

# ICT SUPPORTING HEALTHCARE FOR CHINESE ELDERLY AT HOME: PERSPECTIVES OF INFORMAL CAREGIVERS AND PROFESSIONALS

*Research full-length paper*

*Track N°*

Zihao, Liu, M3S Research Unit, University of Oulu, Oulu, Finland, zihao.liu@student.oulu.fi

Raija, Halonen, M3S Research Unit, University of Oulu, Oulu, Finland, raija.halonen@oulu.fi

Muhammad, Ovais, Ahmad, M3S Research Unit, University of Oulu, Oulu, Finland, Department of Mathematics and Computer Science, Karlstad University, Karlstad, Sweden, & Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology, Poland, ovais.ahmad@kau.se

## Abstract

*Informal caregivers are a significant resource when elderly people need assistance and support to remain living at home. Today, state-of-the-art technology provides the possibilities of applying ways to ease the workload and make it possible to stay at home instead of living in an institutional care setting, such as hospitals or special sheltered accommodations. The current study analysed how information and communication technology (ICT) could support healthcare in Chinese homes from the perspectives of informal caregivers and healthcare professionals. The study focused on elderly people who benefit from caregiving or need personal assistance to help them live at home. A mapping study was conducted to identify existing ICT solutions, and qualitative semi-structured interviews were performed to obtain the perspectives of informal caregivers and professionals. The contributions were identified as objectives of using ICT solutions, relatives' feedback on ICT solutions, opinions about popular ICT solutions and thoughts about future ICT solutions. The empirical study revealed that alerting, communication, monitoring, positioning and assistance are the most important reasons to acquire and apply ICT-based support for elderly people living at home.*

*Keywords: Information and Communication Technology, ICT, Elderly, Home Care, Family Caregivers, Better Living, China, Mapping Study, Semi-structured Interviews.*

## 1 Introduction

Ageing is not only about getting old, it also entails developing chronic diseases and disabilities over time, such as physical, hearing and vision issues. Serious diseases and the dependence of elderly people have created a new area of research (Ward et al., 2011.)

In 2017, the growth rate of the population of China was estimated to be 5.32%, and the number of people older than 60 was estimated to be 241 million, representing 17.3% of the total population. The proportion of elderly in the population of China is expected to reach 30% in 2050 (NBSPRC, 2019). The Chinese government has already paid attention to including information and communication technology (ICT) in the country's healthcare industry (Zhao et al., 2009). However, informal care is an important part of a long-term healthcare system; in this type of care, a family member or friend provides caring activities to an elderly person on a voluntary basis (Francesca et al., 2011). Informal caregivers are usually the main group of people that look after frail elderly at home (Willemse et al., 2016). To investigate how informal caregivers utilise ICTs in the elderly healthcare field, the present study only contacted relatives under the age of 55.

The user experience and attitude toward current ICT solutions can provide very useful information for technologists and developers, such as increasing the functionality and effectiveness of the implementation of the ICT solutions (Kerbler, 2017). The current study aimed to explore using ICT as a way to enable the elderly to have better and healthier lives at home in China from the perspective of informal caregivers and professionals. The research problem was initiated by understanding that ageing is a global issue (e.g. Ward et al., 2011) and that the Chinese population, in general, is growing and the number of ageing people is increasing (see Du and Wang, 2016). Only a few studies about ICT-supported elderly healthcare focus on a Chinese environment, and new efforts and resources are required to address the increasing need and current situation in the field of applying ICT to support home-based elderly healthcare (Liu and Halonen, 2018). Thus, the research question for the present study was: *How can current popular ICT solutions support elderly healthcare at home in China from the perspectives of family caregivers and professionals?*

To achieve the goal, the state-of-the-art ICT solutions in the literature were first investigated using a systematic mapping approach at the abstract level (see Kitchenham et al., 2011). Then, the discovered theoretical results were applied as the basis for conducting in-depth interviews to answer the research question. In the second stage, the identified current prevalent ICT solutions were examined by conducting interviews with Chinese family caregivers and professionals. Therefore, a comparison was conducted between Chinese the interviewees' opinions and earlier studies to derive the study results. The interviews included open-ended, theme-based questions related to the results from the mapping study. The research was conducted by applying a theoretical approach and using a qualitative study design.

The study has two main contributions: it provides practical data and it fills a research gap in Chinese academia (see Du and Wang, 2016; Liu and Halonen, 2018). Furthermore, the study revealed major differences between the Chinese context and the literature research results from other parts of the world. The study's contributions can be divided in four areas: Objectives of using ICT solutions, relatives' feedback about the ICT solutions that are used, opinions about current popular ICT solutions (never used) and the development tendency of ICT solutions in the field of elderly healthcare (only from the professionals' perspectives). These findings are reported in detail in later sections in this paper.

## 2 Background

Recently, ICT has been extended to all areas of life, especially in the medical and healthcare domains (Lal and Adair, 2014). Healthcare is transferring into homes and communities in nowadays' ageing societies (Willems, 2010). ICT transfers the ability to control long-term chronic conditions from a medical doctor to a patient and from a hospital to home; it also promotes independent living and facilitates the ability to prolong life (Powell et al., 2010). People have high expectations that ICT can play a significant role in this process because it integrates healthcare technologies more closely with the everyday

lives of the elderly, caregivers and family members (Mort et al., 2009). Today, ICT provides various solutions to help the elderly manage their lives, obtain useful healthcare services and live conveniently (Afifi and Al-Hussein, 2014). The elderly should be supported in retaining their independence for activities of daily living, and self-care should be encouraged and enabled. In the case of reduced or restricted functionality, the elderly need more care and resources from the organisations that is responsible for economically-significant activities (Valencia, 2012.)

