Digital aging as an essential component of active aging: A literature review

Peishan, Yang[1] and Shan-Ju Lin[2]

[1]Department of Social Work, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan (R.O.C.)
E-mail: peishan@ntu.edu.tw
[2]Department and Graduate Institute of Library and Information Science, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan (R.O.C.)
E-mail: sjlin@ntu.edu.tw

[2]Corresponding author

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Abstract

***Purpose of the study*:** (1) to review how technologies have played out in relation to the WHO framework of active aging around the world; and (2) to discover essential components that may affect older adults' lives in today's digital world.

***Design and Methods*:** A systematic literature review from 2000 to 2017 that discussed the ICT related issues and active aging was conducted.

***Results*:** This study revealed an increasing risk of digital divide among older adults around the world**.** Three components that may affect digital aging were discovered: (1) ICT in senior daily life, (2) senior digital literacy skills, and (3) supportive networks and services.

***Implications*:** This study suggested a greater focus on citizen-centered empirical study linking active aging and digital aging, an expansion on the research subjects into the old (75-84) and the old old (85+) persons, and an investigation of technology use by more diverse groups of older adults.

Keywords: active aging; digital aging; information communication technology (ICT); information literacy; literature review

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Introduction

The world is currently facing a rapidly aging population that results in global demographic changes. In 1998, the World Health Organization (WHO) predicted that the population aged 60 years and over would be increased fourfold by 2050, and it would be the first time in history that the number of the aged population exceeds the young population under the age of 15(WHO, 1998). With the highest life expectancy of all countries, Japan already had a proportion of the elderly population over 30% in 2012. By the middle of the century, many other countries will come to the similar proportion, including the countries in Europe, North America, and part of Asia (WHO, 2015).

To understand the impact of older adults' disability loss in daily life, and its relation to design recommendations for relevant product and services, Seidel et al. (2009) showed that among the total of 12,186 initially healthy participants, locomotion was the first ability to be lost and the highest capability loss, followed accordingly by reaching, thinking, hearing, vision, and dexterity.

In response to the global population aging and huge loss of functional capacity of elders, active aging has been proposed as a promising framework, which refers to the process of achieving the vision of "continuing opportunities for health, participation, and security in order to enhance the quality of life as people age"(WHO, 2002) Older persons are encouraged to not only minimize functional loss but to further maintain active and healthy aging. (AAL Programme, 2017; Chang, Lu, Luor, & Yang, 2015; Walker & Aspalter, 2015)

In the meantime, digitalization has rapidly penetrated into all walks of and all ages of life, such as in the daily activity, safety, entertainment, health care, social relation, and lifelong learning. (Golant, 2017; Kaye, 2017) However, as Chang, Lu, Luor, and Yang (2015) indicated, there is a scarcity of studies that evaluate the technologies that could empower active aging. Little was mentioned about the role of ICT/IoT/smart technology in later life in the original framework of active aging proposed by WHO in 2002.Furthermore, seniors are a very heterogeneous group when they use technology due to their idiosyncrasies and different degree of information literacy. (Hallows, 2013; Science Daily, 2015) For example, Quan-Haase, Martin, and Schreurs (2016) found that the senior aged 60 and older with prior experiences with ICT showed diverse patterns using ICT in their daily life. Some adopted new routines, some combined traditional habits with emerging new habits using ICT, and others even re-created practices with digital means. Thus, while active aging refers primarily to policy framework, it needs further clarity in terms of the specific role of ICT/IoT/smart technology in each individual elder's life, and more dynamically, in the process of individual aging.

Therefore, the purpose of the current article is two folded: (1) to review how technologies have played out in relation to the WHO framework of active aging around the world; and (2) to discover essential components that may affect older adults' lives in today's digital world. We intend to achieve this

purpose by undertaking a systematic literature review dated from 2000 to 2017 that discussed the ICT related issues and active aging.

Research design and methods

In order to define the notion of digital aging in a theoretical lens, this article applied the method of literature review and analysis similar to Matchar, Patwardhan, Sarria-Santamera, and Westermann-Clark (2006).The data sources of the literature review included two main parts: database search, and expert discussions and contributions from this research team members and state-of-the-art scientific community members. The iterative process of the database search is presented in three steps as follows.

