Preventive Medicine Reports 18 (2020) 101082

Contents lists available at ScienceDirect

Preventive Medicine Reports

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

Factors predicting older Adults' attitudes toward and intentions to use stair mobility assistive designs at home

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ARTICLE INFO

Keywords:
Home modifications
Aging-in-place
Older people
Stair mobility
Technology acceptance model

ABSTRACT

Home modifications that increase stair accessibility of existing housing stock are significant for older adults who want to age in place. This sequential mixed-methods study investigated older adults' attitudes toward and intentions to use currently available stair mobility assistive design features, and explored which factors influence these attitudes and intentions to use. The data were collected through a cross-sectional survey of community-dwelling 50 + adults from Southwest Virginia (n = 89) and a focus group (n = 15) in 2018. The survey questionnaire was based on a modified version of the Technology Acceptance Model, and focused on three stair mobility assistive design products representative of varying costs, and a range of mobility challenges: half-steps, StairSteady handrail, and stairlift. Ordinal regression analyses indicated that perceived usefulness consistently predicts older adults' attitudes and intentions to use the three examined stair mobility products. The other factors associated with attitudes and willingness to use the products are dependent on some degree to the examined mobility device. Older age and presence of others in the household negatively influenced attitudes toward stair mobility products. Product aesthetics/unobtrusiveness, fear of falling, and person-environment fit are the three themes emerged from the focus group data analysis as the factors that most influence community-dwelling older adults' attitudes and intention to use stair-mobility assistive features. The findings have implications for design professionals, as they underscore the need for avoiding an institutional look in residential designs, specifying products with high customizability for user needs and preferences, and involvement of users in the decision-making processes.

1. Introduction

By 2050, one in six people in the world will be over age 65 (16%), and one in four people living in Europe and Northern America could be age 65 or over (United Nations, Department of Economic and Social Affairs, Population Division, 2019). In the United States, the population of people age 65 and older is projected to be 98.2 million by 2060, with almost 20 million 85 and older (United States Census Bureau., 2017). According to a recent survey by AARP, 76% of people who are 50 or older want to stay in their homes for as long as possible (AARP, 2018). This growth in the older adult population and their preferences to remain in their current homes raise significant housing and healthcare challenges. While there is a strong emotional attachment to homes and moving can involve stress with negative health effects, most homes do not match the physical needs of older adults who have limited mobility (60.3%) and live with three or more chronic conditions (Herbert and Molinsky, 2019). Among these conditions, difficulty climbing stairs or walking is the most common disability, affecting 17% of households (Joint Center for Housing Studies of Harvard University, 2018). Stair use is a common factor for falls and fall risk, and often associated with severe injury. Stairway falls are a leading cause of death among older adults (Startzell et al., 2000). Older adults are at greater risk for falls on stairs as they negotiate stairs with less stability and at a greater risk of tripping, and can greatly benefit from environmental modifications that increase stair safety regarding handrails and riser heights (Jacobs, 2016). Additionally, following discharge from inpatient rehabilitation, few older adults demonstrate the ability to negotiate stairs –one of the requirements for independent mobility (Gorgon et al., 2007). With only 3.5% of the existing US homes having single-floor living, no-step entry and extra-wide halls and doors, and the ongoing trend of building single-family homes to be two or more stories, home modifications that would increase stair accessibility of the existing housing stock is of

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https://doi.org/10.1016/j.pmedr.2020.101082
Received 23 August 2019; Received in revised form 12 February 2020; Accepted 13 March 2020
Available online 16 March 2020

great significance to older adults who want to age in place (Joint Center for Housing Studies of Harvard University, 2018; US Census Bureau, 2018).

Previous research has shown the benefits of home modifications (Liu & Lapane, 2009; Chase, et al, 2012; Rubenstein, 2006; Hwang, et al, 2011; Tanner et al., 2008, Powell et al, 2017). However, the literature on older adults' attitudes and adoption of home assistive technologies that support aging in place show that older adults resist such home modifications. As Hamm and colleagues (Hamm et al., 2016) highlighted, more than 50% of home modifications and equipment are rejected, due to factors such as lack of knowledge about the equipment's use, user involvement in the decision-making process, user attitudes, and a lack of person-environment fit (Nygard et al, 2004; Martin et al, 2011; Gitlin, 1995). Bailey and colleagues (Bailey et al., 2018) also underscore the limited research regarding older adults' decision-making processes for home adaptations (p.4), and discuss the personal-, resource- and service-related contextual factors influencing such decisions. While home adaptation decisions are often made when the person is already struggling (Bailey et al., 2018, p.6), older adults may also delay the installation due to various reasons, such as product appearance, and negative associations.