Over the last two decades, ICT has offered many versatile possibilities, such as tele-health options, medical sensors and wearable monitoring devices, complete with healthcare applications that can be used by individuals living at home (Vimarlund and Olve, 2005; Pantelopoulos and Bourbakis, 2010). E-health systems have been an important research topic in prior studies. For example, research has focused on combining web functions, network technology and mobile applications to build an integrated system in order to simplify the connection between elderly patients and healthcare professionals (eHealth, 2011.) Another significant research direction has focused on microelectronics and sensor-based technologies, such as Ambient Assistive Living, the Internet-of-Things (IoT) or smart homes. These solutions provide assistance by inserting ICT into a person's daily living environment (Nalin et al., 2016; Patel et al., 2015; Pang et al., 2015). Other studies have explored the elderly's receptivity to feedback about and usability regarding emerging technologies, and how to effectively train them to use new technology (Magnusson et al., 2004; Sayago et al., 2007).

In the Chinese business market, some leading enterprises have already made a significant investment in this field. For example, Tencent added a fitness tracking function to its popular instant messenger application, WeChat (Pai, 2015). The elderly often face challenges when they are dealing with new technologies, such as low self-confidence and physical limitations (Nguyen et al., 2014). However, technology anxiety is high among Chinese elderly (Guo et al., 2013). Some researchers have indicated that many Chinese elderly have little interest in emerging technologies, and their willingness to use new technologies is related to their educational level (Ma et al., 2016). Previous studies have also found that perceived usefulness and ease-of-use can influence the elderly's attitude; for instance, their direct acceptance of ICT solutions (Guo et al., 2013).

### **3 Research Methods and Process**

This research study included two stages: a systematic mapping study and a qualitative study based on interviews.

#### **3.1 Systematic mapping study**

A systematic mapping study has been widely used in the field of ICT research, and it helps researchers map a broader topic domain. Researchers can acquire an overview of the subject for further studies (Kitchenham et al., 2011.) The guidelines defined by Kitchenham et al. (2011) were adopted at the abstract level to retrieve the relevant literature.

##### **Defining the literature review question**

The objective of the mapping study was to obtain information about the state-of-the-art connection between ICT solutions and home-based elderly healthcare, which led to the following research question: *What existing, prevalent ICT solutions are used to support healthcare for the elderly at home?*

##### **Literature search**

The following key search terms were defined based on the literature review question and identified using a combination of different research domains: ICT, elderly, healthcare and home. At the beginning, the search terms included: 'elderly' or 'older people', 'health' or 'healthcare', 'home' or 'home-based' and 'information and communication technology' or 'ICT'. Then, pilot searches in bibliographic databases (Scopus, IEEE, ACM) were implemented to maximise the number of acquired papers. Based on the trial search results, singular, plural and verb forms were considered. Two synonyms for elderly, "senior" and

“aged”, were also included. Synonyms for ICT, such as “technology” and “digital”, were also tested; however, the search results did not return any more relevant papers. The final defined search string was: (“ICT” AND “elder\*” AND “home\*” AND “heal\*”) OR (“ICT” AND “old\*” AND “home\*” AND “heal\*”) OR (“ICT” AND “senior\*” AND “home\*” AND “heal\*”) OR (“ICT” AND “age\*” AND “home\*” AND “heal\*”).

Preliminary searches on different bibliographic databases were performed with the final search string to obtain an initial understanding of the availability of relevant papers. The search string was adjusted to fit the syntax of each database and to search titles, abstracts and keywords. According to the preliminary search results, Scopus and Web of Science provided the highest number of high-quality papers, representing the focus of this study. These two databases also contained papers in the field of information technology and healthcare. Information specialists at the local university library were consulted in the selection of databases. Time restrictions for the searches were defined so that papers published after the beginning of 2015 were included as the goal target to obtain state-of-the-art information.

### Study selection and data extraction

The search results were uploaded to Refworks. After eliminating the duplicate references, the remaining 477 papers were screened for inclusion and exclusion in three rounds (Table 1).

Round	Inclusion Criteria	Exclusion Criteria	Total
1.	Metadata: A conference paper OR a journal paper	Not written in English OR a summary OR an extended abstract OR a thesis OR a review OR an editorial OR an article in press OR published before 2015	197
2.	Title, keywords and abstract: setting is ICT AND elderly/older people AND support/better living	Clearly outside the scope of ICT OR elderly/older people OR not focused on a home environment	124
3.	Light reading: criteria from round 2 exists in the paper	The content cannot answer the research question	59

Table 1. Inclusion/exclusion criteria for the primary study selection.

As summarised in Table 1, thorough screening and assessment were performed to select the articles from the 477 papers to include in the study. In this round, each article was classified as accept, reject or cannot decide. All the articles marked as cannot decide were left for the next round. After the final round, 59 papers were chosen for inclusion as the primary studies from the literature.

## 3.2 Qualitative research approach

The objective of conducting the interviews was to accept or refute the literature review findings and to obtain the first-hand experiences that healthcare professionals and caregivers have about existing ICT support solutions for the elderly.

### Study participants

To exploit the literature review findings, three people representing healthcare professionals and 10 non-professionals were interviewed during July and August 2017. The healthcare professionals were medical specialists and the non-professionals were family caregivers. An informal caregiver is a person who delivers unpaid and ongoing support for daily living activities to a person with a disease or disability (Roth, Fredman and Haley, 2015). The non-professionals group consisted of five males and five females. Most of the caregivers were 25–34 years of age and had more than two years of experience taking care of an older family member. The inclusion criteria for the non-professionals were: 1) being the primary family caregiver for at least one elderly person in his/her family, 2) the elderly person was 60 years of age or older (see WHO, 2015) and 3) the family member had a minimum of two years of caregiving

experience.

### **Data collection**

Semi-structured interviews were conducted with the 13 participants. The interview guide was developed in two versions (English and Chinese) based on the earlier theoretical mapping study and Whiting's guideline (Whiting 2008). The interview guide included questions about the caregivers' experiences and opinions about the impact of current ICT solutions on the elderly's home healthcare domain, such as their opinions on the purpose of using ICT solutions, their experience with ICTs and the benefits of implementing ICTs. The interviewees were also asked to comment on the current popular ICT solutions found in the literature, even if they had never used them.

