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Gerontechnology acceptance of smart homes: A systematic review and meta-analysis

(Work-in-Progress)

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ABSTRACT

Advances in preventive medicine and technology have beneficially affected longevity in the past decades. Unfortunately, longer life expectancy and declining fertility are likely to trigger an increasingly aging population, posing new challenges for social systems. Since aging populations affect the healthcare industry, providing convenient solutions and user-friendly elderly healthcare services is necessary to curb the growing demand by older adults. Several studies have proposed intelligent homes as potential solutions to support old age. However, such solutions raise the question of whether or not elderly persons intend to use smart homes and benefit from them. This paper examines the gerontechnology acceptance of intelligent homes by systematically reviewing previous studies on older people's intention to use innovative home technology. The review was conducted from the Web of Science, Google Scholar, and Scopus, retrieving a thousand articles. Out of these, 40 are selected for the meta-analysis and systematic review. The integrative results showed an increasing intention of older adults to use smart home technology as they believe those innovative ways may improve independent living. However, attributes and drivers like privacy and perceived security show increasing heterogeneity and should draw more attention to prospective researchers.

Keywords: Gerontechnology; older adults; smart home; technology acceptance.

INTRODUCTION

The increase in longevity, the growing number of older adults, and the decreasing number of newborns denote that most countries' populations are aging rapidly (Lamnisos et al., 2021). The increase in the proportion of older people is mainly due to changes in health indicators, including improved nutrition and hygiene (Mehri et al., 2020). Additionally, advances in preventive and curative medicine have enabled many (older) patients to survive life-threatening medical conditions. Unfortunately, this does not mean that all seniors are healthy and well.

To anticipate the growing demand for health care by older adults, governments and policymakers are trying to empower older persons to maintain independence for as long as possible. By enabling them to keep residing in their own homes, i.e., to age in place, costly options such as nursing homes can be avoided. Smart homes have been postulated as a potential solution to support aging in areas. A smart home is a residence equipped with a high-tech network, linking sensors and domestic devices, appliances, and features that can be remotely monitored, accessed, or controlled and provide services that respond to the needs of its inhabitants (Robles & Kim, 2010). Several target groups could benefit from innovative home technology, including older adults who would like to age in place. Furthermore, smart home technology can assist in monitoring and maintaining health status.

Previous studies emphasize intelligent homes, but their existence is not widespread. Consequently, their suggested potential for older adults in promoting independence and aging in place, alleviating pressure on (family) caregivers, and decreasing health care expenditure, has not yet reached its full potential. The question remains why smart home technologies are not yet commonplace in the homes of older people. The present study aims to answer this question by examining and discussing older people's views on independence and intelligent home technology. We will discuss older people's perspectives on aging in place and remaining independent. The remainder of this paper is organized as follows—section 2 describes materials and methods, including search parameters and databases. Section 3 is dedicated to results and discussions.

MATERIALS AND METHODS

Search strategy

This research systematically reviews previous academic works on gerontechnology acceptance of smart homes. The review was conducted by following the reporting checklist of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (Johnson & Hennessy, 2019). This study's comprehensive literature search was undertaken online through Web of Science, Scopus, and Google Scholar databases on August 10, 2022. The searching items consist of "gerontology" OR "elderly" OR "seniors" OR "old age" AND "smart home" OR "home automation" OR "domotique" OR "intelligent home" OR "adaptive home" OR "aware house." We also sought eligible articles according to the reference list of potentially eligible studies. One thousand articles were identified and sorted by "Relevance" from 1996 to 2022. Of these, 40 relevant academic works concerning technology acceptance of smart homes among older adults were studied.

Inclusion and exclusion criteria

Studies were included if the object of each study was technology acceptance and adoption by older adults. Any study matching any of the following criteria was excluded.