Another factor that related to adoption of home modifications is affordability. In the US, Medicare (the federal health insurance program) does not cover home modifications while some federal programs assist older adults to modify their homes, such as Medicaid waivers for disabled elderly beneficiaries, and the USDA's Section 504 home repair program targeting rural communities. However, such programs are limited, and their future is unclear, particularly with the current administration's concerns for government spending, and the desire to cut programs, including Medicaid (Stone, 2018). Such a policy context also puts the burden on older adults who need to prioritize their home-related needs among other health-related decisions.

2. Study purpose

This study aims to contribute to the research in this field by focusing on environmental modifications of stairs through stair mobility assistive designs in order to support active living of older adults. The main objective of this paper is:

1. to understand older adults' attitudes toward and intentions to use currently available stair mobility assistive design features that would support residential stair use, and
2. to explore the demographic and health-related factors that may influence these attitudes and intentions.

Additionally, based on the technology acceptance model (TAM) framework, we hypothesized that:

a. Perceived usability, perceived usefulness, and perceived affordability will be associated with more positive attitudes toward stair mobility assistive design products, and
b. Perceived usability, perceived usefulness, perceived affordability, and more positive attitudes toward about the design products will be associated with higher intentions to use these products in future.

Findings from this study will contribute to the knowledge base in aging-in-place technology adoption in older adults and are expected to assist design professionals who work with older adults by providing them evidence of the value of stair mobility assistive devices for their clients who prefer aging in place. The findings may also help industries that manufacture such products to improve their designs and develop efficient marketing strategies for targeting older adults.

3. Materials and methods

3.1. Study design

We used a sequential explanatory mixed-methods approach that started by collecting and statistically analyzing the quantitative data through a structured survey questionnaire, followed by a focus group to help further explain the quantitative results with qualitative data (Creswell, 2015). In line with the characteristics of such research designs as described by Cresswell and Clark (2011), this study prioritizes the quantitative aspect in addressing the research objectives, and relies on the qualitative strand to provide the insight and additional explanation of the overall findings. The study was approved by the Virginia Tech Institution Review Board (IRB # 17-751).

3.2. Sample

In this study, community-dwelling adults aged 50 and over were sampled from the southwestern Virginia following three different approaches. (1) Online recruitment from the Virginia Tech Center for Gerontology Older Adult Research (OAR) registry to complete the online survey, (2) In-person recruitment from the NRV Agency on Aging lunch program to complete the self-administered survey at community meal sites, and (3) Online invitation sent to the Warm Hearth Village residents to complete the same self-administered survey, attend a hands-on education session on the products, and participate in a focus group to help clarify older adults' attitudes and potential use of home design features and technologies identified in the survey.

We purposefully sampled from these sites because the people they serve include non-institutionalized adults who represent diverse age and socioeconomic groups within the older adult population living independently. Specifically, the 194 enrollees in the OAR registry represent individuals who have high educational attainment and use the internet, yet represent diverse socioeconomic backgrounds. The participants in the lunch program tended to have low fixed incomes, yet represent individuals of great age (i.e., 85 + years), and varying mobility and other physical disabilities, while remaining cognitively intact. The potential participants in the focus group were also likely to represent a wide range of age, income, and physical ability levels. With the exclusion of participants with no stairs in their homes, our quantitative group included 56 participants from the OAR registry, 29 from the meal sites, and 4 from the Warm Hearth Village. The qualitative sample had 15 participants from the Warm Hearth Village. We provided an incentive to all participants for their time and input.

3.3. Measures

3.3.1. Quantitative data collection

As part of a larger project that assessed a range of assistive designs that may support aging in place, this study focused on three stair mobility assistive designs representative of varying cost and complexity levels, and target a range of mobility challenges. A brief description of these products are provided in Table 1. The survey questionnaire first provided participants with an overview of the selected three vertical mobility products. Uses, benefits and cost ranges of the assistive technologies that may support aging in place were explained with visuals (photographs and short videos) and brief textual information. Participants were asked to evaluate the design products.

The cross-sectional survey questionnaire design was based on a modified version of the Technology Acceptance Model (TAM) framework to predict user acceptance of any technology through perceived usefulness, perceived ease of use, and perceived affordability factors (Davis et al, 1989; Orillaza, Orillaza & Barra, 2014). TAM is a widely used model with high reliability and validity in explaining usage behavior in different contexts (Chen Hsieh et al, 2017; Kuo & Yen, 2009; Chen and Chan, 2014; Wu and Lu 2013). Based on Davis (1989), in this

Table 1
Representative Design Products Selected for the Assessment.

