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Explanatory Model of Awareness Factors of Smart Technologies for Independent Living at Home in Later Life

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Abstract

Background: Despite the rapid development of Smart Technologies for Independent Living at Home (STILH) among older adults, their market is still underdeveloped. Low awareness is one of the key reasons for the slow uptake of STILH in later life. A significant gap exists in the literature regarding the factors that shape older adults' awareness of STILH.

Objective: The aim is to provide a conceptual overview and empirical test of awareness factors of STILH in later life. An explanatory model is proposed by integrating insights from consumer behaviour, information processing and technology adoption models.

Methods: The model is tested with structural equation modelling based on survey data from a sample of 1200 internet users aged 55+ in June 2024.

Results: The results support all the proposed hypotheses, indicating that exposure to information about STILH, source expertise, self-source congruity and individuals' innovativeness directly influence awareness of STILH. Moreover, inherent novelty seeking and self-efficacy influence individuals' innovativeness, and together with self-source congruity and source expertise positively affect exposure to information about STILH.

Conclusion: Based on the study results, interventions can be tailored to help scale up STILH more efficiently, ultimately improving quality of life.

Index Terms

Awareness factors; Explanatory model; Older adults; Smart technologies for independent living at home; STILH.

1 INTRODUCTION

The global population is aging rapidly, with the number of older adults increasing faster than any other age group (United Nations, 2020). Many older adults desire to live active and independent lives at home (Ward & Ray, 2011). However, aging brings numerous challenges, such as serious illnesses and decline in cognitive and physical abilities, necessitating the support of carers (LaFave et al., 2021). The rise in retirement age and evolving family dynamics contribute to decreasing availability of possible informal carers (Hlebec et al., 2016).

One plausible solution for the limited availability of informal carers is the use of smart technologies for independent living at home (STILH). They refer to a wide array of devices and applications such as e-care services, motion sensors and health monitoring devices (Ward & Ray, 2011), aiming to improve the quality of life for older adults by facilitating independent living and reducing the need for carer support in later life (Peek et al., 2017).

While some STILH, such as e-care services, require carers' engagement (Kohlbacher & Hang, 2011), others, such as activity and health monitoring devices, are fully automated and user-centric (Edge et al., 2000). By encompassing various digital technologies that autonomously monitor environmental and personal parameters to ensure safe and autonomous living, STILH benefit a wide array of end users concerned with independent living and reduce the need for carer support in later life (Cheek et al., 2005).

Prior literature suggests that STILH facilitate autonomy, safety and quality of life while reducing healthcare costs (Blackman et al., 2016; Ghorayeb et al., 2021). Thus, they are increasingly recognized as vital for improving well-being and ensuring security in daily activities of older adults (Neves et al., 2018; Sen et al., 2022). In fact, since many older adults nowadays are healthy and active, having only minimum impairments (Czaja et al., 2019), overcrowded or understaffed nursing homes are often an inconvenient solution for them. In addition, many older adults prefer staying at home due to the attachment and familiarity with their household, as it serves as a "safe haven" (Ghorayeb et al., 2021). Moreover, existing research shows that STILH not only enhance the well-being of older adults but also offer a cost-effective alternative to traditional caregiving methods and models (Holliday et al., 2015; Peek et al., 2017). Nevertheless, there are some critical voices concerning the use of STILH in eldercare. For instance, the use of STILH could increase older adults' feeling of social isolation, which derives from their fear of losing the existing in-person support provided by informal carers on behalf of the possibility of remote control of their well-being (Kavčič et al., 2023). Besides, the use of STILH could also decrease older adults' peace of mind due to their low level of knowledge and trust in performance of such devices and applications (e.g., Smole Orehek et al., 2019).

Because the adoption of STILH has been slow so far (Kavčič et al., 2023; Rybenská, 2024; WHO & UNICEF, 2022), prior studies explored barriers and facilitators of STILH uptake, such as individuals' preferences (Langley et al., 2020), prior experiences with digital technology (Bradley et al., 2013) and perceptions of assistive technologies and poorly designed products (Petrovčič et al., 2019). Importantly, Heinz et al. (2013) pointed out that *awareness* of STILH among older adults remains very low, while Ward and Ray (2011) suggested that a lack of awareness is one of the key deterrents to STILH uptake in later life. In fact, awareness, which reflects the salience of an entity (e.g., brand, product or service) in the consumer's mind (Aaker, 1996) is essential for the uptake and adoption (i.e., continued use) of any technology (Rogers, 1983). Hence, raising awareness of the existence and benefits of STILH is crucial for scaling up models based on e-care and making them feasible for both providers and end users (Kavčič et al., 2023; Roelands et al., 2002). However, there is a significant gap in the literature regarding the factors that shape awareness of STILH among older adults. While limited qualitative research suggests that doctors, as sources of information, can increase awareness of STILH (Woodcock et al., 2013), these findings remain inconclusive. In addition, comprehensive quantitative research into STILH is virtually non-existent. Accordingly, this study sought to answer the following research question: *What are the factors affecting the level of awareness of STILH among older adults?*

To answer this research question, this paper develops and validates an integrative explanatory model that identifies and explains the factors affecting STILH awareness among older adults. Conceptually, the study draws on *communication processing models* that highlight how messages are encoded and decoded for transmission from the source to the end receiver (e.g., Schramm, 1971), ensuring recognition by the end receiver. Since the effectiveness of message transmission relies upon sources, messages and receivers, the proposed explanatory model suggests that *source, message and consumer characteristics* influence the effective transmission of information (messages) about STILH. In this context, two theoretical frameworks based on information processing models are integrated into the proposed model (see Figure 1) to explain the potential factors of awareness of STILH. On the one hand, perception and perceptual selection models (e.g., Treisman, 1969) are used to underscore the importance of the nature of stimuli that activate consumer's attention. Notably, exposure to the message and source characteristics are recognised as relevant factors influencing awareness of STILH. On the other hand, since individuals tend to see what they need, want or expect to see, internal factors, such as expectations, needs and motives (Evans et al., 2013) should also be considered when investigating awareness of STILH. Thus, the diffusion of innovation model is used to explain potential individual traits influencing the adoption of STILH (Rogers, 1983).

This article proceeds as follows. In the following section, the concept of awareness is presented and a brief overview of scarce prior literature dealing with awareness of STILH among older adults is provided. Next, a set of constructs related to awareness of STILH is defined and 10 explanatory hypotheses within the proposed model are presented. These hypotheses are then tested using survey data collected from a representative sample (N = 1,200) of older

internet users (aged 55 and over) in Slovenia. The article concludes with a discussion of the theoretical and practical significance of our findings.