Two pilot interviews, including one healthcare professional and one family caregiver, were conducted to test and validate the interview guide. The interview contents were reorganised, restructured and reformulated in light of the feedback. All the interviews were audio-recorded with the interviewees' consent, and they were conducted in quiet and peaceful environments. The interviewees were encouraged to talk freely and "as much as possible" about the topics.

The narrative method was applied to guide the interviews (see Larsson and Sjöblom, 2010). The interviewer had the ability to change the sequence of the questions or to add some impromptu questions to facilitate collecting useful information. Before starting the interviews, the objectives of the study were explained to the participants, and during the interview process, the interviewer explained the questions to avoid misunderstanding. Each interview was carried out via a face-to-face conversation in Chinese. Finally, all the interviewed materials were transcribed verbatim to retain the meaning of the responses.

### **Data analysis**

The recorded interviews were transcribed, examined carefully and analysed thematically. The literature review findings played a guiding role in analysing the interviews thematically. For example, each of the ICT solutions discovered from the mapping study could be the basis for a classification scheme for conducting the data analysis from the interviews. The discussion started by comparing interviewee-verified data with the findings of the previous mapping study to examine whether the popular ICT solutions identified from the mapping study were beneficial and applicable in the current Chinese context. The interviewed family caregivers were labelled as N1–N10 (i.e. "Non-professional number 1–10") and the interviewed healthcare professionals (experts) were labelled as E1–E3 (i.e. "Expert 1–3"). The interviews lasted approximately 35 to 45 minutes, and the average interview duration was 38.3 minutes.

## **4 Results**

### **4.1 Mapping study results**

The primary studies from the literature search were classified according to the paper title, abstracts and content of the text to identify current popular ICT solutions in the field of 'using ICT to support elderly healthcare'. Six state-of-the-art solutions were identified in the field of applying home-based ICT solutions to support elderly healthcare (Table 2).

The solution of smart homes or Ambient Assisted Living was the most studied research field in the last five years (2015–2019). It accounted for more than one-third of the total primary studies. To create a required living environment, various sensor-based devices were the most popular research topic. Integrating various ICT systems to create a novel synthesised platform was the second-most studied topic. One-fourth of the research papers were published in this area. This demonstrates that many researchers still struggle with combining different single functional ICT systems into a large multifunctional platform to solve several elderly healthcare issues at the same time. Tele-healthcare or eHealthcare solutions were another significant focused area, which occupied one-sixth of the total primary studies (Table 2).

Identified ICT solutions	Total	Primary studies
Smart homes/Ambient Assisted Living/Living lab	21	[P04], [P06], [P11], [P17], [P21], [P25], [P27], [P30], [P33], [P38], [P39], [P40], [P44], [P45], [P46], [P47], [P50], [P52], [P57], [P58], [P59]
Functional smart devices (wearable, TV or web-based apps, etc.)	8	[P14], [P16], [P19], [P20], [P34], [P36], [P54], [P55].
Integrated/multi-functional ICT platform/system	15	[P01], [P03], [P08], [P22], [P23], [P24], [P26], [P29], [P31], [P32], [P37], [P42], [P48], [P51], [P53].
Robotic solution/virtual butler	2	[P02], [P05]
Serious games, exergames, video and virtual reality (VR) game training	5	[P10], [P13], [P28], [P35], [P41]
Tele-healthcare or eHealthcare	8	[P07], [P09], [P12], [P15], [P18], [P43], [P49], [P56]

Table 2. Identified state-of-the-art ICT solutions.

Eight of the primary studies focused on the single smart device solution. Because a smart device is no longer a novel technology, one can see that the research trend was moving away from “old fashioned” technologies to emerging concepts. Altogether, the four solutions listed above accounted for over 80% of the recent studies. The fewest number of primary studies were published in the field of analysing robotic technique to support elderly healthcare. At the same time, exergames seemed to be a relatively fresh idea in recent years, since only five of the primary studies focused on them.

## 4.2 Empirical study results

This section reports on what the interviews revealed about the participants' viewpoints regarding the suitability and usability of ICT-based solutions in healthcare provided at home. The participants also talked about the advantages and disadvantages of the applied ICT solutions. Moreover, they expressed interest in the requirements and costs related to implementing the ICT solutions, and they shared their opinions and feedback about current and future ICT solutions. The professionals also provided their thoughts about the development trends in this field. The interview findings were discussed and analysed, and all the emerging themes were reported in detail.

### 4.2.1 Objectives of using ICT solutions

Based on the interview responses, there were five major objectives of applying ICT solutions: positioning, monitoring, alerting, communication and assistance. Three of the interviewees (N8, N9, E3) mentioned that their initial motivation to buy a smartphone or a wearable device (e.g. intelligent bracelet) was to help them determine their elderly family member's location. These participants faced the same situation in which one of their older family members had Alzheimer's disease. They thought a smartphone and wearable device could help them easily locate their grandmother/grandfather. One interviewee (N8, a son with 19 years of caregiving experience) shared the following opinion:

*You know, there is a common situation that a senile dementia patient went out and forgot who he was, what he wanted to do, where he was going. [...] The older person may suffer lots of serious problems like falling, losing the way home forever or a disease incident. At that time, when they are missing we need a tool to [...] to find where they are immediately.*

A similar experience was shared by an expert (E3, a daughter with 20 years of caregiving experience): *Before I bought a smartphone for my father, one day, the security told me he saw my father in a place very far from my residential quarter. The security said: “your father seems to be lost and forgot the way home”. Hearing this, I called the police for help instantly. From then on, I made a firm decision to buy a device, which I can use to know where my father is.*

The second purpose of using ICTs was to monitor the older family members' behavioural states and physical health status. For example, because the elderly person they were caring for experienced dizziness, five interviewees (N1, N2, N4, N8, E2) noted they wanted to be able to conveniently detect if their family members had fallen. N2 said: *'Since my grandparents were over 80-years-old, and both of them [had]e bodily weakness, I need a camera at home; then I could check, every once in a while, that everything was on the right track'*.

