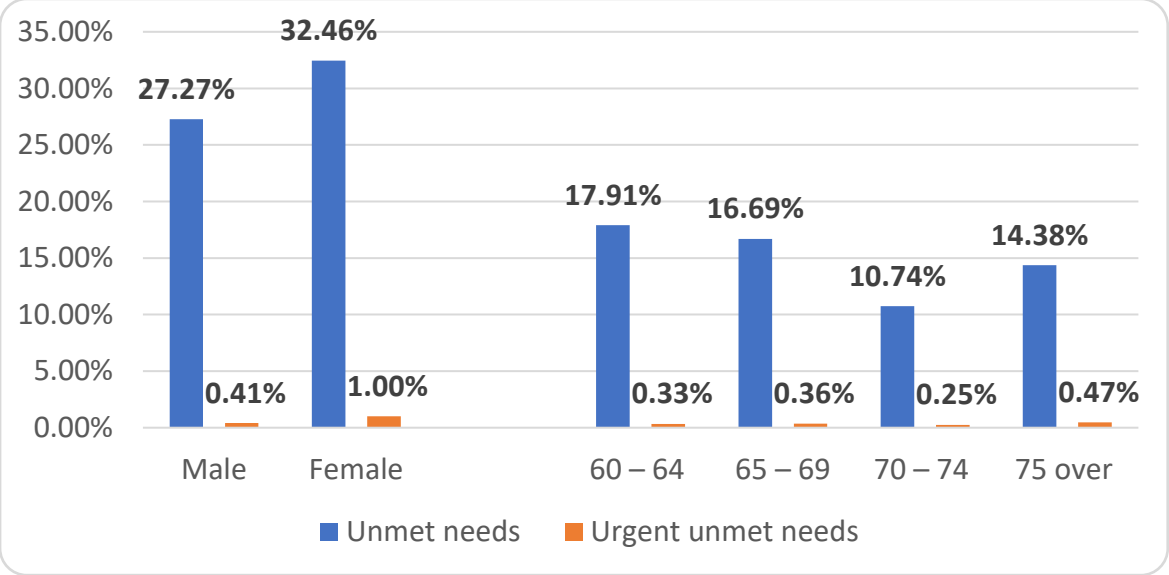
5.6.7 UNMET NEEDS AND URGENT UNMET NEEDS FOR CORRECTIVE LENSES AND GLASSES

Unmet needs for corrective lenses and glasses comprised 59.72% of the total older people in the CHARLS Database. Within the unmet needs, 45.66% were men (55.60% of the male older people and 27.27% of the total older people), and 54.34% were women (63.70% of the female older people and 32.46% of the total older people). As for age group differentiation, 29.98% were older people aged between 60 - 64 years old (57.99% of the older people in this age group and 17.91% of the total older people), 27.95% were older people aged between 65 - 69 years old (57.66% of the older people in this age group and 16.69% of the total older people). In higher age groups, 17.98% were older people aged between 70 - 74 years old (60.18% of the older people in this age group and 10.74% of the total older people), 24.08% were older people aged 75 years and over (64.43% of the older people in this age group and 14.38% of the total older people).

Urgent unmet needs for corrective lenses and glasses comprised 1.41% of the total older people in the CHARLS Database. Within the urgent unmet

needs, 28.76% were men (0.83% of the male older people and 0.41% of the total older people), 71.24% were women (1.98% of the female older people and 1.00% of the total older people). As for age group differentiation, 23.53% were older people aged between 60 - 64 years old (1.08% of the older people in this age group and 0.33% of the total older people), 25.49% were older people aged between 65 - 69 years old (1.25% of the older people in this age group and 0.36% of the total older people). In higher age groups, 17.65% were older people aged between 70 - 74 years old (1.40% of the older people in this age group and 0.25% of the total older people), 33.33% were older people aged 75 years and over (2.11% of the older people in this age group and 0.47% of the total older people). Figure 53 showed the percentage of unmet needs and urgent unmet needs for corrective lenses and glasses in different genders or age groups related to the total number of older people in the database.

Figure 52 - Unmet / Urgent Unmet Needs for Corrective Lenses and Glasses



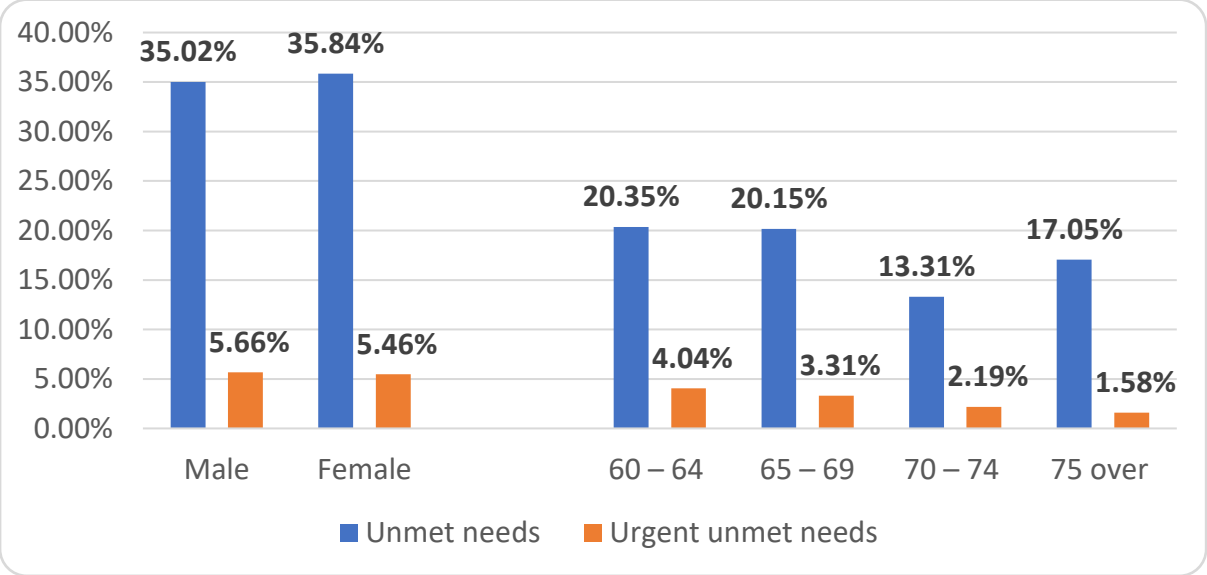
5.6.8 UNMET NEEDS AND URGENT UNMET NEEDS FOR HEARING AIDS

Unmet needs for hearing aids comprised 70.86% of the total older people in the CHARLS Database. Within the unmet needs, 49.43% were men

(71.41% of the male older people and 35.02% of the total older people), and 50.57% were women (70.34% of the female older people and 35.84% of the total older people). As for age group differentiation, 28.72% were older people aged between 60 - 64 years old (65.93% of the older people in this age group and 20.35% of the total older people), 28.44% were older people aged between 65 - 69 years old (69.60% of the older people in this age group and 20.15% of the total older people). In higher age groups, 18.78% were older people aged between 70 - 74 years old (74.57% of the older people in this age group and 13.31% of the total older people), 24.05% were older people aged 75 years and over (76.36% of the older people in this age group and 17.05% of the total older people).

Urgent unmet needs for hearing aids comprised 11.12% of the total older people in the CHARLS Database. Within the urgent unmet needs, 50.87% were men (11.53% of the male older people and 5.66% of the total older people), 49.13% were women (10.72% of the female older people and 5.46% of the total older people). As for age group differentiation, 36.33% were older people aged between 60 - 64 years old (13.08% of the older people in this age group and 4.04% of the total older people), 29.76% were older people aged between 65 - 69 years old (11.43% of the older people in this age group and 3.31% of the total older people). In higher age groups, 19.70% were older people aged between 70 - 74 years old (12.27% of the older people in this age group and 2.19% of the total older people), 14.21% were older people aged 75 years and over (7.08% of the older people in this age group and 1.58% of the total older people). Figure 54 showed the percentage of unmet needs and urgent unmet needs for hearing aids in different genders or age groups related to the total number of older people in the database.

Figure 53 - Unmet / Urgent Unmet Needs for Hearing Aids



5.7 TOTAL NEEDS AND URGENT NEEDS FOR 17 ASSISTIVE TECHNOLOGIES WITHOUT USERS' STATISTICS IN THE CHARLS DATABASE

Appendix 8.13 showed a comprehensive table of total needs and urgent total needs for 17 assistive technologies without users' statistics in the CHARLS Database. The numbers of total and urgent needs were shown in different genders and different aged groups. Numbers were provided with 3 types of percentages. The first percentage was related to the total number of total needs and urgent needs of each specific assistive technology. In this percentage, males and females added up to 100%; different aged groups added up to 100%. The second percentage was related to the total number of older people in the CHARLS database (10818 older people). The third percentage was related to the number of older people in specific gender or age group. The third percentage could not be added up because the number of older people of different genders or age groups was different. The following sections provide narratives of total needs and urgent needs for each one of the 17 assistive technologies without users' statistics in the CHARLS Database. Besides narratives, there were column charts provided to show the percentage of total needs

and urgent needs in different genders or age groups related to the total number of older people in the CHARLS database. The following sections chose column charts but not pie charts because each pair of columns can show both total needs and urgent needs together and can clearly show the volume comparison between different genders and among different age groups.

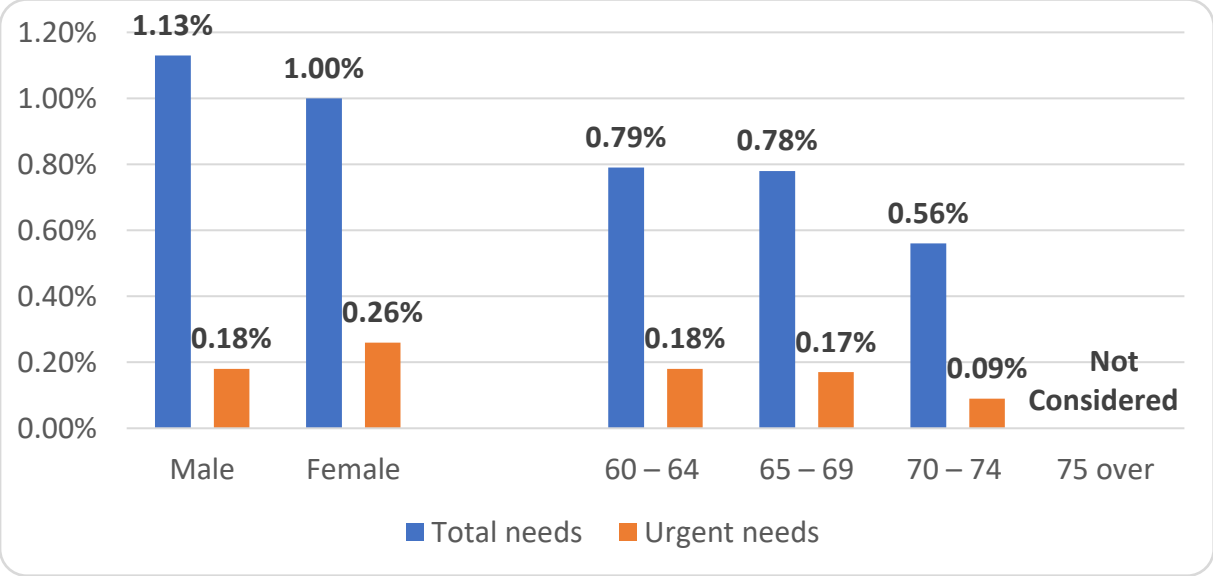
5.7.1 TOTAL NEEDS AND URGENT NEEDS FOR BRAILLE WRITING EQUIPMENT/BRAILLERS

Total needs for braille writing equipment/braillers comprised 2.13% of the total older people in the CHARLS Database. Within the unmet needs, 53.04% were men (2.30% of the male older people and 1.13% of the total older people), 46.96% were women (1.96% of the female older people and 1.00% of the total older people). As for age group differentiation, 36.96% were older people aged between 60 - 64 years old (2.54% of the older people in this age group and 0.79% of the total older people), 36.52% were older people aged between 65 - 69 years old (2.68% of the older people in this age group and 0.78% of the total older people). In higher age groups, 26.52% were older people aged between 70 - 74 years old (3.16% of the older people in this age group and 0.56% of the total older people), and older people aged 75 years and over were not considered to be included in the total needs of braille writing equipment/braillers as this assistive technology requires a lot of learning - it is extremely challenging for people in their later life to learn a new language.

Urgent total needs for braille writing equipment/braillers comprised 0.43% of the total older people in the CHARLS Database. Within the urgent unmet needs, 40.43% were men (0.36% of the male older people and 0.18% of the total older people), 59.57 were women (0.51% of the female older people and 0.26% of the total older people). As for age group differentiation, 40.43% were older people aged between 60 - 64

years old (0.57% of the older people in this age group and 0.18% of the total older people), 38.30% were older people aged between 65 - 69 years old (0.57% of the older people in this age group and 0.17% of the total older people). In higher age groups, 21.28% were older people aged between 70 - 74 years old (0.52% of the older people in this age group and 0.09% of the total older people), still, older people aged 75 years and over were not considered. Figure 55 showed the percentage of total needs and urgent needs for braille writing equipment/braillers in different genders or age groups related to the total number of older people in the database.

Figure 54 - Total Needs and Urgent Needs for Braille Writing Equipment/Braillers



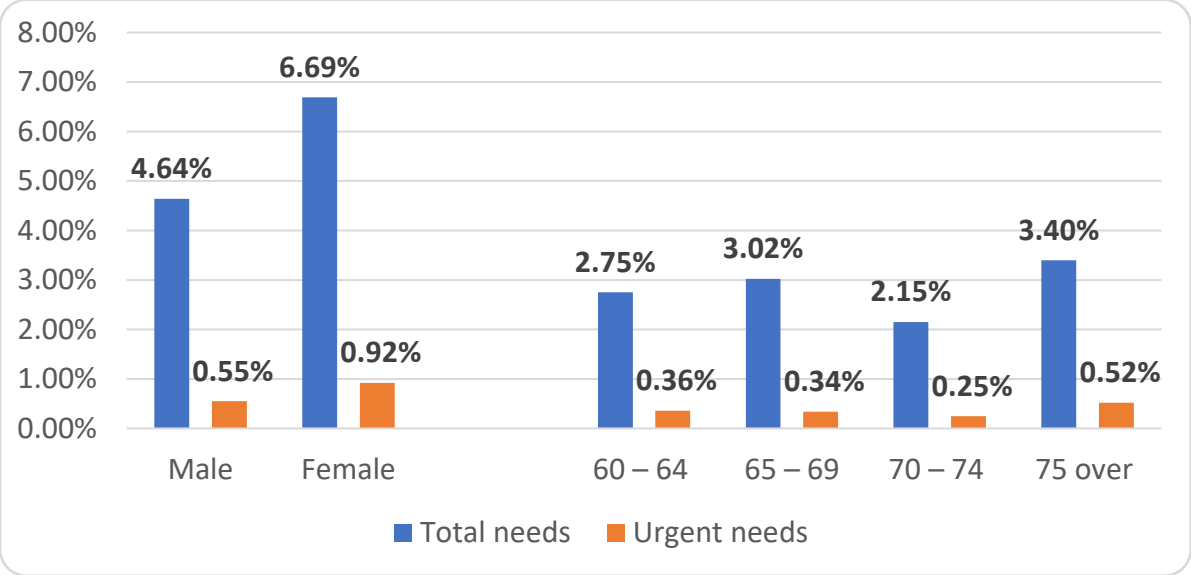
5.7.2 TOTAL NEEDS AND URGENT NEEDS FOR SMART/WHITE CANES

Total needs for smart/white canes comprised 11.33% of the total older people in the CHARLS Database. Of the total needs, 40.95% were men (9.46% of the male older people and 4.64% of the total older people), and 59.05% were women (13.13% of the female older people and 6.69% of the total older people). As for age group differentiation, 24.31% were older people aged between 60 - 64 years old (8.92% of the older people

in this age group and 2.75% of the total older people), 26.67% were older people aged between 65 - 69 years old (10.44% of the older people in this age group and 3.02% of the total older people). In higher age groups, 19.00% were older people aged between 70 - 74 years old (12.07% of the older people in this age group and 2.15% of the total older people), and 30.02% were older people aged 75 years and over (15.24% of the older people in this age group and 3.40% of the total older people).

Urgent total needs for smart/white canes comprised 1.47% of the total older people in the CHARLS Database. Within the urgent total needs, 37.11% were men (1.11% of the male older people and 0.55% of the total older people), 62.89% were women (1.81% of the female older people and 0.92% of the total older people). As for age group differentiation, 24.53% were older people aged between 60 - 64 years old (1.17% of the older people in this age group and 0.36% of the total older people), 23.27% were older people aged between 65 - 69 years old (1.18% of the older people in this age group and 0.34% of the total older people). In higher age groups, 16.98% were older people aged between 70 - 74 years old (1.40% of the older people in this age group and 0.25% of the total older people), 35.22% were older people aged 75 years and over (2.32% of the older people in this age group and 0.52% of the total older people). Figure 56 showed the percentage of total needs and urgent needs for smart/white canes in different genders or age groups related to the total number of older people in the database.

Figure 55 - Total Needs and Urgent Needs for Smart/White Canes



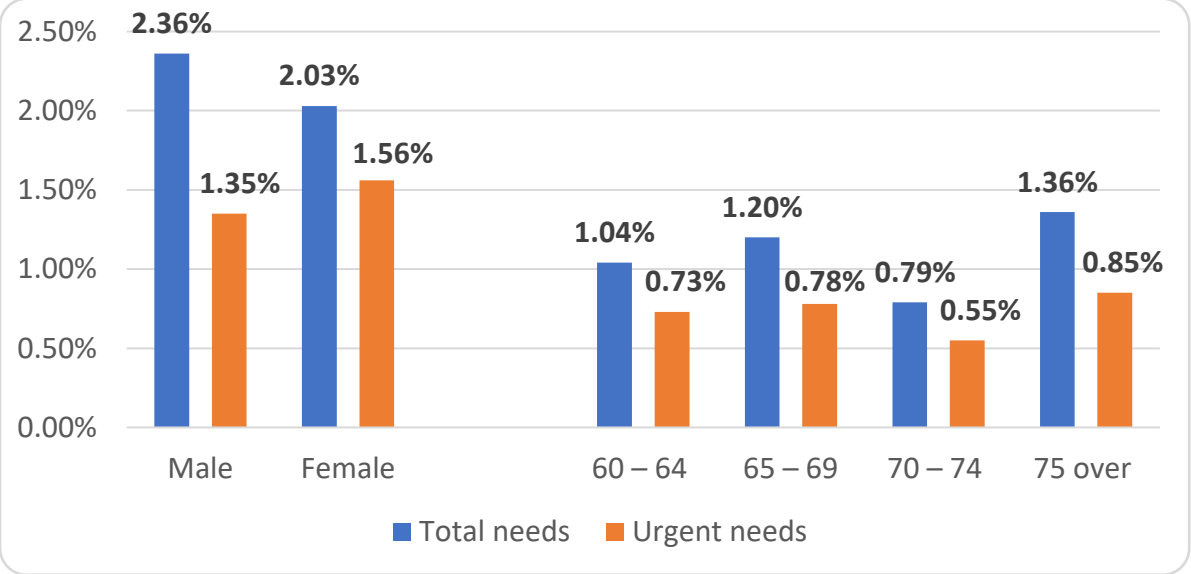
5.7.3 TOTAL NEEDS AND URGENT NEEDS FOR PRESSURE RELIEF MATTRESSES

Total needs for pressure relief mattresses comprised 4.39% of the total older people in the CHARLS Database. Of the total needs, 53.68% were men (4.81% of the male older people and 2.36% of the total older people), 46.32% were women (3.99% of the female older people and 2.03% of the total older people). As for age group differentiation, 23.79% were older people aged between 60 - 64 years old (3.38% of the older people in this age group and 1.04% of the total older people), 27.37% were older people aged between 65 - 69 years old (4.15% of the older people in this age group and 1.20% of the total older people). In higher age groups, 17.89% were older people aged between 70 - 74 years old (4.40% of the older people in this age group and 0.79% of the total older people), 30.95% were older people aged 75 years and over (6.09% of the older people in this age group and 1.36% of the total older people).

Urgent total needs for pressure relief mattresses comprised 2.91% of the total older people in the CHARLS Database. Within the urgent total needs, 46.35% were men (2.75% of the male older people and 1.35% of the

total older people), 53.65% were women (3.07% of the female older people and 1.56% of the total older people). As for age group differentiation, 25.08% were older people aged between 60 - 64 years old (2.37% of the older people in this age group and 0.73% of the total older people), 26.67% were older people aged between 65 - 69 years old (2.68% of the older people in this age group and 0.78% of the total older people). In higher age groups, 19.05% were older people aged between 70 - 74 years old (3.11% of the older people in this age group and 0.55% of the total older people), 29.21% were older people aged 75 years and over (3.81% of the older people in this age group and 0.85% of the total older people). Figure 57 showed the percentage of total needs and urgent needs for pressure relief mattresses in different genders or age groups related to the total number of older people in the database.

Figure 56 - Total Needs and Urgent Needs for Pressure Relief Mattresses



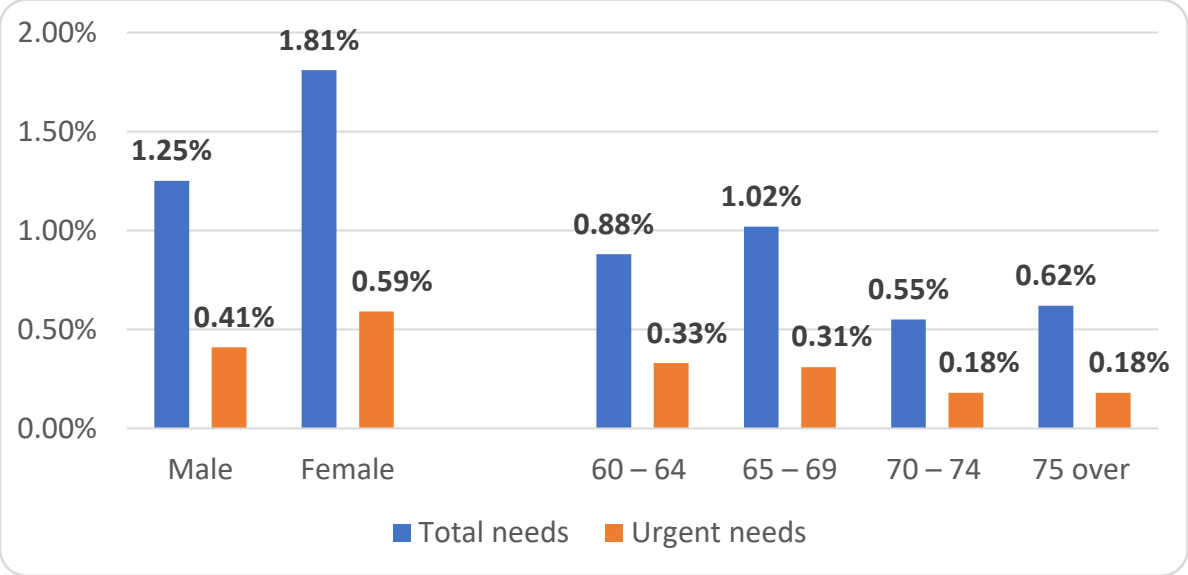
5.7.4 TOTAL NEEDS AND URGENT NEEDS FOR THERAPEUTIC FOOTWEAR

Total needs for therapeutic footwear comprised 3.06% of the total older people in the CHARLS Database. Of the total needs, 40.79% were men (2.54% of the male older people and 1.25% of the total older people),

and 59.21% were women (3.56% of the female older people and 1.81% of the total older people). As for age group differentiation, 28.70% were older people aged between 60 - 64 years old (2.84% of the older people in this age group and 0.88% of the total older people), 33.23% were older people aged between 65 - 69 years old (3.51% of the older people in this age group and 1.02% of the total older people). In higher age groups, 17.82% were older people aged between 70 - 74 years old (3.06% of the older people in this age group and 0.55% of the total older people), 20.24% were older people aged 75 years and over (2.77% of the older people in this age group and 0.62% of the total older people).

Urgent total needs for therapeutic footwear comprised 1.00% of the total older people in the CHARLS Database. Within the urgent total needs, 40.74% were men (0.83% of the male older people and 0.41% of the total older people), 59.26% were women (1.16% of the female older people and 0.59% of the total older people). As for age group differentiation, 33.33% were older people aged between 60 - 64 years old (1.08% of the older people in this age group and 0.33% of the total older people), 30.56% were older people aged between 65 - 69 years old (1.05% of the older people in this age group and 0.31% of the total older people). In higher age groups, 17.59% were older people aged between 70 - 74 years old (0.98% of the older people in this age group and 0.18% of the total older people), 18.52% were older people aged 75 years and over (0.83% of the older people in this age group and 0.18% of the total older people). Figure 58 showed the percentage of total needs and urgent needs for therapeutic footwear in different genders or age groups related to the total number of older people in the database.

Figure 57 - Total Needs and Urgent Needs for Therapeutic Footwear



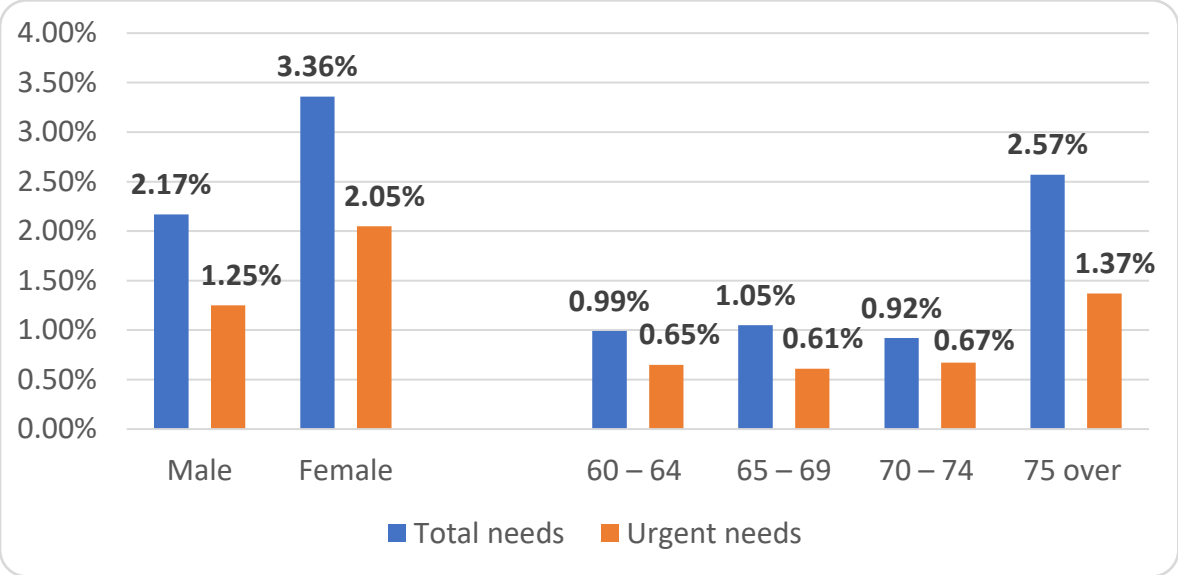
5.7.5 TOTAL NEEDS AND URGENT NEEDS FOR SMART PILLBOX

Total needs for smart pillbox comprised 5.53% of the total older people in the CHARLS Database. Of the total needs, 39.30% were men (4.43% of the male older people and 2.17% of the total older people), 60.70% were women (6.59% of the female older people and 3.36% of the total older people). As for age group differentiation, 17.89% were older people aged between 60 - 64 years old (3.20% of the older people in this age group and 0.99% of the total older people), 19.06% were older people aged between 65 - 69 years old (3.64% of the older people in this age group and 1.05% of the total older people). In higher age groups, 16.56% were older people aged between 70 - 74 years old (5.13% of the older people in this age group and 0.92% of the total older people), 46.49% were older people aged 75 years and over (11.51% of the older people in this age group and 2.57% of the total older people).

Urgent total needs for smart pillbox comprised 3.30% of the total older people in the CHARLS Database. Within the urgent total needs, 37.82% were men (2.54% of the male older people and 1.25% of the total older people), 62.18% were women (4.03% of the female older people and

2.05% of the total older people). As for age group differentiation, 19.61% were older people aged between 60 - 64 years old (2.10% of the older people in this age group and 0.65% of the total older people), 18.49% were older people aged between 65 - 69 years old (2.11% of the older people in this age group and 0.61% of the total older people). In higher age groups, 20.45% were older people aged between 70 - 74 years old (3.78% of the older people in this age group and 0.67% of the total older people), 41.46% were older people aged 75 years and over (6.13% of the older people in this age group and 1.37% of the total older people). Figure 59 showed the percentage of total needs and urgent needs for smart pillbox in different genders or age groups related to the total number of older people in the database.

Figure 58 - Total Needs and Urgent Needs for Smart Pillbox



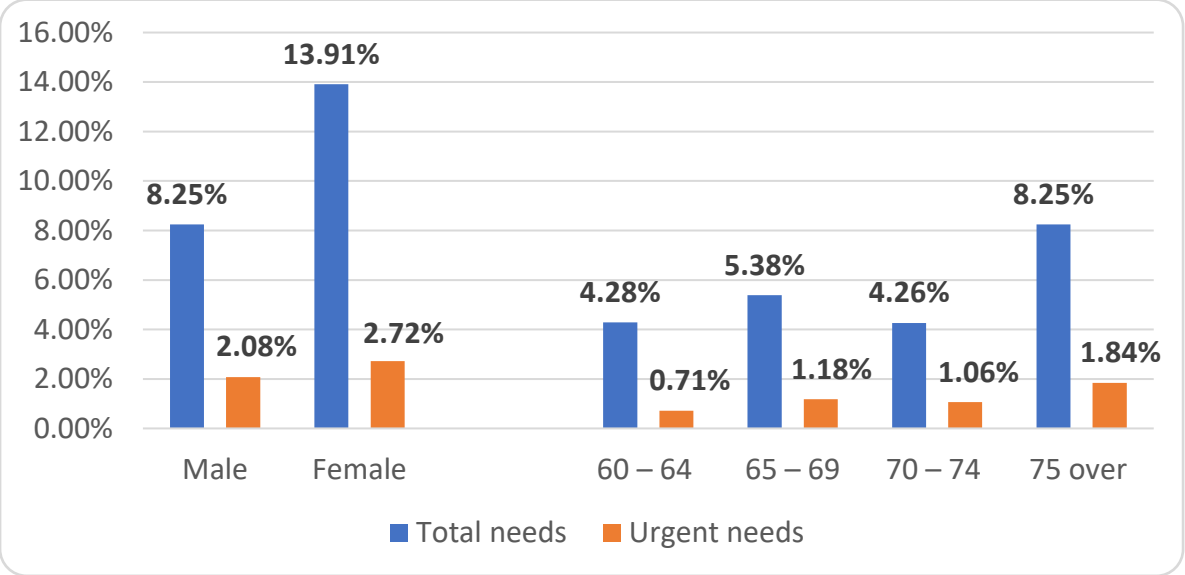
5.7.6 TOTAL NEEDS AND URGENT NEEDS FOR HANDRAIL AND GRAB BAR

Total needs for handrail and grab bar comprised 22.17% of the total older people in the CHARLS Database. Of the total needs, 37.24% were men (16.83% of the male older people and 8.25% of the total older people), 62.76% were women (27.30% of the female older people and 13.91% of

the total older people). As for age group differentiation, 19.31% were older people aged between 60 - 64 years old (13.86% of the older people in this age group and 4.28% of the total older people), 24.27% were older people aged between 65 - 69 years old (18.58% of the older people in this age group and 5.38% of the total older people). In higher age groups, 19.22% were older people aged between 70 - 74 years old (23.87% of the older people in this age group and 4.26% of the total older people), 37.20% were older people aged 75 years and over (36.94% of the older people in this age group and 8.25% of the total older people).