Product Domain	Design Product	Cost Range	Product website
Environmental Adaptations: Products that make the built environment more accessible; vertical accessibility.	StairAide halfsteps (half-height stair blocks added to existing stairs)	$650 for a set	https://stairaide.com/
	StairSteady handrail (a fixed handrail w. a sliding support handle)	$1000 + $150-$200 professional installation	https://www.stairsteady.ca/
	Stairlift	$3000–$5000 w. installation ($200–300/month if rented)	Several manufacturers. E.g. https://www.bruno.com/stair-lifts

Note. Products were selected to represent the aging-in-place supportive domains through the use of the Able Data database, maintained by the Department of Health & Human Services' (HHS), National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR), and its product categories. Five researchers from design and gerontology fields chose the representative products for the survey.

study, perceived usefulness is defined as the degree to which an individual believes the product will enhance his/her life at home, and perceived ease of use is the degree an individual believes that a product will be free of effort. Modified versions of the model also include the cost or perceived affordability as a factor that influences attitude towards the adoption of the product, which then predicts the behavioral intention to use (Kuo & Yen, 2009; Wu & Wang, 2005).

The survey consisted of three major sections:

(1) Ratings of the select products for perceived usefulness, perceived ease of use, perceived affordability, attitude, and intention to use measured through previously validated questions from TAM questionnaires. The questions had a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).
(2) Self-reported health and ability characteristics, and physical activity levels using adapted questions from national health surveys; and
(3) Socio-demographic and economic characteristics, including age, gender, income, educational attainment, housing type and arrangements, existing home modifications.

The questionnaire was pilot-tested on five adults who were not part of the sample, and revisions were done for question clarity, wording of product descriptions, and legibility of the visuals. The data collection from the online survey of the OAR registry and self-administered questionnaire at the meal sites were completed in February and March 2018. Following an initial analysis of the quantitative data, Warm Hearth Village residents were recruited to complete the same survey questionnaire, and participate in the focus group in June 2018.

3.3.2. Qualitative data collection

A subset of participants (n = 15) were provided in-depth overviews through a presentation and hands-on testing opportunities, and they later participated in a post-presentation/post-survey completion focus group, facilitated by two researchers. The aim of this second phase is (1) to provide insights and clarifications on the factors inquired in the survey; and (2) to capture other factors that may influence attitudes and intentions to use these stair mobility products, but are not addressed in the questionnaire. The focus group aimed to complement and further explain the findings of the survey. The semi-structured focus group guide inquired about the challenges the participants faced at home, whether they used any assistance, their views on technology at home, and followed up on the survey questions for each of the three products (halfsteps, StairSteady handrail, and stairlift), asking about the factors that would support or inhibit their use at home. The focus group lasted for 48 min, and one of the researchers transcribed the recordings.

3.4. Data analyses

Qualitative and quantitative data were analyzed separately. Regarding the quantitative survey data, the impact of all investigated factors on the participants' opinions toward the stair mobility assistive designs is evaluated using stepwise regression models. Specifically, two aspects of the opinion, attitude and intention, are evaluated. Attitude and intention to use, presented in Likert scale in the survey, are treated as ordinal responses in the regression model. Therefore, two ordinal logistic regression models are established based on attitude and intention to use, separately. For both models, all investigated factors are considered as candidate predictors (see Appendix A). For the intention to use model, attitude is included as an additional candidate predictor. For the attitude model, intention to use is not included as predictor.

A further covariates screening for all the candidate predictors was conducted using a stepwise selection approach to establish the optimal model. The optimal model is defined as the model that minimizes the corrected Akaike Information Criterion (AIC_c) value (Cavanaugh, 1997; Burnham & Anderson, 2002). For both the attitude model and intention to use models, the odds ratios were calculated by taking the exponential of negative model coefficients from the optimal model selected by AIC_c criterion. The model fitting and variable screenings were implemented using JMP Pro 14.0 software.

The qualitative data were analyzed using systematic text condensation (STC) (Malterud, 2012; Jellesmark, et al, 2012), following these steps: (1) the transcriptions were read to get an overall impression of the content—total impression; (2) all units of meaning were identified and clustered–coding; (3) all units of meaning were condensed to uncover overall themes and subthemes—condensation; and (4) development of descriptions and concepts with credible stories reflecting the validity and wholeness of their original context–synthesizing.

4. Quantitative results

4.1. Descriptive statistics

Characteristics of the participants (n = 89) are summarized in Table 2.

The correlations between attitudes toward and intentions to use stair mobility assistive products and the demographic, health and TAM variables are shown in Table 3. Among the TAM factors, perceived ease of use and perceived usefulness are the two factors that consistently had the higher and statistically significant positive correlations with attitudes and intentions to use the three products.