N4 reported an earlier incident: *My grandmother was 85-years-old. She lived alone and had heart disease for many years. One day, two years ago, she fainted on the floor at home. No one saw it at that time. About half an hour later, I visited my grandma's home and sent her to the nearest hospital immediately. The doctor told me, fortunately, I came back in time to save my grandma. Afterward, I bought a monitoring camera for my grandma, put it in the living room and linked it with my mobile phone. Half a year later the same situation happened. This time I saw quickly, within five minutes, and saved a sudden incident, successfully.*

N2 and N8 had slightly different motivations for using the ICT solution (camera) due to a dissimilar illness situation. N2 said: *'For people with dementia, the camera in the hallway and living room can tell me whether my mother was at home or went out of the front door'*.

Moreover, one expert (E2, a son with 12 years of caregiving experience) had a general expectation of using ICT tools to monitor his parents' blood pressure or heart rate. Thus, he could examine and control their health condition at home: *'Because I am a doctor, I have the basic knowledge of physical health and that was the reason I bought some ICT tools to monitor my older parents' body index, like blood pressure, heart rate and body temperature'*.

Throughout the interviews, all the participants agreed that they preferred an alerting device, so that the emergency issue of the elderly (falling down, leaving home at midnight, abnormal health index, etc.) could be reported in time. For example, N10 (a son with 9 years of caregiving experience) said: *'In my point of view, alerting could be seen as one of the most important functions'*. N7 expressed similar thoughts: *'Perhaps, one life could be saved through a timely alerting.*

Communication was understood as another significant motivation for caregivers to use ICTs. Ten of the participants (N1, N2, N4, N5, N6, N7, N9, E1, E2, E3) repeatedly referred to 'easy contact'. They unanimously considered that ICT solutions could help them overcome geographical difficulties, so they could see or meet their parents or grandparents at any time or any place. N6 (a granddaughter with five years of caregiving experience) was particularly confident about using ICT solutions: *You know, I live far away from my grandparents. Previously, I had to spend two hours on bus to meet them. Nowadays, ICT solutions like the internet, smartphones or tablets, can let us "see" each other conveniently just by a video chat.*

Assisting was the last driver of using ICT solutions mentioned by the interviewed caregivers. Interestingly, one expert (E1) mentioned that the trigger point for using ICTs was to apply it to manage and remind him of telling his parents to take their medicine on time. He said: *Because my mother had a really bad memory, I and my father needed to remind her all the times. However, sometimes also we forgot the important schedule, like taking pills or doing health check-up. Therefore, we bought a smartphone for my grandma, and it helps her to manage the health schedule.*

#### 4.2.2 Personal experiences with ICT solutions

The interviewees commented on a range of personal experiences with a variety of ICT solutions. To some extent, all the participants had already tested or used ICT solution to help them look after their older family members. The only difference was which ICT devices they used and for what purpose. For example, all the interviewees mentioned that they had bought their older relatives mobile phones (feature phone or smartphone) to enable convenient contact. N1 reported: *'Mobile phone was the basic tool that can help me to [stay in] contact with my grandfather without geographical limitation; therefore, I gave*

them one'. Five participants gave their older family members smartphones and tablets, and taught them now to use them. N5 shared a typical point: *'I bought an iPad to my grandparents for frequent video chatting and make their life more interesting'*. Seven interviewees (N1, N2, N4, N8, E1, E2, E3) revealed that they applied ICT solutions to deal with special diseases. One of them (E2) explained: *'I bought a sphygmomanometer to my father to monitor his blood pressure as he had hypertension for many years. This tool will report his health situation [to us] timely and accurately'*. Another respondent (E3) said: *'I gave my father a smart bracelet as he has the precursor of dementia, so that I can discover his location through it when he is lost'*. Only three participants (N2, N3, N7) bought a personal computer for their older family members and taught them how to play electronic games and how to use the internet.

N7 shared openly about her reason for supporting her grandfather in learning how to use a personal computer: *My grandfather usually likes to play mah-jong all day. I think it is better to have more interests in his life, [...]. I decided to buy a computer for my grandfather and teach him how to play the electronic games as well as how to find information and shopping on the internet. I think this might enrich his life experience.*

Unlike the non-professionals, the three professional interviewees taught their older family members to use online healthcare websites so they could manage and control their fitness by themselves. E1 noted: *'Although I am a doctor, I still use [the] eHealth service to help me take care of my older parents because it can provide more comprehensive advice and solution. I also taught them how to use it'*.

One interesting observation was that three non-professional interviewees used ICT solutions unconsciously. Throughout the interviews, they believed that they had not applied any ICT solutions when dealing with their older relatives. N3 (a son with 15 years of caregiving experience) elaborated this view: *'I did not buy any special ICT solutions for my mother. I control her personal situation just through face-to-face asking and video/audio chats'*. When the researcher told him that computers, mobile phones and networks were also forms of ICT solutions, he suddenly realised: *'Oh, because nowadays these devices were so popular and have been commonly used for many years that I did not treat them as some kind of advanced technologies'*.

#### 4.2.3 Relative feedback about the used ICT solutions

The interviews showed that convenience was perceived as the most significant benefit when applying ICT solutions. For example, four interviewees (N1, N2, N8, E2) noted that convenient monitoring is an advantage of these tools. N8 said: *'A home camera can easily help me and other relatives to check whether my parents have any abnormal behaviour or not'*. E2 added: *'Because I bought a sphygmomanometer to my father, we can monitor his blood pressure without visiting the hospital frequently, and it has saved us much time and energy'*. Three respondents claimed that ICT tools helped make it easier and more convenient to assist an elderly relative. N1 said: *My grandfather lives alone, and he had difficulties walking long distances. After I gave him an iPad and taught him how to use online shopping, there is no need for me to buy daily necessities and bring them to his home every day.*

Eight respondents agreed that 'convenient contacting' was an advantage of using ICT. N2 (a grandson with 4 years of caregiving experience) said: *'I and my grandmother lived far away from each other, and after my grandmother learned how to use smart tablets and a personal computer, we have been able to chat conveniently without visiting her house'*. Social interaction was another important benefit widely noted by the participants. Roughly half of them (6 participants) said that their older relatives use social applications to stay connected with others and make new friends via a smartphone or tablet. N7 explained: *My grandmother was a big fan of public square dancing, and afterwards she learned how to use smartphone applications. She downloaded one application and shared her dance experience and interesting things on that platform. Several months later, she already met hundreds of new friends.*

All the participants confirmed that using current ICT solutions can greatly reduce their burden of looking after their elderly family members.