i: the study was not about technology acceptance among elderly people

ii: case report, comment, conference abstract, design research, letter, review

iii: articles that are not written in English

iv: insufficient data or no available data, or inconclusive results

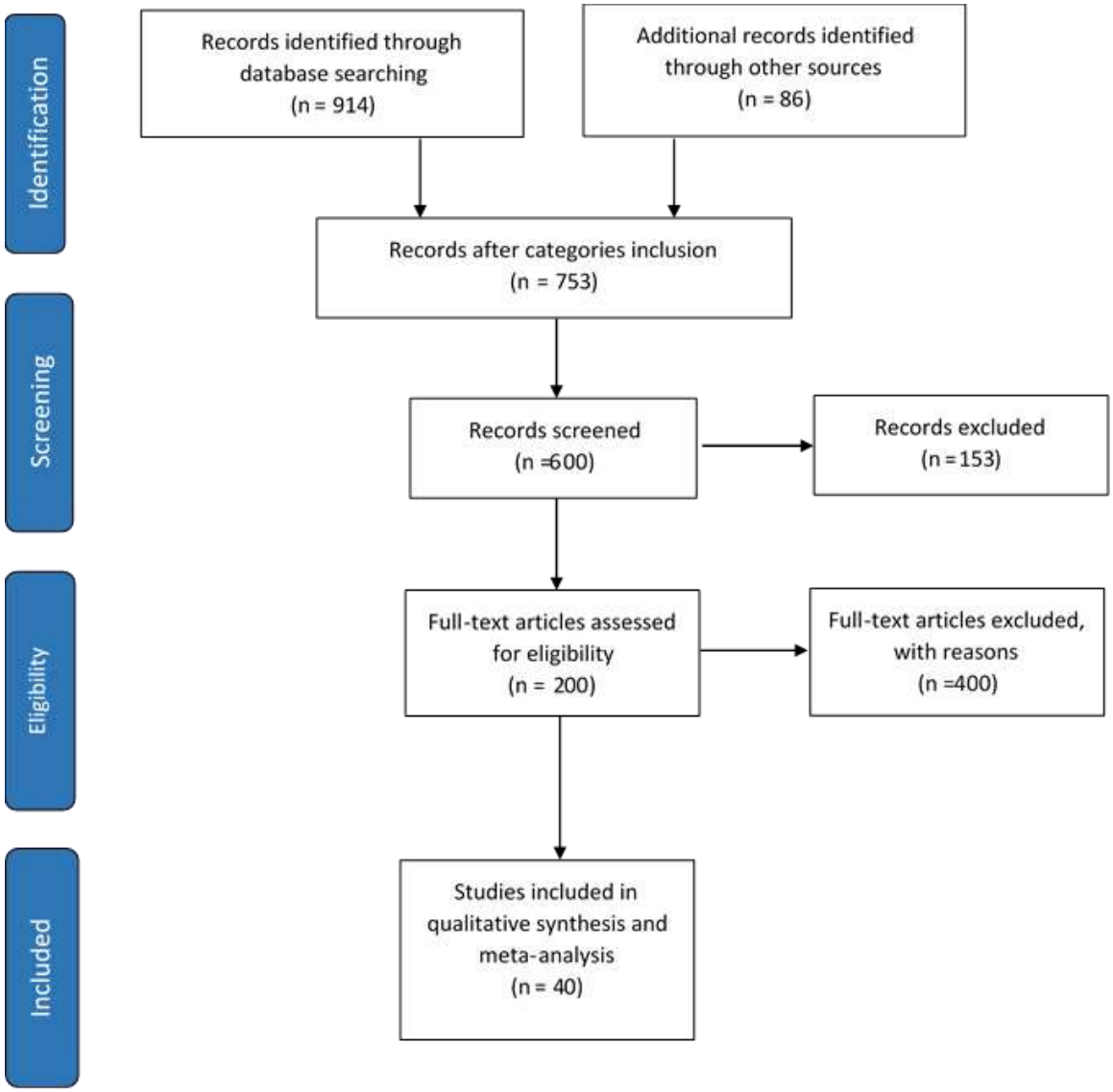

Figure 1: Literature searching following the PRISMA methodology

Quality assessment and statistical analysis

We apply Review Manager 5.4 to evaluate each study's quality and make the meta-analysis's outcomes robust. Through “yes,” “unclear,” or “no,” we apply a risk of bias approach for the included studies, as shown in Fig. 2. Then, the combined data was further analyzed in the forest plots. Each continuous outcome was expressed by weight mean difference and 95% confidence interval. The Inconsistence index was implemented to measure the heterogeneity of all included studies using a random-effects model. Statistical significance was defined by a p-value less than 5% ($p < 0.05$).

