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ICT supporting healthcare for elderly in China: A systematic mapping study

ZIHAO LIU & RAIJA HALONEN

Abstract Ageing population is a global issue. The numbers of elderly people with health problems are increasing globally. This raises the demand for better quality and efficient healthcare services for elderly. Modern information and communication technology (ICT) offers numerous means to support people's lives, and also create the convenience to receive and deliver quality and efficient healthcare services. ICT has become natural part of healthcare, and is entrusted with an important role to support healthcare for elderly in the world context. China, like other countries, also faces fast ageing population. How to better support Chinese elderly's lives and deliver quality and efficient healthcare becomes a great challenge. Through a systematic mapping study this study analysed how the means of ICT in healthcare for elderly in China are discussed in prior literature. The results showed that the existing studies addressing this issue are extremely scarce and relatively recent. The research field in China is still quite young and immature, and more studies focused on the Chinese context in this research field are urgently needed.

Keywords: • Information Communication Technology • ICT • Elderly • Healthcare • China • Systematic mapping study • Bled eConference •

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1 Introduction

The numbers of elderly people with health problems are increasing globally. This raises the demand for better quality and efficient healthcare services for elderly. Elderly usually suffer from health problems such as weaker functionality, and less ability to deal with complicated situations (Mihovska et al., 2014). Nowadays, the majority of elderly receive care predominantly from their family members (Levine et al., 2010). The informal care givers often face intense caring tasks like constant presence with the elderly while quality of healthcare delivered to elderly declines (Hoffmann & Rodrigues, 2010).

China differs from others; it is a developing country with huge population and under-developed healthcare system (Wu, 2016). There is an increasing need to improve healthcare for elderly especially in the context of China. The purpose of this study was to analyse how the information and communication technology (ICT) supports elderly healthcare in China is discussed in literature. The topic was seen significant due to the identified issues related to ageing in the world and especially in China (see e.g. Du & Wang, 2016).

In recent years, ICT has been extending to all area of life. ICT solutions such as tele-health services, medical sensors, and healthcare applications, are widely used and have become natural part of healthcare (Vimarlund & Olve, 2005). ICT is entrusted with the important role of revolutionise traditional approaches in healthcare. Future proposals have concentrated on empowering ICT's capabilities to support people' lives, and improve the quality and efficiency of healthcare. (eHealth, 2011.)

According to National Bureau of Statistics of China (NBSPRC), the number of Chinese citizens aged 60 or over has exceeded 241 million by the end of 2017, representing 17.3% of the total population. Moreover, the Chinese government predict the number of elderly in China will continue to grow until 2050, and the proportion of the Chinese elderly population will finally reach 30% (NBSPRC, 2018). How to better support elderlies' lives and deliver quality and efficient healthcare becomes a great challenge.

To catch the purpose of the current study, a research question was posed: What is known about ICT and Chinese elderly healthcare? The research question was answered with the help of a systematic mapping study (see Kitchenham & Charters, 2007). The rigorous mapping study revealed urgent need to carry out more research. In literature, ICT supported elderly healthcare has been widely studied in the world context. However, even if a vast population is ageing and facing ageing-related problems, only insufficient scientific research is done to provide tools for elderly and relevant stakeholders providing healthcare and wellbeing.

The remainder of the paper is as follows. Section 2 gives the overview of background information, followed by research approach. Section 4 presents results, and the paper ends with discussion and conclusions.

2 Background

The issues related to ageing population confirm the necessity of paying greater attention to elderly healthcare. When studying ICT support healthcare for elderly especially in China, it is important to understand what the current situation is. These topics are presented next.

2.1 Issues Related to Ageing Population

Ageing population is a global issue and raises a remarkable problem for the communities that settle elderly, and especially for health and social care providers (Howdon & Rice, 2018). In general, costs related to health and long-term care are expected to increase in the OECD countries 3.3 and 7.7 percentage of GDP between years 2010 and 2016, respectively, and in the BRICS countries the increase is expected 2.8 and 7.3 percentage, respectively (de la Maisonneuve & Martins, 2015).