4.2. Ratings of the stair mobility assistive design products

Fig. 1 shows how the distribution of responses regarding intention to use and attitude regarding the three products are relatively similar. Unsurprisingly, people's attitudes toward the products tend to be more positive compared to their behavioral intentions to use them in their homes.

4.3. Ordinal regression models

Tables 4 shows the variables selected for each of the attitude and intention to use models fit for each of the three stair mobility assistive

Table 2
Characteristics of Survey Participants (n = 89).

Measure	Number	Percentage
Age		
50–64	26	29.9%
65–74	34	39.1%
75–84	24	27.6%
85 +	3	3.4%
Sex		
Male	28	31.8%
Female	60	68.2%
Education		
High School or less	17	19.5%
Some College	12	13.8%
College Graduate	22	25.3%
Graduate or professional degree	36	41.4%
Monthly household income		
< $1,000	10	12.0%
$1,000–1,999	13	15.7%
$2,000–2,999	13	15.7%
$3,000–4,999	16	19.3%
$5,000 +	31	37.3%
Home type		
House	75	84.3%
Apartment	7	7.9%
Townhouse/duplex	7	7.9%
Mobile home	0	0%
Home ownership		
Own	76	86.4%
Rent	12	13.6%
Living arrangement		
Lives alone	28	31.5%
With 1 other person	51	57.3%
With 2 or more other people	10	11.2%
General health status		
Poor/fair	13	14.9%
Good	22	25.3%
Very good/excellent	52	59.8%
Health interference w. activities		
A great deal	6	6.8%
Not much/somewhat	56	63.6%
Not at all	26	29.5%
Assistance from others		
ADL/personal care assistance	3	3.4%
IADL assistance	11	12.4%
Physical activity during last 7 days	*M*	*SD*
Vigorous activity for at least 10 min.	2.71	2.36
Walk for at least 10 min.	3.82	2.49
Moderate activity for at least 10 min.	4.43	2.38
Sedentary behavior (h/day)	5.25	3.35

technologies. While the survey contained over 20 predictors for each response, the final models based on stepwise regression with AIC have between four and six predictors. These models have an R-squared ranging from 0.1555 to 0.4243, so we are confident in our models explaining a significant amount of the variation in the participants' responses.

4.3.1. Ordinal regression analysis: Half-steps

The regression models predict 21% of the variance in attitude, and 37% of the variance in intention to use half-steps at home. Among the TAM factors, controlling for other predictors, an individual's higher perceived usefulness of half steps is associated with increased odds of having a positive attitude toward the product and a higher intention to use it (odds ratios of 3.76 and 10.06, respectively; $p < .001$). Perceived affordability of half steps that cost $650 is also positively associated with people's attitudes toward half-steps (OR = 1.38, $p < .05$).

Among the physical activity-related predictors, the number of hours a day people report sitting, i.e. sedentary behavior, is negatively associated with the odds of a more favorable attitude toward half steps (OR = 0.87, $p < .05$). Thus, people who reported longer hours of sitting each day on average hold more negative attitudes toward half-steps.

Having an accessibility product (a raised toilet) already installed at home is positively associated with the attitude toward the product (OR = 1.73, $p < .05$). These findings may be explained by the understanding of the usefulness of the product due to having other accessibility assistive products, but the lack of current personal need for stair mobility assistance.

4.3.2. Ordinal regression analysis: StairSteady handrail

The models used to predict a person's attitude towards The StairSteady handrail, a fixed handrail with a sliding support handle that costs around $1000, and their behavioral intention to use the product capture 21% and 42% of the variance in data, respectively. Among the TAM factors, perceived usefulness and perceived ease of use are associated with increased odds of having a favorable view of the product (OR values of 2.72 and 2.27, respectively). Among the personal factors, a higher number of people living at home decreases one's odds of holding a positive attitude toward StairSteady handrail (OR = 0.44, $p < .05$). This may be explained by the possibility of reliance to other people, rather than a product for stair mobility assistance. Unlike the half-steps, a person's self-reported sedentary time has a positive association with a favorable attitude toward the StairSteady (OR = 1.19, $p < .05$).

While perceived usefulness stays as a significant predictor of behavioral intention (OR = 12.84), perceived affordability of StairSteady also appears as a factor that increases one's odds of having a higher intention to use the product (OR = 2.15, $p < .001$). People who are younger, and have better self-reported health have significantly higher intentions to use StairSteady in their homes in future (OR values of 0.37 and 1.85, respectively).

