International Journal of Medical Informatics 129 (2019) 324–333

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.elsevier.com/locate/ijmedinf

Review article

Factors influencing seniors' acceptance of technology for ageing in place in the post-implementation stage: A literature review

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ARTICLE INFO

Keywords:
Seniors
Technology for ageing in place
Ageing
Acceptance
Post-implementation

ABSTRACT

Purpose: To identify factors that influence the acceptance of technology for ageing in place by seniors in the post-implementation stage. This review is among very few that focus on acceptance in post-implementation phase.
Methods: A literature review. We searched six databases (Cinahl, Medline, PsycINFO, PubMed, Science Direct, Scopus). Inclusion criteria were: 1) original and peer-reviewed research written in English, 2) Articles published in 2010–2018, 3) Empirical research papers, 4) Research in which participants are seniors aged above 60 years, 5) Research aimed at investigating factors that influence the acceptance of digital technology for ageing in place, 6) Research conducted in home environment, 7) Focus on post-implementation stage.
Results: Twenty-three out of 2181 papers were included. The results show that acceptance of technology in the post-implementation stage is influenced by 36 factors, divided into six themes: concerns/problems regarding technology (technical errors, etc.), experienced positive characteristics of technology (e.g., ease of use factors, privacy implications), expected benefits of technology (e.g., increased safety, companionship, increased security, etc.), need for technology (e.g., perceived need to use), social influence (e.g., influence by peers, family or surroundings) and characteristics of older adults (e.g., past experiences/attitudes, physical environment). The articles considered different types of technology: health monitoring, ADL, safety and communication. The level of technology readiness for digital technologies supporting ageing in place in post-implementation stage is still low within the scientific literature, since only seven out of 23 articles studied mature technologies (TRL 8–9 of the technology readiness level scale). The majority of the studies were conducted in Western Europe or the US, and only two were conducted in other regions (Australia, and Taiwan). Qualitative and quantitative methods were equally used in the analysed articles.
Conclusions: Acceptance of technology in the post-implementation stage is influenced by multiple factors. An interesting finding was that the seniors' views of technology change between the pre- and post-implementation stages. Some negative concerns that appeared in the pre-implementation stage appear as positive characteristics in the post-implementation stage. In the post-implementation stage, seniors realize the wide variety of benefits that technology can have on their lives. We expect that findings of this review can be utilised by academics and policy-makers for gaining insights for further research and successful implementation of technology for ageing in place.

1. Introduction

The majority of seniors prefer to live their lives independently at their homes for as long as they can [1], and that scenario is also favoured by policy-makers and health providers to avoid the costly options of institutionalised care [2]. However, to be able to carry out independent life at home, seniors must have the capacity to be cognitively stable and capable of performing essential daily activities on their own. In this study, we focus on digital technologies (devices that generate, store or process data) for ageing in place (DTAP) that are used to support the elderly at home such as, sensor-based monitoring systems and other technologies used in home environments. By definition, ageing in place entails "the ability to live in one's own home and community safely, independently, and comfortably, regardless of age, income, or ability level" [3]. Today, there are many such technologies available [4]. While technology providers claim that these technologies prolong independent living and support ageing in place, seniors are the ones who eventually need to accept the technology and decide whether

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https://doi.org/10.1016/j.ijmedinf.2019.06.027
Received 20 March 2019; Received in revised form 20 May 2019; Accepted 26 June 2019
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to use it, and implement it in their homes. Hence, it is important to create an understanding about the factors that influence seniors' acceptance of technologies supporting ageing in place.

A number of literature reviews have been conducted to understand what factors influence seniors' acceptance of DTAP [5–9], but few of these regard the fact that acceptance factors may vary other time [10,11]. An exception is Peek et al. [9], where the authors separate acceptance factors related to the pre-implementation stage (when a technology has not been used yet), i.e. the intention to use a technology [12], from acceptance factors related to the post-implementation stage, i.e. acceptance found during actual use of a technology [12].

At the time when Peek et al. [9] conducted their literature review, only four articles out of 16 could be categorised as post-implementation studies. The authors claim that further research in this area is needed. Hence, as a continuation of the previous work by Peek et.al. [9], we aim to investigate acceptance factors for DTAP in the post-implementation stage. This study addresses the following research question: *Which factors influence the acceptance of DTAP by seniors in the post-implementation stage?*

In order to better understand the context for the implementation of DTAP and the identified acceptance factors we also consider the type of implemented technology, the method used by the authors to identify acceptance factors (type, instrument and number of participants), and the country where the study was conducted. Additionally, we apply the Technology Readiness (TRL) scale [13] (see Table 3) to understand the level of the implemented technologies (from, for example, early prototype to a commercially available technology). In this review, TRL scale 4 is considered as post-implementation since actual users have tested the technology.