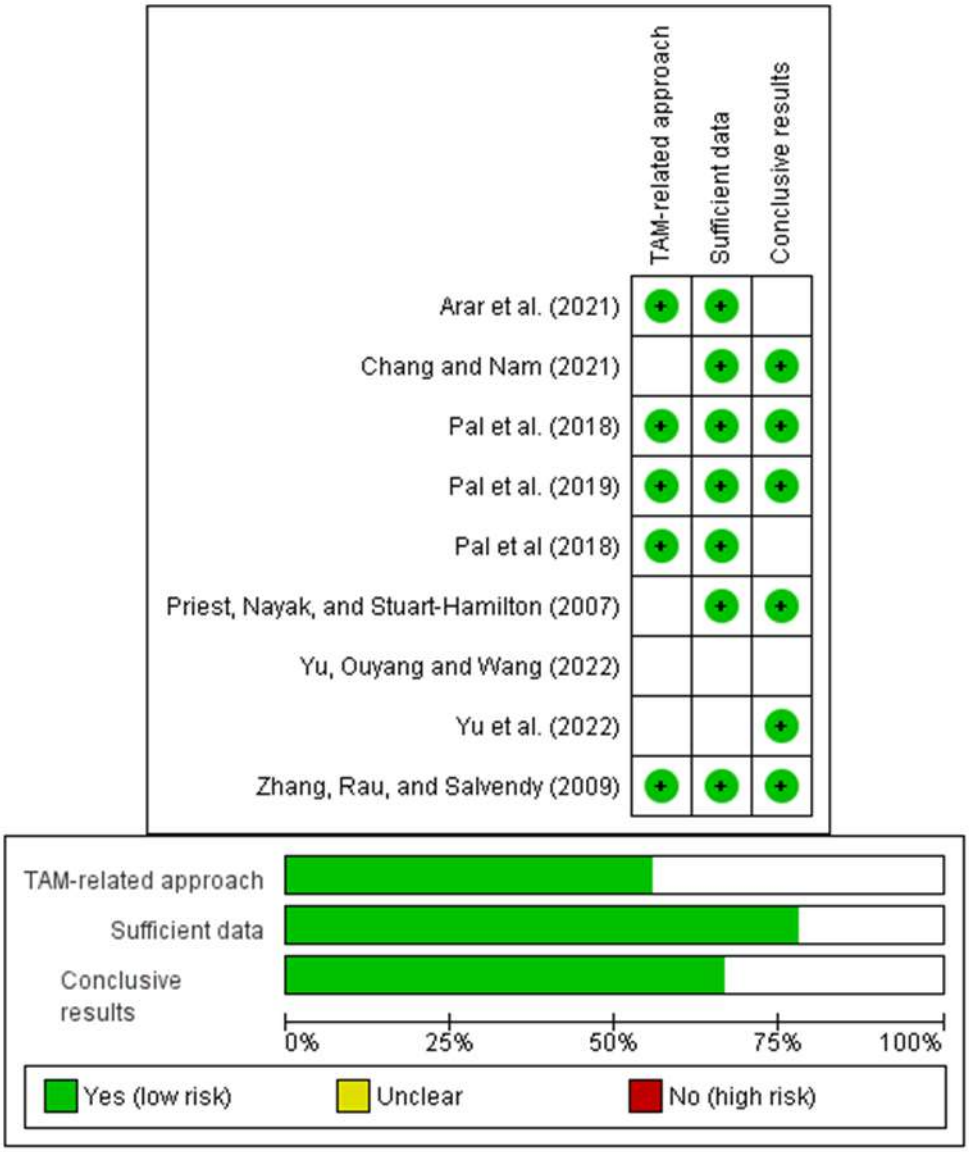

Figure 2: Risk of bias summary

RESULTS AND DISCUSSIONS

Smart home developments and potential benefits for older adults

Many developments are taking place in the field of smart home technology, and expectations are high regarding the potential benefits for the elderly (Barlow & Venables, 2004; Hu et al., 2020). Previous studies have developed new technologies and methodologies to improve older adults' independence and prevent health events (Cho & Kim, 2014; Mihailidis et al., 2004; Ocepek et al., 2013; Ravishankar et al., 2015). These studies showed that home automation's use among older adults positively relates to outcomes such as cognitive status and improved social. The other included studies did not demonstrate strong evidence of support for aging in place, mainly due to their study designs and methodologies.

Our analysis showed that most research on community-dwelling older adults study the elderly's perception of a technology that has not been used yet (Agarwal et al., 2016; Wong & Leung, 2016). These studies typically refer to this stage as the pre-implementation stage and include presentations, prototypes, or scenarios to explain or demonstrate the technology to participants (Ehrenhard et al., 2014; Onibonoje et al., 2016; Yu et al., 2015). Consequently, older adults are asked about a technology they have not used and experienced for a considerable time. They, therefore, raise concerns regarding such technology when benefits have not been demonstrated clearly in terms of scientific evidence. Those concerns are primarily related to drivers, such as usability, cost-effectiveness, behavioral change, showiness, and impracticality. That implies that using home automation technologies may be burdensome. (Gao et al., 2018; Kim et al., 2017; Lago et al., 2019).