1. Initiation

   Publications in Science Direct (SDOL), ProQuest, ISI Web of Knowledge from 2000 to 2017 were searched by using Boolean operators. Initially, the major topic of active aging was searched combined with information and communication technology, ICT, Internet of Things, IoT, artificial intelligence, and AIas below:

   (“active aging” or “active ageing”) and(“information and communication technology” or ICT or “internet of things” or IoT or “artificial intelligence” or AI).

   Secondly, elderly, senior, aged, and older were combined with information technology, IT, and information literacy, and digital literacyas below: (“elderly” or “senior” or “aged” or “older”) and (“information technology” or IT or “information literacy” or “digital literacy”).

   Thirdly, elderly, senior, aged, and older were combined with information technology, IT, and user-centered as below: (“elderly” or “senior” or “aged” or “older”) and (“information technology” or IT) and (“user-centered”).

2. Selection

   The literature that met the following criteria was included for further examination: (1) subjects aged 50 or older, (2) original journal articles in English that provide empirical data, therefore, conference articles were excluded,(3) review articles with systematic analysis of previous literature. The literature regarding cognitive psychology, information inequality, and pedagogies in SSCI were excluded and the medical-related studies in Science Citation Index (SCI) were also excluded.

3. Examination

   In this stage, two research assistants examined the selected articles and excluded those which did not state the age of subjects clearly as well as the duplicates. Then, the two authors of this article reviewed the full text of the selected articles to confirm the quality and relevancy of each article. The final number of articles for analysis was26, including 12 quantitative studies, 9

qualitative studies, 3 literature reviews, and 2 mixed-method studies.(Please see table 1) Quantitative studies mostly applied questionnaires. However, questionnaire samples ranged widely from a few thousands like Chiu& Liu (2017) to only a couple of dozens like Christophorou, et al. (2016) and Tseng, Hsu, & Chuang (2013). Qualitative studies mostly applied focus group, case study, and interview methods. Among the three literature reviews, Ángel, et al. (2017) included 6 studies, Forsman & Nordmyr (2015) included 32 studies, and Hawley-Hague, et al. (2014) included 21 studies.

Table1 26 included articles for analysis

	Author (year)	***N* participants**	**Methodology**	**'Older person' Definition (year)**	**Countries**	**Technology**
1	Ángel ,C., Pinto-Bruno, J., García-Casal, A., Csipke, E., Jenaro-Río, C., & Franco-Martín, M.(2016)	6 studies	literature review	55+	n/a	ICT
2	Barroso, C., Abad, M., & Sánchez-Valle, M. (2015)	Focus group:17	Focus group	55+	Spain	Internet
3	Camarinha-Matos, L., Rosas, J., Oliveira, A., & Ferrada, F. (2015)	n/a	Case Study	n/a	Portugal	AAL (Ambient Assisted Living) platform
4	Chiu, C.J., & Liu, C.W. (2017)	3123	Questionnaire	50+	Taiwan	Internet
5	Christophorou C. et al.(2016)	58	Questionnaire	76+	Netherland Switzerland	General ICT
6	Costa, A., Julián, V., & Novais, P. (2017)	n/a	Case Study	n/a	Portugal	AAL (Ambient Assisted Living) platform

7	Costa, A., Novais, P., & Simoes, R. (2014)	n/a	Case Study	n/a	Portugal	AAL (Ambient Assisted Living) platform
8	Díaz-López, M. del P., López-Liria, R., Aguilar-Parra, J. M., & Padilla-Góngora, D. (2016)	184	Questionnaire	55+	Spain	General ICT
9	Eriksson-Backa, K., Ek, S., Niemelä, R., & Huotari, ML. (2012)	281	Questionnaire	65+	Finland	Internet
10	Fombona, J., Agudo-Prado, S., & de los Ángeles Pascual-Sevillana, M. (2012).	215	Questionnaire	65+	Spain	General ICT
11	Forsman, A. K.,& Nordmyr, J.(2015)	32 studies	Literature review	60+	n/a	ICT
12	Gardner, P., J., Kamber T., & Netherland J. (2012)	66	Telephone Surveys Ethnographic Field-work In-depth Interviews	55+	USA	General ICT
13	Gjevjon, E., Øderud, T., H Wensaas, G., & Moen, A. (2014).	39	Focus group	59+ Average age: 75	Norway	General ICT
14	González, A., Ramírez, M., & Viadel, V. (2012)	240	Questionnaire	55+	Spain	General ICT
15	Hawley-Hague H., Boulton E., Hall A., Pfeiffer K., & Todd C.(2014)	21 studies	Literature review	50+	n/a	ICT

