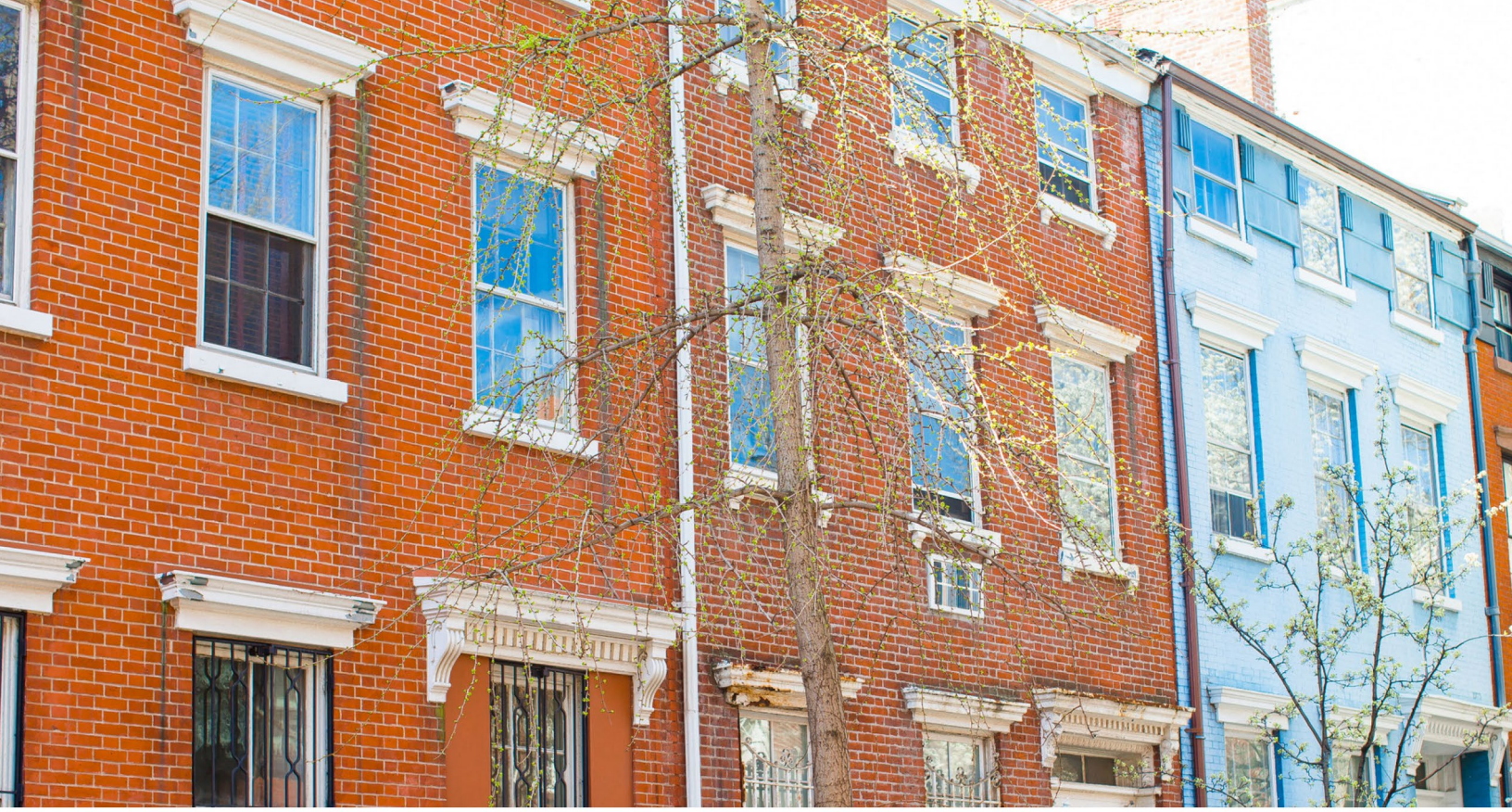

Retrofits & Adaptations: Improving Mobility in the Home

Adaptations for Townhomes and Row Houses

U.S. Department of Housing and Urban Development | Office of Policy Development and Research

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Prepared for

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Office of Policy Development and Research

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FOREWORD

The Centers for Disease Control and Prevention (CDC) estimates that the number of adults 65 years or older will reach 80.8 million by 2040 and 94.7 million by 2060—when older adults will make up nearly 25 percent of the population. As people age, they are more likely to have or develop a mobility impairment. Moreover, the housing market has a significant shortage of units suitable for people with mobility challenges to remain safely in their homes. Solutions call for assistive technologies that are innovative yet affordable and readily available.

Evidence demonstrates that people have a strong desire to remain in their homes—and a strong desire to adapt their homes to meet their changing preferences and needs. However, remodeling to improve accessibility is often expensive, and residents and caregivers cited cost as the most important consideration. Likewise, floor plan constraints and local regulatory requirements can make retrofitting or adapting the property to meet the needs of residents impossible. For example, row houses often are built with little or no front yard, making ramps impossible to install and requiring more expensive solutions.

The main objective of the study, *Retrofits & Adaptations: Improving Mobility in the Home*, was to review and test home modifications for semidetached and nondetached residential buildings (townhomes and row houses) with narrow floorplans and functional areas spread among several levels, and often with elevated entrances. The researchers conducted focus groups and a literature review to understand the daily and long-term challenges of individuals aging in place. Focus group discussions were conducted among three primary stakeholders—users, caregivers, and professionals—to understand better the needs and challenges of making a townhome or row house accessible. Focus group findings confirmed that older adults expected to age in place and a strong desire to do whatever is necessary to adapt their homes; however, they don't want their homes to look like an institution. Professionals regarded safety for all home modifications and fall prevention as the primary concern.

The literature review and feedback from the focus group yielded three key takeaways: (1) The appearance of the assistive device is important and must fit with the character of the existing home; (2) assistive devices need a standard method of evaluation to increase consumers' trust that the devices are safe to use; and (3) affordability is a primary consideration and a potential barrier to making modifications. Ten innovative product solutions were identified as potential solutions to the typical accessibility challenges found in townhomes and row houses such as lack of space, small rooms, narrow hallways, functional areas on multiple levels of the house, etc. The Interdisciplinary Advisory Group (IAG) narrowed the list down to four assistive technologies. The four accessibility products tested improved users' mobility within the house. Many of assistive devices, however, were manufactured outside the United States and are, therefore, less available, and more expensive. Efforts to provide residents with affordable devices are needed.

We hope this study generates interest in developing market-based solutions for expanding access to accessibility devices that can be installed in homes to allow residents to safely remain in their homes.

Solomon J. Greene
Principal Deputy Assistant Secretary for Policy Development and Research
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EXECUTIVE SUMMARY

The U.S. Department of Housing and Urban Development (HUD) has identified townhomes and row houses as needing innovative solutions to accommodate the growing population who experience physical, mental, or sensory challenges, which threaten their ability to remain safely and productively in their homes. Several programs exist that provide retrofits to existing homes, but in many cases, the cost of renovating townhomes and row houses can be prohibitive due to narrow hallways, multilevel stairs, and the lack of bedrooms and full baths on the first floor.

Home Innovation Research Labs (Home Innovation) and the Center for Inclusive Design and Environmental Access (IDeA) partnered to study innovative assistive devices that can improve accessibility without requiring major renovations to the home. The research was conducted using a mixed-methods approach, including data collected from focus groups and product evaluations. The participants in the study included seniors, persons with disabilities, caregivers, and design professionals who specialize in accessibility.

Focus Group Findings: Assistive Devices May Help Individuals Age in Place

Based on focus group findings and other industry data, most older adults are expected to age in place. Seniors in this study expressed a strong desire to do whatever is necessary to adapt their homes to meet their changing needs as they age. Similarly, focus group members strongly desired to remain in their homes. Both groups saw an inherent value associated with staying in their homes because it provides them with a sense of comfort, independence, and well-being. In addition, the findings from the focus group corroborate the key findings from the literature search, including that (1) the appearance of the assistive device is important and must fit with the character of the existing home; (2) assistive devices need a standard method of evaluation to increase trust on the part of the homeowner that the devices are safe to use; and (3) affordability is a primary consideration and a potential barrier to making modifications.

The research project's primary goal was to identify low-cost, low-effort technological adaptions with aesthetically pleasing design modifications that can make existing townhomes and row houses more accessible to those individuals with mobility-related challenges. The initial literature review helped define the starting point for the authors' investigation by highlighting the condition of existing housing and known challenges. Through a combination of stakeholder focus group discussions and the expertise of Home Innovation's research team, the authors identified four promising devices to be installed in the laboratory for evaluation by people with disabilities, their caregivers, and accessibility professionals.

The four accessibility products that Home Innovation evaluated (StairSteady, AssiStep, FlexStep, and All-Push Door) successfully improved the user's mobility, with each varying in associated cost.[1] The StairSteady assistive device costs less than a conventional stair lift product, whereas the AssiStep was similar in cost to a conventional stair lift product. The FlexStep was more expensive than a similarly sized wheelchair lift device but had the benefits of being able to convert into a flight of stairs and a much more participant-preferred appearance. The All-Push Door was comparable in cost to an automatic door opener; however, the installation cost increased if the door frame needed to be widened.

[1] Accessibility products included two stair-climbing devices (StairSteady and AssiStep), one wheelchair lift device (FlexStep), and one door assist device (the All-Push Door).

Remodeling to improve accessibility can be extremely expensive, especially in existing townhomes and row houses. During the focus group discussions, cost was cited as the most important consideration by most residents and caregivers. The general perception was that retrofits and modifications would be cost prohibitive, and some believed that implementing accessibility improvements would be difficult without financial assistance. Some participants noted that a major renovation, including an additional bedroom and full bathroom on the first floor, could increase the home's resale value.

Improving Grants, Loans, and Decisionmaking Tools for Home Assessment

Ultimately, for residents of some townhomes and row houses, the best decision may be to move to a more accessible home. A retrofit or adaptation of the property may not be a good value proposition, especially if grants are used to subsidize construction. Grants are usually capped and may not cover the total cost of the needed improvements, resulting in a less-than-adequate solution. The renovations needed may be extremely expensive. For example, retrofitting a townhouse with accessible entry steps may require the installation of a FlexStep outside and an AssiStep inside. If the home also needs a new roof and furnace, however, investing funds in accessibility improvements without also doing the other repairs does not make sense. Floor plan constraints and local regulatory requirements can make it impossible to retrofit or adapt the property to meet residents' needs. For example, row houses are often built with little or no front yard. Ramps will not fit, so a more expensive solution such as the FlexStep or a conventional lift may be needed to make the home minimally accessible. For some individuals, staying in one's own home may be possible, but it could affect quality of life considerably. An AssiStep or StairSteady could provide access to a second-floor bathroom and bedroom, but stairs at the main entry may become a barrier to someone with a disability, and the resident may be unable to leave the home without assistance. Thus, if not enough money is available to renovate the home successfully, moving may be a better alternative, particularly if the home has significant value that could be tapped to relocate.

As part of home modification, an assessment of the value proposition for the homeowner could help decisionmaking concerning aging in place, the scope of improvements to implement, or whether relocation is more desirable. If the homeowner decides to relocate, assistance in finding an appropriate home may also be needed. In its existing programs, HUD could require that such an assessment be included as part of home modification services funded by the agency. To assist providers, HUD could fund the development of tools for evaluating strategies and making informed decisions. Individuals may resist moving for many reasons, even if it is in their best interest. In many cases, such decisions are made as a family, in consultation with adult offspring or other relatives. Such tools would help to clarify the benefits of each strategy and make the implications clear to all involved.

Many low-income residents do not have the money to pay for moving costs, security deposits, or the first month's rent. That financial stress can be a barrier to relocation, even if the resident understands that it is the best option. In some localities, grants, and loans to cover such costs are available, but no source of funds is generally available for that purpose. HUD may be able to provide funding or assist with the development of a new funding stream in cooperation with other federal agencies, such as the U.S. Department of Health and Human Services (HHS), targeted toward low-income homeowners. For higher-income individuals, a revolving federal loan fund may be a means to maximize the impact of such a program by reaching the population who do not have the funds at hand but are capable of paying the loan back in installments. HUD

could also consider providing incentives such as tax credits or subsidies for homeowners older than 65 to purchase new homes with basic accessibility features, such as ICC/ANSI A117.1 standard, Type C Visitable Dwelling Units. This incentive program could be implemented through a certification and labeling approach, such as that for the ENERGY STAR program for appliances, which may increase demand for accessible housing and subsequently encourage increased builder interest in this market segment.

Improve Program Awareness, Funding Options, and Innovation in the United States

The focus group findings indicated that many residents are unaware of existing retrofit programs. Increasing awareness was beyond the scope of this study, but additional outreach is needed. Home Innovation proposes further research to study how HUD's existing funding programs could include greater outreach and higher funding caps. According to HomeAdvisor (2022), the typical home renovation for accessibility can range from as little as $800 up to $19,000. A closer look at the cost data reveals that major accessibility renovations that include bathrooms and kitchens can be as much as an additional $40,000 to $60,000.

The funding for medical devices is generally covered by health insurance, Medicare, or Medicaid. Assistive devices that improve the accessibility of the home are typically not regarded as medical devices (although some motorized stair lifts may be paid for using health insurance, Medicare, and Medicaid), and government funding is harder to obtain for accessibility improvements in the home. HUD's Older Adult Homes Modification Program can assist with the cost of improving accessibility in the home, but the grants typically cover only a portion of the total cost for minor renovations (if one considers the cost range reported by HomeAdvisor).

The assistive devices in this study were manufactured outside the United States. European countries and Canada have developed assistive devices that can be installed on stairs and doors at a much greater frequency than the United States. Most U.S. companies primarily focus on personal assistive devices, such as canes, walkers, wheelchairs, and braces or prosthetics for individuals with mobility-related issues. Personal assistive devices are generally regarded as medical devices, whereas assistive devices that are installed permanently in the house are generally considered home improvement products in the United States.

To spur more design innovation in the United States, HUD should consider creating an Innovation Competition for Accessibility Products for the Home, similar to HUD's Affordable Housing Student Design and Planning Competition.[2] The competition may drive more innovation in the area of assistive devices permanently installed in the home. Doing so could lead to increased demand for the manufacturing and installation services of assistive devices for U.S. homes.

[2] For more information, see https://www.huduser.gov/portal/challenge/home.html.

INTRODUCTION

The United States has a large housing stock of semidetached and nondetached residential buildings (townhomes and row houses) with narrow floor plans, and functional areas are spread among several levels, often with elevated entrances. Those home configurations are particularly challenging when modifications are required to improve access, safety, and usability for elderly and people with disabilities. HUD has identified townhomes and row houses as needing innovative solutions for the growing population who experience physical, mental, or sensory challenges that threaten their ability to remain safely and productively in their homes.

For this project, Home Innovation Research Labs (Home Innovation) and the Center for Inclusive Design and Environmental Access (IDeA) of the School of Architecture and Planning at the State University of New York (SUNY) at Buffalo conducted research to (1) understand the typical pitfalls of retrofitting for accessibility in townhomes and row houses; (2) identify best practice solutions for overcoming barriers to adoption; and (3) develop construction guidance to support designers, remodelers, and homeowners in their decisionmaking and construction processes.

The scope of work included (1) a comprehensive literature search, (2) focus groups to identify problems and potential solutions, (3) selection of viable accessibility solutions or devices, (4) construction of accessibility solutions or devices for evaluation at Home Innovation, (5) in-person evaluation of accessibility solutions or devices, (6) quantitative and qualitative analysis of evaluation results, (7) a cost-benefit analysis of the selected accessibility solutions or devices, and (8) design guidance for determining if modifications are possible and what is required by homeowners to make the adaptions successful.

Literature Review

In general, people can respond to environmental barriers in their homes in one of four ways (Salomon, 2010):

- Adapt their behavior.
- Move to another home.
- Modify their existing home.
- Turn to institutional care or another supportive housing arrangement.

Adapting behavior can often lead to unsafe conditions; moving can be cost prohibitive or disruptive, especially to persons advanced in age; and institutional care is often the most expensive and least desirable option for homeowners older than age 65. This situation makes the implementation of home modifications an effective and popular option for a wide range of homeowners (Bayer and Harper, 2000).

Home modifications can be categorized by their features and benefits and range in scale from minor adaptations, which include the installation of additional lighting or the replacement of doorknobs with levers, to more significant interventions, such as widening doorways or installing ramps. Although home modifications are defined as any adaptation made to the home that serves to decrease environmental demands for the user, defining modifications through specific goals is often beneficial. Steinfeld and Maisel identified the primary goals of home modifications as—

- Accessibility to interior and exterior spaces in the home and on the property.

- Usability to reduce barriers in the environment (Slaug et al., 2011).
- Safety to reduce the risk of accidents and improve security and fire safety.
- Support for caregiving and health care.
- Support of social integration and engagement.

The literature review focused on strategies that become a permanent feature of the home and bolster or improve the occupant's ability to perform activities of daily living (ADLs), which include independence when—

- Eating.
- Dressing.
- Walking or transferring from one place to another.
- Bathing.
- Using the bathroom for toileting.
- Maintaining continence.

This study excluded interventions that can provide significant benefits but are generally not permanent architectural changes to the home. Those less permanent adaptations could include the mitigation of clutter or the use of temporary assistive devices and equipment, such as a freestanding bath bench or a toilet seat riser.

Although existing research illustrates the effectiveness and benefits of home modifications (Steinfeld and Shea, 1993), public policy and private-sector practices continue to fall short of providing adequate services and financial resources (Pynoos and Nishita, 2003). Many factors have contributed to the gap between knowledge and practice, including limited published research using large and diverse samples, lack of clarity in the definition of *home modifications,* and lack of knowledge about current practices in the construction industry and their effectiveness. Research on this topic is complicated by great variations in housing stock and conditions; construction practices and costs; and disability type, severity, and individual preferences toward home alterations.

A *home modification* is defined as any adaptation made to the home environment that addresses the functional limitations of the occupants and promotes independence, comfort, and safety (Steinfeld and Maisel, 2012). Modifications are not limited to any single population, but the authors' literature search focused on modifications for four primary populations: (1) people advanced in age; (2) individuals with decreased mobility; (3) persons with visual impairments; and (4) individuals with cognitive impairments. Those four populations are explicitly addressed because they constitute significant subpopulations, and the modifications prescribed for them likely benefit a much larger group. Important to note is that the needs of all occupants of the home must be considered when recommending modifications, including family members and guests. Appropriate interventions address the physical and emotional needs of the caregiver as well.

The literature on home modifications has evolved considerably since this topic was identified in the 1970s as an important aspect of adaptation to aging. Government policy and private-sector initiatives in housing for the older generation, however, have consistently favored new construction over investment in the existing housing stock. Likewise, research funding devoted to modifications to keep the aging population in their homes longer has not been a priority of the government or the private sector. The Home Modifications Action Coalition—a collaborative

effort of the American Association of Retired Persons (AARP), the American Society on Aging, academia, and service providers—highlighted the importance of those services through its *Blueprint for Action* (North Carolina State University: School of Design, 1997). Research on practices in the field demonstrates that the mechanisms for delivering home modification services, from financing to construction, are fragmented and uncoordinated. Not much has changed since that time, although now a heightened awareness of the problem exists among service providers, government agencies, and the remodeling industry.

One of the most important findings from the literature review was the disconnect between the expectations of older adults and persons with disabilities with the reality of their housing. Although a large majority of older adults expect to age in place, research demonstrated that their living arrangements do not support that choice without major compromises to their quality of life. Consumers were unaware that they might need deliberate—or even major—interventions in their home environment to realize their aspirations for aging in place. The rising cost of alternatives to renovating one's home, such as moving to a new, universally designed home or service-intensive facility, will likely create a greater demand for home modification design and construction services. A danger exists that the supply of needed services, financing, and expertise may not meet the demand. Even worse, the potential mismatch between expectations and actual outcomes could make older people dread engaging service providers, akin to avoiding a visit to the dentist until it is too late. This dilemma will add to the burden of healthcare providers, relatives, and friends and severely reduce aging homeowners' quality of life.

Research and practice clearly identified the scope of usability-related home modifications and the most common solutions. The authors considered a wide range of interventions, yet each individual and home are different. The challenge was to identify the most strategic interventions to target for in-depth research. For instance, satisfactory, low-cost, and easily implemented modifications such as cueing for people with dementia, improving illumination, and installing grab bars already exist; innovation is unnecessary.

Thus, the focus of research in this project was on improving the effectiveness of some of the most expensive and hard-to-implement modifications related to accessing homes and maintaining the safety of people with disabilities and their caregivers. Initially, the authors thought the focus would be on overcoming inaccessible entries (such as by installing ramps and lifts); access to essential facilities (such as laundry and parking) on inaccessible floors; and bathroom access, particularly access to toilets and bathing arrangements in cramped bathrooms. However, given the unique vertical design layout of townhomes and row houses, the authors' focus shifted to mobility issues, stairs, and door entries.

A large percentage of townhomes and row houses have bedrooms and bathrooms on the second or third level, making vertical navigation a daily challenge for those individuals with mobility-related disabilities. Stair lifts, inclined stair platform lifts, and elevators are potential home modifications for individuals who cannot climb stairs but require access to multiple levels of a home (Steinfeld and Maisel, 2012).

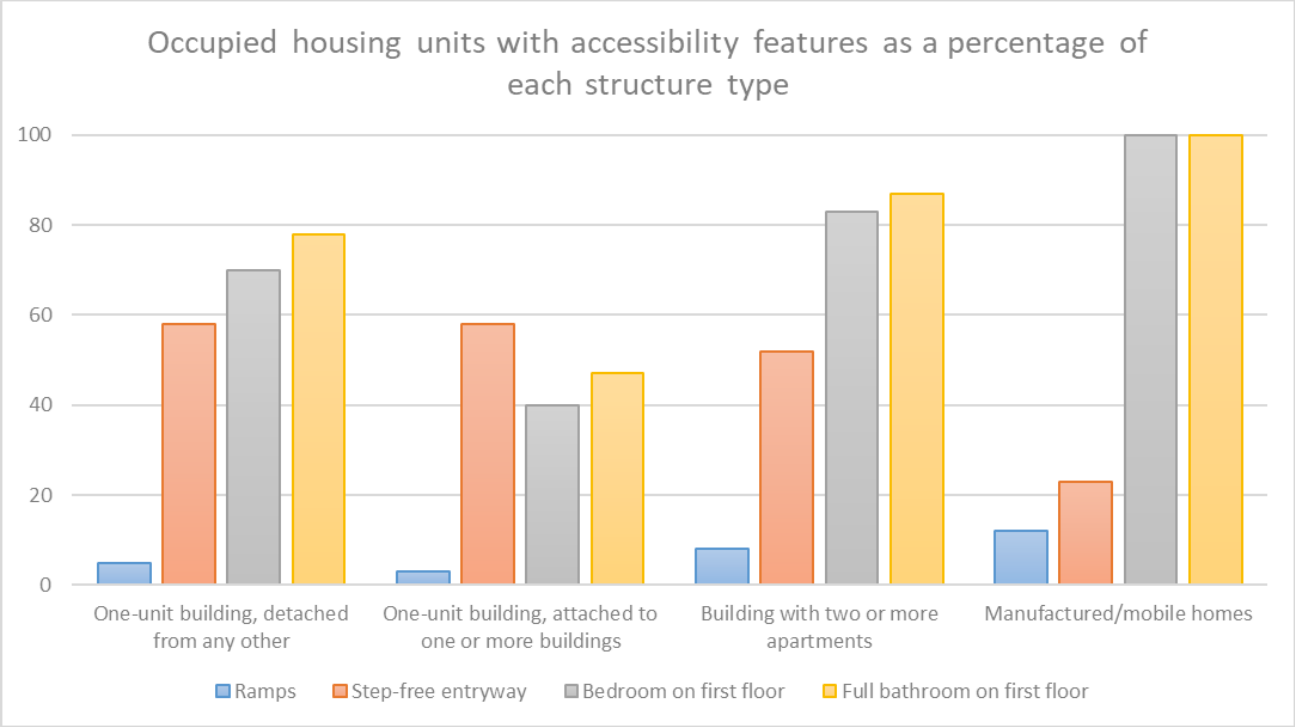
With vertical mobility in mind, the authors evaluated innovative products that make stairways safer and easier to climb, including easier-to-grip railings and innovative devices such as the StairSteady and AssiStep. Initially, the authors thought that evaluating a new lift or elevator technology was outside the scope of this research due to budget, time, and engineering constraints. However, the authors identified a cost-effective option, the FlexStep, an innovative

lift product manufactured in Europe. In addition, the authors secured an easy-to-use door called the "All Push Door" from Taiwan, specifically designed for individuals who have difficulty pulling doors open. Appendix A has the *Home Modification Literature Review* report.

Inventory of Existing Homes

The U.S. Census Bureau and HUD (2021) published the 2019 American Housing Survey (AHS), which includes data concerning home accessibility. The AHS estimates that 48 million households (39 percent of the total households in the United States) have at least one person older than age 65, with a disability, or both. Approximately 35 percent of people who live alone have a disability, and 37 percent of those who live alone are age 65 or older. Approximately 42 percent of people who use a mobility device have a disability, and approximately 26 percent of people who use a mobility device are age 65 or older. The AHS estimates occupied housing units with accessibility features as a percentage of each structure type. Exhibit 1 includes a chart of accessibility features for (1) detached houses, (2) attached and semi-attached houses, (3) multifamily apartment buildings, and (4) manufactured or mobile homes. For each building structure type, the exhibit identifies the percentage with ramps, a step-free entryway, a bedroom on the first floor, and a full bathroom on the first floor.

Exhibit 1. Accessibility Features as a Percentage of Each Building Structure Type



Source: U.S. Census Bureau

Attached and semi-attached houses (townhomes and row houses) are represented in exhibit 1 by the "One-unit building, attached to one or more buildings" bars. The research team attempted to categorize townhomes and row houses on the basis of the floor plan but could not identify a "typical" design. The existing housing stock of attached and semi-attached houses have a wide variety of floor plans based on regional design differences and the age of the homes. Some design features, such as the prominence of garages and limited livable space on the ground level, are recent compared with other, older design features, such as grand stairs (or stoops) seen on

vintage brownstones. Both design features present a challenge for accessibility into the house when the occupant has a mobility-related disability or limitation.

The authors identified three design features—elevated entryways, garages occupying most of the ground level, and stairs to access multiple floors—that made accessibility challenging.

Exhibit 2. Raised Entryway

Exhibit 3. Raised Entryway

Exhibit 4. Garage First Level

Source: Home Innovation

Exhibits 2 and 3 are older vintage row houses with raised entryways. This design feature may present a challenge when considering accessibility, especially when set-back space in the front of the property is limited. The space constraint shown in exhibits 2 and 3 makes installing a conventional ramp impossible. In such cases, a stair lift may need to be installed, or the resident may need to relocate if no retrofit solutions are viable. Exhibit 4 illustrates a common design feature of modern townhouses: the garage occupies most of the ground floor space. The floor plan in exhibit 5 also demonstrates this style of design.

Exhibit 5. Garage on First Floor (No Bedroom or Full Bathroom)

Source: Home Innovation

Two key accessibility features—a bedroom and a full bathroom on the first floor—mentioned in exhibit 1—are not included in the first floor plan shown in exhibit 5. Instead, the second floor

has three bedrooms and two full bathrooms, all accessible only by stairs. If a resident has a mobility-related disability, one of three options must be considered to ensure that the townhome is accessible. First, the homeowner may do a major renovation on the first floor by converting the great room into a bedroom and expanding the half-bathroom into a full bedroom. Second, the homeowner may install a stair assistive device from the garage to the first floor and add a second stair assistive device from the first floor to the second floor. Third, the homeowner—or resident with a disability—may move to a different house or assisted living facility. This study is focused on identifying and evaluating devices that make staying in the home viable in terms of affordability and improving mobility in the home.

METHODOLOGY

The primary goal of the authors' research project was to identify *low-cost, low-effort,* and *aesthetically pleasing design modifications* that can make existing townhomes and row houses more accessible to older adults and persons with disabilities. The literature review helped define the starting point for the authors' investigation by highlighting the condition of existing housing and known challenges. In conjunction with planned stakeholder focus group discussions and the expertise of Home Innovation's research team, the authors identified devices to be installed in the laboratory for evaluation and consideration by persons with disabilities, elderly people, their caregivers, and accessibility professionals.[3]

Focus Groups

As part of the preliminary research plan, focus group discussions were conducted among three primary stakeholders—users, caregivers, and professionals—to better understand the needs and challenges of making a townhome or row house accessible. Each focus group discussion lasted approximately 2 hours, and each group had 8 to 10 participants.[4] The sample sizes for the focus groups were small—nine users, 10 caregivers, and eight professionals—and the responses were qualitative; therefore, extrapolating the results to a larger population is not appropriate. Nonetheless, the findings from the focus group corroborate the key findings from the literature search; for example, (1) the appearance of the assistive device is important and must fit with the character of the existing home; (2) assistive devices require a standard method of evaluation to increase trust on the part of the homeowner that the devices are safe to use; and (3) affordability is a primary consideration and a potential barrier to making modifications.

Caregivers in the focus groups were more likely to report challenges than the users or people with a disability. This difference was likely due to one or more of the following reasons. First, except for one caregiver, all other participating caregivers in the focus group were not assisting the users in the other focus group; for the most part, the caregivers were discussing a different group of people with disabilities, who may have had more limitations than the user cohort in this study. Second, caregivers and users may define *challenges* differently on the basis of their perspectives. The authors noted that caregivers tended to categorize an activity as challenging if any delay or difficulty was perceived. On the other hand, users resisted classifying an activity as a challenge as long as they could ultimately achieve the goal, despite delay or difficulty. Third, users may perceive the word *challenge* negatively and resist applying that word to themselves. In every category, the caregivers consistently rated the activity more difficult than did the users. Caregivers and users prioritized challenges the same, even though the relative incidence of challenges for users was lower than caregivers reported.

Several areas of the home—such as bathrooms, stairs, laundry room, and entryway or entrances—were commonly cited as presenting some of the greatest challenges in terms of accomplishing daily activities and ease of use. Among caregivers and users, the fear of falling was a primary safety concern associated with the bathroom and stairs. Users thought that the stairs and bathrooms needed to be modified for them to remain in their homes long term, and caregivers stressed the importance of having good retrofit solutions for bathrooms and stairways,

[3] Professionals included occupational therapists, physical therapists, architects, designers, remodelers, certified aging-in-place experts, Universal Design experts, and assistive device manufacturers.
[4] The focus group participants were paid an honorarium of $150 (in the form of a gift card).

both interior and exterior. Caregivers thought that stairway solutions were the most important feature because they improved mobility inside the house and prevented the senior or person with a disability from feeling isolated or confined to one part of the house. In general, caregivers in the focus groups thought that mobility-facilitated social interaction kept the user engaged with family, friends, and life in general.

Professionals in the focus groups stated that residents who stayed in their homes rather than transitioning to assisted living or a nursing home facility saw greater benefits in terms of quality of life and added value to their home—if a major renovation expanded the function of the first floor. Most residents prefer to stay in their homes (Goyer, 2021), and professionals have seen an increased demand for aging-in-place solutions.[5] The benefits of aging in place have contributed to more people believing that home retrofits and modifications are a good investment.

Professionals regarded home renovations as an investment that may improve the resale value and marketability because it benefits older adults, people with disabilities, and multigenerational households. The cost of a major renovation, such as adding an accessible bathroom to the main level of an existing home, can range from $20,000 to $30,000. Some insurance companies offer long-term care policies with riders that fund home retrofits as an alternative to placing the family member in assisted living or a nursing home. Insurance companies recognize that an aging-in-place retrofit can be more cost effective and better for the patient's health and well-being in the long run. However, that option depends on the person having a particular type of long-term care insurance (American Association for Long-Term Care Insurance, n.d.).