Various terms are used to refer to technologies supporting seniors at home in current literature [4,14]. Aware of that, in this literature review we use the term *DTAP* and include different types of technologies that support seniors at home, such as for example AAL (ambient assisted living) technologies, telehealth and monitoring systems, robots and other ICT devices. Similarly with Peek et al [9], actual use in our study includes not only implemented fully functioning technology, but also prototype tests.

The rest of the paper is structured as follows. The following section presents existing literature reviews on acceptance factors for DTAP. In Section 3, we present the research method adopted for our literature review. In Section 4, we present the review results, followed by a discussion. Finally, the conclusion highlights the research contributions, acknowledges the study limitations and provides suggestions for further research.

2. Related research

Several literature reviews have been conducted to understand what factors influence seniors' acceptance of DTAP [5–9,15]. The identified factors range from fears for high costs [5,7,8] to social aspects such as more independent life [5,8] and increased interaction with family and friends [7] (see Table 1). Some of the factors are identified in all reviews (e.g. privacy implications, ease of use, increased independence), others only in one or two (e.g. more social activity [7], trust [8]). Although the literature reviews [5,8] include studies concerning both the pre-implementation and post-implementation stage, none of them make any distinction as to whether the identified acceptance factors appear in the pre- or post-implementation stage. This may be a shortcoming of existing literature reviews since previous literature has shown that acceptance of technology varies over time [10,11].

On the contrary, the literature review conducted by Peek et al. [9], makes a clear distinction between acceptance factors that appear in the pre-implementation stage from acceptance factors in the post-implementation stage. The authors found 27 factors influencing the acceptance of DTAP in the pre-implementation stage, which they categorised in six categories (see Table 1). The authors correspondingly found ten acceptance factors concerning the post-implementation stage (see Table 5). They were so few because Peek et al. [9] found only four studies that considered the post-implementation stage. Some of the identified factors were the same as in the pre-implementation stage (e.g., privacy implications, stigmatisation, perceived need, influence of professional caregivers and increased safety), but some new factors were also identified, such as technology not working in certain locations, availability of home care as alternative to technology for ageing in place, level of satisfaction with the new technology, and affect towards new technology after using it. The authors found that some concerns highlighted by seniors in the pre-implementation stage became real-life problems in the post-implementation stage, as for instance false alarms or forgetting or losing the technology. Another literature review concerning acceptance factors in the post-implementation phase was conducted by Liu et al. [15]. Although the focus in this review was on determining the level of technology readiness, and smart monitoring technologies affect ageing in place, the authors also discussed technology acceptance factors. Thirty-two out of 48 studies included in the review considered acceptance factors ranging from technical problems and unreliable systems to improved independence and safety.

3. Methods

3.1. Search strategy and selection of articles

We searched six medical and technological databases to find relevant articles for this study: Cinahl, Medline, PsycINFO, PubMed, Science Direct, and Scopus. Database selection was partly based on the selection of databases in a study by Peek [9], complemented with Science Direct, which includes research from the medical and engineering sciences. The databases were searched using a combination of (1) "senior" and synonyms for this term, (2) "home environment", and "community-dwelling" and similar search terms; (3) "assistive technologies" and lastly (4) "acceptance" and synonyms. The combinations included the AND/OR functions, for example "senior" OR "elderly" AND "home environment" OR "ageing in place", etc. To keep the research on a contemporary level and complement the Peek et al. [9] study, which included articles up to January 2012, we searched for articles published between 2010 and 2018. The search and selection process is shown in Fig. 1. Screening of the abstracts and later the whole articles was done mainly by one author, applying the inclusion criteria presented in Table 2. After the inclusion criteria were applied and the potential hits were collected, the author excluded based on the following: 1) Books, Lecture Notes, proceedings or not available, 2) not including a clear separation of the participant groups, 3) research conducted in hospitals, 4) studies on non-digital assistive technologies such as canes, wheelchairs, 5) studies that did not provide enough

Table 1
Summarised acceptance factors identified in the previous literature reviews.