16	Juznic, P., Blazic, M., Mercun, T., Plestenjak, B., & Majcenovic, D. (2006)	109	Questionnaire	50+ Average age: 63	Slovenia	Internet Web
17	Lai, OK.(2008)	n/a	Case Study	n/a	Japan	General ICT
18	LeRouge, C., Ma, J., Sneha, S.,& Tolle, K.(2013)	Focus groups:9 Semi-structured interviews:30	Qualitative Focus groups Semi-structured Interview	n/a	USA	health technologies
19	Lum, A.S.L., Chiew, T.K., Ng, C.J. et al.(2017)	13	Observation Interview	50+	Malaysia	Web computer
20	Peral-Peral, B., Arenas-Gaitán, J. & Villarejo-Ramos, Á. (2015)	415	Questionnaire	Average age: 63.6	Spain	SNS
21	Román-García, S. , Almansa-Martínez, A., & Cruz-Díaz, M. (2016)	18+:714 55+:478	Questionnaire	55+	Spain	General ICT
22	Stojmenova, E., Imperl, B., Žohar, T., & Dinevski, D. (2012).	12	Interview Focus group Questionnaire	65+	Slovenia	e-Health
23	Tatjana Gazibara et al.(2016)	346	Questionnaire	65+	Serbia	computer
24	Tseng, K.C., Hsu, C.L., & Chuang, Y.H.(2013)	32	Questionnaire	60+	Taiwan	Health monitoring system
25	Vuolo, L. et al. (2015)	87	Questionnaire	65+	Italy	Telehealth
26	Zschippig, C., Kluss, T. (2016)	n/a	Case study	n/a	Germany	AAL systems

Results

This study yielded a total of 26 articles that fit the inclusion criteria. Twenty of the 26 articles were from European countries with Spain taking the lead and Portugal coming second. Four were from Asian countries with Taiwan taking the lead. The remaining two articles were from the US and Canada. It is obvious that active aging was upheld internationally as the policy framework for the fast aging society (WHO, 2002). The development of active aging will first be iterated briefly as follows:

Active aging

Dated back to the 1990s, advocates of healthy aging and productive aging have already fought hard to set up positive and preventive measures that may help maintain older persons' independence and quality of life. Kerschner and Pegues (1998) denoted that meaningful involvement, positive mental outlook, and relationships with others would be the keys to healthy aging. Hinterlong, Morrow-Howell, and Sherraden (2001) delineated four domains to promote productive aging; i.e., employment, volunteering, lifelong learning, and caring.

Active aging was then proposed and adopted by WHO (2002). Please see Figure 1. The widely accepted active aging refers to the process of achieving the vision of "continuing opportunities for health, participation, and security in order to enhance the quality of life as people age." Being active is not only referring to physical status, but the involvement in "social, economic, cultural, spiritual, and civic affairs" (WHO, 2002, p.12).

In the positive course of aging, health, participation, and security are the three key elements that consolidate the foundation of active aging. To augment the framework of active aging, WHO (2002) brought forward the six key determinants that contribute to the design of policies and programs of active aging. Gender and culture are the crosscutting themes that affect the way people age and other determinants. The important elements in each determinant are specifically elaborated by WHO (2002) to fully depict the overall vision of the later life with active aging lifestyle. For example, safe housing, the prevention of falls, clean water, clean air, and safe foods are the crucial elements to pay attention to in order to sustain a physical environment that is "age friendly". The determinants therefore serve as the essential elements in the context of active way of lifestyle in later life.