4.3.3. Ordinal regression analysis: Stairlift

The ordinal logistic regression model for predicting a person's attitude about the stairlift captures 15.55% of the variance in the data. Consistent with the other two products, when all the other predictors are controlled, perceived ease of use and perceived usefulness are statistically significant predictors of a better attitude toward the stairlift (OR values of 2.55 and 1.75, respectively). Similar to StairSteady, having more people living in the home is negatively associated with a more favorable attitude.

The model for the intention to use a stairlift accounts for 29.81% of the variation in the response. Perceived usefulness and perceived affordability are positively associated with intentions to use the product (OR = 3.81, $p < .001$; and OR = 1.80, $p < .05$, respectively). The predictors that are negatively associated with the intention to use the stairlift are age and the self-reported vigorous activity levels.

5. Qualitative insights

The sociodemographic profile of the focus group participants were very similar to the survey respondents: All lived in attached or detached single-family housing, with 66% owning their homes. Among the three male and 12 female participants, the age distribution was as follows: three between 65 and 74 years old, 11 of them between the ages of 74 to 84, and one person aged 85 or older. The sample was highly educated all but one with a college degree or higher, and 11 of them having a $5,000 + monthly income. Two-thirds reported having very good or excellent health, none requiring ADL or IADL assistance.

5.1. Themes

The three themes emerged from the analysis of the focus group data regarding the factors that most influence community-dwelling older adults' attitudes and intention to use stair-mobility assistive features:

Fear of falling. Older adults tended to evaluate and discuss the

Table 3
Correlations with attitude toward and intention to use design products (n = 89).

Measure	Half steps		StairSteady handrail		Stairlift	
	Intention	Attitude	Intention	Attitude	Intention	Attitude
Data collection method	−**0.108***	**0.163***	−**0.157***	0.057	−0.176	0.149
Age	−0.161	0.012	−0.255	−0.143	−**0.266***	−0.059
Sex	0.025	−0.014	**0.19***	0.149	−0.002	0.105
Education	−0.05	**0.048***	0.153	0.021	0.158	0.067
# of people at home	−0.042	−0.003	0.015	−0.155	−0.033	−0.246
Monthly income	−0.072	0.049	0.035	−0.124	0.195	0.061
Home type	**0.217****	0.072	0.092	0.021	0.03	−0.024
Home ownership	−0.014	−**0.092****	−0.144	−0.01	0.055	0.152
HM: Grab bars in bathroom	0.088	0.166	0.094	0.132	−0.119	0.082
HM: Roll-in shower	−0.07	0.022	−0.044	−0.058	−0.175	−0.036
HM: Shower bench/chair	−0.002	0.102	0.038	0.086	**0.011***	0.105
HM: Raised toilet height	−0.097	**0.216***	−0.048	**0.054***	−0.02	0.202
HM: Ramp into home	0.147	0.094	0.073	−0.017	0.088	0.053
HM: Level door handles	0.019	0.132	0.133	0.085	−0.009	0.032
HM: Widened door frames	−0.156	0.009	0.062	0.047	0.038	−0.001
HM: Other	0.01	0.034	−0.005	−0.002	0.016	0.07
HM: None of the above	0.03	−0.07	0.041	−**0.118***	0.062	−0.144
Self-reported health	0.119	0.063	−0.202	−0.025	−0.095	0.057
Health interference	−0.025	−0.038	−0.266	−0.129	−0.179	−0.025
ADL assistance	0.147	0.106	**0.232***	**0.215****	0.101	0.056
IADL assistance	0.003	−0.11	**0.19***	**0.012****	0.18	−0.169
Vigorous PA	0.058	0.043	0.179	−0.061	0.067	−0.102
Walking	0.087	0.027	0.195	0.067	0.076	−0.017
Moderate PA	−0.08	−0.033	0.126	0.121	0.009	−0.047
Sedentary behavior	−0.163	−**0.139***	−0.095	−**0.013****	**0.008***	**0.056***
Perceived ease of use	**0.28****	**0.357****	**0.394****	**0.5****	**0.355****	**0.398****
Perceived usefulness	**0.685****	**0.518****	**0.657****	**0.433****	**0.523****	**0.313****
Perceived affordability	0.05	**0.143***	0.259	0.131	**0.363****	0.155
Attitude	**0.464****	–	**0.433****	–	**0.273****	–

Note. Kendal's tau correlation coefficients presented. Chi-square test is used for significance, *: $p < 0.05$, **: $p < 0.001$.