Ashby and Beech (2016) pointed out several issues related to ageing e.g. limited financial status leading to choose between healthy food and keeping warm; increased risk of falls of the elderly; hidden reason behind falls and injuries; outdated medication; and social isolation. Furthermore, getting passive and inactive in daily life is identified a notable issue among elderly, and getting people activated requires resources but brings profits to the life of the elderly and decreases costs of healthcare (Muramatsu et al., 2017).

2.2 ICT Support Elderly Healthcare in World Context

Modern ICT offer numerous means to support people's lives, manage their health, and also create the convenience to receive and deliver quality and efficient healthcare services (Afifi & Al-Hussein, 2014).

E-health systems such as electronic health and medical records system, telemedicine and telehealth systems, and also web or mobile health applications, provide the platform to centralize and manage health data and facilitate the process to transfer it between elderly patients and healthcare professionals (eHealth, 2011).

The concept of Ambient Assistive Living (AAL) drives the new trend to embed ICT in the living environments to support and assist the daily lives, especially for elderly and disable people (Nalin et al., 2016). ICT devices integrating microelectronics, sensor manufacturing and data analysis techniques, are widely used to monitor the health situation and support daily lives (Patel et al., 2015).

Utilising Internet-of-Things (IoT) is needed to provide integration between healthcare systems for ageing population. IoT offers possibilities to cover larger spatial and temporal coverage of healthcare services to meet the needs of the ageing population. Moreover, IoT-enabled healthcare services will be more efficient and available for users everywhere. (Pang et al., 2015.)

Countries around the world are paying greater attention on the development of care-related ICT systems and devices. According to the statistic, European countries have the advanced E-health industry that develops the chain of digital health systems, and its size has reached around 20 billion euros (eHealth, 2011). Japan with its rapid pace of the ageing population has huge investments in AAL market and estimated reach around 5 billion US dollars by 2024 (ResearchAndMarkets, 2018).

2.3 ICT Support Elderly Healthcare in the Context of China

Chinese government has marked the importance to the construction of ICT techniques in healthcare industry (Zhao et al., 2009). Some influential companies also tried to make innovation in this field. Alibaba invested in building 'future hospital' as an E-health innovation. Patients and healthcare professionals can reach each other and use hospital functions, like clinic and medical services, via an 'online hospital' platform. (Wu, 2016.) Tencent has ready integrated fitness tracking function into WeChat, which is the most popular social media application in China (Pai, 2015).

Though the trend of using ICT to support healthcare appears positive in China, empowering ICT's capabilities to support elderly healthcare still suffer the challenges. Some studies indicated that many Chinese elderly resist to new ICT solutions due to technology anxiety (Guo et al., 2013). Based on their study in Hong Kong, Ma et al. (2016) reported that especially older adults who had higher education are more willing to use ICT enabled applications than the others, but one third of the 109 informants had never used ICT for their healthcare issues. Prior studies have investigated to what extent the Chinese elderly can adopt ICT. The results show that perceived usefulness and ease of use are determining factors to influence the receptivity towards ICT products for older citizens. Therefore, new ICT solution need to pay attention on the technology and service quality as well as provide good illustrations and training and removing their biased evaluations on new technology. (Guo et al., 2013.)

3 Methodology

Systematic mapping study is increasingly applied to in new research areas, in where few relevant and high-class primary studies are available but need to have a board overview. Researchers are able to prepare a synopsis for further studies. (Kitchenham & Charters, 2007.) This study intended to examine how the concerns of this study were addressed in the earlier studies, and to give backgrounds for practical studies. It was conducted by following the guidelines proposed by Kitchenham and Charters (2007), in order to have the rigorous protocol to scan studies, extract and classify data, and analyse and report the study results.