Remodelers, builders, and architects who participated in the research project claimed to encourage their clients to proactively plan for future needs when planning general remodels or designing new homes.[6] Some criticized the term *aging in place* because it emphasizes design for declining abilities. Those professionals have found that their clients were more accepting of solutions that highlight empowerment and the ability to improve one's quality of life. Proactive planning involved considering design choices that can be easily modified in the future or implementing universal design (Center for Universal Design at NC State, n.d.) concepts for a new home. Client relations are an important aspect of home modification services. The professionals involved not only have to be knowledgeable about how to design for aging in place, but they need to present the idea to clients in ways that the client will value. This finding suggests that a valuable follow-up research study could examine how homebuilders, remodeling contractors, and their design consultants communicate the concept of design for aging in place to clients. Research questions could include the following:

- How many home builders, remodeling contractors, and their design consultants know enough to design for aging in place?
- Do they present the idea to clients?
- What language and approaches are most successful in getting clients to adopt aging-in-place practices?

The output could include revisions to the Certified Aging-in-Place Specialist (CAPS) curriculum or online courses that builders and remodelers could access to become more informed.

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[5] *Aging in place* refers to people remaining in their home without losing their quality of life as they age.

[6] The remodelers, builders, and architects who participated in this study were accessibility specialists, hence they often recommended Universal Design and accessibility features to their clients.

Professionals generally ranked exterior access solutions as the most challenging to implement. In some situations, installing a ramp was not possible due to space limitations because ramps may not block the sidewalk or extend into a public area. As illustrated in exhibits 2 and 3, space limitations are common challenges for townhomes and row houses. An occupational therapist in the authors' focus group confirmed this challenge, sharing that a client who lived in Baltimore needed a ramp or wheelchair lift to access the home, but the home's entryway did not have space for a ramp, and the cost of a wheelchair lift was prohibitive—from $15,000 to $20,000); lack of a practical and affordable option for entry and exit ultimately forced the individual to move.

Professionals thought safety was a fundamental consideration for all home modifications. Fall prevention was the primary concern for older clients and persons with mobility-related disabilities. The professionals identified bathrooms, stairs, door thresholds, and floor material transitions as the areas with the highest probability of falls. Professionals thought that typical solutions—grab bars, handrails on stairs, improved lighting, and better entry doors with "no-step" thresholds—were well known and straightforward to implement. Most professionals stated that they relied on device suppliers, or distributors, to keep them apprised of the best practices for remodeling for accessibility. Product availability, performance specifications, warranty, and installation requirements were essential for professionals to know when determining whether a product would be used on a remodeling project.

Professionals believed that aesthetics were very important to encouraging proactive planning with their clients. Although everyone valued safety and ease of use, professionals stated that their clients also wanted their homes to look and feel like "a home," not a hospital or assisted-living facility. Architects, designers, and remodelers were keenly aware that if all devices were equal in terms of performance, clients preferred the best-looking device.

The focus group participants believed that affordability was the number-one barrier to retrofits and renovations. Despite available grant money, rebates, and other funding sources, homeowners often struggled to get needed financial assistance. In some cases, a resident may not qualify for a financial accessibility grant because of income or asset thresholds, lack of homeownership—generally a requirement for many of the programs—or a complex application process. Even when funding is secured, it may not be enough to cover the total cost of the retrofit or renovation. For townhomes and row houses, retrofits and renovations are complicated by narrow hallways, cramped stairways, and other space limitations. To address those constraints, professionals have proposed complex design solutions that include more expensive devices such as elevators or major renovations compared with a one-story house plan. Appendix B contains the *Focus Group Discussion and Exploration of Accessibility Needs and Challenges* report.

Selection of Devices

Using the results from the focus group discussions, Home Innovation and IDeA conducted several brainstorming sessions to identify innovative product solutions that could address the following accessibility challenges typically found in townhomes and row houses:

- Lack of space.
- Small rooms.
- Narrow hallways.
- Stairways, accessing functional areas on multiple levels of the house.
- Elevated exterior door entry.

- Shared walls between the houses (limits renovation options).
- Small lots with limited space between the house and the property line.

Home Innovation's research team identified 10 innovative product solutions, listed in exhibit 6. The Interdisciplinary Advisory Group (IAG) was asked to review the products and rank them on how many challenges they addressed.[7] The IAG also considered (1) safety, (2) functionality, (3) cost effectiveness, (4) aesthetics, and (5) the overall impact if the product were successfully installed.

Exhibit 6. Innovative Product Solutions for Accessibility Improvements in the Home

Accessibility Solutions to Consider and Rank	
All-Push Door	StairSteady
FlexStep	Vehicle Lift
Fixture Integrated Rails/Handholds	Adjustable Height Toilet
Toilet Riser/Step Combination	Movable Storage Wall
SuperPole	Turntable/Carousel

The IAG product ranking is listed in exhibit 7, and the research team's ranking is listed in exhibit 8. The bold items in the exhibit represent the highest scoring items from exhibit 8 and their ranking by IAG Product ranking in exhibit 7.

Exhibit 7. IAG Product Ranking

Ranking	Accessibility Solutions: IAG
4.4	SuperPole
3.9	**StairSteady**
3.5	**All-Push Door**
3.4	Toilet Riser/Step Combination
3.4	**FlexStep**
3.1	Fixture Integrated Rails/Handholds
2.5	**Moveable Storage Wall**
2.5	Turntable/Carousel
2.1	Vehicle Lift
1.8	Adjustable Height Toilet

Exhibit 8. Research Team Product Ranking

Ranking	Accessibility Solutions: Research Team
4.9	**All-Push Door**
4.9	**FlexStep**
4.4	**StairSteady**
3.9	**Moveable Storage Wall**
3.5	Fixture Integrated Rails/Handholds
3.5	Vehicle Lift
3.5	Turntable/Carousel
3.0	Toilet Riser/Step Combination
2.3	Adjustable Height Toilet
1.6	SuperPole

The rankings were the average score from 1 to 5 of the members in the IAG and the research team members. When considering the 10 accessibility solutions, the research team ranked products high that addressed challenge areas from the focus group data: (1) stairways, (2) entryways, and (3) limited space. The IAG generally ranked products high that it thought were innovative, even if widely available (such as the SuperPole). The toilet retrofit devices were

[7] The Interdisciplinary Advisory Group (16 subject matter experts) is identified in the acknowledgment section of this report. They represent a broad group of industry stakeholders and offered various recommendations during the evaluation of product solutions.

good products for improving accessibility in the bathroom but did not address the most challenging areas in townhomes or row houses. The remaining accessibility products ranked too low to be considered for evaluation.

The All-Push Door was selected for further study because it can be adapted to an exterior or interior door opening. The "push-only" concept was designed for people who may have issues pulling a door open due to cognitive impairment or physical limitations in their hands. The product also eliminates the need for someone in a wheelchair to turn around when entering a door from the pull direction. The product is manufactured in Taiwan and has limited availability in the United States, but the manufacturer wanted to have products available to meet anticipated future demand. In general, the All-Push Door must be sized to meet door specifications in the United States, and the manufacturer is aware of those requirements—especially for exterior doors, which must meet building codes, fire codes, and other voluntary product performance requirements.

The FlexStep was selected for further study because it converted from a lift to a staircase, which made it a potential solution when space is limited at a house's main entrance. The product is also well suited for interior doors that enter the house from the garage, as illustrated in exhibits 4 and 5. The FlexStep received a high ranking because it has the potential to address stairs, entryways, and limited spaces; however, a preliminary review of the product's cost revealed that it might be too high to be considered affordable. The product is manufactured in Europe but is readily available for purchase in the United States through distributors.

The StairSteady was selected for further study because the product offered a simple, relatively inexpensive assistive device for climbing stairs. Given the limited space in some older townhome and row house stairways, the StairSteady is compact in size and easy to install—but the user must have some upper body strength to use the manual device. The device was affordable, low maintenance, and compact enough to be concealed when not in use. Because the product can be painted any color, the authors believe it can easily match the surrounding decor of virtually any home, appealing to the aesthetic preferences of most user participants. The device is manufactured in Canada and must be special-ordered because there are no U.S. distributors that offer the product.

The Movable Storage Wall was selected for further study because it was considered useful when space limitations were present and storage was needed. The concept proved limited because the system required a partition wall with no utilities present to have a movable storage unit "embedded" within an interior wall. Home Innovation built a mock-up Movable Storage Wall to illustrate the system's functionality and discovered that although it could work for some existing floor plans, it was not space conserving. The authors eliminated the Movable Storage Wall from further consideration in this project.

Home Innovation identified an additional device to evaluate—the AssiStep—a manual stair assistive device for climbing stairs, similar to the StairSteady. The AssiStep has an adjustable handle and can be installed on stairways with limited space. The manual device is mounted on a track that requires very little upper body strength to move. The product is affordable, low-maintenance, and can be folded up when not in use. The device is manufactured in Europe and must be special-ordered because no U.S. distributors offer the product. Appendix C contains the *Summary of Design Selection and Prototype Construction* report.

In March 2020, Home Innovation installed the accessibility products in the testing and observation spaces in its laboratory facility to conduct in-person product evaluations in April 2020, but the COVID-19 pandemic delayed this key part of the research project. Although a limited product evaluation was conducted with select remodeling professionals in November 2020, Home Innovation continued to delay the comprehensive product evaluations with users, caregivers, and professionals until COVID-19 vaccines were readily available to all adults in June 2021.

Evaluation Protocol

In July 2021, Home Innovation recruited 51 participants—users, caregivers, and professionals—to evaluate accessibility devices. The participants included users with mobility-related disabilities or limitations, caregivers of older adults or individuals with mobility-related disabilities or limitations, and professionals with expertise in accessible design, including physical and occupational therapists, architects, designers, and contractors who specialize in accessibility renovations.

The in-person evaluations were conducted in August 2021. Upon arriving at Home Innovation's location in Upper Marlboro, Maryland, participants read and signed the permission and release documents, authorizing Home Innovation to conduct observational research with the participants as they evaluated accessibility devices. Home Innovation staff followed the Institutional Review Board (IRB) ethical guidelines to ensure a safe research experience and environment.[8]

The participants were given a short orientation that included a review of the evaluation process and a demonstration of how to use each device. Then, the participants were instructed to evaluate each device and answer questions from the IRB-approved survey. Home Innovation staff documented the participant responses, which addressed the ease of use, installation, maintenance, aesthetics, need for the device, price willing to pay, and perceived advantages and disadvantages of each device. After completing the survey questions, the participants engaged in open-ended discussions with Home Innovation staff, which led to further insight into the participants' experiences with the devices. In some cases, participants offered recommendations for how the devices could be improved. Appendix D contains the *Home Innovation Accessibility Evaluation* survey.

Home Innovation did not conduct performance testing on the accessibility devices and does not endorse or debunk any claims made by the manufacturer. Instead, Home Innovation captured the participants' perceptions and comments through observational research. The data gathered cannot be reliably extrapolated to a larger population, and statistical analysis cannot be applied to the results to characterize a larger population accurately. Nonetheless, the results provided valuable insight into how best to select accessibility devices based on the needs of the user.

[8] The IRB is an independent reviewer of research methods (including questionnaires and surveys) to ensure that they are ethical and protect the rights and welfare of human subjects involved in research.

EVALUATION OF DEVICES THAT IMPROVE MOBILITY

The objective of the in-person evaluation was to identify which devices help minimize or eliminate the accessibility challenges within typical townhomes or row houses. The participants evaluated four accessibility devices, which included two stair assist devices (StairSteady and AssiStep), one stair lift device (FlexStep), and one door entry device (All-Push Door).

Home Innovation recruited 15 users, 16 caregivers, and 20 professionals. Many of the caregivers had mobility issues; in fact, the authors observed several elderly caregivers with mild mobility-related limitations, though not as severe as those of the person they were assisting. As a result, the authors considered responses from users and caregivers together as one larger group called Cohort 1. The professionals were called Cohort 2.

For Cohort 1, the participants—users and caregivers—were required to have a mobility-related disability or care for someone with a mobility-related disability. In addition, Cohort 1 had to reside in or assist someone in a townhome or row house. For Cohort 2, the participants (professionals) had to have experience evaluating individuals with mobility-related disabilities or have design or installation experience—or both—with accessibility devices.

Construction of Demonstration Platform and Doorway Mock-Up

Home Innovation hired a contractor who specialized in installing accessibility devices—lifts, ramps, grab bars, etc.—to build the demonstration structure and doorway mock-up used during the in-person evaluations. The contractor was able to easily install the accessibility devices using the manufacturer's instructions. None of the accessibility products evaluated are considered do-it-yourself devices. The manufacturers recommended using a remodeler or contractor to ensure that the devices are installed correctly. The *StairSteady, AssiStep, and FlexStep* devices were installed on the demonstration platform shown in exhibit 9. A separate doorway mock-up structure was built to install the *All-Push Door* shown in exhibit 10.

Exhibit 9. StairSteady, AssiStep, and FlexStep

Source: Home Innovation

Exhibit 10. All-Push Door

Source: Home Innovation

The StairSteady and AssiStep—shown on the right of exhibit 9—are assistive devices that aid the user in climbing stairs. When installing these devices, the contractor must know the height and stature of the person who will use them because the structural supports must be mounted at a

height that "fits" the biometric measurements of the user. Because 51 participants were of unknown height and stature, Home Innovation was unable to customize the installation of the StairSteady and AssiStep for each person in the study. As a result, the contractor installed both devices on the basis of the standard height of the railing used on the platform. That height corresponds to a person with an approximate height of 5 feet 5 inches. The StairSteady handle cannot be vertically adjusted once mounted and installed. The AssiStep handle can be vertically adjusted (within a 6-in. range) after being mounted, but doing so requires removing attachment screws and re-installing the handle. All 51 participants evaluated the StairSteady and AssiStep without adjusting them for biometric differences. Appendix E contains the *Installation Instructions for Accessibility Devices*.[9]

Findings and Observations

In general, each participant evaluated the accessibility devices one at a time using the IRB-approved survey. Home Innovation staff typically started with the StairSteady and then proceeded to the AssiStep and FlexStep devices, all located on the demonstration platform (exhibit 9). After completing surveys for StairSteady, AssiStep, and FlexStep, administered by Home Innovation staff, the participants completed the All-Push Door evaluation (exhibit 10).

Overall, each participant required approximately 2 hours to evaluate all accessibility devices and provide additional comments. Each accessibility device required approximately 20–30 minutes to complete the evaluation. After completing the evaluations, each participant was asked open-ended questions to understand why specific responses were provided; this final step took an additional 20 minutes. Upon completing the open-ended discussion questions, all participants were paid a $150 honorarium for offering their insight and time for the study.

Data Analysis

Home Innovation compiled and analyzed the data from the 51 participant surveys. First, the authors considered how the data were useful to residents of townhomes and row houses that required retrofits and adaption for mobility. Second, the authors considered that manufacturers of accessibility devices could benefit from the data if they used them to improve existing devices or develop new devices.

In most cases, Home Innovation observed that the survey responses were similar for Cohort 1 and Cohort 2. As a result, the responses from both cohorts were combined and the data analyzed as one group—statistically, a case was made for doing this given the small number of participants in each cohort. An observational market research report was prepared, including general findings and perceptions from the participants concerning safety, ease of use, aesthetics, installation, and maintenance. Appendix F contains the *Evaluation of Assistive Devices by Users, Caregivers, and Professionals* report.

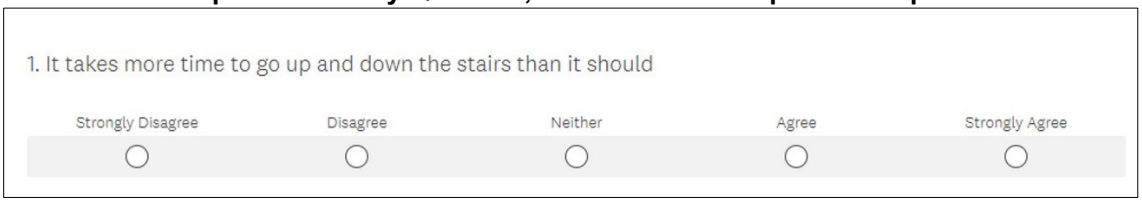
In a few cases, Home Innovation observed differences between the cohorts—the users and caregivers did not agree with the professionals—and the authors observed differences within the cohorts. To better understand those differences in perception and opinion, the authors revisited the recorded interviews to gain context for why certain questions were answered in a particular way. To explore those differences further, the authors reanalyzed the data and illustrated the

[9] Instructional videos are also available at www.homeinnovation.com.

distribution of the answers instead of focusing on an average or median response among a cohort. This closer look at the data proved valuable when coupled with comments from the recorded interviews and provided insight into how the cohorts were similar but, equally important, why they were divided at times.

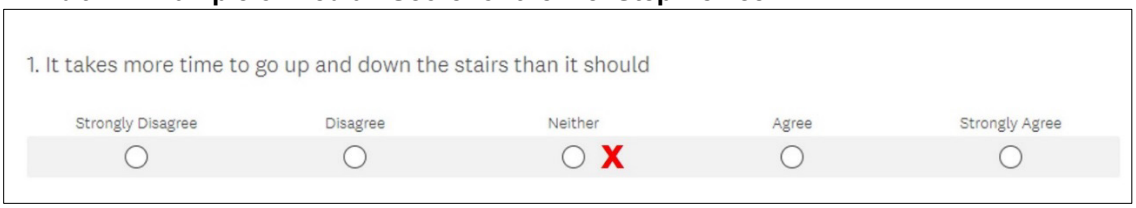
The survey questions are designed using declarative statements on a Likert scale to which the participant must respond by selecting one of five specific answers, as exhibit 11 illustrates.[10]

Exhibit 11. Example of a Survey Question, Which Solicits a Specific Response



Home Innovation assigned numerical values to each of the discrete responses—Strongly Disagree was "1," Disagree was "2," Neither was "3," Agree was "4," and Strongly Agree was "5." The numerical values were then calculated to determine a single median score, which was used to represent the collective response of a cohort to a specific question. Exhibit 12 illustrates an example of this with a red "X" at the point on the scale for the median score of 3.1, which is Cohort 1's collective response to the declarative statement, "It takes more time to go up and down the stairs than it should," for the FlexStep device.

Exhibit 12. Example of Median Score for the FlexStep Device



A single score simplifies the analysis when considering multiple participant responses, but a single score can also hide valuable information. When considering the mean score of 3.1 in exhibit 12, the reader may ask, "Did the participant reply 'neither' for virtually all responses, or did the score of 3.1 represent a divided cohort (with approximately one-half agreeing with the statement and one-half disagreeing with the statement)?"

In this report, the authors have included the distribution in responses using three categories on a single graph:

Disagree includes a count of both "Strongly Disagree" and "Disagree" responses. It means that the participant disagreed with the statement (some more than others).

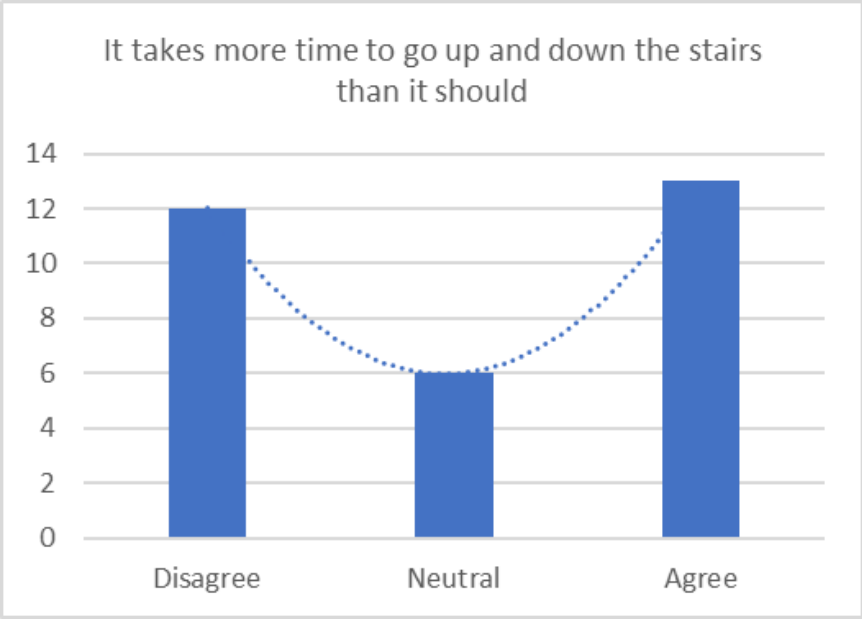
Neutral includes a count of only "Neither" responses. It means that the participant could neither disagree nor agree with the statement. The participant could have responded this way for a variety of reasons, including (1) not having an opinion, (2) believing that the answer could vary depending on the circumstance, or (3) believing that the statement was not applicable.

[10] The Likert scale assumes that the strength or intensity of an opinion or attitude can be measured on a continuum from "Strongly Agree" to "Strongly Disagree" (or other variations, such as frequency, quality, and likelihood). It was used in the *Evaluation of Assistive Devices by Users, Caregivers, and Professionals* report (appendix F).

Agree includes a count of both "Strongly Agree" and "Agree" responses. It means that the participant agreed with the statement (some more than others).

Exhibit 13 illustrates the responses using the three categories previously defined. Although the median score was 3.1, as illustrated in exhibit 12, a closer look at the distribution of responses shows a divided Cohort 1—some believing that it took more time than it should to go up and down the stairs, whereas others thought the time was reasonable. Many of the neutral respondents were of two minds—they understood that the FlexStep should move slowly for safety reasons but could see why people would be frustrated by the device taking so long to ascend or descend (four steps).

Exhibit 13. Cohort 1 (Users and Caregivers) Divided Response: Speed of the FlexStep



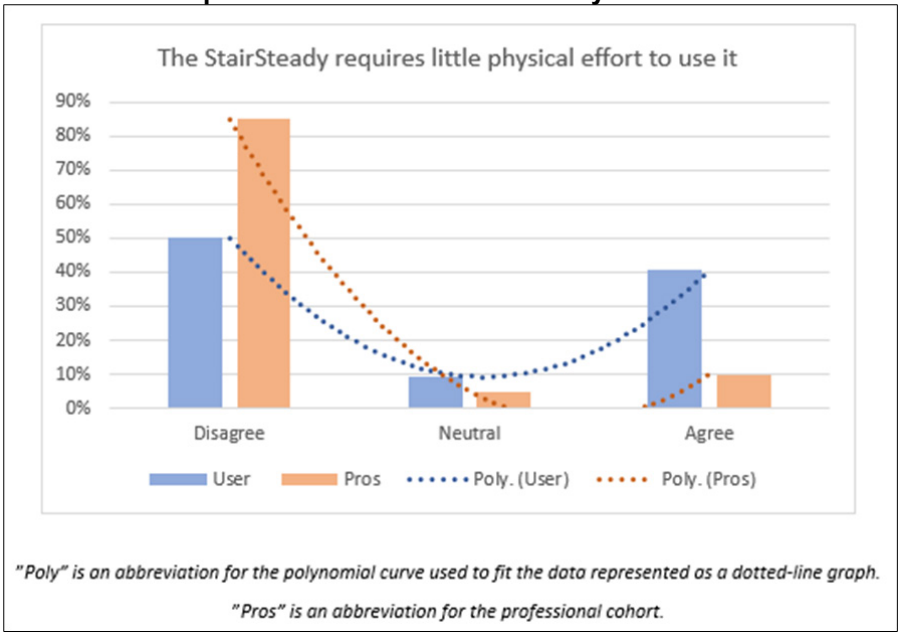
Home Innovation provided cohort graphs, such as exhibit 13, for all questions for each accessibility device. The cohort graphs are presented together on a single graph such that the reader can compare the responses of Cohort 1 with those of Cohort 2. During the discussion that follows, the authors highlight certain questions that yielded a significant response difference and provide some context based on the comments provided by the participants. In cases in which the cohorts were in agreement, the authors summarize the findings and observations to indicate that result. Appendix G contains the *Cohort Response Distribution Graphs for Each Device* report.

StairSteady Evaluation

Professionals, users, and caregivers considered the StairSteady easy to install, clean, and match with any home decor—provided the device was painted. All participants thought the StairSteady required little maintenance because it did not have any mechanisms or motors—it is a manual device with a simple handle and rail. Both cohorts found the StairSteady instructions easy to understand, but most thought the device handle required some practice. During the evaluation, the handle did not glide smoothly and required maneuvering to move from one position to the next. As a result, most professionals, users, and caregivers "had problems using the device" and believed that others would have the same problems they encountered.

The professionals and the users and caregivers disagreed about the physical effort needed to use the StairSteady. Nearly all professionals thought that the upper body strength needed to maneuver the handle of the StairSteady would make the device difficult to use for most frail elderly users or any client recovering from a stroke (exhibit 14, orange bars). When answering this question, the physical and occupational therapists considered a wider range of potential users, not only those individuals with mobility-related disabilities or limitations. The users and caregivers were divided about the physical effort necessary to use the StairSteady (exhibit 14, blue bars). Some believed they could improve the ease of use with some practice; others thought the device was not positioned correctly for their body size and stature. The distribution of responses to the question of physical effort is illustrated in exhibit 14.

Exhibit 14. Comparison of Cohorts 1 and 2: Physical Effort



"Poly" is an abbreviation for the polynomial curve used to fit the data represented as a dotted-line graph.

"Pros" is an abbreviation for the professional cohort.

The participants for the in-person evaluation varied in size and stature. The StairSteady was installed according to the manufacturer's instructions, but the device could not be adjusted for each participant and is not designed to be adjusted after it is installed. The in-person evaluations proved that the StairSteady has no "one-size-fits-all" installation. The device must be installed on the basis of the user's physical measurements.

The users and caregivers who required little effort to use the device were simply fortunate enough to fit the installation of the StairSteady. If one was taller, the handle did not line up at 90° with the person's elbow, and the user was pushing the handle at an angle that kept it from moving smoothly. For a taller individual, the StairSteady installation was more difficult coming down the stairs than going up because a taller person's center of gravity (COG) was typically over the handle, which made pushing the handle less safe.

Exhibit 15. Height of Handle

Source: Home Innovation

Exhibit 16. Adjust to Be at 90°

Source: Home Innovation

Exhibit 17. Handle Too Low

Source: Home Innovation

Exhibit 15 illustrates that the handle is too low for this Home Innovation staff person (he is 6 ft. 2 in. tall). Exhibit 16 illustrates that the device should be raised so that the arm is at 90°. Exhibit 17 illustrates the difficulty and risk of going downstairs when the device is mounted too low for the individual. Although most of the participants were not 6 ft. 2 in. tall, the device was determined to be too low for many participants who tried to use it—an unavoidable outcome given the random nature of the recruiting of participants—and may partially explain some of the poor ratings received by the StairSteady.

Although the StairSteady is straightforward to install, it must be installed at the correct height for the user. One physical therapist regarded the StairSteady as a quasi-medical device that should be installed by a trained professional to ensure that the user knows how to use the device correctly. One professional thought that the device's simplicity leads do-it-yourself installers to believe that they can install the device—only to mount it incorrectly.

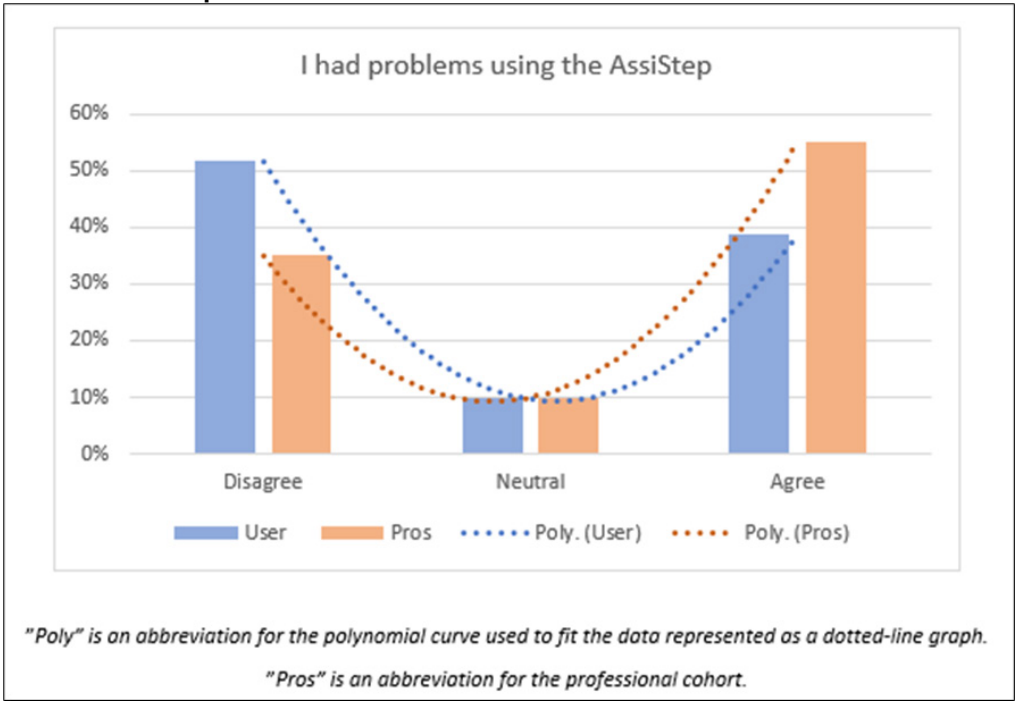
Both cohorts were divided on whether an immediate need existed for the StairSteady or if a future need would arise. The professionals were less likely than the users and caregivers to believe that the device was needed. In some cases, users thought they did not need the StairSteady now because they could still navigate the stairs using a cane. Nonetheless, some professionals thought the device needed improvements before they would recommend it.

AssiStep Evaluation

The responses from the participants about the AssiStep are like the ones provided for the StairSteady device. Professionals, users, and caregivers considered the AssiStep easy to install and clean but not easy to match with any home decor, given the design of the device. Most participants believed that the AssiStep required little maintenance, even though the rail has a sophisticated metal track with special gears inside. In general, the users and caregivers liked the

appearance of the AssiStep more than did the professionals.[11] Both cohorts found the AssiStep instructions easy to understand, but most thought the device required some practice to use correctly. During the evaluation, most participants found going up the stairs very easy because of the special track on which the handle glides. However, an equal number of participants struggled with disengaging the handle from the track when going down the stairs. As a result, most professionals, users, and caregivers were divided about whether they "had problems using the device." Exhibit 18 illustrates the difference in opinion within both cohorts and that professionals more often cited problems than did the users and caregivers.

Exhibit 18. Comparison of Cohorts 1 and 2: Had Problems with Device



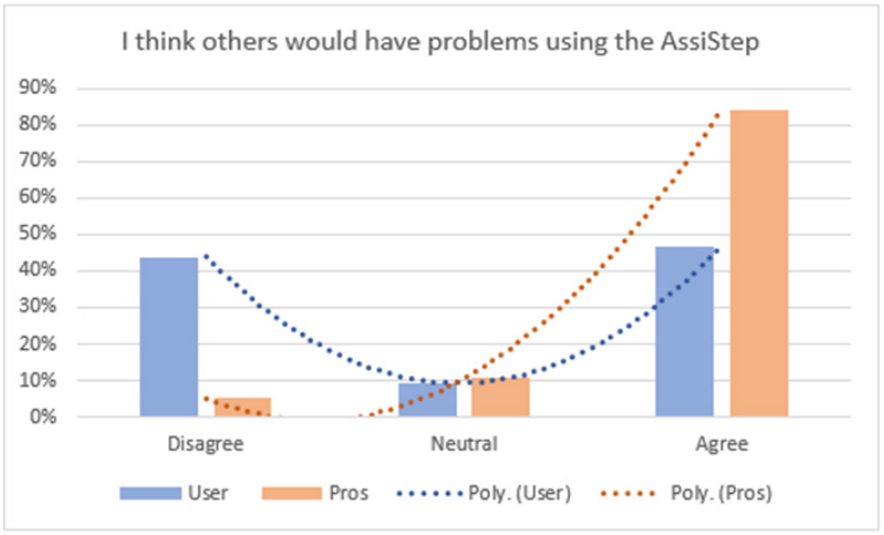
"Poly" is an abbreviation for the polynomial curve used to fit the data represented as a dotted-line graph.