Urgent total needs for handrail and grab bar comprised 4.80% of the total older people in the CHARLS Database. Within the urgent total needs, 43.35% were men (4.24% of the male older people and 2.08% of the total older people), 56.65% were women (5.33% of the female older people and 2.72% of the total older people). As for age group differentiation, 14.84% were older people aged between 60 - 64 years old (2.31% of the older people in this age group and 0.71% of the total older people), 24.66% were older people aged between 65 - 69 years old (4.09% of the older people in this age group and 1.18% of the total older people). In higher age groups, 22.16% were older people aged between 70 - 74 years old (5.96% of the older people in this age group and 1.06% of the total older people), 38.34% were older people aged 75 years and over (8.24% of the older people in this age group and 1.84% of the total older people). Figure 60 showed the percentage of total needs and urgent needs for handrails and grab bars in different genders or age groups related to the total number of older people in the database.

Figure 59 - Total Needs and Urgent Needs for Handrails and Grab Bars



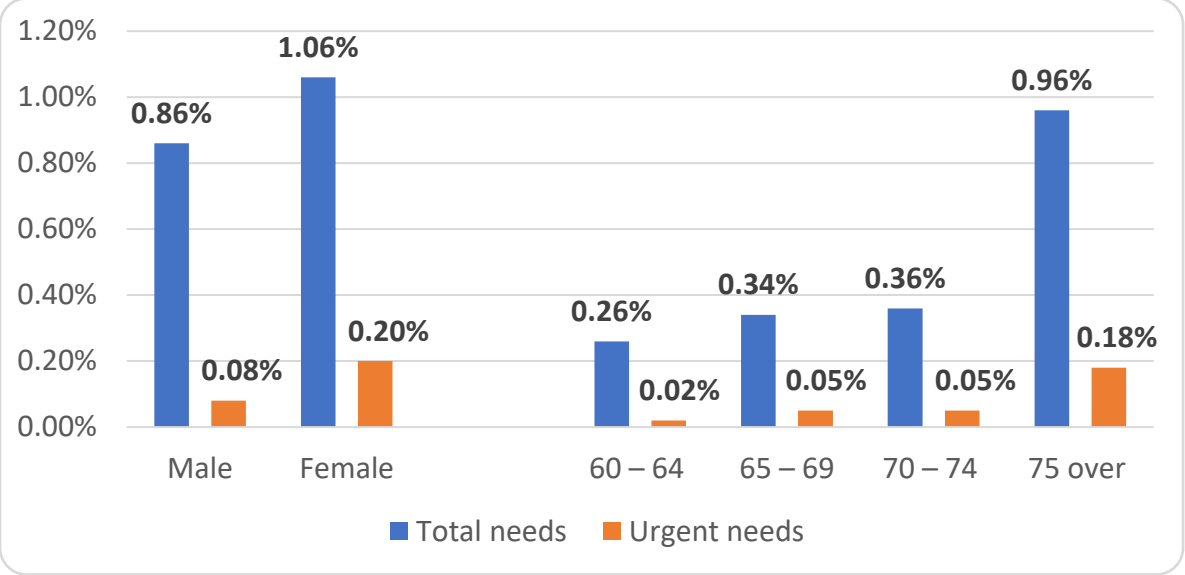
5.7.7 TOTAL NEEDS AND URGENT NEEDS FOR RAMP, PORTABLE

Total needs for portable ramps comprised 1.92% of the total older people in the CHARLS Database. Of the total needs, 44.71% were men (1.75% of the male older people and 0.86% of the total older people), 55.29% were women (2.09% of the female older people and 1.06% of the total older people). As for age group differentiation, 13.46% were older people aged between 60 - 64 years old (0.84% of the older people in this age group and 0.26% of the total older people), 17.79% were older people aged between 65 - 69 years old (1.18% of the older people in this age group and 0.34% of the total older people). In higher age groups, 18.75% were older people aged between 70 - 74 years old (2.02% of the older people in this age group and 0.36% of the total older people), 50.00% were older people aged 75 years and over (4.31% of the older people in this age group and 0.96% of the total older people).

Urgent total needs for portable ramps comprised 0.29% of the total older people in the CHARLS Database. Within the urgent total needs, 29.03% were men (0.17% of the male older people and 0.08% of the total older people), 70.97% were women (0.40% of the female older people and

0.20% of the total older people). As for age group differentiation, 6.45% were older people aged between 60 - 64 years old (0.06% of the older people in this age group and 0.02% of the total older people), 16.13% were older people aged between 65 - 69 years old (0.16% of the older people in this age group and 0.15% of the total older people). In higher age groups, 16.13% were older people aged between 70 - 74 years old (0.16% of the older people in this age group and 0.05% of the total older people), 61.29% were older people aged 75 years and over (0.79% of the older people in this age group and 0.18% of the total older people). Figure 61 showed the percentage of total needs and urgent needs for ramp (portable) in different genders or age groups related to the total number of older people in the database.

Figure 60 - Total Needs and Urgent Needs for Ramp (Portable)



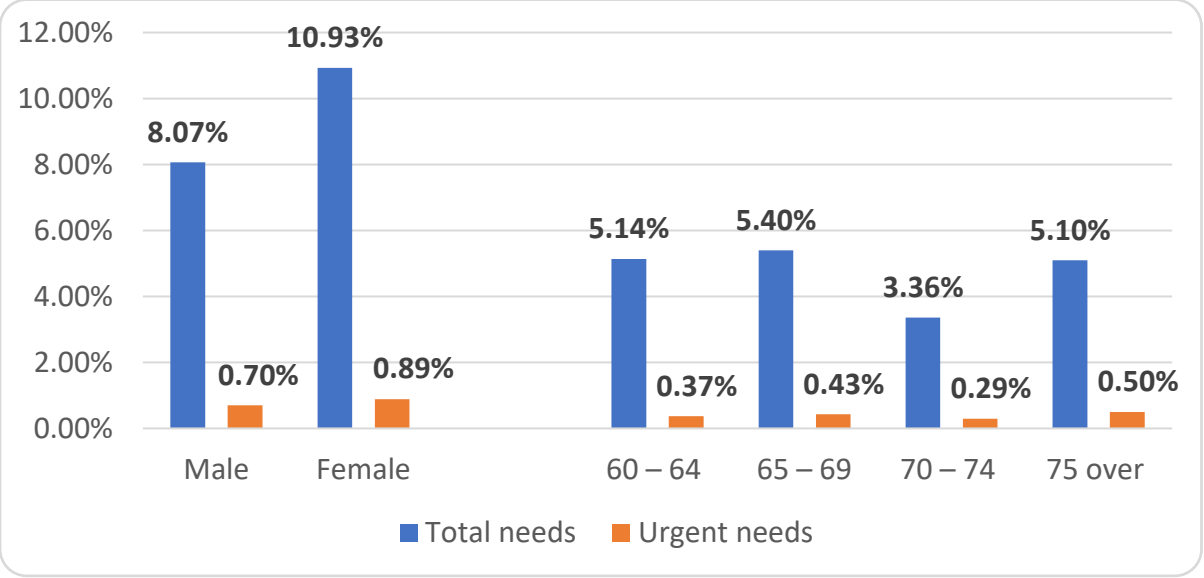
5.7.8 TOTAL NEEDS AND URGENT NEEDS FOR WATCHES, TALKING/TOUCHING

Total needs for talking/touching watches comprised 19.00% of the total older people in the CHARLS Database. Of the total needs, 42.48% were men (16.45% of the male older people and 8.07% of the total older people), 57.52% were women (21.44% of the female older people and

10.93% of the total older people). As for age group differentiation, 27.06% were older people aged between 60 - 64 years old (16.65% of the older people in this age group and 5.14% of the total older people), 28.42% were older people aged between 65 - 69 years old (18.65% of the older people in this age group and 5.40% of the total older people). In higher age groups, 17.66% were older people aged between 70 - 74 years old (18.80% of the older people in this age group and 3.36% of the total older people), 26.86% were older people aged 75 years and over (22.86% of the older people in this age group and 5.10% of the total older people).

Urgent total needs for talking/touching watches comprised 1.59% of the total older people in the CHARLS Database. Within the urgent total needs, 44.19% were men (1.43% of the male older people and 0.70% of the total older people), 55.81% were women (1.74% of the female older people and 0.89% of the total older people). As for age group differentiation, 23.84% were older people aged between 60 - 64 years old (1.23% of the older people in this age group and 0.37% of the total older people), 26.74% were older people aged between 65 - 69 years old (1.47% of the older people in this age group and 0.43% of the total older people). In higher age groups, 18.02% were older people aged between 70 - 74 years old (1.61% of the older people in this age group and 0.29% of the total older people), 31.40% were older people aged 75 years and over (2.24% of the older people in this age group and 0.50% of the total older people). Figure 62 showed the percentage of total needs and urgent needs for watches, talking/touching in different genders or age groups related to the total number of older people in the database.

Figure 61 - Total Needs and Urgent Needs for Watches, Talking/Touching



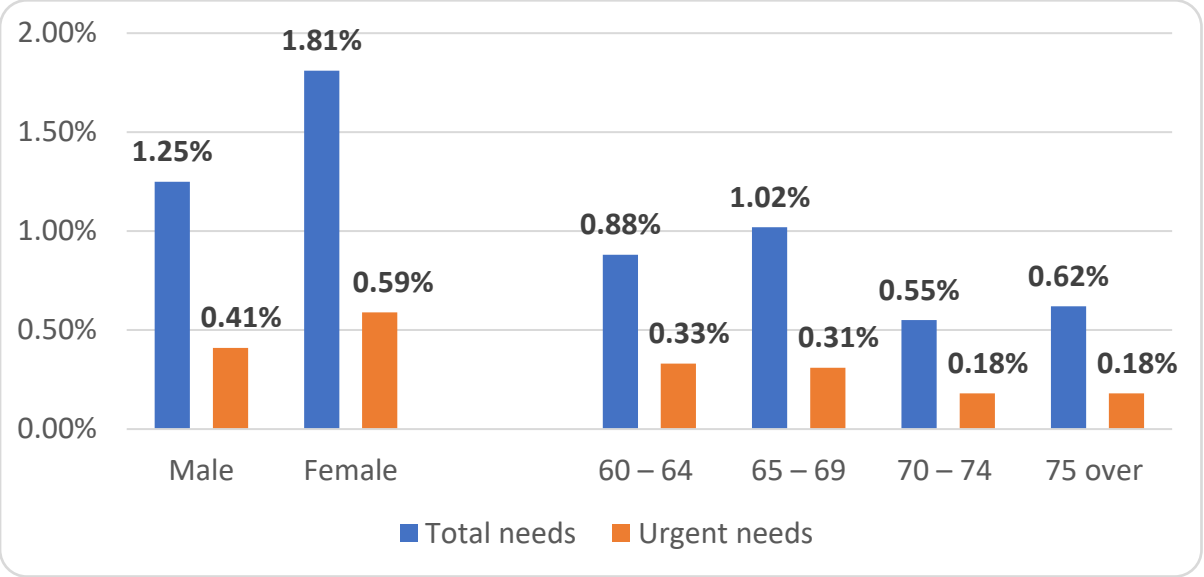
5.7.9 TOTAL NEEDS AND URGENT NEEDS FOR GLUCOMETER

Total needs for glucometer comprised 3.06% of the total older people in the CHARLS Database. Of the total needs, 40.79% were men (2.54% of the male older people and 1.25% of the total older people), 59.21% were women (3.56% of the female older people and 1.81% of the total older people). As for age group differentiation, 28.70% were older people aged between 60 - 64 years old (2.84% of the older people in this age group and 0.88% of the total older people), 33.23% were older people aged between 65 - 69 years old (3.51% of the older people in this age group and 1.02% of the total older people). In higher age groups, 17.82% were older people aged between 70 - 74 years old (3.06% of the older people in this age group and 0.55% of the total older people), 20.25% were older people aged 75 years and over (2.77% of the older people in this age group and 0.62% of the total older people).

Urgent total needs for glucometer comprised 1.00% of the total older people in the CHARLS Database. Within the urgent total needs, 40.74% were men (0.83% of the male older people and 0.41% of the total older people), 59.26% were women (1.16% of the female older people and

0.59% of the total older people). As for age group differentiation, 33.33% were older people aged between 60 - 64 years old (1.08% of the older people in this age group and 0.33% of the total older people), 30.56% were older people aged between 65 - 69 years old (1.05% of the older people in this age group and 0.31% of the total older people). In higher age groups, 17.59% were older people aged between 70 - 74 years old (0.98% of the older people in this age group and 0.18% of the total older people), 18.52% were older people aged 75 years and over (0.83% of the older people in this age group and 0.18% of the total older people). Figure 63 showed the percentage of total needs and urgent needs for glucometer in different genders or age groups related to the total number of older people in the database.

Figure 62 - Total Needs and Urgent Needs for Glucometer



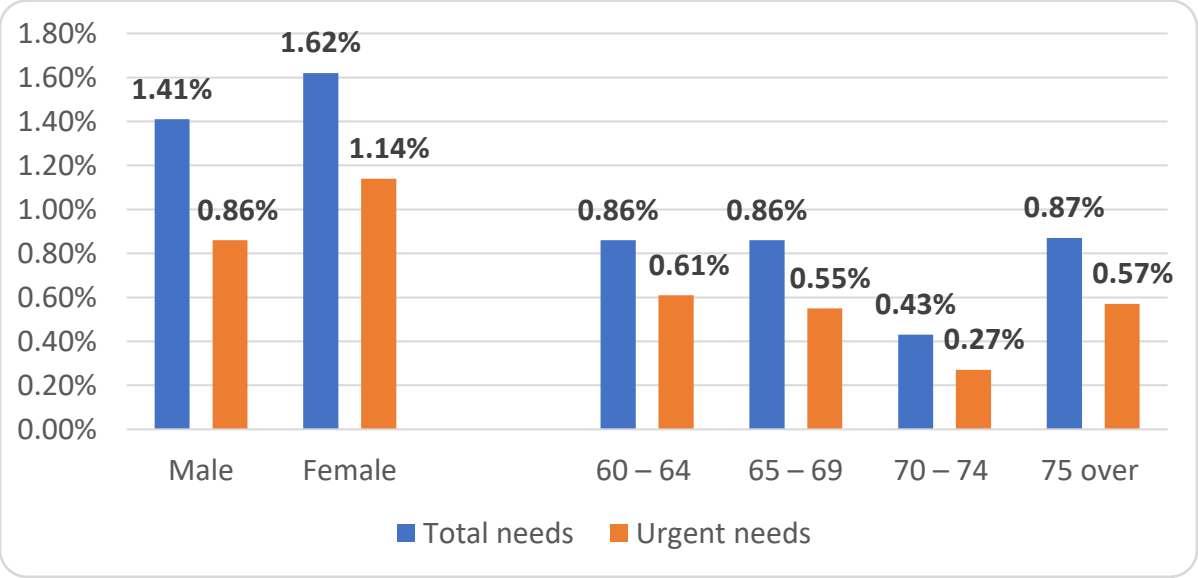
5.7.10 TOTAL NEEDS AND URGENT NEEDS FOR TALKING BLOOD-PRESSURE MONITOR

Total needs for talking blood-pressure monitor comprised 3.02% of the total older people in the CHARLS Database. Of the total needs, 46.48% were men (2.86% of the male older people and 1.41% of the total older people), 53.52% were women (3.17% of the female older people and

1.62% of the total older people). As for age group differentiation, 28.44% were older people aged between 60 - 64 years old (2.78% of the older people in this age group and 0.86% of the total older people), 28.44% were older people aged between 65 - 69 years old (2.97% of the older people in this age group and 0.86% of the total older people). In higher age groups, 14.37% were older people aged between 70 - 74 years old (2.43% of the older people in this age group and 0.43% of the total older people), 28.75% were older people aged 75 years and over (3.89% of the older people in this age group and 0.87% of the total older people).

Urgent total needs for talking blood-pressure monitor comprised 2.00% of the total older people in the CHARLS Database. Within the urgent total needs, 42.86% were men (1.75% of the male older people and 0.86% of the total older people), 57.14% were women (2.25% of the female older people and 1.14% of the total older people). As for age group differentiation, 30.41% were older people aged between 60 - 64 years old (1.98% of the older people in this age group and 0.61% of the total older people), 27.65% were older people aged between 65 - 69 years old (1.92% of the older people in this age group and 0.55% of the total older people). In higher age groups, 13.36% were older people aged between 70 - 74 years old (1.50% of the older people in this age group and 0.27% of the total older people), 28.57% were older people aged 75 years and over (2.57% of the older people in this age group and 0.57% of the total older people). Figure 64 showed the percentage of total needs and urgent needs for talking blood-pressure monitor in different genders or age groups related to the total number of older people in the database.

Figure 63 - Total Needs and Urgent Needs for Talking Blood-Pressure Monitor



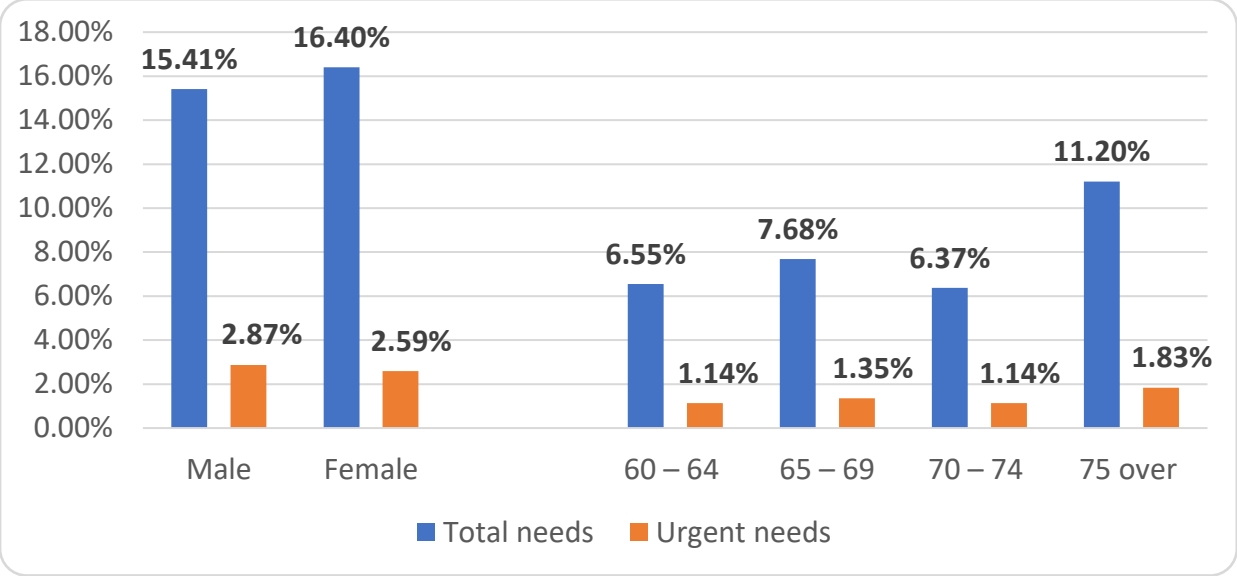
5.7.11 TOTAL NEEDS AND URGENT NEEDS FOR ALARM SIGNALLERS WITH LIGHT/SOUND/VIBRATION

Total needs for alarm signallers with light/sound/vibration comprised 11.20% of the total older people in the CHARLS Database. Of the total needs, 48.45% were men (31.42% of the male older people and 15.41% of the total older people), and 51.55% were women (32.18% of the female older people and 16.40% of the total older people). As for age group differentiation, 20.60% were older people aged between 60 - 64 years old (21.23% of the older people in this age group and 6.55% of the total older people), 24.15% were older people aged between 65 - 69 years old (26.53% of the older people in this age group and 7.68% of the total older people). In higher age groups, 20.02% were older people aged between 70 - 74 years old (35.68% of the older people in this age group and 6.37% of the total older people), 35.22% were older people aged 75 years and over (50.19% of the older people in this age group and 11.20% of the total older people).

Urgent total needs for alarm signallers with light/sound/vibration comprised 1.83% of the total older people in the CHARLS Database.

Within the urgent total needs, 52.54% were men (5.84% of the male older people and 2.87% of the total older people), 47.46% were women (5.08% of the female older people and 2.59% of the total older people). As for age group differentiation, 20.85% were older people aged between 60 - 64 years old (3.68% of the older people in this age group and 1.14% of the total older people), 24.75% were older people aged between 65 - 69 years old (4.66% of the older people in this age group and 1.35% of the total older people). In higher age groups, 20.85% were older people aged between 70 - 74 years old (6.37% of the older people in this age group and 1.14% of the total older people), 33.56% were older people aged 75 years and over (8.20% of the older people in this age group and 1.83% of the total older people). Figure 65 showed the percentage of total needs and urgent needs for alarm signallers with light/sound/vibration in different genders or age groups related to total number of older people in the database.

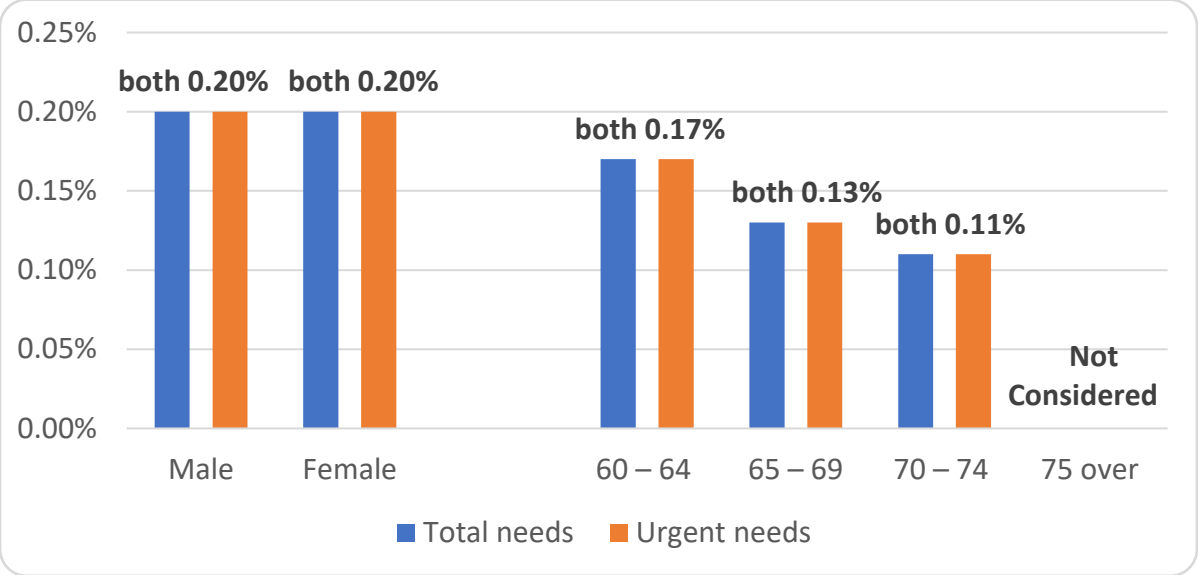
Figure 64 - Total Needs and Urgent Needs for Alarm Signallers with Light/Sound/Vibration



5.7.12 TOTAL NEEDS AND URGENT NEEDS FOR DEAFBLIND COMMUNICATORS

Every need for deafblind communicators was an urgent need. Total needs (and also urgent needs) for deafblind communicators comprised 0.41% of the total older people in the CHARLS Database. Of the total needs, 50.00% were men (0.41% of the male older people and 0.20% of the total older people), 50.00% were women (0.40% of the female older people and 0.20% of the total older people). As for age group differentiation, 40.91% were older people aged between 60 - 64 years old (0.54% of the older people in this age group and 0.17% of the total older people), 31.82% were older people aged between 65 - 69 years old (0.45% of the older people in this age group and 0.13% of the total older people). In higher age groups, 27.27% were older people aged between 70 - 74 years old (0.62% of the older people in this age group and 0.11% of the total older people). Older people aged 75 years and over were not considered to be included in the needs of deafblind communicators as this assistive technology requires a lot of learning - it is extremely challenging for people in their later life to learn a new language. Figure 66 showed the percentage of total needs and urgent needs for deafblind communicators in different genders or age groups related to total number of older people in the database.

Figure 65 - Total Needs and Urgent Needs for Deafblind Communicators



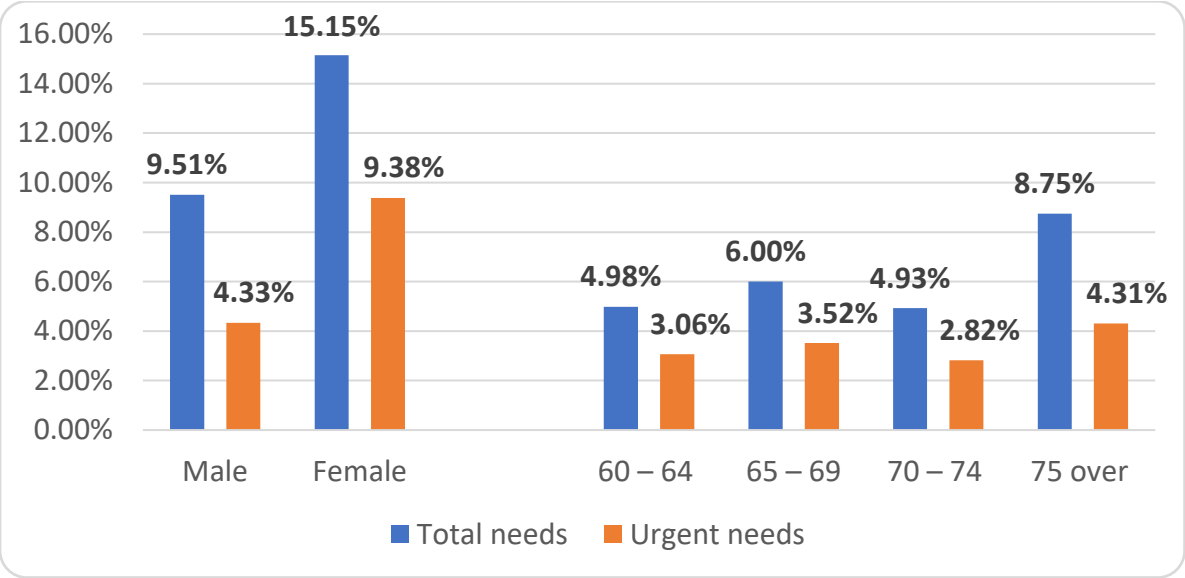
5.7.13 TOTAL NEEDS AND URGENT NEEDS FOR GRASPING TOOLS OR REACH EXTENDERS

Total needs for grasping tools or reach extenders comprised 24.66% of the total older people in the CHARLS Database. Of the total needs, 38.57% were men (19.39% of the male older people and 9.51% of the total older people), 61.43% were women (29.74% of the female older people and 15.15% of the total older people). As for age group differentiation, 20.20% were older people aged between 60 - 64 years old (16.14% of the older people in this age group and 4.98% of the total older people), 24.33% were older people aged between 65 - 69 years old (20.72% of the older people in this age group and 6.00% of the total older people). In higher age groups, 19.98% were older people aged between 70 - 74 years old (27.60% of the older people in this age group and 4.93% of the total older people), 35.49% were older people aged 75 years and over (39.21% of the older people in this age group and 8.75% of the total older people).

Urgent total needs for grasping tools or reach extenders comprised 13.71% of the total older people in the CHARLS Database. Within the

urgent total needs, 31.56% were men (8.82% of the male older people and 4.33% of the total older people), 68.44% were women (18.41% of the female older people and 9.38% of the total older people). As for age group differentiation, 22.32% were older people aged between 60 - 64 years old (9.91% of the older people in this age group and 3.06% of the total older people), 25.69% were older people aged between 65 - 69 years old (12.16% of the older people in this age group and 3.52% of the total older people). In higher age groups, 20.57% were older people aged between 70 - 74 years old (15.79% of the older people in this age group and 2.82% of the total older people), 31.42% were older people aged 75 years and over (19.30% of the older people in this age group and 4.31% of the total older people). Figure 67 showed the percentage of total needs and urgent needs for grasping tools or reach extenders in different genders or age groups related to the total number of older people in the database.

Figure 66 - Total Needs and Urgent Needs for Grasping Tools or Reach Extenders

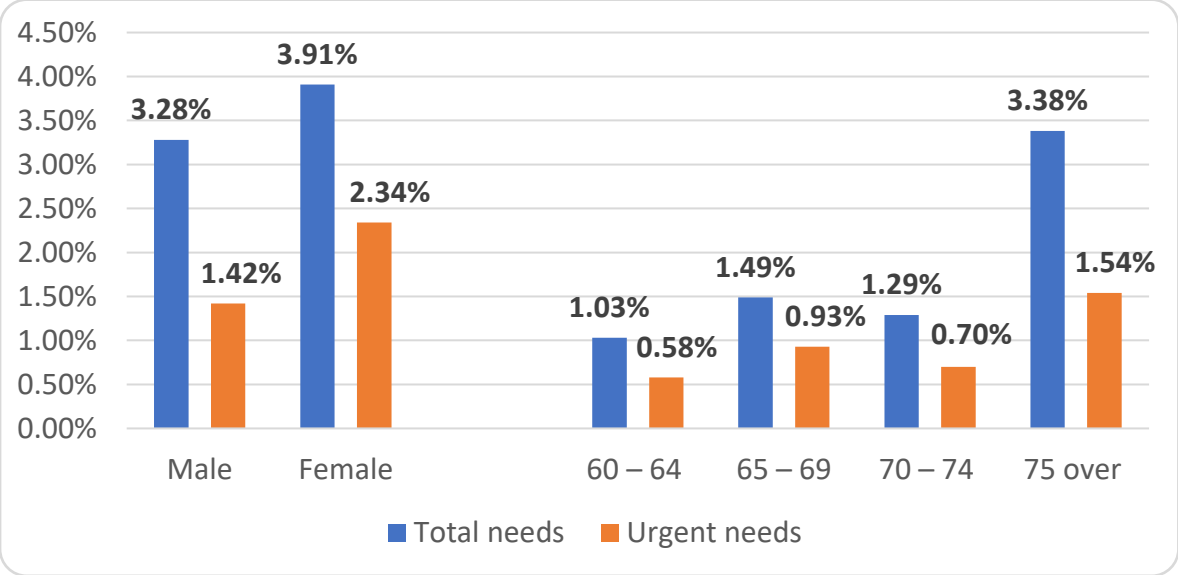


5.7.14 TOTAL NEEDS AND URGENT NEEDS FOR SHOWER CHAIRS

Total needs for shower chairs comprised 3.38% of the total older people in the CHARLS Database. Of the total needs, 45.63% were men (6.69%

of the male older people and 3.28% of the total older people), 54.37% were women (7.67% of the female older people and 3.91% of the total older people). As for age group differentiation, 14.27% were older people aged between 60 - 64 years old (3.32% of the older people in this age group and 1.03% of the total older people), 20.69% were older people aged between 65 - 69 years old (5.14% of the older people in this age group and 1.49% of the total older people). In higher age groups, 17.99% were older people aged between 70 - 74 years old (7.25% of the older people in this age group and 1.29% of the total older people), 47.04% were older people aged 75 years and over (15.16% of the older people in this age group and 3.38% of the total older people). Urgent total needs for shower chairs comprised 1.54% of the total older people in the CHARLS Database. Within the urgent total needs, 37.84% were men (2.90% of the male older people and 1.42% of the total older people), 62.16% were women (4.59% of the female older people and 2.34% of the total older people), 15.48% were older people aged between 60 - 64 years old (1.89% of the older people in this age group and 0.58% of the total older people), 24.82% were older people aged between 65 - 69 years old (3.22% of the older people in this age group and 0.93% of the total older people). In higher age groups, 18.67% were older people aged between 70 - 74 years old (3.94% of the older people in this age group and 0.70% of the total older people), 41.03% were older people aged 75 years and over (6.92% of the older people in this age group and 1.54% of the total older people). Figure 68 showed the percentage of total needs and urgent needs for shower chairs in different genders or age groups related to the total number of older people in the database.