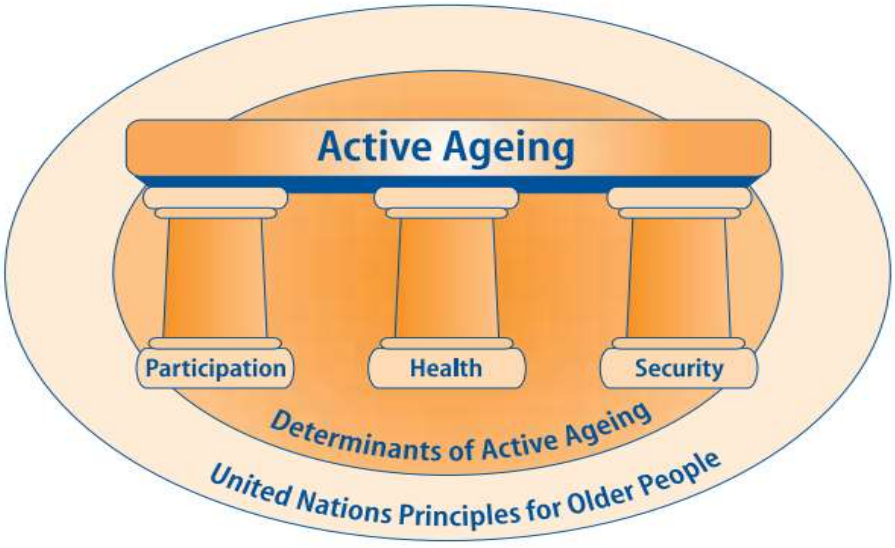

Figure 1. The three pillars of a policy framework for active ageing

Note. Adapted from "Active ageing: A policy framework," (p. 45), by World Health Organization, 2002.

In a nutshell, the three goals of health, participation, and security emphasize the social involvement based on the civil society mechanism that supports quality care and ensures the social security rights, e.g. the rights of receiving steady income, protection from unsafe medical treatment, and protection from physical, mental, financial, and sexual abuse. In this active aging framework, the improvement of physical health status and the promotion of mental health and social connections share equal importance. Active aging shifts away from passive "needs-based" strategic planning to the human "rights-based" or citizen-centered approach that strives for equal opportunity and treatment in various aspects of aging life(Bowling, 2008).

Chang, Lu, Luor, and Yang (2015) conducted a systematic review regarding active aging by reviewing journal articles from 2000 to 2014. The study indicated that the research assets were mainly distributed in the developed European and northern American countries, even though the bulk of the aged population would be in the developing countries. The research's meta-analysis found that the most recurring research themes were lifelong learning, labor policy, and gender. In addition, physical activity was another most studied determinant in active aging.

In 2002 when active aging was first promoted, technology and information communication technology (ICT), e. g., computer technology, assistive technology, home-based technology, smart home technology, wearable devices, Internet of Things (IoT), let alone artificial intelligence (AI), was rarely known by seniors. The situation is very different now. Pew Research Center (2017) reported a record high rate of technology adoption among older adults. In America, roughly two-thirds of those aged 65 and older go online, and more and more seniors use smartphones. However, challenges remain severe, including physical barriers, lacking confidence, insufficient knowledge and skills, and environmental/broadband limitation. It is noted time and again that many seniors need help to apply new technologies. How to support seniors beyond those who are younger, more highly educated, and healthier to live an active life in digital age requires much more research attention.(Chiu & Liu, 2017; Golant, 2017; Lai, 2008)

Definition of ICT

What is ICT? How ICT is defined in the literature? Most articles and policy statements used ICT as a general and all-inclusive term. (European Commission, 2007; Lai, 2008; Gardner, Netherland, & Kamber, 2012). Golant (2017) introduced specific terms such as ICT, ambient assisted living (AAL), ambient intelligence or assistive technology, pervasive computing technologies, telehealth, telecare, domotics, robotics, ubiquitous computing, and gerontechnology, but chose to use a collective term of 'smart technology'. Hawley-Hague, Boulton, Hall, Pfeiffer, & Todd (2014) used a total of 70 search terms for ICT intervention, applications and technologies by grouping them into two categories of 'activity monitoring'

such as AAL, cell phone, camera, ICT, e-mail, etc., and 'intelligent environment' such as Internet, personal digital assistant, reminder system, smart technology, telemedicine, web, etc..

Vichitvanichphong, Talaei-Khoei,Kerr, and Ghapanchi (2014) classified ICT/assistive technologies into 7 major categories as follows:

(1) General purpose ICT: Email, Mobile/smart phone, Digital camera, MP3, GPS, Personal Digital Assistant (PDA), Computer, and Internet;
(2) Social media: Online social network and Online community;
(3) Games: Video games and Mobile games;
(4) Robots: Interactive social software and social robot;
(5) Online information services: Online health services, Electronic health records, Online daily services, and Online learning;
(6) Smart home and remote care: Remote monitoring, Motion detecting sensor, Surveillance camera, Recording device, Flood alarm, and Telecare;
(7) Supportive devices: Medication reminder device, Hearing assistance devices, Rehabilitation assistance devices.