"Pros" is an abbreviation for the professional cohort.

When the professionals evaluated the AssiStep, they were not evaluating the device for personal use but were considering whether their clients or patients could use it. Nearly all professionals thought that others would have problems with the AssiStep even when they did not have difficulty using the device. However, the users or caregivers typically supposed, "If I can do it, anyone can," or "If I had a problem, someone else will have a problem too."
Exhibit 19 illustrates how the users and caregivers and the professionals thought about other potential users differently.

[11] Because the AssiStep and StairSteady devices were side by side on the demonstration platform, the participants often compared the appearance and other functions of the two devices, likely because both the AssiStep and StairSteady devices were stair-climbing assistive devices.

Exhibit 19. Comparison of Cohorts 1 and 2: Others Would Have Problems with Device



"Poly" is an abbreviation for the polynomial curve used to fit the data represented as a dotted-line graph.

"Pros" is an abbreviation for the professional cohort.

The AssiStep was installed according to the manufacturer's instructions. The device's handle can be adjusted vertically after it has been installed on the metal track. No handle adjustments were made for participants, and the handle position was not considered an issue. Instead, most participants were concerned with (1) how to disengage the handle when going downstairs and (2) how to fold the device away when it is not being used.

Exhibit 20. Correct Position of Handle

Source: Home Innovation

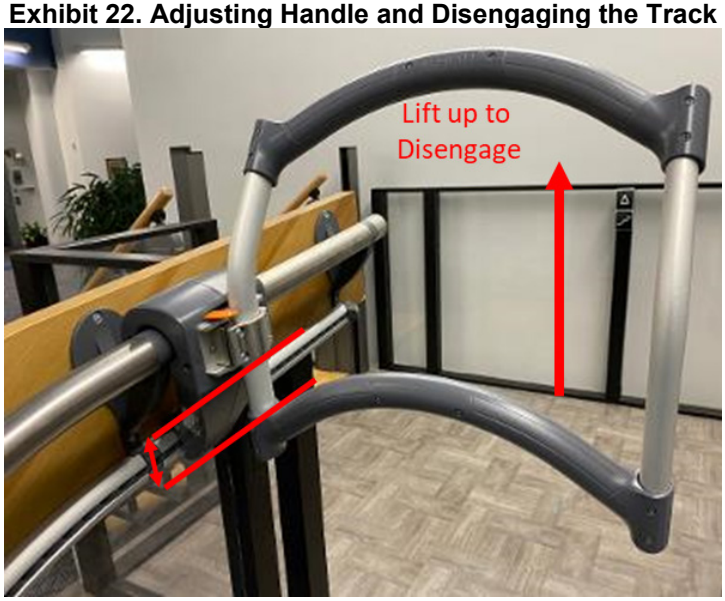
Exhibit 21. Upper and Lower Bars

Source: Home Innovation

A closer look at the AssiStep illustrates the adjustability of the handle in relation to the user. The participants could hold one of two locations (the upper bar or the lower bar) of the handle while allowing the standing user's elbow to be at 90°. Exhibit 20 illustrates the correct standing position for the AssiStep, and exhibit 21 illustrates the handle's two bar locations.

The AssiStep's handle can be adjusted up and down, as shown in exhibit 22. When one is walking down the stairs, the device's handle must be lifted to disengage the metal track, as shown in exhibit 23. The center of gravity for the Home Innovation staff person is not leaning over the handle. Nonetheless, some participants thought that lifting the handle could be difficult for some elderly users.

Exhibit 22. Adjusting Handle and Disengaging the Track



Source: Home Innovation

Exhibit 23. Descending the Stairs

Source: Home Innovation

Although the AssiStep was considered easy to install, it must be adjusted to the user's height. Most professionals expressed concerns about having to lift the handle on the device while descending the stairs; they believed that it could be difficult for an older person. The users and caregivers were less concerned, believing that, with practice, a person could safely disengage the handle from the track.

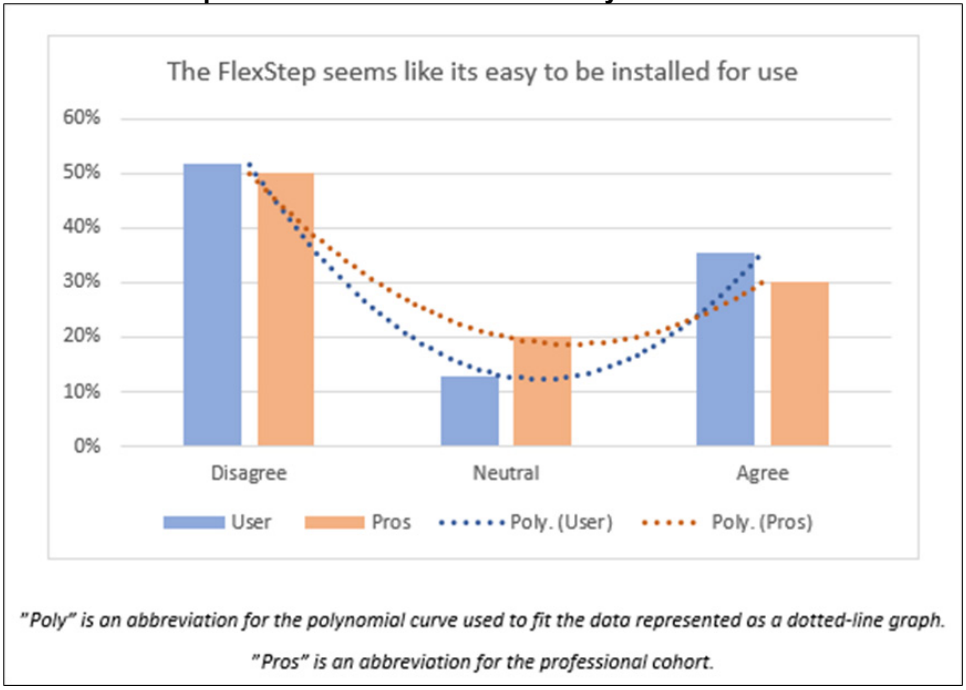
Both cohorts were divided on whether an immediate need existed for the AssiStep or if a future need was likely. The professionals were less likely to believe that the device was needed than were the users and caregivers. In some cases, users thought they did not need the AssiStep now because they could still navigate the stairs using a cane. Some professionals said that the device needed a mechanism to lock in an emergency—in case the handle was disengaged from the track—as an additional safety feature before they would recommend it.

FlexStep Evaluation

Professionals, users, and caregivers considered the FlexStep easy to clean and maintain, nice looking, and easy to match with any home decor. Both cohorts found the FlexStep instructions easy to understand but also thought the control buttons on the device required some practice to use correctly. During the evaluation, most participants had to try the control buttons several times to understand how to operate the FlexStep. As a result, most professionals, users, and caregivers "needed Resistance to use the FlexStep." They believed that others would need formal training to remember what control buttons to push and what to do in a power outage. The FlexStep comes with a backup battery, but many participants were worried that power would go out and they would be trapped on an upper floor in the house if they depended solely on the FlexStep.

Both cohorts agreed that installing the FlexStep would not be easy. They assumed that the user would need to hire a professional to complete the installation and provide training to use the device correctly. Exhibit 24 illustrates how similar the responses were for the users and caregivers and the professionals.

Exhibit 24. Comparison of Cohorts 1 and 2: Easy to Be Installed



"Poly" is an abbreviation for the polynomial curve used to fit the data represented as a dotted-line graph.

"Pros" is an abbreviation for the professional cohort.

Both cohorts were concerned about maintenance and repair options for the FlexStep. Users and caregivers thought that finding general maintenance service for the device would be difficult. In addition, some respondents expressed concern about the cost of maintenance and repair. Many thought that if the purchase cost of the FlexStep was expensive, then maintenance and repair would likely be equally expensive. The manufacturer stated that authorized FlexStep dealers throughout the United States offer maintenance plans. Furthermore, the manufacturer stated that the FlexStep would not need annual maintenance; the company recommends maintenance every 5 years.

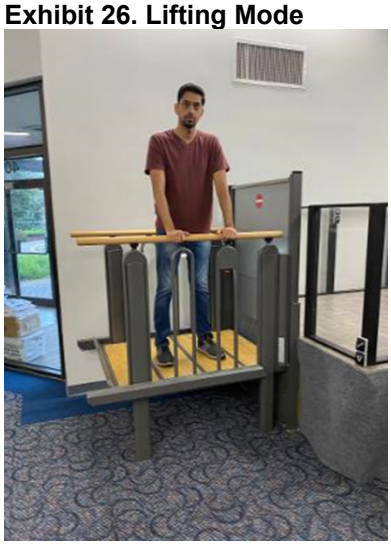
The users and caregivers complained about the noisy operation and warnings from the FlexStep. When in operation, the device made multiple "beeping" noises and flashed lights. The manufacturer stated that many warning cues can be disabled, or the device's volume can be turned down. The automatic sensors and safety features on the FlexStep were well received—the device is designed to prevent pets and objects from getting trapped under the stairs as it converts from stairs to a lift. Some additional features were recommended for individuals who are hearing impaired.

The FlexStep can accommodate individuals with a wide range of mobility-related disabilities, including users who have moderate mobility limitations and those who use wheelchairs. Participants liked that multiple people of different sizes and statures could use the FlexStep without special configurations. Exhibit 25 illustrates the FlexStep in the default step mode, exhibit 26 illustrates the transition mode, and exhibit 27 illustrates the final lift position at the top of the landing.

Exhibit 25. Stair Mode

Source: Home Innovation

Exhibit 26. Lifting Mode



Source: Home Innovation

Exhibit 27. Final Position

Source: Home Innovation

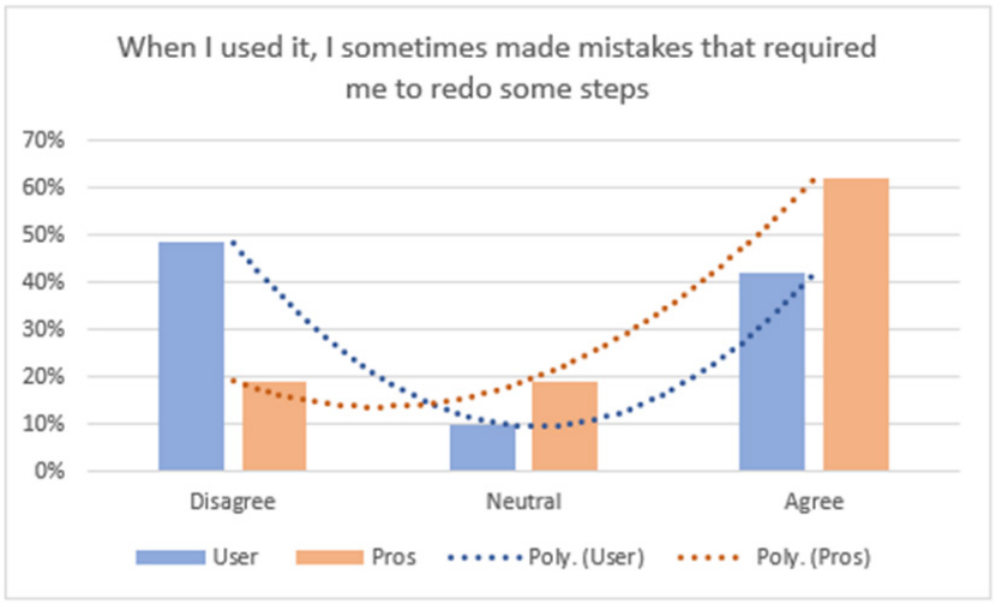
Most users and caregivers who did not want the FlexStep thought it would not fit in their house due to the layout of their exterior or interior stairs—multiple levels in their townhome or row house, older narrow stairways—and they were concerned about the cost of major renovation to use the device. Many participants thought that the FlexStep would be almost impossible to integrate into interior floor spaces, but most thought that the FlexStep could work at entryways such as backyard doors or inside garages, where short flights of steps were common.

All-Push Door Evaluation

Professionals, users, and caregivers considered the All-Push Door easy to install and clean and would match any home decor. Most participants believed that the All-Push Door required little maintenance. Both cohorts found the instructions easy to understand but also thought the locking mechanism on the door should be easier to operate. Some participants thought that knowing whether the door was locked was difficult because of the two sets of locks. During the evaluation, most participants had to try out the locking sequence several times to understand how to operate the All-Push Door. As a result, most professionals "needed assistance to use the All-Push Door." In addition, many professionals, users, and caregivers "made mistakes that required them to redo some steps." The participants believed that others would need some practice to learn how to use the double set of locks; a few other participants recommended different locks for the All-Push Door.

Both cohorts disagreed about how much assistance was needed to operate the All-Push Door. The users and caregivers appeared to make fewer mistakes operating the door than did the professionals. Exhibits 28 and 29 illustrate the differences in the number of mistakes made and in the need for assistance, respectively, comparing both cohorts.

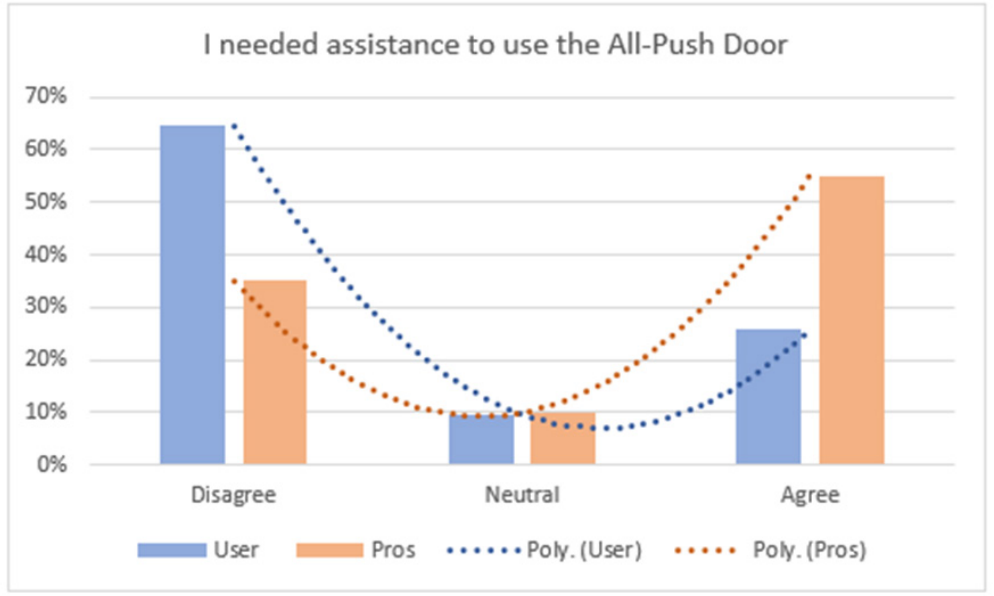
Exhibit 28. Comparison of Cohorts 1 and 2: Mistakes Made and the Need to Redo Steps



"Poly" is an abbreviation for the polynomial curve used to fit the data represented as a dotted-line graph.

"Pros" is an abbreviation for the professional cohort.

Exhibit 29. Comparison of Cohorts 1 and 2: Needed Assistance



"Poly" is an abbreviation for the polynomial curve used to fit the data represented as a dotted-line graph.

"Pros" is an abbreviation for the professional cohort.

As shown in exhibit 28, the users and caregivers were somewhat divided about how many mistakes were made that required them to redo steps during the operation of the All-Push Door.

However, most of the professionals stated they had to redo steps. The locking sequence was the step that required some clarification.

As shown in exhibit 29, most users and caregivers did not need much assistance to use the All-Push Door. They were able to figure out the function of the locking mechanism and were confident that with some practice, they could master all functional aspects of the All-Push Door. Many professionals thought that the small locking mechanisms of the device could present a problem to those individuals with arthritis or other hand grasping issues. When the professionals considered the operation of the All-Push Door and whether their clients or patients could operate the device with ease, many thought that some elderly clients or patients could accidentally leave one of the multiple locks open. Exhibits 30 and 31 illustrate the operation of the All-Push Door.

Exhibit 30. Outer Door Frame Operation

Source: Home Innovation

Exhibit 31. Inner Door Frame Operation

Source: Home Innovation

The All-Push Door has a double-hinged mechanism that allows the door to be pushed from either direction to go through the doorway. In exhibit 30, the door is being pushed from the inside. In exhibit 31, the door is being pushed from the outside. The user of this door type does not have to pull the door open. The All-Push Door operates just like swinging doors in a restaurant.

The participants believed that the All-Push Door addresses the problem of having to back up when approaching a door that opens toward the person using an assistive device. Whether the individual is in a wheelchair, using a walker or cane, or simply having a mobility issue, being able to push the door open from either side of the doorway is of great benefit.

Although operating the door was not completely intuitive due to the double set of locks on the inner and outer frames of the door (the locks are best seen in exhibit 30, near the door handle),

the participants thought that it was a minor issue that could be overcome with some instruction and practice. The door was considered attractive, and it appears to be a standard door size.

The manufacturer claims that the door can be made available in many styles to fit almost any interior or exterior decor; other features such as peepholes, glass panes, and keypad entries instead of a lock and key can be easily added to the All-Push Door. The door is not widely available in the United States, but the manufacturer plans to distribute the product in the United States in the near future.

COST-BENEFIT ANALYSIS

When considering the costs and benefits of the accessibility devices in the study, Home Innovation focused on answering two key questions:

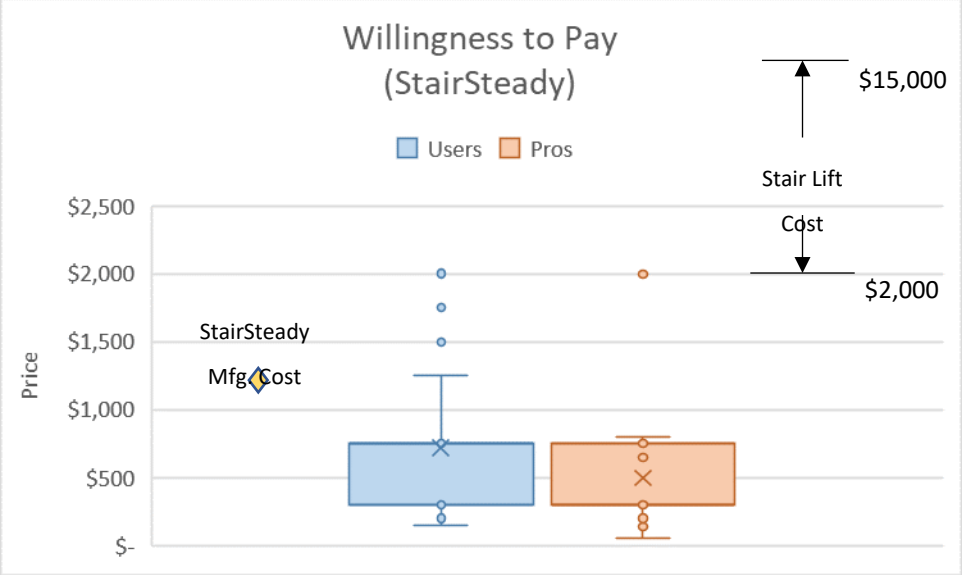
How does the cost of the accessibility device compare with the typical retrofit solution?
Does the device improve mobility within the home?

Home Innovation identified the cost range for typical retrofit solutions, whereas the product manufacturers in the study provided cost ranges for their accessibility devices. In addition, the survey asked participants to identify the price they were "willing to pay" for each accessibility device they evaluated. As a result, the cost analysis included a comparison of (1) the typical retrofit solution, (2) the innovative accessibility device, and (3) the price participants were willing to pay. Only some participants in the study answered the willingness-to-pay question.

StairSteady Cost-Benefit Analysis

Exhibit 32 illustrates the cost comparison for the StairSteady. The authors identified the amount of money that Cohorts 1 and 2 were willing to pay. They included the cost range for the typical retrofit solution: a stair lift device. The authors also provided the manufacturer's price for the StairSteady.

Exhibit 32. Cost Comparison—Willingness to Pay: StairSteady and Stair Lift



Mfg. = manufacturing. Pros = professionals.

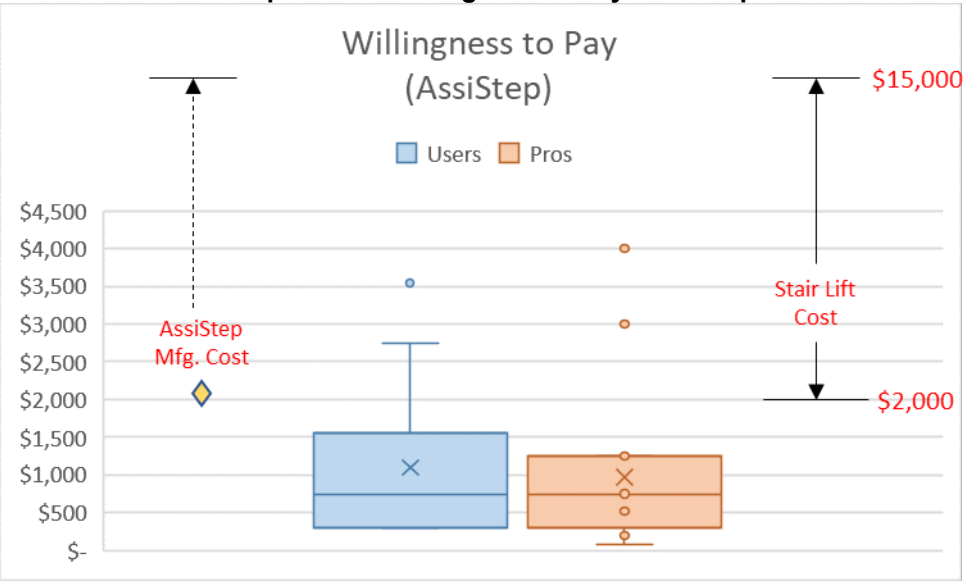
The StairSteady was approximately $1,150, not including $500 for shipping the device from Canada. The StairSteady price was based on the straight length of the stairs, hardware, and the number of turns the rail must accommodate. When comparing the median price that the users and pros were "willing to pay" ($300 to $750) for 6 to 8 ft. of straight-run StairSteady product with what the manufacturer's price was—without the cost of labor to install—the costs were similar. If one considers the price for a stair lift traveling straight for 8 to 10 ft., the best price is approximately $2,000. The price range can easily go up to $15,000 if complexity is added to the stairs (Robinson-Walker and Millard, 2022).

The StairSteady costs less than a typical stair lift, and it can improve mobility in the home, but it has limitations. The StairSteady must be customized and installed for just one user. A stairlift can accommodate more than one user—provided the additional users do not exceed the chair's weight limit. The StairSteady is a manual device; therefore, the user must have some upper body strength to use the handle. If users have a degenerative condition in which their mobility-related disability progresses, they may not be strong enough to use the StairSteady device in the future. A stairlift can remain useful even as a user's mobility-related limitations worsen.

AssiStep Cost-Benefit Analysis

Exhibit 33 illustrates the cost comparison for the AssiStep. The authors identified the amount of money that Cohorts 1 and 2 were willing to pay, including the cost range for the typical retrofit solution—a stair lift device. The authors also provided the manufacturer's price for the AssiStep.

Exhibit 33. Cost Comparison—Willingness to Pay: AssiStep and Stair Lift



Mfg. = manufacturing. Pros = professionals.

The AssiStep was approximately $2,060, not including $680 for shipping the device from Norway. The AssiStep price was based on the straight length of the stairs, hardware, and the number of turns the rail must accommodate. When comparing the median price that the users and pros were "willing to pay" ($750) for 6 to 8 ft. of straight-run AssiStep product with what the manufacturer's price was—without the cost of labor to install—the manufacturer's price was twice as much as the willing-to-pay price. If one considers the price for a stair lift traveling straight for 8 to 10 ft., the best price is approximately $2,000. The price range can easily go up to $15,000 if complexity is added to the stairs (Robinson-Walker and Millard, 2022).

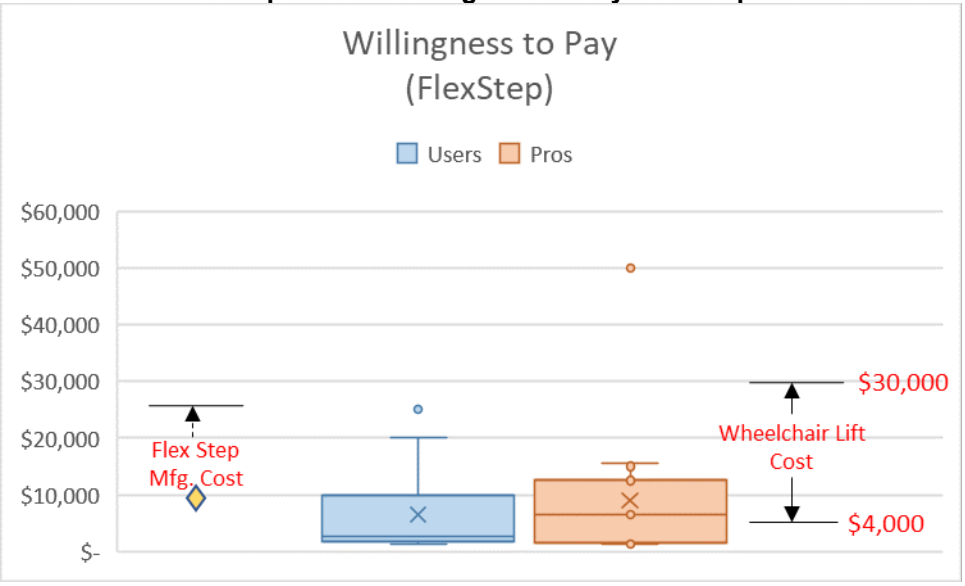
The AssiStep manufacturer stated that the cost range is virtually the same as a typical stair lift. The AssiStep does have more functionality than the StairSteady device and can improve mobility within the home, but there are limitations. It must be customized and installed for one user (but can be adjusted to accommodate another user of similar stature). A stair lift can accommodate more than one user (provided the additional users do not exceed the chair's weight limit). The AssiStep is a manual device, but the gear design of the track does not require much upper body strength to push the handle. However, if users have a degenerative condition in which their

mobility-related disability progresses, they may not be strong enough to use the AssiStep device in the future. A stair lift can remain useful even as a user's mobility-related limitations worsen.

FlexStep Cost-Benefit Analysis

The cost comparison for the FlexStep is illustrated in exhibit 34. The authors identified the amount of money that Cohorts 1 and 2 were willing to pay and included the cost range for the typical retrofit solution—a wheelchair lift device. The authors also provided the manufacturer's price for the FlexStep.

Exhibit 34. Cost Comparison—Willingness to Pay: FlexStep and Wheelchair Lift



Mfg. = manufacturing. Pros = professionals.

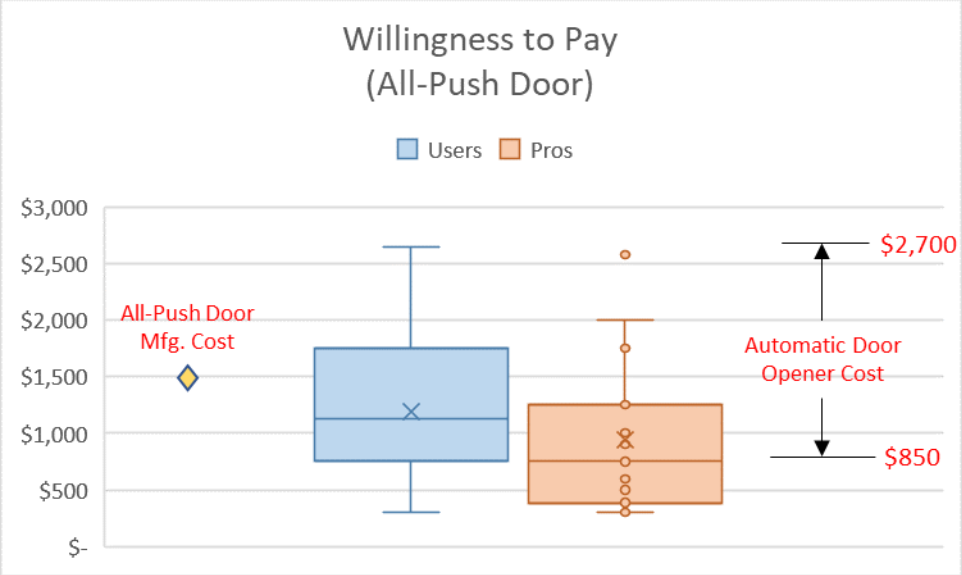
The FlexStep was approximately $10,400, not including $640 for shipping the device from Norway. The FlexStep price was based on raising the user's height by four steps (or approximately 3 ft.). When comparing the median price that the users and pros were "willing to pay" ($2,750 to $6,500) with what the manufacturer's price was (without the cost of labor to install), the manufacturer's price was twice as much as the willing-to-pay price. If one considers the price for a wheelchair lift raising the user approximately 3 ft., the best price is approximately $4,000 to $6,000. The price range can easily go up to $30,000 if additional stairs or a second story is included (HomeElevators.com, n.d.).

The FlexStep is more expensive than the typical wheelchair lift, but the FlexStep can serve as both a lift and traditional stairs, accommodating more user types in one building. It has more utility than a traditional wheelchair lift because it requires less space. The FlexStep is also more aesthetically appealing and less "institutional-looking" than a traditional wheelchair lift. Both products can remain useful as a user's mobility-related limitations worsen.

All-Push Door Cost-Benefit Analysis

Exhibit 35 illustrates the cost comparison for the All-Push Door. The authors identified the amount of money that Cohorts 1 and 2 were willing to pay, including the cost range for the typical retrofit solution—a residential automatic door opener. The authors also provided the manufacturer's price for the All-Push Door.

Exhibit 35. Cost Comparison—Willingness to Pay: All-Push Door and Door Opener



Mfg. = manufacturing. Pros = professionals.

The All-Push Door was approximately $1,500—not including $2,265 for shipping the door from Taiwan. The All-Push Door price was based on a heavy-duty, 36-in.-wide door. When comparing the median price that the users and pros were "willing to pay" ($750–$1,150) for the door with the manufacturer's price—without the cost of labor to install—the manufacturer's price was 50 percent more than the willing-to-pay price. If one considers the price for an automatic door opener, the best price is approximately $850. The price can increase to $2,700 if more controllers are added (Gentleman Door Automation LLC, n.d.).

The manufacturer stated its intention to mass produce the All-Push Door in the United States to further reduce costs. The All-Push Door can improve mobility in the home by making entering and exiting the house easier. As a retrofit product, the All-Push Door may reduce the width of the door opening because the double-hinge frame requires more space than a standard door frame. The automatic door opener may be more cost effective and easier to retrofit if major modifications are made to the existing door framing.

CHALLENGES AND BARRIERS

The challenge for homeowners attempting to improve the accessibility and function of their townhome or row house starts with one question: "Where do I begin?" Based on the literature review, any home improvement for accessibility should bolster or improve the occupant's ability to perform activities of daily living (ADLs). The needs of the occupants must be known to ensure the best remodeling outcome. In planning for a home modification, an individual with a disability or physical limitation should have an ADL assessment (Gaunt, 2022), which is typically done by a physician or occupational therapist. For ADL assessment, the occupational therapist visits the home and completes an *OT Home Health Evaluation Checklist and Quality Measures* assessment form (AOTA, n.d.). The occupational therapist evaluates the person's physical capabilities in his or her home environment and identifies barriers to be addressed.

A barrier can be a physical condition of the home that prevents an individual with a disability from using the house safely. Retrofits or adaptations may be necessary to remove the barriers. The occupational therapist can prescribe assistive devices and minor home modifications, but any major retrofits or renovations are typically done by a remodeler specializing in accessibility. For example, mobility is one of the ADLs that are evaluated. If someone has a mobility-related disability and needs assistance walking or transferring from one place to another, the occupational therapist may prescribe an assistive device such as a cane or walker. The occupational therapist may note that the person would benefit from a ramp and a no-threshold doorway home modification, but those products are not medical devices that the doctor or occupational therapist can prescribe.