However, the caregivers also noted that aspects of ICTs need to be improved. Functionality was the element that was most often mentioned in the interviews. Twelve respondents noted that only a few ICT solutions contained all the desired functions. Many of them could be improved by adding new functions in the future. E1 stated this view very well: *The camera was useful to make sure my mother is at home. However, in my opinion, it still can be improved to adapt to the customers' needs. For example, many home cameras only have a surveillance function. [...] The thing is, I do not know if my mother was safe or if she is doing some immoral things during the blank period. Therefore, I think it is better to add an alerting function to every home camera.*

Designing ICT tools specifically for older people was another element that was repeatedly mentioned. Eight respondents (N1, N3, N4, N5, N7, N10, E1, E2) explained that too few ICT solutions on the market were specifically designed for the elderly. N1 elaborated: *My grandfather is 88-years-old and has presbyopia. I need to help him to confirm the texts and numbers on the small screen every time he uses a smartphone or blood-pressure metre. Moreover, some ICT tools are too complicated for the elderly to learn. Thus, I would like get a product that is targeted only for older people.*

Except for the functional design and quality issues perceived in the ICT solutions, all the interviewees had a positive attitude about applying ICT solutions to help them take better care of their older family members. For example, E1 said: *In terms of the ICT solutions we have tried, we believe that the advantages outweigh the disadvantages, and we are very happy and feel excited to try new technologies'.*

#### 4.2.4 Opinions about the effect of using the current popular ICT solutions

Based on the mapping study results, and to collect more users' opinions, all six of the discovered ICT solutions were proposed to the interviewees. This section focuses on their thoughts, attitudes and viewpoints related to the current popular ICT solutions, which the participants had never tried.

##### **Tele-healthcare/eHealthcare**

Four of the 13 interviewees had never used the tele-healthcare solution during their care experience with their older family members. However, all of them had heard of it. Two interviewees were optimistic about using in this solution. One granddaughter (N9) caregiver said: *Since my grandparents were in good health, I never thought to try this tele-health method. However, I still think it could greatly reduce the uncontrollable situations'.* The other (caregiving son, N8) expressed: *I totally agree this solution is very useful for the family caregivers like me. [...] Because my work is quite busy, I cannot stay with my parents for a long time. The tele-healthcare method can fulfil my requirements because it can help the doctor and us to remotely control disease.*

Two interviewees thought this solution could only provide limited help for family caregivers. They also questioned the accuracy, reliability and privacy issues of the existing service providers in the market. As N1 explained: *I noticed that some of the so-called 'experts' in the tele-healthcare websites provide only an incomprehensible description for a minor illness, like faucitis, and the users usually cannot understand the hidden meaning of this information. They still need to visit normal hospital physically.* The other (N5) questioned: *I just want to ask if you can guarantee that the suggestions, answers and methods from the remote experts are right and accurate information. And can you guarantee your privacy like health information is not leaked or the camera is not controlled by others?*

##### **Smart homes and ubiquitous environments**

None of the interviewees had experience using a smart environment solution. However, all of them showed great interest in applying this solution in the elderly healthcare domain. They were looking forward to the popularisation of smart home technology in the near future. N1 said: *This solution sounds amazing. I am happy to see my home becoming a smart living environment'.* Another (E1) noted: *It will significantly reduce my burden of taking care of my older parents if this solution is deployed in their home. For instance, there is no need for me to always remind my poor grandmother to turn off the gas.*

Although the interviewees had positive opinions of the smart environment solution, half of them were still worried about the implementation cost. They were concerned that they could not afford the deployment of this solution. N3 elaborated his viewpoint in detail: *My mother lives alone; she has pain in her leg, so she is somewhat disabled in action. [...] If she lived in the smart home, she could control everything to fulfil her demand without outside help. [...] However, I am just a salary man and cannot even afford some small smart devices, not to think about smart home solution.*

### **Multifunctional integrated ICT systems**

All the non-professional interviewees did not have the opportunity to use multifunctional integrated ICT systems to help them take care of their older family members. However, all of them had heard of or had seen these systems, for example, in the news and in advertisements. Different from the smart home solution, four of the interviewees were not interested in multifunctional integrated ICT systems (all of them were older than 45) even if they thought it was useful. They were most concerned about the difficulty of using of this system.

N10 explained his opinion particularly well: *I agree that this solution is useful. I have heard some multifunctional systems can record and update the patients' physical data in real-time through network technology. [...] We could receive that information at any time, any place. [...] As for me, I think some of the systems are too complicated to operate.* Another middle-aged interviewee (N8) added: *'Even if smartphones and computers were popularised nowadays, I am still not good at them. I feel there are many complex procedures to manipulate the applications or software'.*

### **Robotic solution and virtual butler**

All the interviewees thought that applying robotic technology in the elderly healthcare field was the correct direction. However, none of them had used robotic technology to support them in taking care of their older family members. Similar to the smart home solution, every interviewee was excited about this novel solution. They wanted to experience it soon, if the technical conditions were met. N4 said: *I definitely will be happy if I saw a virtual butler in my grandmother's home'.* N9 said: *'Using a functional robot to help me to take care of my old grandmother sounds amazing; it can release me to a great extent.* However, two interviewees (N7, N5) worried about the safety issues. N5 said: *'Nowadays, more and more experts warn us about the artificial intelligence technology and I am afraid if the robot was controlled by someone else. How to solve that problem?'* All the interviewees agreed that a robotic solution will provide great support in terms of the elderly's physical healthcare. However, E3 said: *'A robot caregiver cannot replace human caregivers in the psychological level. Beyond question, the elderly need their relatives to stay with them'.*