Similarly, another review by Khosravi and Ghapanchi (2016) clustered ICT/assistive technologies into six categories: general ICT, robotics, telemedicine, sensor technology, medication management applications, and video games, with social media being left out. They also proposed eight scenarios of life risks in which technologies may be helpful: chronic disease, fall, social isolation, poor well-being, dementia, dependent living, depression, and poor medication management. The cross table of technologies against risk scenarios proposed by Khosravi and Ghapanchi (2016) may work as a guide to further develop possible technological interventions for each scenario.

It seems that as technology develops so fast that literature cannot catch up in finding a universally agreed label to include all new and smart technology for wearable devices, social media, applications in hospitals, institutions, individual homes, communities, and even on the streets and public space.

Cognizant of the time needed for research and publication, this study found that even the more updated empirical studies may have only referred to very basic computer skills but not the information capacity necessary for active aging today. Or, the projects using technologies were not tested on real users. For example, the only article this research found by combining "information literacy" and "active aging" and "old" (Chiu & Liu, 2017) asked three questions in the studied survey: (1) Do you know how to apply for a user account and password? (2) Do you know how to use a word processing program? (3) Do you know how to upload and download files? Such basic questions obviously cannot delve into the actual digital life of older adults now. Another example was Costa, Julian and Novais (2017), while their ambient-assisted platforms for caregivers ended short and did not get a chance to do testing with real users.

This study also found that the role of technologies was not developed universally around the world. There was an increasing risk of digital divide among various regions and countries. Results of this study indicated three themes that may affect the digitalization of older adults' lives, including ICT in senior daily life, senior digital literacy, and support networks and services.

ICT in senior daily life

Literature supports that the application of general ICT has become indispensable in the senior daily life, and the number of articles on the investigation of older adult's technology adoption is growing fast. Whether at their own homes and communities, at lifelong learning institutes, and more generally in the society, a growing population of seniors live independently in their own places with technology (Vichitvanichphong, Talaei-Khoei, Kerr, & Ghapanchi, 2014; Zwijsen, Niemeijer, & Hertogh, 2011; Reid, Abdulrazak, & Alas, 2016). In other words, ICT plays a big role in supporting older citizens aging in place (AIP).

Smart home is a general term to describe appliances and services that make residences equipped with advanced automatic devices and functions to better provide a high quality of living for seniors. Good designs of a smart home can be characterized by five basic features, automation, multi-functionality, adaptability, interactivity, and efficiency (Lê, Nguyen, & Barnett, 2012).

Home telecare technologies, or more narrowly termed as telemedicine or telehealth, are functional in helping seniors to ageinplace. Koch (2006, p. 566) defined that telehealth refers to "the use of audio, video and other telecommunications and electronic information processing technologies for the transmission of information and data relevant to the diagnosis and treatment of medical conditions, or to provide health services or aid healthcare personnel at distant sites". Besides, ICTmay support monitoring, detecting health situation, and facilitating communication with family, friends, caregivers, and professionals (Doyle & Walsh, 2015). Further, remote therapeutic assessment and intervention could be provided. Even Virtual Reality (VR) may be applied to make residential homes 'smart' and further analysis be accomplished by immersing a rehabilitation professional in the virtual environment.

For those with hearing, visual or cognitive impairments, smart home technology can also provide fall prevention/detection, reminder systems, and medication administration via sensor technologies(Cheek, Nikpour, & Nowlin, 2005). A ubiquitous sensor technology in the non-obtrusive smart home setting is no longer an imaginative concept, which could monitor the physical conditions of seniors, and greatly enhance the 'security, mobility, independence, and interaction' in the active lifestyle (Farina, Cianca, Marchetti, & Frattasi, 2012; Lê et al., 2012).In addition, companion or social robots are burgeoning media hits that assist humans with special needs.