Figure 67 - Total Needs and Urgent Needs for Shower Chairs



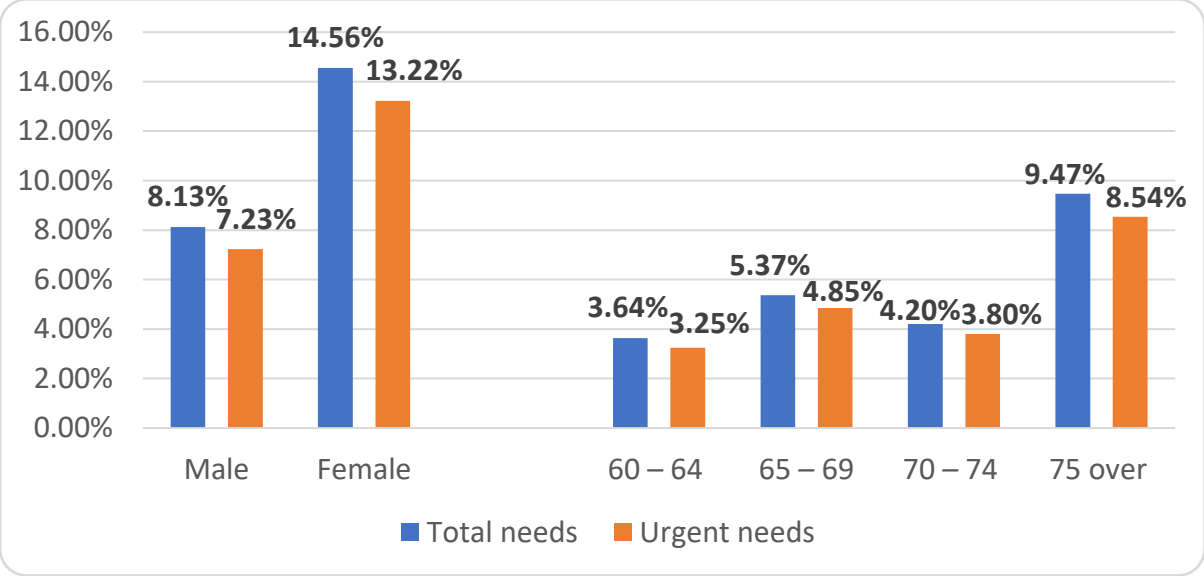
5.7.15 TOTAL NEEDS AND URGENT NEEDS FOR PERSONAL EMERGENCY RESPONSE SYSTEMS

Total needs for personal emergency response systems comprised 22.68% of the total older people in the CHARLS Database. Of the total needs, 35.82% were men (16.57% of the male older people and 8.13% of the total older people), 64.18% were women (28.57% of the female older people and 14.56% of the total older people). As for age group differentiation, 16.06% were older people aged between 60 - 64 years old (11.80% of the older people in this age group and 3.64% of the total older people), 23.68% were older people aged between 65 - 69 years old (18.55% of the older people in this age group and 5.37% of the total older people). In higher age groups, 18.50% were older people aged between 70 - 74 years old (23.51% of the older people in this age group and 4.20% of the total older people), 41.77% were older people aged 75 years and over (42.44% of the older people in this age group and 9.47% of the total older people).

Urgent total needs for personal emergency response systems comprised 20.45% of the total older people in the CHARLS Database. Within the

urgent total needs, 35.35% were men (14.74% of the male older people and 7.23% of the total older people), 64.65% were women (25.94% of the female older people and 13.22% of the total older people). As for age group differentiation, 15.91% were older people aged between 60 - 64 years old (10.54% of the older people in this age group and 3.25% of the total older people), 23.73% were older people aged between 65 - 69 years old (16.76% of the older people in this age group and 4.85% of the total older people). In higher age groups, 18.58% were older people aged between 70 - 74 years old (21.28% of the older people in this age group and 3.80% of the total older people), 41.77% were older people aged 75 years and over (38.26% of the older people in this age group and 8.54% of the total older people). Figure 69 showed the percentage of total needs and urgent needs for personal emergency response systems in different genders or age groups related to the total number of older people in the database.

Figure 68 - Total Needs and Urgent Needs for Personal Emergency Response Systems

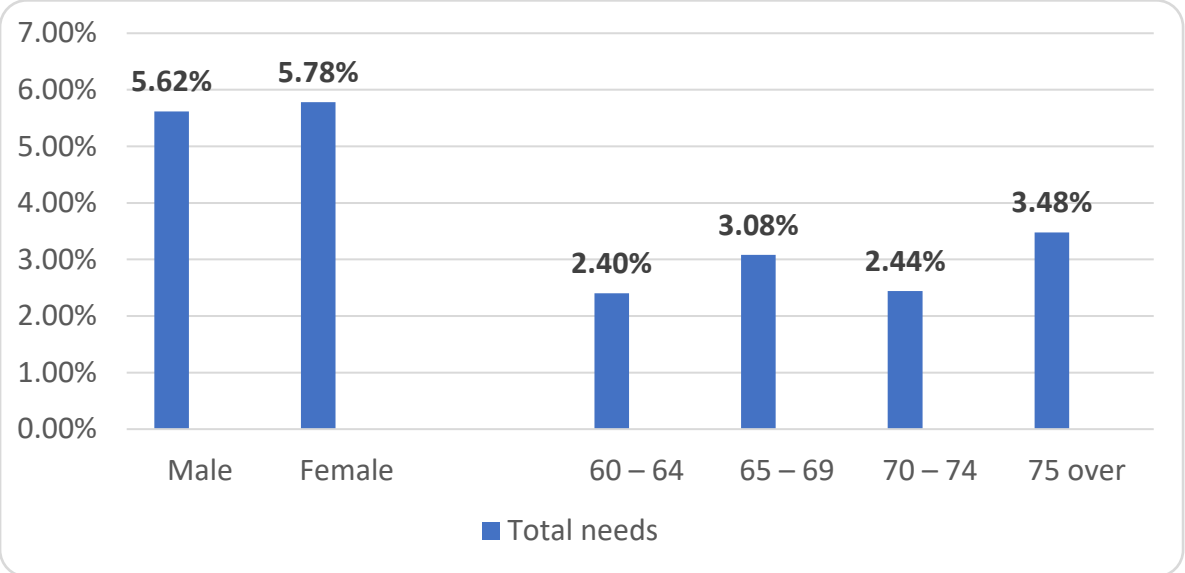


5.7.16 TOTAL NEEDS FOR TIME MANAGEMENT PRODUCTS

Total needs for time management products comprised 11.40% of the total older people in the CHARLS Database. Within the total needs, 49.31%

were men (11.46% of the male older people and 5.62% of the total older people), 50.69% were women (11.34% of the female older people and 5.78% of the total older people). As for age group differentiation, 21.09% were older people aged between 60 - 64 years old (7.78% of the older people in this age group and 2.40% of the total older people), 27.01% were older people aged between 65 - 69 years old (10.63% of the older people in this age group and 3.08% of the total older people). In higher age groups, 21.41% were older people aged between 70 - 74 years old (13.67% of the older people in this age group and 2.44% of the total older people), 30.49% were older people aged 75 years and over (15.57% of the older people in this age group and 3.48% of the total older people). Figure 70 showed the percentage of total needs for time management products in different genders or age groups related to the total number of older people in the database. Urgent needs were not defined.

Figure 69 - Total Needs for Time Management Products



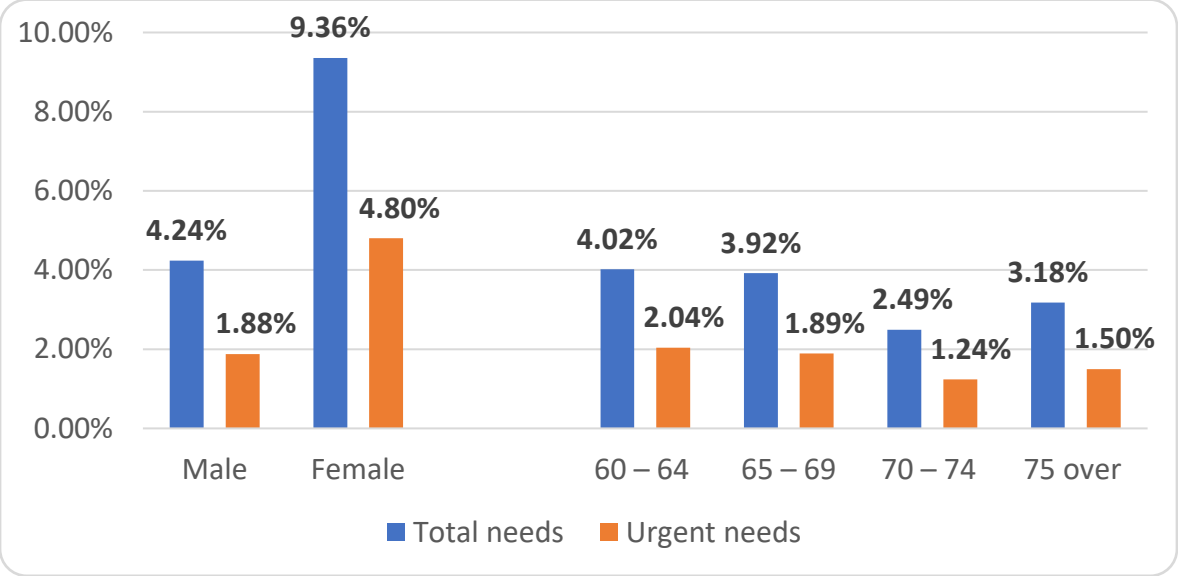
5.7.17 TOTAL NEEDS AND URGENT NEEDS FOR ELECTROTHERAPY DEVICES FOR PAIN

Total needs for electrotherapy devices for pain comprised 13.61% of the total older people in the CHARLS Database. Of the total needs, 31.18% were men (8.65% of the male older people and 4.24% of the total older people), 68.82% were women (18.38% of the female older people and 9.36% of the total older people). As for age group differentiation, 29.55% were older people aged between 60 - 64 years old (13.02% of the older people in this age group and 4.02% of the total older people), 28.80% were older people aged between 65 - 69 years old (13.54% of the older people in this age group and 3.92% of the total older people). In higher age groups, 18.27% were older people aged between 70 - 74 years old (13.93% of the older people in this age group and 2.49% of the total older people), 23.37% were older people aged 75 years and over (14.24% of the older people in this age group and 3.18% of the total older people).

Urgent total needs for electrotherapy devices for pain comprised 6.67% of the total older people in the CHARLS Database. Within the urgent total needs, 28.12% were men (3.83% of the male older people and 1.88% of the total older people), 71.88% were women (9.42% of the female older people and 4.80% of the total older people). As for age group differentiation, 30.61% were older people aged between 60 - 64 years old (6.62% of the older people in this age group and 2.04% of the total older people), 28.39% were older people aged between 65 - 69 years old (6.55% of the older people in this age group and 1.89% of the total older people). In higher age groups, 18.56% were older people aged between 70 - 74 years old (6.94% of the older people in this age group and 1.24% of the total older people), 22.44% were older people aged 75 years and over (6.71% of the older people in this age group and 1.50% of the total older people). Figure 71 showed the percentage of total needs and urgent

needs for electrotherapy devices for pain in different genders or age groups related to the total number of older people in the database.

Figure 70 - Total Needs and Urgent Needs for Electrotherapy Device for Pain



5.8 RESULTS OF AGED CARE EXPERTS' INTERVIEW

5.8.1 AGGREGATION INFORMATION OF RECRUITED EXPERTS

This section shows the results of interviews with experts in aged care. Results include the aggregation information gleaned from the interviewed experts. The researcher interviewed aged care experts to discuss the interpretation of the research results. The discussion includes the analysis of the possible cause of the calculation results (how these results can be explained), and the factors that might affect older people's needs or assistive technologies to turn into real opportunities for assistive technology providers. Every expert who participated in the interviews signed a one-page questionnaire (attached in Appendix 8.6) including their basic demographic information and professional backgrounds, and a Participant Information Sheet/Consent Form (attached in Appendix 8.5). Their information was aggregated into the following Table 33.

Table 33 - Aggregation Information of Interviewed Experts

Information Category	Information description	Number of
Years of experience in assistive technology	< 10 years	0
	> 10 years	6
Years of providing information and advice	< 10 years	0
	> 10 years	6
Professional Qualification	Occupational Therapist	3
	Healthcare Provider	1
	Lecturer	1
	Clinical Educator	1
	Registered Nurse	2
	Audiologist	1
Sectors that the expert works in	Government	0
	University/Research Centre	6
	Private Practice/Service	1
	Other	1
The main client groups that the expert provides assistive technology	Children 0-18 years old	0
	Adults 18-60 years old	1
	Older adults over 60 years old	6
Field(s) of assistive technology that the experts is most experienced in	Aged care generally	2
	People with disability	1
	Hearing aids	1
	Hearing communication	1
	Auditory training	1
	Technology development	1
	Cognitive support	1
	Low vision	1
	Care planning	1
	Alarm	1
	Falls Prevention	1

The information showed that the experts interviewed all had more than 10 years of experience in the assistive technology industry or as a health professional providing information and advice on assistive technology or prescribing assistive technology. Recruited experts had qualifications

including an occupational therapist, healthcare provider, lecturer, clinical educator, registered nurse, and audiologist. All of the experts worked in universities, research centres or academic institutions. One of them was also working in private practice/service. All of them regard older people over 60 years old as the main client to provide assistive technology services to. Experts' experienced field(s) of assistive technology include aged care, people with disability, hearing aids, hearing communication education, auditory training, technology development, cognitive support, low vision, care planning, alarm, and fall prevention. Experts' suggestions and interpretations were used in the following sections.

5.8.2 RESULTS FROM THEMATIC ANALYSIS OF INTERVIEWS

After the interviews with aged care experts, several topics were commonly raised, which indicated information saturation due to thematic analysis. These topics related to the included attitudes of acceptability, affordability, technical issues and learning requirements, cultural issues, support system issues, privacy concerns, awareness, ease of use, feasibility, substitution, stigma and social embarrassment. The following Table 34 showed the emerging themes from the interviews with the aged care experts.

Table 34 - Emerging Themes from the Interview with Aged Care Experts

Emerging Themes	Frequency	ATs mentioned related to the emerging themes
Affordability	Mentioned 9 times by 6 experts	Personal emergency response system, electric wheelchair, walking stick, talking blood-pressure monitor, corrective lenses and glasses, hearing aids
Stigma/ Social embarrassment	Mentioned 8 times by 6 experts	Manual wheelchair, electric wheelchair, hearing aids, personal emergency response system, watches (talking/touching)
Attitudes of acceptability	Mentioned 7 times by 5 experts	Travel device, personal emergency response system, smart pillbox/pill organisers, hearing aids, talking blood-pressure monitor, manual wheelchair, electric wheelchair
Technical issues/ Learning requirement	Mentioned 7 times by 5 experts	Hearing aids, personal emergency response system, deafblind communicator, brailler/braille writing equipment, electric wheelchair
Support system issues	Mentioned 5 times by 3 experts	Manual wheelchair, electric wheelchair, hearing aids
Cultural issues	Mentioned 4 times by 3 experts	Travel devices, smart / white canes, personal emergency response system, hearing aids
Ease of use/ Feasibility	Mentioned 3 times by 2 experts	Catheter and urine collecting bags, smart/white canes, toilet series
Awareness	Mentioned 2 times by 1 expert	Personal emergency response system, Toilet series
Substitution	Mentioned 2 times by 2 experts	Catheter and urine collecting bags, toilet series
Privacy concerns	Mentioned 1 time by 1 expert	Personal emergency response system

The researcher interviewed six aged care experts. Emerging themes according to their interviews were illustrated according to the frequency.

Theme One - Attitudes of Acceptability

Attitudes of acceptability mentioned by experts referred to older people's willingness of using the product when they are in need. This is widely used not only in overall needs analysis but also in the explanation of needs differentiation between different gender and among different age groups. An example of this was a reflection of one expert who stated:

"Women are more likely to admit difficulties than men, they are more likely to seek for assistance."

Another expert reflected:

"High-level usage of hearing aids is not because males have more serious hearing problems, but because men act on their hearing loss more actively."

This theme included discussion on travel devices, personal emergency response systems, smart pillbox/pill organisers, hearing aids, talking blood-pressure monitors, manual wheelchairs and electric wheelchairs.

Theme Two – Affordability

This theme emerged as experts reflected that if people cannot afford the product, they will decide to not use it regardless of their needs. Affordability mentioned by experts was not only about the cost of products themselves but also about the ongoing cost. Experts mentioned that if the cost to run the product or assistance system is higher than older people's expectations, older people tend not to choose the product. The following statement was one of many statements from the experts interviewed when reflecting on affordability:

"If older people cannot afford it, they do not use it even if they need it."

Another expert commented:

"Affordability is a problem for the hearing aid."

Affordability is the most frequently mentioned theme during the interview. This theme included personal emergency response systems, electric wheelchairs, walking sticks, talking blood-pressure monitors, hearing aids, corrective lenses and glasses.

Theme Three - Technical issues and learning requirements

Technical issues and learning requirements mentioned by experts included the difficulties of use of the product, as well as the time and learning ability required to start to use the product. The brailler/braille writing equipment needs older people to learn a new language, for example, the personal emergency response system needs older people to learn to manipulate. This was reflected by an expert in the following statement:

"It is almost impossible for older people to learn a new language in their later life."

This was also reflected by another expert who stated:

"The hearing aid needs to be adjusted every time when people use it or needs to be adjusted on a regular basis."

This theme included discussion on hearing aids, personal emergency response systems, deafblind communicators, brailler/braille writing equipment, and electric wheelchairs.

Theme Four - Cultural issues

Cultural issues can be some thoughts related to assistive technology use under specific cultural circumstances. It can also come from young children's filial piety. This was reflected in the interviews conducted of the experts, with one stating:

"Confucius filial piety is significant for many Chinese people. When older people need to go out for groceries, sometimes their children drive them in the car. As a result, these older people do not need a travel device."

Another expert commented:

"Culturally, Australia does not have a tight family unit, such as that seen in China."

Cultural issues discussed included the impact on travel devices, smart/white canes, personal emergency response systems and hearing aids.

Theme Five - Support system issues

Support system issues mentioned by experts included health care professionals' access to help users with fitting and instruction of technology use. These issues are also related to accessibility which is friendly to any products, such as electric wheelchairs - older people might be living in an environment where the wheelchair might not work. This is demonstrated in a statement from one expert who stated:

"In China, some of the older people not only lack of money to buy a hearing aid but also lack of access and the quick response from audiology support, as well as troubleshooting if the hearing aid is not working."

Another expert stated:

"Health care professionals are often not easily accessible to assist with fitting and instruction of wheelchair use."

Support system issues discussed by the experts included manual wheelchairs, electric wheelchairs and hearing aids.

Theme Six - Privacy concerns

Privacy concerns included that older people are tracked by devices that can access some private data and information. These devices can track their location and other related conditions and this concern was discussed by a number of experts. Some older people are not willing to be tracked by devices and are not happy to let other people know their location.

"Older people do not want to be tracked by such devices. They do not want others to know where they are."

Another expert reflected:

"They also worried about their own security if the positioning information is leaked or hacked."

Privacy concerns discussed included personal emergency response systems.

Theme Seven – Awareness

The experts interviewed discussed that older people should be both aware of their problems, diseases, functional limitations, and what kind of products can address their problems. According to experts, when older people know their functional limitation, have enough money to pay and are open-minded to new technologies but do not know what is available, they still cannot be a user of an existing product. This was reflected in such statements as:

"Some older people are just not aware of such products."

Another expert stated:

"There are some technologically modified and smaller hearing aids which are more comfortable to wear and less problematic. However, most older people have not yet tried them.."

The awareness concerns discussed by experts included personal emergency response system and toilet series (commodes).

Theme Eight - Ease of use and Feasibility

According to experts, the use of some assistive technologies sometimes is not a good experience for older people. When the technology is not easy to use, or does not provide a comfortable experience, or is not as effective as older people expect, older people normally stop using it. One expert commented:

"There are some voice and sound feedback issues in a hearing aid. Hearing aid amplifies every sound, including the noise that can be far away."

Another expert commented:

"For females, catheter is very intrusive and can result in infections"

Catheter and urine collecting bags, smart/white canes and toilet series (commodes) were discussed by experts within this key theme.

Theme Nine - Substitution

Substitution mentioned by experts meant that there could be other products, which are cheaper and easier to get, to take place of the discussed products. Older people can also get the same products from other people (like friends and relatives) other than buying from the market and commercial providers. One expert stated:

"Men can easily use a bottle to urinate; Women tend to use pads."

This theme was also demonstrated by another expert who stated:

"Applying catheter and urine collecting bags into women's body is much more complicated than using against men. Females tend to use substitutes."

In this theme, experts discussed catheter and urine collecting bags and toilet series.

Theme Ten - Stigma/social embarrassment

The experts interviewed discussed how sometimes it could potentially be a stigma for older people to use a specific product because that can make them feel like they are relying on some equipment which removes their locus of control and self-efficacy. An expert stated:

"The use of hearing aids may have stigma and may contribute to agism and age discrimination."

Another expert reflected:

"Older people might not need it anyway because they think other people are looking at this big and ugly watch which is badly designed."

Stigma and social embarrassment concerns discussed by the experts interviewed involved manual wheelchairs, electric wheelchairs, hearing aids, personal emergency response systems, and watches (talking/touching).

5.9 SUMMARY OF THE CHAPTER

This chapter explored research questions 2.2, 2.3 and 2.4. They were explained one by one in the following three paragraphs.

Answering RQ2.2 - Unmet Needs and Urgent Unmet Needs for Assistive Technologies

It was found that all 8 selected assistive technologies had more unmet needs than met needs. The unmet needs for hearing aids were the highest among all - there is only about 1 person who has access to a hearing aid among 80 older people who have a hearing impairment. Electric wheelchair, catheter and urine collecting bags also had high

unmet needs with only one older person's need met in every five to six older people. Travel devices, walking sticks, toilet series (commodes), manual wheelchairs, corrective lenses and glasses had relatively high unmet needs that were two to three times more than met needs. Regarding urgent unmet needs, hearing aids still have the highest urgent unmet needs that were 12.4 times higher than older people's current access to them. The number of urgent unmet needs for electric wheelchairs, walking sticks and toilet series (commodes) was slightly higher than the number of older people who had access to them. Whilst the number of urgent unmet needs for travel devices, manual wheelchairs, corrective lenses and glasses, catheters and urine collecting bags were lower than the number of older people's current access to them.

Answering RQ2.3 - Total Needs and Urgent Total Needs for Assistive Technologies

It has been found that the highest total needs - alarm signallers with light/sound/vibration - were found in 31.81% of older people. Relatively high needs have been found in grasping tools or reach extenders, personal emergency response systems, handrails and grab bars, which were around 22%-25% of older people. Some considerable needs have been found in watches (talking/touching), electrotherapy devices for pain, time management products and smart/white canes, which is between 10% to 20% of the older people. Moderate total needs have been found in shower chairs, smart pillbox/pill organisers, pressure relief mattresses, therapeutic footwear, glucometer, talking blood pressure monitor, braille writing equipment/braillers and portable ramps that were between 1% to 10% of the older people. Deafblind communicators were of low need, which consists only 0.41% of the total older people population in the CHARLS database.

Answering RQ2.4 - Gender and Age Differentiation

It has been found that men had higher unmet needs than women for catheter and urine collecting bags, toilet series and electric wheelchairs. Women had higher unmet needs than men for corrective lenses and glasses and hearing aids. Women had significantly higher unmet needs than men for walking sticks, travel devices and manual wheelchairs. Men had higher total needs than women for braille writing equipment/braillers and pressure relief mattresses. Women had higher total needs than men for smart/white canes, talking blood-pressure monitor, therapeutic footwear, portable ramps, watches (talking/touching), glucometer, alarm signallers with light/sound/vibration, shower chairs and time management products. Women had significantly higher total needs than men for smart pillbox/pill organisers, handrail and grab bar, grasping tools or reach extenders, personal emergency response systems, and electrotherapy devices for pain. Among different age groups, older people aged 75 years old and over were most likely to have the highest unmet needs and total needs for assistive technologies. These older people have the least total need for therapeutic footwear and glucometers. On the other hand, older people aged 60 to 64 years old were most likely to have the lowest unmet needs and total needs for assistive technologies.

To sum up, the above calculation results from section 5.6 to 5.7 showed the numbers and percentages of older people's unmet needs, urgent unmet needs, total needs and urgent total needs for 25 selected assistive technologies. They also showed the gender and age differentiation of users, unmet needs, urgent unmet needs, total needs, and urgent total needs of assistive technologies. The numbers themselves indicate the needs and opportunities for assistive technologies. The possible cause of these numbers and the interpretation of the phenomenon lying under these numbers suggest how people can address these needs and opportunities. These address research question 3, which asks "What

opportunities exist for assistive technologies to assist older people with healthcare and independent living?” Detailed answers, discussion and interpretation are provided in Chapter 6.

CHAPTER 6 : DISCUSSION, CONCLUSION AND FUTURE RESEARCH

This section aims to turn the calculation results into useful information - it showed how the calculation results answered the research questions and offered a guide to future research. This chapter consists of three parts. Part one discusses the calculation results. This part provides thorough interpretations of older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities, older people's unmet needs and urgent unmet needs for assistive technologies that had users' statistics in the CHARLS Database, Older people's total needs and urgent total needs for assistive technologies that did not have users' statistics in the CHARLS Database, as well as the differentiation existing with respect to users and users' needs (both unmet needs and total needs) between different gender and among different age groups. Together, the above interpretations indicate opportunities existed for assistive technologies to assist older people with healthcare and independent living and other deeper thoughts that could emerge from the outcomes. Some of the interpretation presented in part one of this chapter was derived from the interview with aged care experts. Part two concludes the research. This part is a combination of the brief answer to each one of the research questions, showing how the research addressed all research questions and what had been found. Part three is about the future research opportunities identified by the conclusion of this thesis. This part addresses how the future research can address the limitation of this research and how the future research can develop from the results of this research.

6.1 THE CONNECTION BETWEEN RESEARCH QUESTIONS AND THIS CHAPTER

The following research questions introduced in Chapter two are now restated:

Research Question 1:

What theoretical framework provides a method to best explore the user needs identified in the CHARLS data?

Research Question 2:

2.1 What are older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, personal and social activities?

2.2 What are the unmet needs and urgent unmet needs for assistive technologies that can be identified from the CHARLS Database?

2.3 What are the total needs and urgent total needs for assistive technologies that can be identified from the CHARLS Database?

2.4 What differentiation exists with respect to users and users' needs (both unmet needs and total needs) between gender and age?

Research Question 3:

What opportunities exist for assistive technologies to assist older people with healthcare and independent living?

As a discussion chapter, this chapter mainly provided discussion to detailed answers to research questions. This chapter contributed to the discussion of Research Question 2.2, 2.3, 2.4, and 3. The answer to the Research Question 2.2, 2.3 and 2.4 not only included the calculation results shown in the tables in Chapter 5, but also included a deep and detailed interpretation of the results. This chapter provided deeper insights and interpretation of the calculation results shown in Chapter 5. The interpretation was based on several sessions of interviews with aged

care experts. The answer to research question 3 was derived from the interpretation of answers to Research Questions 2.2, 2.3 and 2.4. Moreover, this chapter concluded all of the answers to all research questions at the end, as the conclusion of the thesis. Table 35 showed every research question number and its related sections.

Table 35 - Research Question and Its Related Sections

Research Question	Detailed Answer	Discussion	Conclusion
RQ 1	Section 3.9 and 3.10	No Discussion	Section 6.8
RQ 2.1	Section 4.2 – 4.5	Section 6.4.1 and 6.4.2	Section 6.8
RQ 2.2	Section 5.6	Section 6.2	Section 6.8
RQ 2.3	Section 5.7	Section 6.3	Section 6.8
RQ 2.4	Section 6.4	Section 6.4	Section 6.8
RQ 3	Section 6.5	Section 6.5	Section 6.8

6.2 DISCUSSION OF THE ANSWER TO RESEARCH QUESTION 2.2 - UNMET NEEDS AND URGENT UNMET NEEDS FOR ASSISTIVE TECHNOLOGIES

Research question 2. 2 was about unmet needs and urgent unmet needs for 8 assistive technologies that had users' statistics in the CHARLS Database. The detailed answer to research question 2.2 was presented in Section 5.6. This section provided the discussion of the answer in section 5.6. The discussion mainly included the possible cause of the unmet needs and urgent unmet needs, implications for the aged care industry and other deeper thoughts that emerged from the calculation results.

6.2.1 MOBILITY AIDS: WALKING STICK AND TRAVEL DEVICE

Unmet needs for walking sticks were 2.33 times more than the existing users. The overall ratio was not too high because walking sticks were cheap, easy to get and easy to use. Older people with mobility difficulty could easily get one from lots of retailers. Older people can also get their mobility aids from relatives, friends, neighbours and other people as it was very easy for people to pass them on to other people requiring those.

The number of urgent unmet needs almost equalled the number of users. However, that was not a significant problem as walking sticks were easily available and affordable. Women were significantly higher both in unmet needs and urgent unmet needs for walking sticks. The percentage of unmet needs and urgent unmet needs for walking sticks were higher in a higher age group. These two phenomena are further discussed in Section 6.4.

Travel devices had a slightly higher ratio of unmet needs compared with walking sticks. When there was one older person who had the access to it, there were on average 3.47 older people who did not have access to a walking stick, but needed one. During the interview, an expert explained that this was not only because travel devices were more expensive than walking sticks, but also because some of the older people who needed a travel device could get help and assistance from their friends and relatives who could drive them to their destiny, so they did not actually need a travel device for themselves. On the other hand, travel devices were commonly seen and widely provided in most of the cities in China, they were more acceptable and understandable so that people might be willing to spend money on them no matter if they could get any rebate from the healthcare system. The urgent unmet needs were just half of the number of users. Women were significantly higher both in unmet needs and urgent unmet needs for travel devices. The percentage of unmet needs and urgent unmet needs for travel devices were higher in a higher age group. These two phenomena are further discussed in Section 6.4.

6.2.2 WHEELCHAIRS: MANUAL WHEELCHAIRS AND ELECTRIC WHEELCHAIRS

There was a relatively low unmet needs ratio for manual wheelchairs when compared with electric wheelchairs. Electric wheelchair, according to an aged care expert’s comment during the conducted interviews, is difficult to control especially for older people in later life. Sometimes older

people failed to realise the different types of wheelchairs available - an expert mentioned, that there was a whole range of different types of wheelchairs. It could be complex to provide the correct solution for wheelchair use. Older people generally needed health professionals involved in the selection and prescription of a particular type of wheelchair. No matter if it was a manual or electric wheelchair, if the wrong type of wheelchair was chosen, there might be a risk of someone harming themselves by not fully knowing how to correctly use a wheelchair. Health care professionals were often not easily accessible to assist with fitting and instruction of wheelchair use. Sometimes it could potentially be a stigma for older people to use wheelchairs because that could make them feel like they were relying on some equipment to get them around which removed their locus of control and self-efficacy.