If a home retrofit or renovation is needed, the homeowner will need to hire a remodeler with expertise in accessible design. The homeowner would benefit from understanding some basic information about improving accessibility. AARP publishes an easy-to-use home assessment document titled, *AARP HomeFit Guide,* which highlights features every house should have and recommends improvements to make the house easier for older adults to use (AARP, 2021). The homeowner should consider consulting with a remodeler that specializes in accessibility, such as a universal design (UD) professional (NARI, n.d.) or a Certified Aging-in-Place Specialist (CAPS; NAHB, n.d.).

In some cases, the homeowner may benefit from engaging multiple experts on a team, including a physician, an occupational therapist, and a remodeler specializing in accessibility. A plan can be developed so that the improvements are prioritized and done in phases if financing the home improvements is cost prohibitive.

Affordability

Remodeling to improve accessibility is expensive, especially in existing townhomes and row houses. During the focus group discussions, most residents and caregivers cited cost as the most important consideration. A general perception existed that retrofits and modifications would be too expensive to afford, and some believed that implementing accessibility improvements would be difficult without financial assistance.

Participants noted a lack of resources and did not know where to find reliable information about accessibility for residential houses or government grants, rebates, and other incentives that could reduce the cost of remodeling. In general, greater awareness and understanding of available options are needed.

Several federal grants and loans are available for home improvements. The U.S. Department of Veterans Affairs (VA) offers four grant programs that include Specially Adapted Housing (SAH) Grants, Special Housing Adaptation (SHA) Grants, Temporary Residential Adaptation (TRA) Grants, and Home Improvements and Structural Alterations (HISA) Grants (VA, 2022). The requirements for each grant vary, and applicants must be veterans. The U.S. Department of Agriculture offers the Rural Housing Repair Loans and Grants program for seniors who live in rural areas of the United States (USDA, n.d.). The U.S. Department of the Interior, Bureau of Indian Affairs, offers the Housing Improvement Program (HIP) for members of Native American tribes (DOI/BIA, n.d.).

Several state grants and loans for home improvements are obtainable:

- The State of Maine offers the Home Accessibility and Repair Program for low-income people living with disabilities.
- The State of Illinois offers a Home Accessibility Program for people with disabilities.
- The State of Maryland offers an Accessible Homes for Seniors Program for people older than age 55. Many other state grant programs are accessible throughout the country.

Several private disability grants for home improvements are also available:

- The Travis Roy Foundation Grant is available to homeowners with spinal cord injuries.
- The Modest Needs Foundation offers Self-Sufficiency Grants to homeowners with lower incomes.
- Rebuilding Together offers volunteer no-cost home repairs and upgrades. For homeowners who do not qualify for any of those grants, other low-cost loan programs are available through the Federal Housing Administration (FHA) 203 (k) rehabilitation loan and the Federal National Mortgage Association (Fannie Mae) Home Style Renovation Mortgage.

In some cases, the cost of major renovations, retrofits, and remodeling projects may still be prohibitive because the grants are not large enough to cover the total cost of the project. One solution explored by this project was to identify more accessibility product options that are affordable and functional.

Accessibility Products and Availability

The four accessibility products evaluated by Home Innovation successfully improved the user's mobility. The StairSteady assistive device costs less than a conventional stair lift product, and the AssiStep was similar in cost to a conventional stair lift product. The FlexStep was more expensive than a similarly sized wheelchair lift device but could also convert into a flight of stairs and had superior aesthetics—preferred by users of accessibility devices. The All-Push Door was comparable in cost to an automatic door opener but could easily exceed that range if installation requires a major door frame modification.

The assistive devices in this study were manufactured outside the United States. European countries and Canada have developed assistive devices that install on stairs and doors at a much greater frequency than the United States. Those devices were considered against other devices and selected by the research team in consultation with the technical advisory group. Because the assistive devices were manufactured outside the United States, their availability was limited, and there were added costs associated with shipping. Most products in this study must be purchased

directly through the manufacturer's website, and then the buyer must wait several weeks for the product to arrive. Purchasers of the StairSteady, AssiStep, and All-Push Door must hire a remodeler to install those products. The manufacturer of the FlexStep has distributors in the United States, so the product can be readily found, and the distributor will complete the installation, provide maintenance, and offers warranty services. The manufacturer of the All-Push Door is interested in manufacturing the product in the United States; that interest may lead to lower costs and wider availability in the long term. If the other product manufacturers do the same, these accessibility products could be widely used; but for now, all have limited availability.

In other countries, particularly the Nordic countries, national health services—financed through mandatory long-term care insurance—will pay for these assistive devices. This arrangement increases demand, establishes a built-in market, and provides a mechanism to market the products through the professionals who provide the services. In the United States, developing innovative products such as these devices is much riskier because manufacturers need significant capital to reach the market. That financial reality is an important finding of the research and suggests that HUD develop a program to help designers and manufacturers develop innovative products or facilitate the introduction of such products into the U.S. market.

One of the barriers to introducing products from other countries into the U.S. market is compliance with codes and standards. The FlexStep complies with ASTM A18.1 *Safety Standard for Platform Lifts and Stairway Chairlifts*; therefore, the product can be used in accessibility applications in which an ASTM A18.1 product is specified (American Society of Mechanical Engineers, 2021). The AssiStep complies with the requirements of a low-risk medical device in Europe, and the manufacturer is considering applying for a similar designation in the United States. Gaining that designation will be challenging because the StairSteady and AssiStep products are regarded as home remodeling or improvement products in the United States; no similar devices are listed in Medicare's Durable Medical Equipment directory (U.S. Centers for Medicare and Medicaid Services, n.d.). The U.S. Food and Drug Administration recognizes certain stair lifts as a Physical Medicine Therapeutic Device (under Part 890, Subpart F—Section 890.5150—Powered Patient Transport).[12] HUD could be influential in working with industry to develop standards for products that do not fit in the FDA's domain of medical equipment or in the domain of existing standards for building products such as ASTM A18.1. The Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) is the International Organization for Standardization (ISO)-designated organization in the United States for the development of standards in the field of assistive technology. HUD could work with RESNA to identify which additional standards are needed and coordinate with ISO standards committees so that standards approved by ISO could be simultaneously approved in the United States.

In rare cases, persons with disabilities can get certain devices paid for by Medicare or Medicaid if they can prove that a device is medically necessary for their safety or welfare in the home. Typically, the user of the device has a waiver to receive care in the home instead of moving to a nursing facility. In general, a physician must make a case for certain devices and complete a Certificate of Medical Necessity form CMS-849—this form is explicitly for seat lift mechanisms (U.S. Centers for Medicare and Medicaid Services, 2019). Getting approval for the waiver may

[12] "Physical Medicine Therapeutic Devices," 21 CFR Part 890.5150. March 4, 2013. https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=890.5150.

take a long time. HUD could coordinate with the Centers for Medicare and Medicaid Services to establish a list of approved devices that do not require the waiver process. This procedure would make devices such as the ones tested in this project easier to fund through an established and well-funded federal program. It would also eliminate the cost of such devices to HUD's home modification program so that those grants could also be applied to brick-and-mortar retrofits and adaptations rather than only the cost of devices. Such a program could be tied to the standards initiative proposed previously.

RECOMMENDATIONS

Residents in the study expressed a strong willingness to adapt their homes to meet their needs. Improving a home's functionality to accommodate the needs of individuals with disabilities or limitations was of primary importance to both the users and the caregivers. An inherent value is associated with staying in one's home; it provides a sense of independence and well-being. Although aspects of existing townhomes and row houses presented a challenge, the residents wanted to stay in their homes.

The accessibility devices evaluated in this study offer some new options, but in terms of performance, they are not "game changers." The StairSteady is the most affordable option but is a manual device that can only be used by individuals with some remaining upper body strength. If the person suffers from a degenerative disease or osteoarthritis, walking up and down stairs using a manual device may cause the person's joints to deteriorate faster. The AssiStep is also a manual device for stairs, but it is somewhat easier to use, requiring less upper body strength. The price of the AssiStep is only slightly less than a conventional stair lift device; it is marketed as a rehabilitation device, suggesting that the user may get some exercise or other physical benefits through using the device. The FlexStep is innovative because it can transform from a lift to a flight of stairs. The price is about 30 percent more than a traditional chair lift, but the innovation may be worth that premium—it eliminates the need to have a lift *and* a separate set of stairs. The All-Push Door, a manual door that can be "pushed open" in both directions, is comparable in price to an automatic door opener device.

For some townhomes and row houses, the best decision is for the homeowner to move because (1) a major retrofit or adaptation of the property, such as adding a bedroom or full bathroom on the first floor, cannot be done cost effectively; and (2) the floor plan constraints and local building code requirements may make retrofitting or adapting the property impossible. Many residents may want to move but may also believe that they have no good alternatives because of the stigma associated with assisted living, nursing homes, and certain types of senior housing options (Zimmerman et al., 2016). If the property value is depressed, the homeowner may be unable to move or retrofit the property due to a lack of equity. Another challenge is a lack of affordable, accessible housing and long waiting lists when housing does exist.

Home Innovation recommends the following activities for HUD to implement:

- In collaboration with occupational therapists, develop better assessment tools that prioritize retrofits and adaptations so they can be done incrementally, as funding becomes available. For example, a full home assessment may identify five areas that need retrofits: those areas should be prioritized so that the most important improvements are made in sequence (from most to least important). An assessment tool could help residents and service providers understand the value proposition for implementing renovations or, as an alternative, relocating to a more accessible dwelling.
- In collaboration with HHS, consider working with the Centers for Medicare & Medicaid Services to approve the purchase of home accessibility products that meet safety and usability requirements. This activity can be coupled with a new product-testing and certification program to provide guidance for product manufacturers and give consumers more confidence in the safety and usability of such products.

- Partner with RESNA, the ISO-designated standards organization in the United States for assistive technology, to coordinate with ISO standards committees so that products that meet ISO standards are also approved in the United States. This collaboration should include funding RESNA to develop new standards for products such as the StairSteady and AssiStep, the All-Push Door, and others that should not be treated like prosthetic devices.[13] This partnership could facilitate importing products that have been developed and opening new markets for U.S. manufacturers.
- Study the impact of relocation costs on decisions to move when home modifications are not a good value proposition for the household. This research could also determine whether existing HUD programs, such as the Community Development Block Grant program and the Older Adult Home Modification Program, can be used to provide relocation expense grants or whether a new program might be needed.

HUD should partner with RESNA and the Assistive Technology Industry Association (ATIA) to create an innovation competition focused on developing better devices for accessibility. The first competition can focus on the type of products that most effectively overcome barriers in existing townhomes and row houses. The participants in the competition could be university graduate students or seasoned industry subject matter experts.

HUD should evaluate the existing program with the American Institute of Architects to determine whether it effectively promotes professional education on design for aging in place. The assessment should include criteria such as the adoption of the program by a broad range of architecture schools, the knowledge about aging in place represented in the winning entries in previous years, and the inclusion of innovative ideas. The evaluation could also engage faculty at architecture schools who have not adopted the program to find out why and obtain their opinions on what could be improved to make the program more effective.

Home Innovation will disseminate consumer-friendly information gathered during this research project. The authors believe that this type of outreach is critical given that many participants stated they did not know where to go for reliable accessibility information. The authors will share their findings and tips with advocacy organizations such as AARP, NAHB, and the National Association of Area Agencies on Aging.

[13] The manufacturer of the FlexStep has already gone through the process of having their product recognized by the FDA under lift device requirements.

FUTURE RESEARCH

The four innovative products described in this study show that many opportunities exist for innovation. They also demonstrate the economic value of government support for home modification services. Such support can create a market for innovation, improve product quality, and reduce the cost of retrofits and adaptations. Spending caps and the available funding are much higher there because the governments' national healthcare programs bear the cost of home care and other assistance. Furthermore, home modification services in those countries routinely involve professional physical therapists and designers. That arrangement creates an infrastructure to assess homes adequately, make informed recommendations to households, and develop the most effective solution for each household.

Home Innovation and the IDeA Center recommend that HUD support future research to study European approaches to home modifications. That research should include the economics of product development and best practices in service delivery. The study could also identify European products that could be imported to the United States and assess potential barriers perceived by European companies. Exceptional European researchers who study home modifications could collaborate with U.S. colleagues.

All the research on preferences for housing in old age has demonstrated that older people want to age in place. However, the cost of home modifications is clearly a major barrier for homeowners. The desire to age in place may be an artifact of the lack of incentives to relocate. The lack of incentives plus the psychic and economic cost of relocation could be fueling the desire to age in place, even when, objectively, it may not make sense. The authors know of no study that explored the reasons why older people do not relocate rather than remain in place, especially when their housing is not amendable to supporting independence.

The focus group finding suggests that a valuable followup research study could examine how home builders, remodeling contractors, and their design consultants communicate the concept of design for aging in place to clients. Research questions could include—

- How many home builders, remodeling contractors, and their design consultants know enough to design for aging in place?
- Do they present the idea to clients?
- What language and approaches are most successful in getting clients to adopt aging-in-place practices?

The output could include revisions to the CAPS curriculum and online courses that builders and remodelers could access to become more informed.

According to the Census Bureau, a house is considered accessible when it has a step-free entrance or ramp, a bedroom on the first floor, and a full bathroom on the first floor. Although the Fair Housing Act requires a range of accessibility features in new construction of dwelling units, many types of housing are exempt from these requirements. HUD may consider incentivizing accessible features in new townhomes and row houses that are otherwise exempt from the design and construction requirements of the Fair Housing Act. By adding more universal design features to new housing, the need for accessible modifications in the future may be avoided.

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APPENDIX A:
HOME MODIFICATION LITERATURE REVIEW

Home Modification Literature Review

Prepared for
U.S. Department of Housing and Urban Development
Office of Policy Development and Research

HUD FR-6000-N-29

Research, Prototype Testing, and Evaluation of Accessible Design Retrofits for Semi-Detached and Nondetached Houses

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March 2018

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Preface

This literature review is part of a 3-year research project funded by the U. S. Department of Housing and Urban Development (HUD). HUD has identified a housing typology—townhomes and row houses—in need of innovative solutions for the growing population who experience physical, mental, or sensory challenges that threaten their ability to remain safely and productively in their homes. Such homes are characterized by narrow floor plans and functionality spread among several levels, often with elevated entrances. Those home configurations are particularly challenging when modifications are required to improve access, safety, and usability for elderly residents and residents with disabilities. The United States has a large housing stock of semi-detached and nondetached residential buildings that fits this description. Home Innovation Research Labs (Home Innovation) and the Center for Inclusive Design and Environmental Access (IDeA) of the School of Architecture and Planning at the State University of New York (SUNY) at Buffalo have undertaken a 3-year research project to (1) study the typical pitfalls of retrofitting for accessibility in townhomes and row houses; (2) identify best practice solutions for overcoming barriers to adoption; and (3) develop construction guidance to support designers, remodelers, and homeowners in their decisionmaking and construction processes. This literature review helps to define the starting point for the investigation, including current best practices and known challenges. In conjunction with planned stakeholder focus group discussions and the expertise of the research team, the literature review will inform the development of prototype solutions to be mocked up in the laboratory for evaluation and optimization. The primary deliverable is an inventory—a plan book—of specific and coordinated accessibility modifications to meet budget, construction, and geometry constraints unique to the target housing types.

Introduction

People can respond in four ways to environmental barriers in their homes (AARP, 2010):

- Adapt their behavior.
- Move to another home.
- Modify their existing home.
- Turn to institutional care or another supportive housing arrangement.

Adapting behavior can often lead to unsafe conditions, moving can be cost prohibitive or disruptive, especially to those persons advanced in age, and institutional care is often the most expensive and least desirable option for homeowners older than age 65. This situation makes the implementation of home modifications an effective and popular option for a wide range of homeowners (AARP, 2000).

In recent years, designers and builders have become more conscious of the varying physical and cognitive abilities of their residential end users and the impact the built environment has on the health, safety, and well-being of such consumers. Although this has led to improvements in new construction of multifamily and government-subsidized building projects, the majority of existing and new residences nationwide are not equipped to support independence for people who have functional limitations and disabilities (AARP, 2000; Kochera, 2002). Home modification, as defined by Gitlin (1998), is a process that includes evaluation, identification, and implementation of adaptations to permanent physical features of the home environment to reduce the difficulty of living independently by making tasks easier, reducing the risk of accidents, and supporting independent living and social integration (Pynoos, 1993; Gitlin, 1998; Fänge and Iwarsson, 2005). When designed and implemented properly, those modifications will not only benefit the resident for whom the adaptation was intended but should also serve to improve the overall functionality and safety for all occupants. Functionality is often measured by the resident's ability to complete activities of daily living (ADLs), which include independence when—

- Eating.
- Dressing.
- Walking or transferring from one place to another.
- Bathing.
- Using the bathroom for toileting.
- Maintaining continence.

According to a 2010 U.S. Census Bureau report, 19 percent of the population reported having a disability, with more than half of those reporting their disability as severe (Brault, 2012). This number is expected to grow due to the aging of Americans and the direct relationship between aging and disability rates. By 2030, all baby boomers will be older than age 65, and by 2060, people in this age group will make up one quarter of the population (He et al., 2005). Severe disability rates increase to one in four after the age of 65. An aging housing stock and the increasing cost of institutional long-term care create a significant need for accessible housing (Brault, 2012; Lankford, 2016)—a strong argument for implementation of home modifications.

This literature review aims to identify relevant research related to home modifications such that public organizations, policymakers, and design professionals can be effective decisionmakers when developing home modification policy and implementing residential accessibility features.

The ultimate goal of home modifications within this context is to allow people to safely remain in their homes while reducing caregiver burden. Solutions in this area have the advantage of serving a much broader cohort of four distinct—but related—populations: rehabilitation, visibility, disability, and aging.

Inclusion and Exclusion Criteria

This review includes peer-reviewed literature and nonpeer-reviewed literature, including trade journals, to ensure that all key publication sources were addressed. Reference materials were screened based on several inclusion criteria:

- Accessible design retrofits of semi-detached and nondetached residential buildings.
- Solutions for accessibility in houses of the target typology.
- Grey literature materials that were readily available online or in the IDeA Center library.

Materials were excluded if they met any of the following criteria: (1) resources were not printed in English; (2) research published in peer-reviewed journals and conference proceedings before 1998 (20 years); (3) books published before 2008 (10 years); (4) trade publications published before 2013 (5 years); (5) literature referencing federal, state, and local home modification policy; (6) product information (catalogs and databases) produced by vendors; (7) research related specifically to fall epidemiology and prevention; and (8) publications focused on meeting accessibility, such as the Americans with Disabilities Act (ADA), guidelines. Seminal sources cited within this document that fall outside of the previous exclusion criteria were intentionally included due to their sustained relevance.

A database search for research and grey literature was conducted between December 9, 2017, and February 12, 2018 using the following keywords: *home modification*, *environmental modification*, *disability retrofit*, *housing adaptation*, *environmental intervention, and remodeling*. It also included filters related to (1) participants (i.e., disabilities, impairments, aging-in-place, older adults, and elderly) and (2) housing type (i.e. single-family, townhouse, and row house). Major works cited in the relevant papers were also reviewed. The focus was on actual modifications in residential buildings; the term “accessibility” was considered as a secondary search term only. In the primary sense, “accessibility” often leads to strategies that are “100 percent” solutions. Instead, this research concentrated on interventions homeowners and designers implement that greatly increase accessibility in a home but which may not qualify as an accessible feature under ADA guidelines.

The search included the following five databases: Avery, Education Resources Information Center (ERIC), MedlinePlus SAGE, and PubMed Health. Grey literature was sought using databases, search engines, and websites of organizations involved in the home modifications industry. They included Google, USC Leonard Davis School of Gerontology, Home Modification Information Clearinghouse, National Association of Home Builders (NAHB), National Resource Center on Supportive Housing and Home Modifications (NRCSHHM), American Association of Retired Persons (AARP), United Spinal Association, and American Occupational Therapy Association (AOTA). This literature review aims to provide a wide range of home modification strategies and does not focus on a single question; therefore, a systematic review methodology was not used. Searches were supplemented by reviewing the references cited within the selected articles to find any other relevant papers.

Universal Design

Universal design (UD) is a term first coined by Ronald L. Mace (architect, product designer, and educator) who described the concept of "products and environments … usable by all people, to the greatest extent possible, without the need for adaptation or specialized design."[14] It has been further defined as a process that enables and empowers a diverse population by improving human performance, health and wellness, and social participation (Steinfeld, Maisel, and Levine, 2012). Universally designed home modifications benefit a wider range of users than interventions focused on the specific needs of one household and can maintain or improve the value of a home. For the purposes of this literature review, the recommendations and research cited will not focus on UD. This is not to minimize the benefits of UD but rather to acknowledge that home modifications often are very specific interventions that benefit only one household, and perhaps only one occupant.

Description and Scope of Home Modifications

Home modifications can be categorized by their features and benefits, and range in scale from minor adaptations, which include the installation of additional lighting or the replacement of doorknobs with levers, to more significant interventions such as widening doorways or installing ramps. Although home modifications are defined as any adaptation made to the home that serves to decrease environmental demands on the user, it is often beneficial to define modifications through specific goals. Levine and Steinfeld (2012, 1981) identify the primary goals of home modifications as—

- Accessibility to interior and exterior spaces in the home and on the property.
- Usability, to reduce barriers in the environment (Slaug et al., 2011).
- Safety, to reduce the risk of accidents and improve security and fire safety.
- Support for caregiving and healthcare.
- Support of social integration and engagement.

This literature review focuses on strategies that become a permanent feature of the home and bolster or improve the occupant's ability to perform ADLs, and standard tasks that indicate a high degree of self-sufficiency. This study specifically excludes less-permanent adaptations such as the mitigation of clutter or the provision of assistive devices and equipment such as a freestanding bath bench or a toilet seat riser—interventions that can provide significant benefits but are generally not a permanent architectural change.

Although existing research illustrates the effectiveness and benefits of home modifications (Steinfeld and Shea, 1993; Fänge and Iwarsson, 2005), public policy and private sector practices continue to fall short of providing adequate services and financial resources (Pynoos and Nishita, 2003). Many factors have contributed to this gap between knowledge and practice, including limited published research using large and diverse samples, lack of clarity in the definition of home modifications, and lack of knowledge about current practices in the construction industry and their effectiveness. Research on this topic is complicated by great variations in housing stock and conditions; in construction practices and costs; and in disability type, severity, and individual preferences toward home alterations.

[14] https://projects.ncsu.edu/ncsu/design/cud/about_us/usronmace.htm.

In a home services context, it is important to understand that the need for home modifications is only one possible deficiency faced by individuals in their existing housing. Other needs include addressing deferred maintenance, repairs to equipment, and improving fire safety and home security. Services that address needs such as these are not always included in research relating to this topic, yet occupants cannot attain independence and autonomy in homes that are unsafe and unhealthy. Although this review will not go into detail regarding these services and supplemental conditions, policymakers and practitioners should be aware that successful implementation of home modifications will require that residents and their caregivers have access to home maintenance services that address the following (Community Research Applications, Steinfeld et al., 1977):

Emergency repairs such as for severe roof leaks or plumbing breaks.
Weatherization strategies to provide safety during extreme temperatures and weather events.
Security modifications for windows and doors, increased surveillance, and lighting.
Fire safety improvements such as fire-rated doors, fire extinguishers, and smoke detectors.
Removal of clutter and access to handyman services.

Characteristics of Target Populations

For the purpose of this report, home modification is defined as any adaptation made to the home environment that addresses the functional limitations of the occupants and promotes independence, comfort, and safety (Levine, 2012). Modifications are not limited to any single population, but this report addresses modifications for four primary populations: (1) those advanced in age, (2) those with decreased mobility, (3) those with visual impairments, and (4) those with cognitive impairments. Accommodating aging in place will be the primary focus. Those four populations are explicitly addressed because they constitute significant subpopulations and because the modifications prescribed for them are likely to benefit a much larger group. It is important to note that the needs of all occupants of the home must be considered when recommending modifications, including family members and guests. Appropriate interventions address the physical and emotional needs of the caregiver as well.

Aging

When making home modifications to support aging in place, useful features should address typical issues older adults encounter such as decreases in functional mobility, balance, strength, and sensory sensitivity. AARP conducted a 2012 survey of 2,250 Americans older than age 60 regarding their current and future housing situations and found that more than 90 percent of respondents planned to stay in their homes for as long as possible. Of this population, 85 percent felt confident that they would be able to do so without making significant modifications to their homes (AARP, 2012). This finding is problematic because the vast majority of the housing stock in the United States will not accommodate the limitations in function associated with aging. Data from research conducted by the Census Bureau indicate that one in three adults older than age 65 has trouble using some feature of their home (U.S. Census Bureau, 2016). Census information also indicates that one in five individuals older than age 65 is reported to have a disability, with this number increasing to one in four beyond the age of 85 (Brault, 2012). Lack of accessibility can leave residents confined to small spaces within their homes, which limits their activity, curtails their participation in the community and family life, requires them to depend on others for basic needs, and by extension limits their overall quality of life (Pynoos, Caraviello et al., 2009). Promotion of independence and autonomy while aging in place can improve overall physical, psychological, and emotional health and well-being and can reduce instances of premature

institutionalization and the resulting increased healthcare costs for residents and their families (Pynoos, Caraviello, and Cicero, 2009). Furthermore, studies have indicated that older people generally spend more time overall in their homes than younger people do, especially if they are retired from work, making it a place of greater significance (Tanner, Tilse, and de Jonge, 2008).

Tanner, Tilse, and de Jonge (2008) conducted a study on the delivery and effectiveness of accessibility modifications and found that residents reported improved function, comfort, and ease of access around the home after modifications were complete (Tanner, Tilse, and de Jonge, 2008). The limited negative feedback in one study was evidently related to the homeowner not having been involved in the modification design and installation process, highlighting the importance of the resident's participation throughout the process. This reinforces the importance of independence and autonomy when managing one's home and making large changes (Tanner, Tilse, and de Jonge, 2008). It also identifies dissatisfaction resulting from potential disruption to daily patterns. Home modifications can provide security, safety, and comfort while also supporting social relationships (Mathieson, Kronenfeld, and Keith, 2002). Modifications implemented before the user's health has significantly declined will generally be more effective and cause less stress in the short and long term, as compared to waiting until conditions are dire.

Decreased Mobility

Perhaps the most well-known modifications for those with decreased mobility are highly visible features such as ramps, lifts, widened doorways, and automatic doors. Decreased mobility can be the result of aging, disease, accident, or injury. The percentage of individuals in the United States who have difficulty with ambulation (walking or climbing stairs) is 0.6 percent, 5.1 percent, and 22.6 percent for ages 5–17, 18–64, and 64 and older, respectively (Kraus, 2017), again pointing to the appropriateness of such modifications later in life. HUD-sponsored research analyzed data from the 2011 American Housing Survey (Bo'sher et al., 2015) on the accessibility of the current housing stock for people with mobility impairments. The results show that most U.S. homes are not fully accessible. Only about one third have features that are potentially modifiable, and less than 1 percent of all units are equipped with the features needed for a wheelchair user to live independently. Only 0.13 percent of owner-occupied homes are equipped for independent living by wheelchair users.

Home modifications that help to accommodate those with mobility impairments include (Levine 2012)—

- Installing nonslip floor materials.
- Increasing overall lighting levels.
- Creating step-free entries (implementation of ramps, vertical lifts, elevators).
- Installing handrails.
- Widening doorways and hallways to accommodate mobility aids (e.g., wheelchair, walker, scooter, cane).

Cognitive Impairments

Individuals with a wide range of conditions can suffer from cognitive impairments such as stroke, Parkinson's disease, traumatic brain injury, developmental disabilities, and dementia due to Alzheimer's disease and other causes. Those conditions can lead to difficulty remembering, concentrating, or making decisions. Although the prevalence of all types of disabilities increases with age, cognitive impairment shows the least variation between age groups and accounts for

4.8 percent of the population aged 5 to 64 in the United States and 9.0 percent for those aged 65 and older (Kraus, 2017). This increase after age 65 is in large part a result of dementia. Modifications that support independence for those with cognitive impairments most commonly relate to simplified informational cueing and the removal of elements in the home that may cause risk of injury.

More than 4 million Americans suffer from dementia. This number will increase significantly in the coming years due to the aging population (Marquardt et al., 2011). It is estimated that 73 percent of dementia patients are cared for in their homes, highlighting the demand for appropriate housing (Wimo et al., 2013). Dementia is the leading chronic disease that contributes to disability and the need for care (Wimo et al., 2013). The majority of dementia patients receive informal, at-home treatment, so home modifications would provide much-needed aid to caregivers as well (Wimo, Winblad, and Jonsson, 2007).

Home modifications designed to reduce the agitation and confusion of those suffering from dementia and other cognitive disabilities provide helpful cues by using features of the home to aid residents in orienting themselves and understanding their surroundings (Calkins, 2001). Examples include—

- Highly visible environmental controls.
- Increased light levels.
- Illumination that minimizes shadows.
- Increased visibility of railings and stairs.
- Avoidance of patterns on flooring and walls.

Marquardt et al. (2011) and others have reported that dementia caregivers most frequently requested modification of bathrooms, followed by the implementation of kitchen safety features. They also reported that several of the respondents often used furniture for balance as they navigated their homes, highlighting the benefit that additional railings and grab bars can offer (Marquardt et al., 2011). As disorientation and confusion are synonymous with this disease, implementing the previous strategies in a way that minimizes changes from the original home design is vital to supporting this population's independence. For example, modifications should be integrated into the existing floor plan and color scheme to avoid a drastic visual change (Belchior, 2005). Additional modifications that help to accommodate those with cognitive impairments are—

- Installing grab bars in bathrooms and handrails along primary paths of travel.
- Installing nonslip flooring.
- Removing any high-gloss materials that cause glare and distract users from finding their way.
- Implementing a combination of visual, audio, and tactile cues as a means of communicating environmental information.
- Implementing safety features such as locking mechanisms that may help to keep residents safely within a space.

Visual Impairment

Low vision can occur as a result of birth defect, injury, disease, or age. Although severity varies, it is defined as vision that cannot be corrected by eyeglasses, contact lenses, medication, or

surgery (National Institute of Building Science, 2015). A lack of visual clarity can cause functional limitations and reduce the ability to navigate the built environment safely.

Modifications for this population include (National Institute of Building Science, 2015)—

- Increasing overall illumination and task lighting.
- Increasing the color contrast between elements such as walls and light switch plates.
- Decreasing glare.
- Decreasing or reducing tripping hazards.
- Increasing tactile and auditory cues.

Beyond Codes and Standards

Many recommendations for design of home modifications are based on existing standards and guidelines for accessible design. For example, guidelines for home modifications recommend that a wheelchair turning space be 60 inches in diameter, which is derived from accessibility standards, but there is better information available. Human factors and ergonomics (HFE) is a multidisciplinary field of research and application that seeks to increase human performance by improving the fit between human abilities and environmental demands. HFE includes research from rehabilitation science and engineering, psychology, biomedical sciences, and design. HFE knowledge is often applied in the design of products and devices to improve safety, reduce effort, and minimize errors in use. It is less common for HFE knowledge to be applied in the design of the built environment, but some requirements in building standards are based on HFE principles, including safety and accessibility standards.

One major topic in HFE research is anthropometry—the science of measuring body sizes and abilities such as range of motion and maneuvering a wheelchair. Modern accessibility standards and guidelines are based on anthropometric data generated from anthropometric research completed more than 40 years ago from 1974 to 1978 (Steinfeld et al., 2010). Accessibility for people who use wheeled mobility devices is a critical part of anthropometry research because the space needs of users of these devices are usually greater than other individuals. Since that time, both the bodies of Americans and the design of wheeled mobility devices have significantly changed (Steinfeld et al., 2010). New data exist that can be used to ensure that wheeled mobility users can be better accommodated (Steinfeld et al., 2010). Some criteria in the ICC/ANSI A117.1 Standard, which is the consensus standard on accessibility in the United States referenced by building codes, were revised in 2017 to reflect that research but are not yet referenced by the International Building Code or state and local codes. New tools are being developed to help designers apply the research findings that will be useful for home modification design for wheeled mobility users (D'Souza et al., 2017).