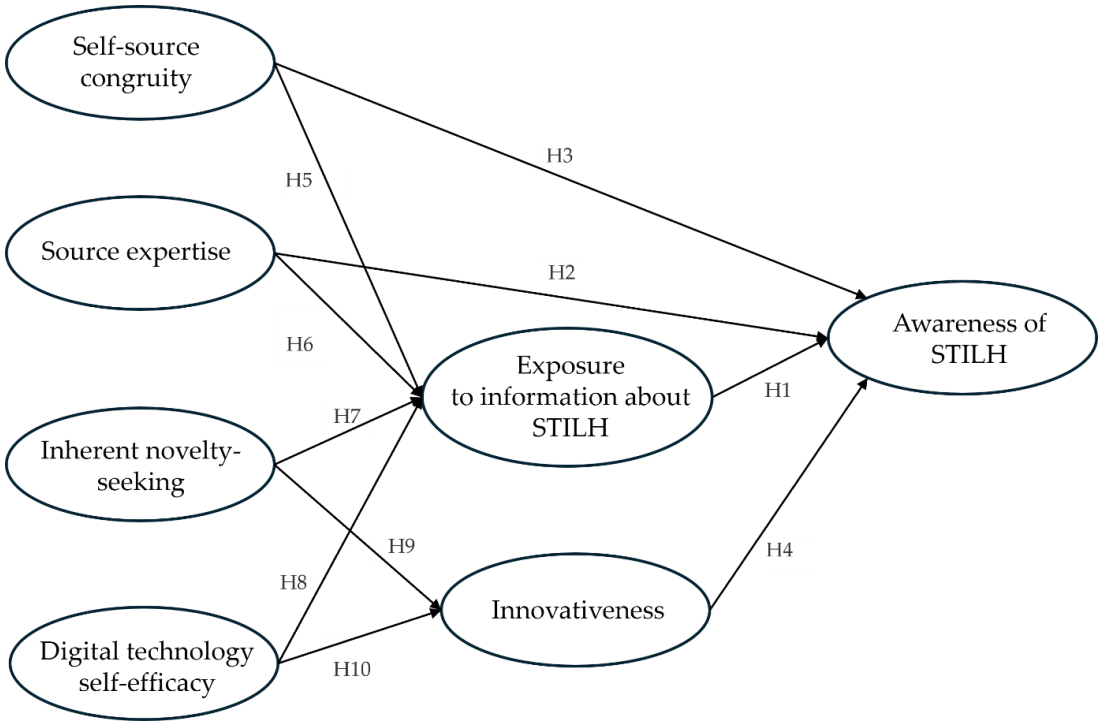


Figure 1. *Explanatory model of factors affecting awareness of STILH.*

2 BACKGROUND

2.1 Awareness and STILH

Prior studies have indicated that older adults are willing to embrace innovations related to STILH (Heinz et al., 2013; Peek et al., 2014) and awareness has been recognised as an important stage in the STILH adoption process (Lee & Coughlin, 2015). Such findings are in line with the marketing literature, which defines awareness as "the strength of a brand's presence in the consumers' minds" (Aaker, 1996, p. 10). This suggests that awareness plays a pivotal role in shaping consumer choices by acting as the initial touchpoint between consumers and brands, products or services (Kotler & Keller, 2016). In fact, awareness is the first step in the consumer decision-making process and serves as the foundation for subsequent actions such as information search, evaluation of alternatives and purchase (Rossiter & Percy, 1987). Alba and Hutchinson (1987) found that consumers are more likely to consider and ultimately purchase brands or products of which they are aware. This is because awareness acts as a filter, narrowing down the vast array of options available to a manageable set of choices.

Importantly, Rogers (1983) suggested that the same mechanisms also apply to diffusion of innovations, identifying awareness as the first phase in the technology adoption process. However, the focus of existing research into STILH has been on the *consequences* of awareness, explaining how awareness of assistive technologies can lead to, for example, more positive attitudes towards them (Peek et al., 2017). Relatedly, Heinz et al. (2013) found that awareness of STILH was very low among older adults, while Ward and Ray (2011), Fischer et al. (2014) and Golant (2017) noted that lack of awareness is one of the major barriers of STILH adoption among older adults. Most (smart) technology acceptance models and theories (e.g., Peek et al., 2014; Venkatesh et al., 2003; Venkatesh et al., 2012) have not addressed factors related to awareness. However, prior literature identifies some potential factors affecting awareness in relation to awareness-raising initiatives.

According to the information processing models (Engel et al., 1995), all key stages in the message transmission process influence the probability of message retrieval, namely message, source and receiver characteristics. Regarding the message characteristics, exposure to the message needs to be provided to ensure further cognitive responses. Heinz et al. (2013) suggested that demonstrations in communities can provide more hands-on experience

with STILH. In addition, not only exposure to the message but also its relevance needs to be ensured. In fact, the probability that a person will pay focal attention to information increases if it has some relevance and is of interest to them (Evans et al., 2013). As Lee and Coughlin (2015) pointed out, information about STILH should be disseminated through significant others in social (support) networks of older adults (e.g., carers and core discussants), while Woodcock et al. (2013) emphasized the important role of doctors in raising awareness of STILH. Hence, source characteristics can heighten exposure. Finally, the ease of message transmission also depends on the end receiver. Flynn et al. (2006) explored how health condition shapes intentional information-seeking behaviour in later life. They found that older adults with health issues were more likely to engage in information-seeking actively than their healthier counterparts. Since older adults are a very heterogeneous population group, some perceive themselves as more innovative than their peers (Czaja et al., 2019) and, in turn, may express a higher willingness to try new STILH (Heinz et al., 2013).

The presented literature suggests that the level of STILH awareness among older adults is determined by two sets of factors. Firstly, exposure to the message and the characteristics of the source, namely source expertise and self-source congruity can be acknowledged as important exogenous antecedents. Secondly, individuals' characteristics (innovativeness, self-efficacy, inherent novelty seeking) can also play a significant role in the process of perceiving, selecting and remembering information in the context of STILH. Below, we propose an explanatory model with 10 theoretical hypotheses that integrate both conceptual frameworks derived from the technology adoption and information processing models.