### **Virtual reality and serious games training**

The serious game solution was a totally new concept for the interviewees. None of them had heard of it before. Only the professionals expressed interest in this solution. One of them (E2) said: *Fitness game training is a very good idea. Firstly, it will help the elderly spend their spare time in a worthy way. Secondly, there are not many premises required to implement this solution. Finally, it will provide useful supportive exercise to the elderly, like [for their] brain and limbs.*

Four of the non-professionals had a positive opinion about this solution. N2 said: *'If the serious game solution was popularised, I could play it with my grandparents. It will not only improve their body fitness, but also let them feel happy'.* The remaining non-professionals seemed to be uninterested in this solution. N3 said: *'I think my mother has no interest in playing games. She has other hobbies, and I also do not have time to teach her'.* N6 said: *'I doubt if this game solution can improve my grandparents' body function a lot because they already do exercise every day'.*

#### 4.2.5 Development trends in ICT solutions in this field

All the professionals agreed that, in addition to Western countries, the Chinese government attaches great importance to applying ICT solutions in the elderly healthcare field. They thought this area would reinforce high speed development from now on, especially in China. Multifunctional integrated ICT systems, smart devices, tele-healthcare and smart home solutions will become the main tools to solve elderly healthcare challenges because they thought these solutions were most likely to be applied in the near future. The oldest professional (E1) said: *'I think, at least in China, that smart devices and integrated ICT systems are the major research directions now because we have already mastered some techniques'*. Another professional (E3) revealed: *I saw from the news that the Chinese government put great effort into implementing a new policy, which aims at building the community tele-healthcare centre in each community. Each elderly patient's personal health information will be recorded in the community database and the community health consultants will follow the recorded information to give healthcare suggestions to the elderly or his family caregivers.*

However, E2 chose the smart home solution as the most important trend. He explained: *'I saw there was a lot of smart furniture with functionality in the market. For instance, an intelligent temperature-controlled fridge, a remote-controlled lamp and a smart lock. [...] I think the next step will be concentrated on the elderly population'*.

## 5 Discussion

The family caregivers' feedback highlighted five elements that induced them to implement ICT solutions to assist them in taking care of their elderly family members. These elements were (sorted based on the popularity of their mention by the interviewees): alerting, communication, monitoring, positioning and assistance. As Mihovska, Kyriazakos and Prasad (2014) reported, the elderly usually suffer from health problems, such as weaker body functions and declining memory. These issues were also mentioned by the interviewees who noted that reducing their influence could help the elderly have easier and more efficient lives.

All the interviewees mentioned alerting as a good reason to implement ICT solutions. Ten of the 13 interviewees used ICTs for easier communication. Nearly half (6 out of 13) of the interviewees stated monitoring as an important reason for implementing ICT solutions. Three interviewees noted that positioning was the main reason that impelled them to use ICTs. Finally, only one interviewee mentioned assistance as an objective.

The use of mobile phones was the ICT solution that most of the non-professional interviewees used. However, most of the older family members used feature phones because smartphones and tablets were more difficult for them to operate. Moreover, only three of the non-professionals had taught their grandparents to use a computer and network technology for the same reason. The same situation was reported in a previous study (Guo et al., 2013). The present study proposes that technology anxiety is still perceivable among Chinese elderly. However, all the professional interviewees had used smart devices and integrated ICT systems. This could be because professionals usually have more opportunities to learn this technology because their work provides more possibilities for doing so.

Guo et al. (2013) and Ma et al. (2016) reported that emerging technologies face significant challenges among the Chinese elderly related to healthcare issues. Those studies found that Chinese elderly resist using new ICT solutions. Based on the participants' feedback in the present study, the emerging technologies, for example, smart home solutions, robotic solutions and serious game solutions, seemed to be novel concepts in China. None of the interviewees had used these technologies within their caregiving career.

According to the interviewees, convenience was the most significant benefit when the informal caregivers applied ICT solutions. This can be expanded to many aspects, for instance, convenient monitoring of the fitness status of the elderly (healthcare aspect), convenient living in daily life (assistive aspect)

and convenient contact with family members and friends (social interaction aspect). All the interviewees agreed that ICT solutions can greatly reduce the care burden for informal caregivers. This finding supports the results reported by Mort et al. (2009) and Afifi and Al-Hussein (2014).

In all, the main research question was answered by identifying alerting, communication, monitoring, positioning and assistance as the most important reasons to implement ICT-based support for the elderly at home in the Chinese context.

### The implications and limitations of the study

Six summarised state-of-the-art ICT solutions were identified through the systematic mapping study results (Figure 1). However, only three of the solutions are popular in China based on the interview results. The interview results also revealed that the most widely used ICT solutions in China were personal smart devices (computers, mobile phones, etc.), tele-healthcare (i.e. network technology) and ICT systems. The related purposes included improving convenience and quality of life, helping caregivers easily stay in contact with their elderly family members and dealing with special diseases.

Based on the interview results presented in Section 4.2.4, the deployment of a multifunctional integrated ICT system solution was on a small-scale; it is usually applied in hospitals or other relevant healthcare institutions, such as nursing homes. It was still a relatively new concept for most people in China.

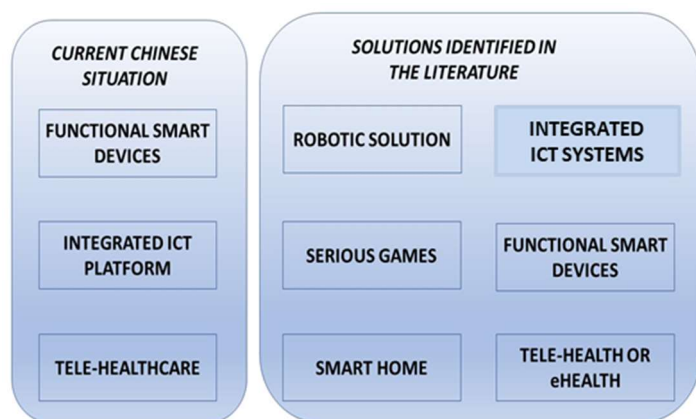


Figure 1. Current situation in China and in the literature.