Because a significant percentage of home modifications are concerned with accommodating wheeled mobility device users, a good understanding of the space requirements of a user and his or her device is vital to a successful modification. Through their research of the anthropometry of wheeled mobility devices, Steinfeld et al. (2010) found that a significant proportion of wheelchair users would not be accommodated by the current U.S. accessibility standards for clear floor space, knee and toe clearances, and wheelchair turning space. For example, the research demonstrated that a better guideline for a wheelchair turning space is 68 rather than 60 inches. Those data illustrate the importance of designing each home modification to the specific

end user's needs, as even designing to national standards will at times fail to enable a user to meet the functional goal of completing ADLs.

Anthropometry is just one area of research in HFE studies. Other research evidence and design principles from this field can be applied to home modification design. Much of that knowledge has not been incorporated into existing standards and guidelines for accessible design or home modifications. Examples of applications include design of cueing for people with dementia, reducing risk of falls on stairs, improving usability and safety of fixtures and equipment, and improving illumination. Steinfeld and Maisel (2012) provide an overview of the potential applications of HFE knowledge that can improve the existing standards and guidelines.

It is important to note that different individuals may have different needs. Although the larger wheelchair users and those who use power chairs may require 68 inches to turn around, a smaller person using a small chair who has good upper body abilities may be accommodated with a much smaller turning area. HFE practitioners and researchers have developed clinical methods and principles that can be used to create the best fit for an individual with the lowest investment of resources. For example, biomechanics is an important area of HFE research that studies lifting, among other issues. Knowledge from this area of research can be applied to select equipment and furniture when arranging a bedroom or bathroom to reduce the risk of injury to both individuals and caregivers (Salvendy, 2012).

Design

When designing home modifications to decrease environmental barriers impacting activities of daily living, the main issues to consider are—

- Safety when using entrances and exits independently.
- Sufficient clearance through doorways and hallways to ensure general safety and accommodate mobility devices.
- Safety when using stairs.
- Independent and safe bathing and use of the toilet.
- Independent and safe transfers into and out of bed.
- Safety and full facility in the kitchen.
- The ability to turn doorknobs and control all home hardware.

Although not always possible without major renovations, homes that provide a kitchen, full bath, bedroom, and laundry on one level that are accessible without the use of steps greatly increase a home's accessibility for residents and visitors alike. When focusing specifically on townhomes and row houses—often defined by long, narrow floor plans—designers may need to consider widening paths of circulation and borrowing space from neighboring rooms.

Entrances and Exits

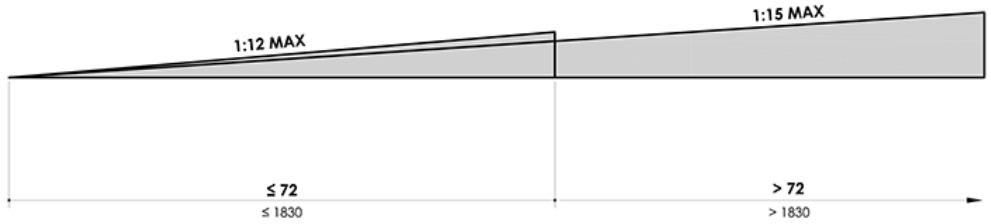
Access into and out of a home is vital to the independence and safety of residents, specifically in the housing typology the authors are focused on—townhomes and row houses—as the floor plan often includes narrow, stepped entrances. Some minor modifications that can help to make entryways safer include (Steinfeld and White, 2010)—

- Increasing illumination to both the interior and exterior of the entryway.
- Replacing doorknobs with easy-to-operate lever handles.
- Installing overhangs for protection from rain and snow.

- Installing sturdy, easy-grip, multiple-height railings that extend beyond the first and last steps.
- Adding nonslip surfaces on steps and landings.

Stepless, nonslip entries should be implemented to provide greater access to those with limitations of mobility, vision, or balance. Because the entrance level of many homes is positioned above grade, ramps or lifts are often installed. Ramps can be constructed of wood, metal, concrete, or composite material (Levine, 2012). Although modular, lightweight aluminum ramps are a good option for temporary use, permanent ramps consisting of durable, nonslip materials should be implemented for long-term use (Levine, 2012). The U.S. Access Board recommends that ramps have a maximum 1:12 slope, with a maximum cross slope of 1:48, a minimum unobstructed, flat, 5-foot square landing at the top and bottom of the ramp, a minimum ramp width of 36 inches, and edge protection and handrails for any rise greater than 6 inches. (U.S. Department of Justice, 2010). If enough space is available, a shallower slope is preferable than the maximum slope. Although accessibility standards do not apply to private residences constructed without public funding, it is valuable to reference those standards when designing residential ramps for individuals with mobility impairments. Exhibit A-1 illustrates the appropriate slope for accessibility and UD standards.

Exhibit A-1. Ramp Slope Recommendations



MAXIMUM SLOPES

SLOPE	ACCESSIBLE	UD
≤ 36 ≤ 915	1:8	1:12
≤ 72 ≤ 1830	1:10	1:12
> 72 > 1830	1:12	1:15

Note: The diagram illustrates the maximum slope (1:12) and straight run length (72 in. or less) required by the ADA and the maximum slope (1:15) and straight run length (greater than 72 in.) required to meet Universal Design recommendations of ramps.
Source: University at Buffalo Center for Inclusive Design and Environmental Access

Homeowners are often deterred from installing ramps due to their utilitarian and clinical appearance. Planners should consider side, rear, or garage entrances when architecturally appropriate designs are prohibitively expensive or dimensionally impossible at the front entrance (Levine, 2012). When space for a ramp is not available, platform lifts can be installed within a much smaller footprint. Although there are additional mechanical and safety considerations related to a lift, it is a reliable and functional option (Levine, 2012).

Bathrooms

The personal nature of tasks performed in bathrooms, combined with an increased risk of slips and falls that can result in injury, mean that bathrooms frequently need modification. Gitlin, Miller, and Boyce (1999) conducted a pre- and post-analysis by an OT of bathroom

modifications for 34 people along with a telephone survey of an additional 75 people who had also received bathroom modifications. When asked about their home's usability, respondents complained most of difficulty bathing and performing tub and toilet transfers (Gitlin, Miller, and Boyce, 1999). Despite a wide range of functional disabilities, all respondents reported that easier, more confident shower and toileting tasks were supported by the following design solutions (Gitlin, Miller, and Boyce, 1999; Levine 2012):

- Textured grab bars and/or handholds in the shower and beside the toilet.
- Raised toilets with elongated seats.
- Nonslip surfaces on the bathroom floor and in the shower and tub.
- Roll-in, barrier-free showers.
- Temperature-balancing shower and faucet controls.

In addition to increased safety and independence, resident privacy was improved because such modifications helped to reduce the amount of assistance required when performing those tasks (Gitlin, Miller, and Boyce, 1999). Other modifications that increase the functional and safe use of bathrooms include (Levine, 2012)—

- Increasing the overall illumination levels.
- Providing unobstructed, clear floor space of at least 5 feet x 5 feet when mobility aids such as wheelchairs are being used.
- Replacing faucet knobs with levers.
- Installing countertop surfaces with rounded edges.
- Installing countertop and floor surfaces that limit glare from overhead lighting.
- Removing base cabinets to provide wheelchair users knee and toe clearance beneath a vanity.
- Adding structural reinforcement to walls to support grab bars.
- Providing a handheld shower head with offset controls to minimize reaching and bending.
- Installing a walk-in bathtub.

In addition to assistive devices such as shower seats, those modifications can greatly decrease risk of injury and improve independence.

Kitchens

Kitchens can be dangerous for anyone, but particularly for those with functional limitations, cognitive disabilities, and decreased sensory perceptions. When planning for modifications within kitchens, designers should first consider space planning and identify how the space is used by the residents, i.e., how many people will be using the space, who is the primary user, and what activities are most often performed in the space (Peterson, 1998; The Internet Stroke Center, 2018). Identified by Pynoos (1993), the "kitchen triangle" refers to the recommended triangular path of travel between the sink, stove, and refrigerator. (USC Leonard Davis School of Gerontology, 2018). For safety and efficiency, those areas should be arranged to accommodate linear or triangular travel between these steps, should not cut through an island or peninsula by more than 12 inches, and should be located adjacent to a heat-resistant workspace surface (USC Leonard Davis School of Gerontology, 2018). Work aisles should have a width of at least 42 inches, or 48 inches for more than one user, with perpendicular walkways providing ample

turn space—a minimum of 60 inches, but preferably sized to meet the individual needs of the resident (VGM Live at Home, 2018).

As with bathrooms, base cabinets in the kitchen can be removed to accommodate knee and toe clearance for wheelchair users, and adjustable height countertops or multiple height countertops provide comfortable work spaces for a variety of users (Levine, 2012). Lever handles on sink faucets provide easier control with decreased strength and dexterity, whereas shallow sink designs can provide increased knee clearance for a seated user (Levine, 2012). Additional modifications that decrease environmental demands and hazards include (Levine, 2012; USC Leonard Davis School of Gerontology, 2018)—

- Installing pull-down shelving and pull-out, pantry-style cabinets.
- Replacing drawer and cabinet knobs with handles.
- Increasing room and task (surface) lighting.
- Providing accessible appliances such as:
- Side-by-side refrigerators or freezers.
- Appliances mounted at heights customized for the user.
- Ovens, microwaves, and dishwashers that provide large-format, front-mounted controls to limit bending and reaching across hot surfaces.
- Counter space or slide out platforms adjacent to appliances for easy food transfer.
- Installing nonslip flooring.
- Installing flooring and surface finishes that limit glare.

Doorways and Hallways

One of the most commonly implemented structural home modifications is the widening of doorways. Many homes do not provide circulation space that can easily accommodate mobility devices such as walkers, wheelchairs, or scooters. To adequately support the use of those devices, doorways should ideally have a clear width of at least 32 inches (for 34-inch doors), whereas hallways should be 42 inches wide. (Levine, 2012; VGM Live at Home, 2018). If increasing the width of a doorway is not possible, offset hinges can add 2 inches of additional clearance to most doorways by allowing the entire door panel to swing clear of the opening (Levine, 2012). For some users this slight increase will be sufficient. Doorknobs can be replaced with levers, which magnify force with a one-way action that does not require grip strength. Navigation and access can be improved by removing latches, locks, or other operating devices that require a person to exert a significant amount of strength or dexterity (Levine, 2012). Marquardt et al. (2011) found that more than 28 percent of individuals with dementia and functional limitations reported holding on tightly to furniture and walls when navigating through and between rooms, indicating that users would benefit from support devices in more spaces than just bathrooms and stairways, such as kitchens and halls (Marquardt, 2011). The installation of threshold ramps, where a raised threshold either is needed due to a floor material change or is required due to a change in level, eliminates abrupt level changes, which decreases tripping hazards and improves navigation with mobility devices (Levine, 2012). Ramps can be added to address an elevation change between neighboring rooms, but care must be taken to avoid introducing an entirely new tripping hazard with the ramp's placement. As mentioned previously, increased light levels and implementation of lighting controls at each entrance improve visibility and orientation, highlighting trip or bump hazards.

Stairs

A large percentage of homes have bedrooms and bathrooms located on the second level, making vertical circulation a daily challenge for those with functional disabilities. Stair lifts, inclined stair platform lifts, and elevators are potential home modifications for individuals who lack the ability to climb stairs but require access to multiple levels of a home (Levine, 2012).

Stair lifts are mechanical assistive devices that are installed in stairways and consist of a seat that moves the user along a track mounted to the wall or stair nosing that follows the length of the stairway (Levine, 2012). The seat rotates at the top and bottom landings to allow user access. Stair lifts are generally the most affordable option for this type of assistance (Levine, 2012). The structure, width, and geometry of the stairway are issues to consider with this modification, because stairways often lack the structural capacity to support these lifts, are too narrow, or have a curved or switchback orientation that requires customization (Levine, 2012). An additional issue is the need for multiple mobility devices to accommodate the user at each level. Stair lifts also require the user or caregiver to have appropriate strength and balance for transferring to and from the device, particularly when doing so at the top of the stairs (Levine, 2012).

An inclined stair platform lift consists of a platform traveling on a rail, which moves along the pathway of the stairs (Levine, 2012). The open platform allows users either to remain in their mobility device, while it is secured to the platform, or to simply stand. This may be preferred over the stair lift because it does not require users to transfer from a mobility device at each level but can also pose fall hazards if the platform has no rail or if the user lacks functional control of the device (Levine, 2012). This type of modification fills the entire width of the stair, making it undesirable for some situations.

Elevators offer accessibility superior to each of the previous devices, but costs for residential elevators are often prohibitive, starting around $20,000 per lift (Levine, 2012). It can also be difficult to meet space requirements on each floor to accommodate the shaft, typically taking up the same amount of space on each floor as a half bath, approximately 4 feet x 6 feet (Levine, 2012). Residential elevators are available in a wide variety of sizes and configurations to provide optimal usability for diverse needs. Issues to consider when purchasing and installing a residential elevator are (Levine, 2012)—

- Cab size should accommodate the needs (and potential needs) of everyone in the house and may need to accommodate two adults if the user is not capable of entering, exiting, and operating the controls of the elevator without assistance.
- Door configuration should increase accessibility and ease of entering and exiting.
- Door type should be selected to provide the largest clear opening possible and may be automatic or manual, as need dictates.
- Accessible controls for the individuals using the elevator.
- Selection of safety features such as an accessible emergency control or battery-powered telephone that can be used in the event of an emergency or power failure, or an emergency call button.

Additional modifications to consider for stairs without the implementation of a lift device include—

- Increasing illumination at the top and bottom of a stairway.
- Installing handrails on both sides of a stairway, extending past the top and bottom steps.

- Implementing high-contrast nosing for treads to accentuate the edge of each step.
- Installing nonslip materials on stair treads.
- Removal of thick carpeting that can negatively alter the stair geometry and create overly rounded nosings.
- Ensuring that the tread and riser dimensions meet building standards (recommended: 7-inch riser height with 11-inch tread depth).

Effectiveness

Although this literature review primarily focuses on the functional value of modifications made to permanent physical features of the home, additional characteristics must be considered, such as—

- Cost (materials and installation price, and impact on the home's value).
- Available funding (insurance, grants, Medicare).
- Service delivery (local designers and contractors who are knowledgeable and competent in the field of home modifications).
- Durability (long-lasting, robust materials that are easy to clean and maintain).
- Appearance (colors and styles that complement the existing aesthetic).
- Means of prescription (design recommendations from a physical or an occupational therapist).

In addition, the impacts of home modifications as they relate to personal, physical, and social dimensions, and the impacts on caregivers, should be addressed.

The majority of home modification research is based on data collected through interviews and surveys. Although this information provides direct user input, the available research shows gaps in reliable quantitative measurements. A solution to this gap in research may be the further development of the *Housing Enabler*, which is a tool that was developed for occupational therapists, a group often responsible for prescribing home modifications. The tool is designed to assess the accessibility of housing by documenting functional limitations and environmental barriers for use in the calculation of an accessibility score (Iwarsson, 2016). Iwarsson and her colleagues have completed extensive research on the reliability and effectiveness of the tool, although it has not been used extensively in the United States. Gitlin (2003) found that gaps in research are also attributed to a lack of data from diverse racial and ethnic groups, housing conditions, and socioeconomic level.

Perceptions and Motivations

Home modifications are implemented for a variety of reasons, but one primary purpose is to increase safety. Aplin, de Jonge, and Gustafsson (2015) found that modifications typically resulted in an increased sense of safety, a reduced level of anxiety, and a decreased rate of injuries and falls for people with a broad range of impairments (Stark et al., 2009; Stark et al., 2017). Regardless of functionality and safety, the appearance of home modifications, specifically those visible from the exterior of the home, can have a positive or negative impact on a respondent's subjective evaluation of the modification. This effect occurs when homeowners associate the appearance of their home with their identity (Aplin, de Jonge, and Gustafsson, 2015). For example, a visible ramp leading to the front entrance of a home can be stigmatizing, and users may resist this public announcement of their disability. Similarly, Aplin found that if a

modification installed within the privacy of the home was designed in a way that made the resident feel "disabled" or as if he or she was "in the hospital," the resident would rate the modification as less effective (Aplin, de Jonge, and Gustafsson, 2015). Conversely, the participants in the same study who reported low concern about the appearance of the modifications tended to rate the modifications as more effective (Aplin, de Jonge, and Gustafsson, 2015), which highlights the importance of the homeowners' preferences. Therefore, for maximum user satisfaction and perceived effectiveness, contractors and designers should consult with homeowners, prior to any home modification installation, to understand what visual elements are of primary importance and to respect the resident's sense of personal control in the process.

Outcomes

Regaining or maintaining independence within the home is highly valued for residents and caregivers alike. Studies have shown that home modifications often yield outcomes that reduce the amount of assistance needed from spouses and caregivers when completing ADLs. Effective home modifications also reduce the level of difficulty and can sometimes completely restore the resident's ability to participate in everyday life tasks and valued activities such as socializing, cooking, and gardening (Petersson et al., 2009; Aplin, de Jonge, and Gustafsson, 2015). Additional studies have shown that home modifications for persons with dementia led to slower declines in patients' ability to perform ADLs, whereas the spouses or other caregivers of those individuals reported reduced upset and enhanced self-efficacy in managing behaviors (Gitlin et al., 2001). Furthermore, Petersson et al. (2009) found that implementation of prescribed home modifications helped recipients to continue to live in their homes and to take part in social activities in spite of decreases in functional abilities (Petersson et al., 2009). Although independence is often cited as a primary goal for persons with functional limitations, it also provides additional benefits of improved health and well-being through increased activity and social participation.

Negative outcomes of home modifications often result from poor service delivery such as ineffective prescriptions from healthcare professionals, long lead times for installation, unacceptable levels of disruption, poor communication with the homeowner, poor workmanship, and little to no followup or training as to how to properly operate or use modifications (Aplin, de Jonge, and Gustafsson, 2015; Stark et al., 2017). Petersson et al. (2009) found that modification lead time had an impact on the perceived effectiveness of modifications. Survey respondents reported that their difficulty performing ADLs increased with each month that the modification was delayed, meaning that the benefits delivered by modification can be completely obviated if homeowners are left to wait for longer than 1 year (Petersson et al., 2009). This was an unexpected result that has major implications and further highlights the important role that service delivery has in the home modification process.

In surveys, a typical report from a satisfied modification recipient describes a positive experience with the builder, noting that the builder was clean and respectful of the recipient's home and took care to include the recipient in the process by listening to his or her requests (Aplin, de Jonge, and Gustafsson, 2015). In this same study, the most satisfied respondents were part of a program in which their occupational therapists were also in constant contact with the builder, and instead of using multiple subcontractors, the single builder was responsible for all modifications (Aplin, de Jonge, and Gustafsson, 2015). An additional factor related to positive experiences was client involvement in decisionmaking (Aplin, de Jonge, and Gustafsson, 2015). This factor needs to be

considered at the earliest phase of the home modification process. Occupational therapists, physical therapists, and other qualified design specialists should not simply be prescribing modifications but instead should engage in an open, responsive negotiation (Iwarsson, 2014). Those professionals must understand not only their patients' functional limitations but also their priorities and values. Research has shown that standard environmental modification practices work effectively, but the relationship of humans to their environments and the meaning of "home" are complex; including the end user throughout the design process will yield improved usability and effectiveness of modifications.

Certification Programs

One solution to problematic service delivery is the improved standardization and completion of training and credentialing programs. Programs such as the Certified Aging-in-Place Specialist (CAPS) provide participants with technical, business management, and customer service skills training to better close gaps that are often present between care coordinators or prescribers, such as occupational therapists, and the individuals responsible for construction and design of modifications. Appendix B contains a list of certification programs.

Discussion

Key Findings

The literature on home modifications has evolved considerably since this topic was identified as an important aspect of adaptation to aging in the 1970s. Government policy and private sector initiatives in housing for the older generation, however, have consistently favored new construction versus investment in the existing housing stock. Likewise, research funding devoted to the topic of modifications with the goal of keeping the aging population in their homes longer has not been a priority of the government or the private sector. The Home Modifications Action Coalition, a collaborative effort of AARP, the American Society on Aging, academics, and service providers, highlighted the importance of those services through its *Blueprint for Action* in 1997 (Duncan et al., 1997). Research on practices in the field demonstrates that the mechanisms in place for delivery of home modification services, from financing to construction, are fragmented and uncoordinated. Not much has changed since that time, although there is a heightened awareness of the problem among service providers, government agencies, and the remodeling industry.

As the population ages rapidly, the demand for home modifications will increase. Local community agencies such as Area Agencies on Aging and other nonprofits have demonstrated service models that work. Researchers have demonstrated that home modifications are effective, providing significant benefits for older residents. The private sector has also responded to the growing need by developing training programs for contractors, equity conversion instruments such as reverse annuity mortgages, and provisions in long-term care insurance to cover the cost of modifications. However, there is still a gap between demand and the availability of resources and expertise. Many unanswered questions and unexplored areas in research also still exist.

One of the most important findings from this literature review was the disconnect between the expectations of older Americans and the reality of their housing. Although a large majority of older Americans expect to age in place, research demonstrates that their living arrangements do not support this choice without some major compromises to their quality of life. Consumers are not aware that they may need deliberate, or even major, interventions in their home environment

to realize their aspirations for aging in place. The rising cost of alternatives to renovating one's home, such as moving to a new, universally designed home or service-intensive facility, will likely create a greater demand for home modification design and construction services. A danger exists that the supply of needed services, financing, and expertise may simply not meet the demand. Even worse, the potential mismatch between expectations and actual outcomes could make older people dread engaging service providers, akin to avoiding a visit to the dentist until it is too late. This complication will add to the burden of healthcare providers, relatives, and friends, and it will severely reduce aging homeowners' quality of life.

A definition of home modifications emerged in the literature; it is "a process that includes evaluation, identification, and implementation of adaptations to permanent physical features of the home environment to reduce the difficulty of living independently by making tasks easier, reducing the risk of accidents, and supporting independent living and social integration" (Fänge and Iwarsson, 2005; Gitlin, 1998; Pynoos, 1993). This definition provides a comprehensive view of home modifications, useful for development of policy and service programs. It is particularly valuable for educating construction professionals who may erroneously view their service as just another application of a standard approach to home improvements with a few twists thrown in (e.g., ramps and roll-in showers), not recognizing the need for evaluation, integration, and anticipation. The definition does not adequately take into consideration the perspectives of consumers who may not believe that their homes have any major barriers to living independently. They may resign themselves to the belief that certain inconveniences are an unavoidable part of aging. Thus, they may resist engaging in a complicated intervention without a good understanding of the potential benefits for themselves, their ability to control the process, and the ultimate costs of a project. They may think that home modifications are for people with more serious limitations.

One set of research findings that should be particularly compelling to the building industry is the discovery that when homeowners actively value the appearance of their home, they perceive the modification's effectiveness in proportion to its visual appeal. Clearly, appearance must be addressed in developing modification strategies that will be acceptable to consumers. Research questions include: How do consumers define "intrusive"? What materials and styles are favored over others? What tradeoffs on usability and safety are acceptable to achieve a positive emotional response? Are homeowners concerned that modifications could affect the resale value of their homes?

Research and practice clearly identify the scope of usability-related home modifications and the most common solutions. There is a wide range of interventions, yet each individual and home is different, which presents a challenge for the future tasks of this project, which will complete focused R&D on innovative approaches. The challenge will be to identify the most strategic interventions to target for indepth research. For instance, satisfactory, low-cost, and easily implemented modifications such as cueing for people with dementia, improving illumination, and installing grab bars already exist; innovation is not necessary.

Thus, the focus of R&D in this project will be on improving the effectiveness of some of the most expensive and hard-to-implement modifications related to access of essential facilities and maintaining the safety of residents and caregivers. These goals clearly are related to overcoming inaccessible entries (e.g., ramps and lifts); access to essential facilities on inaccessible floors (e.g., laundry and parking); and bathroom access, particularly access to toilets and bathing

arrangements in cramped bathrooms. Improving kitchen cabinet accessibility and usability is less of a safety concern, but it can also be very valuable for maintaining independence.

With regard to attached single-family housing, which is the focus of this research, some of these topics can be investigated by research at the "drawing table" rather than in the laboratory. For example, access to inaccessible floors does not necessarily mean providing lifts or elevators. Design explorations on the reconfiguration of spaces to move essential facilities to an accessible floor could be accomplished using computer-aided drafting and graphic visualization techniques. Consumer acceptance can be effectively evaluated using such methods.

Testing innovative products that make stairways safer and easier to climb, including easier-to-grip railings and innovative devices such as the StairSteady, is certainly possible. Even though the development of new lift and elevator technologies is outside the scope of this research due to budget, time, and engineering constraints, it may be possible to study innovative applications of technologies available in other sectors but not currently in use in the home market. For example, federal, state, and local regulations prohibit the use of vehicle lifts in housing. However, vehicle lifts are much less expensive, can be installed without foundations, and are engineered for many more cycles of use than porch lifts. They could be evaluated for use in housing, leading to product improvements specific to building installations and potential changes in regulations that would ultimately allow for their use.

Finally, this project will identify counterexamples: existing conditions that indicate a positive outcome is unlikely or not cost-effective, given standard accessible modification design options and typically acceptable budgets.

Identified Gaps

There are some important gaps in the literature that are beyond the scope of this research but that should be addressed by others.

Research on outcomes has explored the impact of providing people with individualized modifications based on a professional assessment, but it has not explored the impact of less-than-ideal modifications. Understanding of the relative impact of a graduated set of interventions would be particularly valuable for policymakers and third-party payers.

Many reference works speculate that the need for accessible residential modification is severely underreported (Duncan et al., 1997). Comprehensive, nationwide surveys to corroborate this expectation and identify nuances related to geography, demography, etc. would be useful. Such research can also identify the extent of latent demand that could be addressed through better public education and marketing of services.

Industry lacks detailed understanding of the limitations of accessibility standards in application to personalized home adaptations. Do current standards intended for public spaces and accessible hotel rooms make sense for home modifications? Evidence indicates that full-bore ADA standards such as those developed for toilet height and grab bars may not be effective for older people with less severe limitations (Sanford, 1995). Departure from those standards may pose liability risks for service providers and safety hazards for clients.

More research is needed on the perceptions of older people toward home modifications and service providers. How prevalent is the belief that home modifications could reduce the value of a home? What level of trust do older homeowners have in service providers, including social

service agencies and for-profit builders? What can improve perceptions of the process and the providers, e.g., certification of builders, public education, etc.?

The home remodeling industry has initiated programs to improve education of builders on home modifications such as NAHB's CAPS program. However, no studies to date have evaluated the effectiveness of such efforts. Do builders with the CAPS certificate actually offer better services and improved outcomes? Do they get more business than other builders with the same experience? Research that demonstrates the value of certification could improve consumer trust and potentially increase interest in obtaining more education.

Steinfeld and Shea (1993) found that many elderly households need a comprehensive approach to addressing their housing needs. The current fragmented service delivery system provides narrowly focused funding (e.g., funding can only be used for ADL- related improvements) that may be irrelevant for many households that have other critical housing-related needs such as deferred maintenance and high energy bills. Corroboration of this finding by a larger study would imply that funding for home modification services should be part of a broader scope of service delivery that can meet several needs at once.

Finally, further research is needed to understand how to help older people and people with disabilities identify their own needs and make the proactive decision to modify their homes before they have an accident, curtail their quality of life, or reluctantly relocate. Steinfeld and Shea (1993) found that a simple assessment can be helpful to motivate individuals to make minor improvements but not those that are more difficult or costly. That research used an expensive professional assessment, but it was before the days of self-help apps and websites. Perhaps digitally based tools could be effective in enabling self-assessments and providing access to resources to help with implementation.

Conclusion

This literature review confirms the operating assumptions of many experts in the field while adding valuable scope and detail. The fundamental desire of the majority of aging occupants or occupants with disabilities is to stay in their own homes for as long as possible. The high cost of institutional care and the intrinsic value of personal independence make this an appropriate societal goal as well. Numerous studies confirm, though, that typical residential housing includes barriers to the ability of aging occupants or occupants with disabilities to complete the basic activities of daily living. Several viable modifications appear to exist for most architectural conditions that present safety or accessibility issues to that population. The challenge seems to be a combination of evaluating, designing, and installing those solutions in a cost-effective, attractive, and durable manner that meets the client's goals and expectations for independence and control. The target house typology—single-family attached and semi-attached houses—will present constraints to the design team in solving the identified problems but offer opportunities to identify approaches that can provide solutions in the most challenging situations.

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Exhibit A-2. Average 2018 Costs of Most Commonly Implemented Home Modifications in the Western New York Region

Modification (installation included)	Range of Costs
Widen doorway to 36 in. (interior)	$1,400–$1,800
Widen doorway to 36 in. (exterior)	$2,100–$2,400
Installation of offset hinges	$90
Installation of lever handles	$50–$60
Installation of grab bars	$90–$400
Custom tiled roll-in-shower (excluding demolition)	$5,800–$6,400
Prefabricated fiberglass roll-in shower (excluding demolition)	$1,000 or less
Vertically adjustable and removable shower head	$200
Nonslip floor tiles (including all associated materials)	$35–$40 per sq. ft.
Wall-hung sink	$600 on average
Raised toilet	$380 on average
Wooden ramp with handrails, straight run (20 ft long total)	$5,000 on average
Wooden ramp with handrails, turns with landing (20 ft long total)	$7,000 on average
Vertical platform lift (exterior installation, would include a concrete pad)	$8,400–$12,800
Stair lift (straight run)	$7,000–$9,000
Residential elevator	$18,000–$26,000

Source: Data from Amico Home Improvement

Credentialing

(Note: All websites were accessed on March 7, 2019.)

Abilities OT Online Seminars in Accessibility

Abilities OT and Accessibility Services

Program description (from website: https://www.aotss.com/online-seminars/)

A dynamic learning experience is combined with personal email communication with mentors who are national experts. Learners receive access to the Abilities OT Services & Seminars (AOTSS) Accessibility Consultants Network (ACN) containing lessons, conference call lectures, discussion board, networking, and extensive links to resources. Training will focus on promoting safety and independent living services for pediatric through geriatric populations and will encompass a wide range of physical and cognitive disabilities. Participants learn from the comfort of their own environment using their own timeframe and earn continuing education credits. College credits are also available.

Certified Aging-in-Place Specialist (CAPS)

National Association of Home Builders

Program description (from website: https://www.nahb.org/Education%20and%20Events/Education/Designations/Certified%20Aging-in-Place%20Specialist%20CAPS)

Certification requires the successful completion of three courses:

Marketing and Communicating with the Aging-in-Place Client (CAPS I)
https://www.nahb.org/education-and-events/education/course-overviews/marketing-and-communicating-with-the-aging-in-place-client-caps-i
Design Concepts for Livable Homes and Aging-in-Place (CAPS II)
https://www.nahb.org/education-and-events/education/course-overviews/design-concepts-for-livable-homes-and-aging-in-place-caps-ii
Details and Solutions for Livable Homes and Aging-in-Place (CAPS III)
https://www.nahb.org/education-and-events/education/course-overviews/details-and-solutions-for-livable-homes-and-aging-in-place-caps-iii

The CAPS designation program teaches the technical, business management, and customer service skills essential to competing in the fastest growing segment of the residential remodeling industry: home modifications for the aging in place.

Executive Certificate in Home Modification Program

https://homemods.org/echm/

USC Leonard Davis School of Gerontology

Program description (from website: https://homemods.org/online-courses/)

This program is designed for professionals who work directly or indirectly in the field of supportive home environments. Students include remodelers and contractors, planners, personnel of organizations representing the elderly and people with disabilities, occupational and physical therapists, policymakers, and others interested in starting their own home modification business. The courses connect professionals from around the country who learn from each other and experts in the field.