Literature review	Weegh & Kampel [5]	Chung [6]	Mostaghel [7]	Yusif [8]	Peek et al [9]	
Included studies	16 total	16 total	18 articles total (11 on elderly)	44 total	16 total	
	10 pre-implementation	8 pre-implementation	9 pre-implementation	39 pre-implementation	12 pre-implementation	
	6 post-implementation	8 post-implementation	3 post-implementation	5 post-implementation	4 post-implementation (not shown in this table)	
Acceptance factors	Perceived ease of Use	Usability	Usability	Ease of use	**Concerns regarding technology**	**Need for technology**
	Control & Security	Privacy	Improvement of quality of life	Privacy	High cost	Perceived need
	Financial ability & Willingness	Autonomy	More independent life	Trust	Privacy implications	Subjective health
	Privacy vs independence/ safety	Equal access	More opportunities for interaction with family and friends	Functionality/added value	Forgetting or losing technology	status
	User involvement	Obtrusiveness	More social activity involvements	Cost suitability for daily use	False alarms	**Alternatives to technology**
	Human replacement	Reduction in human contact	Affordable (being able to buy and maintain the technology)	Perception of no need	Obtrusiveness	Help by family or spouse
	Awareness	Stigmatisation	Accessible (information and services about the technology are available), Usable (ease of use, the usage does not lead to feelings of stress and confusion)	Stigma	Burdening children	Current technology
	Reputation / alignment to current lifestyle	Reliability of technology	Personal characteristics (age, education)	Fear of dependence	Ineffectiveness	**Social influence**
	Government/politics/legal aspects	Maintenance of the system	elders' physical and mental status	Feeling of embarrassment	Impracticality	Influence of family and friends
	Experience	Security Risks	Less privacy	Autonomy	Low ease of use	Influence of professional caregivers
	Perceived usefulness	Informed Consent	More security and safety	Loss of Dignity	Negative effect on health	Use by peers
		Accuracy of technology	replacement of humans with technology	Limited training tailored to older learners	No control over technology	**Characteristics of older adults**
		Data security	Using/maintenance/training and education costs	Lack of accessibility and social inclusion	Stigmatisation	Desire to age in place
					Benefits expected of technology	Cultural background
					Increased safety	Familiarity with electronic technology
					Perceived usefulness	Housing type
					Increased independence	
					Reduced burden on family caregivers	

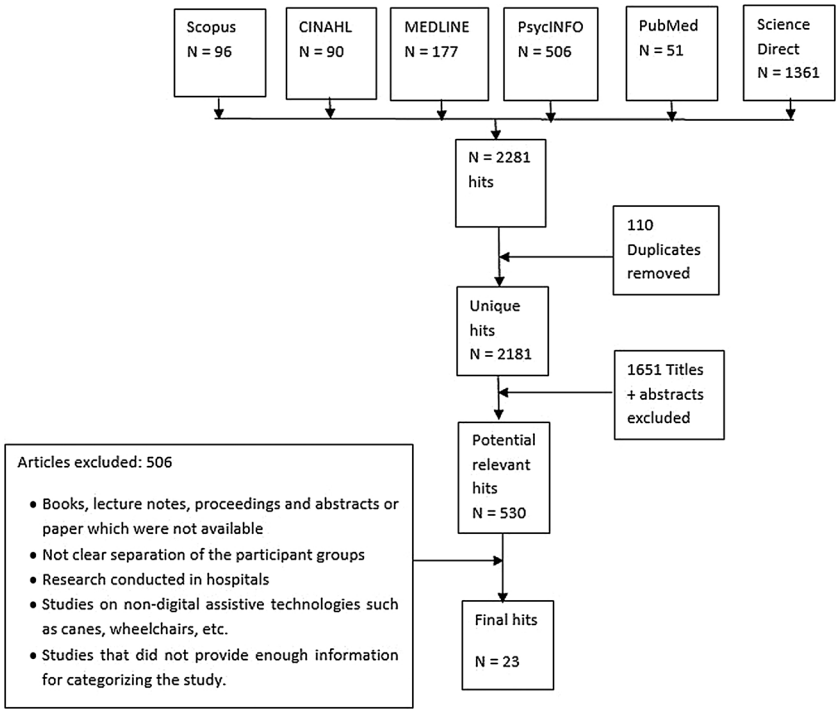


Fig. 1. Flow diagram of the article selection process.

Table 2
Inclusion Criteria.

- Original and peer-reviewed research written in English
- Articles published between 2010-2018
- Empirical research papers
- Research in which participants are seniors aged above 60 years
- Research aimed at investigating factors that influence the acceptance of digital technology for ageing in place
- Research conducted in home environment
- Focus on post-implementation stage

information for categorizing the study. In case of ambiguity, the selection and exclusion were discussed with the two other authors'. The selection process resulted in 23 articles that were included in the review. Finally, we would like to mention that we did not perform a quality assessment of the articles such as Peek et al. [9] but the articles included in this review have all passed a peer review stage before their publication.

3.2. Data analysis

Similarly to Peek et al. [9], we analysed the reviewed articles with respect to 1) acceptance factors, 2) type of technology, and 3) method

Table 3
Technology readiness scale according to the United States Department of Energy [13].