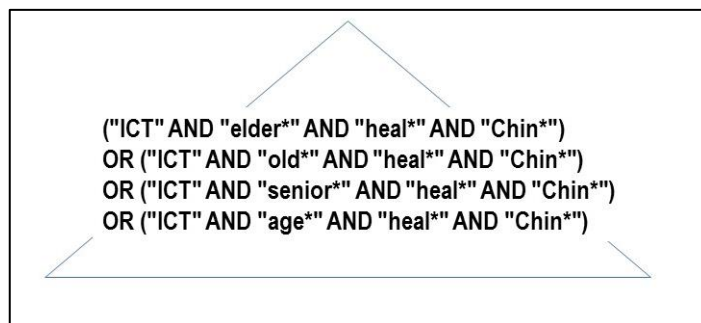
3.2 Research Questions and Protocol

The following assisting research questions were formulated to acquire an overview of the connection between ICT and Chinese elderly healthcare in the existing research:

- What are the publication trends of the research topic?
- What specific research areas are most explored?
- What are the focuses of the research?

In regards to the search keywords, the starting point for conducting the mapping study was the understanding of how ICT was applied to assist the elderly's healthcare in the context of China. Therefore, the key search terms were formed based on the combination of different research fields: ICT, elderly, healthcare and China. It originally contained four parts: 'elderly' or 'older people', 'health' or 'healthcare', 'China' or 'Chinese' and the key word of 'information and communication technology' or 'ICT'.

Pilot searches in the bibliographic databases were conducted to test the defined set of keywords, with the purpose to maximise the results and acquire more the relevant papers for this study. The piloting results reflected that very few studies were conducted relating to the focus of this study. In order to extend the search, alternative terms and concepts addressing the same problems were considered, and singular/plural forms and verbal forms of key terms were also taken into account. Two terms similar to elderly, "aged" and "senior", were included.



```
("ICT" AND "elder*" AND "heal*" AND "Chin*")  
OR ("ICT" AND "old*" AND "heal*" AND "Chin*")  
OR ("ICT" AND "senior*" AND "heal*" AND "Chin*")  
OR ("ICT" AND "age*" AND "heal*" AND "Chin*")
```

Figure 1: The search string

The final search string (Fig. 1) was applied in different bibliographic databases to get the understanding of the availability of relevant papers. It was adjusted to fit the syntax of each database and to search in the titles, abstracts and keywords. Information specialists of the Oulu University Library were consulted in the selection of databases, and eight digital databases were selected as literature sources.

3.3 Study Selection and Data Extraction

After applying the search string in the chosen databases, the results were uploaded to Refworks. By removing duplicate papers, the remaining papers were screened for inclusion and exclusion in three rounds (Table 1). The first round was done using metadata, to screen papers based on publication quality and availability (Table 2). In the second round, the remaining papers were reviewed based on their titles, keywords, and abstracts to deduct the irrelevant papers that were clearly outside of the research domain of this mapping study.

Table 1: Criteria for primary study selection

Round	Inclusion Criteria:	Exclusion Criteria:	Total#
1.	Metadata: A conference paper OR a journal paper OR a book chapter	Not written in English	182
2.	Title, keywords and abstract: setting is ICT AND elderly/older people AND support/better living	Clearly outside the scope of ICT OR elderly OR health OR not focused on the Chinese context	43
3.	Light reading: criteria from round 2 exists in the paper	The content cannot answer the research questions	12

Table 2: Hits after the first round

Database	Total#
Scopus	30
Web of Science	4
ACM digital library	8
ScienceDirect	4
Academic Search Premier (EBSCO)	52
IEEE Xplore	4
ProQuest Social Sciences Premium Collection	52
Wiley Online Library	28
	182

Each paper was marked as either “relevant”, “irrelevant”, “cannot decide”. All papers marked as “relevant” and “cannot decide” were left for the next round. The final round was conducted through light reading of the paper. This resulted in 12 papers chosen as the primary studies (Table 3).

The data extraction from the primary studies was performed using a standardised Excel template to obtain relevant metadata, classification data and descriptive data. The extracted data were: title of the paper, year of publication, publication venue, authors, acknowledgments, contribution, and concerns addressed in the research.