Home Modifications Practitioner Certificate Program (VGM Group)

The VGM Group

Program description (from website: https://www.vgm.com/pages/home-modification)

The courses are valuable to individuals who provide any type of home evaluation, design, or construction service for seniors or people with disabilities, such as occupational therapists, physical therapists, nurses, home healthcare workers, case managers/social workers, builders and remodelers, architects, and interior designers.

NARI Universal Design Certified Professional (UDCP)

https://www.nari.org/certification-accreditation/certification/universal-design-certified-professional

National Association of the Remodeling Industry

Program description
(from website: https://www.nari.org/industry/development/certification/universal-design-certified-professional-udcp/)

This certificate is intended for remodeling professionals interested in becoming experts in Universal Design practices. Courses focus on topics such as conducting client needs assessments; Universal Design applications used in residential remodeling; construction techniques used to implement Universal Design to a remodeling project; plumbing and electrical systems unique to Universal Design; and differences between model building codes and ones described in the Americans with Disabilities Act.

IDEA 107: Universal Design and Home Modifications

Center for Inclusive Design and Environmental Access

Program description (from website: *https://www.udeducation.org/allcourses/)*

This course examines the role that home modifications play in improving the fit between people and their homes. It describes the primary goals of home modifications and policies and methods of home assessment. In addition, it discusses several common home modifications and case studies to exemplify both good and bad home modifications.

Popular Home Modification Products and Suppliers

- 800Wheelchair.com
- AbleData: Assistive Technology Product Guide
- Access Able Designs, Inc.
- Access Lifts & Ramps
- AlumiRamp, Inc.
- AmeriGlide
- Amramp®
- Arjo
- Bruno®
- CleanCut™
- Drive DeVilbiss Healthcare
- Easy Climber®
- ELDERLUXE®
- EZ-ACCESS®
- Grab Bar Specialists©
- #GRABDASHBAR©
- Great Grabz®
- Handi-Ramp®
- Mor-Medical International™
- Open Sesame Door Systems, Inc.
- Prairie View Industries, Inc.
- Prism Medical, Inc.
- Roll-A-Ramp®
- SafePath Products™
- Savaria®
- Silver Spring®
- StairSteady
- SureHands®
- TubcuT

APPENDIX B:
FOCUS GROUP DISCUSSION AND EXPLORATION OF ACCESSIBILITY NEEDS AND CHALLENGES

Focus Group Discussion and Exploration of Accessibility Needs and Challenges

Qualitative Research

Key Points Summary

Background

The United States has a large housing stock of semi-detached and nondetached residential buildings (townhomes and rowhouses) with narrow floorplans and functionality spread among several levels. These home configurations are particularly challenging when modifications are required to improve access, safety, and usability for elderly and disabled residents.

Home Innovation Research Labs and the Center for Inclusive Design and Environmental Access (IDeA), in the School of Architecture and Planning at SUNY at Buffalo are conducting a three-year research project to--

1. Study the typical pitfalls of retrofitting for accessibility in the target building type.
2. Identify best practice solutions for overcoming barriers to adoption.
3. Develop construction guidance to support designers, remodelers.
4. Homeowners in their decision-making and construction processes.

As part of the primary research plan, focus group research was conducted among three audience segments to better understand needs and challenges. The following report provides a summary of the focus group research.

Qualitative Research Objectives and Methodology

MARKET RESEARCH OBJECTIVES

- Identify and understand the daily and long-term challenges of accessibility in the target building type for adults with physical disabilities or limitations.
- Categorize and prioritize their accessibility, usability, and safety challenges.
- Identify and understand barriers to successful accessibility. modifications in homes generally and in the target building type specifically.
- Explore ideas for potential solutions to these challenges and barriers.

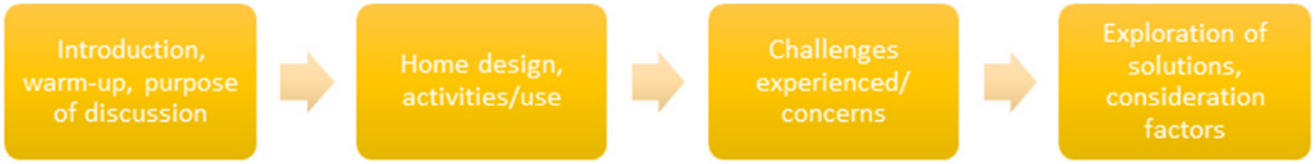
METHODOLOGY

- Three focus group discussions were conducted, each among a different sample segment (Residents, Caregivers, Professionals)
- Discussions were conducted December 12 and 14, 2018 at Home Innovation Research Labs in Upper Marlboro, Maryland
- Each group discussion lasted approximately two hours
- Groups consisted of 8 – 10 participants each; participants were paid an honorarium of $150 for their time

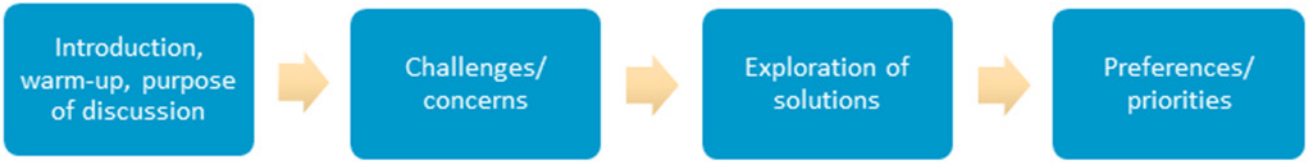
Qualitative research explores attitudes, beliefs, perceptions, and practices. In qualitative research, insights are gained through open-ended discussion that enables respondents to express their thoughts and feelings in their own words and allows the moderator to dig deeper as needed. This report summarizes, lists, paraphrases, and directly quotes the opinions expressed by the focus group participants.

Discussion Structure

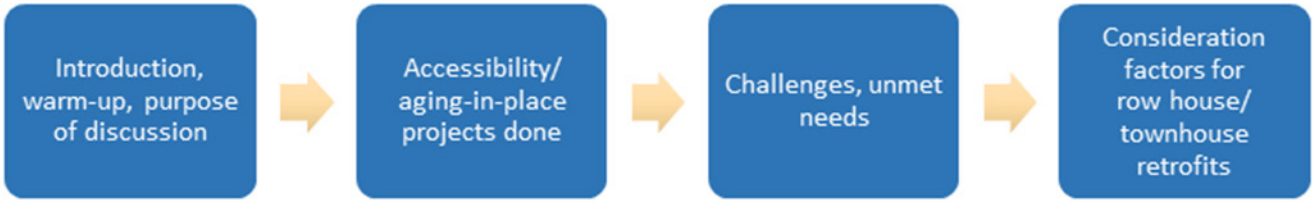
RESIDENTS



CAREGIVERS



PROFESSIONALS



Sample Summary

RESIDENTS

Adults living in single-family homes and who have a physical challenge or disability that affects their stability/balance, strength, vision, or mobility.

QUALIFICATION CRITERIA

- Must have at least two physical challenges/disabilities affecting stability/balance, strength, vision, hearing, or mobility.
- Some live in a home with stairs leading to the main entry; some live in a home with two or more levels connected by a staircase with 5 or more steps.

RECRUITING MIX

- ~ half age 65+; mix of 21—64-year-olds
- Variety of cane, walker, wheelchair, scooter users
- Gender mix
- Variety of challenges/disabilities

CAREGIVERS

Family, friends, or professional caregivers who provide regular support/assistance to adults with some type of physical challenge/disability that affects their stability/balance, strength, vision, or mobility.

QUALIFICATION CRITERIA

- Provide part-time or full-time care for an elderly adult or adult with a disability.
- Person cared for meets qualification criteria for residents' group.

RECRUITING MIX

- Relationship to person caring for (family, friend, home health aide)
- Type of challenges/disabilities of person cared for

PROFESSIONALS

Builders, remodelers, architects/planners, and occupational therapists who recommend, design, or install accessible design solutions.

QUALIFICATION CRITERIA

- CAPS designation preferred
- Have assessed/prescribed/overseen (OTs) or recommended/designed/installed (Contractors) aging-in-place or accessibility modifications for homes. Have completed at least 10 of these projects in the past 3 years.

RECRUITING MIX

- Profession - approximately half should be builders/remodelers
- Several with experience constructing/installing ramps and/or providing/installing a stair lift, porch lift, or elevator

Respondent Profiles - RESIDENTS

Gender	Age, years	Current home stairs	Assistive Devices	Personal Task Challenges
Female	59	2–3 steps in; 2+ levels with 5—8 steps	Wheelchair, walker	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects, turning knobs, seeing small objects in low light conditions
Male	41	4+ steps in; 2+ levels with 8+ steps	Wheelchair	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects
Female	23	4+ steps in; 2+ levels with 8+ steps	Walker, wheelchair	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, turning knobs
Male	49	2+ steps in; 2+ levels with 8+ steps	Wheelchair	Getting on/off toilet, getting in/out of tub, climbing stairs, reaching in closets, standing from seated position, lifting heavy items
Female	49	2+ steps in; 2+ levels with 8+ steps	Cane, walker, wheelchair	Getting on/off toilet, getting in/out of tub, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects, turning knobs
Male	90	2 steps in; 2 levels inside	Cane	Lifting heavy items, hearing TV
Male	70	4+ steps in; 2+ levels with 8+ steps & sunken room	None	None
Female	86	4+ steps in; 2+ levels with 5- 8 steps	None	None
Male	70	2 steps in; 2 levels with 8+ steps	None	None

Respondent Profiles - PROFESSIONALS

Specialty	Typical Accessibility Services Provided	Stair Accommodation Performed	# Years Providing Accessibility Solutions (New Construction | Remodeling)		Most Typical Accessibility Features Provided
OT	Home assessment & accessibility	Exterior ramp, elevator, stair lift, inclined platform stair lift	22 yrs as OT, 7 yrs doing accessibility	n/a	n/a
OT	Home & patient assessment, treatment	Exterior ramp, elevator, stair lift, inclined platform stair lift	n/a	n/a	n/a
Build/ Design/ Remodel	Universal Design & ADA plans, 5' radius bathrooms, increased light, specialty cabinets	Exterior ramp, elevator, stair lift, inclined platform stair lift, porch lift	24 yrs	24 yrs	Zero elevation entrance, wider halls, 5' radius in bathroom, exterior ramps/lifts elevators, auto shutoffs on stoves, robotics, swings
Design/ Remodel	Grab bars, widening doors, ramps, showers	Exterior ramp, elevator, stair lift	n/a	15 yrs	Shower construction, grab bars
Design/ Remodel	Work 5—10 yrs ahead of need to allow retrofit at time of need (block for bars, wider frames)	Exterior ramp, elevator, stair lift, porch lift	n/a	20+ yrs	Lifts, elevators, lighting
Build/ Remodel	Ramps, ground floor bedroom & bath, wider doors, elevator, lifts	Exterior ramp, elevator, stair lift, inclined platform stair lift	30 yrs	n/a	Elevators, ramps
Build/ Remodel	ADA compliance for all new construction	Exterior ramp, elevator, stair lift, inclined platform stair lift, porch lift	20—25 yrs	20—25 yrs	Ramps, remote monitors, lifts
Architect	AIA architecture for Universal Design, AIP, etc.	Exterior ramp, elevator, stair lift, porch lift	23 yrs	23 yrs	Wider door frames, turning radius, showers

Respondent Profiles - CAREGIVERS

Gender	Situation of Person Providing Care To		
	Current home stairs	Assistive Devices	Personal Task Challenges
Female	2+ steps in; 2 levels w/stairs	None	Navigation in home
Male	2+ steps in; 2 levels with 5—8 steps	Wheelchair, walker	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects, turning knobs, seeing small objects in low-light conditions
Female	4+ steps in; 2+ levels with 5—8 steps	Walker, wheelchair	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects, turning knobs
Female	4+ steps in; 2+ levels with 8+ steps	Cane, walker, wheelchair, scooter	Getting on/off toilet, getting in/out of tub, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects, turning knobs
Female	4+ steps in	Walker	Getting in/out of tub, climbing stairs, lifting heavy items
Female	None	Cane	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects, seeing small objects in low-light conditions, hearing conversations/TV
Female	2+ levels inside with 8+ steps	Wheelchair	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects
Female	2+ steps in; 2 levels with 5—8 steps	Cane, wheelchair	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects
Female	2+ steps in	Walker	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, carrying heavy objects
Female	4+ steps in; 2+ levels with 8+ steps	Wheelchair	Getting on/off toilet, getting in/out of tub, using appliances/cabinets/fixtures in kitchen, climbing stairs, reaching in closets, standing from seated position, carrying heavy objects, turning knobs, seeing small objects in low-light conditions, hearing conversations/TV

Respondent Profiles and Recruitment Summary Details

RESIDENTS

Age range: 23—90

Number of participants: 9 (4 females, 5 males)

Entry conditions: 7 with two or more steps up to entrance

Interior levels: 6 had at least two levels of living inside

Assistive devices: 6 (3 females and 3 males) used a walker, wheelchair or cane; 3 used no devices

1 male reported limited challenges

2 males and 1 female reported no challenges

CAREGIVERS

Number of participants: 10 (4 females, 5 males)

The majority reported their family member or client has challenges similar to those reported by the residents.

CONTRACTORS

Number of participants: 8—2 OTs, 1 architect, 5 builders/ remodelers, 3 of whom also provide design services

Experience: 5 had 20+ years experience in the field

Typical solutions provided:

- No-step entrance.
- wider door frames, halls.
- 5' radius in bathroom.
- exterior ramps.
- lifts and elevators.
- auto shut-offs on stoves.
- No-step showers.
- grab bars.
- remote monitoring.
- Robotics.
- Swings.
- Lighting.

Challenges Summary, in Order – Residents and Caregivers

These responses were gathered during the recruitment process and serve as a baseline

Residents	Caregivers	Challenges Reported
Out of 9	Out of 10	
5	9	Getting in/out of tub
5	8	Getting on/off toilet
4	9	Climbing stairs
4	9	Lifting, carrying heavy items
4	7	Reaching in closets
4	7	Standing from a seated position
3	7	Using appliances/ cabinets/ fixtures in kitchen
3	4	Turning knobs
1	3	Seeing small objects in low-light conditions
1	2	Hearing conversations/TV
0	1	General navigation in home

Research caveats: The sample size is small (9 residents, 10 caregivers) and responses are qualitative in nature; extrapolation of results to an entire population is not appropriate.

- Research team professionals in the field of accessibility modification and aging in place developed typical categories of challenges that were presented to the focus group candidates to qualify them for participation. Candidates were asked to provide yes or no answers for each list item and were prompted to add any additional challenges they (or their charges) experience in daily living. All responses were placed in appropriate categories;
- Only one participant in the caregivers' group was the designated caregiver for someone in the residents' group

Discussion of results:

Caregivers in the focus groups were more likely to report challenges than were residents. This could be because:

- All of the independent caregivers (the 9 out of 10 not associated with any of the residents in the earlier group) care for residents who experienced more challenges by comparison; that is, the groups represent genuinely different populations.
- Caregivers and residents may define "challenge" differently due to perspective. Caregivers may be more likely than residents to categorize activities as "challenges" if any degree of delay or difficulty is perceived. Residents may resist classifying an action as a "challenge" if they can ultimately achieve the goal, despite delay or difficulty.
- Residents may perceive the word "challenge" negatively and resist applying it to themselves.

Residents and caregivers prioritized challenges the same, even though the relative incidence residents reported was lower than caregivers reported.

Solutions Summary – Modification Professionals

Characteristics of Accessibility Home Modification Providers			
Most Typical Solutions		**Stair Accommodation Capability**	
4	Bathroom remodel	8	Stair lift/Stair glide
3	Stair lift/stair glide	8	Elevators
3	Elevators	8	Ramps
3	Ramps	5	Inclined platform lift
2	Accessible or curbless showers	4	Porch lift
2	5' radius in bathroom		
1	Zero elevation entrance		
1	Lighting		
1	Wider door frames		
1	Wider halls		
1	Grab bars	**Training or Credentials**	
1	Remote monitors	7	Remodeling
1	Auto shutoffs on stoves	7	Certified Aging in Place (CAPs)
1	Robotics	6	Design/home assessment
1	Swings, ceiling/Hoyer lifts	4	New Construction
1	Bath/bedroom add'n to main floor	2	Occupational therapist
1	Kitchen remodel	1	Architect

Research caveats: The sample size (10 invited, 8 participants) is small and responses are qualitative in nature; extrapolation of results to an entire population is not appropriate.

- The responses at left were gathered during the recruitment process. Professionals in the field of accessibility modification and aging in place developed typical categories of general solutions and stair accommodations that were presented to the focus group candidates to qualify them for participation. Candidates were asked to provide yes or no answers for each list item and were prompted to include any additional solutions they typically provided for older adults or disabled clients.
- Two of the confirmed participants whose responses are shown here did not ultimately participate: one was a remodeler, the other did both new construction and remodels. Neither had CAPs training.

Discussion of results:

- Professionals cited electronic or controls-based solutions more frequently than researchers expected or predicted.
- Professionals reported Inclined platform lifts and porch lifts as standard capabilities and typical solutions much less frequently than they reported elevators, stair glides, and ramps.

Executive Summary

Overall Key Findings

Results from qualitative research provide DIRECTIONAL insights and cannot be reliably projected to a larger audience.

Executive Summary - Overview

- **Primary challenges were related to balance and stability, strength, and stamina:**
  - Going up and down stairs.
  - Maneuvering safely in bathrooms.
  - Getting into and out of bed.
  - Getting in and out of the tub/shower.
  - Getting on/off the toilet.
  - Reaching and carrying items.
  - Opening/closing windows and doors.

- **Concerns and negative impacts of inappropriate design include--**
  - Safety-persistent concern about falling
  - Security-fire safety, fear of criminal activity
  - Confidence-constrained social activity; difficulty to do chores such as grocery shopping and laundry
  - Independence-dependence on paid or family help for these tasks

Executive Summary – Key Locations

- **Bathroom challenges—**
  - No bathroom on the main level of the home.
  - Tight entry.
  - Poor bathroom layout.
  - No maneuvering space.
  - Hard to transfer to and from bathtub, shower, or toilet.

- **Kitchen and storage challenges—**
  - Reaching up, down or into cabinets (poor cabinet design).
  - Lifting and carrying heavy items.
  - Maneuvering within the space.
  - Can't get close enough in wheelchair or walker.
  - Incorrect height and location of counters, sink, and appliances.

Executive Summary - Priorities

- **Retrofit priorities--**
  - Full bath on the main floor.
  - Curbless showers or easyentry bathtub.
  - Entry solutions that blend.
  - Interior stair solutions that work reliably and easily without hindering other family members.
  - Laundry area near the bedroom.

- **Additional considerations--**
  - Blocking/structural support for grab bars or railings
  - Bathroom layout, size
  - Stair railings
    - Both sides
    - Extends past top and bottom steps
    - Proper diameter for grip
  - Shelving/storage
    - Height (low is better) and depth (shallow is better)
    - Drawers and pull-outs preferred
    - Flexibility--intermediate workspaces near oven, range, sink, dishwasher to minimize carrying, holding, and balancing
  - Smooth flooring transitions between rooms
  - Wide doorways and halls
  - Easy open/close windows and doors

Executive Summary – Modification Investment Decisions

- **Affordability is important**
  - Cited as most important consideration factor for selecting solutions.
  - Cited as the most limiting factor with the greatest need for improvement (especially retrofit).
  - Lack of stair solution – particularly entry – cited as the primary factor contributing to people having to move—out of their homes; consistently cited as a financial challenge (stairs solutions can be expensive).
  - Bathrooms and stairways are the two greatest challenges; both are expensive to address.
  - Architectural or structural constraints drive up costs.
    - Lack of total floor space
    - Location of structural support walls
    - Location of plumbing drains
  - Perceived high-cost can prevent needed exploration for solutions.

- **Aesthetics are important, too!**
  - "My house should look like a home."
  - Accessibility features should blend in.
  - Don't "*broadcast disabled*":
    - General curb appeal/resale value.
    - The disability does not define the resident.
    - A disabled resident may seem like an "easy target" for crime.
    - Expensive, vulnerable equipment may be "easy pickings."
    - HOA or municipality restrictions may limit options .

Executive Summary – Barriers to Action

- **Perceived Cost**
- **Actual Cost**
- **Inadequate planning due to lack of—**
  - Imagination.
  - Urgency.
  - Forewarning.
- **Inaction due to a lack of—**
  - Direction
  - Knowledge
  - Support
- **Lack of space to accommodate the needed change**
- **Concern about the value, appearance, or functionality of the outcome**
- **Residents were more likely than their caregivers to…**
  - Focus on staying at home (versus moving to a care facility)
  - Find lots of DIY solutions and work-arounds (versus professional or purchasable solutions)
  - Highly value self-sufficiency and accommodate their own limitations as long as possible
- **Residents with major or numerous limitations were more attuned to current and future challenges than those with few limitations, and more willing to seek out professional support.**

Summary of Key Findings

Residents and Caregivers

Participant comments in red are paraphrased.

Results from qualitative research provide DIRECTIONAL insights and cannot be reliably projected to a larger audience.

RESIDENTS & CAREGIVERS

Insights

- **Residents–Staying at home**
  - Want to stay AND maintain a sense of independence and well-being.
  - Preferred adapting or making modifications to moving.
  - Strong willingness to adapt their homes to meet their needs.
  - Resale value of the home was not top of mind for the residents, and when brought up as a discussion point was not a marked concern.

"I'm doing what I need to do for me right now."
(Resident)

- **Caregivers– Emotional component**
  - Watching their loved one battle disease, life-altering injury, or the effects of aging.
  - Struggling to get them to the bathroom, into the bath or shower, in and out of the house, keeping them safe.
  - Demands on time, strength, mental state, flexibility, social opportunities.
  - Concerns about where to find information about available options, where to turn for help, or whether they could even afford to make modifications.
  - Solutions will improve quality of life for both the resident and the caregiver.

- **Counterintuitive situations**
  - Residents in the focus groups described difficult tra[illegible]
    - Shops and public amenities in the neighborhood, but two sets of stairs inside, with no elevator
    - Accessible designs for individual rooms, but no accommodation to go up and down stairs to reach them
    - Brand-new home custom-built for the owner's disabilities, but using two lifts and a stair glide instead of simply designing the geometry to accommodate one-level living.

"I picked a neighborhood where I would always be able get the necessary supplies. But in my 3-level house I have to get out of my wheelchair and drag myself up and down the stairs to do the laundry or go to bed."
(Resident)

RESIDENTS & CAREGIVERS

Insights (continued)

- **Compared to people who use wheelchairs or walkers, people without major physical limitations were--**
  - Not focused on current or future challenges.
  - Less aware of aging-in-place solutions that could benefit them.
  - More likely to purchase big-box store solutions such as detachable grab bars, grabber/picker tools.
  - More likely to develop ad hoc coping strategies.
- **Barriers to decisionmaking included—**
  - Actual cost.
  - Perceived cost.
  - Lack of an immediate need (no sense of urgency).
  - Lack of resources.
    - Financial assistance (e.g., government grants, rebates, incentives, etc.)
    - Reliable information or education
  - Lack of imagination or experience (don't know what's currently available)
  - Preconceptions about barriers (possibly erroneous)
    - Not enough space
    - Not enough money
    - Won't look good
    - Will make my home look like a hospital

"I'm thinking about the average retiree. How do they afford some of these things?" (Resident)

RESIDENTS& CAREGIVERS

Insights (continued)

- **Consistent priorities**
  - Connection to the outdoors
    - Easy, fast, safe to go in and out.
    - A large, easy-operation window can provide the views, breeze, light, and fresh air that residents crave.
  - The visual appearance of solutions should
    - Convey a sense of safety and stability
    - Complement the home style
    - Not appear "institutional" or "handicapped"
  - Aesthetics were--
    - More important for public areas such as the entry, living room, and kitchen for a sense of normalcy
    - Less important in private areas such as bathrooms and bedrooms–safety and affordability govern here

- **Good solutions--**
  - Are affordable, reliable, maintainable.
  - Effectively provide the needed benefit by improving
    - Safety.
    - Access.
    - Functionality.
  - Blend in well and are aesthetically pleasing.
  - Give users a sense of dignity and independence.
  - Convey a sense of safety and ease.

RESIDENTS & CAREGIVERS

Primary targets for accessibility and aging in place

- **The top areas of concern were universal:**
  - Bathroom.
  - Stairs.
  - Laundry.
  - Entry.

- **Stairs and bathrooms tied as the single modification that folks perceived as necessary to allow them to stay in their home. These solutions—**
  - Reduce isolation.
  - Reduce dependence.
  - Improve confidence.
  - Improve safety.
  - Improve engagement.

- **Secondary areas of concern were related to ease, comfort, speed, reach, and access**
  - Kitchen.
  - Bedroom.
  - Windows and doors.
  - Ceiling lights, smoke detectors.
  - Controls (thermostat, appliance controls).

RESIDENTS & CAREGIVERS

Bathrooms: a particular challenge

- **The bathroom is one of the most frequently used rooms in the house, yet many felt typical bathrooms are poorly-designed.**
  - Poor layout, relationship between elements.
  - Location – a main level without a full bath or even a powder room.
  - Entry and exit
    - Narrow halls leading to the bathroom.
    - Narrow bathroom doorways.
    - In-swinging doors.
  - Space:
    - Front or side clearance for assistance getting into and out of the bathtub or shower
    - Clear space for approaching the toilet
    - Room for supports near the toilet
    - 5-ft turning radius
    - Vanity undercut or knee space

"Why is it that the bathrooms are like a second thought?" (Resident)

"[My] son can only access one of the bathrooms in our home with his wheelchair, and he has to go in forward to use the toilet, but then has to back out and re-enter backwards to be able to transfer and take a shower (Resident)

- **The most common safety concerns affect balance, strength, and range of motion:**
  - Stepping over the edge of the bathtub or shower pan.
  - Standing up in the shower.
  - Sitting down and getting up out of the bathtub.
  - Transferring from a wheelchair onto the toilet, into the tub, or onto a shower seat.
  - Sitting down on the toilet and standing up.

"The bathrooms in my home are all upstairs; my mother, who has Alzheimer's disease and is in a wheelchair, does not have access to a genuine bathroom and is forced to use a "port-a-potty" because she sleeps downstairs in a hospital bed in the living room. (Resident)

RESIDENTS & CAREGIVERS

Bathrooms: a particular challenge (continued)

- **Additional concerns:**
  - Slippery surfaces, especially when water, soap, and shampoo spill
    - Shower chairs.
    - Floors.
    - Faucets.
  - Proximity to needed items
    - Grab bars.
    - Faucets.
    - Shower wands.
    - Toiletries.

"My little bathroom, the little walk-in shower is so small. I only give my mother a shower once a week. I have to have help getting her up the steps, and then the shower's small and I get in with her. Just having something to hold on to [is a challenge]. I don't have a bar, I have one of those little suction things. Sometimes she'll pull it and it'll fall and then I'm struggling to hold her. I really need a more permanent bar in there for her. I don't know how much longer I'm going to be able to do that." (Caregiver)

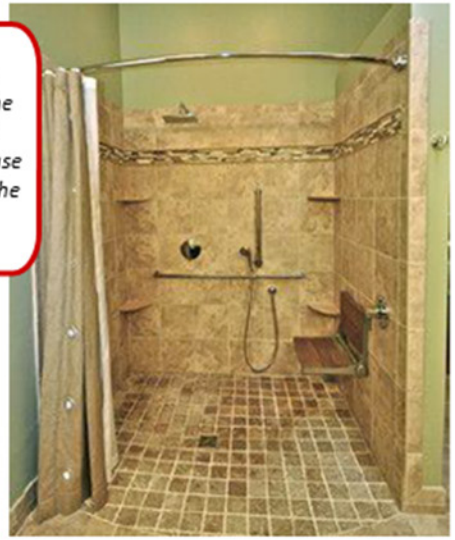
- **Temporary, detachable grab bars typically rely on suction cups:**
  - Cheap, easy, available
  - Caution! Not designed to bear weight and can potentially create a hazard
  - Removable
    - When house is sold.
    - To use in other locations.
  - Don't meet safety and appearance goals

"I keep my grab bars in the cabinet under the sink and just take them out and put them up when I bathe. (Resident)

RESIDENTS & CAREGIVERS

Bathroom solutions – space to move

"Before my father had the shower chair he wouldn't take showers because he was afraid he would fall." (Caregiver)



- **Favorite solutions, perceived best practices:**
  - Walk-in/roll-in showers
    - No lip, curb, or raised edge
    - Multiple, well-placed, permanent grab bars aid with stability and transfers
    - Easy-to-reach ledges for toiletries
    - Bench design and placement:
      - Within easy reach of the shower wand and controls
      - Not too small! Americans tend to be larger and need wider, deeper seats
      - Holes or slats make for easy cleanup
      - Drainage and textured surfaces prevent slips
      - Proper height enables sitting down and standing up.
      - Placement for best wheelchair transfer.
  - Accessible bathtubs
    - Multiple handholds for entry, exit, and for sitting down and standing up
    - Space for wheelchair approach or assistant
  - Several participants recommended the SuperPole™, which can be equipped with a rotating horizonal support, and can be installed nearly anywhere to assist with getting into and out of the tub, getting on and off the toilet, drying off, and undressing/dressing.

RESIDENTS & CAREGIVERS

Bathroom solutions – space to move (continued)

- **Toilet handhold solutions:**
  - Folding bar
    - Ideally one for each side.
    - Folding devices free space for helper.
  - The SuperPole™ also good.

- **Floor plans:**
  - 5-ft turn radius for people in wheelchairs.
  - Room to transfer.
  - Space for helper.
  - Handholds on various walls.

- **Other important considerations…**
  - Pedestal sinks or vanities with knee space
  - Mirrors extending down to the top of the counter
  - Storage
    - Shallow
    - Easy-opening
    - Multiple heights
  - Nonslip floors are vital

RESIDENTS & CAREGIVERS

The challenge of stairs

- Steep, no railings, narrow porches
- Small foyers, as with split-level homes, lack room for turning and door swing
- Lack of a bathroom on each level requires multiple dangerous, time-consuming trips.
- Carrying laundry or groceries up and down is challenging.
- Casual trips for water, snacks, or everyday items are limited.
- Difficult to take out the garbage and recycling.
- Reduces time outside for fresh air, exercise, and socialization.

RESIDENTS & CAREGIVERS

The challenge of stairs (continued)

- **Concerns about stairs differed for those who use a wheelchair compared to those who do not.**
  - Problems with walking some people had difficulty moving their legs due to illness, weakness, or excessive weight, whereas others simply felt less stable due to age. Coping strategies included–
    - Hold on to railings.
    - Don't carry anything while using the stairs (makes laundry, cleaning, etc. difficult.)
    - Sit down to scoot from step to step.
  - Several had explored a stair glide but found the structure of the home would not support it.
  - One resident put a small refrigerator in her bedroom to avoid casual trips up and down the stairs.
  - Problems with wheelchairs or walkers--
    - An assistive device is required at each level; solutions are expensive and cumbersome.

"We have a narrow landing at the foot of the main stairs into our home. To use the stair glide to go up, I have to transfer to a walker and stand in the corner behind the front door, wait for my parents to take my wheelchair up, then scoot over to the stair glide to get on and ride up. My parents then have to maneuver the chair in a narrow hallway for me to get back into it"
(Resident)

RESIDENTS & CAREGIVERS

Interior stair solutions - general

- **Few or minor mobility challenges = easier solutions**
  - An additional railing to provide handholds on both sides of the stairway.
  - Slip-resistant stair coverings or treads.
  - Entrance ramps.

- **Several or major mobility challenges = fewer solutions with more expense, disruption and complication**
  - Stair glides work well, but require:
    - Width.
    - Structural support.
    - Budget.
    - Straightforward geometry (U-shaped, L-shaped, or curved designs increase the cost dramatically.)
  - Transporting wheelchairs or walkers from level to level is a temporary, unsatisfying solution.
  - A wheelchair or walker stored at each level is an unsophisticated, unsatisfying solution.
  - An elevator is appealing but flummoxing: high cost, shaft location, loss of floor space.