Level of technology readiness (TRL)	Description
TRL 1	Basic principles of technology are observed and reported
TRL 2	Technology concept and/or application is formulated
TRL 3	Analytical and experimental critical functions and/or characteristic proof of concept
TRL 4	Component and/or system validation is conducted in laboratory environment
TRL 5	Technology is developed and tested both in laboratory and validated in relevant environments
TRL 6	Technology demonstration, in which engineering and pilot-scale, similar prototypical system validation in relevant environment is conducted
TRL 7	System commissioning I, in which full scale similar prototypical system is demonstrated in relevant environments
TRL 8	System commissioning II, actual system is completed and qualified through test and demonstration in relevant environments
TRL 9	System operation, actual system operate over the full range of expected mission conditions

Table 4
Characteristics of reviewed articles.

Article	TRL	Technology type	Method	Data collection	Participants	Country
Cotten et al. [17]	9	Communication	Quantitative	Survey	205	USA
Demiris et al. [18]	9	Health monitoring	Qualitative	Focus group	12	USA
Giger et al. [19]	9	Health monitoring	Quantitative	Survey	14	USA
Luijkx et al. [20]	9	ADL	Qualitative	Interviews	53	Netherlands
Peek et al. [21]	9	ADL	Qualitative	Interviews	53	Netherlands
Reeder et al. [22]	9	ADL	Quantitative	Survey	96	USA
Wade et al. [23]	9	Health monitoring	Mixed	Survey + interviews	43	Australia
Boise et al. [24]	7	Health monitoring	Quantitative	Survey	119	USA
Gellis et al. [25]	7	Health monitoring	Quantitative	Survey	94	USA
Pecina et al. [26]	7	Health monitoring	Qualitative	Survey	20	USA
Planinc et al. [27]	7	ADL	Mixed	Survey + Interviews	259	Italy, Spain, Germany, Austria
Ravishankar et al. [28]	7	ADL	Qualitative	Interviews	4	USA
Tseng et al. [29]	7	Health monitoring	Quantitative	Survey	32	Taiwan
Van Hoof et al. [30]	7	ADL + Safety	Qualitative	Interviews + Observations	18	Netherlands
Chen et al. [31]	6	Monitoring system	Mixed	Interviews + measurements	4	USA
Doering et al. [32]	6	ADL	Qualitative	Observations + interviews	3	Germany
Dupuy et al. [33]	6	ADL + Safety	Quantitative	Survey	34	France
Saracchini et al. [34]	6	ADL	Qualitative	Focus group	13	Spain
Vaziri et al. [35]	6	Safety	Mixed	Survey + Interviews	153	Germany
Vermeulen et al. [36]	6	Health monitoring	Mixed	Survey + Interviews	5	Belgium
Fischinger et al. [37]	5	Safety	Mixed	Survey + Interviews	49	Austria, Greece, Sweden
Garg et al. [38]	5	ADL	Quantitative	Survey	101	USA
Pino et al. [39]	5	ADL	Mixed	Survey + Focus group	18	France

(type, instrument and number of participants). Additionally, similarly to Liu et al [15], we analysed the level of technology readiness (TRL) using the 9-levels readiness scale [13] (see Table 3).

To ensure a common interpretation of the categories, 15 articles were analysed by all the three authors. These 15 articles were randomly selected. First, each researcher was given the same 5 articles which were separately analysed. The individual analysis was subsequently discussed by all three researchers until consensus was reached on every entry in the data extraction form (excel sheet) for each article. This was conducted for 5 articles at a time in weekly/bi-weekly sessions, until the categories were stabilised and all the researchers categorised the articles in the same way.

We used Peek et al's [9] categories and themes as a starting point for our categorisation of acceptance factors to be able to compare the factors influencing the acceptance of technology in the pre-implementation stage and those in the post-implementation stage. However, we were open to add or remove themes/categories if needed. For instance, we removed a theme called *alternatives to technology* since we did not find any acceptance factors within this theme, and we added a theme *experienced positive characteristics of technology*, since we found that e.g. experienced ease of use positively influenced seniors' acceptance of this technology. The factors were derived directly from the identified papers in line with [16], where acceptance factors were derived from approval or disapproval, like or dislike, rejection or acceptance of technology by seniors who tested or used it. The categorisation of the factors was validated through discussions amongst the three researchers conducting the analysis. During meetings, the three authors discussed the categorisation of the factors and, where deemed that the labelling of some factors coincided with others, then they were grouped up together as a common factor.