Regarding outcomes of applying ICT, reports are mixed. Many studies reported significant improvement of senor's daily life with the use of ICT (Aslan, 2013; Frennert, Forsberg, & Östlund, 2013; Khosravi & Ghapanchi, 2016). Health benefits are evident, for example, health promotion, prevention of hospital re-admissions, correct administration of medicine, reduced level of depression, lowered risk of falls, supporting well-being, and assisting seniors with dementia and their caregivers. Higher engagement in social activities and higher level of senior autonomy were also reported. The Microsoft Virtual Senior Center project in the City of New York reported reconnecting homebound seniors via computers and broadband technology, thus breaking their social isolation. Physical, cognitive, and social benefits were well reported by this online project.(Microsoft Corp, 2010) Mitzner et al. (2010)likewise found positive feedback abound, stressing that technology reinforces activities in all the context of the home, work, and health setting. Technology can provide communication, leisure and entertainment, and search functions, making the older adults' life more convenient.

However, technology has caused concerns as well, such as security, reliability, interruptions in daily lives, and the expensive costs. (Mitzner et al., 2010; Zwijsen,Niemeijer, & Hertogh, 2011)Hawley-Hague, et al. (2014) alerted that issues of control, independence, and perceived need/requirements for safety are critical in determining the adoption and withdrawal of technology, especially when there are an increasing types of technology. Zwijsen, Niemeijer, & Hertogh (2011) found that ethical debate did not appear as a priority in the literature of assistive technology. The underlying philosophy regarding how people should be viewed may further complicate the situation. Whether people should be independent/ self-determinant or social/reciprocal will influence the development and design of technology and the marketing strategies of various technologies.

Socio, economic, and environmental factors have been demonstrated to be more significant barriers for seniors to use technology than age alone. Lai (2008) argued that socio-familial culture is a key factor affecting whether Japanese seniors may age in place and simultaneously maintain inter-generational relationships through ICT. There are also concerns that using technology in care may diminish the role of family as caregivers. (Golant, 2017) Chiu & Liu (2017) analyzed the data from a national survey in Taiwan and found that education level independently predicted senior Internet use, which leads to the importance of education and training of ICT for seniors.

Senior digital literacy

In the face of the burgeoning digital technologies, the senior's life can be suffused by the digital advancement; therefore, the ICT engagement and relevant digital literacy become inevitable and necessary. Nevertheless, the literature in discussing gerontology and technology rarely touches the notion of senior digital literacy.

"digital literacy is the ability to use information and communication technologies to find, understand, evaluate, create, and communicate digital information, an ability that requires both cognitive and technical skills." (American Library Association, 2013, p. 2)The possession of digital literacy is therefore a crucial element that could affect the way of aging in later life (Feist & McDougall, 2013).Learning to use ICT-related products and services is essential in the senior adult's everyday life. Thus, the notion of e-literacy or digital literacy should be embedded in the ICT training program for seniors.

Although acquisition of digital literacy by the seniors, or senior digital literacy, is the basis for digital aging, the interaction with ICT among older adults was reported as positive experiences for some and frustrating for others. Seniors would encounter various obstacles while dealing with ICT, including financial barriers such as cost or accessibility, psychological barriers such as lack of interest, and technical barriers such as lack of assistance or fear of doing things wrong, and cognitive declination or physical impairments in general terms.

With the difficulties arising from using all kinds of ICT, it may not be easy for older adults to adopt technology (Fernández-Ardèvol, 2010). However, Caprani et al. (2012)indicated that 72% of the participants would like to have some level of training on ICT; higher level of interest in purchasing computers and advanced level of training was even requested by the older groups. According to Feist and McDougall (2013), the willingness of engaging in technology was evident if the older adults were given enough training and assistance. Further, the changes in attitudes toward new technology after training were obvious, especially when it comes to the connection to family.

Korea's Research Institute of Science for the Better Living of the Elderly (RISBLE) executed a Cyber-Family Program to help older adults develop the ability on mastering new technology, cultivating social skills and leadership, and finally being teachers in communities, all of which constitute the nature of active aging. Meaningful activities could be brought in older adults' life after adoption of new technologies, such as searching for health-related information online (Turnhout, Jeurens, Verhey, Wientjes, & Bakker, 2014). Morris, Goodman, and Brading (2007) also reported that information seeking and research in older adults' activity was most popular in information related to hobbies, interests, finance, health, and medical advice.

In the future world where digital will be ubiquitous, seniors will be increasingly engaging with digital devices. To develop the skills, concepts, approaches, and attitudes for digital competence, Martin (2009) denoted that older adults must "acquire mastery of digital tools and facilities" with the main purpose of communicating with family members. For the older adults, the digital activity can be a "valuable source of identity-building", which could strengthen the family bonding and further develop a sense of confidence.