4 Results

In this section, the results of systematic mapping study are summarised to answer the research questions. The publication trends were identified. The primary studies were categorised to examine research areas of ICT and elderly healthcare in relation to the Chinese context. In addition, the contents from the paper were analysed to highlight the research focus.

4.1 Identified Publication Trends

The identified trend associated with publication year and author. In the context of China, all of the papers were published in the latest ten years and most of them were recent (11 out of 12 papers), having been published after the year of 2011. The earliest identified publication was from 2007 while the newest one was published in 2017.

Table 3: Publication situation in the Chinese context

Authors	Publication year	Total#
Hong Kong	2011, 2012, 2017	3
Collaborative author	2013, 2015	2
Chinese (Mainland China)	2007, 2012, 2014, 2015	7

The primary studies were classified according to the analysis of the authors and acknowledgements: 3 of them were published by Hong Kong (HK) researchers, 2 were collaborated by Chinese and American authors and the remaining 7 were contributed only by the researchers from Mainland China (Table 3). Among the seven Chinese contributed papers, the Chinese government supported six of them. The publication time of those government supported papers were 2007 (1 paper), 2012 (2 papers), 2014 (2 papers) and 2015 (1 paper). One can see that in China (except Special Administrative Region), the publication trend in this field mainly depends on the Chinese government, either policy support or academic funding.

4.2 Identified Research Areas

The research area in this field included 5 research disciplines (Table 4). The overall identified research areas were based on publication venue. Meanwhile, the research areas were discussed from the perspective of timeline and region respectively.

Table 4: Identified Research Area

Research Forum Focus	Total#	Primary Studies
Nursing or Care management	2	P04, P12
Medical Science	3	P03, P01, P06
Computer Science	2	P11, P10
Engineering or Mechatronics	4	P02, P09, P07, P08
Consumer Science	1	P05

One third of them were published in various Engineering and Mechanics forums. A quarter of the papers were published within medical science area. Two papers were related to nursing and care management field. Another two belong to the computer science studies and the remaining one was published about consumer studies. If the perspective is changed and topics looked from a more general aspect, half of them were in healthcare related forums and the rest were published in computer engineering related area.

From the timeline aspect, the topic was first emerged in care management area. Table 5 displays the identified research area based on publication year.

Table 5: Identified Research Area based on Timeline

Year	Research Forum Focus	Primary Studies
2007	Care management	P12
2011	Mechatronics	P02
2012	Medical Science, Engineering, Mechatronics	P01, P08, P09
2013	Medical Science	P6
2014	Medical Science, Computer Science	P03, P10, P11
2015	Consumer Science, Mechatronics,	P05, P07
2017	Nursing	P04

During year 2011 to 2015, the studies were mainly focused on the area of medical science, mechanic engineering and computer science. The last study was concentrated on nursing and care management area again. Table 5 also indicates healthcare and medical areas have been continuously studied. Technology area was emerged and received great attention after 2010.

Table 6: Identified Research Area based on Region

Region	Research Forum Focus	Primary Studies
Hong Kong	Nursing, medical, Mechatronics	P01, P02, P04
Mainland China	Care Management, Engineering, Computer Science, Medical, Mechatronics	P03, P07, P08, P09, P20, P11, P12
Overseas	Medical, Consumer Science	P05, P06

An interesting phenomenon is that the studies in mainland China and Overseas covered not only medical related research fields but also other various research areas such as engineering and consumer science. On the contrary, most of the papers in HK region were focused on elderly healthcare research area (Table 6).

4.3 Identified Research Focuses

The main research focuses emerged from primary studies are non-physical well-being with ICT, physical healthcare with ICT, and also attitude towards ICT. Those ICTs range from “old fashion” Internet technology to the cutting-edge virtual reality technology. The details of identified research focuses are discussed next. Table 7 shows the identified research focuses.