4. Results

4.1. Characteristics of reviewed articles

The characteristics of the reviewed articles are presented in Table 4. Out of the 23 selected articles, three concerned tests and validation of technology both in laboratory and in relevant environments (TRL 5), six articles considered demonstration and testing of prototypes (TRL 6), seven included testing of whole-system prototypes distributed in a real environment (TRL 7), and seven included commercially available technologies (TRL 9). Quantitative (survey and questionnaires) and qualitative (interviews, focus groups, observations) methods were equally (8 and 8 respectively) used in the analysed articles. Seven of the articles used mixed methods combining interviews or observation with a questionnaire or objective measurements. As shown in Table 4, articles considered acceptance of different types of technology: health monitoring (Devices measuring Health stats), ADL (Activities of Daily living, for example memory aids, reminding devices), safety (fall prevention devices, personal alarms) and communication (Devices used as means to communicate with others). The vast majority of articles considered health monitoring and ADL, and two articles described combinations of types of technology. Almost all studies were conducted in Western Europe (11), or the US (10); only two were conducted in other regions: Australia (1), and Taiwan (1).

4.2. Post-implementation acceptance factors

In this section, we present a summary of our literature review regarding the post-implementation factors. Table 5 shows the identified acceptance factors categorised into six themes. The factors are described in the text below.

Table 5
Post-implementation acceptance factors.

Theme	Factor	No of articles	Ref
Concerns/ problems regarding technology	Technical issues (i.e. false alarms, system malfunction)	8	(18, 23, 26, 28, 30-31, 35-36)
	Poor fit with preferences	7	(21, 29-30, 33-35, 39)
	High Cost / unwillingness to pay	3	(27, 37-38)
	Stigmatisation	3	(20-21, 39)
	Information accuracy	3	(27, 31, 38)
	Insufficient training for use	2	(18, 29)
	Feeling unsafe	2	(24, 32)
	Fear of becoming dependent	2	(21, 34)
	Lack of adaptability	2	(27, 39)
	Lack of control over data and recipient	2	(18, 38)
	Fear of use /anxiety	1	(30)
	Unfamiliarity	1	(34)
	Easily forgetting functions	1	(31)
Experienced positive characteristics of technology	Ease of use	11	(18-19, 21-22, 26, 29, 31-32, 34-35, 37)
	No privacy intrusion	6	(21, 24, 28, 30, 38-39)
	Usefulness	4	(19, 33, 38-39)
	Unobtrusiveness	1	(31)
Experienced benefits of technology	Increased safety / security	7	(20-21, 25-26, 30, 33, 39)
	Increased awareness over health condition	6	(18, 25-26, 29, 35-36)
	Increased independency	5	(18, 25, 27-28, 30)
	Increased enjoyment	4	(32, 35-37)
	Increased communication	4	(17, 26, 32, 34)
	Companionship	2	(32, 39)
	Increased social interaction	2	(18, 27)
	Increased capabilities to perform ADL	2	(22, 29)
	Increased reliability / trust	1	(22)
	Reduced burden on family	1	(21)
	Decreasing the digital divide	1	(17)
Willingness to use technology	Perceived need to use	6	(21-22, 28-29, 37, 39)
	Increased willingness to use	4	(19, 22, 32-33)
	Time of using (testing) technology	3	(19, 22, 33)
Social influence	Influence of social networks	4	(19, 21, 29, 33)
	Influence of family	3	(19-21)
	Influence of organisations	1	(21)
Characteristics of seniors	Previous technological experience	5	(19, 21, 29, 32, 35)
	Physical environment	3	(21, 29, 31)

4.2.1. Concerns/problems regarding technology

One of the major concerns regarding technology in the post-implementation phase are technical issues [18,23,26,28,30,31,35,36] that varied from false alarms to system malfunction. Another concern relates to the poor fit with preferences of those technologies (such as unattractive form of the technological product, bulky design, etc.), which is often not in line with what the seniors would prefer [21,29,30,33–35,39]. High cost or unwillingness to pay appears to be another technology-related concern [27,37,38] since seniors not always have the economic ease to actually buy a technology. Another factor found in the literature was stigmatisation [20,21,39]. In a few cases, after the seniors tested the technologies, they felt that the technology would make them feel older or more fragile, or that their social milieu would think they are frail since they need to use a technology. Information accuracy is another concerning factor. Some of the tested technologies concerned showing vital signs, such as blood pressure and sugar levels and information accuracy is vital [27,31,38] for this type of technology. Training for use was emphasised as an important precondition for seniors to be able to use the technology [18,29]. Two of the studies [24,32] showed that seniors felt unsafe while using the technology. Interestingly, fear of becoming too dependent on the technology seemed to be a concern for seniors [21,34], stating that they would feel incapable of doing things on their own after some time. Fear of use/anxiety was also a technology-related concern; seniors are not as tech savvy as younger generations so this creates the fear of using something completely new to them [30]. Unfamiliarity (insecurity about new technologies) was another concern hampering seniors' acceptance of technology [34]. Some of the least mentioned concerns that showed up in our literature were lack of adaptability (not having the ability to further adapt to needs) [27,39], control over data and recipient (having the ability to choose what data is sent and who receives the data) [18,38], and lastly easily forgetting the functions (forgetting things such as charging batteries, turning on/off etc.) [31].