2.2 Explanatory model

In psychology, exposure refers to "a condition which makes the given stimulus accessible to the individual's perception" (Zajonc, 1968, p. 1). Since individuals have a limited capacity to process the abundance of stimuli or information they receive, exposure is a basic requirement if marketers want to change consumer perceptions, attitudes and behaviour (Evans et al., 2013). The *models of hierarchy of communication effects* define exposure as a prerequisite for creating further cognitive responses (e.g., attention and retention) that subsequently affect attitudes and attitude change (Barry, 1987). "In order to be effective, marketers have to make sure that consumers are exposed to their marketing activities" (Evans et al., 2013, p. 47). The challenge of ensuring exposure is particularly relevant for consumers in later life since aging generally slows down information processing (Cerella & Halle, 1994; Diamond et al., 2000). In addition, older adults may face challenges such as visual impairments and declining hearing capabilities that affect their ability to process, store and retain information (Czaja et al., 2019). Repeated exposure to specific stimuli can help overcome these challenges. Exposing older adults to a message just once may not be enough for its acceptance; thus, a message needs to be delivered repeatedly to ensure its effective exposure and processing (Solomon et al., 2016). In fact, repetition enhances memory retention (Ebbinghaus, 1964; Nieuwenhuis-Mark, 2012), facilitates the encoding of information into long-term memory (Zhan et al., 2018) and increases brand recall (Singh & Cole, 1993; Tsuji et al., 2009). Given the diversity of stimuli and the impairments faced by older adults in information processing, increasing exposure to information about STILH will more likely capture their attention and lead to greater awareness of STILH. Accordingly, we hypothesise:

H1: Exposure to information about STILH positively affects the level of awareness of STILH.

While exposure is important, it is not enough to ensure that consumers will indeed perceive the message and focus their attention on it because they are more likely to pay attention only to relevant messages (Evans et al., 2013). In fact, only a small number of stimuli undergo the perception process in which stimuli are selected, organised and interpreted (Solomon et al., 2016). Selection criteria and processing rules are applied to filter only relevant information (Taylor & Crocker, 1981), such as *schemas*. Schemas are organised collections of beliefs and feelings affecting information selection, interpretation and integration (Alba & Hasher, 1983). Consequently, they shape the level of attention that individuals give to specific information (Solomon et al., 2016). The finding that doctors can stimulate awareness of STILH (Woodcock et al., 2013) corroborates *source effectiveness models* (e.g., Ohanian, 1990) in which source expertise is recognised as an important facet of source credibility affecting its effectiveness. Hovland et al. (1953) defined source expertise as "the extent to which a communicator is perceived to be a source of valid assertions" (p. 22 in Ohanian, 1990, p. 41). An expert has been characterised as someone who is perceived to have the knowledge or skills to make informed claims about a specific subject or topic (Biswas et al., 2006; McCroskey, 1966). Since source expertise is not an objective but rather a perceived characteristic that is ascribed to a source by a

message receiver, "expertise may be inferred because the source has special training or experience, education, history of success in problem solution, or from general attributes such as age, position, seniority or social background" (Tedeschi & Bonoma, 2017, p. 23). While source expertise was found to affect message persuasion (Chung et al., 2020), Roth-Cohen et al. (2021) showed a direct and positive relationship between information credibility and awareness of patient rights. Moreover, in their investigation into the credibility of influencers on the awareness of endorsed brands, Lou and Yuan (2019) showed that source credibility can enhance followers' brand awareness when they view influencer-generated branded posts. Based on this, we propose:

H2: Source expertise positively affects the level of awareness of STILH.

Self-source congruity is another *schema* that can heighten the level of attention that individuals pay to information about STILH. Self-source congruity, or the degree of similarity between two entities (e.g., individuals and sources of information), affects individuals' persuasion process (Kirmani & Shiv, 1998; Lu, 2013). According to *congruity theory*, individuals compare their personal identity to the object of observation, such as other individuals or brands (Epstein et al., 2016; Sirgy, 1982). Cognitive consistency shapes social schematic representation, with individuals seeking equilibrium in cognition and behaviour (Trepte, 2008). Dissonance from conflicting cognition or behaviour prompts efforts to reduce it, seeking validation from similar individuals (Turner, 1991). Similarity enhances trust, making those perceived as similar more appropriate for assessing social validity (Festinger, 1950). Similar sources are more compelling and reduce cognitive dissonance while enhancing information retention (Petty & Cacioppo, 2018). In the context of the diffusion of innovation, individuals share meanings and characteristics; communication of new ideas results in greater knowledge gain and behavioural change (Rogers, 1983). For instance, Kalyanaraman and Sundar (2006) found that source similarity increases personal relevance, motivating blog readers and improving message processing. Hence, we suggest:

H3: Self-source congruity positively affects the level of awareness of STILH.

The process of selection, organization, interpretation and storage of information in the memory also depends on individuals' personal characteristics in later life (Czaja et al., 2019). To uncover personal characteristics influencing older adults' awareness, we draw on the literature related to technology adoption. The *diffusion of innovation theory* (Rogers, 1983) argues that innovative individuals are more likely to actively seek information about new technologies. Rogers (1983) defined innovativeness as "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system" (p. 22). Similarly, Tsikriktsis (2004) suggested that innovative individuals "tend to be pioneers and thought leaders" (p. 43). Although older adults generally adopt new technology less readily than their younger counterparts, there is a segment of older adults that demonstrates early adoption tendencies (Czaja et al., 2019). Notably, about one out of five older adults in the USA prefer being early tech adopters (Anderson & Perrin, 2017). Since many STILH-based devices (e.g., digital medication reminders, wearable activity trackers) and services (e.g., e-care) are relatively new technologies with a low adoption rate (Rybenská, 2024), it is reasonable to assume that older adults with a more pronounced self-perception of being early adopters of digital technologies will pay more attention to information about STILH. Therefore, we hypothesise:

H4: Innovativeness positively affects the level of awareness of STILH.

Through the perception process, in which stimuli are selected, organised and interpreted, individuals assign meanings to sensations (or raw data) to which they are exposed (Solomon et al., 2016). Consumers are open to information that interests them and even seek it out, while they avoid messages that are incongruent with their worldview (Evans et al., 2013). According to social identification theory (Tajfel & Turner, 1979), individuals are more inclined to trust significant others with whom they identify. They regard them as trustworthy due to their perceived similarity, which reinforces their own positive self-image. Additionally, similarity-attraction theory (Byrne, 1961) argues that individuals are more likely to interact with sources that they perceive as similar to themselves in various aspects, such as attitudes, values and beliefs. Consequently, older adults will be more inclined to seek information about STILH from sources that are perceived as more similar to them. Moreover, Hunsaker et al. (2020) suggested that not only similarity with the source but also perceived expertise is an important factor when acquiring information about digital technologies. Their findings align with uncertainty reduction theory (Berger & Calabrese, 1975), which suggests that individuals seek information to reduce doubt and ambivalence. Source expertise can be

crucial in minimizing technology-related uncertainty in later life, as older adults who perceive the source as an expert are more likely to have confidence in the information they receive from this source (Hunsaker et al., 2020; Quan-Haase et al., 2018). Given that older adults are likely to experience heightened uncertainty when faced with unknown and/or complex digital technology, they are more inclined to repeatedly turn to helpers and information sources that they perceive as experts or similar to them. Based on this, we hypothesise:

H5: Self-source congruity positively affects exposure to information about STILH.
H6: Source expertise positively affects exposure to information about STILH.