presented assistive technologies from a fear of falling (FOF) framework: whether the product may help prevent future falls, or whether it poses a fall risk, or can aggravate or alleviate the effects of an inevitable fall: "If you're going up, as long as you maintain your grip, you're ok. If you lose your grip, you can go down…" (P03). Examining the handrail, another participant said:

"Going down is wonderful, going up, you can fall backward… not helpful… They tell you if you are getting dizzy and falling [on the stairs], falling down, go forward so that you don't fall down. But with the handrail, you can't do that" (P04)

Aesthetics/unobtrusiveness. Older adults value how others view their homes. Comments such as "having a regular look," "being able to store away [halfsteps] and others won't see" or "collapse the handrail to look like a regular one" highlight the cultural judgments regarding independence and dependence, or having or not having a disability. Thus, acceptance for assistive technologies for aging in place relates to cultural attitudes toward disability, as well as aesthetic aspects of designs. Comparing the half-steps to the StairSteady handrail, one participant said "It doesn't change the aesthetics as the handrail would" (P02)

Person-environment fit. While older adults "like[d] the concept" for several assistive technologies, they emphasized the need to adapt the designs for varying physical abilities of users. For example, P08 underscored how certain vertical mobility assistive devices (stair-steady handrail or half steps) would not be functional if they are installed only on one side of the stairs for people who are weaker on one side of the body.

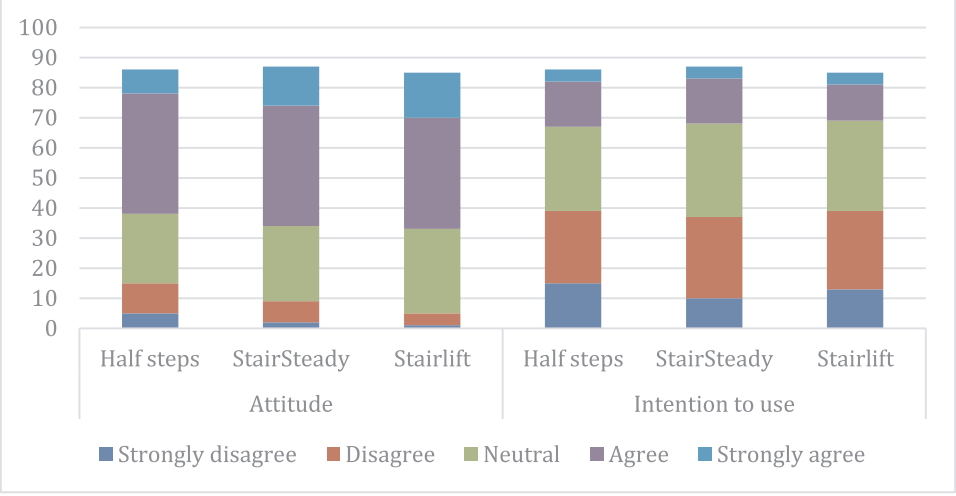

Fig. 1. Ratings of stair mobility products for attitudes and intentions to use.

Table 4
Regression models.

Attitude	**Half steps**				**Stair Steady**				**Stairlift**			
Predictors	**Estimate**	**SE**	**OR**	**95% CI**	**Estimate**	**SE**	**OR**	**95% CI**	**Estimate**	**SE**	**OR**	**95% CI**
Data collection method									−0.77	0.552	2.159	(0.732,6.364)
Home ownership					−0.23	0.34	1.259	(0.646,2.454)				
Household size					**0.824***	0.39	0.439	(0.204,0.942)	**0.876***	0.353	0.417	(0.208,0.833)
HM: Raised toilet	**−0.505***	0.27	1.733	(1.021,2.939)								
Sedentary behavior	**0.140***	0.071	0.869	(0.757,0.998)	**−0.174***	0.078	1.19	(1.020,1.387)				
Perceived ease of use					**−1.002****	0.256	2.722	(1.647,4.499)	**−0.935****	0.28	2.548	(1.472,4.409)
Perceived usefulness	**−1.324****	0.242	3.76	(2.337,6.040)	**−0.821****	0.242	2.272	(1.414,3.651)	**−0.559***	0.219	1.748	(1.137,2.687)
Perceived affordability	**−0.318***	0.16	1.375	(1.004,1.883)								
R Square	0.2059				0.2078				0.1555			
Chi Square	44.99				42.81				32.51			
AICc	191.46				183.65				194.5			
N	83				83				85			
Intention to use	**Half steps**				**StairSteady handrail**				**Stair lift**			
Predictors	**Estimate**	**SE**	**OR**	**95% CI**	**Estimate**	**SE**	**OR**	**95% CI**	**Estimate**	**SE**	**OR**	**95% CI**
Age					**0.971***	0.324	0.379	(0.201,0.714)	**1.155****	0.317	0.315	(0.169,0.587)
Monthly income					0.433	0.222	0.649	(0.420,1.002)				
Home ownership					−0.541	0.389	1.718	(0.802,3.682)				
HM: Raised toilet	0.433	0.274	0.648	(0.379,1.109)								
Self-reported Health					**−0.616***	0.297	1.851	(1.035,3.312)				
Vigorous PA									**0.223***	0.113	0.8	(0.641,1.000)
Walking	−0.201	0.105	1.223	(0.995,1.503)								
Moderate PA	0.15	0.106	0.86	(0.699,1.060)								
Perceived ease of use									−0.426	0.317	1.531	(0.824,2.849)
Perceived usefulness	**−2.309****	0.365	10.06	(4.919,20.590)	**−2.552****	0.388	12.84	(5.998,27.476)	**−1.338****	0.273	3.81	(2.229,6.511)
Perceived affordability					**−0.767****	0.231	2.154	(1.368,3.389)	**−0.586***	0.187	1.797	(1.245,2.595)
Attitude	−0.6032	0.315	1.828	(0.986,3.389)								
R Square	0.3747				0.4243				0.2981			
Chi Square	90.56				93.99				66.81			
AICc	171.65				150.77				177.99			
N	82				79				77			