4.2.2. Experienced positive characteristics of technology

In the identified literature, we found that seniors often experienced the tested technology as easy to use (i.e., ease of use (how natural it is to use something)), which was a positive experience [18,19,21,22,26,29,31,32,34,35,37]. Privacy (freedom from unauthorised intrusion), which was also identified in the literature, indicated that seniors had positive feelings about maintaining their privacy while using the technology [21,24,28,30,38,39] and were not afraid that the use of technology would jeopardise their privacy. Usefulness (the degree something is useful for a certain purpose) was another factor that positively influenced seniors' acceptance of technology. Interestingly, the degree of usefulness fluctuated over time, i.e. after interacting with the technology for a period of time seniors' perceptions of usefulness became stronger [19,33,38,39]. Giger et al. [19] point out that participants require more time to use the technology and that the interaction is highly affected by social influences. A last characteristic of the technology that was appreciated by seniors was its unobtrusiveness [31], as they reported that they felt the technology was not intruding their lives.

4.2.3. Experienced benefits of technology

Increased sense of safety and security is a major factor regarding the experienced benefits of technology expressed by seniors in the post-implementation stage. Seniors expressed that the technology increased their safety at home and provided them with a sense of security [20,21,25,26,30,33,39]. Another benefit that showed up in the

literature is that the technology provided seniors with increased awareness over their health condition [18,25,26,29,35,36]. This was a factor merged from three different descriptions, which were control over health [18,25], feedback regarding health condition [18,29,35,36], and awareness [26] of their health condition. Seniors experienced that because they received more information about their health they could control it better [18,25,26,29,35,36]. Another benefit of the technology experienced by seniors was increased independency (being free from the control or power of another person). They felt more capable to act and be more independent thanks to the technology [18,25,27,28,30]. Increased enjoyment was also a beneficial factor experienced by seniors, after having used the technology [32,35–37]. Seniors identified that the use of technologies helped them to increase their communication [17,26,32,34] with their social circles, making it easier to communicate even with people who were not in close proximity. Companionship was a factor mentioned in the literature in relation to social robots [32,39]. Companionship concerns having someone/something to be there for you, like having a cat or a dog at home. Least identified in the literature but still important factors were: increased social interaction (interaction with other users of the same technology and exchange of opinions) [18,27], increased reliability/trust (easier to accept a technology – no fear of using) [22], increased capabilities to perform ADL (being able to perform activities of daily living) [22,29], reduced burden on family [21], and decreasing the digital divide (reducing the uneven distribution in the access to, use of, or impact of information and communication technologies between distinct groups) [17].

4.2.4. Willingness to use technology

Seniors' willingness to use technology depends on their need for technology (need to use) [21,22,28,29,37,39]. In most cases, seniors found the technology useful for others and not for themselves and as Pino et al. [39] states, they tend to reach the maximum limit of their capacities before they admit that they need a technology. Yet, several studies reported an increased willingness to use after seniors tried the technology, i.e. seniors wanted to keep using the technology provided to them [19,22,32,33]. It was also shown that time of using the technology [19,22,33] was an important factor that heavily influenced the willingness to use technology; the more time seniors were given to try/test the technology, the more their willingness to use it gradually increased.

4.2.5. Social influence

Social influence was a highly mentioned factor in the identified literature. In our literature, we identified three different types of social influence. These are (1) influence of social networks (friends) [19,21,29,33], influence of family [19–21], and lastly influence of organisations [21]. Giger et al. [19] suggest that the longer seniors used the technology, the more social factors influenced technology adoption behaviour. It was also shown that seniors were willing to adopt technologies that their children or grandchildren like [20]. According to a study by Tseng et al. [29], behaviour intention can also be influenced by opinions of other elderly in the social circle.

4.2.6. Characteristics of older adults

Previous experience in using technology was another factor influencing post-implementation acceptance [19,21,29,32,35]. In some cases, the physical environment would hinder the use of technology, due to lack of space [21,29,31]; the technology would be placed where it was hard to reach and other times the participants did not want to place the technology in a certain room because they felt it took up too much space and they were not willing to make adjustments to their home [21].