Inherent novelty seeking is defined as the "desire of the individual to seek out novel stimuli" (Hirschman, 1980, p. 284). As a personality trait, it is an inherent drive or motivational component that underlies information retrieval. Novelty seekers will actively look for information about new products and services, which increases their adoption compared to non-novelty seekers (Foxall et al., 1998). Moreover, a distinguishing characteristic of novelty seekers is their need to repeatedly engage with or explore something new or unfamiliar (Foxall et al., 1998). They intentionally try to gain diverse information about novel experiences, deliberately exposing themselves to various stimuli (McCrae & Costa, 1997). Such individuals often prefer sources known for delivering fresh, unconventional or groundbreaking perspectives, leading them to return repeatedly to sources that satisfy their desire for novelty. Therefore, it is anticipated that older adults who possess a greater inclination towards inherent novelty seeking will be more frequently exposed to information about STILH.

H7: Inherent novelty seeking positively affects exposure to information about STILH.

Self-efficacy refers to "judgments of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1982, p. 122) or "perceived competence and mastery, confidence in one's ability" (Czaja et al., 2019, p. 16). Bandura's (1982) *theory of self-efficacy* explains how individuals' beliefs in their capabilities influence their motivation, behaviour and perseverance across various tasks. He suggests that when individuals believe in their ability to learn and master a skill, they are more likely to adopt and engage with tasks they may not know well. Peral-Peral et al. (2019) applied the concept of self-efficacy to technology use, defining technological self-efficacy as "people's beliefs in their skills to use technologies" (p. 827), while Compeau and Higgins (1995) demonstrated that computer self-efficacy positively influences technology adoption. Furthermore, in their *technology adoption models*, Davis et al. (1989) and Venkatesh et al. (2003) described concepts similar to self-efficacy (i.e., perceived ease of use and performance expectancy) which have important impacts on technology adoption. Moreover, technology adoption literature suggests that in contexts characterised by perpetual change, users' judgments of how well they can handle technological innovations are related to information exposure. Tellingly, individuals with high levels of self-efficacy and, consequently, higher confidence in their ability to use new (digital) technologies are more inclined to search for information about similar technologies. This inclination arises from a desire to maintain or augment their level of control and mastery in effectively handling and adapting to new technologies. While prior literature has not examined the effect of self-efficacy on exposure to information about STILH among older adults, higher self-efficacy has been associated with increased health-related information-seeking behaviour (Rimal, 2001). Based on these premises, we propose:

H8: Digital technology self-efficacy positively affects exposure to information about STILH.

Hirschman (1980) proposed that inherent novelty seeking, as an innate component of individuals' motivation, also influences the level of their innovativeness. Dabholkar and Bagozzi (2002) argued that "consumers high in inherent novelty seeking tend to look favourably on technology and the use of technology-based products, have stronger intrinsic motivation to use such products, and enjoy the stimulation of trying new ways to approach old problems" (p. 188). Novelty seekers form more positive attitudes towards new and/or unknown technologies, which are associated with enjoyment, expected positive experiences and ease of learning. Consequently, they are also more likely to perceive themselves as more innovative, i.e., as early adopters compared to their peers (Dabholkar & Bagozzi, 2002). While the relationship between novelty seeking and innovativeness among older adults has not been empirically explored so far, we propose that older adults who are more inclined to seek out new information will find information about new technologies faster and, consequently, perceive themselves as being among the first to access and try these technologies. Therefore, we assume:

H9: Inherent novelty seeking positively affects innovativeness among older adults.

Individuals' self-efficacy is another factor influencing innovativeness in a technology-based context. Prior studies (e.g., Hasan, 2007; Mitzner et al., 2018; Tyler et al., 2020) have integrated the theory of self-efficacy (Bandura, 1982) with technology adoption models (e.g., Venkatesh et al., 2003). These studies have demonstrated that self-efficacy fosters the adoption of new digital technologies because individuals who feel more confident in their ability to quickly learn and adapt to new technologies are, in turn, more likely to use them (e.g., Compeau & Higgins, 1995; Tyler et al., 2020; Venkatesh et al., 2003). Furthermore, Dabholkar and Bagozzi (2002) noted that individuals with higher self-efficacy will perceive activities (i.e., using technology-based self-service) as more enjoyable, suggesting that they will engage in technology-based activities more often. Higher self-efficacy also reduces the (perceived) effort required to use new technologies, leading individuals to perceive them as easier to use (Hasan, 2007). Moreover, individuals who believe that they are more efficient in handling digital technologies will also view themselves as capable of quickly learning and adapting to new technologies (Mitzner et al., 2018; Tyler et al., 2020). Consequently, they are more likely to perceive themselves as being among the first to adopt new technologies. Hence, we propose:

H10: Digital technology self-efficacy positively affects innovativeness among older adults.

The socio-demographic background of older adults can also be an important aspect of STILH adoption process. Even though no prior study has explored the role of socio-demographic background in raising awareness of STILH, it has been shown that various characteristics of older adults, such as gender, age, education, income, chronic health conditions, household size and access to informal help shape the adoption or acceptance of assistive technologies among older adults (e.g., Kavčič et al., 2023; Peek et al., 2017; Petrovčič et al., 2019; Tsertsidis et al., 2019). Accordingly, we will assess the validity of the hypotheses by incorporating socio-demographic characteristics as covariates in the explanatory model of awareness factors of STILH.

3 RESEARCH METHODS

3.1 Procedures and data

The data were collected using a web survey in June 2024. The target population consisted of internet users who were residents of Slovenia and aged 55+ years. The respondents were recruited using quota sampling from the largest Slovenian online access panel. After stratification by region, gender and four age categories (see Table 1), target quotas were set for each stratum and used to send invitations. In each stratum, invitations were sent to a proportional number of participants based on the overall percentage of the population in the corresponding strata. The final sample consisted of 1,200 internet users (participation rate: 52%). The sample structure, which mirrors the characteristics of the target population, is presented in Table 1.