Table 7: The research focuses

Categories	Related ICTs	Primary Studies
Psychological	Internet, Computer, Smart device	P12, P05, P04
Physical	Telehealth, Robotics, Virtual reality, Smart device application	P01, P02, P06, P07, P08, P09, P10
Reflections	Computer, Internet, Social media, Smart device	P03, P11

ICT and psychological well-being

Simultaneous discussion about ICT and elderly’s non-physical well-being in the Chinese context emerged at 2007. The first identified paper (P12) focused on analysing the connection among ICT (Internet), elderly and well-being. It investigated how the Internet affects elderly’s life and what are their opinions after frequently using network technology. The second identified paper (P05) was written 8 years later at 2015. The focused region was mainland China context. Rather than the first paper collecting the feedbacks after using ICTs, it was from a different angle to study the elderly’s well-being through exploring how they use Internet in their daily lives. The remaining one was published in 2017 (P04). The focused region was HK. The paper was mainly about the

positive influences of general ICT (computers, smartphones and tablets) on elderly's psychological well-being and the related associated elements, for instance, different age groups among the elderly.

ICT and physical healthcare

Seven papers concentrated on applying ICT to enhance elderly's physical health. Three of them examined telehealth solution. In recent decade, HK initiates many telehealth deployments elderly healthcare field (P02). It introduced three ongoing telehealth solutions in HK, which were electronic health record (eHR), mobile nurse patient folder and remote patient monitoring. eHR focused on patients' medical data record, and supported interoperable medical data exchange between public and private healthcare institutes. Mobile nurse patient folder let the nurses to retrieve and update the health data at real time when they visit patients' homes. It aimed to assist the nurses to help their patients timely and effectively. Remote patient monitoring connected medical professionals and patients without home visiting. It helped the patients to manage their health at home to reduce the nurses' burden and save their own costs. Similarly, P09 predicted the future situation of telemedicine technology demand among the elderly in mainland China and examined ICTs' effectiveness. It demonstrated healthcare information demand is the key demands of Chinese elderly in the future and Internet is the main frequently used ICT solution. P08 was focused on enhancing the current encryption technique to build a better remote continuous healthcare monitoring system. It proposed a new cryptography to protect the patients' vital medical data.

Two identified papers (P07, P01) were concentrated on body function rehabilitation, including P07 summarising the current state of the art studies on the area of robot-assisted lower limb rehabilitation and P01 introducing interactive virtual reality Wii technology as supporting the whole body rehabilitation in a geriatric day hospital in HK. Another two papers (P06, P10) examined the use of portable instruments, such as wearable sensors and smartphones, to enhance elderly healthcare in China. P06 focused on improving the design quality of mobile application for the elderly who has chronic diabetic disease. It investigated user-centred design, specifically ageing population profiles and personas. P10 systematically analysed recent health sensing technologies for health data detection and classified them by their application functions.

Attitude towards ICT

The final research focus was studying the feedbacks of ageing population regarding to ICT. Two papers (P11, P03) concentrated on investigating Chinese elderly's perceptions of ICT. P011 explored the reason of using ICT (Computer and Internet, social media application) in their daily lives. P03 studied the elderly's attitude towards to the adoption of mobile health service in China.

5 Discussion and Conclusion

In this study, the chosen research method was followed rigorously, and 12 primary studies discussing ICT's capabilities to support elderly healthcare in the Chinese context were identified. The results showed that prior studies addressing this issue are extremely scarce

and relatively recent. At the time of the study, this research domain was still quite young and immature, and it seems there is a huge academic vacancy in the current the Chinese context. Consequently, it offers huge potentials for innovative research opportunities.

Because the ageing problem will become more serious in the upcoming decades in China (NBSPRC, 2018), more studies in this research domain are in urgent need in the future. As the support from Chinese government has big influence on the academic study in this field and Chinese government emphasised on implementing ICT in healthcare industry (Zhao et al., 2009), one can predict that increasing number of studies will be conducted and more academic paper will be published in the near future. The researchers in HK region were likely more interested in this topic. The reason could be considered as HK was an early developed region with no stringent family planning policy and it faced more serious ageing situation than mainland China (LifeNews, 2013).