5. Discussion

The literature review was conducted to *identify factors influencing the acceptance of DTAP by seniors in the post-implementation stage.* Table 6 shows factors identified in this literature review (column 4) compared to previous literature reviews: Peek et al. [9] (column 2) and Liu et al. [15] (column 3). We present these factors in relation to the pre-implementation stage acceptance factors identified by Peek et al. [9] (column 1).

As Table 6 shows, the current literature review is the most comprehensive of all reviews of factors influencing post-implementation acceptance of DTAP (column 2 and 3). We found that acceptance of technology in the post-implementation stage is influenced by 36 factors, divided into six themes.

Consistent with prior reviews of post-implementation acceptance factors (Column 2 and 3) we found that several concerns regarding technology identified in the pre-implementation phase become real-life problems in the post-implementation phase. We found for instance that seniors experience many technical problems when testing and using the provided DTAP. This problem emerged even if the tested technologies were almost fully developed (TRL 6–9). However, in addition to Peek et al [9] and Liu et al [15], we found that some of the pre-implementation concerns expressed by seniors did not appear in the post-implementation stage (e.g. concerns regarding ease of use, usefulness), but in some cases emerged as positive characteristics of technology as experienced. That could have occurred due to the different types of participants. For instance, in the pre-implementation studies, the participants may have been significantly different from the participants in the post-implementation studies. In this review though, this was not something that was taken into consideration.

Several factors identified in the pre-implementation phase (column 1), such as cost, stigmatisation, perceived need for technology etc. were also identified in this literature review. Comparing with factors implemented in pre-implementation [9] (column 1), the most remarkable difference concerns the theme benefits expected of technology. After using the technology, seniors acknowledge a huge variety of benefits that the new technologies can bring to their lives. In our study, we see factors identified as concerns regarding technology, e.g. burden on family and negative effect on health, portrayed as benefits (reduced burden on family, receiving feedback, helpful in ADL and increased awareness), which is in line with the argument of Peek et al. [9] about acceptance fluctuations in different times. Surprisingly, we found that privacy is not an issue in the post-implementation stage. Seniors in the reviewed articles did not experience any negative impact of the technology on their privacy.

After conducting the literature review, we note that there are still few studies considering post-implementation acceptance factors; (23) out of 530 potential studies after duplicate removal (2181). This means that the level of technology readiness for digital technologies supporting ageing in place is still low within the scientific literature, since only seven out of 23 articles studied mature technologies (TRL 8–9 of the technology readiness level scale) [13]. These findings are similar to those of Liu et al [15] who showed that level of technology readiness for smart homes and home health-monitoring technologies was low. The majority of studies focus on health monitoring technologies and technologies supporting activities of daily living. This means that possibilities to study post-implementation acceptance factors are still limited. Another notable fact is that a huge majority of studies included in the literature review were conducted in Western Europe (11), or the US (10). This means that we are unaware of factors influencing seniors' acceptance of DTAP in other countries and regions. Previous research shows that acceptance of technology differs between different cultures and socio-economical environments [40]. Studies considering acceptance factors apply both quantitative and qualitative methods; however there are still very few studies (7 out of 23) studying larger numbers of participants (more than 94) so the generalisability of the identified

Table 6
Comparison between the current and previous reviews.