Note. *: $p < 0.05$, **: $p < 0.001$.

6. Discussion and conclusions

To our knowledge, this is the first mixed-methods study that examined the relationships between a range of demographic, self-reported health and physical activity, and technology acceptance model (TAM) variables and older adults' attitudes toward and intentions to use stair mobility assistive technology products for home modifications. Our quantitative findings helped confirm the relevance of certain TAM-related constructs to predict older adults' acceptance of aging-in-place technologies. Overall, our survey results indicated that perceived usefulness consistently predicts older adults' attitudes among the three examined stair mobility products, and their intentions to use them in their homes. Consistent with other literature on older adults' acceptance of other types of assistive technology for aging in place (Peek, et al, 2014), older adults are much more likely to consider adopting a stair mobility product if they perceive that it will be useful for them. The two themes from the focus group, "fear of falling" and "person-environment fit," offers insights on this finding. One participant questioning whether the handrail would be useful in preventing a fall if one is ascending the stairs, or the focus group attendees discussing whether one can adapt the products for people with different needs provide further contexts to the "perceived usefulness" factor.

Another significant finding of this study relates to the differences in the ratings among attitudes toward and intentions to use the products (Fig. 1). Most survey participants held positive attitudes toward the stair assistive products, but the intentions to use them in their own homes were relatively low. This was in line with the focus group participants "liking the concept" of the products, in general. The previous literature highlights that home modifications were often done when there is a "trigger," such as a fall, or a "tipping point, e.g. as a general understanding that existing coping strategies are likely to become unmanageable in future." (Bailey et al., 2018, p.72). While we acknowledge that a current lack of a trigger may explain the low intentions to adopt the products, product appearance and their institutional look seem to be an influential factor. An important finding from the focus groups is the ongoing stigma against disability, and the value of aesthetics regarding home modifications. This issue is in line with previous research that discussed clinical appearance and negative associations with loss of independence (Bailey et al., 2018) that helps explain the differences among ratings of attitude versus intentions to adopt the products at home. This has significant implications for design professionals, as it underscores the need for avoiding an institutional look in residential designs, specifying products with high customizability for user needs and preferences with "device aesthetics" and "social acceptability" in mind (Parette and Scherer, 2004). It also points to the need of involving users in the design decision-making processes so that the proposed design solutions have a higher rate of acceptance. Lastly, our finding underscores the need for positive messaging about assistive home products, and their health- and independence-related benefits.

The other factors associated with attitudes and willingness to use the products are dependent on some degree to the examined mobility device. Another TAM factor, perceived affordability is significantly related to positive attitudes toward half-steps—the most affordable product of the three, but predicts intentions to use the other two products, StairSteady handrail and stairlifts. With limited funding assistance available in the US for home modifications, and the unclear nature of future funding, it is utmost importance to bring such products to a cost range affordable to the majority older adults, and develop innovative federal-, state-, and local-level funding assistance programs to offset the cost of home modifications. This would help keep older adults in their homes for a longer time, reducing healthcare-related costs of institutional care.

In line with the findings of Ahn and colleagues' (Ahn et al., 2008)

study on older adults' attitudes about and potential adoption of residential technology products and services, respondents who were younger had higher intentions to adopt StairSteady handrail and stairlifts in future. Our findings also align with previous research (Peek, et al, 2014) and suggest that possibility of assistance by other household members can negatively influence the attitude toward stair mobility products.