- **Planning and logistical hurdles:**
  - Cost—Stair glides, elevators, and new bathrooms are all $10,000 or more (may be hard to justify).
  - Research—Planning and design resources are sometimes difficult to locate.
  - Financial assistance—It is hard to find and can be restrictive or limited.
  - Hiring a professional—Locating reputable service providers was a genuine concern.

RESIDENTS & CAREGIVERS

Interior stair solutions—general (continued)

- **Main level living**
  - Caregivers were more amendable than residents to moving all necessary functionality – bedroom, bathroom, kitchen, laundry—to the main level of the home.
  - Residents preferred solutions that allowed them to continue to use their home as they had for decades. They were more willing to explore modifications that would solve the "stair problem" to maintain…
    - independence
    - connectedness
    - no loss of square footage
- **Partial solutions**
  - Adding or modifying an existing bathroom on the main level can limit stair use to just once in the morning, once in the evening.
  - Moving the laundry area to the main level, or upstairs near the bedroom
  - Converting a den or other main level room to a bedroom

"I do find myself as I get older fantasizing about just a one level place."
(Resident)

RESIDENTS & CAREGIVERS

Interior stairs—lift systems versus stair glides

- **Stair glides were considered a standard–though not optimal – solution.**
  - Advantages
    - Safe access to a second level
    - Cheaper than an elevator
  - Disadvantages
    - Takes up space at top or bottom
    - No room for the caregiver to accompany the occupant up or down during operation
    - Difficult to carry laundry or groceries
    - Fear of scraping or crushing knees or feet
    - Structure may not support the stair glide.
  - Non-straight configurations raise the cost.
  - Still requires separate transport of wheelchairs and walkers, or one for each level

- **Elevators (lifts) were more appealing but considered too expensive.**
  - Advantages
    - No need to transition from a wheelchair/walker
    - Fast and easy
    - Sense of stability, ease, flexibility (can carry additional items)
    - Concealed (preserves appearance of "normalcy")
    - Room for a helper
  - Disadvantages
    - Cost
    - Space--Trading two closets for an elevator may not work in older or space-constrained homes.

"I just want an efficient way to bring me and my wheelchair up." (Resident)

RESIDENTS & CAREGIVERS

Interior stairs: lift systems versus stair glides (continued)

- **Short path of travel (one level or less)**
  - No shaft or mechanical pit required
  - Entry from outside or from garage
  - Quietness and having a battery backup in case of power failure were important features.
  - One resident in a wheelchair shared that he had a lift similar to the one shown in the image (left) in his garage. He spent around $6,000 for it, which others in the focus group thought was a reasonable price. They could envision themselves using this type of solution and felt the benefits were well worth the price.

- **Shaftless**
  - Goals include
    - Traditional appearance when stored out of sight
    - Unobtrusiveness
    - Flexibility

"I think that's better than a stair lift for me." (Resident)

RESIDENTS & CAREGIVERS

Interior challenges–laundry

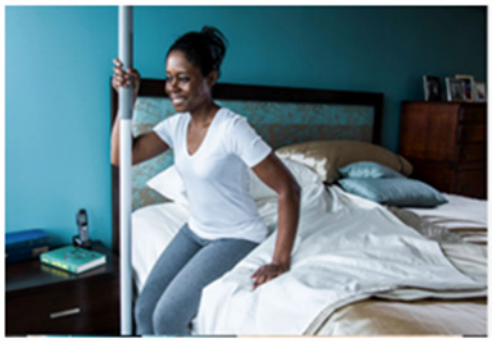
"The most difficult part of the place is the whole laundry factor." (Resident)

- **A test of independence**
  - Navigating the stairs, halls, and doors *while carrying laundry*
    - Concerns about balance/stability
    - Smaller loads may be doable, but require more trips
  - Reliance on someone else to do this routine task can be a reminder of the loss of independence.

- **Needs: size, layout, configuration**
  - Same level and near the bedroom
  - Need space to maneuver, turn
  - Need to be able to reach all needed items and controls
  - Stackable washer/dryers can save space, but may put controls and loading door out of reach
  - Top-loading washers and dryers may also put controls and loading door out of reach
  - The idea of an all-in-one washer/dryer (if it performs well) was appealing to the group:
    - Frees up laundry room floor space
    - Only have to put clothes in and take them out once rather than twice—less lifting and bending

RESIDENTS & CAREGIVERS

Interior challenges--bedroom



- **Difficulty getting in and out of bed was common, especially for—**
  - People in wheelchairs or
  - People who lack strength in legs and hands
  - People with limited motion due to arthritis or other conditions

- **Closets can also be challenging:**
  - Reaching up or down, bending over, lifting weight above the shoulder
  - Location of the closet and operation of closet doors
  - Location of shelves and rods

'I use a bench next to my bed to help make the transition." (Resident in a wheelchair)

One resident with MS has tried several solutions (bars, poles) to assist with getting in and out of bed. Diminishing core strength makes it difficult for her to pull herself up, and her legs "don't bend like they used to," so she has a hard time sitting up to be able to get into the chair from the bed. The SuperPole™ helps her to maneuver her body into the right position.

- **Other challenges:**
  - Maintenance of ceiling-mounted fixtures
  - Accessibility and flexibility of light switches and other room controls

Feedback on Solutions – Bedrooms

- **Solutions:**
  - A variety of poles, handles, and braces for near the bed
  - Reinstalling clothing rods and shelving at appropriate heights
  - Adding double-switch lighting or task lighting near the bed

RESIDENTS & CAREGIVERS

Interior challenges—kitchen

- **Primary difficulties include:**
  - Reaching up into wall cabinets
  - Reaching down into deep lower cabinets
  - Transferring hot or heavy items from the oven
  - Sink access
    - People using wheelchairs not able to roll directly under the sink
    - Can't reach controls and all areas in basin
    - Arms and hands in faucet "spray zone" during operation
    - Cutlery and knives create a hazard when the entire basin and work area can't be seen.
  - Limited access to small, frequently used appliances
  - Stove control locations that expose hands or arms to hot surfaces
  - Taking out the garbage: removing heavy bags from tubs or cabinets, carrying to garage or curb
  - General maneuverability and access

RESIDENTS & CAREGIVERS

Kitchen solutions–general

- **Typical solutions include—**
  - Rearranging and reorganizing
  - Using a grabber or other mechanical extension

- **Based on presented images and discussions of available kitchen devices and cabinets, preferred solutions include—**
  - Drawers in lower cabinets (versus doors), especially with full extension sliders
  - A shelf (possibly pullout) near or underneath the oven to allow easy transfer of hot or heavy items
  - Shelving that does not require reaching up or down to access, such as—
    - Narrow, roll-out pantry shelving (preferred)
    - Pull-down shelving for upper cabinets (concerns about ultimate height, required strength)
  - Efficient kitchen layout
    - Sink, prep area, stove, and refrigerator all nearby
    - Large enough counter space to minimize the need to move around
  - Electrical outlets that are easy to see and reach
  - Lights double- or triple-switched
  - For people using wheelchairs or with reach issues, it is important—
    - Being able to roll up underneath the sink and counter at the right height,
    - Being able to reach faucet and appliance controls, and
    - Having the oven and stove a safe height were important.

"I've rearranged things so that it's his level and he can just reach it; he doesn't have to reach too far down or too far up." (Caregiver)

RESIDENTS & CAREGIVERS

Kitchen solutions improve transitions, movement, and access

A full extension pullout pantry uses the full depth of the cabinet

Lower and mid-level shelves are reserved for the most frequently used items.

Some worried pull-down shelving didn't come down far enough or may require too much strength or dexterity to operate. *Motorized operation was preferred.

Transfer surface next to the oven

Appropriate counter heights

Lower appliance heights

Sink undercut

Roll-under work surfaces

A central turning area

Full-extension drawers in lower cabinets

RESIDENTS & CAREGIVERS

Other challenges

- **Windows**
  - Sliders preferred over single- and double-hung.
  - Lock mechanisms are often too small, poorly located, or require strength and dexterity.
  - Fire safety implications can cause anxiety.

- **Doorknobs**
  - Levers preferred over knobs.

- **Elevation (access for viewing, operation, cleaning, maintenance, repair)**
  - Thermostat (Digital controls can be hard to read.)
  - Ceiling lights (replacing bulbs).
  - Ceiling fans (cleaning and balancing blades).
  - Smoke detectors (test operation, battery replacement).
  - Electrical outlets (low, awkward locations).

"My elderly father has trouble turning doorknobs, and as a result cannot open any of the doors within our home. He gets frustrated and agitated easily by this restriction. It also creates safety concerns. [I] plan to change to door handles that are easy for him to operate." (Caregiver)

"I use a wheelchair. When my smoke detector battery ran down, I had to listen to the beep until I could get someone to come and change the batteries for me. I felt helpless, dependent and frustrated." (Resident)

RESIDENTS & CAREGIVERS

Entry and exit challenges–exterior stairs

- **Lack of railing = fear of falling**
- **Residents who use wheelchairs or scooters require structural modification such as a ramp or a lift**
- **Self-help solutions included—**
  - Installing a short railing for balance going up a few steps
  - Installing a square wooden structure to help create a platform area for the steps to provide increased sense of stability

One caregiver shared that she has considered getting a ramp but didn't know if she should get a portable one to use as needed, or have a permanent ramp installed. The cost and impact on her front yard were deterring factors. Moreover, she wasn't sure how long she would stay in that home and wondered if it would be worth it to go through the process and expense of getting a ramp at all.

- **Caregivers emphasized the importance of the resident being able to get outside for a change of scenery, fresh air and sunshine, and to be able to socialize and meet friends away from home**

"When you can get outside it brightens your day. You can feel better, get fresh air." (Caregiver)

RESIDENTS & CAREGIVERS

Entry and exit challenges–thresholds and doors

- **A raised threshold**
  - Difficult to roll over with wheelchairs and scooters
  - Tripping hazard
- **No maneuvering room**
  - Dependence on others for operation of exterior doors is a fire safety concern.
  - Heavy doors
  - Narrow opening
  - Out-swing doors with narrow landing—no room for a wheelchair, scooter, or walker
  - In-swing doors with small foyer—no room to turn around to shut the door
  - Small landings—no room for a helper to stand beside or for someone with a wheelchair, scooter or walker to safely reach the handle, swing the door, pass through, and shut the door
  - Stairs directly to the side or behind are hazardous.

One caregiver shared that the difficulty getting out the door often discourages people who use wheelchairs or scooters from going outside because they get frustrated and give up.

"It's a state of depression for them because they're losing their independence."
(Caregiver)

Feedback on Solutions

RESIDENTS & CAREGIVERS

Entry and exit challenges— function and appearance

"What I'm looking for most is stability." (Resident)

- **Priorities**
  - Respondents valued both actual and perceived safety. Visual cues included—
    - Slope
    - Railings
    - Evenness of surface
    - Width/amount of space
  - The aesthetic design is important because it conveys impressions of the home's occupants.

- **Insights–safety and stability:**
  - Wide, ramped walkways with no steps
  - Smooth, even, slightly textured surfaces
  - Direct pathways (not U- or L-shaped) seemed less conspicuous, but lack of landings created concerns about user fatigue.
  - Railings:
    - Preferred even for wide paths with very gradual slopes
    - Valued by all respondents, including older adults and heavyset people
    - Even for people using wheelchairs, scooters, or walkers the lack of railings seemed "unsafe;" concerns included wheelchairs rolling backward or the possibility of slipping off the side
  - Preferred railing characteristics:
    - Easy to grab onto and hold
    - Dual height to accommodate all users, including someone in a wheelchair

Feedback on Solutions

RESIDENTS & CAREGIVERS

Entry and exit challenges–function and appearance (continued)

- **Insights–aesthetics:**
  - A ramp or lift should convey security and ease of use, but it should also look good.
  - People want visitors to see that it's a home, not an institution.
  - An obvious entrance ramp may put the person at risk of being targeted for crime (conveys "disabled").
  - Color and material influence impressions and desirability and should blend in with the home as much as possible.
    - Steel gray and brushed aluminum railings triggered negative associations with "hospital" and "institutional." Painted railings were preferred.
    - Concrete ramps implied safety and stability but also seemed institutional. Wooden ramps with railings were preferred.
  - Caregivers valued portable ramps as easy to implement, affordable, and removable.
  - Outdoor lifts that blend were considered potentially less conspicuous than ramps.

"It's still our home. We want it to look nice." (Resident)

"I don't want it to look real disabled. That's probably why I haven't done it at my house." (Caregiver)

"It doesn't scream at you that this is a disabled house." (Caregiver)

Feedback on Solutions

RESIDENTS & CAREGIVERS

Entryway functionality and safety drawbacks

- A smooth, even, nearly flat driveway and entryway were complimented for avoiding steps altogether
- However, the sharp 90-degree angle to transition past the corner of the garage from the driveway to the front porch created concerns about--
  - Space, balance, and stability while turning the corner
  - Width for wheelchairs and walkers

- The slope of the ramp in the image on the left was considered too steep.
- The lack of a landing at the bottom of the ramp was also criticized.

- The absence of railings in all examples created immediate perceptions of "unsafe," even for walkways with a very gradual slope.

- Respondents expressed concern that cobblestones, flagstones, and pavers were tripping and balance hazards, and were a challenge for people using wheelchairs.

RESIDENTS & CAREGIVERS

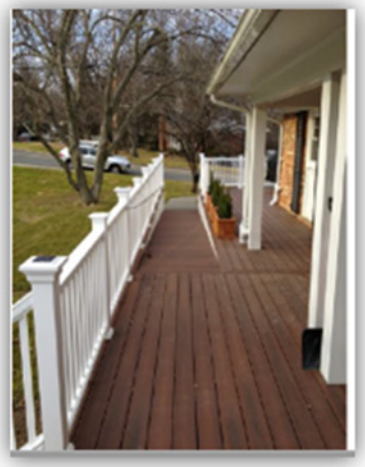
Aesthetics was also a lively topic of discussion

- Good: stable, safe, and functional
- Bad: "institutional"

- Good: Colored railings were preferred as less 'institutional."
- Good: Complementary colors blend in better
- Bad: planter in path

- Good: width, length and gradual incline
- Good: Wood complements the house.
- Good: room near the door to maneuver
- Bad: no landing at the bottom.

Although this ramp had great aesthetics, blended well with the house, and had a railing, the length of the ramp was considered a big drawback.

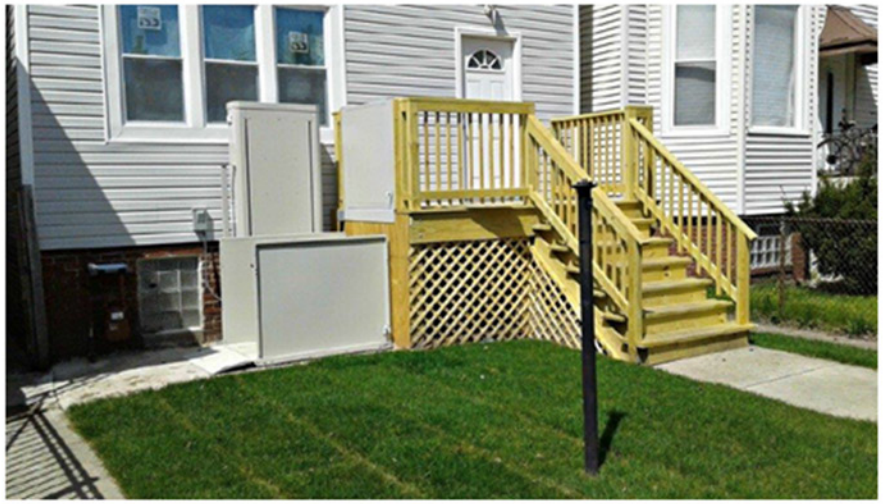


- Good: portability
- Good: stability
- Bad: too narrow
- Bad: no landing to operate door

RESIDENTS & CAREGIVERS

Solutions that blend into the home had strong appeal

- Residents and caregivers liked the two lifts shown below because they:
  - Blend in well/look natural
  - Provide more direct access compared to a ramp
  - Take up less space than a ramp
  - Require less effort than a ramp



Summary of Key Findings

PROFESSIONALS

Participant comments in red are paraphrased.

Results from qualitative research provide DIRECTIONAL insights and cannot be reliably projected to a larger audience.

PROFESSIONALS

Increasing demand for aging-in-place solutions…

"People are looking more and are more [interested in] keeping their investment under their own roof and living life the way they want to."
(Builder)

- **Builders, designers, and occupational therapists all noted increased demand for aging-in-place solutions as more people begin to realize the need to plan ahead to ensure the ability to stay in their own homes.**
  - Seeing grandparents, parents, or friends struggle with leaving their homes is often a motivator for seeking retrofit solutions.
- **More people now view aging-in-place solutions as a wise investment.**
  - The benefits of aging in place has contributed to more people perceiving modifications as a good investment.
  - Retrofitting a home can be a better value than the long-term cost of assisted living.
  - Specifically, adapting the main floor to include a bedroom and bathroom is an investment that can potentially improve resale value and marketability because it is beneficial for so many populations: older adults, those with a disabled family member, multigenerational households.
- **More insurance companies are willing to fund home retrofits as an alternative to placing the family member in assisted living or a nursing home. The insurance companies recognize that--**
  - The retrofit can be more cost-effective in the long run
  - It is much better for the patient's health and well-being
- **Not all long-term insurance supports this arrangement**
  - The cap on modifications is typically around $10,000-$15,000; may only cover a portion of the costs.
    - exterior wheelchair lifts can cost $15,000-$20,000
    - adding an accessible bathroom to the main level of the house could cost $20,000-$30,000

PROFESSIONALS

Proactive planning

- **Professionals encourage clients to proactively plan for future needs when planning general remodels or designing new homes.**
  - Take care of bigger structural and/or design considerations in advance so that it is easier to implement need-specific solutions in the future.
  - Modifications are intended to enhance the quality of the living environment by delivering good functionality, ease of use, and long-term safety.
  - Terminology: "Aging-in-place" emphasizes declining abilities. People are more accepting of solutions that highlight empowerment.
  - Proactive planning means making wise choices to ensure a long, comfortable, easy, and safe future at home.
  - Many modifications have practical benefits that extend to other family members and friends, or that make certain tasks easier regardless of limitations—for example getting strollers in and out of the house, carrying groceries or other items in, etc.
  - Modifications can support unexpected short-term disability due to surgery or accident or illness.

"It's much easier to do when it's all ripped apart than to come back in after the fact and have to do it." (Remodeler)

- **Recommended advance modifications include--**
  - For frame door openings of 3'0" door, a 2'6" door can be installed, but can be easily swapped outIf there is a need to accommodate a wheelchair.
  - Frame the shower with plywood or add blocking in strategic locations to provide support for future grab bars.
  - Improve lighting (entryway, stairs, bedrooms).
  - Replace bathtubs with curbless showers.
  - Add a bathroom on the main level, or run secondary piping in existing powder rooms for a future shower.
  - Stack closets for a future elevator shaft, potentially include wiring.
  - Provide lever door handles instead of knobs.

PROFESSIONALS

Responding to needs

- **Need may be specific, unexpected, and immediate. Priorities include:**
  - Entrance solutions
  - Access to, and safety within, bathrooms
  - Solutions for moving from level to level
- **Exterior access solutions can be particularly challenging due to…**
  - Space limitations
  - Municipality/HOA/landlord restrictions
    - Aesthetics
    - Public safety (sidewalk access)
  - Risk of equipment getting stolen
  - Perception of "disabled" may create a target for crime.
  - Lack of funding
- **In some older homes or row houses, the width of the hallways is a bottleneck.**
  - Even if the doorways in the home can be widened, it is often difficult to widen an entire hallway to accommodate someone who has a wide wheelchair.

"Approximately 80% of my company's work is in reaction to a situation that has arisen suddenly (e.g., illness or injury such as paralysis, loss of limb, etc.) and they are having to find solutions more out of 'damage control' than being able to proactively plan."
(Occupational Therapist)

"One of the worst scenarios has been for people in Baltimore who need either a wheelchair lift or ramp to get into their home, but there is no space outside for a ramp, and they can't afford to get a lift because they are state-funded and the state will not pay for a lift because of the cost ($15,000-$20,000). The people may then be forced to move because they are no longer able to get in and out of their home.
(Occupational Therapist)

PROFESSIONALS

The challenge of geometry and area

- **Space for an accessible bathroom, bedroom, or hallway may require**
  - Additions
  - Major redesign of interior walls
  - Possible loss of another room
- **Bathroom and kitchen renovations may be restricted by—**
  - Foundation type
  - Location of drains
  - Door swings in the wrong direction, which can't be reversed due to location of fixtures or a too-narrow hall.
- **Hallway limitations**
  - Too narrow to maneuver a wheelchair
  - No room for 90-degree turns into bathroom or bedroom
- **Staircases**
  - They are too narrow for a stair glide. Larger adults and people who have difficulty bending their legs can't sit comfortably and may fear for their knees or toes.
- **Laundry**
  - Full-sized washers and dryers (W/D) are space hogs.
  - Stackable or all-in-one units can save space and be installed in closets or other small areas, but load size is restricted. Sometimes there's not enough approach space, and people who use wheelchairs cannot reach high enough to use stackable W/Ds.
    Builders reported low confidence in the performance of combination W/D units.

"A townhouse had the garage as the first level. The owners used a wheelchair, and the garage was too narrow for them to get out of the car, into the wheelchair, and then into the house. The garage couldn't be widened so the owner had to park their car on the street to be able to get in and out of the house with the wheelchair." (Remodeler)

"Spatial constraints are a constant." (Remodeler)

One professional expressed frustration with having to incorporate all-in-one washer/dryers in accessible apartments designed and built for HUD.

"The washer/dryer is one of the worst things out there for handicap accessibility. The appliance didn't work well and was poorly received, yet space did not permit including regular front-loading washers and dryers." (Remodeler)

PROFESSIONALS

Bathrooms are a priority, but rife with challenges

- **Space and geometry are typical challenges for bathroom modifications.**
  - Retrofitting tub with door/opening: This solution is potentially low cost, but does not eliminate the step-up transition.
  - Walk-in tubs: They also have step-up curb. Size and shape make them difficult to install. The whole door frame must be removed to get the tub into the room, even if the bathroom has adequate space for the unit. Because most are jetted, they require new electrical work--additional trouble and expense.
  - Curb-less showers: They are optimal solution; however, in slab-on-grade foundations the drain can't be moved without major demolition and new concrete work. Even second floor bathrooms may require floor joist adjustment.
  - Wet room: Sometimes the best solution is to make the entire bathroom a wet room. Does not have universal appeal.
  - Spatial Complications: Existing drain lines for sinks, showers, and tubs require problem-solving and skill, especially when the bathroom's size, layout, or location are lacking. The ideal 5-ft. wheelchair turning circle is a challenging target. In some cases the remodeler may replace the vanity with a wall-mounted or pedestal sink, or steal space from another room. Using "crossing guard" grab bars for toilets can help to create space because they fold up out of the way when not in use.

"The closer you can get your tie in, the less drop you need on that waste line." (Remodeler)

- **Plumbing is a primary when adding a new bathroom to the main level**
  - Easiest and least expensive: above or below an existing bathroom, to share a wet wall.
  - Alternate: hide the waste line in the existing wall or a new, insulated chase on the outside of the house.

- **Finding Space**
  - Consider taking space from a dining room, living room, underneath the stairs or a porch.
  - If a fully accessible three-piece bathroom is not possible, at least try to provide an accessible powder room.

PROFESSIONALS

Safety is fundamental

- **Safety considerations include—**
  - Fall prevention
  - Fire safety
  - Drowning prevention
  - Security and crime avoidance

- **Falls are a primary concerns for older adults—**
  - Contributing factors:
    - Weakness
    - Pain that hinders movement
    - Vertigo or poor balance
    - Physical instability
    - Vision issues
    - Cognitive decline
  - High beds and leaving the light off when getting up in the middle of the night to go to the bathroom also contribute to falls, particularly among older adults.
  - Hazardous locations:
    - Bathrooms
    - Stairs (especially steps with no railings)
    - Door thresholds and flooring transitions

"Billions of dollars are spent in the US every year as a result of fall-related injuries." (Occupational Therapist)

PROFESSIONALS

Good retrofit solutions are well-known, readily available

- **Kitchen**
  - Cabinets must put frequently used items within easy reach.
  - More nontraditional configurations are available than ever before.
  - Custom height and depth of cabinets and countertops is vital.
    - Modification: time-consuming, often requires a skilled carpenter
    - Factory-built accessible sizes, custom-built cabinets are available, but expensive
    - Cabinets made for the commercial trade offer more variety of sizes
  - Sink height and location must allow wheelchairs access.
    - Cutouts to allow roll-under
    - Side-access can sometimes work, but not for corner locations
- **Home automation**
  - Automated systems for
    - Locking/unlocking doors
    - Controlling HVAC system
    - Opening/closing windows, doors
  - Motion-activated lights
    - Improve safety, prevent falls
    - Don't require behavior changes
- **General**
  - Color contrast between walls, floor, furniture, transitions, etc. (for people with low vision)

"Residents may forget to turn the light on when they get up or may not have a bedside switch. OTs shared that entrenched habits are hard to break for anyone, but people with dementia are at a particular disadvantage. (Occupational Therapist)

PROFESSIONALS

Good retrofit solutions are well-known, readily available

- **Bathrooms**
  - Mounted grab bars
  - Enlarging the turning radius or providing more maneuvering room
  - Nonslip floors
  - Curbless showers
- **Stairs**
  - Handrails on both sides that extend beyond the last step
  - Smaller width (1.5") handrail for easy grip
  - Good lighting on staircase
  - Slip-resistant treads
  - Color contrast or a colored strip on the edge of the steps
- **Flooring**
  - flat, even surfaces and smooth transitions
- **Entry doors**
  - Flat, even threshold (no lip/ridge)
  - Eliminating small steps at entry by making the porch level with the doorway, adding a small ramp
- **Lighting**
  - Motion sensors
  - Easy-reach placement of switches
  - General--color contrast between walls, floor, furniture, transitions, etc. (for people with low vision)

Finding resources:

Keeping up with newly available devices and products is a challenge, and professionals often rely on suppliers for recommendations:

- Availability
- Performance metrics
- Installation requirements
- Warranty

OTs stressed a team approach (medical professional, contractor, client) for decisionmaking.

There are specific reasons that a medical professional recommends a particular solution for an individual client. For example, the OT understands each client's transfer capabilities and can recommend support locations.

PROFESSIONALS

Appearance is important for acceptance

- **Improved aesthetics have encouraged proactive planning for aging in place.**
  - People value safety and ease of use: they also want their home to look and feel like a home, not a hospital or an assisted living facility.
  - Solutions that are beautiful and look like a normal, natural part of the home have real value.
  - Change can be unsettling; options that complement the design of the house encourage acceptance.
  - Good aesthetics frame the solution as a benefit instead of a reminder of a limitation or a signal of disability.

- **Aesthetics are particularly important in public or high-visibility locations.**
  - Curb appeal of entry ramps or lifts--
    - Conveys a strong impression of the occupant
    - May need to pass aesthetic design standards of an HOA
    - Can be improved by blending, hiding, or integrating with the home's exterior
    - Can improve security by not broadcasting that a resident is "disabled"

- **Affordable and portable solutions typically have poorer aesthetics.**
  - Aluminum ramps are considered among "the worst"--metallic appearance makes it seem institutional

"I think it's shifting with more of this awareness of everything. I think before, a lot of people thought it looked hospital-like and they didn't really want to see that." (OT)

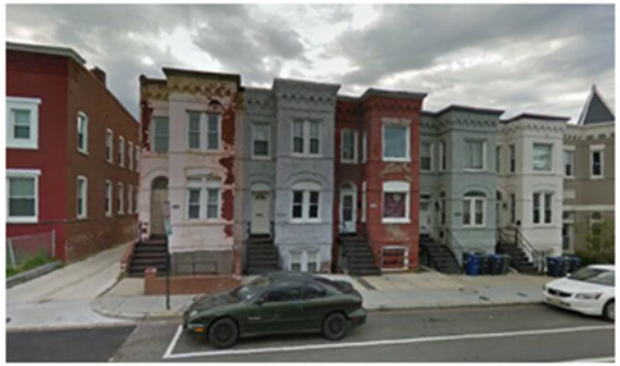
PROFESSIONALS

Walk-ups present additional challenges…

A narrow floor plate often results in inside hallways that are tight, stairs with 90-degree turns at the top or the bottom, and small rooms.

Typically, bathrooms have poor layouts and no room to maneuver.

Townhomes and row houses often have narrow entrances, shallow approaches, and no room for a ramp due to the public sidewalk. Side or rear entries are typically not an available solution.



Need for Improvement

- **Affordability ranked highest overall.**
  - If keeping people in their homes is the top priority, then affordability is the first consideration.
  - People with low or fixed incomes are particularly challenged by cost.
  - Despite available grants, rebates, and other funding sources, homeowners often struggle to get needed financial assistance. Challenges include--
    - Not knowing what the options are/whom to contact
    - Difficulty understanding technical and financial information, following complex processes with multiple steps and requirements

- **Functionality was ranked a close second.**
  - All other other considerations are moot if the client simply can't afford the solution.

- **Factors that drive up costs--**
  - Code requirements.
  - No room for a ramp = wheelchair lift = more expensive.
  - Lack of square footage = move walls to steal space = more expensive.
  - Drains embedded in concrete slabs = more complex = more expensive.
  - No structure or width = no stair glide = elevator = more expensive.
  - Large, highly complex solutions = design and labor requirements = more expensive.

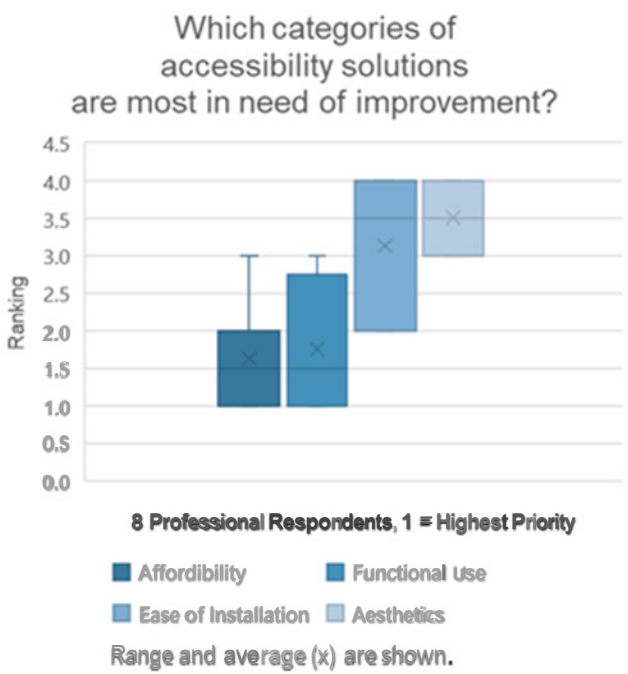
PROFESSIONALS

Builders and Designers – Summary of Suggestions

LIMITED MODIFICATIONS	GENERAL
Modify bath with wider door, grab bars, larger floor space	When possible, include Universal Design concepts into planning
Replace tub with roll in shower	During general renovations add blocking, etc. for future needs
Install a straight or curved stair lift	Include single-level living spaces when possible
Add railings to stairs where needed	Consider adding "stacked" closets for possibility of future elevator
Relocate controls for better access	Check long-term care policies for modification funding coverage
Making entry doors accessible	Affordability is typically a major factor--set a realistic budget
Use contrasting paint colors where appropriate	
Use team approach to designing the space	**NEW BUILD OR MAJOR MODIFICATION**
Similar suggestions to others for kitchen accessibility	Add wider halls and doorways to new or renovation plans
Plenty of general and task lighting, consider smart home devices	Choose curb-less showers rather than standard tubs
Consider aesthetics when choosing solutions	Plenty of general and task lighting, consider smart home devices
Affordability is typically a major factor--set a realistic budget	Locate wall switches/outlets/thermostats at accessible height
	Include a full bath on main level or add rough-in plumbing for later
	Consider an elevator or wheelchair lift for access to multiple levels
	Choose windows that are easiest to open
	Use team approach to designing the space
	Consider aesthetics when choosing solutions

Need for improvement

The eight builders and remodelers in the focus group were presented with four accessibility characteristics and asked to rank typical modifications available in the marketplace.