Other factors involved might be the tight-knit network of family support in China, which was pointed out during the interview with aged care experts. As reflected in the interviews undertaken with the experts, culturally, Australia does not have a tight family unit, such as that seen in China. In China, children and other family members are more likely to look after the older adults, assisting with getting things from shops where there is generally no accessibility for wheelchairs. This could result in a person not necessarily requiring a wheelchair. The affordability was a big issue for electric wheelchairs.

The high unmet needs for electric wheelchairs were not only because of their high price but also because in most cities of China, many buildings and places were not accessible to wheelchairs, both manual and electric. This was seen and expressed by an aged care expert during the interviews conducted, who had been living in Hong Kong and Mainland China for many years. Older people might be living in an environment where the wheelchair might not work, such as a house with numerous stairs, levels and/or uneven walkways. Additionally, some older people with severe mobility impairment had given up doing things that they

needed to do, with the assistance of wheelchairs. Women were significantly higher both in unmet needs and urgent unmet needs for manual wheelchairs. The percentage of unmet needs and urgent unmet needs for both manual and electric wheelchairs were higher in a higher age group. These two phenomena were further discussed in Section 6.4.

6.2.3 TOILET ISSUES: CATHETER, URINE COLLECTING BAGS AND TOILET SERIES

Catheter and urine collecting bags were lower in urgent unmet needs because they were normally linked with urgent medical needs. Older people normally urgently needed one when they were dealing with incontinence problems. However, the interviewed aged care experts stressed that they often required specific healthcare professional assistance to assist with the use of these devices. On the other hand, the provision of catheters and urine collecting bags was not as high as walking sticks, commodes, corrective lenses and glasses. Thus, the unmet needs for catheters and urine collecting bags were still higher than the provision. Additionally, the use of a catheter and urine collection bags could be stigmatising.

The number of older people who have unmet needs for toilet series was two times of those who were currently using them. Women were significantly higher in unmet needs for toilet series. As for urgent unmet needs, women and men were similar. The percentage of unmet needs and urgent unmet needs for toilet series were higher in a higher age group. These two phenomena were further discussed in Section 6.4.

6.2.4 SENSORY AIDS: HEARING AIDS, CORRECTIVE LENSES AND GLASSES

Corrective lenses and glasses were easy and cheap to buy with increased accessibility. The author lived in China for 25 years and knew that some

of the corrective lenses and glasses purchases required a clinical test and prescription from an optometrist, some of them did not require a prescription. Thus, the unmet needs for corrective lenses and glasses were relatively low. The urgent unmet needs were extremely low, which was much lower than the number of users.

Women were significantly higher both in unmet needs and urgent unmet needs for hearing aids. The percentage of unmet needs and urgent unmet needs for hearing aids were higher in a higher age group. These two phenomena were further discussed in Section 6.4. Hearing aids had very high unmet needs - on average when there was one existing older people user, there were more than 79 older people who had hearing impairment but did not have a hearing aid.

Besides the reason that the hearing aid was very costly, another big issue for it was that older people did not like to use hearing aids. Not only the audiologist but also some other aged care experts that were interviewed, stressed that there were some voice and sound feedback issues in a hearing aid. Hearing aids amplify every sound, including the noise that can be far away. This did not provide older people with good using experiences. Some of the older people had a family history that some of their family members used the really old type of hearing aid with lots of noise. Many people stopped using them because of the experience of voice feedback. Technical issues were also mentioned by two aged care experts interviewed, that the hearing aid needs to be adjusted every time when people use it or needs to be adjusted on a regular basis. Without the adjustment, they might not be effective for the user. Whilst hearing aids are highly available in Australia, there is still a high level of abandonment. Even if older people got prescribed hearing aids by a professional audiologist, there could be still other problems such as battery failure. Many other assistive technologies, such as corrective lenses and pressure relief mattresses, did not have many technology components. The reason for abandonment was sometimes very complex,

and sometimes very obvious. If the device hurt when people were wearing it, if the device was lost, older people could easily stop using it. Hearing aids were very easily lost.

The interviewed aged care experts reflected that there were some technologically modified and smaller hearing aids which were more comfortable to wear and less problematic. However, most older people had not yet tried them. There were missing education and support elements that would help older people to successfully use it. The interviewed expert who had been living in Hong Kong and Mainland China reflected that some older Chinese people not only lack the money to buy a hearing aid but also lack of access to them and a lack of timely response from audiology support services, as well as troubleshooting if the hearing aid is not working. The number of audiologists in China, compared with the older people population in China, was very low. Audiologists in China could not serve all the older people with hearing loss. In addition, the use of hearing aids might have stigma and might contribute to ageism and age discrimination. Therefore, hearing aid users also needed social support. They needed the people around them to encourage them to use hearing aids, and to be positive about hearing aids.

The audiologist interviewed suggested that hearing aids users should know that the device was just a support, the device did not fix the hearing loss. Some people expected that when they wore a hearing aid, they could be able to hear perfectly again, and their family members expected that they could communicate perfectly again. However, this was not the case. They still needed family members to be effective communicators and they still needed lots of support using hearing aids. Other aged care experts who were interviewed commented that there could be cultural issues related to hearing aid provision that children could be responsible for looking after parents and providing a hearing aid to parents. But older parents did not want to bother and did not want to be

a burden to their children. So, they tended not to tell their children that they had hearing problems. Until people had a successful experience of using a hearing aid, they tended to abandon it. People had them, tried them and had a bad experience when going somewhere noisy, and then they did not wear them anymore. The two situations of not having it, and having it but not using it, could certainly cycle.

The audiologist expert who was interviewed was not surprised by the high unmet need for hearing aids. This was not something that audiologists would see in China; this was something they see worldwide. This was quite typical in hearing aids' uses, that for some reason they had either been given or purchased the hearing aids but did not use them. Since there was quite a range of people who had hearing aids but did not use them, there were three categories of older people regarding hearing aid use according to the interviewed audiologist: those people who did not have hearing aids, those people who did have hearing aids but did not use them, those people who used hearing aids. There was an explanation for this high percentage that within this percentage of unmet needs, there could be older people who did have them but did not use them. This was a global phenomenon, especially in low- and middle-income countries - WHO estimates that global hearing aid production covers just 3% of the need in these countries (World Health Organazation 2022b). This high percentage in China did not surprise the audiologist who was interviewed in this research. Based on the very low number of hearing aids users in the CHARLS Database (97 users out of 10818 older people, which was 0.89% of the older people participants), the audiologist believed that most of the non-users were those who simply did not have them and did not use them, but not those who had them but stopped using them.

To sum up, 8 assistive technologies discussed above all had unmet needs, more or less. Hearing aids had the highest unmet needs and urgent unmet needs but could also have the high abandonment among older people. Thus, the actual unmet needs for hearing aids might be lower

than that indicated by the calculation result. Catheter and urine collecting bags, electric wheelchairs, and travel devices had relatively high unmet needs but low urgent unmet needs. Walking stick, corrective lenses and glasses, toilet series (commodes), and manual wheelchair had relatively low unmet needs and urgent unmet needs. Unmet needs could be not only because of the affordability, and low level of access to assistive technologies but also because of the low level of access to professionals who could provide and prescribe correct assistive technologies. For example, the lack of audiologists who could prescribe the correct type of hearing aids could be an important reason why people were not getting and using hearing aids.

6.3 DISCUSSION OF THE ANSWER TO RESEARCH QUESTION 2.3 - TOTAL NEEDS AND URGENT TOTAL NEEDS FOR ASSISTIVE TECHNOLOGIES

Research Question 2. 3 was about needs and urgent total needs for 17 assistive technologies that did not have users' statistics in the CHARLS Database. The detailed answer to research question 2.3 was presented in section 5.7. This section provided the discussion of the answer in section 5.7. The discussion mainly included the possible cause of the total needs and urgent needs, the indication for aged care industry and other deeper thoughts that emerged from the calculation results.

6.3.1 ASSISTIVE TECHNOLOGIES FOR BLIND PEOPLE

A. Braille writing equipment/braillers

Older people aged 75 years and over were not considered to be included in the total and urgent needs of braille writing equipment/braillers as this assistive technology requires a lot of learning - it was extremely challenging for people in their later life to learn a new language. Men were higher in total needs than women, while women were higher in urgent total needs than men. But the difference was not significant.

Teaching braille to people who are blind from an early age is easily adopted and very accessible, according to the optometrist, however, teaching braille to people who lost their vision in later life is extremely challenging. Some optometrists did not expect older people with severe problems to learn braille, which was a new language for them. Optometrists would rather use other strategies that were less intensive on the learning, such as digital magnifiers or auditory alarms or text-to-speech technology that would not expect so much learning. Also, for some people with diabetic vision changes, their finger sense was not as good as for non-diabetics, so being able to detect or find braille might be more challenging for them. Braille writing equipment/braillers were not something the optometrist would exclude any people from, but it might not be the best solution for an older person with a new disability.

B. Smart/white canes

Women were higher in total needs than men, and significantly higher in urgent total needs than men.

C. Watches, talking/touching

Aged care experts interviewed suggested that the design of this type of watch could significantly affect older people's willingness of using them. Large, aesthetically unpleasant and poorly designed watches made people feel embarrassed and reluctant to use them and could finally lead to abandonment. Women were higher than men both in total needs and urgent total needs. However, the difference was not significant.

D. Deafblind communicators

Older people aged 75 years and over were not considered to be included in the needs for a deafblind communicator as this assistive technology required a lot of learning– - as was discussed before, it was extremely challenging for people in their later life to learn a new language. Total needs and urgent total needs from women and men were exactly the same regarding deafblind communicators.

6.3.2 ASSISTIVE TECHNOLOGIES FOR CHRONIC DISEASE CONTROL

A. Pressure relief mattresses

Men were higher in total needs than women, while women were higher in urgent total needs than men. But the difference was not significant.

B. Therapeutic footwear

Women were higher than men both in total needs and urgent total needs. But the difference was not significant.

C. Glucometer

Women were higher than men both in total needs and urgent total needs. However, the difference was not significant.

D. Talking blood-pressure monitor

Women were higher than men both in total needs and urgent total needs. But the difference was not significant.

E. Electrotherapy device for pain

Women were significantly higher than men both in total needs and urgent total needs.

6.3.3 ASSISTIVE TECHNOLOGIES FOR SAFETY AND MEMORY PROBLEMS

A. Smart pillbox

Women were significantly higher than men both in total needs and urgent total needs. According to interviewed aged care experts, “feeling old” was an important topic for smart pillbox use. Some older people did not like to use pill boxes because they might feel old if they used them and this contributed to ageism. They needed to be organised by somebody if they

used a smart pill box. An expert pointed out three questions related to smart pillbox use - who put the medicine in the pill box and who could be responsible for monitoring whether or not the pills were being taken? Were there the correct pills in the pillbox and were the pills stored in the right way and right condition (such as the right temperature)? These were the questions older people needed to address if they could not manage medication activities by themselves. Thus, the use of a smart pillbox required a supporting system around the technology use. This system could involve the pharmacist and family members.

B. Personal emergency response system

Women were significantly higher than men both in total needs and urgent total needs. The high level of need for a personal emergency response system could be explained as including lots of different products. Personal emergency response systems in this research included fall detectors. One-fourth of the older people actually fell (Centers for Disease Control and Prevention 2020). An interviewed expert who had been working for a personal emergency response system company stated that the system could detect a fall no matter whether the older person was at home or outside. Older people were self-reporting that they were unsteady and unbalanced, but whether or not it was a clinical risk of falling (if the unsteady and unbalanced condition was clinically important), was another problem. A variety of different conditions such as ageing, muscle pain, muscle strength, and affected balance, could increase the risk of falling (Lessard et al. 2021). Thus, the total needs for fall detectors were high. However, the outcome of falling could be quite different at different ages. Young people normally did not hurt themselves severely after a falling. But older people could break their bones including fracturing their hips which could result in severe and chronic disability; Sometimes a falling could be catastrophic (Centers for Disease Control and Prevention 2020). Though older people might have young generation family members at home, family members still went to work and went to school and could

leave older people alone at home. Thus, older people still needed assistance and monitoring to be in place in this situation. Fall detectors, as commented by the interviewed aged care experts, in terms of being assistive, told someone when their relatives and friends were likely to have fallen or provided a mechanism for someone to call for help. When people wore a pendant alarm but did not intend to use it, the alarm still worked when they fell. This occasion can cause social embarrassment when older people do not necessarily want other people to know that they fell. Also, having a fall detector, while someone lived alone, and did not have anyone in the network to tell and call for help, fall detectors were not fully useful as there were no doctors or call centres for help. Aged care experts who were interviewed, concluded that a lot of older people were at risk of falling but a fall detector might not be useful for all of them. In terms of considering the market of fall detectors, it is worth considering lots of other factors, in addition to considering if the older people were at risk of falling.

There was a very high correlation between hearing loss and balance problems. As people age and their hearing ability worsen, their chance of falling increases. It was not 100% clear about the pathway of how it happens. The audiologist who was interviewed believed this was physiological because the human balance organ was part of the ear so any ageing of the ear or any conditions with the ear meant also that there were disturbances of the balancing organs. Another explanation from the interviewed audiologist was that human beings use hearing to be aware of the environment. So, when the hearing ability decreased, people's awareness of the environment also decreased, which led to a greater risk of falls. The audiologist explained that people subconsciously built a 3D map of the environment around the body and hearing ability played a role in it. Thus, if the hearing ability was affected, people's ability to have that special coordination was also affected.

For personal emergency response systems, many interviewed experts stressed that there could be a monthly ongoing cost to keeping it running. Therefore, older people might think it is too expensive or may not have the funds to pay for this. Personal emergency response systems were usually bought by younger children for their older parents. Fall detectors and global positioning systems sometimes made older people think that they were being watched. They did not like to be watched or be followed. They also worried about their own security if the positioning information was leaked or hacked.

C. Time management products

Women were higher than men in total needs, but not significant. Urgent total needs for time management products were not defined.

6.3.4 ASSISTIVE TECHNOLOGIES FOR EVERYDAY LIVING

A. Handrail and grab bar

Women were higher than men in urgent total needs and significantly higher than men in total needs. One aged care expert who was interviewed pointed out that not only the availability and the affordability could be problems, but also home condition and home ownership could be problems. If the older people do not own the house, they may not be allowed to install a handrail and grab bar.

B. Ramp, Portable

Women were higher than men in total needs and significantly higher than men in urgent total needs. Portable ramps were usually used to help wheelchair users with getting on the vehicle (Kumtepe et al. 2020), if the older people wheelchair users could actually get assistance from their friends and relatives who could lift them on the vehicle, or drive them to their destiny, then they did not actually need a portable ramp. Moreover, for older people who lived in less developed areas and did not have

access to a vehicle, there was no point for portable ramps. Thus, the actual need for portable ramps could be lower than what the data indicated.

C. Alarm signallers with light/sound/vibration

Women were higher than men in total needs, while men were higher than women in urgent total needs. But the differences were not significant.

D. Grasping tools or reach extenders

Women were significantly higher than men both in total needs and urgent total needs.

E. Shower chairs

Women were higher than men in total needs and significantly higher than men in urgent total needs.

6.4 THE ANSWER AND DISCUSSION OF THE ANSWER TO RESEARCH QUESTION 2.4 - GENDER AND AGE GROUP DIFFERENTIATION REGARDING USES AND NEEDS OF ASSISTIVE TECHNOLOGIES

This section both answered and discussed Research Questions 2.4, which was about the gender and age group differentiation regarding the uses and needs of assistive technologies. The arrangement of the following 6 sub-sections was listed in Table 36.

Table 36 - Sub-sections Arrangements

	Regarding Users	Regarding Unmet Needs	Regarding Total Needs
Gender Differentiation	Sub-section 6.4.1	Sub-section 6.4.3	Sub-section 6.4.5
Age group Differentiation	Sub-section 6.4.2	Sub-section 6.4.4	Sub-section 6.4.6

6.4.1 GENDER DIFFERENTIATION OF ASSISTIVE TECHNOLOGY USERS

Overall, the percentage of male users and female users was similar. There were three interesting findings which were different from the overall situation.

The first one was about catheter and urine collecting bags users, here, male users were 106% more than female users. According to interviews with the experts, it was known that males were more likely to have urination problems because males have prostates and could suffer from prostate cancer. The aged care expert explained from each gender: For males, urine can be collected more easily because of males' body structure. For females, a catheter is very intrusive and can result in infections. Applying catheter and urine collecting bags to women's bodies is much more complicated than using them for men. Females tended to use substitutes. Females were more likely to use pads rather than catheters and urine collecting bags, which might cause some urine leaks and skin breakdown. Men had a higher risk to have medical conditions related to their bladders and urination tracts and prostates. As men age, they more tended to have these conditions.

The second one is about toilet series users, here, female users were 51% more than male users. It was interesting that toilet series, catheter and urine collecting bags were all related to toileting issues, but they had different users' gender distributions. This was because that toilet series aimed to help those people who had difficulties in using the toilet, on the other hand, catheter and urine collecting bags aimed to help those who had difficulties in controlling urination and defecation. In other words, toilet series were related to mobility problems, disability or the distance of walking to the toilet, catheters and urine collecting bags were related to nerve controlling problems. Some other reasons emerged during the interview with experts. When females went to the toilet, they tended to sit down. When males went to the toilet, they tend to stand up when

urinating. Males had a lower incidence of sitting on the toilet bowl, so they are not likely to purchase the toilet series. Most of the commodes were not very user-friendly to men because men normally stood up to urinate.

The third one was about hearing aid users, here, male users were 69% more than female users. The first thought the researcher came up with is that hearing loss from harmful occupations were always conducted by males (industrial hearing loss). According to National Health and Nutrition Examination Survey of USA, the weighted prevalence of workplace noise exposure was highest for mining, followed by lumber/wood product manufacturing (Tak, Davis & Calvert 2009). High-risk occupations included repair and maintenance, motor vehicle operators, and construction trades (Tak, Davis & Calvert 2009). Males undertook most of the roles in these occupations, thus this might rationalise why males had more hearing problems which led to higher usage of hearing aids during their old ages. According to aged care experts who were interviewed, in a working environment with a high level of noise, men were less likely to equip to protect their hearing. Globally, hearing loss was more prevalent amongst males because they developed hearing loss earlier which was likely due to the noise exposure (Le et al. 2017).

The fact in China was different from the above thoughts according to the CHARLS Database. The researcher looked back into older people's hearing abilities and expected to see a significant gender differentiation in this profile. The question investigating older people's hearing ability, DA039, which asked "Is your hearing very good, good, fair, poor, or very poor?", showed no significant gender differentiation in Mann-Whitney U Test (Gender). Another question investigating older people's hearing and their level of disability, DA005[4], asked "Do you have a hearing problem", also showed no significant gender differentiation - in the database, there were 696 older people who indicated to have hearing problems, among them, 336 were male and 360 were female. Therefore, high level of usage of

hearing aids was not because males had more serious hearing problems, but because men acted on their hearing loss more actively. According to the interviewed audiologist, there might be some hearing aids provisions for males in their workplace. Or they were more aware of their hearing loss because they had hearing loss tested in the workplace. More noise exposure could lead to high levels of concern about hearing ability testing.

6.4.2 AGE GROUP DIFFERENTIATION OF ASSISTIVE TECHNOLOGY USERS

It was projected that when people get older, their health problems escalate, which results in a higher-level usage of assistive technologies. Based on the four age groups set in this thesis (60-64; 65-69; 70-74; 75 and over), the oldest group (75 and over) was expected to appear with the highest user percentage. This was the case for most of the assistive technologies included in this research. Corrective lenses and glasses users were the special ones. Older people in higher age groups had a lower percentage of corrective lenses and glasses users. Three reasons for this phenomenon were derived during the interview with the aged care experts. First, they were not active - people in very old age tended to withdraw and disconnect from reading newspapers, watching television and doing everyday chores. They were more likely to stay at home and they might not be overly concerned with their eyesight impairment. As a result, they did not use glasses even if they had poor eyesight. Second, older people in higher age groups might have an eye disease, which might require corrective surgery more so than glasses or corrective lenses. Third, older people might have limited access to glasses vendors or have difficulties in managing glasses. It was not less acceptable to wear a pair of glasses. But it could be a problem to keep them or keep them clean.

6.4.3 GENDER DIFFERENTIATION OF ASSISTIVE TECHNOLOGIES' UNMET NEEDS

There were 8 types of assistive technologies in the CHARLS Database that have users' statistics. Unmet needs calculation was provided for these assistive technologies. Regarding the gender differentiation of unmet needs, men were higher than women in using a catheter and urine collecting bag, toilet series and electric wheelchairs. Women were higher than men in hearing aids, corrective lenses and glasses. Women were significantly higher than men in walking sticks, travel devices and manual wheelchairs. Classifying these assistive technologies, it could be concluded that: men were higher than women mostly in products related to toileting; Women were higher than men in products related to sensory problems; Women were significantly higher than men in products related to mobility problems. There were no assistive technologies that men had significantly higher unmet needs than women do.

Unmet needs in this research referred to older people whose profile was in need of assistive technology but did not have it. In terms of men having higher unmet needs than women mostly in products related to toileting, it was explained in terms of substitution provision during the interview - as men had more other solutions for toileting rather than using toilet series (commode), catheter and urine collecting bags. Men could simply use a bottle or some other containers to address their urination needs. In terms of women requiring mobility assistance, it was explained from the working environment perspective by aged care experts who were interviewed. Men were more likely to be involved in strong physical labours, as a result, they might have stronger core muscles and better balancing ability. Whereas women tended to do less labour-intensive jobs, and they were more likely to be weak in mobility abilities. Older women got different kinds of support rather than using mobility aids. They could still get around safely without simply a walking stick and travel device. In terms of women having higher unmet needs than men in

products related to sensory problems, the aged care experts thought that was because some older women relied on their children and family members' decisions - women tended not to undertake lots of hazardous work during their young ages thus their children and family members tended to think that they did not really need these sensory assistances. Another reason suggested by an interviewed expert was the concern of appearance - traditionally, social things were regarded as important for a woman. Older women sometimes were concerned about the negative effect brought by wearing glasses or hearing aids. Another reason was that women had been traditionally doing things at home after they retire, and they were more likely to be accompanied by other people when they went out. So, they had not prioritised sensory assistance.

6.4.4 AGE GROUP DIFFERENTIATION OF ASSISTIVE TECHNOLOGIES' UNMET NEEDS

According to the calculation result, unmet needs increased in higher age groups. This was commonly explained by the interviewed aged care experts as older people normalised their functional limitations as they aged. Hearing loss, for example: generally, the degree and prevalence of hearing loss increased as people got older, however, their reported disability from hearing loss went down. This seemed contradictory at the first glance. However, as the audiologists investigated deeper, they found that hearing loss was normalised as people aged. By the time when people reached 75 years or older, a large majority of people had some level of hearing loss. Therefore, they no longer perceived this as a disability, they saw it as normal. As a result, there was a group of older people who simply say, "everybody else has gotten a hearing loss, so why would I go and get a hearing aid? This is just normal. This is just what happened to people when they get older." Some older people saw this as a life-course health issue and did not seek to resolve or address it. Similar to the unmet needs for other assistive technologies, aged care experts

suggested in their interviews, that older people normalised their functional limitations which changed their ADL and tended not to use the corresponded assistive technology.

6.4.5 GENDER DIFFERENTIATION OF ASSISTIVE TECHNOLOGIES' TOTAL NEEDS

There were 17 types of assistive technologies in the CHARLS Database that did not have users' statistics. Total needs calculation was provided for these assistive technologies. Regarding the gender differentiation of total needs, men were higher than women in the use of braille writing equipment/braillers, and pressure relief mattresses. Women were higher in use than men in smart/white canes, talking blood-pressure monitor, therapeutic footwear, ramp (portable), watches (talking/ touching), glucometer, alarm signallers with light/sound/vibration, and shower chairs. Women were significantly higher in use than men in smart pillbox/pill organisers, handrails and grab bars, grasping tools or reach extenders, personal emergency response systems, and electrotherapy devices for pain. Still, there were no assistive technologies that men have significantly higher total needs than women do.

The phenomenon that men were never significantly higher than women regarding unmet needs and total needs was partially explained by aged care experts in the conducted interviews, as women had a higher chronic disease burden in later life. Moreover, some aged care industry experts thought that among the older people participants in the CHARLS Database, women were more likely to admit difficulties than men - men had a higher sense of independence and needed to be perceived that they were being capable. Whereas women normally feel free to say, "I have problems and troubles with that." Women were more alert to the changes as they age. As the result of reaching higher age groups, with various conditions of ageing, with the incident in the final few years of a person's life, there were probability various conditions that made people seek

assistance. The interviewed experts also expressed that men had a higher mortality rate before they reached that age group which they were classified as sort of frail,

6.4.6 AGE GROUP DIFFERENTIATION OF ASSISTIVE TECHNOLOGIES' TOTAL NEEDS

There were 17 types of assistive technologies in the CHARLS Database that did not have users' statistics. According to the calculation result, total needs for most of the assistive technologies increased in higher age groups. However, there was one interesting phenomenon that emerged: total needs for therapeutic footwear, glucometer and talking blood pressure monitor were not in accordance with the above-illustrated age group distribution. For therapeutic footwear and glucometer, the highest total needs appeared in the 65 - 69 age group, the second-highest total needs appeared in the 70 - 74 age group, the third-highest total needs appeared in the 60 - 64 age group, and the lowest total needs appeared in 75 and over age group. For talking blood pressure monitors, the highest total needs appeared in 75 and over age group, the second-highest total needs appeared in the 65 - 69 age group, the third-highest total needs appeared in the 60 - 64 age group, and the lowest total needs appeared in 70 - 74 age group.

6.5 THE ANSWER AND DISCUSSION OF THE ANSWER TO RESEARCH QUESTION 3 – OPPORTUNITIES FOR ASSISTIVE TECHNOLOGIES IN CHINA

Those assistive technologies with high rankings in unmet needs should be put in the priority place in strengthening the provision of the product itself and the supporting system/professionals related to the product, in managing the awareness, attitude and adoption of older people, or in healthcare system rebate. These assistive technologies were: hearing aids, electric wheelchairs, catheters and urine collecting bags. Those

assistive technologies with high rankings in total needs should be put in the priority place in technology development, they were: alarm signallers with light/sound/vibration, grasping tools or reach extenders, personal emergency response system, handrail and grab bar, watches (talking/touching), electrotherapy device for pain, and time management products.

The growth of smart assistive technology was tricky, though assistive technology providers were excited to see this high opportunity. An interviewed expert who worked in the assistive technology industry argued that there were many new technologies being worked on, but people were too focused on the technology itself - technology developers were always happy that a product could do some new things but tended to overlook how older people could learn to use it, and what they could actually use it for and whether older people were going to accept using it. The newly innovated smart assistive technology was criticised by this expert for a perceived lack of the combination between bringing the technology from experts and informing people who were caring for dependent people or working in the aged care sector. In other words, it was critical to match up what older people needed and what assistive technology could do or could be practical with a person. One of the overlooked factors in the development of assistive technologies, mentioned by experts in the interviews, was that they lacked grounding/trailing on people first and were sometimes without enough research on the practice of assistive technologies. People could easily find hundreds or even thousands of assistive technologies, but it was still hard to find a solution that was the most suitable one for them. And there were not enough supporting professionals and systems for older people to inform their needs which they did not know. Experts also expressed that there were some early signs of something going wrong that indicated needing an assistive technology, but older people sometimes failed to detect them. For example, a pressure sore could be detected very early

and could be addressed by applying pressure relief products. But older people sometimes sought help too late when the pressure sore is too severe to be cured. Even if they started to use pressure relief product very early and used a high-quality product, they might still fail to relieve the pressure sore if they could not learn to distribute the weight in a proper way or if they did not reduce the body weight. Some bad designs which increased the feeling of stigma were also criticised by experts during the interview. For example, a smartwatch could combine lots of functions and provide good assistance for older people. But older people might not need it anyway because they thought other people were looking at this big and ugly watch which was badly designed. Therefore, needs-driven research is more important than technology led research. The function of assistive technology is actually of lower value than the practicality of assistive technology.

Older people, in Chinese culture, are highly valued, but sometimes are not highly financially valued because of the limited personal income in China. Some people do not like to be told about their limitations. It is a complex issue to tell the opportunities from the percentage of needs. The percentage of older people who are in need of a specific assistive technology does not exactly refer to the actual opportunities of this assistive technology. The correct strategy is to find the values behind people's technology decisions and look them off by telling them what they cannot do. Not only the technology itself can be the solution, but also older people themselves can be the solution. Assistive technology developers should help them understand what it is, and what the benefit would be for them. The discussion with funding bodies is different from the discussion with users. The core potential to localise a solution is to make the assistive technology acceptable - what is going to work, what is going to be acceptable, what is embarrassing and what is not embarrassing. In China, cultural and social issues are complicated in affecting older people's adoption to assistive technologies. Confucian filial

piety, as one of the most valuable cultural elements in China, provokes adult children to help older people get more access to the most updated assistive technologies, on the other hand, adult children also try to look after their parents by themselves which substitutes some of the assistive technologies. In rural areas, older people's children tend to leave their hometowns and work in metropolitans, which leaves older people needing more assistive technologies, on the other hand, in rural areas people have low levels of income, which results in lower access to assistive technologies.

6.6 FUTURE RESEARCH INDICATION

This research matched older people's needs for assistive technologies, and answered all research questions, but left some limitations. Future research should focus on solving the research limitation and taking more advanced advantage of the data used in this research.

6.6.1 TAKING ADVANTAGE OF "LONGITUDINAL" CHARACTER ESPECIALLY FOR PREDICTION

This research took advantage of the CHARLS Database, which was a longitudinal database. This research only used one wave of the database (the newest wave). The baseline data collection of the CHARLS was conducted in 2011 and further included about 10,000 households and 17,500 individuals in 150 counties/districts and 450 villages/resident committees in following waves (Zhao et al. 2013; Zhao et al. 2014). The individuals supplying the data were re-surveyed every two years. All data was made public one year after the end of data collection (Zhao et al. 2020). A longitudinal database has great potential for data prediction. Multiple waves in different years are effective in determining variable patterns over time. A longitudinal database helps researchers with clear focus and validity - the database that provides high accuracy when

observing changes is effective in doing research on developmental trends. The research reported on this thesis used just one wave of the CHARLS Database, which provided a condition in a specific year. A dynamic prediction design taking advantage of the longitudinal database can be of more value for future research and informing the industry. According to the changing pattern of older people's profiles regarding their health, disability, social and personal activities, predicting research can be done. The researcher suggests further research predicting the needs, and unmet needs for assistive technologies based on the data in every existing wave of the CHARLS Database.

6.6.2 CONSIDERING BARRIERS TO ADOPTION

As illustrated in Figure 1, this research is needs-driven research, but not technology-push research. To be specific, this research has found the number and the percentage of older people with the need for specific types of assistive technology. These numbers and percentages can never 100% transform into actual needs and market opportunities. That is because in the technology push process, marketing cannot cover every older people, and not every older people would adopt and accept the assistive technology they are actually in need. The relationship between older people and assistive technologies is more complex than it is studied in this research. This research started from the access to the CHARLS Database and was driven by older people's needs. Older people's attitudes towards assistive technologies and their adoption definitely affect the users' statistics in CHARLS Database. This research did not systematically analyse the exact percentage of adoption and did not provide a comprehensive framework of how older people's attitudes affected the adoption of assistive technologies. Many issues related to attitude and adoption that can affect the real needs of assistive technologies have been discussed in sections 6.2 and 6.3. The development of the assistive technology, the access to healthcare professionals for correct

prescriptions, the requirement of learning, older people's awareness, the affordability, etc., open up the possibility of assistive technologies making a greater contribution provision to older people's care. If future research can both address older people’s needs and adoption/attitude to assistive technologies, then the aged care industry can be better informed.