Utilising a functional smart device to support elderly healthcare seems to be the ICT solution that is most often used in China, since all the interviewees experienced it during their time as a family caregiver. Smartphones and tablets were the types of equipment that were most often used by family/informal caregivers. This indicates that a functional smart device solution is relatively mature. Tele-healthcare was the second most applied solution in China; nine of the 13 interviewees had used it before. Finally, only the three professionals had used the multifunctional ICT system solution as part of their work.

Prior studies in other regions show that emerging technology, such as Ambient Assistive Living smart homes and the IoT have been investigated for years (Nalin, Baroni and Mazzara, 2016; Patel, Asch and Volpp, 2015; Pang et al., 2015). However, none of the interviewees had used the smart home solution, the serious game solution or the robotic solution during their caregiving career. This may indicate that the smart environment solution and robotic technology are not popular in the elderly healthcare industry in China. This cross-disciplinary research field was still very new in China at the time the present study was conducted. Consequently, it offers significant innovative research opportunities.

Previous results have also showed that knowing how to use the popular ICT solutions is one of the premises of applying them. For instance, a family caregiver needs to know how to utilise the network technology without any difficulties (Sayago et al., 2007). According to the interviews, members of the older generation in China do not seem to be interested in ICT solutions they need to use by themselves. For example, the interview results showed four of the interviewees, who were older than 45, had a passive attitude towards using the integrated ICT systems solution and the serious game solution. One can assume that this hesitancy exists because many older Chinese adults lack the skills to use information technology. Therefore, it is necessary to increase the knowledge and improve the skills of members of the older generation in China.

In relation to the family caregivers' feedback about improving the current ICT solutions, the interviewees noted that it was important to make the operation procedures as simple as possible. Also Guo et al. (2013) earlier reported that ease-of-use is the determining factor that can impact receptivity towards ICT solutions for the elderly. In addition, the presents study's results showed that there is an urgent need to develop and design more useful functions that should, specifically, focus on older citizens. The present study's interview results also showed there is no significant difference between non-professionals and professionals in terms of the objectives, experiences and feedback of using ICT solutions. All the professionals agreed that sensor-based technologies, such as smart homes, smart devices and multifunctional ICT systems, are the current development trends. To summarise, all the participants were looking forward to the new era of applying ICT in the elderly healthcare domain. They also had an open and positive attitude towards accepting disruptive technologies.

A major limitation of this study is that only 13 participants were interviewed. As most of the interview participants were from the southern part of China, and the participants were not randomly sampled, it is unknown if their opinions differed in any significant way from people in the northern part of China. Thus, the collected data might have regional differences. Consequently, the transferability and generalisability of the analysed results are questionable. Moreover, only one of the three interviewed professionals was primarily engaged in nursing affairs; thus, if the conditions permit, it would be better to include more specialists in nursing and healthcare in future work.

## **6 Conclusion**

This study applied a systematic mapping approach to identify the existing research focusing on the current popular ICT solutions in the field of elderly healthcare. To validate the discovered ICT solutions in the current context of China, the semi-structured interview method was implemented with professionals and non-professional caregivers.

This study makes several contributions to this field. It provides an overview of the current popular ICT solutions in the elderly healthcare field in the past five years. It identified previous research on this topic and shed light on the research trends. It showed the previous priority research areas and identified the research areas that have being ignored (e.g. only three papers focused on the robotic solution in elderly healthcare). Thus, this study provides a significant starting point for potential research in the future. The study applied the theoretical findings in the context of China. It collected detailed empirical data from the perspectives of Chinese family caregivers, and it provided comprehensive qualitative analyses of the impact of ICTs in the elderly healthcare domain. To some extent, the findings revealed how Chinese citizens apply current ICTs to support better healthcare for the elderly, and it fills the gap in the literature regarding the lack of relevant studies in the Chinese context in this field (see Liu and Halonen, 2018).

This study suggests significant future research directions. For example, the study's results could be used to analyse the differences of the opinions between Chinese informal caregivers and Western caregivers, and to identify the challenges of applying ICTs in informal caregiving environments. In the future, research could focus on following the technology development trend and studying how to apply each innovative ICT solution in this area, for instance, smart environment buildings, serious game development, VR or augmented reality technology, real-time healthcare supporting systems and artificial intelligence (robotic solution) and block-chain technology, by including the elderly person's attitude about and the caregiver's experience of emerging ICTs, as well as their feedback about those technologies.