Table 1. *Sample characteristics.*

Variable	Categories	%
Gender	Male	48.8
	Female	51.2
Age	55–64	41.8
	65–74	40.3
	75–84	17.6
	85+	0.2
Education	High school or less	58.2
	Higher education	41.3
Employment status	Retired	70.4
	Working or other (e.g., unemployed)	29.6
Type of settlement	Urban and suburban	59.8

Variable	Categories	%
	Rural	40.2
Household size	Living alone	17.2
	Living with someone	82.2
Receives help	Yes	7.5
	No	92.5
Long-term sickness or disability	Yes	51.5
	No	48.5
Income (How hard it is for you to make ends meet?)	Very hard, hard	16.2
	Not hard, not easy	44.2
	Very easy, easy	38.7

Notes: N = 1,200. Total sample sizes per variable may vary due to item non-response and refusals. Total percentages may not add up to 100 because of rounding.

3.2 Measures

The measures used in this study were adapted from existing literature and then translated into Slovenian utilizing the TRAPD (translation, review, adjudication, pretesting and documentation) approach (Harkness, 2003).

Awareness of STILH was measured as the level of recognition and familiarity (Keller, 1993) of six STILH (i.e., mobile apps, smartwatches, smart bracelets for activity and vital sign tracking, home e-care services, a medication intake reminder and a smart blood pressure and sugar monitor). In terms of recognition, respondents indicated whether they had (0 = "no", 1 = "yes") heard about each STILH. Then, they reported on a 5-point Likert scale (1 = "I am very unfamiliar with it" to 5 = "I am very familiar with it") their level of familiarity with each STILH they had heard of. Recognition and familiarity with STILH were used to compute a single composite variable to indicate the level of awareness. To calculate the score for the level of awareness, first, respondents who had not heard of a specific type of STILH were assigned a value of 0 in the familiarity question to ensure that all respondents provided values for each technology. Then, the level of awareness score was calculated by averaging respondents' responses to the familiarity question across the six technologies, with an overall higher score value corresponding to a higher level of STILH awareness.

Exposure to information about STILH was measured with the question adapted from Shen et al. (2018): "How often would you say that you have received information from [the source the respondent has selected] about [the device or service the respondent has chosen]?:" The frequency of STILH-related information given to the respondent from the source from whom they most often obtained information about the STILH with which they were most familiar was measured on a 5-point scale ranging from 1 ("very rarely") to 5 ("very often").

Self-source congruity was measured using six items on a 5-point Likert scale from 1 ("I don't agree at all") to 5 ("I agree completely"). The items were adapted from Wangheim and Bayon's (2004) measure of similarity between the source of information and the individual. The instrument captures older adults' perception of overall similarity with the source from whom they most often obtained information about the STILH with which they were most familiar as well as the similarity with the source in terms of their values and beliefs.

Source expertise was assessed with an inventory adapted from Ohanian's source credibility scale (1990) using a 5-point semantic differential. Respondents rated five opposite pairs of information source characteristics on a scale from -2 to 2 to assess the expertise of the source from whom they most often obtained information about the STILH with which they were most familiar. Negative values indicated negative source characteristics (e.g., unskilled), whereas positive values indicated positive source characteristics (e.g., skilled). For the purpose of the analysis, the scale values were recoded into positive values (1-5), so that a higher score indicated higher perceived expertise of the source.

Inherent novelty seeking was measured using four items on a 5-point Likert scale from 1 ("not true at all") to 5 ("completely true"). The items were retrieved from Dabholkar and Bagozzi's (2002) measure of inherent novelty seeking. The instrument captures individuals' intention to engage in new activities, experiences and ideas in general.

Innovativeness was measured using four items on a 5-point Likert scale from 1 ("not true at all") to 5 ("completely true"). The items were adapted from Wu and Wang's (2011) scale for assessing individuals' perception of being innovative in the context of information technology.

Digital technology self-efficacy was assessed with a 4-item inventory adapted from the scale used by Rahman et al. (2016) for individuals' self-efficacy towards internet health services. To evaluate the individuals' perception of their self-efficacy towards digital technologies, a 5-point Likert scale from 1 ("not true at all") to 5 ("completely true") was used.

Socio-demographic characteristics of older adults that were entered into the explanatory model as covariates were measured using questions adapted from the European Health Interview Survey (EUROSTAT, 2024) (i.e., age, gender, education, household size, presence of chronic health conditions) and Survey of Health, Ageing and Retirement in Europe – SHARE (2024) (i.e., provision of informal help). Income was measured as perceived financial difficulty (i.e., ability to make ends meet) with a question adapted from UNECE (2021).

Table 2 presents the internal consistency and convergent and discriminant validity of all the reflective measurement scales which were obtained using confirmatory factor analysis (CFA). As *level of awareness* and *exposure* are considered formative constructs, they were included into the CFA as composite variables due to identification issues (Kline, 2015).

Table 2. *Reliability and convergent and discriminant validity of measurement scales.*

	M	SD	α	CR	AVE	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Awareness	2.45	1.06	NA	NA	NA	NA						
(2) Exposure	3.14	1.03	NA	NA	NA	0.453	NA					
(3) Self-source congruity	3.67	0.83	0.936	0.936	0.747	0.337	0.374	0.864				
(4) Source expertise	4.12	0.87	0.944	0.944	0.772	0.365	0.495	0.456	0.879			
(5) Innovativeness	2.76	1.01	0.898	0.896	0.688	0.437	0.257	0.207	0.129	0.829		
(6) Novelty seeking	3.74	0.74	0.805	0.817	0.595	0.254	0.206	0.233	0.108	0.417	0.771	
(7) Self-efficacy	3.23	0.89	0.891	0.896	0.740	0.390	0.209	0.213	0.158	0.619	0.299	0.860

Notes: N=1,200. NA: not applicable, M: mean, SD: standard deviation, α: Cronbach's alpha, CR: composite reliability, AVE: average variance extracted. Values on the diagonal are the square root of AVEs, whereas off-diagonal elements are correlations.

