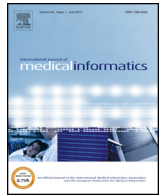




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Investigating the effectiveness of technologies applied to assist seniors: A systematic literature review

Pouria Khosravi^a, Amir Hossein Ghapanchi^{a,b,*}

^a School of Information and Communication Technology, Griffith University, Gold Coast, Queensland 4222, Australia

^b Institute for Integrated and Intelligent Systems, Gold Coast, Queensland 4222, Australia

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ABSTRACT

Background: Recently, a number of Information and Communication Technologies have emerged with the aim to provide innovative and efficient ways to help seniors in their daily life and to reduce the cost of healthcare. Studies have been conducted to introduce an assistive technology to support seniors and to investigate the acceptance of these assistive technologies; however, research illustrating the effectiveness of assistive technologies is scant.

Method: This study undertakes a systematic literature review of ScienceDirect, PubMed, ProQuest and IEEE Explore databases to investigate current empirical studies on the assistive technologies applied in aged care. Our systematic review of an initial set of 2035 studies published from 2000 to 2014 examines the role of assistive technologies in seniors' daily lives, from enhancements in their mobility to improvements in the social connectedness and decreases in readmission to hospitals.

Results: This study found eight key issues in aged care that have been targeted by researchers from different disciplines (e.g., ICT, health and social science), namely, dependent living, fall risk, chronic disease, dementia, social isolation, depression, poor well-being, and poor medication management. This paper also identified the assistive technologies that have been proposed to overcome those problems, and we categorised these assistive technologies into six clusters, namely, general ICT, robotics, telemedicine, sensor technology, medication management applications, and video games. In addition, we analyzed the effectiveness of the identified technologies and noted that some technologies can change and enhance seniors' daily lives and relieve their problems. Our analysis showed a significant growth in the number of publications in this area in the past few years. It also showed that most of the studies in this area have been conducted in North America.

Conclusion: Assistive technologies are a reality and can be applied to improve quality of life, especially among older age groups. This study identified various assistive technologies proposed by ICT researchers to assist the elderly. We also identified the effectiveness of the proposed technologies. This review shows that, although assistive technologies have been positively evaluated, more studies are needed regarding the outcome and effectiveness of these technologies.

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1. Introduction

Current demographic trends show that the percentage of older people will rise dramatically. For instance, from 10% worldwide in 2000, the percentage of older people is predicted to reach 21% in 2040¹. This increase has a large influence on social and

health care systems such as the increased use of health care, the cost of caring and the need for more qualified caregivers [62]. For instance, fall injuries and chronic disease are reported as two major health issues among the elderly, and 20% of the elderly who fall require some form of medical treatment [48]. Chronic disease accounts for 78% of all medical costs in the United States and seniors bear a large burden of the chronic disease among the larger population [32,8]. In addition, seniors tend to prefer to remain in their own home and in remote and regional areas, the need to travel for regular medical visits is difficult for seniors with limited mobility [26]. To provide independent living for seniors and maintain their health, there is a need to develop various technologies to assist seniors in their daily life [44].

* Corresponding author at: Office G09-1.60, School of Information and Communication Technology, Griffith University, Gold Coast, Parklands Drive, Queensland 4222, Australia. Fax: +61 7 5552 8834.

E-mail addresses: pouria.khosravi@griffithuni.edu.au (P. Khosravi), a.ghapanchi@griffith.edu.au (A.H. Ghapanchi).

¹ United Nations Department of Economic and Social Affairs Population Division. World population ageing: 1950–2050. 2002. Available at: <http://www.un.org/esa/population/publications/worldageing19502050/>.

Recently, a number of information and communication technologies (ICT) have emerged with the aim to provide innovative and efficient ways to help seniors in their daily lives and to reduce the cost of healthcare [5,27]. Early researches on assistive technologies commenced in the late 1990s [66]. Technologies are able to assist seniors to live independently in their own homes for longer periods and provide healthcare services in remote areas through mobile health and monitoring [25,43]. An early review conducted by [19] determined that remote health monitoring and sensor technologies improve seniors' safety and reduce their risk of falls. With recent advances in technology and the potential of technology to play a significant role in assisting seniors, researchers have targeted various problems among seniors such as dementia, social isolation and chronic disease [22,70]. As [26] in their recent review state, telemedicine is an effective technology to alleviate seniors' health problems. These assistive technologies are defined by Marshall (1997) [86] as "any item, piece of equipment, product or system, whether acquired commercially, off-the-shelf, modified or customized, that is used to increase, maintain or improve functional capabilities of individuals with cognitive, physical or communication disabilities".