Barriers to adoption include but are not limited to the following factors:

A. Cost/Affordability

This is one of the most important barriers to older people’s adoption of assistive technologies. This was mentioned 9 times during the interviews with aged care experts. Personal emergency response system, electric wheelchair, walking stick, talking blood-pressure monitor, hearing aids, corrective lenses and glasses were mentioned their cost and affordability issues. According to aged care experts who were interviewed, affordability can be a big problem in China, which is a middle-income country. Though the personal income level in China is continuously growing, the older people in China (mostly retired) do not receive a high pension. Buying expensive assistive technology products, such as electric wheelchairs and hearing aids, can put a huge financial burden on older people. On the other hand, cheap products, such as walking sticks, which do not put much burden on older people, are easily accepted by them.

B. Family/culture issues

China has its own family culture which can affect older people’s adoption of assistive technologies. Older people’s adult children tend to look after their parents or pay for any professional carer to look after their parents. This can be a substitution for some assistive technologies. Travel devices, smart/white canes, personal emergency response systems and hearing aids were mentioned with family and cultural issues. Older people might not need travel devices if their children can ride them in the car. Blind older people might not need white canes when their children can do all chores and grocery shopping for them.

C. Stigma/Social Embarrassment

Stigma/Social embarrassment is one of the most important barriers to older people's adoption of assistive technologies. This was mentioned 8 times during the interview with aged care experts. According to aged care experts, manual wheelchairs, electric wheelchairs, hearing aids, personal emergency response systems and watches (talking/touching) all might cause stigma and social embarrassment. Even if the product assists well for older people's independent living, older people might still refuse to use them when they care about the feeling of being old and embarrassed.

D. Learning Requirement/Technical Support

Many assistive technologies require learning and contain technical components, which need older people to have learning ability, and a support system to ensure the function and correct prescription of the product. Hearing aids, personal response systems, deaf-blind communicator, brailler/braille writing equipment, electric wheelchair, manual wheelchair and hearing aids were mentioned to require learning and technical support. Supporting systems are mentioned in the experts' interviews. For example, a call centre is critical for some personal emergency response systems. A brailler needs the user to learn. a new language. Another important thing included in this factor is the access to professionals who can evaluate and prescribe the correct type of product.

E. Other factors

Other factors include privacy concern, awareness, ease of use, etc.

6.7 CONTRIBUTION TO THEORIES

"Theoretical contribution is a process which is based on the theory development and advancement in existing theory with some logics and facts" (Zhou et al. 2017). Theories involved in this thesis, according to section 2.5, not only guided the author to fulfil the research but also got

extended, modified and organised with new understandings by the research. There were three theories related to the macro-structure, the "Proximate-Determinants Framework", the Demographic Transition Theory and Maslow's Hierarchy of Human Needs. There were six Theories related to aged care, health, and quality of life, which were the Active Ageing Framework, the Ageing in Place Theory, the Successful Aging Theory, the Continuity Theory, the Social Model of Disability and the Activity Theory. There were four frameworks used for assistive technologies, which were the Comprehensive Assistive Technology Model, International Classification of Functioning, Disability and Health, the Matching Person and Technology Model, Human Activity Assistive Technology Model.

Drawing from a range of scholarly findings, the current research has presented a new and more comprehensive understanding of theories that were informative and guided the research to focus on the correct direction. These informative theories were those 6 theories related to aged care, health, and quality of life. They got organised with new understandings in section 6.7.1. The calculation process and results of this research explained the scientific value and practical utility for both scholars and practitioners. Several new theoretical contributions could be noted in the "Proximate-Determinants Framework" and the Socio-technical Theory, providing revelatory knowledge that built on, extended, and enriched research related to aged care and assistive technologies. These contributions were shown in Sections 6.7.2 and 6.7.3.

6.7.1 NEW UNDERSTANDING OF INFORMATIVE THEORIES

Six theories related to aged care, health, and quality of life mentioned different aspects of factors that could improve older people's health and independent living skills, were previously discussed in detail in Sections 2.5.3 and 2.5.4. These similar theories had never been combined together to guide aged care research according to their common value.

The information stressed in these theories could be divided into social aspects and technical aspects. Social aspects included participation, well-being with activities, community environment and involvement, activities of daily living, recreation, continued engagement with life, redefinition of the self and of relationships, more selective and active in social interaction, as well as maintaining the same activities, behaviours, relationships, families' isolation prevention and discrimination prevention (Rowe & Kahn 1997; Atchley 1999; World Health Organization 2002b; Fänge, Oswald & Clemson 2012). Technical aspects included health and security, home modification, preventative healthcare, medical care, to minimise the risk of disease and disability, maintaining physical and cognitive function, better building design and mobility assists to prevent medical problems (Rowe & Kahn 1997; Atchley 1999; World Health Organization 2002b; Fänge, Oswald & Clemson 2012).

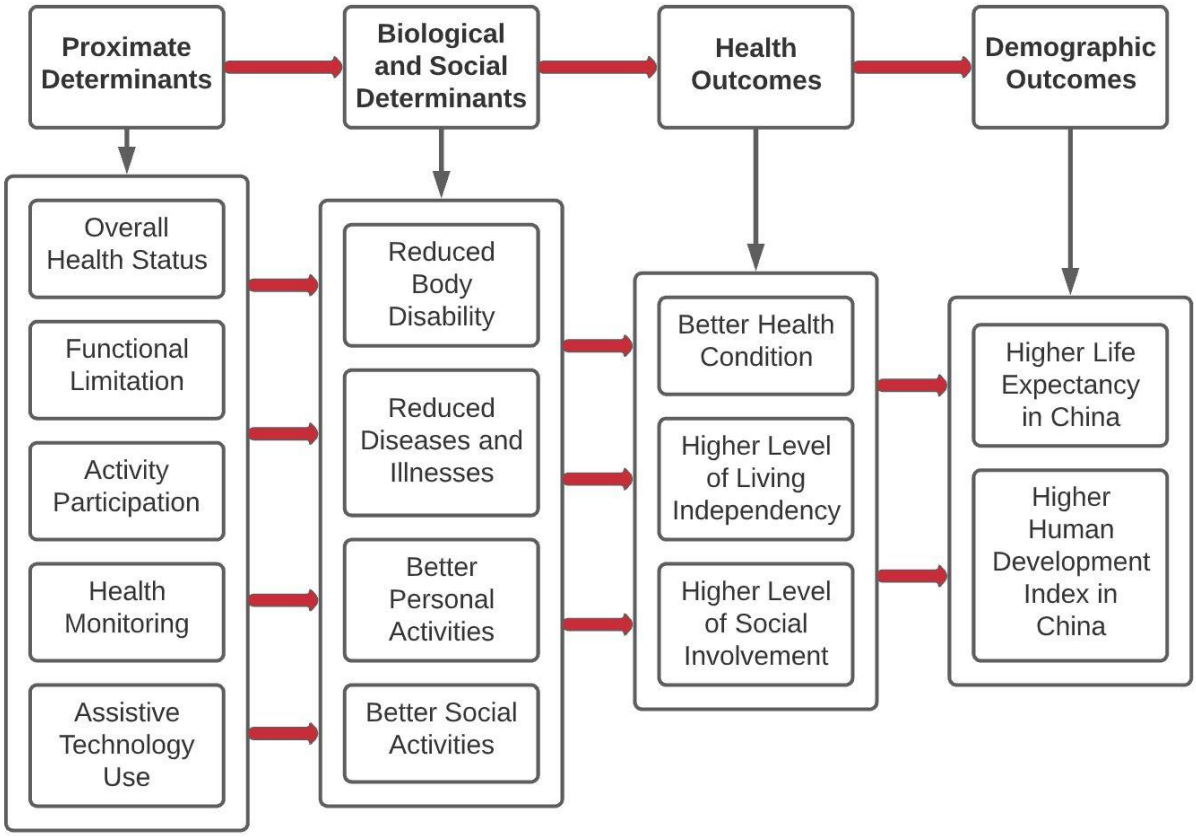
From a practical aspect, the significance of this new understanding was not only to classify their contents but also to notify the information to concern in any research related to older people and aged care, especially when analysing a complex database. By systematically organizing these theories, researchers could be aware that both social issues and technical issues should be the focuses when older people's profiles were to be matched with any type of product.

6.7.2 EXTENDING THE "PROXIMATE-DETERMINANTS FRAMEWORK"

In relation to the "Proximate-Determinants Framework", this was previously discussed in detail in sections 2.5.1 and 2.5.2. For The "Proximate-Determinants Framework", two contributions to existing theory should be noted. First, the research results showed the need for assistive technologies determined by older people's overall health status, functional limitation, activity participation, health monitoring and assistive technology use were chosen for calculation, which were regarded as

proximate determinants in Figure 72. Assistive technology use helped with older people's independence. Thus, the results extended biological determinants in the "Proximate-Determinants Framework" (Boerma & Weir 2005) into biological and social determinants. Second, all elements involved in the calculation results helped to extend the specified determinants under each one of the categories including proximate determinants, biological determinants, health outcomes and demographic outcomes. Access to assistive technologies optimised older people's quality of life by reducing the difficulties brought by disability and diseases, and by better personal and social activities, which were shown as biological and social determinants. These elements were all beneficial for higher life expectancy in China, and furthermore, higher Human Development Index in China which were shown as demographic outcomes in Figure 72. With this contribution, the "Proximate-Determinants Framework" could be applied not only in the analysis and interpretation of risk factors or intervention studies that included both biological and behavioural data, and in ecological studies (Boerma & Weir 2005), but also in aged care research.

Figure 71 - New Extension to Proximate-Determinants Framework



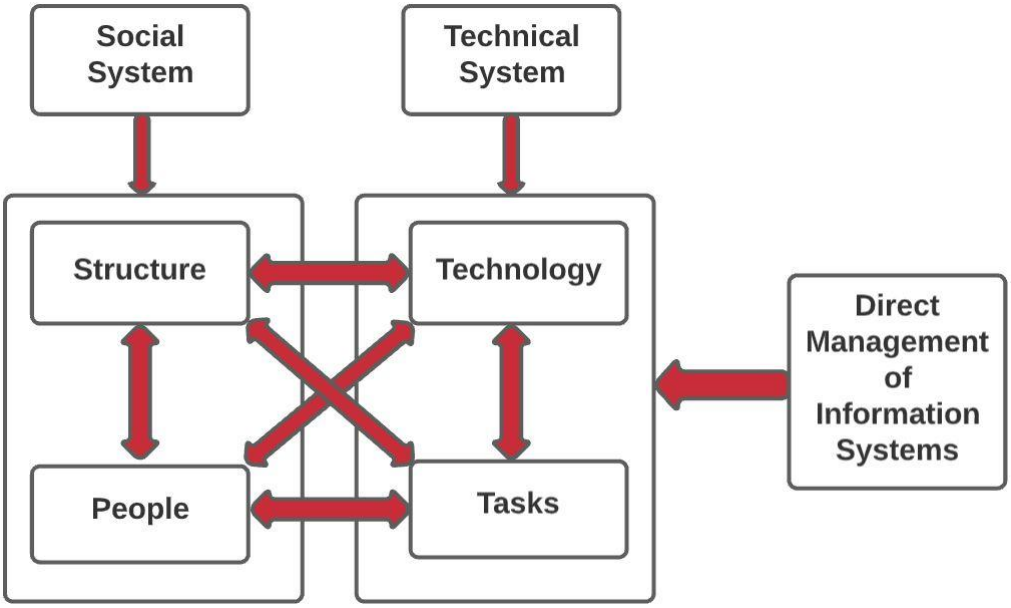
As it is illustrated in above Figure 72, different research can extend different factors under determinants and outcomes within the "Proximate-Determinants Framework". This research, for the first time, extended the "Proximate-Determinants Framework" with factors and elements about aged care and assistive technology use. This process well illustrated the logic of how assistive technology use optimised and lead to higher quality of life and higher life expectancy.

6.7.3 MODIFYING AND EXTENDING THE SOCIO-TECHNICAL THEORY

The Socio-technical Theory, which was previously discussed in detail in sections 2.5.7 and 2.5.8, was first used for joint optimization, with a shared emphasis on the achievement of both excellence in technical performance and quality in people's work lives (Militello et al. 2014). Sociotechnical theory, as distinct from sociotechnical systems, proposes a

number of different ways of achieving joint optimisation (Tetiana & Yuliya 2019). The technical system is concerned with the processes, tasks, and technology needed to transform inputs such as raw materials to outputs such as products; the social system is concerned with the relationships among people and their attitudes, skills, and values (Xiang, Archer & Detlor 2014). The relationship among full components can be illustrated in Figure 73.

Figure 72 - Interacting Components in Socio-technical Theory

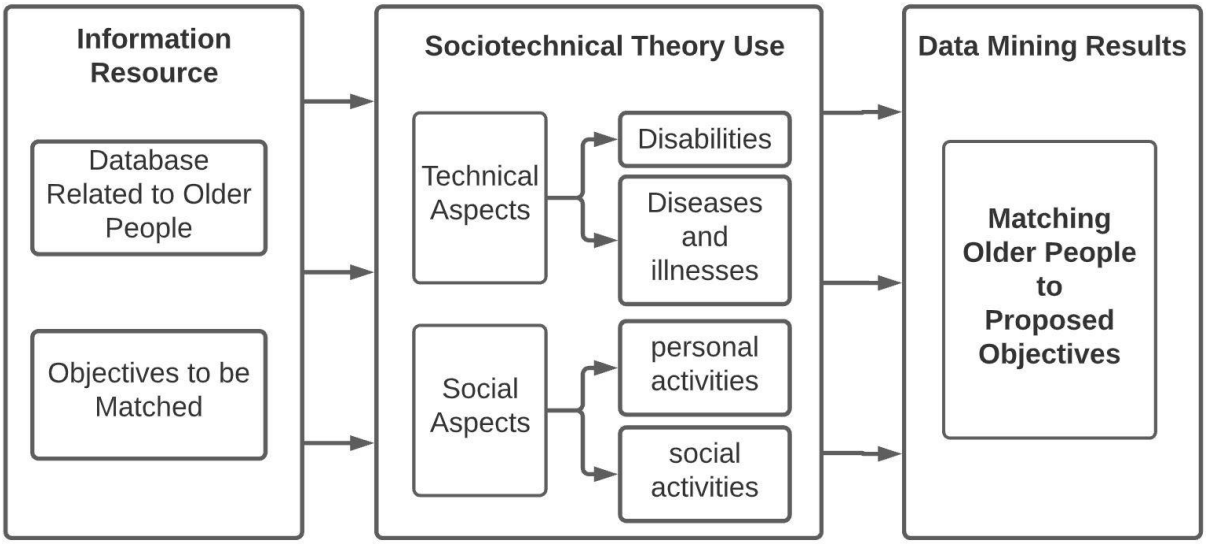


(Bostrom & Heinen 1977)

This study provided revelatory advances to the Socio-technical Theory in three ways. First, it modified the correlation between the structure, people, technology and tasks. The research formed a social system and technical system in a relatively separate way for the research that does data analysing through a broad range of variables. As it was shown in Figure 74, Social aspects and technical aspects separately functioned in the data analysis process, which made the researcher manipulate different types of data systematically from the information source. Second, not as a tool to reach an optimization in an organization (Bostrom & Heinen 1977), the Socio-technical system in this research was placed in the middle of a data analysing process, which aimed to extract

information from a database and match older people's profile with proposed objectives. Third, the research specified what new sub-elements should be under the social system and the technical system. In the technical system, disabilities, diseases and illnesses were defined. In the social system, personal activities and social activities were defined.

Figure 73 - Modified Interacting Components in Socio-technical Theory



The above Figure 74 showed the modified interacting components in Socio-technical Theory that can guide further research and data analysing related to aged care. The theoretical contribution, for the first time, found the applicability of socio-technical theory in detecting older people's needs for assistive technologies. Starting from this application, for any research related to matching older people's profiles with some other objectives (such as other types of assistive technologies or other aged care-related products), especially analysing the data from a complex database with a broad range of data and various metrics, the following modified framework could guide the research working flow. This helped to match every variable related to older people's technical aspects and social aspects with the information or needs of proposed objectives.

6.7.4 THE ALIGNMENT OF THEORETICAL CONTRIBUTION AND RESEARCH QUESTIONS

The following Table 37 listed how the researcher aligned the earlier parts of the thesis to show the contribution to the theory.

Table 37 - The Alignment of Theoretical Contribution and Research Questions

Research Questions	Emerging Themes	Data Matched to Emerging Themes	Contributions to Theory
RQ1 - What theoretical framework provides a method to best explore the user needs identified in the CHARLS data?	Frameworks Used for Assistive Technologies: The Comprehensive Assistive Technology Model (Hersh & Johnson 2008) International Classification of Functioning, Disability and Health (World Health Organization 2002a) Human Activity Assistive Technology Model (Cook & Hussey 2002) The Matching Person and Technology Model (Scherer & Craddock 2002)	All existing frameworks used for assistive technologies failed to fit the CHARLS Database. But a creative use of Sociotechnical Theory can fit. It views an organization as a work system with two interrelated subsystems: the technical system and the social system (Bostrom & Heinen 1977).	**Findings' contribution to theory:** Any Database similar to the CHARLS Database, which contains a broad range of data and various metrics, can be analysed using Sociotechnical Theory **Theory's contribution to findings** Sociotechnical Theory was for the first time used against the CHARLS Database by analysing older people's body disability, disease and illness, personal activity and social activity. Sociotechnical Theory helps to indirectly detect older people's needs by analysing a database.
RQ2.1 - What are older people's profiles regarding general health, disease and illness, functional limitation,	Information about older people's general health, disease and illness, functional limitation, assistive technology use, and personal and social activities.	Corresponded questions in the CHARLS Database Questionnaire related to older people's general health, disease and illness, functional limitation, assistive	**Findings' contribution to theory:** Older people's profiles are the bases to determine their needs for assistive technologies. Assistive technologies help with higher quality of life and independent living skills. This is a process from biological

assistive technology use, and personal and social activities?	The Proximate-Determinants Framework (Boerma & Weir 2005)	technology use, and personal and social activities	determinants to health outcomes and finally to demographic outcomes, which is a practice of the Proximate-Determinants Framework. **Theory's contribution to findings:** In the Proximate-Determinants Framework, researchers must determine biological determinants before reaching to demographic outcome and health outcome. This chapter is the presentation and description of biological determinants, which is a process based on the Proximate-Determinants Framework development.
RQ2.2 - What are the unmet needs and urgent unmet needs for assistive technologies that have users' statistics in the CHARLS Database?	Among 25 selected assistive technologies, 8 of them have users' statistics in the CHARLS Database, 17 of them do not have users' statistics in the CHARLS Database. The condition of use of 25 selected assistive technologies	Corresponded questions in the CHARLS Database Questionnaire related to older people's body disability, disease and illness, personal activity and social activity that match the condition of use of each selected assistive technology. The Sociotechnical Theory guided	**Findings' contribution to theory:** Matching older people's needs to assistive technologies helped to optimise older people's health status, independence skills, social involvement and assisted with older people's disability and functional limitation. All above illustrated issues are in accordance with the Active Aging Framework, the Ageing in Place Theory, the Successful Aging Theory, the Continuity Theory, the Social Model of Disability and the Activity Theory, which
RQ2.3 - What are the total needs and urgent total needs	Unmet needs and urgent unmet needs for 8 assistive technologies that have users'		

for assistive technologies that do not have users' statistics in the CHARLS Database?	statistics in the CHARLS Database Total needs and urgent total unmet needs for 17 assistive technologies that do not have users' statistics in the CHARLS Database	the choose of corresponded questions	suggested enhanced independence in everyday life and continuous engagement with family members and the community (Rowe & Kahn 1997; Atchley 1999; World Health Organization 2002b; Fänge, Oswald & Clemson 2012) **Theory's contribution to findings:** Active Aging Framework, the Ageing in Place Theory, the Successful Aging Theory, the Continuity Theory, the Social Model of Disability and the Activity Theory all contain social aspects and technical aspects (Rowe & Kahn 1997; Atchley 1999; World Health Organization 2002b; Fänge, Oswald & Clemson 2012). They guided the researcher to turn to sociotechnical theory to detect older people's needs and unmet needs indirectly.
RQ2.4 - What differentiation exists with respect to users and users' needs (both unmet needs and total needs) between gender and age?			
RQ3 - What opportunities exist for assistive technologies to assist older people with	Any possible causes of previously revealed unmet needs, urgent unmet needs, total needs, and urgent total needs.	Calculation results of unmet needs, urgent unmet needs, total needs, and urgent total needs of assistive technologies generated in previous chapters.	**Findings' contribution to theory:** Optimising the provision of assistive technology can result in older people's outcome and further lead to better demographic outcomes. This is the general logic of the Proximate-Determinants

healthcare and independent living?	Discussion of the needs illustrated above and the indication to assistive technology and aged care industry.	Gender and age group differentiation regarding the needs illustrated above. Interviewing with aged care experts.	Framework (Boerma & Weir 2005). Growing opportunities surely rely on the growing number of older people, which is proofed and predicted by Demographic Transition Theory. **Theory's contribution to findings:** Older people's better healthcare and better independent living refer to better demographic outcomes in the Proximate-Determinants Framework. Assistive technologies help with better health outcome, which further lead to better demographic outcomes.

6.8 CONCLUSION OF THE RESEARCH

The conclusion is the combination of the answers to research questions.

The answer to research question 1 was about the theoretical framework used in this research that provided a method to best explore the user needs identified in the CHARLS data. This framework was the Sociotechnical Framework. The contribution of this thesis could be described into two aspects. The first aspect was the contribution to a broad set of new results, including the total needs, unmet needs of assistive technologies as well as their gender and age group differentiation. The second aspect was the contribution of manipulating a database in a creative way, which was to use sociotechnical theory to indirectly extract the results of assistive technology needs. The sociotechnical theory, which was originally used as an analysis tool for organizational efficiency and optimization, was creatively used here to guide the research with a systematic way to extract information related to the research question from CHARLS Database. Analysing older people's needs for assistive technologies had great significance for both assistive technology developers and providers. The creative use of sociotechnical theory in this research could be further applied to many other similar data resources, which included a broad range of data collection and various metrics, but not specifically designed for assistive technologies. On the other hand, along with the development of assistive technology products, there would be more and more emerging new devices which needed this kind of analysis. Moreover, this could be used in different countries where there was no information on assistive technology needs analysis. There are ample databases investigating older people's health conditions, activities and family relationships. For example, US Health and Retirement Study (HRS), English Longitudinal Survey of Aging (ELSA), the Survey of Health, Aging and Retirement in Europe (SHARE), Japanese Study of Aging and Retirement (JSTAR), the Longitudinal Aging Survey of India (LASI), the Indonesia Family Life Survey (IFLS) and the Korean

Longitudinal Survey of Aging (KLoSA), which are conducted in different countries, can be available for further research using sociotechnical theory in this research.

The answer to research question 2.1 was about older people's profiles regarding general health, disease and illness, functional limitation, assistive technology use, and personal and social activities. Chinese older people's health status faces some challenges. Hypertension, Dyslipidaemia, Arthritis or Rheumatism were the most common chronic diseases that they suffer from. Sensory disabilities, such as vision and hearing problems, were the most common disabilities. The occurrence of intellectual disabilities was higher than physical disabilities. Lung cancer, stomach cancer, colon or rectum cancer had the highest occurrence. Most of older people had a fair or poor vision and hearing ability. A few of the older people had lost all their teeth. Many older people suffered from body pain. Specifically, knee pain and waist pain were the most common. Some older people in China suffered from functional limitations, especially the limitation of mobility, including running, walking and climbing.

The answer to research question 2.2 was about the unmet needs and urgent unmet needs for 8 assistive technologies that had users' statistics in the CHARLS Database. Ranking these unmet needs from high percentage to low percentage, the result was: hearing aids, corrective lenses and glasses, walking sticks, toilet series, catheter and urine collecting bags, manual wheelchair, travel devices, and electric wheelchairs.

The answer to research question 2.3 was about the total needs and urgent total needs for 17 assistive technologies that did not have users' statistics in the CHARLS Database. Ranking these total needs from high percentage to low percentage, the result was: alarm signallers with light/sound/vibration, grasping tools or reach extenders, personal emergency response system, handrail and grab bar, watches (talking/touching), electrotherapy device for pain, time management

products, smart/white canes, shower chairs, smart pillbox/pill organisers, pressure relief mattresses, therapeutic footwear, glucometer, talking blood pressure monitor, braille writing equipment/braillers, ramp, portable, deafblind communicators.

The answer to research question 3 was about opportunities that existed for assistive technologies to assist older people with healthcare and independent living. Those assistive technologies with high rankings in unmet needs should be put in the priority place in strengthening the provision of the product itself and the supporting system/professionals related to the product, in managing the awareness, attitude and adoption of older people, or in healthcare system rebate. These assistive technologies were: hearing aids, electric wheelchairs, catheters and urine collecting bags. Those assistive technologies with high rankings in total needs should be put in the priority place in technology development, they were: alarm signallers with light/sound/vibration, grasping tools or reach extenders, personal emergency response system, handrails and grab bars, watches, talking/touching, electrotherapy device for pain, and time management products.

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8. APPENDICES

8.1 QUESTIONS INCLUDED IN THIS THESIS FROM THE CHARLS DATABASE

BD001_W2_4 What's the highest level of education you have now (not including adult education)?

1. No formal education (illiterate)
2. Did not finish primary school
3. Sishu/home school
4. Elementary school
5. Middle school
6. High school
7. Vocational school
8. Two-/Three-Year College/Associate degree
9. Four-Year College/Bachelor's degree
10. Master's degree
11. Doctoral degree/Ph.D.

BD007_W2_1 Have you attended school for adult education? (Choose all that apply)

1. None
2. TV University
3. Night School
4. Zikao (examinations for self-taught students)
5. Hanshou/Correspondence course/Distance learning
6. Literacy course
7. Accelerated education course
8. Other

DA002 Next, I have some questions about your health. Would you say your health is very good, good, fair, poor or very poor?

1. Very good
2. Good

3. Fair

4. Poor

5. Very poor

997 Don’t know

DA005[1] Do you have physical disabilities?

1. Yes

2. No

DA005[2] Do you have brain damage/intellectual disability?

1. Yes

2. No

DA005[3] Do you have vision problem?

1. Yes

2. No

DA005[4] Do you have hearing problem?

1. Yes

2. No

DA005[5] Do you have speech impediment?

1. Yes

2. No

DA007_1_ Have you been diagnosed with Hypertension by a doctor?

1. Yes

2. No

DA007_2_ Have you been diagnosed with Dyslipidaemia (elevation of low density lipoprotein, triglycerides (TGs), and total cholesterol, or a low high density lipoprotein level) by a doctor?

1. Yes

2. No

DA007_3_ Have you been diagnosed with Diabetes or high blood sugar by a doctor?

1. Yes

2. No

DA007_4_ Have you been diagnosed with Cancer or malignant tumour (excluding minor skin cancers) by a doctor?

1. Yes

2. No

DA007_5_ Have you been diagnosed with Chronic lung diseases, such as chronic bronchitis, emphysema (excluding tumours, or cancer) by a doctor?

1. Yes

2. No

DA007_6_ Have you been diagnosed with Liver disease (except fatty liver, tumours, and cancer) by a doctor?

1. Yes

2. No

DA007_7_ Have you been diagnosed with Heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems by a doctor?

1. Yes

2. No

DA007_8_ Have you been diagnosed with Stroke by a doctor?

1. Yes

2. No

DA007_9_ Have you been diagnosed with Kidney disease (except for tumour or cancer) by a doctor?

1. Yes

2. No

DA007_10_ Have you been diagnosed with Stomach or other digestive diseases (except for tumour or cancer) by a doctor

1. Yes

2. No

DA007_11_ Have you been diagnosed with Emotional, nervous, or psychiatric problems by a doctor?

1. Yes

2. No

DA007_12_ Have you been diagnosed with Memory-related disease (such as dementia, brain atrophy, and Parkinson’s disease) by a doctor?

1. Yes

2. No

DA007_13_ Have you been diagnosed with Arthritis or rheumatism by a doctor?

1. Yes

2. No

DA007_14_ Have you been diagnosed with Asthma by a doctor?

1. Yes

2. No

DA008_W2_1 How did you know that you had had [preload disease], through routine or CHARLS physical examination, or any other?

1. Physical examination after had attack
2. Physical examination after had ill
3. Physical examination organized by work unit
4. Physical examination organized by community
5. CHARLS physical examination CHARLS
6. Other, please specify

DA017 In which organ or part of your body do you have cancer? Including the origins and metastasis of tumour (check all that apply)

1. Brain
2. Oral cavity
3. Larynx
4. Other pharynx
5. Thyroid
6. Lung
7. Breast
8. Oesophagus
9. Stomach
10. Liver
11. Pancreas
12. Kidney
13. Prostate
14. Testicle
15. Ovary
16. Cervix
17. Endometrium
18. Colon or rectum
19. Bladder
20. Skin

21. Non-Hodgkin lymphoma

22. Leukaemia

23. Other organ

DA018_W4 Have you taken any of the following treatments to treat your cancer or relieve

its/their symptoms (e.g., pain, nausea, etc.) in the past two years? (Check all that apply)

Taking Chinese traditional medicine, taking Western modern medicine, chemotherapy,

surgery, radiation therapy?

1. Taking Chinese traditional medicine

2. Taking Western modern medicine

3. Chemotherapy

4. Surgery

5. Radiation therapy

6. Other treatments, please specify

7. None of the above

DA023 Have you fallen down?

1. Yes

2. No

DA023_W4 Have you fallen down since we talked last time?

1. Yes

2. No

DA025 Have you ever fractured your hip?

1. Yes

2. No

DA025_W4 Have you fractured your hip since we talked last time?

1. Yes

2. No

DA032Now I have some questions about your eyesight. Do you usually wear glasses or corrective lenses?

1. Yes

2. Legally Blind

3. No

4. Sometimes

DA033 How good is your eyesight for seeing things at a distance, like recognizing a friend from across the street (with glasses or corrective lenses if you wear them)? Would you say your eyesight for seeing things at a distance is excellent, very good, good, fair, or poor?

1. Excellent

2. Very good

3. Good

4. Fair

5. Poor

997 Do not know

DA034 How good is your eyesight for seeing things up close, like reading ordinary newspaper print (with glasses or corrective lenses if you wear them)? Would you say your eyesight for seeing things up close is excellent, very good, good, fair, or poor?

1. Excellent

2. Very good

3. Good

4. Fair

5. Poor

997 Do not know

DA037 Has a doctor/nurse/paramedical/doctor of traditional Chinese medicine doctor ever treated you for glaucoma?

1. Yes

2. No

DA037_W2 You told us you had glaucoma, has a doctor/nurse/paramedical/ doctor of traditional Chinese medicine doctor ever treated you for glaucoma relapses since last wave

1. Yes

2. No

3. Never had glaucoma

DA039 Is your hearing very good, good, fair, poor, or very poor (with a hearing aid if you normally use it and without if you normally don't)? Would you say your hearing is excellent, very good, good, fair, or poor?