3.3 Analytical strategy

The proposed explanatory model (see Figure 1) was tested using structural equation modelling (SEM). All analytical procedures, including descriptive analyses and SEM, were run in R (R Core Team, 2020) with the *lavaan* package (Rosseel, 2012). We screened the data for missing values and variable distributions before running the SEM. Next, because the distributions of some variables deviated from normality, we chose robust maximum likelihood estimation (MLR) (Kline, 2015). The fit of the model to the data was assessed using the Satorra-Bentler scaled chi-square test statistic (SBχ2), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA) and standardised root mean square residual (SRMR). The fit was evaluated based on the guidelines by Hair et al. (2018, p. 642). We then estimated the measurement model, which included items for reflective constructs that were modelled as latent variables, as well as the composite variables as single indicators for the formative constructs (level of exposure and level of awareness). Next, we ran the structural equation model with covariates (i.e., gender, age, formal education, income, presence of chronic health conditions, household size and whether respondents received any type of informal help).

4 RESULTS

Before testing the proposed model, we analysed the level of awareness in terms of recognition and familiarity for six STILH (see Table 3). The results showed that the highest percentage of participants had heard of smartwatches (96.4%), followed by mobile apps that allow users to track their steps, water intake, calorie consumption and other vital signs (91.6%). Next, 89.8% of participants had heard of smart bracelets and 80.6% had heard of an e-care service.

The percentage of participants who had heard of internet-enabled blood sugar/pressure monitors (73.1%) was higher than that of the medication-reminding device, which was the least recognised STILH (67.5%). However, the level of familiarity with the studied STILH was fairly low. On average, participants who had heard of smartwatches (M = 3.11) and mobile apps (M = 3.27) were somewhat familiar with these two types of STILH. However, participants were on average relatively less familiar or unfamiliar with other types of STILH, as presented in Table 3. On average, participants were least familiar with devices that remind users to take their medication on time (M = 2.65), followed by e-care services that enable an emergency call (i.e., SOS call) or detect the presence of a fall, smoke, water leakage, etc. at home.

Table 3. *Level of awareness in terms of recognition and familiarity for six STILH.*

STILH	Recognition[a]	Familiarity		
	%	M	SD	N[b]
A smartwatch that gives users information on heart rate, number of steps walked, calories burned and more	97.1	3.11	1.24	1165
A mobile app that allows users to track their steps, water intake, calorie consumption and other vital signs	92.3	3.27	1.22	1108
A smart bracelet that gives users information on heart rate, number of steps walked, calories burned and more	90.5	2.86	1.13	1086
An e-care service that detects the presence of a fall, smoke, water leakage, makes an emergency call (SOS call) and so on	81.2	2.66	1.05	975
A blood pressure or blood sugar monitor that can connect to your smartphone or tablet	73.7	2.86	1.11	884
A device that reminds users to take their medication on time	68.0	2.65	1.05	816

Notes: [a] Percentages are presented for recognition (Yes/No) on the whole sample size (N = 1,200). M (mean) and SD (standard deviation) are presented for familiarity on a 5-point scale (1 = "I am very unfamiliar with it" to 5 = "I am very familiar with it"). [b] N – number of respondents who answered for each specific STILH.

The SEM results show that the proposed model exhibits an adequate fit (SBχ2 (df) = 677.957(300), CFI = 0.978, TLI = 0.970, RMSEA [90% confidence interval] = 0.035 [0.031–0.038], SRMR = 0.024). The results support all the proposed hypotheses in the model (see Table 4).

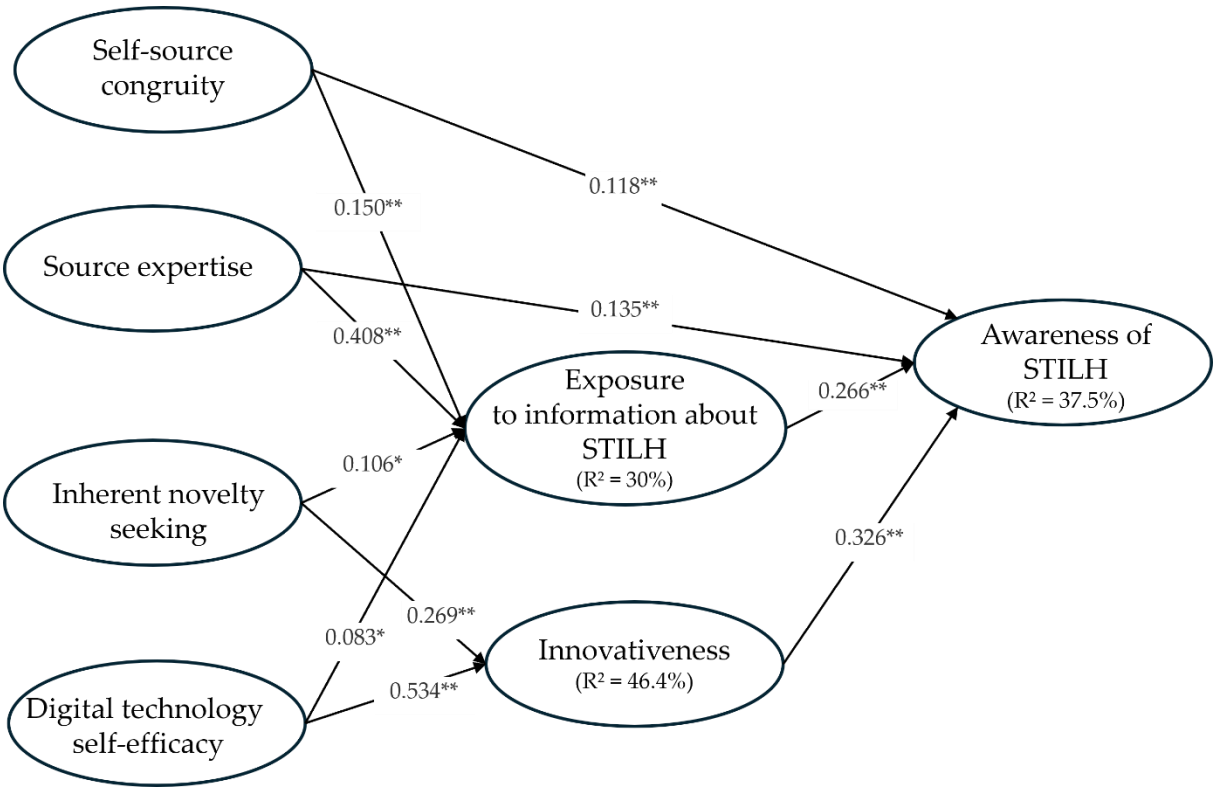
Table 4. *Parameter estimates and hypothesis validation results.*