In short, senior digital literacy enables the older adults not only to "achieve life goals, but to rethink the goals, to aim for what was previously unattainable" via digital means (Martin, 2009, p. 11).

As Han and Braun (2010) argued, digital literacy is the major element of active aging, which could increase older adults' access to information and facilitate the opportunities for communication and social interaction and further reduce the digital divide. With the literacy that could enable the practice of ICT, the elderly could actually take an active role in extending their original professional activities with both leisure and social incentives (Camarinha-Matos & Afsarmanesh, 2012).

Supportive networks and services

Williamson and Asla (2009) stated that even the oldest old aged 85 and above still have information needs. However, older people usually acquire "incidental information" through discussion with friends or via the mass media. Such supportive network is therefore vital for older adults to seek information and enhance healthy aging in the everyday life. Niemelä, Huotari, and Kortelainen (2012) declared that active use of media, such as television and the Internet, could motivate older adults to age in the healthy and active ways.

With the biological and cognitive decline, the alternative way of seeking information is through the assistive technology of ICT. However, according to Aslan (2013), even the simplest assistive technology or a minor change in the appearance of interface devices could impede the information seeking behavior of the oldest old. The communication with family members and friends is therefore essential in acting concert with assistive technology to support the older adult's information seeking.

In the study of ICT training for older adults, Lin & Chang (2009) showed that social support from family is critical for most of the elderly under study, and that older adults relied heavily on family bonds because family members could respond in time. It was also found that the higher degree of social support, the greater benefits gained from ICT. Those informants with sufficient assistance were more active in learning advanced skills of ICT other than the regular ones taught in class.

Community-based organizations implemented with information technology may help create an environment with "efficient, less costly, and higher-quality service" for older people (Renold, Meronk, & Kelly, 2005). Renold et al. (2005) showed that efficient workflow and positive attitudes toward technology could lead to improvements of services to older people. For example, regular evaluations of patients by case manager could be easily generated via reminder systems; centralized client records could be easily shared organization-wide and the electronic documentation could reduce paperwork loading. The enhancement of efficiency was an obvious outcome after employing computer technology in the organization.

Technology plays a vital role in senior's later life. With appropriate assistance and the relevant literacy of utilizing technology, older adults' feelings of loneliness and isolation from society may be reduced, so is the cost of healthcare services in the near future. IAGG (2013) chose "Digital Ageing: A New Horizon for Health and Active Ageing" as the overarching them for the 20th World Congress. This theme embraces the unique opportunities that information technology or information and communication technology provides for global aging societies. With the new technological advances, a wide array of aging-related or age-related issues may be solved, and social exclusion or isolation can thus be prevented. With the emphasis on the provision of digital literacy in the ICT training session for older adults, a sustainable and high quality of later life could be maintained. In the near future, the aging population would live in an active and independent lifestyle in order to be connected with family and the society by means of all kinds of assistive technologies with the knowledge and skills of using a wide range of digital devices in the digital era.

Conclusion: digital aging as an essential component to active aging

The contribution of this study lies in discovering that though digital aging is an essential conponent for enactment of active aging in information society, but there is an increasing risk of inequality internationally as well as intra-nationally. Three key categories of factors may affect digital aging: (1) ICT in senior daily life,(2) senior information literacy skills, and (3) supportive networks and services. It is a valuable addition to the scarce literature of ICT/IoT/AI with older adults, active aging, and their digital literacy. On one hand, it will be increasingly more difficult to achieve the right to equitable and high quality life for all seniors without connecting them to the digital world (Ángel, et al., 2017). On the other hand, there remain tremendous challenges how to remove existing barriers and to enhance enablers.

Further research implications are three-folded. First, there should be a greater focus on citizen-centered empirical study on the linkage of active aging and digital aging. Secondly, most existing literature of active aging are investigations of the pre-old (50+) or the young old (60+). While the average life expectancy has exceeded 80 in many countries, the future research in gerontechnology needs to focus on the old (75+) and the old old (85+) as research subjects. Thirdly, most studies of technology for the elderly focus on physical or technical barriers. Psychosocial, economic, and environmental barriers need to be specifically investigated, and strong actions targeted to remove those barriers need to be taken. Future research should also include more diverse groups of older adults, in particular those who are most disadvantaged, to reach higher equality.

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