A variety of assistive technologies have been adopted to help seniors in their daily life, such as robotics [44], sensors [21], and computers and the internet [31]. Although some studies report obstacles and failures [9,17], assistive technologies have considerable potential to support seniors in their daily life. Since assistive technologies aim to improve the quality of life, especially among seniors, it is vital to develop systems and devices that suit seniors' needs, limitations and can provide benefits. Studies have been conducted to introduce an assistive technology to support seniors and to investigate the acceptance of these assistive technologies [14,23]; however, research illustrating the effectiveness of assistive technologies is scant [30,45]. Assistive technologies need to be evaluated not only for their feasibility and acceptance, but also for their effectiveness. According to [29], that gap can be attributed to a variety of factors including the lack of theories about continued or discontinued use, the emphasis on demonstrating the technical performance of an assistive technology rather than the outcome, the focus on subjective reports, and the lack of a mandate to gather data about the effectiveness. The gap in the literature on the effectiveness of assistive technologies warrants a synthesis of the existing empirical data regarding how these technologies assist seniors in their daily life.

In this systematic literature review, we identify assistive technologies that are designed to help seniors in their daily life and relieve their problems. We then analyse whether or not these technologies are effective in providing assistance for seniors. This study aims to fill the gap identified in the literature and answer the call for more research that provides a broader picture of the various technology interventions and their effectiveness, rather than merely providing a comprehensive list of assistive technologies [45]. Therefore, this study poses the following research questions:

RQ1. What problems of the elderly have been targeted and investigated by ICT researchers?

RQ2. What technologies have been proposed for aged care problems?

RQ3. How effective have such assistive technologies been in alleviating the targeted issues?

This study contributes to the literature on assistive technologies in various ways. First, it furthers the attempt to identify seniors' problems and the technologies proposed to assist them. Second, it develops further the insights into the effectiveness of assistive technologies and how these technologies impact on the seniors' daily life. Lastly, the findings of this study should enable practitioners to better understand the various technologies and their effectiveness. With this understanding, practitioners can better advise seniors as

to how they might gain an improved quality of life through the use of appropriate assistive technologies.

The remainder of the study is structured as follows: the next section describes the methodology chosen for this study. The subsequent section presents an overview of the findings. This paper concludes with a discussion of the findings, the implications of the study and recommendations for future research directions.

2. Methodology

To classify assess and interpret the existing empirical studies and answer our research questions, a systematic literature review was conducted in this study [51]. Many studies have used the same approach [33,61,35,68]. Following the guidelines proposed by Kitchenham [51], we conducted the study in three stages, namely, planning, conducting, and reporting the review.

2.1. Search terms

We undertook systematic searches using keywords of publications between 2000 to the present in the following databases: ScienceDirect, PubMed, ProQuest and IEEE Explore. The following keywords were used: ("elderly" or "older" or "aged" or "senior" or "elders") and ("technology" or "adoption" or "benefits" or "information and communication technology" or "intervention") in the publication's titles; keywords; abstracts or full texts.

2.2. Inclusion/exclusion criteria

We included studies if they met the following criteria: (1) involved seniors aged 60 or older with different types of study designs, (2) included technologies related to aged care problems, (3) published between 2000 and 2015, (4) provided empirical evidence on changes in the lives of seniors or the effectiveness of specific technologies by recording some form of outcome measure, and (5) stated how the technology intervention effects are to be obtained. Studies in languages other than English, letters to the editor, conceptual papers, opinions and unpublished full-text documents were excluded.

2.3. Data extraction and synthesis

Fig. 1 shows the selection procedures. First, two authors independently reviewed the abstracts of the retrieved sources and agreed on the included articles. In total, 2069 titles and abstracts were screened to find the qualified studies for the review. Full papers of 248 studies were retrieved and evaluated by the authors. Based on the predefined criteria, 41 articles were included in this review. In addition, an independent reviewer independently evaluated the paper against the inclusion criteria.

Subsequently, the key details were extracted and synthesised from the 41 studies included in our systematic review. Various types of data were extracted from the studies: (1) demographics including the year of publication and continent, (2) study design, (3) type of technology, (4) targeted seniors' issue, and (5) effectiveness or benefit of the technology. For the analysis of the data and to draw diagrams, we used Microsoft Excel.

2.4. Evaluation of the effectiveness of the technologies in the studies

We adopted the method proposed by Morrison et al. [59] to evaluate the effectiveness of the technologies in the studies in the final pool, and developed a set of criteria that enabled us to assess the results in the studies (Table 1). These criteria focused on important domains such as research design, conduct and analysis [59]. We

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