Hypotheses	Estimate	SE	Standardized	Z	p	Validation
H1: Exposure to inf. about STILH → Awareness of STILH	0.271	0.031	0.266	8.726	≤ 0.001	Yes
H2: Source expertise → Awareness of STILH	0.164	0.035	0.135	4.629	≤ 0.001	Yes
H3: Self-source congruity → Awareness of STILH	0.162	0.040	0.118	4.072	≤ 0.001	Yes
H4: Innovativeness → Awareness of STILH	0.366	0.032	0.326	11.279	≤ 0.001	Yes
H5: Self-source congruity → Exposure to inf. about STILH	0.201	0.045	0.150	4.426	≤ 0.001	Yes
H6: Source expertise → Exposure to inf. about STILH	0.489	0.039	0.408	12.382	≤ 0.001	Yes
H7: Inherent novelty seeking → Exposure to inf. about STILH	0.191	0.060	0.106	3.156	≤ 0.01	Yes
H8: Digital technology self-efficacy → Exposure to inf. about STILH	0.114	0.044	0.083	2.563	≤ 0.01	Yes
H9: Inherent novelty seeking → Innovativeness	0.440	0.053	0.269	8.327	≤ 0.001	Yes
H10: Digital technology self-efficacy → Innovativeness	0.662	0.040	0.534	16.538	≤ 0.001	Yes

Notes: N = 1,179.

Specifically, self-source congruity ($\beta = 0.118$, $p \leq 0.001$), source expertise ($\beta = 0.135$, $p \leq 0.001$), exposure to information about STILH ($\beta = 0.266$, $p \leq 0.001$) and innovativeness ($\beta = 0.326$, $p \leq 0.001$) had a significant positive effect on the

level of STILH awareness, explaining together 35.7% of the variance (see Figure 2). Moreover, innovativeness was positively affected by novelty seeking (β = 0.269, $p \leq 0.001$) and self-efficacy (β = 0.534, $p \leq 0.001$), which together explained 46.4% of the variance in innovativeness. Source expertise (β = 0.408, $p \leq 0.001$), self-source congruity (β = 0.150, $p \leq 0.001$), novelty seeking (β = 0.106, $p \leq 0.01$) and self-efficacy (β = 0.083, $p \leq 0.01$) had a positive effect on exposure to information about STILH, explaining 30% of the variance.



*Notes: N = 1,179 (21 participants did not respond to some of the covariates and were therefore excluded from the model). SBχ2 (df) = 677.957(300), CFI = 0.978, TLI = 0.970, RMSEA [90% confidence interval] = 0.035 [0.031–0.038], SRMR = 0.024. ** p ≤ 0.001, * p ≤ 0.01.*

***Figure 2**. Structural equation model results.*

Moreover, the SEM results show only one significant relationship between the covariates and awareness of STILH: older adults of higher age (β = -0.091, $p \leq 0.001$) were slightly but significantly less aware of STILH. In addition, two covariates marginally correlate with the level of awareness: older adults without a long-term illness (β = 0.043, $p \leq 0.10$) and women (β = -0.042, $p \leq 0.10$) were somewhat more aware of STILH. The other characteristics, such as formal education, income, household size and whether respondents received any type of informal help, do not correlate significantly with the level of awareness of STILH.

5 DISCUSSION

5.1 Substantive findings and practical implications

While the level of recognition for all six STILH included in the survey was relatively high among older adults, ranging from 68.0% for medication-reminding devices to 97.1% for smartwatches, the level of familiarity with those STILH they had already heard of was much lower, averaging from 2.65 for medication-reminding devices to 3.27 for mobile apps that enable step tracking, water intake, calorie consumption and more (see Table 3). Even though respondents recognised various STILH, their familiarity was not as extensive as anticipated. The general awareness of STILH, averaging 2.45, confirms the challenge of low levels of STILH awareness. However, prior research into factors affecting awareness of STILH in later life has been very limited and inconclusive. The current study sought to fill this knowledge gap with the development and empirical test of an explanatory model that explains the role of message and information source characteristics, as well as personal characteristics of older adults as factors influencing STILH awareness. By integrating different perspectives and theoretical frameworks of consumer behaviour (e.g., Evans et al., 2013), information processing (e.g., Engel et al., 1995) and technology adoption (e.g.,

Rogers, 1983), we proposed 10 explanatory hypotheses and tested them for relevance using SEM. The results support all the proposed hypotheses, explaining 35.7% of the variance in STILH awareness. Importantly, our results indicate that exposure to information about STILH, source expertise, self-source congruity and older adults' innovativeness positively and significantly influence awareness of STILH. Below, we highlight our key findings and discuss their implications for research and practice.

Deriving from prior research into the effectiveness of message repetition in advertising (Evans et al., 2013), exposure to information about STILH was found to play an important role in raising awareness of STILH as well. Repeatedly exposing older adults to STILH-related information can increase their awareness, even among those who perceive themselves as less innovative. This finding corroborates the work of Heinz et al. (2013), who suggested that exposing older adults to STILH through practical demonstrations can be a valuable tool for raising awareness. However, not only does exposure to the message matter but the relevance of the source who transmits the information about STILH has also been found to have a significant effect on awareness of STILH.

Previous studies have underscored the role of information source characteristics (Woodcock et al., 2013), but the empirical investigation of these factors has been scarce in the STILH context. In this study, source expertise and self-congruity with a source who transmits the information about STILH to the older adult showed similar positive but weak effects on awareness. However, their influence on exposure was higher and differed, with source expertise having a nearly three times stronger impact on exposure compared to self-source congruity. These results suggest that older adults are more likely to engage with STILH-related information from a source that they consider an expert, rather than a source that they perceive as similar to them. Corroborating research into source credibility (Ohanian, 1990), source expertise appears to be an effective collection of beliefs (schema) influencing attention paid to information about STILH and its further selection, interpretation and storage in older adults' memory. In addition, perceived expertise and similarity of the information source have a stronger effect on the exposure to STILH information than the personal characteristics of older adults such as inherent novelty seeking and self-efficacy. Accordingly, it seems that policy programmes and initiatives could most efficiently utilize the awareness of STILH among older adults if they cross-fertilise the positive effects of experts and significant others as their information sources.