1. Excellent

2. Very good

3. Good

4. Fair

5. Poor

997 Do not know

DA040 Have you lost all of your teeth?

1. Yes

2. No

DA040_W4_1 Do you wear dentures?

1. Yes

2. No

DA041_W4 Are you often troubled with any body pains

1. None

2. A little

3. Somewhat

4. Quite a bit

5. Very much

DA042 On what part of your body do you feel pain? Please list all parts of body you are currently feeling pain.

1. Head (Headache)

2. Shoulder

3. Arm

4. Wrist

5. Fingers

6. Chest

7. Stomach (Stomach-ache)

8. Back

9. Waist

10. Buttocks

11. Leg

12. Knees

13. Ankle

14. Toes

15. Neck

16. Other

DA042_W2_1 Are you taking measures to reduce the pain? (Check all that apply)

1. Taking Chinese traditional medicine

2. Taking Western modern medicine

3. Acupuncture treatment

4. Professional massage therapy

5. Other treatments, please specify

6. None of the above

DA048 How would you evaluate your health during childhood, up to and including age 15? Excellent, very good, good, fair, poor?

1. Excellent

2. Very good

3. Good

4. Fair

5. Poor

997 Do not know

DA049 During the past month, how many hours of actual sleep did you get at night (average hours for one night)? (This may be shorter than the number of hours you spend in bed.)

_____Hours (0-24)

DA051 Please recall the [preload the type of physical activity] that you have taken part in for at least 10 minutes every time in a week. Do you usually take this type of activity for at least 10 minutes every week?

1. Yes

2. No

DA051_1 What's the purpose for doing these physical activities, for entertainment, job demand

or exercise in doing these physical activities?

1. Job demands

2. Entertainments

3. Exercise

4. other

DA052 How many days a week do you take part in [preload the type of physical activity] for at least 10 minutes?

_____Days (1-7)

DA053 During the days you take part in [preload the type of physical activity], how long do you do [preload the type of physical activity] every day?

1. < 2 hours

2. ≥ 2 hours

DA054 During the days you take part in [preload the type of physical activity], how long do you do [preload the type of physical activity] every day?

1. < 30 minutes

2. ≥ 30 minutes

DA056 Have you done any of these activities in the last month? (Check all that apply)

1. Interacted with friends

2. Played Ma-Jong, played chess, played cards, or went to community club

3. Provided help to family, friends, or neighbours who do not live with you

4. Went to a sport, social, or other kind of club

5. Took part in a community-related organization

6. Done voluntary or charity work

7. Cared for a sick or disabled adult who does not live with you

8. Attended an educational or training course

9. Stock investment

10. Used the Internet

11. Other

12. None of these

DB001 Do you have any difficulty with running or jogging about 1 Km?

1. No, I don’t have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB002 Do you have difficulty with walking 1 km?

1. No, I don’t have any difficulty
2. I have difficulty but can still do it
3. Yes, I have difficulty and need help
4. I cannot do it

DB003 Do you have difficulty with walking 100 metres?

1. No, I don’t have any difficulty
2. I have difficulty but can still do it
3. Yes, I have difficulty and need help
4. I cannot do it

DB004 Do you have difficulty with getting up from a chair after sitting for a long period?

1. No, I don’t have any difficulty
2. I have difficulty but can still do it
3. Yes, I have difficulty and need help
4. I cannot do it

DB005 Do you have difficulty with climbing several flights of stairs without resting?

1. No, I don’t have any difficulty
2. I have difficulty but can still do it
3. Yes, I have difficulty and need help
4. I cannot do it

DB006 Do you have difficulty with stooping, kneeling, or crouching?

1. No, I don’t have any difficulty
2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB007 Do you have difficulty with reaching or extending your arms above shoulder level? (he/she is regarded as not having difficulty only if he/she can extend both of his/her arms, otherwise he/she is regarded as having difficulty.)

1. No, I don't have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB008 Do you have difficulty with lifting or carrying weights over 10 jin (5kg), like a heavy bag of groceries?

1. No, I don't have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB009 Do you have difficulty with picking up a small coin from a table?

1. No, I don't have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB010 Because of health and memory problems, do you have any difficulty with dressing? Dressing includes taking clothes out from a closet, putting them on, buttoning up, and fastening a belt.

1. No, I don't have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB011 Because of health and memory problems, do you have any difficulty with bathing or showering?

1. No, I don’t have any difficulty
2. I have difficulty but can still do it
3. Yes, I have difficulty and need help
4. I cannot do it

DB012 Because of health and memory problems, do you have any difficulty with eating, such as cutting up your food? (Definition: By eating, we mean eating food by oneself when it is ready)

1. No, I don’t have any difficulty
2. I have difficulty but can still do it
3. Yes, I have difficulty and need help
4. I cannot do it

DB013 Do you have any difficulty with getting into or out of bed?

1. No, I don’t have any difficulty
2. I have difficulty but can still do it
3. Yes, I have difficulty and need help
4. I cannot do it

DB014 Because of health and memory problems, do you have any difficulties with using the toilet, including getting up and down?

1. No, I don’t have any difficulty
2. I have difficulty but can still do it
3. Yes, I have difficulty and need help
4. I cannot do it

DB015 Because of health and memory problems, do you have any difficulties with controlling urination and defecation? If you use a catheter (conduit) or a pouch by yourself, then you are not considered to have difficulties.

1. No, I don’t have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB016 Because of health and memory problems, do you have any difficulties with doing household chores? (Definition: By doing household chores, we mean house cleaning, doing dishes, making the bed, and arranging the house)

1. No, I don't have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB017 Because of health and memory problems, do you have any difficulties with preparing hot meals? (Definition: By preparing hot meals, we mean preparing ingredients, cooking and serving food)

1. No, I don't have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB018 Because of health and memory problems, do you have any difficulties with shopping for groceries? By shopping, we mean deciding what to buy and paying for it.

1. No, I don't have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB020 Because of health and memory problems, do you have any difficulties with taking medications? By taking medications, we mean taking the right portion of medication right on time.

1. No, I don't have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DB029 Do you use the following auxiliary? (Check all that apply)

1. Walking stick

2. Travel device

3. Manual wheelchair

4. Electric Wheelchair

5. Catheter, urine collection bag

6. Toilet Series

7. None of the above

DB035 Because of health and memory problems, do you have any difficulties with making phone calls?

1. No, I don’t have any difficulty

2. I have difficulty but can still do it

3. Yes, I have difficulty and need help

4. I cannot do it

DC028_W4_1 Please record reasons for refusal

1. Refused or unwilling to

2. Cannot speak in whole life

3. Cannot speak when getting old

4. Deaf or poor hearing

5. Other

DC039_W4_1 Please record reasons for not completing this test

1. Refused or unwilling to

2. Cannot speak in whole life

3. Cannot speak when getting old

4. Deaf or poor hearing

5. Other

DC068_W4 Does any of the following happen during the interview?

1. Poor eyesight

2. Poor hearing without hearing-aid

3. Wearing hearing-aid

4. Shaking hands

5. The interview is interrupted by some stuff or noises

6. The quality of the interview is doubted due to some emotional problems

7. Others, please specify

8. None

DD008_W4 Has [Respondent] been diagnosed with stroke?

1. Yes

2. No

9. Do not know

DD009_W4 Has [Respondent] been diagnosed with Parkinson’s disease?

1. Yes

2. No

9. Do not know

DD010_W4 Has [Respondent] been diagnosed with Alzheimer’s disease?

1. Yes

2. No

9. Do not know

DD011_W4 Has [Respondent] been diagnosed with memory problems?

1. Yes

2. No

9. Do not know

DD040_W4 Regarding using the toilet, would you say the respondent can clean and care for (himself/ herself) at a toilet, has occasional incontinence or needs to be reminded, has frequent incontinence or needs much assistance, or has little or no control?

1. Clean, cares for self at toilet
2. Occasional incontinence, or needs to be reminded
3. Frequent incontinence, or needs much assistance
4. Little or no control
8. Do not know
9. Refuse to answer

EH007_W3 Are you satisfied with the quality, cost and convenience of local medical services? Choose from very satisfied, somewhat satisfied, neutral, somewhat dissatisfied and very dissatisfied.

1. Very satisfied
2. Somewhat satisfied
3. Neutral
4. Somewhat dissatisfied
5. Very dissatisfied

I009 Does it have elevator?

1. Yes
2. No

I011 How many steps had to be climbed to get to the main entrance of the household’s flat?

1. 0 step
2. 1 to 5 steps
3. 6 to 15 steps
4. 16 to 25 steps
5. More than 25 steps

I013 How far is the nearest toilet to your house?

_____Meters

I014 What is the type of toilet? Is it with or without a seat? If the respondent has both, select “toilet with a seat”

1. Toilet without a seat

2. Toilet with a seat

(National School of Development of Peking University & Institute of Social Science Survey of Peking University, 2020)

8.2 OLDER PEOPLE'S NEEDS IN SPECIFIC CATEGORIES

Category	Sub-Category	References for Articles Mentioned	Frequency
Independent Living (Total Frequency is 95) (40% of the total concern)	Automatic Control Technology for Home Appliance	(García-Soler et al. 2018), (Kamei et al. 2015), (Thoma-Lürken et al. 2018), (Peek et al. 2016), (Boman, Persson & Bartfai 2016), (Orellano-Colon et al. 2018), (Kamilaris, Kondepudi & Danial 2016), (Lee, Lim & Lee 2015), (Mayer, GÜLdenpfennig & Panek 2019), (Bedaf et al. 2018)	10
	Gardening/Farming Assistance	(Casten, Rovner & Fontenot 2016), (O'Connell et al. 2018)	2
	Smart Cooking/kitchen Technology	(Casten, Rovner & Fontenot 2016), (García-Soler et al. 2018), (Nasr et al. 2016), (Thoma-Lürken et al. 2018), (Jiancaro, Jaglal & Mihailidis 2017), (Egan & Pot 2016), (Boman, Persson & Bartfai 2016), (Löfqvist et al. 2016), (Jännes et al. 2015), (Orellano-Colon et al. 2018), (Kamilaris, Kondepudi & Danial 2016), (O'Connell et al. 2018)	12
	Toilet Use Assistance	(Thoma-Lürken et al. 2018), (Jiancaro, Jaglal & Mihailidis 2017), (Egan & Pot 2016), (Boman, Persson & Bartfai 2016),	9

	(Löfqvist et al. 2016), (Jännes et al. 2015), (Orellano-Colon et al. 2018), (Mayer, GÜLdenpfennig & Panek 2019), (O'Connell et al. 2018)	
Cleaning and Laundry Assistance	(García-Soler et al. 2018), (Thoma-Lürken et al. 2018), (Jiancaro, Jaglal & Mihailidis 2017), (Egan & Pot 2016), (Boman, Persson & Bartfai 2016), (Löfqvist et al. 2016), (Callari et al. 2019), (Orellano-Colon et al. 2018), (Kamilaris, Kondepudi & Danial 2016), (O'Connell et al. 2018)	10
Reaching and Grasping Technology	(García-Soler et al. 2018), (Kamei et al. 2015), (Nasr et al. 2016), (Peek et al. 2016), (Jiancaro, Jaglal & Mihailidis 2017), (Egan & Pot 2016), (Löfqvist et al. 2016), (Orellano-Colon et al. 2018), (O'Connell et al. 2018), (Bedaf et al. 2018)	10
Showering Assistance	(García-Soler et al. 2018), (Kamei et al. 2015), (Nasr et al. 2016), (Jiancaro, Jaglal & Mihailidis 2017), (Egan & Pot 2016), (Boman, Persson & Bartfai 2016), (Löfqvist et al. 2016), (Jännes et al. 2015), (Orellano-Colon et al. 2018), (O'Connell et al. 2018)	10
Dressing Assistance	(García-Soler et al. 2018), (Thoma-Lürken et al. 2018), (Jiancaro, Jaglal & Mihailidis 2017), (Egan & Pot 2016),	8

		(Boman, Persson & Bartfai 2016), (Löfqvist et al. 2016), (Orellano-Colon et al. 2018), (O'Connell et al. 2018)	
	Walking and Mobility Assistance	(García-Soler et al. 2018), (Kamei et al. 2015), (Nasr et al. 2016), (Andrews et al. 2019), (Thoma-Lürken et al. 2018), (Peek et al. 2016), (Jiancaro, Jaglal & Mihailidis 2017), (Egan & Pot 2016), (Löfqvist et al. 2016), (Orellano-Colón et al. 2017), (Smaerup et al. 2017), (Callari et al. 2019), (Orellano-Colon et al. 2018), (Mayer, GÜLdenpfennig & Panek 2019), (Meristö 2018), (O'Connell et al. 2018)	16
	Eating Reminder and Assistance	(Thoma-Lürken et al. 2018), (Jiancaro, Jaglal & Mihailidis 2017), (Egan & Pot 2016), (Boman, Persson & Bartfai 2016), (O'Connell et al. 2018)	5
	Item Locating System	(Thoma-Lürken et al. 2018), (Boman, Persson & Bartfai 2016), (Kamilaris, Kondepudi & Danial 2016)	3
Safety (Total Frequency is 37)	Overall Sense of Safety	(Orellano-Colón et al. 2017), (Lee, Lim & Lee 2015), (Nguyen et al. 2015), (Karlsen et al. 2017), (Mattie et al. 2016)	5
	Falling prevention	(García-Soler et al. 2018), (Kamei et al. 2015), (Thoma-Lürken et al. 2018), (Boman, Persson & Bartfai 2016),	7

		(Doughty & Williams 2016), (Callari et al. 2019), (Mayer, GÜLdenpfennig & Panek 2019)	
(16% of the total concern)	Reminder for Declined Memory	(Thoma-Lürken et al. 2018), (Saracchini, Catalina & Bordoni 2015), (Orellano-Colon et al. 2018), (Kamilaris, Kondepudi & Danial 2016), (Meristö 2018), (Bedaf et al. 2018)	6
	Home/Location Finding Technology	(Thoma-Lürken et al. 2018), (Egan & Pot 2016), (Boman, Persson & Bartfai 2016), (Saracchini, Catalina & Bordoni 2015), (Doughty & Williams 2016), (Callari et al. 2019)	6
	Technology of Emergency Response/Warning about Potential Hazards	(Jiancaro, Jaglal & Mihailidis 2017), (Jännes et al. 2015), (Saracchini, Catalina & Bordoni 2015), (Doughty & Williams 2016), (Callari et al. 2019), (Orellano-Colon et al. 2018), (D'Onofrio et al. 2019), (Mayer, GÜLdenpfennig & Panek 2019)	8
	Gas Leakage Detector	(Jännes et al. 2015), (Lee, Lim & Lee 2015)	2
	Transportation Assistance	(Peek et al. 2016), (Egan & Pot 2016), (Orellano-Colon et al. 2018)	3

Health **(Total Frequency is 36)** **(15% of the total concern)**	Sight/Vision Assistance Technology	(Casten, Rovner & Fontenot 2016), (García-Soler et al. 2018), (Peek et al. 2016), (Egan & Pot 2016), (Boman, Persson & Bartfai 2016), (Orellano-Colon et al. 2018), (Meristö 2018), (O'Connell et al. 2018), (Kim 2019)	9
	Long-term Pain Management	(Burrows, Gooberman-Hill & Coyle 2015), (Callari et al. 2019)	2
	Rehabilitation Management	(Nasr et al. 2016)	1
	Mood Recording/Management Technology	(Andrews et al. 2019), (Jiancaro, Jaglal & Mihailidis 2017), (D'Onofrio et al. 2019), (Lee, Lim & Lee 2015), (O'Connell et al. 2018)	5
	Medication Reminder/Treatment	(García-Soler et al. 2018), (Andrews et al. 2019), (Thoma-Lürken et al. 2018), (Boman, Persson & Bartfai 2016), (Orellano-Colon et al. 2018), (Kamilaris, Kondepudi & Danial 2016), (Lee, Lim & Lee 2015), (O'Connell et al. 2018)	8
	General Health Monitoring Technology	(Peek et al. 2016), (Egan & Pot 2016), (Boman, Persson & Bartfai 2016), (Lee, Lim & Lee 2015), (Mayer, GÜLdenpfennig & Panek 2019)	5

	Cognitive Ability Assistance Technology	(Egan & Pot 2016), (Boman, Persson & Bartfai 2016), (D'Onofrio et al. 2019), (Meristö 2018), (O'Connell et al. 2018)	5
	Nurse Call System	(Lee, Lim & Lee 2015)	1
Family Relationship and Social Involvement (Total Frequency is 26)	Finance Managing Assistance	(Casten, Rovner & Fontenot 2016), (Thoma-Lürken et al. 2018)	2
	Appointment/Issue Reminding Technology	(García-Soler et al. 2018), (Thoma-Lürken et al. 2018), (Peek et al. 2016), (Boman, Persson & Bartfai 2016), (Saracchini, Catalina & Bordoni 2015)	5
	Shopping Assistance/Delivery	(García-Soler et al. 2018), (Thoma-Lürken et al. 2018), (Boman, Persson & Bartfai 2016), (Orellano-Colon et al. 2018), (D'Onofrio et al. 2019)	5
	Video Call System	(Lee, Lim & Lee 2015)	1
	Assistance of Social Contacts with Family	(Thoma-Lürken et al. 2018), (Egan & Pot 2016), (Löfqvist et al. 2016), (D'Onofrio et al. 2019), (Lee, Lim & Lee 2015), (Chang, Lu & Yang 2018), (Meristö 2018), (O'Connell et al.	12

(11% of the total concern)	member/Other People	2018), (Nguyen et al. 2015), (Kim 2019), (Chu et al. 2017), (Ku 2018)	
	Relative Recognizing Technology	(Thoma-Lürken et al. 2018)	1
Leisure (Total Frequency is 24) (10% of the total concern)	General Recreational/Entertainment Technology	(Casten, Rovner & Fontenot 2016), (Nguyen et al. 2015)	2
	Tailored Games Condition-specific management	(Casten, Rovner & Fontenot 2016), (García-Soler et al. 2018), (Nasr et al. 2016), (Andrews et al. 2019), (Smaerup et al. 2017), (Saracchini, Catalina & Bordoni 2015), (Lee, Lim & Lee 2015), (Ku 2018)	8
	Sports Assistive Technology	(Casten, Rovner & Fontenot 2016), (Boman, Persson & Bartfai 2016), (Orellano-Colón et al. 2017)	3
	Musical Instrument Playing Assistance	(Casten, Rovner & Fontenot 2016), (Nasr et al. 2016), (Andrews et al. 2019), (Saracchini, Catalina & Bordoni 2015), (Lee, Lim & Lee 2015)	5

	Television and Radio	(Peek et al. 2016), (Lee, Lim & Lee 2015), (Kim 2019)	3
	Travel Assistance	(D'Onofrio et al. 2019)	1
	Education Technology	(Lee, Lim & Lee 2015), (Nguyen et al. 2015)	2
Communication (Total Frequency is 20) (8% of the total concern)	Personal Communication Technology	(Casten, Rovner & Fontenot 2016), (García-Soler et al. 2018), (Saracchini, Catalina & Bordoni 2015), (D'Onofrio et al. 2019), (Chang, Lu & Yang 2018), (Chu et al. 2017), (Peek et al. 2016)	7
	Smart Phone and Computer	(Casten, Rovner & Fontenot 2016), (Peek et al. 2016), (Saracchini, Catalina & Bordoni 2015), (Doughty & Williams 2016), (Kamilaris, Kondepudi & Danial 2016), (Meristö 2018)	6
	Companionship Technology/Robots	(García-Soler et al. 2018), (Kamei et al. 2015), (Nasr et al. 2016), (Andrews et al. 2019), (Shishehgar, Kerr & Blake 2019), (Chang, Lu & Yang 2018), (Chu et al. 2017)	7
Total			238

8.3 PRIORITY ASSISTIVE PRODUCTS LIST PUBLISHED BY WORLD HEALTH ORGANIZATION

1 Alarm signallers with light/sound/vibration

2 Audioplayers with DAISY capability

3 Braille displays (note takers)

4 Braille writing equipment/braillers

5 Canes/sticks

6 Chairs for shower/ bath/toilet

7 Closed captioning displays

8 Club foot braces

9 Communication boards/books/cards

10 Communication software

11 Crutches, axillary/ elbow

12 Deafblind communicators

13 Fall detectors

14 Gesture to voice technology

15 Global positioning system (GPS) locators

16 Hand rails/grab bars

17 Hearing aids (digital) and batteries

18 Hearing loops/FM systems

19 Incontinence products, absorbent

20 Keyboard and mouse emulation software

21 Magnifiers, digital hand-held

22 Magnifiers, optical

23 Orthoses, lower limb

24 Orthoses, spinal

25 Orthoses, upper limb

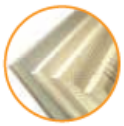
26 Personal digital assistant (PDA)

27 Personal emergency alarm systems

28 Pill organizers

29 Pressure relief cushions

30 Pressure relief mattresses



31 Prostheses, lower limb

32 Ramps, portable

33 Recorders

34 Rollators

35 Screen readers

36 Simplified mobile phones

37 Spectacles; low vision, short distance, long distance, filters and protection

38 Standing frames, adjustable

39 Therapeutic footwear; diabetic, neuropathic, orthopaedic

40 Time management products

41 Travel aids, portable

42 Tricycles

43 Video communication devices

44 Walking frames/ walkers

45 Watches, talking/ touching

46 Wheelchairs, manual for active use

47 Wheelchairs, manual assistant-controlled

48 Wheelchairs, manual with postural support

49 Wheelchairs, electrically powered

50 White canes

Source of the Picture: (World Health Organization 2016)

8.4 FACTORS RELATED TO ASSISTIVE TECHNOLOGY AND REFERRED QUESTION CODES FROM THE CHARLS DATABASE

Technology	Factor	Description	CHARLS items	Additional Explanation
Walking Stick	Body disability	Difficulty in one or more of the following: •Walking 100m •Climbing stairs •Stooping, kneeling, or crouching •Getting out of the bed	DB003 DB005 DB006 DB013	To be considered for total needs
	Disease and illness	**Slightly to severe body pain** **Arthritis or rheumatism**	**DA042** **DA007_13_**	**To be considered for urgent needs within total needs**
	Personal activity	Large number of steps entering home without elevator Far distance to the toilet	I011 I013	To be considered only within the above stated factors.
	Social activity	Any		
Travel Device	Body disability	Difficulty in one or more of the following: •Walking 1 km •Carrying items	DB003 DB008	To be considered for total needs
	Disease and illness	No or slight body pain Good vision (with or without glasses)	DA042 DA033 DA034 DA005[3]	Basic requirement for using this device
	Personal activity	Frequent shopping	DB018	To be considered for total needs
	Social activity	**Involving in social activities such as visiting friends**	**DA056**	**To be considered for urgent needs within total needs**

Manual Wheelchair	Body disability	Severe difficulties in one or more of the following: •Walking 100m •Getting up after sitting •Stooping, kneeling, or crouching	DB003 DB004 DB006	To be considered for total needs
	Disease and illness	**Moderate body pain**	**DA042**	**To be considered for urgent needs within total needs**
	Personal activity	Enough arm and hand strength to roll the wheel	DB007 DB009	"Any" means no need to pick questions to cull the sample
	Social activity	Any		
Electric Wheelchair	Body disability	Severe difficulties in one or more of the following: •Walking 100m •Getting up after sitting •Stooping, kneeling, or crouching	DB003 DB004 DB006	To be considered for total needs
	Disease and illness	**Severe body pain** **Very limited arm and hand strength**	**DA042** **DB007** **DB009**	**To be considered for urgent needs within total needs**
	Personal activity	Any		
	Social activity	Any		
Catheter and Urine Collecting Bags	Body disability	Difficulties in controlling urination and defecation	DB015 DD040_W4	Both DB015 and DD040_W4 are related to controlling urination and defecation. To be considered for total needs

	Disease and illness	**Cancer related to urinating and defecating**	**DA017**	**To be considered for urgent needs within total needs**
	Personal activity	Any		
	Social activity	Any		
Toilet Series	Body disability	Physical Disabilities Difficulty in using the toilet	DA005[1] DB014	To be considered for total needs
	Disease and illness	**Any or both of the following:** **●Moderate to severe body pain** **●Cancer related to urinating and defecating**	**DA042** **DA017**	**To be considered for urgent needs within total needs (Either DA042 or DA017)**
	Personal activity	**Far distance to the toilet**	**I013**	**To be considered only within the above stated factors.**
	Social activity	Any		
Corrective Lenses and Glasses	Body disability	Vision problem when seeing things up close or far away	DA033 DA034 DC068_W4	DA033 and DA034 are both about reading and watching abilities. They can be related to either body disability or personal activity To be considered for total needs
	Disease and illness	**Glaucoma**	**DA037** **DA037_W2**	**To be considered for urgent needs within total needs**
	Personal activity	Reading and Watching Recognizing/Identifying other people	DA033 DA034	Same as for body disability
	Social activity	Any		

Hearing Aids	Body disability	Hearing Disability/Being Deaf Severe hearing impairment	DA005[4] DA039 DC028_W4_1 DC039_W4_1 DC068_W4	To be considered for total needs
	Disease and illness	As above	As above	
	Personal activity	Any		
	Social activity	**Communication with others**	**DA056**	**To be considered for urgent needs within total needs**
Braille writing equipment/braillers	Body disability	Being blind	DA005[3] DA032	Older people 75 years old and over are not considered
	Disease and illness			As brailler might be hard to use late in life
	Personal activity	Attended basic education to be literate	BD001_W2_4 BD007_W2_1 BD007_W4_1	Illiterate older people can hardly learn to use this
	Social activity	Communication with others	DA056	
Smart/ White canes	Body disability	Being blind Very Low vision ability	DA005[3] DA032 DA033 DA034	Blind people are in urgent needs. Blind and low vision people together are in total needs.
	Disease and illness	Can walk 100 metres	DB003	Being able to walk is the basic requirement
	Personal activity	Any		
	Social activity	Any		
	Body disability			

Electrotherapy device for pain	Disease and illness	**Frequent body pain** Multiple parts of body pain	**DA041_W4** DA042	**The frequency decides whether it is an urgent need**
	Personal activity	Already have some treatment with body pain (caused by any reason, including cancer)	DA018 _W4 DA042 _W2_1	Pain and treatment for pain together call for the need for the electrotherapy device
	Social activity			
Pressure Relief Mattresses	Body disability	Physical disability (that makes older people immobile and spend long time in bed)	DA005[1]	To be considered for total needs
	Disease and illness	**Arthritis or rheumatism** **Frequent body pain** **Severe body pain** **Stroke**	**DA007_13_** **DA041_W4** **DA042** **DA007_8_**	**To be considered for urgent needs within total needs**
	Personal activity	Long-time Sleeping	DA049	To be considered for total needs
	Social activity	N/A		
Therapeutic footwear	Body disability	N/A		
	Disease and illness	**Diabetes or high blood sugar diagnose** **Diabetes or high blood sugar symptoms and complications**	**DA007_3_** **DA008_W2_1**	**Urgent need is for those who have already experienced complications**
	Personal activity	Any activities that involves standing and walking		
	Social activity	Any activities that involves standing and walking		
Smart Pillbox/ Pill Organisers	Body disability	Difficulties in taking medication because of memory problems	DB020	To be considered for total needs

	Disease and illness	**Memory Related Disease Overall Poor Health condition so that older people require a lot of medications**	**DA007_12_ DD010_W4 DD011_W4 DA002**	**To be considered for urgent needs within total needs**
	Personal activity	Taking medication	DB020	Same as it is in body disability
	Social activity	Any		
Handrail and Grab bar	Body disability	Difficulty in one or more of the following: •Walking 100m •Getting up after sitting •Stooping, kneeling, or crouching •Using toilet •Showering or bathing	DB003 DB004 DB006 DB014	To be considered for total needs
	Disease and illness	**Parkinson Disease Stroke Dementia Brain atrophy Alzheimer's disease**	**DA007_8_ DA007_12_ DD009_W4 DD010_W4**	**To be considered for urgent needs within total needs**
	Personal activity	Going to toilet Walking and moving at home	DB014	Also included in body disability
	Social activity	N/A	N/A	
Ramps, portable	Body disability	Wheelchair users	DB029	
	Disease and illness	N/A	N/A	
	Personal activity	N/A	N/A	
	Social activity	**Taking part in community-related organizations**	**DA056**	**Urgent need is for wheelchair users who take part in at least one social**

				activity at the same time
Watches, talking/ Touching	**Body disability**	**Being blind Being able to hear**	**DA005[3] DA032 DA005[4]**	**Urgent need is for blind people A fair hearing ability is the basic requirement**
	Disease and illness	Vision problem when seeing things up close	DA034	To be considered for total needs
	Personal activity	Any Activity		
	Social activity	Any Activity		
Glucometer	Body disability	N/A		
	Disease and illness	**Diabetes or high blood sugar diagnose Diabetes or high blood sugar symptom complications**	**DA007_3_ DA008_W2_1**	**Urgent need is for those who have already experienced complications**
	Personal activity	Any Activity		
	Social activity	Any Activity		
Talking Blood-pressure Monitor	Body disability	Being Blind or very poor vision ability Being Blind or very poor vision ability when seeing things up close	DA005[3] DA032 DA034	Total needs for those with Hypertension diagnose and poor vision ability both
	Disease and illness	**Hypertension diagnosis Hypertension symptom complications**	**DA007_1_ DA008_W2_1**	**Urgent need is for those who have already experienced complications**
	Personal activity	Any Activity		
	Social activity	Any Activity		

Alarm signallers with light/ sound/vibration	**Body disability**	**Being deaf** **Body disability**	**DA005[1]** **DA005[4]**	**To be considered for urgent needs within total needs**
	Disease and illness	Memory Related Disease Alzheimer's disease Hearing impairment Brain damage/intellectual disability Parkinson Disease Dementia	DA007_12_ DD010_W4 DD011_W4 DA039 DA005[2]	To be considered for total needs
	Personal activity	Difficulty in Cooking / Using kitchen because of health and memory problems	DB017	To be considered for total needs
	Social activity	N/A		
Deafblind Communicators	**Body disability**	**Being both deaf and blind**	**DA005[3]** **DA032** **DA005[4]**	**Every need is urgent need**
	Disease and illness	N/A		Older people aged 75 years and over are not considered to have potential needs.
	Personal activity	Attended basic education to be literate	BD001_W2_4 BD007_W2_1	Illiterate older people can hardly learn to use this
	Social activity	Communication with others	DA056	To be considered within deaf blind condition, does not change the calculation result
Shower chair	Body disability	Difficulty with bathing or Showering	DB011	To be considered for total needs
	Disease and illness	**Moderate to Severe Body pain**	**DA042**	**To be considered for urgent needs**

	Personal activity	Taking a bath or shower	DB011	To be considered for total needs
	Social activity	**N/A**		
Personal Emergency Response System	Body disability	Physical disability (especially caused by Dementia or Parkinson's disease) Low vision ability or being blind Difficulty in walking 100m Having one of the difficulties: •Using toilet •Bathing or Showering •Making telephone call	DA005[1] DA005[3] DA032 DA033 DA034 DC068_W4 DB003 DB011 DB014 DB035	To be considered for total needs
	Disease and illness	**Dementia or Parkinson's disease** **Ever fallen down and fractured the hip** **Stroke** **Hypertension** **Heart failure/Heart attack** **Emotional, nervous or psychiatric problems** **Moderate to severe body pain** Memory Related Disease Alzheimer's disease Brain damage/intellectual disability Dementia	**DA007_1_** **DA007_7_** **DA007_8_** **DA007_11_** **DA007_12_** **DA042** **DA023** **DA023_W4** **DA025** **DA025_W4** DD010_W4 DD011_W4 DA005[2]	**To be considered for urgent needs within total needs.** **For urgent need: also consider older people aged 80 years and over**
	Personal activity	Any Especially Using toilet and taking a bath	DB011 DB014	

	Social activity	Any **Visiting friends** **Going to community club** **Going Shopping alone** Interacting with/visiting/calling other people	**DA056** **DB018** **DB035**	
Grasping tool or reach extender	Body disability	Any of difficulties in: Reaching the floor Reaching upper shelves Picking up items	DB006 DB007 DB009	To be considered for total needs
	Disease and illness	**Pain in body parts that are related to reaching and grasping (arm, shoulder, wrist, back, leg, knee, ankle)** **Arthritis or rheumatism**	**DA042** **DA007_13_**	**To be considered for urgent needs**
	Personal activity	Reaching and grasping	DB006 DB007 DB009	To be considered for total needs
	Social activity	N/A	N/A	
Time management products	Body disability	N/A	N/A	
	Disease and illness	Memory Related Disease Acquired brain injury Alzheimer's disease Brain damage/intellectual disability Dementia	DA007_12_ DD010_W4 DD011_W4 DA005[2]	To be considered for total needs. No urgent need
	Personal activity	Any activity		
	Social activity	Any activity		

8.5 PARTICIPANT INFORMATION SHEET/CONSENT FORM FOR EXPERT INTERVIEW

Participant Information Sheet / Consent Form

Health/Social Science Research - Adult Providing Own Consent

University of Southern Queensland, Australia

Title	Exploring the Need for Assistive Technologies Through Analyses of a Longitudinal Database of Older People in China
Principal Investigator	Lei Yu
Location	Queensland, Australia

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1. Introduction

You are invited to take part in this research project, which is called Exploring the Opportunities for Aged Care Products and Assistive Technologies for Older People in China. You have been invited because I am wanting to consult with assistive technology experts to assist with the interpretation of data analysis results.