## References

- Afifi, M. and M. Al-Hussein (2014). "Benchmark study for technological options available for older adults to reduce family and caregiver burden." *Gerontechnology* 13 (2), 164. doi: 10.4017/gt.2014.13.02.161.00
- Du, P. and Y. Wang (2016). "Population ageing and the development of social care service systems for older persons in China." *Ageing in Developing Countries* 1 (1), 40–52.
- eHealth. (2011). *European Commission Information Society and Media. Policy and Research ICT for a Healthier EU*. URL: [http://ec.europa.eu/information\\_society/doc/factsheets/009-ehealth-en.pdf](http://ec.europa.eu/information_society/doc/factsheets/009-ehealth-en.pdf) (visited on 02/22/2018).
- Francesca, C., L. Ana, M. Jérôme and T. Frits (2011). *OECD Health Policy Studies Help Wanted? Providing and Paying for Long-Term Care: Providing and Paying for Long-Term Care*, OECD Publishing.
- Guo, X., Y. Sun, N. Wang, Z. Peng and Z. Yan (2013). "The dark side of elderly acceptance of preventive mobile health services in China." *Electronic Markets* 23 (1), 49-61. doi:10.1007/s12525-012-0112-4
- Kerbler, B. (2017). "Using information and communication technology in home care for the elderly." *Caregiving and Home Care*. IntechOpen. doi: 10.5772/intechopen.72083
- Kitchenham, B. A., D. Budgen and O. P. Brereton (2011). "Using mapping studies as the basis for further research: A participant-observer case study". *Information and Software Technology* 53 (6), 638–651.
- Lal, S. and C. E. Adair (2014). "E-mental health: A rapid review of the literature." *Psychiatric Services* 65 (1), 24–32. doi: 10.1176/appi.ps.201300009
- Larsson, S., and Y. Sjöblom (2010). "Perspectives on narrative methods in social work research." *International Journal of Social Welfare* 19 (3), 272–280.
- Liu, Z. and R. Halonen (2018). "ICT supporting healthcare for elderly in China: A systematic mapping study." *BLED 2018 Proceedings*. 14, 415–428. DOI <https://doi.org/10.18690/978-961-286-170-4.28>
- Ma, Q., A. H. S. Chan, P. L. Teh and S. N. Poon (2016, July). Over 60 and ICT: Exploring factors that affect older adults' ICTs usage. In: *International Conference on Human Aspects of IT for the Aged Population* (pp. 196–208). Springer, Cham.
- Magnusson, L., E. Hanson and M. Borg (2004). "A literature review study of information and communication technology as a support for frail older people living at home and their family carers." *Technology and Disability* 16 (4), 223–235.
- Mihovska, A., S. A. Kyriazakos and R. Prasad (2014). "eWALL for active long living: Assistive ICT services for chronically ill and elderly citizens." In: *IEEE International Conference on Systems, Man and Cybernetics (SMC), 2014* (pp. 2204–2209). IEEE. doi: 10.1109/smc.2014.6974251
- Mort, M., C. Roberts and C. Milligan (2009). Ageing, technology and the home: A critical project. doi: 10.1016/j.alter.2009.02.004
- Nalin, M., I. Baroni and M. Mazzara (2016). "A holistic infrastructure to support elderlies' independent living. In: Maria Manuela Cruz-Cunha, Isabel Maria Miranda, Ricardo Martinho and Rui Rijo (Eds.), *Encyclopedia of E-health and Telemedicine* (pp. 591–605). Hershey, PA, USA: IGI Global. doi:10.4018/978-1-4666-9978-6.ch046
- NBSPRC (2019). "National Bureau of Statistics of China. Statistical Communiqué of the People's Republic of China on the 2017 National Economic and Social Development". URL: <http://www.stats.gov.cn/tjsj/ndsj/2018/indexeh.htm> (visited on 02/05/2019)
- Nguyen, T. T. H., T. Tapanainen and T. Obi (2014). "A Review of Information and Communication Technology (ICT) Training for Elderly People-toward Recommendations for Developing Countries." In: *PACIS* (p. 267).

- Pai, A. (10.02.2015). *Messaging app WeChat adds WeChat Sports for fitness tracking*. URL: <http://www.mobihealthnews.com/40474/messaging-app-wechat-adds-wechat-sports-for-fitness-tracking> (visited on 02/22/2018).
- Pang, Z., L. Zheng, J. Tian, S. Kao-Walter, E. Dubrova and Q. Chen (2015). "Design of a terminal solution for integration of in-home health care devices and services towards the Internet-of-Things." *Enterprise Information Systems* 9 (1), 86–116.
- Pantelopoulos, A. and N. G. Bourbakis (2010). "A survey on wearable sensor-based systems for health monitoring and prognosis." *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, (40:1), pp.1–12.
- Patel, M. S., D. A. Asch and K. G. Volpp (2015). "Wearable devices as facilitators, not drivers, of health behavior change." *Jama* 313 (5), 459–460.
- Powell, J., L. Gunn, P. Lowe, B. Sheehan, F. Griffiths and A. Clarke (2010). "New networked technologies and carers of people with dementia: An interview study." *Ageing & Society* 30 (6), 1073–1088.
- Roth, D. L., L. Fredman and W. E. Haley (2015). "Informal caregiving and its impact on health: A reappraisal from population-based studies." *The Gerontologist* 55 (2), 309–319.
- Sayago, S., P. Santos, M. Gonzalez, M. Arenas and L. López (2007). Meeting educational needs of the elderly in ICT: Two exploratory case studies. XRDS: Crossroads, *The ACM Magazine for Students* 14 (2), 2.
- Valencia, M. I.B. (2012). "Aging population: A challenge for public health. Colombian Journal of Anesthesiology" (40), pp. 192-194.
- Vimarlund, V. and N. Olve (2005). "Economic analyses for ICT in elderly healthcare: Questions and challenges." *Health Informatics Journal* 11 (4), 309–32.
- Ward, S. A., S. Parikh and B. Workman. (2011). "Health perspectives: International epidemiology of ageing." *Best Practice and Research Clinical Anaesthesiology* 25 (3), 305–317.
- Whiting, L. S. (2008). "Semi-structured interviews: guidance for novice researchers." *Nursing Standard* 22 (23), 35–40.
- WHO, World Health Organization (2015). "World report on ageing and health 2015." URL: <http://who.int/ageing/events/world-report-2015-launch/en/> (visited on 8/12/2019).
- Willems, D. (2010). "Varieties of goodness in high-tech home care." *Care in Practice: On Tinkering in Clinics, Homes and Farms*, 257–276.
- Willemse, E., S. Anthierens, M. I. Farfan-Portet, O. Schmitz, J. Macq, H. Bastiaens, T. Dilles and R. Remmen (2016). "Do informal caregivers for elderly in the community use support measures? A qualitative study in five European countries." *BMC Health Services Research* 16 (1), 10 pages. DOI:10.1186/s12913-016-1487-2
- Zhao, J., Z. Zhang, H. Guo, Y. Li, W. Xue and Y. Chen (2009). "E-health in China, our practice and exploration." In *Proceedings of the 31st Annual International Conference of the IEEE Engineering in Medicine and Biology Science, Minneapolis, MN*, 4888 (489).

[The list of original papers analysed in the mapping study can be requested from the authors.]