However, initiatives should also consider the personal characteristics of older adults as awareness-raising factors. In fact, our results show that innovativeness had the strongest impact on STILH awareness in the proposed model. This finding is aligned with the theoretical framework of an *active message receiver* (Solomon et al., 2016) and Roger's (1983) diffusion of innovation theory, which suggests that innovative individuals are more likely to be early adopters of innovations. Older adults who tend to be pioneers and thought leaders about digital technology are also more likely to be aware of new digital technologies such as STILH. Innovativeness, however, significantly depends on older adults' digital technology self-efficacy and inherent novelty seeking. While the former had a stronger effect on innovativeness than the latter, we can conclude that older adults who tend to be more self-efficient and perceive themselves as having the competence and mastery to meaningfully engage with digital technology in their life are more innovative and, in turn, more attentive to information about STILH. However, not only does self-efficacy influence innovativeness, but also older adults' desire to seek novel stimuli. The finding that self-efficacy and inherent novelty seeking are important antecedents of innovativeness is important from a theoretical perspective. Tellingly, our results provide additional empirical evidence that the notions of innovativeness and inherent novelty seeking should not be understood and used interchangeably (e.g., Khare et al., 2010; Truong, 2013).

In terms of covariances, we found that women and older adults of higher age are significantly less aware of STILH. Interestingly, we found that older adults who do not have a long-term illness are more aware of these technologies. This finding suggests that the *digital health paradox*—which argues that digital technologies do not support health equity but rather exacerbate existing inequality in access to valuable healthcare services among disadvantaged groups of older adults in terms of their socio-economic and health status (Hvalič-Touzery et al., 2024; van Kessel et al., 2022)—also applies to STILH. This problem seems to be even more critical, given that the digital health paradox affects awareness as the first stage in the adoption process. However, it is also important to consider the positive implications of higher levels of awareness of STILH among older adults without chronic health conditions. For instance, older adults who are not affected by chronic conditions but are familiar with STILH might be more motivated to use STILH in preventive health behaviour, which, as Ghorayeb et al. (2021) pointed out, should be considered when designing and delivering STILH to end users.

The original findings of this study have several practical implications for initiatives aimed at making use of awareness and large-scale adoption of STILH in later life. Our study showed that information about STILH should become more accessible to older adults because exposure to information has a significant impact on awareness. Therefore, a portion of the promotional budget in awareness-raising campaigns must be invested in generating a sufficient level of exposure to messages about STILH. However, it is important that information about STILH be communicated to older adults from sources that they perceive as experts or people like them (Kavčič et al., 2023; Peek et al., 2017; Tsertsidis et al., 2019). Thus, the sources used in mass communication must be carefully chosen—they should be recognized as qualified experts on STILH, already having skills and experience with these technologies. In addition, the chosen source should be someone to whom older adults could easily relate. Sources giving the information on STILH should be perceived as having common values, attitudes and interests that align with the specific target. Importantly, the results of this study also suggest that the key target of awareness-raising campaigns is older adults who think of themselves as innovative. They will be more inclined to notice the communication about STILH and, in line with the diffusion of innovation theory (Rogers, 1983), they will also be among the first to adopt STILH. Thus, another part of the promotional budget can then be invested in these early adopters to use them as "champions" (Howell et al., 2005; Miyawaki et al., 2018) in generating word-of-mouth in organizational and community settings, since innovators are more inclined to act as opinion leaders in their social circles (Thakur et al., 2016). Importantly, STILH-related awareness-raising initiatives could capitalise on the support of champions, defined as "charismatic advocates of a belief, practice, programme, policy and/or technology" (Miyawaki et al., 2018, p. 729), because they have been shown to play a positive role among older adults when adopting and implementing health programmes in community settings (Miyawaki et al., 2018). Thus, the role of champions could be extended to other types of interventions aimed at raising awareness of STILH as part of active and healthy ageing initiatives. These include training programmes for improving older adults' engagement with assistive technology, digital literacy, cognitive abilities, social integration, intergenerational cooperation, etc. Additionally, as champions are perceived as experts by their peers and are "one of them", these early adopters can also become ambassadors of STILH in mass communications to further sustain and enhance the sufficient level of exposure to the messages about STILH on a larger scale, strengthening the level of awareness of STILH among the broader population.

5.2 Limitations and future research

Although the current study provides strong empirical support for the explanatory model, it has some limitations that can be addressed in further research. One limitation of the proposed model is its focus on source, message and receiver characteristics in the model of communication (Lasswell, 1971), leaving out the type/content of information and the communication channels used to transmit messages about STILH (e.g., word of mouth, online/offline). Another limitation lies in the investigation of source characteristics. Although we examined the effects of source expertise and self-source congruity, future studies could also explore the influence of different sources (e.g., media, experts, family sources) to determine whether different types of sources transmitting information about STILH have varying impacts on awareness. Next, since this is the first large-scale study dealing with awareness of STILH, the awareness survey inventory was designed to measure respondents' familiarity with a set of STILH-based devices and services that are available in Slovenia. However, future research might test the proposed model on a specific STILH-based device or service. Moreover, while Slovenia is an average-performing county according to the Digital Economy and Society Index (European Commission, 2023), validation of the proposed model in different countries is warranted to assess whether differences emerge across markets and cultures with various levels of STILH penetration. As Armstrong and Kotler (2013) pointed out, market-specific and cultural contexts may influence different stages in the consumer decision-making process. In this context, it is also important to point out that most studies investigating older adults set 65 years as the lower age bound. In our study, we sampled respondents aged 55 years and older to capture the heterogeneous structure of the aging population in Slovenia, including individuals who provide and/or receive social care. This decision is in line with the approach used by SHARE (2024), which has an even lower inclusion age of 50 years.

6 CONCLUSION

The adoption of STILH has been shown to have a positive impact on quality of life of older adults. Although awareness has been highlighted in previous studies as an important driver and barrier to STILH adoption among older adults, the factors affecting awareness have not yet been conceptually elaborated and empirically explored in a large-scale study. By proposing an original exploratory model, we aimed to determine the role of STILH awareness factors derived from information processing models and technology adoption theories. The results indicated that self-source congruity, source expertise, exposure and innovativeness are significant predictors of STILH awareness in later life. Additionally, we examined factors influencing exposure (i.e., source expertise, self-source congruity, inherent novelty seeking, self-efficacy) and innovativeness (i.e., inherent novelty seeking and self-efficacy). With the validation of all 10 hypotheses, this study provides a foundation for further research in the context of STILH. It also lays out practical implications for how to convey information about STILH to older adults so that they become attentive to it and store it in their memory for further use in the STILH adoption process. Stakeholders who want to strengthen the awareness of information about STILH among older adults, which is a prerequisite for further phases in the adoption process, should ensure a sufficient level of exposure to information about STILH among older adults. By reaching out to older adults who are more receptive to innovation, they could additionally reach those who may be less inclined towards new technologies in general but rely on early adopters in their social networks as information sources about digital technologies.

ADDITIONAL INFORMATION AND DECLARATIONS

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