This Participant Information Sheet/Consent Form tells you about the research project. It explains the topics that we are going to talk about. Knowing what is involved will help you decide if you want to take part in the research. Participation in this research is voluntary. If you don't wish to take part, you don't have to.

Please read this information carefully. You can ask questions about anything that you don't understand or want to know more about. Please feel free to contact us if you wish to know more about the project before agreeing to participate.

If you decide you want to take part in the research project, you will be asked to sign the consent form. By signing it you are telling us that you:

• Understand what you have read

• Consent to be involved in part of the research project (interpretation of data analysis results)

• Consent for your professional and demographic information to be aggregated in a summary of the expert participation in the report.

You will be given a copy of this Participant Information and Consent Form to keep.

2. What is the purpose of this research?

The research aims to map older people's needs for assistive technologies, to find and calculate the use, the needs, unmet and urgent needs of older people for 25 selected assistive technologies by analysing the "China Health and Retirement Longitudinal Study" (CHARLS) database. The database collects demographical information, health status, functional limitations, disabilities, illnesses, assistive technology use and other indexes related to their quality of life. Older people's needs are analysed by analysing their profiles including health condition, functional limitations, disability and illness, social activities involvement etc. The unmet needs are shown as the percentages of older people who are in need for a specific type of assistive technology but do not currently use or have one.

The research aims to build an evidence-based guideline to identify the gap of assistive technology use. The research will not only lead to many social benefits but

will also assist the researcher to engage with business and industry. The results of the research are expected to enhance the researcher's capability to advise Australian businesses on assisting China in relation to the assistive technology challenges of an ageing society.

3. What does participation in this research involve?

Your participation will be an interview with me.

This interview has been designed to make sure the researcher interprets the results in a fair and appropriate way and avoids any potential misunderstandings. The results are related to older people's assistive technology use, needs, unmet needs and urgent unmet needs of several types of assistive technologies, as well as their age and gender differentiation. The content of the interview is shown below.

Discussion for Interpretation of Calculation Results

We are going to discuss two questions for every one of the following issues.

Q1 - What is the possible cause for this result/phenomenon? (Hint: the cause can be related to the provision of the assistive technology, older people's attitudes of adoption, the quality of the data…)

Q2 - What would you comment/discuss more about this result/phenomenon? (Hint: The comment/discuss can be related to the opportunities of any assistive technology, any needs for increasing the provision and access of assistive technology, any needs for technological innovation that helps older people with health problems and functional limitations more and better than current available assistive technologies do…)

The issues that we are going to discuss are:

I. Issues related to Older People's Needs and Unmet Needs for Assistive Technologies

•Percentage of older people's unmet needs compared with recorded older people users

• Percentage of older people with needs for specific assistive technologies

II. Issues related to Users:

•Three types of assistive technologies have significant gender differentiation

•One assistive technology is abnormal regarding users in different age groups

III. Gender and Age Differentiation regarding Needs and Unmet Needs of Assistive Technologies

•Gender differentiation regarding unmet needs for 8 assistive technologies

•Gender differentiation regarding total needs for 17 assistive technologies

•Age Differentiation regarding Older People's Unmet Needs for 8 Assistive Technologies

•Age Differentiation regarding Older People's Total Needs for 17 Assistive Technologies

IV. Gender and Age Differentiation and some other less important issues regarding Older People's Profile (Ordinal Questions)

The above issues will be shown in PowerPoint slides as tables or statements of findings during our interview.

The Interview will be video recorded. The interview also records your name, email, place and position of employment, professional experience provided your consent.

If you decide to take part in the research project, you will first be given a questionnaire asking about your place and position of employment, years of experience in assistive technology industry or as a health professional, years that you have been providing information and advice on assistive technology or prescribing assistive technology, details of your professional qualification, the main client groups you provide at services to. This will assist me in identifying a good mix of experts. Once you have completed the questionnaire, and provided information about your expertise, you will be contacted to arrange an interview.

4. Other relevant information about the research project

Database used in this research: The China Health and Retirement Longitudinal Study (CHARLS) database.

The CHARLS database aims to collect a high quality nationally representative sample of Chinese residents aged 45 and older, using scientific research, to serve the needs of the elderly. The baseline national wave of CHARLS was conducted in 2011 and now includes about 10,000 households and 17,500 individuals in 150 counties/districts and 450 villages/resident committees. The individuals supplying the data are re-surveyed every two to three years. The newest wave of CHARLS Database collection was conducted in 2018, which involved 10,818 older people participants. The data of the newest wave was released in September 2020.

5. What are the possible benefits of taking part?

There will be no clear benefit to you from your participation in this research other than contributing to the findings of the research.

There are no costs associated with participating in this research project, nor will you be paid.

6. What are the possible risks and disadvantages of taking part?

According to National Statement on Ethical Conduct in Human Research (2007), the risk of a research refers to a potential for harm, discomfort or inconvenience.

As for the interview of asking for your suggestions and ideas, there is no harm to you. The time imposition might be a potential discomfort or inconvenience for you because the interview consumes your time. To minimise the discomfort or inconvenience of time imposition, the interview will be kept to the suggested timeframe of 60 minutes. The interview starts only when you know everything about the research conduct and are 100% happy with the intended interview process.

7. What if I withdraw during the interview?

If you decide to withdraw during the interview, I will not collect additional personal information from you, although personal information already collected will be retained to ensure that the results of the research project can be measured properly and to comply with law. You should be aware that information collected up to the time you withdraw will form part of the research project results. If you do not want your data to be included, you must tell the researcher when you withdraw during the interview.

8. What happens when the research project ends?

The results of this research will be used by the researcher Lei Yu, a PhD student in University of Southern Queensland, to obtain a Doctor of Philosophy degree.

9. What will happen to information about me?

Any information obtained in connection with this research project that can identify you will remain confidential. It will be disclosed only with your permission, or as required by law. Your expression and explanation during the interview will be anonymously used in the research. Your professional and demographic information will be aggregated in a summary of the expert participants in the thesis. Your personal information will not be disclosed in the thesis, except as required by law.

In accordance with relevant Australian and/or Queensland privacy and other relevant laws, you have the right to request access to the information about you that is collected and stored by the research team. You also have the right to request that any information with which you disagree be corrected. Please inform Lei Yu if you would like to access your information.

10. Who is organising the research?

This research project is being conducted by Lei Yu, a PhD student in the University of Southern Queensland

11. Who has reviewed the research project?

All research in Australia involving humans is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this research project have been approved by the HREC

of the University of Southern Queensland. The Ethics Review Approval Number is H18REA259 (v2).

This project will be carried out according to the National Statement on Ethical Conduct in Human Research (2007). This statement has been developed to protect the interests of people who agree to participate in human research studies.

12. Further information and research contact person

If you want any further information concerning this project or if you have any problems which may be related to your involvement in the project, you can contact the researcher, Lei Yu, with the following details:

Research contact person

Name	Lei Yu
Position	PhD student in the University of Southern Queensland
Telephone	0450365803
Email	Yulei19900803@gmail.com U1102259@umail.usq.edu.au

Consent Form - *Adult providing own consent*

Title	Exploring the Need for Assistive Technologies Through Analyses of a Longitudinal Database of Older People in China
Principal Investigator	Lei Yu
Location	Queensland, Australia

Declaration by Participant

I have read the Participant Information Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research described in the project.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time during the project without affecting my future care.

I understand that I will be given a signed copy of this document to keep.

Name of Participant (please print) _____

Signature _____ Date _____

Declaration by Researcher†

I have given the explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Name of Researcher (please print) Lei Yu

Signature Lei Yu Date

† An appropriately qualified member of the research team must provide the explanation of, and information concerning, the research project.

Note: All parties signing the consent section must date their own signature

8.6 THE ONE-PAGE-QUESTIONNAIRE FOR THE INFORMATION AGGREGATION OF DEMOGRAPHIC AND PROFESSION BACKGROUND

Questionnaire for Experts - Demographic and Profession Background

Expert Name: _____

Date Collected: _____

Place and position of Employment: _____

Email: _____

1. Years of experience in assistive technology industry or as a health professional:

□ < 10 years

□ > 10 years

2. How long have you been providing information and advice on assistive technology or prescribing assistive technology?

□ < 10 years

□ > 10 years

3. Please provide details of your professional qualification e.g. OT Physio, etc.

_____

4. Which sector(s) do you work in?

□ Government

□ University/Research Centre/Academic institution

□ Private Practice/Service

□ Other (please specify) _____

5. What are the main client groups you provide assistive technology services to?

- □ Children 0-18 years old
- □ Adults 18-60 years old
- □ Older adults over 60 years old

6. Which field(s) of assistive technology are you most experienced in?

8.7 OLDER PEOPLE USERS' STATISTICS OF 8 ASSISTIVE TECHNOLOGIES ILLUSTRATED IN CHARLS DATABASE

AT Product	Category	Item	Older People Users' Statistics				
			Total	%#	%##	%###	%####
Walking Stick	Gender	Male	490	4.53%	39.36%	9.23%	45.88%
		Female	578	5.34%	46.43%	10.49%	54.12%
	Age Group	60 - 64	109	1.01%	8.76%	3.26%	10.21%
		64 - 69	172	1.59%	13.82%	5.49%	16.10%
		70 - 74	175	1.62%	14.06%	9.06%	16.39%
		75 over	612	5.65%	49.15%	25.34%	57.30%
	Total		1068	9.87%	85.79%	N/A	100.00%
Travel Device	Gender	Male	28	0.26%	40.00%	0.53%	50.91%
		Female	27	0.25%	38.57%	0.49%	49.09%
	Age Group	60 - 64	7	0.06%	10.00%	0.21%	12.73%
		64 - 69	10	0.09%	14.29%	0.32%	18.18%
		70 - 74	12	0.11%	17.14%	0.62%	21.82%
		75 over	26	0.25%	37.14%	1.08%	47.27%
	Total		55	0.51%	78.57%	N/A	100.00%
Manual Wheelchair	Gender	Male	84	0.77%	35.29%	1.58%	43.75%
		Female	108	1.00%	45.38%	1.96%	56.25%
	Age Group	60 - 64	27	0.25%	11.34%	0.81%	14.06%
		64 - 69	34	0.31%	14.29%	1.09%	17.71%
		70 - 74	34	0.31%	14.29%	1.76%	17.71%
		75 over	97	0.90%	40.77%	4.02%	50.52%
	Total		192	1.77%	80.67%	N/A	100.00%
Electric Wheelchair	Gender	Male	11	0.10%	45.83%	0.21%	61.11%
		Female	7	0.07%	29.17%	0.13%	38.89%
	Age Group	60 - 64	2	0.02%	8.33%	0.06%	11.11%
		64 - 69	3	0.03%	12.50%	0.10%	16.67%
		70 - 74	5	0.05%	20.84%	0.26%	27.78%
		75 over	8	0.07%	33.33%	0.33%	44.44%
	Total		18	0.17%	75.00%	N/A	100.00%
Catheter and Urine Collecting Bags	Gender	Male	36	0.33%	58.06%	0.68%	66.67%
		Female	18	0.17%	29.03%	0.33%	33.33%
	Age Group	60 - 64	5	0.05%	8.06%	0.15%	9.26%
		64 - 69	14	0.13%	22.58%	0.45%	25.93%
		70 - 74	10	0.09%	16.13%	0.52%	18.52%
		75 over	25	0.23%	40.32%	1.04%	46.30%
	Total		54	0.50%	87.09%	N/A	100.00%
Toilet Series	Gender	Male	120	1.11%	33.15%	2.26%	38.96%
		Female	188	1.74%	51.93%	3.41%	61.04%
	Age Group	60 - 64	36	0.33%	9.93%	1.08%	11.69%
		64 - 69	53	0.49%	14.64%	1.69%	17.21%
		70 - 74	67	0.62%	18.52%	3.47%	21.75%
		75 over	152	1.41%	41.99%	6.29%	49.35%
	Total		308	2.85%	85.08%	N/A	100.00%
Corrective Lenses	Gender	Male	1660	15.35%	32.61%	31.29%	55.00%
		Female	1358	12.55%	26.67%	24.64%	45.00%

and Glasses	**Age Group**	**60 - 64**	960	8.87%	18.85%	28.74%	31.81%
		64 - 69	926	8.56%	18.19%	29.57%	30.68%
		70 - 74	570	5.27%	11.20%	29.52%	18.89%
		75 over	562	5.20%	11.04%	23.27%	18.62%
	Total		3018	27.90%	59.28%	N/A	100.00%
Hearing Aids	**Gender**	**Male**	60	0.55%	45.45%	1.13%	61.86%
		Female	37	0.34%	28.03%	0.67%	38.14%
	Age Group	**60 - 64**	25	0.23%	18.93%	0.75%	25.77%
		64 - 69	21	0.19%	15.91%	0.67%	21.65%
		70 - 74	14	0.13%	10.61%	0.73%	14.43%
		75 over	37	0.34%	28.03%	1.53%	38.14%
	Total		97	0.89%	73.48%	N/A	100.00%

%#: Percentage related to total number of older people in database (10818 respondents)

%##: Percentage related to total users in database (check Table 31)

%###: Percentage related to the number of older people in this age group

%####: Percentage related to total older people users in the CHARLS database

8.8 NORMALITY TEST RESULTS FOR ORDINAL VARIABLES

No.	Item Statement	Item Code	Tests of Normality					
			Kolmogorov-Smirnov[a]			Shapiro-Wilk		
			Statistic	df	Sig.	Statistic	df	Sig.
1	Would you say your health is very good, good, fair, poor or very poor?	DA002	.271	9897	.000			
2	How good is your eyesight for seeing things at a distance, like recognizing a friend from across the street (with glasses or corrective lenses if you wear them)? Would you say your eyesight for seeing things at a distance is excellent, very good, good, fair, or poor?	DA033	.302	10695	.000			
3	How good is your eyesight for seeing things up close, like reading ordinary newspaper print (with glasses or corrective lenses if you wear them)? Would you say your eyesight for seeing things up close is excellent, very good, good, fair, or poor?	DA034	.303	10691	.000			
4	Is your hearing very good, good, fair, poor, or very poor (with a hearing aid if you normally use it and without if you normally don't)? Would you say your hearing is excellent, very good, good, fair, or poor?	DA039	.314	10745	.000			
5	Do you have difficulty with walking 100 metres?	DB003	.310	2827	.000	.718	2827	.000
6	Do you have difficulty with getting up from a chair after sitting for a long period?	DB004	.379	10764	.000			
7	Do you have difficulty with climbing several flights of stairs without resting?	DB005	.268	10764	.000			
8	Do you have difficulty with stooping, kneeling, or crouching?	DB006	.325	10764	.000			
9	Do you have difficulty with reaching or extending your arms above shoulder level? (he/she is regarded as not having difficulty only if he/she can extend both of his/her arms, otherwise he/she is regarded as having difficulty.)	DB007	.490	10764	.000			
10	Do you have difficulty with lifting or carrying weights over 10 jin (5kg), like a heavy bag of groceries?	DB008	.458	10764	.000			

11	Do you have difficulty with picking up a small coin from a table?	DB009	.526	10764	.000			
12	Because of health and memory problems, do you have any difficulty with bathing or showering?	DB011	.495	8468	.000			
13	Do you have any difficulty with getting into or out of bed?	DB013	.505	8468	.000			
14	Because of health and memory problems, do you have any difficulties with using the toilet, including getting up and down?	DB014	.468	8468	.000			
15	Because of health and memory problems, do you have any difficulties with controlling urination and defecation? If you use a catheter (conduit) or a pouch by yourself, then you are not considered to have difficulties.	DB015	.520	8468	.000			
16	Because of health and memory problems, do you have any difficulties with preparing hot meals? (Definition: By preparing hot meals, we mean preparing ingredients, cooking and serving food)	DB017	.494	10763	.000			
17	Because of health and memory problems, do you have any difficulties with shopping for groceries? By shopping, we mean deciding what to buy and paying for it.	DB018	.507	10763	.000			
18	Because of health and memory problems, do you have any difficulties with taking medications? By taking medications, we mean taking the right portion of medication right on time.	DB020	.528	10763	.000			
19	Because of health and memory problems, do you have any difficulties with making phone calls?	DB035	.492	9833	.000			
20	Regarding using the toilet, would you say the respondent can clean and care for (himself/ herself) at a toilet, has occasional incontinence or needs to be reminded, has frequent incontinence or needs much assistance, or has little or no control?	DD040 _W4	.533	9834	.000			

8.9 BIVARIATE CORRELATION INFORMATION USING SPEARMAN'S RANK CORRELATION

Bivariate Correlation Information																				
Item Code	Item	DA002	DA033	DA034	DA039	DB003	DB004	DB005	DB006	DB007	DB008	DB009	DB011	DB013	DB014	DB015	DB017	DB018	DB020	DB035	DD040_W4
DA002	Correlation Coefficient	1.000	.330**	.294**	.293**	.137**	.322**	.375**	.338**	.247**	.307**	.147**	.258**	.239**	.237**	.164**	.296**	.255**	.176**	.157**	.103**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9897	9855	9848	9877	2371	9888	9888	9888	9888	9888	9888	7698	7698	7698	7698	9887	9887	9887	9110	8998
DA033	Correlation Coefficient	.330**	1.000	.516**	.389**	.079**	.224**	.254**	.228**	.168**	.204**	.132**	.143**	.140**	.134**	.097**	.172**	.168**	.126**	.157**	.075**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9855	10695	10678	10675	2777	10686	10686	10686	10686	10686	10686	8399	8399	8399	8399	10685	10685	10685	9767	9758
DA034	Correlation Coefficient	.294**	.516**	1.000	.361**	.098**	.168**	.204**	.181**	.164**	.165**	.124**	.130**	.124**	.129**	.085**	.152**	.145**	.115**	.142**	.066**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9848	10678	10691	10674	2779	10682	10682	10682	10682	10682	10682	8395	8395	8395	8395	10681	10681	10681	9767	9755
DA039	Correlation Coefficient	.293**	.389**	.361**	1.000	.044*	.179**	.201**	.186**	.162**	.171**	.115**	.121**	.115**	.115**	.095**	.155**	.156**	.120**	.183**	.063**

	Sig. (2-tailed)	0.000	0.000	0.000		0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9877	10675	10674	10745	2818	10737	10737	10737	10737	10737	10737	8447	8447	8447	8447	10736	10736	10736	9813	9807
DB003	Correlation Coefficient	.137**	.079**	.098**	.044*	1.000	.386**	.363**	.316**	.307**	.378**	.238**	.403**	.398**	.343**	.221**	.388**	.407**	.260**	.257**	.333**
	Sig. (2-tailed)	0.000	0.000	0.000	0.020		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	2371	2777	2779	2818	2827	2827	2827	2827	2827	2827	2827	2826	2826	2826	2826	2826	2826	2826	2423	2597
DB004	Correlation Coefficient	.322**	.224**	.168**	.179**	.386**	1.000	.466**	.516**	.349**	.390**	.246**	.358**	.385**	.389**	.234**	.357**	.332**	.253**	.249**	.222**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9888	10686	10682	10737	2827	10764	10764	10764	10764	10764	10764	8468	8468	8468	8468	10763	10763	10763	9833	9830
DB005	Correlation Coefficient	.375**	.254**	.204**	.201**	.363**	.466**	1.000	.525**	.335**	.438**	.229**	.347**	.309**	.325**	.206**	.397**	.385**	.263**	.307**	.210**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9888	10686	10682	10737	2827	10764	10764	10764	10764	10764	10764	8468	8468	8468	8468	10763	10763	10763	9833	9830
DB006	Correlation Coefficient	.338**	.228**	.181**	.186**	.316**	.516**	.525**	1.000	.365**	.432**	.244**	.361**	.337**	.412**	.220**	.385**	.353**	.248**	.245**	.210**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9888	10686	10682	10737	2827	10764	10764	10764	10764	10764	10764	8468	8468	8468	8468	10763	10763	10763	9833	9830

DB007	Correlation Coefficient	.247**	.168**	.164**	.162**	.307**	.349**	.335**	.365**	1.000	.409**	.306**	.384**	.347**	.306**	.225**	.368**	.341**	.266**	.265**	.236**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9888	10686	10682	10737	2827	10764	10764	10764	10764	10764	10764	8468	8468	8468	8468	10763	10763	10763	9833	9830
DB008	Correlation Coefficient	.307**	.204**	.165**	.171**	.378**	.390**	.438**	.432**	.409**	1.000	.289**	.419**	.369**	.337**	.235**	.460**	.439**	.303**	.315**	.262**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9888	10686	10682	10737	2827	10764	10764	10764	10764	10764	10764	8468	8468	8468	8468	10763	10763	10763	9833	9830
DB009	Correlation Coefficient	.147**	.132**	.124**	.115**	.238**	.246**	.229**	.244**	.306**	.289**	1.000	.301**	.291**	.236**	.250**	.315**	.306**	.241**	.244**	.239**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	9888	10686	10682	10737	2827	10764	10764	10764	10764	10764	10764	8468	8468	8468	8468	10763	10763	10763	9833	9830
DB011	Correlation Coefficient	.258**	.143**	.130**	.121**	.403**	.358**	.347**	.361**	.384**	.419**	.301**	1.000	.529**	.473**	.363**	.558**	.495**	.369**	.331**	.393**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	7698	8399	8395	8447	2826	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	7652	7749
DB013	Correlation Coefficient	.239**	.140**	.124**	.115**	.398**	.385**	.309**	.337**	.347**	.369**	.291**	.529**	1.000	.525**	.365**	.443**	.411**	.340**	.291**	.382**

	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	7698	8399	8395	8447	2826	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	7652	7749
DB014	Correlation Coefficient	.237**	.134**	.129**	.115**	.343**	.389**	.325**	.412**	.306**	.337**	.236**	.473**	.525**	1.000	.358**	.413**	.371**	.294**	.252**	.335**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
	Correlated sample	7698	8399	8395	8447	2826	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	7652	7749
DB015	Correlation Coefficient	.164**	.097**	.085**	.095**	.221**	.234**	.206**	.220**	.225**	.235**	.250**	.363**	.365**	.358**	1.000	.329**	.306**	.317**	.232**	.384**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
	Correlated sample	7698	8399	8395	8447	2826	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	8468	7652	7749
DB017	Correlation Coefficient	.296**	.172**	.152**	.155**	.388**	.357**	.397**	.385**	.368**	.460**	.315**	.558**	.443**	.413**	.329**	1.000	.593**	.409**	.402**	.349**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
	Correlated sample	9887	10685	10681	10736	2826	10763	10763	10763	10763	10763	10763	8468	8468	8468	8468	10763	10763	10763	9833	9830
DB018	Correlation Coefficient	.255**	.168**	.145**	.156**	.407**	.332**	.385**	.353**	.341**	.439**	.306**	.495**	.411**	.371**	.306**	.593**	1.000	.439**	.458**	.354**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
	Correlated sample	9887	10685	10681	10736	2826	10763	10763	10763	10763	10763	10763	8468	8468	8468	8468	10763	10763	10763	9833	9830

DB020	Correlation Coefficient	.176**	.126**	.115**	.120**	.260**	.253**	.263**	.248**	.266**	.303**	.241**	.369**	.340**	.294**	.317**	.409**	.439**	1.000	.374**	.334**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
	Correlated sample	9887	10685	10681	10736	2826	10763	10763	10763	10763	10763	10763	8468	8468	8468	8468	10763	10763	10763	9833	9830
DB035	Correlation Coefficient	.157**	.157**	.142**	.183**	.257**	.249**	.307**	.245**	.265**	.315**	.244**	.331**	.291**	.252**	.232**	.402**	.458**	.374**	1.000	.271**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
	Correlated sample	9110	9767	9767	9813	2423	9833	9833	9833	9833	9833	9833	7652	7652	7652	7652	9833	9833	9833	9833	8972
DD040_W4	Correlation Coefficient	.103**	.075**	.066**	.063**	.333**	.222**	.210**	.210**	.236**	.262**	.239**	.393**	.382**	.335**	.384**	.349**	.354**	.334**	.271**	1.000
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	Correlated sample	8998	9758	9755	9807	2597	9830	9830	9830	9830	9830	9830	7749	7749	7749	7749	9830	9830	9830	8972	9834

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

(Note: As for missing values: Exclude cases pairwise)

8.10 WILCOXON SIGNED RANK TEST

Assistive Technology	Differentiation (X - Y)	Negative Rank	Positive Rank	Ties	Total	Z	Asymp. Sig
1. Walking Stick	DB013 - DB003	1023 a	244 b	1559 c	2826	-23.234 e	0.000
	DB006 - DB003	318 a	1349 b	1160 c	2827	-23.268 d	0.000
	DB005 - DB003	169 a	1650 b	1008 c	2827	-31.141 d	0.000
	DB013 - DB005	5314 a	85 b	3069 c	8468	-64.210 e	0.000
	DB006 - DB005	2710 a	1560 b	6494 c	10764	-14.979 e	0.000
	DB013 - DB006	4230 a	108 b	4130 c	8468	-56.856 e	0.000
2. Travel Device	DA034 - DB003	420 a	1901 b	458 c	2779	-32.601 d	0.000
	DA033 - DB003	376 a	1943 b	458 c	2777	-34.469 d	0.000
	DB018 - DB003	665 a	581 b	1580 c	2826	-1.342 d	0.180
	DB008 - DB003	455 a	936 b	1436 c	2827	-14.919 d	0.000
	DA034 - DB008	1062 a	7849 b	1771 c	10682	-71.752 d	0.000
	DA033 - DB008	920 a	7896 b	1870 c	10686	-73.844 d	0.000
	DB018 - DB008	1728 a	620 b	8415 c	10763	-20.734 e	0.000
	DA034 - DB018	587 a	8515 b	1579 c	10681	-78.694 d	0.000
	DA033 - DB018	509 a	8543 b	1633 c	10685	-79.801 d	0.000
	DA034 - DA033	2420 a	1676 b	6582 c	10678	-8.774 e	0.000
3. Manual Wheelchair	DB009 - DB003	1066 a	229 b	1532 c	2827	-19.949 e	0.000
	DB007 - DB003	760 a	570 b	1497 c	2827	-2.190 e	0.029
	DB006 - DB003	318 a	1349 b	1160 c	2827	-23.268 d	0.000
	DB004 - DB003	678 a	889 b	1260 c	2827	-3.005 e	0.003
	DB009 - DB004	3423 a	466 b	6875 c	10764	-38.218 e	0.000
	DB007 - DB004	2726 a	1187 b	6851 c	10764	-7.446 e	0.000
	DB006 - DB004	1008 a	2921 b	6835 c	10764	-36.620 d	0.000
	DB009 - DB006	4229 a	279 b	6256 c	10764	-52.000 e	0.000
	DB007 - DB006	3465 a	681 b	6618 c	10764	-35.696 e	0.000
	DB009 - DB007	1468 a	411 b	8885 c	10764	-23.526 e	0.000

4. Electric Wheelchair	DB009 - DB003	1066 a	229 b	1532 c	2827	-19.949 e	0.000
	DB007 - DB003	760 a	570 b	1497 c	2827	-2.190 e	0.029
	DB006 - DB003	318 a	1349 b	1160 c	2827	-23.268 d	0.000
	DB004 - DB003	678 a	889 b	1260 c	2827	-3.005 e	0.003
	DB009 - DB004	3423 a	466 b	6875 c	10764	-38.218 e	0.000
	DB007 - DB004	2726 a	1187 b	6851 c	10764	-7.446 e	0.000
	DB006 - DB004	1008 a	2921 b	6835 c	10764	-36.620 d	0.000
	DB009 - DB006	4229 a	279 b	6256 c	10764	-52.000 e	0.000
	DB007 - DB006	3465 a	681 b	6618 c	10764	-35.696 e	0.000
	DB009 - DB007	1468 a	411 b	8885 c	10764	-23.526 e	0.000
5. Catheter and Urine Collecting Bags	DD040_W4 - DB015	559 a	145 b	7045 c	7749	-13.941e	0.000
6. Toilet Series	No ordinal variable pairs						
7. Corrective Lenses and Glasses	DA034 - DA033	2420 a	1676 b	6582 c	10678	-8.774 e	0.000
8. Hearing Aids	No ordinal variable pairs						
9. Braille writing equipment / braillers	No ordinal variable pairs						
10. Smart / White canes	DA034 - DA033	2420 a	1676 b	6582 c	10678	-8.774 e	0.000
	DA034 - DB003	420 a	1901 b	458 c	2779	-32.601 d	0.000
	DA033 - DB003	376 a	1943 b	458 c	2777	-34.469 d	0.000
11. Electrotherapy device for pain	No ordinal variable pairs						
12. Pressure Relief Mattresses	No ordinal variable pairs						

13. Therapeutic footwear	No ordinal variable pairs						
14. Smart Pillbox/ Pill Organiser	DB020 - DA002	7448 a	174 b	2265 c	9887	-75.135 e	0.000
15. Handrail and grab bar	DB004 - DB003	678 a	889 b	1260 c	2827	-3.005 e	0.003
	DB006 - DB003	318 a	1349 b	1160 c	2827	-23.268 d	0.000
	DB014 - DB003	916 a	456 b	1454 c	2826	-15.347 e	0.000
	DB006 - DB004	1008 a	2921 b	6835 c	10764	-36.620 d	0.000
	DB014 - DB004	2723 a	497 b	5248 c	8468	-34.763 e	0.000
	DB014 - DB006	3863 a	203 b	4402 c	8468	-52.554 e	0.000
16. Ramps, portable	No ordinal variable pairs						
17. Watches, talking/touching	No ordinal variable pairs						
18. Glucometer	No ordinal variable pairs						
19. Talking Blood-pressure Monitor	No ordinal variable pairs						
20. Alarm signallers with light/sound/vibration	DA039 - DB017	690 a	8245 b	1801 c	10736	-76.661 d	0.000
21. Deafblind communicators	No ordinal variable pairs						
22. Shower Chair	No ordinal variable pairs						
23. Personal Emergency Response System	DA034 - DA033	2420 a	1676 b	6582 c	10678	-8.774 e	0.000
	DA033 - DB003	376 a	1943 b	458 c	2777	-34.469 d	0.000
	DA033 - DB011	238 a	7157 b	1004 c	8399	-74.145 e	0.000
	DA033 - DB014	213 a	7284 b	902 c	8399	-74.918 e	0.000
	DA033 - DB018	509 a	8543 b	1633 c	10685	-79.801 d	0.000
	DA033 - DB035	687 a	7471 b	1609 c	9767	-72.993 e	0.000
	DA034 - DB003	420 a	1901 b	458 c	2779	-32.601 d	0.000

	DA034 - DB011	271 a	7051 b	1073 c	8395	-72.948 e	0.000
	DA034 - DB014	243 a	7169 b	983 c	8395	-73.979 e	0.000
	DA034 - DB018	587 a	8515 b	1579 c	10681	-78.694 d	0.000
	DA034 - DB035	765 a	7433 b	1569 c	9767	-71.691 e	0.000
	DB011 - DB003	894 a	431 b	1501 c	2826	-11.712 d	0.000
	DB014 - DB003	916 a	456 b	1454 c	2826	-15.347 e	0.000
	DB018 - DB003	665 a	581 b	1580 c	2826	-1.342 e	0.180
	DB035 - DB003	641 a	553 b	1229 c	2423	-1.486 e	0.137
	DB014 - DB011	742 a	952 b	6774 c	8468	-1.070 d	0.284
	DB018 - DB011	597 a	1070 b	6801 c	8468	-14.106 e	0.000
	DB035 - DB011	572 a	1322 b	5758 c	7652	-21.892 e	0.000
	DB018 - DB014	991 a	1156 b	6321 c	8468	-13.872 e	0.000
	DB035 - DB014	896 a	1394 b	5362 c	7652	-21.418 e	0.000
	DB035 - DB018	567 a	1115 b	8151 c	9833	-14.159 e	0.000
24. Grasping tool or reach extender	DB009 - DB006	4229 a	279 b	6256 c	10764	-52.000 e	0.000
	DB007 - DB006	3465 a	681 b	6618 c	10764	-35.696 e	0.000
	DB009 - DB007	1468 a	411 b	8885 c	10764	-23.526 e	0.000
25. Time management products	No ordinal variable pairs						

a. X < Y

b. X > Y

c. X = Y

d. Based on negative ranks.

e. Based on positive ranks.