Peek et al [9] pre-implementation	Peek et al [9] post-implementation 4 articles	Liu [15] post-implementation 32 articles	Current literature review 23 articles
• **Concerns regarding technology** • High cost • Privacy implications • Forgetting or losing technology • False alarms • Obtrusiveness • Burdening children • Ineffectiveness • Impracticality • Low ease of use • Negative effect on health • No control over technology • Stigmatisation	**Concerns regarding technology** • Privacy implications • Stigmatisation	**Concerns regarding technology** • Loss of privacy • Risk of information falling to unauthorised parties • Obtrusiveness	**Concerns regarding technology** • High Cost / unwillingness to pay • Stigmatisation • Information accuracy • Insufficient training to use • Fear of becoming dependent • Fear of use /anxiety • Lack of adaptability • Lack of control over data and recipient • Easily forgetting functions
–	**Concerns that become real problems** • False alarms • Forgetting or losing technology • Technology not working in certain locations	**Concerns that become real problems** • Technical problems • Unreliable system	**Concerns that become real problems** • Technical issues (i.e. false alarms, system malfunction) • Design issues • Unfamiliarity
–	**Experienced positive characteristic of the technology**	**Experienced positive characteristic of the technology**	**Experienced positive characteristic of the technology** • Ease of use • No privacy intrusive • Usefulness • Unobtrusiveness
Benefits expected of technology • Increased safety • Perceived usefulness • Increased independence • Reduced burden on family caregivers	**Benefits experienced of technology** Increased safety	**Benefits experienced of technology** • Supporting to age in place • Improved independence • Improved safety • Help in an emergency • Assistance with hearing and visual impairment • Prevention and detection of falls • Monitor physiological parameters (e.g., blood pressure, glucose levels), • Ensure property security (i.e., intruder alarm), • Announce upcoming appointments or events, • Provide timely and accurate information on adverse drug events and contraindications • Improving quality of life	**Benefits experienced of technology** • Increased safety / security • Increased awareness over health condition • Increased independency • Increased enjoyment • Increased communication • Companionship • Increased social interaction • Increased reliability / trust • Increased capabilities to perform ADL • Reduced burden on family • Technological inclusion
Need for technology • Perceived need • Subjective health status	**Willingness to use** • Perceived need • Level of satisfaction	**Willingness to use**	**Willingness to use** • Perceived need to use • Increased willingness to use • Time of using (testing) technology
Alternatives to technology • Help by family or spouse • Current technology	**Alternatives to technology** • Availability of home care (alternative to technology for ageing in place)	**Alternatives to technology** –	**Alternatives to technology** –
Social influence • Influence of family and friends • Influence of professional caregivers • Use by peers	**Social influence** –	**Social influence** –	**Social influence** • Influence of social networks • Influence of family • Influence of organisations
Characteristics of older adults • Desire to age in place • Cultural background • Familiarity with electronic technology • Housing type	**Characteristics of older adults** • Affect towards the new technology	**Characteristics of older adults** • Personal characteristics (age, gender, cognitive ability, personality traits)	**Characteristics of older adults** • Previous experience • Physical environment

acceptance factors may be low.

We believe that this study carries a number of implications for science. We have identified a vast amount of acceptance factors in the post-implementation stage. This review leaves the stage for researchers to see how these factors can be possibly imbued in the design process of a digital technology. Senior citizens participation is another crucial point for when designing a digital technology to support ageing in place. We have placed the acceptance factors in order of appearance in the articles and so this gives the researchers some valuable insight into which factors could potentially be of higher importance. With that being said, we do not want to disregard the rest of the acceptance factors that appear in a smaller frequency since sometimes these factors can be rather crucial too, maybe not in the design process, but in different stages of technology production. An interesting idea for future would be the possible development of a standardized evaluation tool that could prioritize the acceptance factors regarding the context that is being researched. To improve our understanding of post-implementation acceptance it is suggested that new research clearly describes the type of the technology that is being tested. We also suggest increasing the number of longitudinal studies considering the fact that there are not many such studies, which study the same technology over time. It would also be of value that future research takes place in a home

environment. Lastly, we would like to mention the idea of conducting cross-case analysis of different countries that could potentially lead that for example different acceptance factors apply for different countries and from that point then proceed by analysing why it possibly is like that.

6. Conclusion

This paper contributed to a better understanding of acceptance factors of digital technologies for ageing in place and reveals several important facts about technology acceptance by seniors related to the post-implementation stage: 1) acceptance factors differ between pre- and post-implementation stage, 2) previous concerns regarding technology now appear as positive characteristics, 3) in the post-implementation stage seniors realise a wide variety of benefits that technology can have on their lives, 4) there are still few studies considering post-implementation acceptance factors, 5) the level of technology readiness for digital technologies supporting ageing in place is still low within the scientific literature, 6) the huge majority of studies considering acceptance factors in the post-implementation stage are conducted in Western Europe, or the US, and 7) there is a limited generalisability of acceptance factors due to the low number of participants in the reviewed studies.

The findings can be used by professionals who are aiming to create new technologies for seniors. By taking into consideration our results, they can create a product with higher chances of successful implementation.

Author statement

All authors (Antonios Tsertsidis, Ella Kolkowska, Karin Hedström) certify that they have seen and approved the final version of the manuscript being submitted. The article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

All authors have made a substantial contribution to this study. Tsertsidis: study concept and design, data analysis, data interpretation and drafting of the manuscript. Kolkowska and Hedström: analysis of data, critical revision of the manuscript for important intellectual content.

Summary points

What is already known on the topic?

- The increase of the ageing population is a topic of interest in many countries.
- A variety of different factors influence seniors' acceptance of technologies supporting ageing in place

What does this study add to our knowledge?

- Identification of acceptance factors related to the post-implementation stage.
- Seniors view of technology changes between the pre- and post-implementation stages.
- Previous concerns regarding technology now appear as positive characteristics.
- In the post-implementation stage, seniors realise a wide variety of benefits that technology can have on their lives.

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