Limited mobility and insufficient physical activity are common problem among older adults. Previous research has found health and ability characteristics to affect technology acceptance (Chen and Chan, 2014). In our study, respondents who had better self-reported health scores had higher intentions to adopt the StairSteady handrail, but not the other two products. In addition, the attitude scores toward half-steps tended to decrease with increased sedentary time, but increase for StairSteady handrail. Such contradictions point to a need for further study with additional physical activity variables in relation to stair mobility product acceptance. Increased stair mobility may have significant effects on increasing physical activity levels of older adults, including IADL, so further research to inquire physical activity and such home modifications to increase active living at home is needed.

These findings should be considered in light of the study's limitations. First, we should note the geographical limitation of the study, and self-selection bias. Additionally, the email list we utilized for the online portion of the survey had older adults with higher educational attainment and income levels, compared to the general US population. Secondly, the selected stair mobility products represent a different mobility assistance needs and cost ranges, but does not capture all home modification design and technology options for stair mobility, such as different handrail designs. Research on other stair mobility products should confirm the study findings. Lastly, the research project and the data collection instruments involved a range of aging-in-place technologies in addition to the stair mobility products due to the exploratory nature of the study. Thus, the researchers needed to limit the number of measures of each factor for feasibility purposes, relying on previously validated questions. Further research will need to confirm these preliminary findings, utilizing multiple items for each measure.

CRediT authorship contribution statement

Elif Tural: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Funding acquisition. **Danni Lu:** Formal analysis, Data curation, Visualization. **David A. Cole:** Formal analysis, Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This project was supported by the American Society of Interior Designers (ASID) Foundation, Virginia Tech Open Access Subvention Fund.

Appendix

Table A. Model responses and candidate predictors

Model responses	Type	Values
Attitude: "In general, I think using __ is a good idea"	Ordinal	1–5 (Strongly disagree - Strongly agree)
Intention to use: " There is a good possibility that I will use __ in my home in the future"	Ordinal	1–5 (Strongly disagree - Strongly agree)
Candidate predictors	Type	Values
Perceived ease of use: "I think learning to use __ was/will be easy."	Continuous	1–5 (Strongly disagree - Strongly agree)
Perceived usefulness: "I think __ will be helpful for me."	Continuous	1–5 (Strongly disagree - Strongly agree)
Perceived affordability: "I could afford __ if I decide to use them in my home."	Continuous	1–5 (Strongly disagree - Strongly agree)
Currently have assistive product at home	Categorical	1 (Yes), 0 (No)
Data collection method	Categorical	0 (Online), 1 (in person-meal site), 2 (in-person- Warm Hearth Village)
Age	Continuous	1 (50–64), 2 (65–74), 3 (75–84), 4 (85+)
Gender	Categorical	1 (Male), 2 (Female)
Education	Continuous	1 (up to 8th grade) – 7 (post-grad or prof.)
Number of other people living in home	Continuous	1 (none), 2 (1 other), 3 (2+)
Monthly Income	Continuous	1 (< 1,000) − 5 (5000+)
Home type	Categorical	0 (House), 1 (Mobile home), 2 (Apartment), 3 (Townhome/Duplex)
Own home	Categorical	1 (Yes), 2 (No)
HM: Grab bars in bathroom	Categorical	1 (Yes), 0 (No)
HM: Roll-in shower	Categorical	1 (Yes), 0 (No)
HM: Shower bench/chair	Categorical	1 (Yes), 0 (No)
HM: Raised toilet height	Categorical	1 (Yes), 0 (No)
HM: Ramp into home	Categorical	1 (Yes), 0 (No)
HM: Level door handles	Categorical	1 (Yes), 0 (No)
HM: Door frames wide for wheelchair	Categorical	1 (Yes), 0 (No)
HM: Other	Categorical	1 (Yes), 0 (No)
HM: None of the above	Categorical	1 (Yes), 0 (No)
Self-reported health	Continuous	1–5 (Poor - Excellent)
Health interference	Continuous	1–4 (Not at all - a great deal)
Need ADL assistance	Categorical	1 (Yes), 0 (No)
Need IADL assistance	Categorical	1 (Yes), 0 (No)
# of days/week engaged in vigorous PA	Continuous	0–7
# of days/week engaged in moderate PA	Continuous	0–7
# of days/week walked for at least 10 min.	Continuous	0–7
Sedentary behavior: Hours sitting per day	Continuous	0–24

Note. HM: home modification. ADL: Activities of daily living. IADL: Instrumental activities of daily living. PA: Physical activity

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