(Note: As for missing values: Exclude cases test-by-test)

8.11 MANN-WHITNEY U AND KRUSKAL WALLIS TEST

Item Code	Mann-Whitney U Test (Gender)				Kruskal-Wallis Test Results (Age Group)		
	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)	Kruskal-Wallis H	df	Asymp. Sig.
DA002	11233893.50	23133774.50	-7.618	0.000	59.058	3	0.000
DA033	12684100.000	26483731.000	-10.931	0.000	186.989	3	0.000
DA034	13289605.000	27089236.000	-6.757	0.000	37.962	3	0.000
DA039	14401603.000	29359318.000	-0.174	0.862	299.730	3	0.000
DB003	874854.500	1436124.500	-3.194	0.001	75.812	3	0.000
DB004	12365360.500	26328330.500	-15.482	0.000	243.929	3	0.000
DB005	11632864.500	25595834.500	-19.000	0.000	511.952	3	0.000
DB006	12230020.500	26192990.500	-15.541	0.000	372.872	3	0.000
DB007	13639384.000	27602354.000	-7.989	0.000	177.140	3	0.000
DB008	12066825.500	26029795.500	-20.175	0.000	632.889	3	0.000
DB009	14368940.000	28331910.000	-1.486	0.137	154.968	3	0.000
DB011	8705164.000	15659749.000	-1.848	0.065	243.214	3	0.000
DB013	8542681.500	15497266.500	-4.526	0.000	124.086	3	0.000
DB014	8424473.500	15379058.500	-5.271	0.000	121.196	3	0.000

DB015	8701634.000	19933064.000	-2.450	0.014	158.140	3	0.000
DB017	14026206.000	27989176.000	-4.346	0.000	587.854	3	0.000
DB018	13417278.000	27380248.000	-10.922	0.000	581.755	3	0.000
DB020	13888159.500	27851129.500	-7.712	0.000	176.216	3	0.000
DB035	10909218.000	23148096.000	-12.572	0.000	581.471	3	0.000
DD040_W4	12058143.000	23725008.000	-0.620	0.536	216.938	3	0.000

(Note: As for missing values: Exclude cases test-by-test)

8.12 UNMET NEEDS AND URGENT UNMET NEEDS FOR 8 ASSISTIVE TECHNOLOGIES WITH USERS' STATISTICS IN CHARLS DATABASE

AT	Category	Group	Existing Users		Total Unmet Needs				Urgent Unmet Needs			
			Total	%##	Total	%#	%##	%###	Total	%#	%##	%###
Walking Stick	Gender	Male	490	4.53 %	885	35.56%	8.18%	16.68%	328	26.89%	3.03%	6.18%
		Female	578	5.34 %	1604	64.44%	14.83%	29.10%	892	73.11%	8.25%	16.18%
	Age Group	60 - 64	109	1.01 %	565	22.70%	5.22%	16.92%	300	24.59%	2.77%	8.98%
		65 - 69	172	1.59 %	719	28.89%	6.65%	22.96%	378	30.98%	3.49%	12.07%
		70 - 74	175	1.62 %	510	20.49%	4.71%	26.41%	251	20.57%	2.32%	13.00%
		75 over	612	5.65 %	695	27.92%	6.42%	28.78%	291	23.85%	2.69%	12.05%
	Total		1068	9.87 %	2489	100.00%	23.01%	N/A	1220	100.00 %	11.28 %	N/A
Travel Device	Gender	Male	28	0.26 %	65	34.03%	0.60%	1.23%	1	6.25%	0.01%	0.02%
		Female	27	0.25 %	126	65.97%	1.16%	2.29%	15	93.75%	0.15%	0.27%
	Age Group	60 - 64	7	0.06 %	36	18.85%	0.33%	1.08%	6	37.50%	0.06%	0.18%
		65 - 69	10	0.09 %	49	25.65%	0.45%	1.56%	3	18.75%	0.03%	0.10%
		70 - 74	12	0.11 %	29	15.18%	0.27%	1.50%	3	18.75%	0.03%	0.16%
		75 over	26	0.25 %	77	40.31%	0.71%	3.19%	4	25.00%	0.04%	0.17%

	Total		55	0.51 %	191	100.00%	1.77%	N/A	16	100.00 %	0.16%	N/A
Manual Wheelchair	Gender	Male	84	0.77 %	64	27.47%	0.59%	1.21%	24	22.43%	0.22%	0.45%
		Female	108	1.00 %	169	72.53%	1.56%	3.07%	83	77.57%	0.77%	1.51%
	Age Group	60 - 64	27	0.25 %	39	16.74%	0.36%	1.17%	17	15.89%	0.16%	0.51%
		65 - 69	34	0.31 %	42	18.03%	0.39%	1.34%	21	19.63%	0.19%	0.67%
		70 - 74	34	0.31 %	42	18.03%	0.39%	2.18%	25	23.36%	0.23%	1.29%
		75 over	97	0.90 %	110	47.21%	1.02%	4.55%	44	41.12%	0.41%	1.82%
	Total		192	1.77 %	233	100.00%	2.15%	N/A	107	100.00 %	0.99%	N/A
Electric Wheelchair	Gender	Male	11	0.10 %	54	56.25%	0.50%	1.02%	16	55.17%	0.15%	0.30%
		Female	7	0.07 %	42	43.75%	0.39%	0.76%	13	44.83%	0.12%	0.24%
	Age Group	60 - 64	2	0.02 %	12	12.50%	0.11%	0.36%	5	17.24%	0.05%	0.15%
		65 - 69	3	0.03 %	15	15.63%	0.14%	0.48%	7	24.14%	0.06%	0.22%
		70 - 74	5	0.05 %	17	17.71%	0.16%	0.88%	3	10.34%	0.03%	0.16%
		75 over	8	0.07 %	52	54.17%	0.48%	2.15%	14	48.28%	0.13%	0.58%
	Total		18	0.17 %	96	100.00%	0.89%	N/A	29	100.00 %	0.27%	N/A
Catheter and Urine Collecting Bags	Gender	Male	36	0.33 %	176	50.43%	1.63%	3.32%	22	53.66%	0.20%	0.41%
		Female	18	0.17 %	173	49.57%	1.60%	3.14%	19	46.34%	0.18%	0.34%
	Age Group	60 - 64	5	0.05 %	51	14.61%	0.47%	1.53%	4	9.76%	0.04%	0.12%

		65 - 69	14	0.13 %	65	18.62%	0.60%	2.08%	2	4.88%	0.02%	0.06%
		70 - 74	10	0.09 %	56	16.05%	0.52%	2.90%	9	21.95%	0.08%	0.47%
		75 over	25	0.23 %	177	50.72%	1.64%	7.33%	26	63.41%	0.24%	1.08%
	Total		54	0.50 %	349	100.00%	3.23%	N/A	41	100.00 %	0.38%	N/A
Toilet Series	Gender	Male	120	1.11 %	317	50.16%	2.93%	5.97%	132	40.62%	1.22%	2.49%
		Female	188	1.74 %	315	49.84%	2.91%	5.71%	193	59.38%	1.77%	3.50%
	Age Group	60 - 64	36	0.33 %	139	21.99%	1.28%	4.16%	70	21.54%	0.65%	2.10%
		65 - 69	53	0.49 %	160	25.32%	1.48%	5.11%	85	26.15%	0.79%	2.71%
		70 - 74	67	0.62 %	115	18.20%	1.06%	5.96%	55	16.92%	0.51%	2.85%
		75 over	152	1.41 %	218	34.49%	2.02%	9.03%	115	35.38%	1.06%	4.76%
	Total		308	2.85 %	632	100.00%	5.84%	N/A	325	100.00 %	3.00%	N/A
Corrective Lenses and Glasses	Gender	Male	1660	15.35 %	2950	45.66%	27.27%	55.60%	44	28.76%	0.41%	0.83%
		Female	1358	12.55 %	3511	54.34%	32.46%	63.70%	109	71.24%	1.00%	1.98%
	Age Group	60 - 64	960	8.87 %	1937	29.98%	17.91%	57.99%	36	23.53%	0.33%	1.08%
		65 - 69	926	8.56 %	1806	27.95%	16.69%	57.66%	39	25.49%	0.36%	1.25%
		70 - 74	570	5.27 %	1162	17.98%	10.74%	60.18%	27	17.65%	0.25%	1.40%
		75 over	562	5.20 %	1556	24.08%	14.38%	64.43%	51	33.33%	0.47%	2.11%
	Total		3018	27.90 %	6461	100.00%	59.72%	N/A	153	100.00 %	1.41%	N/A

Hearing Aids	Gender	Male	60	0.55 %	3789	49.43%	35.02%	71.41%	612	50.87%	5.66%	11.53%
		Female	37	0.34 %	3877	50.57%	35.84%	70.34%	591	49.13%	5.46%	10.72%
	Age Group	60 - 64	25	0.23 %	2202	28.72%	20.35%	65.93%	437	36.33%	4.04%	13.08%
		65 - 69	21	0.19 %	2180	28.44%	20.15%	69.60%	358	29.76%	3.31%	11.43%
		70 - 74	14	0.13 %	1440	18.78%	13.31%	74.57%	237	19.70%	2.19%	12.27%
		75 over	37	0.34 %	1844	24.05%	17.05%	76.36%	171	14.21%	1.58%	7.08%
	Total		97	0.89 %	7666	100.00%	70.86%	N/A	1203	100.00 %	11.12 %	N/A

%[#]: Percentage related to total number of unmet needs / urgent unmet needs of each specific assistive technology

%[##]: Percentage related to total number of older people in database (10818 older people)

%[###]: Percentage related to the number of older people in specific gender or age groups

8.13 TOTAL NEEDS AND URGENT NEEDS FOR 17 ASSISTIVE TECHNOLOGIES WITHOUT USERS' STATISTICS IN CHARLS DATABASE

AT	Category	Group	Total Needs				Urgent Total Needs			
			Total	%#	%##	%###	Total	%#	%##	%###
Braille writing equipment/ braillers	Gender	Male	122	53.04%	1.13%	2.30%	19	40.43%	0.18%	0.36%
		Female	108	46.96%	1.00%	1.96%	28	59.57%	0.26%	0.51%
	Age Group	60 - 64	85	36.96%	0.79%	2.54%	19	40.43%	0.18%	0.57%
		65 - 69	84	36.52%	0.78%	2.68%	18	38.30%	0.17%	0.57%
		70 - 74	61	26.52%	0.56%	3.16%	10	21.28%	0.09%	0.52%
		75 over	Not considered	N/A	N/A	N/A	Not considered	N/A	N/A	N/A
	Total		230	100.00%	2.13%	N/A	47	100.00%	0.43%	N/A
Smart/ White canes	Gender	Male	502	40.95%	4.64%	9.46%	59	37.11%	0.55%	1.11%
		Female	724	59.05%	6.69%	13.13%	100	62.89%	0.92%	1.81%
	Age Group	60 - 64	298	24.31%	2.75%	8.92%	39	24.53%	0.36%	1.17%
		65 - 69	327	26.67%	3.02%	10.44%	37	23.27%	0.34%	1.18%
		70 - 74	233	19.00%	2.15%	12.07%	27	16.98%	0.25%	1.40%
		75 over	368	30.02%	3.40%	15.24%	56	35.22%	0.52%	2.32%
	Total		1226	100.00%	11.33%	N/A	159	100.00%	1.47%	N/A
Pressure Relief Mattresses	Gender	Male	61+194=255	53.68%	2.36%	4.81%	23+123=146	46.35%	1.35%	2.75%
		Female	54+166=220	46.32%	2.03%	3.99%	31+138=169	53.65%	1.56%	3.07%
	Age Group	60 - 64	16+97=113	23.79%	1.04%	3.38%	5+74=79	25.08%	0.73%	2.37%
		65 - 69	28+102=130	27.37%	1.20%	4.15%	14+70=84	26.67%	0.78%	2.68%
		70 - 74	21+64=85	17.89%	0.79%	4.40%	13+47=60	19.05%	0.55%	3.11%
		75 over	50+97=147	30.95%	1.36%	6.09%	22+70=92	29.21%	0.85%	3.81%
	Total		115+360=475	100.00%	4.39%	N/A	54+261=315	100.00%	2.91%	N/A
Therapeutic footwear	Gender	Male	135	40.79%	1.25%	2.54%	44	40.74%	0.41%	0.83%
		Female	196	59.21%	1.81%	3.56%	64	59.26%	0.59%	1.16%
	Age Group	60 - 64	95	28.70%	0.88%	2.84%	36	33.33%	0.33%	1.08%
		65 - 69	110	33.23%	1.02%	3.51%	33	30.56%	0.31%	1.05%
		70 - 74	59	17.82%	0.55%	3.06%	19	17.59%	0.18%	0.98%
		75 over	67	20.24%	0.62%	2.77%	20	18.52%	0.18%	0.83%

	Total		331	100.00%	3.06%	N/A	108	100.00%	1.00%	N/A
Smart Pillbox / Pill Organisers	Gender	Male	235	39.30%	2.17%	4.43%	135	37.82%	1.25%	2.54%
		Female	363	60.70%	3.36%	6.59%	222	62.18%	2.05%	4.03%
	Age Group	60 - 64	107	17.89%	0.99%	3.20%	70	19.61%	0.65%	2.10%
		65 - 69	114	19.06%	1.05%	3.64%	66	18.49%	0.61%	2.11%
		70 - 74	99	16.56%	0.92%	5.13%	73	20.45%	0.67%	3.78%
		75 over	278	46.49%	2.57%	11.51%	148	41.46%	1.37%	6.13%
	Total		598	100.00%	5.53%	N/A	357	100.00%	3.30%	N/A
Handrail and Grab bar	Gender	Male	893	37.24%	8.25%	16.83%	225	43.35%	2.08%	4.24%
		Female	1505	62.76%	13.91%	27.30%	294	56.65%	2.72%	5.33%
	Age Group	60 - 64	463	19.31%	4.28%	13.86%	77	14.84%	0.71%	2.31%
		65 - 69	582	24.27%	5.38%	18.58%	128	24.66%	1.18%	4.09%
		70 - 74	461	19.22%	4.26%	23.87%	115	22.16%	1.06%	5.96%
		75 over	892	37.20%	8.25%	36.94%	199	38.34%	1.84%	8.24%
	Total		2398	100.00%	22.17%	N/A	519	100.00%	4.80%	N/A
Ramp, Portable	Gender	Male	93	44.71%	0.86%	1.75%	9	29.03%	0.08%	0.17%
		Female	115	55.29%	1.06%	2.09%	22	70.97%	0.20%	0.40%
	Age Group	60 - 64	28	13.46%	0.26%	0.84%	2	6.45%	0.02%	0.06%
		65 - 69	37	17.79%	0.34%	1.18%	5	16.13%	0.05%	0.16%
		70 - 74	39	18.75%	0.36%	2.02%	5	16.13%	0.05%	0.26%
		75 over	104	50.00%	0.96%	4.31%	19	61.29%	0.18%	0.79%
	Total		208	100.00%	1.92%	N/A	31	100.00%	0.29%	N/A
Watches, talking / touching	Gender	Male	873	42.48%	8.07%	16.45%	76	44.19%	0.70%	1.43%
		Female	1182	57.52%	10.93%	21.44%	96	55.81%	0.89%	1.74%
	Age Group	60 - 64	556	27.06%	5.14%	16.65%	41	23.84%	0.37%	1.23%
		65 - 69	584	28.42%	5.40%	18.65%	46	26.74%	0.43%	1.47%
		70 - 74	363	17.66%	3.36%	18.80%	31	18.02%	0.29%	1.61%
		75 over	552	26.86%	5.10%	22.86%	54	31.40%	0.50%	2.24%
	Total		2055	100.00%	19.00%	N/A	172	100.00%	1.59%	N/A
Glucometer	Gender	Male	135	40.79%	1.25%	2.54%	44	40.74%	0.41%	0.83%
		Female	196	59.21%	1.81%	3.56%	64	59.26%	0.59%	1.16%
	Age Group	60 - 64	95	28.70%	0.88%	2.84%	36	33.33%	0.33%	1.08%
		65 - 69	110	33.23%	1.02%	3.51%	33	30.56%	0.31%	1.05%
		70 - 74	59	17.82%	0.55%	3.06%	19	17.59%	0.18%	0.98%
		75 over	67	20.25%	0.62%	2.77%	20	18.52%	0.18%	0.83%

	Total		331	100.00%	3.06%	N/A	108	100.00%	1.00%	N/A
Talking Blood-pressure Monitor	Gender	Male	152	46.48%	1.41%	2.86%	93	42.86%	0.86%	1.75%
		Female	175	53.52%	1.62%	3.17%	124	57.14%	1.14%	2.25%
	Age Group	60 - 64	93	28.44%	0.86%	2.78%	66	30.41%	0.61%	1.98%
		65 - 69	93	28.44%	0.86%	2.97%	60	27.65%	0.55%	1.92%
		70 - 74	47	14.37%	0.43%	2.43%	29	13.36%	0.27%	1.50%
		75 over	94	28.75%	0.87%	3.89%	62	28.57%	0.57%	2.57%
	Total		327	100.00%	3.02%	N/A	217	100.00%	2.00%	N/A
Alarm signallers with light / sound / vibration	Gender	Male	1667	48.45%	15.41%	31.42%	310	52.54%	2.87%	5.84%
		Female	1774	51.55%	16.40%	32.18%	280	47.46%	2.59%	5.08%
	Age Group	60 - 64	709	20.60%	6.55%	21.23%	123	20.85%	1.14%	3.68%
		65 - 69	831	24.15%	7.68%	26.53%	146	24.75%	1.35%	4.66%
		70 - 74	689	20.02%	6.37%	35.68%	123	20.85%	1.14%	6.37%
		75 over	1212	35.22%	11.20%	50.19%	198	33.56%	1.83%	8.20%
	Total		3441	100.00%	31.81%	N/A	590	100.00%	5.45%	N/A
Deafblind communicators	Gender	Male	22	50%	0.20%	0.41%	22	50%	0.20%	0.41%
		Female	22	50%	0.20%	0.40%	22	50%	0.20%	0.40%
	Age Group	60 - 64	18	40.91%	0.17%	0.54%	18	40.91%	0.17%	0.54%
		65 - 69	14	31.82%	0.13%	0.45%	14	31.82%	0.13%	0.45%
		70 - 74	12	27.27%	0.11%	0.62%	12	27.27%	0.11%	0.62%
		75 over	Not considered	N/A	N/A	N/A	Not considered	N/A	N/A	N/A
	Total		44	100.00%	0.41%	N/A	44	100.00%	0.41%	N/A
Grasping tools or reach extenders	Gender	Male	1029	38.57%	9.51%	19.39%	439+29=468	31.56%	4.33%	8.82%
		Female	1639	61.43%	15.15%	29.74%	973+42=1015	68.44%	9.38%	18.41%
	Age Group	60 - 64	539	20.20%	4.98%	16.14%	315+16=331	22.32%	3.06%	9.91%
		65 - 69	649	24.33%	6.00%	20.72%	370+11=381	25.69%	3.52%	12.16%
		70 - 74	533	19.98%	4.93%	27.60%	288+17=305	20.57%	2.82%	15.79%
		75 over	947	35.49%	8.75%	39.21%	439+27=466	31.42%	4.31%	19.30%
	Total		2668	100.00%	24.66%	N/A	1412+71=1483	100.00%	13.71%	N/A
Shower Chairs	Gender	Male	355	45.63%	3.28%	6.69%	154	37.84%	1.42%	2.90%
		Female	423	54.37%	3.91%	7.67%	253	62.16%	2.34%	4.59%
	Age Group	60 - 64	111	14.27%	1.03%	3.32%	63	15.48%	0.58%	1.89%
		65 - 69	161	20.69%	1.49%	5.14%	101	24.82%	0.93%	3.22%
		70 - 74	140	17.99%	1.29%	7.25%	76	18.67%	0.70%	3.94%
		75 over	366	47.04%	3.38%	15.16%	167	41.03%	1.54%	6.92%

	Total		778	100.00%	7.19%	N/A	407	100.00%	3.76%	N/A
Personal Emergency Response System	Gender	Male	879	35.82%	8.13%	16.57%	782	35.35%	7.23%	14.74%
		Female	1575	64.18%	14.56%	28.57%	1430	64.65%	13.22%	25.94%
	Age Group	60 - 64	394	16.06%	3.64%	11.80%	352	15.91%	3.25%	10.54%
		65 - 69	581	23.68%	5.37%	18.55%	525	23.73%	4.85%	16.76%
		70 - 74	454	18.50%	4.20%	23.51%	411	18.58%	3.80%	21.28%
		75 over	1025	41.77%	9.47%	42.44%	924	41.77%	8.54%	38.26%
	Total		2454	100.00%	22.68%	N/A	2212	100.00%	20.45%	N/A
Time management products	Gender	Male	608	49.31%	5.62%	11.46%	N/A	N/A	N/A	N/A
		Female	625	50.69%	5.78%	11.34%	N/A	N/A	N/A	N/A
	Age Group	60 - 64	260	21.09%	2.40%	7.78%	N/A	N/A	N/A	N/A
		65 - 69	333	27.01%	3.08%	10.63%	N/A	N/A	N/A	N/A
		70 - 74	264	21.41%	2.44%	13.67%	N/A	N/A	N/A	N/A
		75 over	376	30.49%	3.48%	15.57%	N/A	N/A	N/A	N/A
	Total		1233	100.00%	11.40%	N/A	N/A	N/A	N/A	N/A
Electrotherapy device for pain	Gender	Male	459	31.18%	4.24%	8.65%	203	28.12%	1.88%	3.83%
		Female	1013	68.82%	9.36%	18.38%	519	71.88%	4.80%	9.42%
	Age Group	60 - 64	435	29.55%	4.02%	13.02%	221	30.61%	2.04%	6.62%
		65 - 69	424	28.80%	3.92%	13.54%	205	28.39%	1.89%	6.55%
		70 - 74	269	18.27%	2.49%	13.93%	134	18.56%	1.24%	6.94%
		75 over	344	23.37%	3.18%	14.24%	162	22.44%	1.50%	6.71%
	Total		1472	100.00%	13.61%	N/A	722	100.00%	6.67%	N/A

%[#]: Percentage related to total number of total needs / urgent total needs of each specific assistive technology

%[##]: Percentage related to total number of older people in database (10818 older people)

%[###]: Percentage related to the number of older people in specific gender or age groups

8.14 THE GLOSSARY

1. Walking Stick

A walking stick is a stick with a curved handle used for support when walking.

2. Travel Device:

The phrase “travel device” is used in CHARLS Database questionnaire official English translation. According to its original Chinese expression, “travel device” refers to a group of assistive technology products including scooter, tricycle that not only help older people with mobility but also carry goods and groceries while shopping.

3. Manual Wheelchair

A wheelchair is a chair with wheels. Manual wheelchairs are wheelchairs propelled by the user or pushed by another person.

4. Electric Wheelchair

A motorized wheelchair, powerchair, electric wheelchair or electric-powered wheelchair is a wheelchair that is propelled by means of an electric motor (usually using differential steering) rather than manual power.

5. Catheter and Urine Collecting Bags

The phrase “catheter and urine collecting bags” is used in CHARLS Database questionnaire official English translation. According to its original Chinese expression, “catheter” refers to urinary catheter, which can be inserted into the bladder through the urethra and allows free flow of urine; “urine collecting bags” refers to urine collection bags, which are designed to collect urine drained from the bladder via urinary catheter.

6. Toilet Series

The phrase “toilet series” is used in CHARLS Database questionnaire official English translation. According to its original Chinese expression, “toilet series” refers to commodes.

7. Corrective Lenses and Glasses

A corrective lens is a lens typically worn in front of the eye to improve vision because it allows the eye to focus light in the right spot on the retina.

8. Hearing Aids

A hearing aid is a small electronic device to wear in or behind the ear. It makes some sounds louder so that a person with hearing loss can listen, communicate, and participate more fully in daily activities. A hearing aid has three basic parts: a microphone, amplifier, and speaker.

9. Braille writing equipment/braillers

A braille writing equipment, or say, a brailler, is a machine for writing braille.

10. Smart/White canes

A white cane is a device that allows its user to scan their surroundings for obstacles or orientation marks but is also helpful for onlookers in identifying the user as blind or visually impaired and taking appropriate care.

11. Grasping tool or reach extender

A grasping tool or a reach extender, also known as a grabber arm, helping hand, picker-upper, extended gripper, long arm gripper, extended reach grabber, is a handheld mechanical tool used to increase the range of the user's reach when grabbing objects. A reach extender takes the form of a long metal or plastic pole with a handle at one end and a pair of jaws at the other end. The handle is equipped with a trigger that, when pulled, closes the jaws via a lever-and-spring system within the pole. The

jaws are open by default and become open when the trigger is released. Some reach extenders may possess a secondary trigger which locks the jaws in position around whatever object they are holding, so the user does not need to maintain a tight grip on the handle. Others have jaws equipped with suction cups for holding round objects more easily, and still others have small magnets for collecting lightweight metallic items. Variations on the basic form of a reach extender depend on what task needs to be accomplished, and significant variation is found in the length of the pole and the maximum weight the reach extender can bear.

12. Pressure Relief Mattresses

A pressure relief mattress is a mattress that uses a combination of engineered foam and air cells to redistribute pressure and prevent the formation of bedsores and ulcers by varying the pressure between a patient and the mattress.

13. Therapeutic footwear

Therapeutic footwears are specially designed shoes, or shoe inserts, intended to reduce the risk of skin breakdown and to prevent foot ulceration in diabetics.

14. Smart pillbox/Pill organiser

Smart pillbox and pill organiser are electronic pill boxes incorporates a storage device with built in reminder alarms, designed as a medication reminder when medicine is required at various times during the day.

15. Handrail and grab bar

Handrail and grab bar are secure rails, typically mounted on the wall, ceiling, or floor, to help weakened, disabled, or elderly individuals safely access and navigate rooms and facilities.

16. Ramps, portable

Ramps, portable, refers to portable ramps, which are inclined planes installed in addition to or instead of stairs. Ramps permit wheelchair users, as well as people pushing strollers, carts, or other wheeled objects, to access a building or a van more easily

17. Watches, talking/touching

Watches, talking/touching, refer to talking clocks that tell the time verbally through the touch of a button. They are available in many forms, ranging from tiny key chain clocks to bedside table clocks to digital touchscreen clocks.

18. Glucometer

A blood glucose meter is a small, portable machine that's used to measure how much glucose, which is a type of sugar, is in the blood.

19. Talking blood-pressure monitor

A talking blood-pressure monitor, also known as a blood pressure gauge, is a device used to measure blood pressure, composed of an inflatable cuff to collapse and then release the artery under the cuff in a controlled manner, and a mercury or aneroid manometer to measure the pressure with vocal function.

20. Alarm signallers with light/sound/vibration

Alarm signallers with light/sound/vibration refer to a group of products that alert people who are deaf and/or hard of hearing to changes within their environment. These devices can provide a warning signal in a modality that is accessible to them (such as through a vibration, or a flashing light, or an amplified signal) to alert them of imminent danger (such as smoke, fire or a security breach). These signallers or transmitters can also bring their attention to their environment, such as when a doorbell is pressed, a phone rings, or a baby cry.

21. Deafblind communicators

A deafblind communicator is a device that enable deafblind people to communicate with a braille keyboard and a refreshable braille display.

22. Electrotherapy device for pain

Electrotherapy devices deliver a mild level electric current through the skin to interfere the transmission of pain signals by exciting sensory nerves and stimulate the production of endorphins - the bodies' natural painkiller (Liu et al. 2020).

23. Shower chair

A shower chair is a device that offers postural support and stability and comes with or without armrests. Adjustable legs allow users to position the seat at the optimum height and also to overcome uneven surfaces. Shower chairs are usually fitted with non-slip rubber feet for safety and drainage holes for thorough washing. Wheeled chairs are also available which can make entering the shower easier for people with mobility issues or who require the use of a wheelchair.

24. Personal Emergency Response Systems

Personal emergency response systems, also known as medical alert systems, offer a fast and easy way for the elderly people with health issues, and those who live alone, to get help during an emergency, whether it be a medical issue, a fall, a fire, or any event that requires an immediate response. The most basic systems use a landline and consist of a base unit and a portable help button the older people can wear around the house, but there are cellular options and GPS-based mobile solutions for people on the go, as well as options that automatically send an alarm when a fall is detected.

These systems can include personal emergency alarm systems, global positioning system (GPS) locators, and fall detectors. To be specific: a fall detector is a device which can automatically detect if the user has fallen and raise an alarm call for help. Personal alarms are devices used to alert

someone, such as neighbours, relatives, friends or a monitoring centre, in an emergency, normally activated either by a button, or a tag. A global positioning system (GPS) locator is a device with GPS tracking unit, which is a navigation and positioning device with a person that uses the Global Positioning System (GPS) to determine the movement and geographic location.

25. Time management products

Time management products refer to time assistive products which is a group of products to help users with daily time management, especially for those with dementia and problems related to thinking, memory, behaviour and ability to perform everyday activities.

8.15 THE PRISMA FLOW OF LITERATURE CHOOSING AND CULLING FOR SECTION 2.4.4