However, despite rising concerns, older adult users may also expect benefits, such as increased safety and independence (Ahmad et al., 2016; Jung, 2017; Monteriù et al., 2018). But, it is worth noting that these perceived benefits do not "automatically" translate into accepting adaptive home technologies, as illustrated by Shuhaiber and Mashal (2019). Many older adults may believe that innovative home technology can contribute to independent living, yet these conditions often do

not lead to a willingness to accept intelligent home technology. However, studies such as Arar et al. (2021) found that age group and computer technology affinity are the most influential variables and elderly users have anxiety about technology, which influenced the acceptance of innovative home technology. (Fig. 3). The following paragraph will look more closely at older adults' concept of independence and its relation to their perceptions and acceptance of smart home technology.

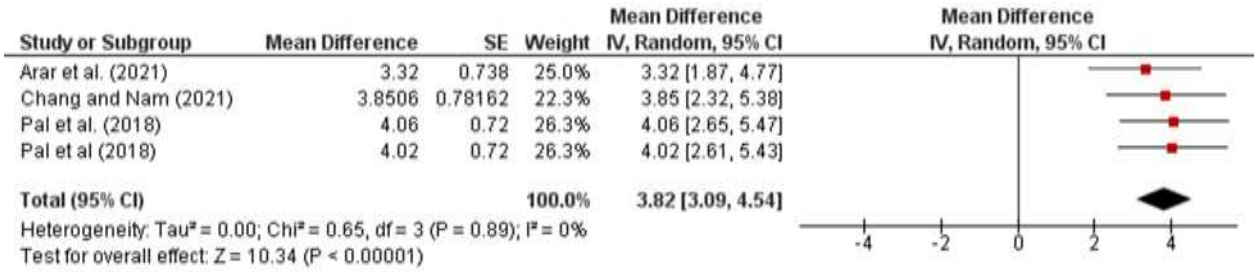

Figure 3: Intention to Use

Independence and its relations to the acceptance of technology

Independence is referred to the ability to live without relying on external help or not feeling obligated to someone (Plath, 2008). Privacy issues are an example of how independence perception can influence the acceptance of smart home technology. Fig. 4 depicts Studies in which community-dwelling older persons can see technologies that enable sharing personal information with formal and informal caregivers as something that allows them to stay in their current dwelling (Arar et al., 2021; Pal et al., 2019; Pal, Triyason, et al., 2018). In other words, they perceive that technology can favor the ability to look after oneself. This outlines that intelligent home technology can positively and negatively influence the feeling of being obligated to someone.

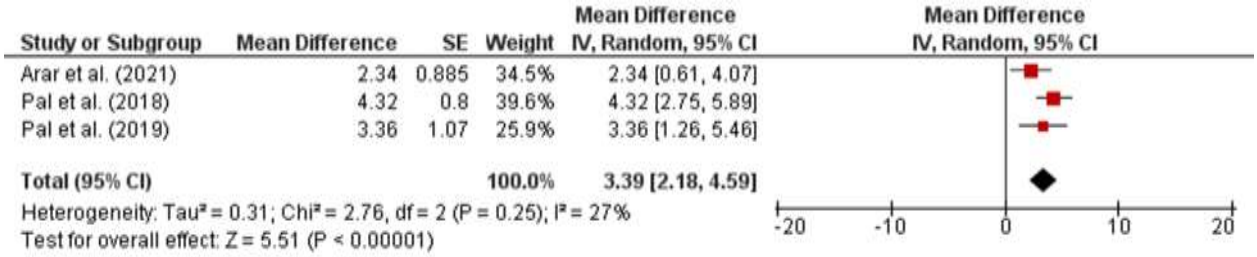

Figure 4: Perceived Security and Privacy

The examples mentioned in this paragraph show that many older people's perceived positive and negative consequences of using technology in the context of aging in place can be defined in terms of the impact of technology on their perceived independence.