The identified primary studies were almost equally either from the healthcare field or the technology field. However, the numbers of technical papers were increasing after 2010. Ericsson (2016) predicted cloud technology, self-managing devices, IoT, Virtual and augmented reality, robotics will be the near future technology trend. The emerging ICTs will play a significant role in healthcare industry (eHealth, 2011). One can predict that the future research will concentrate on computer science and mechanic engineering area.

Three research focuses emerged from primary studies were: psychological well-being, physical healthcare, and attitude towards ICT. How the Internet technology affects elderly's well-being has been seen as the main research direction for psychological well-being studies in the early times, while more recent researchers tend to focus more on the smart ICT equipment like smartphone and wearable device. It seems that the research focused in non-physical field is transforming based on the development trend of ICT. Physical healthcare studies focus on applying different ICTs to address the realistic problems for elderly. Telehealth seems to be the most popular solution to solve various geographic healthcare challenges. The novel technology like robotics and virtual reality were applied to solve elderly's body rehabilitation challenges. Meanwhile, smart phone applications and wearable devices were used for elderly to manage their own health and lives. Those are seen as the mature techniques, because the prior studies concentrated on improving the design quality instead of exploring the feasibility and some systematic analyses and classifications were existed. The attitude studies focus on Chinese elderly's perception regarding the adoption of ICTs such as computer, Internet, social media and smartphone in healthcare industry. The research on the perception for emerging ICTs still leave blank.

The current literature study revealed "old fashion" ICT like Internet, computer and smartphone, only few of them emphasised on emerging technologies while there are studies elsewhere made on both aspect of "old" technologies and novel concept. E.g. Nalin et al. (2016) introduced the concept of AAL and smart homes. Pang et al. (2015) pointed out the efficiency of IoT concept in the future.

To conclude, this study was searching for existing researches that concentrated on the capability of ICT to support the elderly healthcare in China. Although this cross-disciplinary research field was quite young in China and limited the identified primary studies, the study still provides a comprehensive overview of the research field. It also discovered the research trend and its inducement. Meanwhile, the study classified the previous research focuses. It showed the previous priority research areas in China and found what research areas have being ignored, thus provided a significant starting point for the potential research. Overall, this study laid the foundation of synthesising existing knowledge from different research areas for ICT and elderly healthcare in the Chinese context.

The current study proposes more rigorous studies of the topic in the Chinese context to spread the knowledge. More research directions can follow the technology development trend and study how to apply each innovative ICT in this area, for instance, virtual reality or augmented reality technology, real-time healthcare supporting system and artificial intelligence (robotic solution) without forgetting elderly's attitude, caregiver's experience and feedbacks towards those emerging ICTs.

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Appendix A: List of Primary Studies

	Authors	Title	DOI
P01	Chan et al.	Interactive virtual reality Wii in geriatric day hospital: a study to assess its feasibility, acceptability and efficacy	10.1111/j.1447-0594.2012.00848.x
P02	Chao	Telehealth initiative in Hong Kong. In Technologies Beyond 2020 (TTM)	10.1109/TTM.2011.6005176
P03	Deng et al.	Comparison of the middle-aged and older users' adoption of mobile health services in China.	10.1016/j.ijmedinf.2013.12.002
P04	Fang et al.	Information and communicative technology use enhances psychological well-being of older adults: the roles of age, social connectedness, and frailty status	10.1080/13607863.2017.1358354
P05	Fowler et al.	Analyzing Chinese older people's quality of life through their use of the internet	10.1111/ijcs.12194
P06	LeRouge et al.	User profiles and personas in the design and development of consumer health technologies	10.1016/j.ijmedinf.2011.03.006
P07	Meng et al.	Recent development of mechanisms and control strategies for robot-assisted lower limb rehabilitation	10.1016/j.mechatronics.2015.04.005
P08	Pan et al.	Security mechanism for a wireless-sensor-network-based healthcare monitoring system	10.1049/iet-com.2011.0097
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