Determinants of home automation services for elderly people

The potential intelligent home services market is still in its early stages. As such, existing research has primarily focused on the determinants of its adoption. Based on a value network analysis of a Dutch smart home implementation case, Ehrenhard et al. (2014) identified several factors that impact the adoption of IoT intelligent home services. They confirm that successful market adoption of multi-stakeholder technology like smart homes is low and low adoption is due to the complexity of the surrounding business ecosystem.

Our review also indicates that studies mainly extend the Technology Acceptance Model (TAM) to scrutinize factors impacting the adoption of innovative home technology or services by the elderly (Table 1). For example, Pal et al. (2021) extend the technology acceptance model with three additional factors: compatibility, perceived complementarity, and privacy concerns. They found that usefulness, ease of use, compatibility, and perceived complementarity significantly and positively affect behavioral intention. Similarly, Etemad-Sajadi and Dos Santos (2019) integrated several latent variables, such as social presence, trust, and degree of intrusiveness, into the TAM. Their findings show that trust in these technologies significantly impacts the perception of usefulness and the degree of intrusiveness.

However, previous studies have widely criticized the TAM and proposed several revisions and theories to address its limitations (Arthanat et al., 2020; Opoku & Francis, 2019). For instance, Sequeiros et al. (2021) employ the unified theory of acceptance and use of technology 2 (UTAUT 2) to evaluate the impact of smart home usage on well-being. They found that hedonic motivation associated with adopting some intelligent home services moderates continuing use, suggesting a positive relationship between the use of IoT innovative home services and well-being. Those insights align with the findings from Jiang et al. (2021), proposing a stimuli-Organism-Response (S-O-R) model to investigate the direct influence of trust and self-efficacy on well-being and learning performance and the mediating role played by these variables. The results show that intelligent technologies can affect learning performance through self-efficacy and well-being. Other research has also

demonstrated the well-being benefits of intelligent homes, assigning greater importance to services within the lifestyle support category, such as e-health, assisted living, entertainment, convenience, and comfort (Hersh, 2015; Pirzada et al., 2022).

Table 1: Summary of gerontechnology acceptance models included in this review

Framework	Drivers	Smart home technology/feature	Studies
Technology Acceptance Model	Perceived usefulness; perceived ease of use; attitude; behavioral intention; Social presence; Degree of intrusiveness	Intercom systems; motorized shutters; smart lighting bulbs; smart speakers; intelligent smoke detectors	Peek et al. (2016); Pal, Triyason, et al. (2018); Pal, Funilkul, et al. (2018); Etemad-Sajadi and Dos Santos (2019); Pal et al. (2021); Arar et al. (2021); Pirzada et al. (2022); Hubert et al. (2018); Nikou (2019); Gaul and Ziefle (2009); Al-Husamiyah and Al-Bashayreh (2022); Mashal et al. (2020); Pal et al. (2019)
Unified Theory of Acceptance and Use of Technology	Technology anxiety; Effort expectancy; Facilitating conditions; Social influence; Hedonic motivation; Well-being	Assistive robot; e-health; assisted living;	Arthanat et al. (2020); Sequeiros et al. (2021); Pirzada et al. (2022); Hersh (2015)
Technology to Performance Chain Model	Perceived need; Appearance; Perceived usefulness; Perceived stigma	Legged Robots; Robotic Wheelchairs;	Kencebay (2019); Hersh (2015);
Theory of Planned Behavior	Mobility; privacy risk; trust;	N/A	Watfa and Akili (2021); Yang et al. (2017); Zhang and Liu (2022); Chang and Nam (2021)
Task Technology Fit model	Perceived task technology fit; Perceived usefulness; Perceived ease	N/A	Marikyan et al. (2021) ; Marikyan et al. (2019) ;
Skill-Rule-Knowledge model	Cognitive mode; Skill-based tasks; Rule-based tasks; Knowledge-based tasks; Task Accuracy Rate	Button Size; Icon Style	Zhang et al. (2009); Yu, Ouyang, Wang, et al. (2022); Yu, Ouyang and Wang (2022); Priest et al. (2007)

Other results pinpoint the cognitive ability and performance across different generations (Fig. 5). For instance, Priest et al. (2007) scrutinized the influences of fluid intelligence and website experience on a website task by 99 community-dwelling older adults. Their results show that task performance was not significantly influenced by fluid intelligence score or age, but there was a significant influence by prior website experience. In contrast, Yu, Ouyang and Wang (2022) show that the results and performance of the older group were consistent, while the younger group had no significant difference in sliding orientation and track color.

Figure 5: Cognitive ability and performance

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