Key takeaways from all three focus groups:

- *Affordability is the top need; functionality is a close second.*
- *Spatial constraints are a major difficulty, especially for bathrooms and entries.*
- *Plumbing coordination – especially drain location – complicates bathroom solutions.*
- *Aesthetics are important. Solutions should convey taste, style, normalcy, and a sense of confidence.*
- *Manufacturers are recently providing a wider range of attractive, functional products to meet market demand.*
- *Residents ultimately prioritize their own safety and comfort over resale value.*

Milestone M4.1

Categorized, prioritized list of challenges

REPORTED PRIOR TO DISCUSSION	ADDED DURING DISCUSSION
Getting in/out of tub	Hard-to-operate, unreachable windows & doors
Getting on/off toilet	Height of ceiling lights, smoke alarms, outlets, t-stats and switches
Climbing stairs	Cabinet and counter workspace height
Lifting, carrying heavy items	Getting in and out of bed
Reaching in closets	Tight or inaccessible washer and dryer
Standing from a seated position	Bathroom size, location, layout
Using appliances/ cabinets/ fixtures in kitchen	Slippery floor surfaces
Turning knobs	Solutions for heavyset people
Seeing small objects in low-light conditions	Poorly situated appliance and fixture controls
Hearing conversations/TV	Transferring heavy, hot items in kitchen
General navigation in home	Stair glide limitations--how to transfer a wheelchair or walker?

Milestone M4.2

Categorized, prioritized list of user-suggested solutions

INTERIOR STAIRS	ENTRY STAIRS - EXTERIOR
Elevator	VPL (porch lift- two levels)
Shaftless residential elevator (two levels)	Ramp-- permanent/architectural
Stair lift (chair glide)	Ramp-- modular/semipermanent
Stair lift (chair glide) curved	Railing (additional)
IPL (Inclined personal lift--platform)	Ramp portable/folding
Moving all functions to main level	Gradually sloping walk with railings

LAUNDRY	BEDROOM
Reposition washer and/or dryer	Install floor to ceiling support pole
Widen doorway	Replace bed with adjustable model
Install stacked units	Install bed-mounted grab rail
Install "all-in-one" washer/dryer	Modify closet for better access
Relocate laundry to preferred level	

DOORWAYS AND WINDOWS	KITCHEN
Reverse swing of door	Modify parts of counters for wheelchair access
Install lever handles	Relocate most frequently used items for easier reach
Widen frame--with no door	Modify sink for better access
Widen frame--with new door	Accessible storage: reachable or pullout/pull-down shelves
Install new barn door (outside wall)	Add lighting and accessible outlets
Install new wider pocket door	Accessible appliances, storage platforms for oven, microwave
Replace double-hung with more accessible type	Use a “reacher/grabber” for high, deep areas

Milestone M4.2 (continued)

Categorized, prioritized list of user-suggested solutions

BATHTUB	LACK OF BATHROOM TURNING SPACE
Add grab bars only	Remove vanity--replace with pedestal sink
Install shower bench and hand shower	Use new roll-in shower to add floor space
Suction mount grab bars **perceived as safe but actually not*	Create wet room
Convert tub to curbless shower	Expand bath to adjacent room/closet
Replace tub with walk-in tub with door	Reposition fixtures
Add shelves in shower that are easy to reach	Widen doorway
Modify space to create a "wet room"	
Install floor-to-ceiling support pole	

BATHROOM SINK	LOW TOILET
Replace with accessible wall mount	Install wall mount grab bars
Replace with accessible sink/counter	Install fold-down grab rails
Convert existing cabinet for roll-under	Add seat riser
	Install accessible height toilet
	Install floor-to-ceiling support pole

APPENDIX C:
SUMMARY OF DESIGN SELECTION AND PROTOTYPE CONSTRUCTION

Home Innovation Research Labs and SUNY IDeA Center present:

Task 5 – Design

Leading to

Task 6 – Prototype Construction

Prepared for:

IAT and Team Feedback

February 2020

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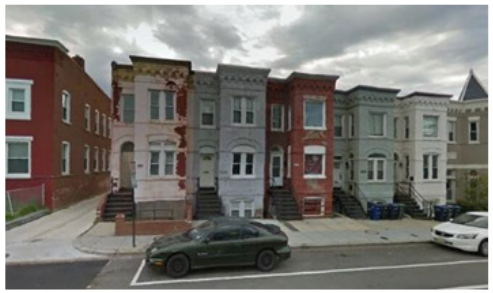
- **The House Typology**
  - Townhouses, rowhouses, etc.
  - Small rooms, narrow floor plates
  - Functionality on several levels
  - Elevated entrances
- **The Population**
  - Aging adults
  - Those with disabilities
  - Those recovering from injury, illness
- **The Objectives**
  - Study the typical pitfalls of home mods
  - Identify best practice solutions
  - Define counter examples
  - Overcome barriers to adoption
  - Optimize design, coordination, and installation
  - Maximize benefits and minimize cost, complexity, and risk



The Team:

- **Home Innovation Research Labs**
  - Patti Gunderson–lead investigator, PE
  - John Peavey–director, applied engineering

- **SUNY, IDeA Center**
  - Ed Steinfeld–director, architect, professor
  - Danise Levine–assistant Director, architect, home mod expert

- **Subcontractors**
  - Jim Costello– Affordable Adaptive Solutions
  - Richard Duncan–Universal Design Institute
  - Louis Tenenbaum–Homes Renewed Resource Center
  - Helen Eltzeroth–Accessibility consultant, IAT liaison
  - Charlotte Wade–Aging-in-place consultant
  - Sue Weideman–Environmental psychologist, statistician

Methodology–Investigative Approach:

These precursor research tasks are complete:

- *Interdisciplinary Advisory Team (IAT)*
- *Literature Review*
- *Focus Groups*
- *Site Observation*

These research tasks are next:

- *Prototype Development and Construction Coordination*
- *Testing and Evaluation*
- *Optimization*
- *Results dissemination (including projected costs)*

Takeaways from precursor research–Literature Review

- **Little innovation:** not much has changed, though there is-
  - a **heightened awareness** and new, exciting **digital sensors/controls.**
- **Process**: critical to overall satisfaction and reported utility
  - personal **relationship** with the contractor, real **control** of the project.
- **Appearance** : highly valued by homeowners
  - impacts perceived effectiveness.
  - It's not just about beauty, it's about confidence and naturalness.
- **Key research areas**
  - Access **in and out**
  - Access to all **essential facilities**
  - Access within **bathrooms**
  - Access and usability of **storage**

Takeaways from precursor research–Focus Groups

- **Three cohorts**
  - Users/Caregivers/Providers
- **Key research areas (confirmed the Lit Rev)**
  - Entries (getting into and out of the home)
  - Stairs (or "one-level living")
  - Bathrooms
  - Kitchens and Laundry (especially storage and work surfaces)
- **An interesting (anecdotal) difference in perception***

Users (%)	Caregivers (%)	Described Challenge as a Major Impediment
55	90	Getting in/out of tub
55	80	Getting on/off toilet
44	90	Climbing stairs
44	90	Lifting, carrying heavy items
44	70	Reaching in closets
44	70	Standing from a seated position
33	70	Using appliances/cabinets/fixtures in kitchen
33	40	Turning knobs
11	30	Seeing small objects in low-light conditions
11	20	Hearing conversations/TV
0	10	General navigation in the home

* "Can-do" phenomenon confirmed by providers and IAT

Takeaways from precursor research–Site Observation

- There is no "typical" floorplan.
- There is a broad variety of "existing conditions."
- Remodeling to prepare for a sale is a perfect time to add accessibility/Universal Design features.
- Three logistical challenges define the typology:
  - Small rooms and limited floor area
  - Functional areas on multiple floors
  - Limited setback space in front and rear
- Recent complexity: *GARAGE AS GROUND LEVEL*

Next Steps: Construction, Evaluation, Optimization

- **Prototypes in the lab**
  - Prioritize affordability (cost and market drivers are research tasks)
  - Both large-scale and small-scale solutions
  - Select integrated, attractive, and approachable solutions
  - Identify and solve coordination and construction barriers
  - Focus on a small handful of important potential solutions that…
    - *Meet the **unique** needs of the house typology*
    - *Can help the **most** users*
    - *Show promise for a **large improvement** in cost, functionality, or appearance*
- **Development**
  - Evaluation—Bring back the most engaged and thoughtful members from each cohort of our Focus Groups to test, question, and provide feedback.
  - Optimization—Use an iterative process to identify opportunities for improvement and maximize benefits while reducing cost, effort, complexity.

Design Team Brainstorming; IAT and Team QC

Team	
4.9	All-Push Door
4.9	FlexStep
4.4	StairSteady
3.9	Movable Storage Wall
3.5	Fixture-Integrated rails
3.5	Vehicle Lift
3.5	Turntable/Carousel
3.0	Toilet Riser/Step Combination
2.3	Adjustable-Height Toilet
1.6	SuperPole

IAT	
4.4	SuperPole
3.9	StairSteady
3.5	All-Push Door
3.4	Toilet Riser/Step Combination
3.4	FlexStep
3.1	Fixture-Intg'd rails/handholds
2.5	Movable Storage Wall
2.5	Turntable/Carousel
2.1	Vehicle Lift
1.8	Adjustable-Height Toilet

1st (tied) All-Push Door

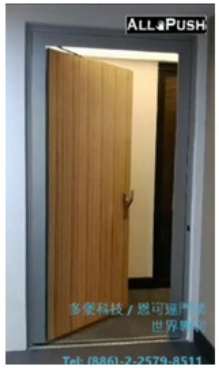
- **Opportunities**
  - Interior
    - Bathroom and bedrooms, narrow hallway approaches
    - Potentially eliminates costly modifications such as hall widening (though likely requires door widening)
  - Exterior
    - Frame in each direction allows for locking mechanism (security) and gasketing (draft-reduction and energy efficiency).

- **Existing Alternate Solutions**
  - Stair lift (obtrusive, structural limits)
  - Platform lift (obtrusive, expensive)

Proposed Prototypes in the Lab

Research

- Moveable walls that allow various widths/configurations for approach
- Installation in Lab House exterior door openings
- Investigation of gaskets/thresholds
- Constructability issues – coordination with U.S. sizing, materials, locksets, etc.



1st (tied) All-Push Door

Proposed Prototypes in the Lab

Notes and Feedback

Support: Concept of double-swing is good. Saloon (alternate) with double-acting hinges requires removal of door stop, handle and lockset—All-Push can accommodate those.

Concern: doors already hard to size—changing door frame is a major modification (better to use existing opening); demolition and foreign sizing/shipping are potential problems.

Note: Door operators can be inexpensive—$1,000 and sometimes can solve the majority of problems. Auto openers have battery backup AND will open normally (manually).

https://www.gentlemandoorautomation.com/?gclid=EAIaIQobChMI54aKuvDv5gIVDWKGCh2hJQxHEAAYASAAEgJXW_D_BwE

Concern: Would NOT work if opening already is too narrow; then widening the opening alleviates the bulk of the problem—the All-Push door is a costly way to achieve the last 5%.

Support: Study as exterior doors—may be highest and best use of the All-Push Door.

Concern: For *remodeling,* the frame must be wood because it may need to be modified to fit into crooked opening (typical existing condition). Prob more expensive.

Note: Must have VISION PANEL to avoid accidents.

Note: Floor-mounted closure from restaurant (saloon) configuration works well, but the residential version of this has never taken off so far.

Team Note: Manufacturer offered to provide sample for lab testing. Success would increase the range of solutions to a major architectural problem.

1st (tied) FlexStep

- **Opportunities**
  - Single footprint for BOTH stair and lift
  - Avoids awkward appearance of platform lifts (salability, stigma, crime target)
- **Existing Alternate Solutions**
  - Ramps (require MUCH more space)
  - Porch lift (advertises "disabled")
- **Challenges**
  - High cost
  - Limited to six steps above grade

Proposed Prototypes in the Lab

Research

- Deck at Lab House's east side exterior wall, adjustable height
- Onsite observation and interviews with existing homeowners in NYS who've had this device installed
- Investigation of potential code considerations
- Exploration of acceptance, interest by U.S. buyers

Photo Credit Liftup

1st (tied) FlexStep

Notes and Feedback

Concern: Internal power? Fail-safe?

Note: On the issue of stigma or advertising a disabled person lives there—People already know. They would much rather have something that's reliable and perfectly functional.

Support: Space saving (double duty) is key.

Note: Previous version (all commercial) never caught on.

Concern: what about a mech breakdown half-way down or up? Lose BOTH means of egress. Concern: open stairs—shear point issues (obstacles) must have sensors. ACME screws or hyd. actuators are needed.

Alternatives: Straight stairs w/folding inclined platform lift: stairs are then permanent and less costly. Platform lift is removable.

Note: needs mechanical crank or SOME MEANS to operate without power (both directions)

Concern: Cost!

Team note: Manufacturer has agreed to provide test unit at discount. Existing installations in NYS will provide survey and interview opportunities

Photo Credit Liftup

3rd StairSteady

- **Opportunities**
  - Simple, inexpensive, manual, low/no maintenance
  - Fills a definite, though narrow, gap
  - Uniquely appropriate to TH/RH
  - Ripe for review and installation guidance
- **Existing Alternate Solutions**
  - Stair lift (obtrusive, structural limits)
  - Platform lift (obtrusive, expensive)
- **Challenges**
  - Continued loss of strength, stability may mean time range of usefulness is limited

Proposed Prototypes in the Lab

Research

- Device has been available in other countries for several years; value and usability for U.S. buyer needs testing (third-party validation).
- Investigation of potential code issues, conformance with U.S. safety standards
- Installation in full height stairs in Lab House
- Installation at exterior deck of Lab House
- Exploration of acceptance, interest for U.S.

Photo Credit Hillz Tech Ltd

3rd StairSteady

Notes and Feedback

Concern: Maintenance—painted enamel–may chip, look old quickly.

Concern: Requires both upper and lower body strength, stability

Support: Horizontal bar provides stability so dominant side is always engaged. Steep staircases with only a single banister are common in older, urban homes. May need to lean heavily on rail. If it's single, can't provide good support both directions.

Concern: Need for disclaimer, training? How to address varied abilities and overconfidence.

Support: Good concept. Usually looking for two rails (no useful quad muscles mean pull up on rails, lock knees. Always go down backwards. This would work well with StairSteady. Locking mechanism is very reliable.

Concern: Limited # of clients

Concern: May require training, disclaimers, avoidance of overconfidence

Team notes: It fills a need uniquely with a low-cost, manual, low-maint. solution. It may be interim but may also keep people at home for months or years.

Photo Credit StairSteady

4th Moveable Storage Wall

Proposed Prototypes in the Lab

- **Opportunities**
  - Potentially increases number of functional areas on a single floor
  - ADDS storage instead of robbing space from storage
  - Very appropriate to TH/RH
  - Alternate sharing of square footage where partition wall does not include plumbing/mechanical
- **Existing Alternate Solutions**
  - Additions (expensive, requires yard space)
  - Lifts and elevators (expensive, obtrusive)
  - Mech'd storage systems
- **Challenges**
  - May only be appropriate for limited layouts/ floor plans

Research

- Use plywood proxies within lab house to determine best configurations, likely layouts
- Modify commercial options for residential use
- Explore operation methods: manual, flywheel assist, electric motor
- Explore architectural coordination issues—door, soffit, flooring

Photo: ORI Pocket Closet

Graphic: Spacesaver Intermountain LLC

4th Moveable Storage Wall

Proposed Prototypes in the Lab

Notes and Feedback

Concern: Floor space is already limited.

Support: Potential. Like a divider. Similar solution for client: ceiling-hung fixed curtain, moved back and forth btwn workout room and laundry room. Power wheelchair user. Office partitions. (similar to using hallway space—two uses, rather than solely dedicated to a single use [laundry])

Note: Also Murphy bed–flips up, desk stays. Same concept – use floor space alternately for different purposes.

Support: In limited cases may allow all functionality to move to main level, avoiding huge cost and disruption of stairway solutions.

Team note: Initial research would use plywood cabinets on casters to confirm functionality and potential layouts that would be suitable. Devices currently available for other industries would be re-designed to match residential scale and needs—dimension, weight, appearance, functionality.

Photo: ORI Pocket Closet

Graphic: Spacesaver Intermountain LLC

Potential 2nd round

Proposed Prototypes in the Lab

- **Fixture-integrated rails/handholds**
- **Vehicle lift**
- **Turntable/carousel**

Notes and Feedback

Fixture-Integrated rails/handholds—There are already many wall-mounted options available. Reasonable cost, good aesthetics.

Vehicle Lift–expensive, possibly not an improvement over porch lifts. The one exception may be a cassette or "stow-and-go" version that can live under a porch, protected from weather, vandalism and theft, and which can utilize the public right-of-way temporarily

Turntable/Carousel–IAT: many pitfalls and dangers, though a few found the concept intriguing for a targeted cohort. Team: could explore an "early stage" design as proof-of-concept. Determine things like what uses/locations are suitable, whether permanent or moveable is best approach.

Additional Topics

Lift-wall tubs–Elevance, Elevate: Cost up to $12,000-$15,000, Kohler version fraught with failures, leaks. What would team study? Possibly compatibility with Hoyer and ceiling lifts

Top-pour garage floor to avoid single step: One or two steps from garage is VERY common; an easy, single approach solution would have major impact.

Lowest-ranked Prototypes

Proposed Prototypes in the Lab

- **Toilet Riser/Step Combination**
- **Adjustable-Height Toilet**
- **SuperPole**

Notes and Feedback

General agreement between IAT and Team regarding these lowest-ranked items

1. Toilet Riser/Step Combination was considered an unlikely combination subject to maintenance issues and trip hazard potential. Simply replacing with a comfort-height toilet is safe and inexpensive.

2. Adjustable-Height Toilet was considered gimmicky and far too expensive, likely to be prone to breakdown. Satisfies too small a cohort to warrant expense and attention.

3. SuperPole, unlike the other two, was rated highly by IAT but mostly because it is an excellent solution for certain situations. All agreed it is often prescribed, not used, as frequently as warranted. Team pointed out it is already well-developed, with several accessories available, and would not likely benefit from this project's research.

Final lab research choices remain the same

Team	
4.9	All-Push Door
4.9	FlexStep
4.4	StairSteady
3.9	Movable Storage Wall
3.5	Fixture-Integrated rails/handholds
3.5	Vehicle Lift
3.5	Turntable/Carousel
3.0	Toilet Riser/Step Combination
2.3	Adjustable-Height Toilet
1.6	SuperPole

IAT	
3.9	SuperPole
3.8	StairSteady
3.6	Toilet Riser/Step Combination
3.4	All-Push Door
3.2	FlexStep
3.2	Fixture-Integrated rails/handholds
2.4	Movable Storage Wall
2.4	Turntable/Carousel
2.4	Vehicle Lift
1.8	Adjustable-Height Toilet

APPENDIX D:
HOME INNOVATION
ACCESSIBILITY EVALUATION SURVEY

SURVEY: HOME INNOVATION ACCESSIBILITY EVALUATION

The authors thank users very much for coming to the lab recently and helping them to evaluate the StairSteady, FlexStep, All-Push Door, and AssiStep. The input was very helpful. Home Innovation's research of these accessibility devices is sponsored by the U.S. Department of Housing and Urban Development (HUD). It is intended to gather user opinions of each device and does NOT include any sales or marketing activities.

Now the authors request that participants complete a short survey about their experiences with each of these three products. For the following sets of questions, respondents should check the response that best reflects how they felt about each accessibility device. Participants will also be able to type in their own descriptions

StairSteady

1. Please indicate range of agreement or disagreement with each of the following aspects of the **StairSteady**.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
It is easy to understand how to use the StairSteady.	❍	❍	❍	❍	❍
It takes more time to go up and down the stairs than it should.	❍	❍	❍	❍	❍
The StairSteady requires little physical effort to use it.	❍	❍	❍	❍	❍
Needed assistance to use the StairSteady	❍	❍	❍	❍	❍
When using it, sometimes made mistakes that required redoing some steps	❍	❍	❍	❍	❍
Using the StairSteady raised concerns about personal safety	❍	❍	❍	❍	❍

Any additional comments about previous answers can be added here:

2. Please indicate range of agreement or disagreement with each of the following aspects of the **StairSteady**.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
Using the StairSteady could draw unwanted attention to the user.	❍	❍	❍	❍	❍
The StairSteady seems like it's easy to install for use.	❍	❍	❍	❍	❍
The StairSteady seems like it's easy to clean and maintain.	❍	❍	❍	❍	❍
The StairSteady wouldn't get in the way of others using the area around it.	❍	❍	❍	❍	❍
The StairSteady looks nice.	❍	❍	❍	❍	❍
The StairSteady could be made to match one's home décor.	❍	❍	❍	❍	❍

Any additional comments about previous answers can be added here:

3. POSSIBLE USE OF THE **StairSteady**: Please indicate range of agreement or disagreement with each of the following questions.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
Had problems using the StairSteady	❍	❍	❍	❍	❍
Think others would have problems using the StairSteady	❍	❍	❍	❍	❍
Would like to have this product in home now	❍	❍	❍	❍	❍
Would like to have this product in home in the future	❍	❍	❍	❍	❍

Any additional comments about previous answers?

4. If you needed it, how much would you pay for the STAIRSTEADY?

❍ $100–$500
❍ $501–$1,000
❍ $1,000–$1,500
❍ $1,500–$2,000
❍ $2,001 or more

Any comments about the price?

5. What are the ADVANTAGES of using the STAIRSTEADY?

6. What are the DISADVANTAGES of using the STAIRSTEADY?

FlexStep

7. Please indicate range of agreement or disagreement with each of the following aspects of the **FlexStep**.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
It is easy to understand how to use the FlexStep.	❍	❍	❍	❍	❍
It takes more time to go up and down when using the FlexStep than it should.	❍	❍	❍	❍	❍
The FlexStep requires little physical effort to use it.	❍	❍	❍	❍	❍
Needed assistance to use the FlexStep	❍	❍	❍	❍	❍
When using it, sometimes made mistakes that required redoing some steps	❍	❍	❍	❍	❍
Using the FlexStep raised concerns about personal safety	❍	❍	❍	❍	❍

Any additional comments about previous answers can be added here:

8. Please indicate range of agreement or disagreement with each of the following aspects of the **FlexStep**.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
Using the FlexStep could draw unwanted attention to me.	❍	❍	❍	❍	❍
The FlexStep seems like it's easy to install for use.	❍	❍	❍	❍	❍
The FlexStep seems like it's easy to clean and maintain.	❍	❍	❍	❍	❍
The FlexStep wouldn't get in the way of others using the area.	❍	❍	❍	❍	❍
The FlexStep looks nice.	❍	❍	❍	❍	❍
The FlexStep could be made to match one's home décor.	❍	❍	❍	❍	❍

Any additional comments about previous answers can be added here:

9. POSSIBLE USE OF THE **FlexStep**: Please indicate range of agreement or disagreement with each of the following questions.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
Had problems using the FlexStep	❍	❍	❍	❍	❍
Think others would have problems using the FlexStep	❍	❍	❍	❍	❍
Would like to have this product in home now	❍	❍	❍	❍	❍
Would like to have this product in home in the future	❍	❍	❍	❍	❍

Any additional comments about previous answers?

10. If you needed it, home much would you pay for the FlexStep?

❍ $5,000–$10,000
❍ $10,001–$15,000
❍ $15,501–$20,000
❍ $20,001–$25,000
❍ $25,001 or more

Comments about the price?

11. What are the ADVANTAGES of using the FlexStep?

12. What are the DISADVANTAGES of using the FlexStep?

All-Push Door

13. Please indicate range of agreement or disagreement with each of the following aspects of the **All-Push Door**.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
It is easy to understand how to use the All-Push Door.	❍	❍	❍	❍	❍
It takes more time to go through the door than it should.	❍	❍	❍	❍	❍
It requires little physical effort to use the All-Push Door.	❍	❍	❍	❍	❍
Needed assistance to use the All-Push Door	❍	❍	❍	❍	❍
When using it, sometimes made mistakes that required redoing some steps	❍	❍	❍	❍	❍
Using the All-Push Door raised concerns about personal safety	❍	❍	❍	❍	❍

Any additional comments about previous answers can be added here:

14. Please indicate range of agreement or disagreement with each of the following aspects of the **All-Push Door**.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
Using the All-Push Door could draw unwanted attention to the user.	❍	❍	❍	❍	❍
The All-Push Door seems like it's easy to install for use.	❍	❍	❍	❍	❍
The All-Push Door seems like it's easy to clean and maintain.	❍	❍	❍	❍	❍
The All-Push Door wouldn't get in the way of others using the area.	❍	❍	❍	❍	❍
The All-Push Door looks nice.	❍	❍	❍	❍	❍
The All-Push Door could be made to match one's home décor.	❍	❍	❍	❍	❍

Any additional comments about previous answers can be added here:

15. POSSIBLE USE OF THE **All-Push-Door**: Please indicate range of agreement or disagreement with each of the following questions.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
Had problems using the All-Push Door	❍	❍	❍	❍	❍
Think others would have problems using the All-Push Door	❍	❍	❍	❍	❍
Would like to have the All-Push Door in home now	❍	❍	❍	❍	❍
Would like to have the All-Push Door in home in the future	❍	❍	❍	❍	❍

Any additional comments about previous answers?

16. If you needed it, how much would you pay for the All-Push Door?

❍ $100–$500
❍ $501–$1000
❍ $1,001–$1,500
❍ $1,501–$2,000
❍ $2,001 or more

Comments about the price?

17. What are the ADVANTAGES of using the All-Push Door?

18. What are the DISADVANTAGES of using the All-Push Door?

AssiStep

19. Please indicate range of agreement or disagreement with each of the following aspects of the **AssiStep**.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
It is easy to understand how to use the AssiStep.	❍	❍	❍	❍	❍
It takes more time to go up and down the stairs than it should.	❍	❍	❍	❍	❍
The AssiStep requires little physical effort to use it.	❍	❍	❍	❍	❍
Needed assistance to use the AssiStep	❍	❍	❍	❍	❍
When using it, sometimes made mistakes that required redoing some steps	❍	❍	❍	❍	❍
Using the AssiStep raised concerns about personal safety	❍	❍	❍	❍	❍

Any additional comments about previous answers can be added here:

20. Please indicate range of agreement or disagreement with each of the following aspects of the **AssiStep**.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
Using the AssiStep could draw unwanted attention to the user.	❍	❍	❍	❍	❍
The AssiStep seems like it's easy to install for use.	❍	❍	❍	❍	❍
The AssiStep seems like it's easy to clean and maintain.	❍	❍	❍	❍	❍
The AssiStep wouldn't get in the way of others using the area.	❍	❍	❍	❍	❍
The AssiStep looks nice.	❍	❍	❍	❍	❍
The AssiStep could be made to match one's home décor.	❍	❍	❍	❍	❍

Any additional comments about previous answers can be added here:

POSSIBLE USE OF THE **AssiStep**: Please indicate range of agreement or disagreement with each of the following questions.

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
Had problems using the AssiStep	❍	❍	❍	❍	❍
Think others would have problems using the AssiStep	❍	❍	❍	❍	❍
Would like to have the AssiStep in home now	❍	❍	❍	❍	❍
Would like to have the AssiStep in home in the future	❍	❍	❍	❍	❍

Any additional comments about previous answers?

21. If you needed it, how much would you pay for the **AssiStep**?

❍ $100–$500
❍ $501–$1,000
❍ $1,001–$1,500
❍ $1,501–$2,000
❍ $2,001 or more

Comments about the price?

22. What are the ADVANTAGES of using the **AssiStep**?

23. What are the DISADVANTAGES of using the **AssiStep**?

SURVEY: HOME INNOVATION ACCESSIBILITY EVALUATION

THANKS VERY MUCH!!!

The authors want to thank everyone very much for all the help and information they provided.

For any questions about this survey, or about one's participation, please call:

Ed Hudson

Director, Market Research Division

John Peavey

Director, Building Science Division

Home Innovation Research Labs

1-800-638-8556

APPENDIX E:
INSTALLATION INSTRUCTIONS
FOR ACCESSIBILITY DEVICES

ADAPTING USER'S HOME

STEP 1

Measure key dimensions of stairway

This information must be provided to the manufacturer. It will be used to precut the StairSteady components.

STEP 2

Measure user's key dimensions

This biometric information will be used to custom-mount the StairSteady at the correct height for the user.

ADAPTING USER'S HOME

STEP 3

Add structural support to mount the StairSteady

The railing on the authors' test platform required additional structural support to install the StairSteady assistive device.

STEP 4

Install the StairSteady rail

This StairSteady rail must be level and installed at the height of the user's biometric measurements.

STEP 5

Add StairSteady handle

The StairSteady handle provides support to the user as the person walks up and down the stairs.

STEP 6

Use the StairSteady assist device

The user can test the StairSteady assist device to ensure that it has been installed correctly and works well.

ADAPTING USER'S HOME

STEP 1

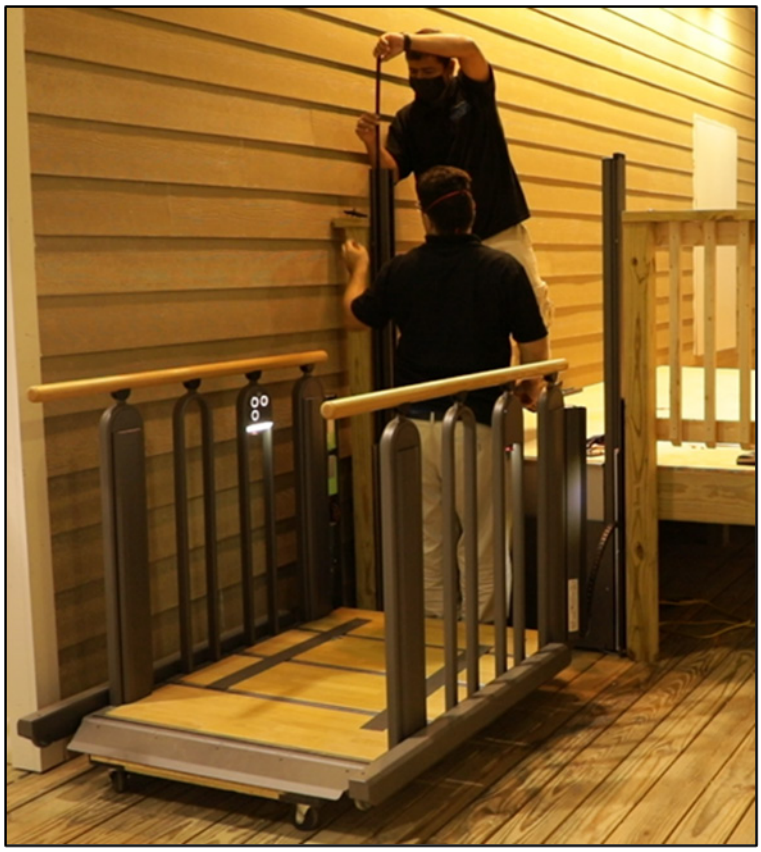
Unpack the FlexStep

The FlexStep is fully assembled and shipped in a crate; but it must be hardwired in order to operate. The wiring includes power, a motor, a safety guard, and controls.

STEP 2

Prepare the FlexStep for installation

The FlexStep must be wired to operate the safety guard, motor, and controls.



STEP 3

Wire the supports for the safety guard

The safety guard must be wired to the FlexStep along with the controls that operate the device.

STEP 4

Install the safety guard

The safety guard must be synchronized with the FlexStep. The motor and controls must also be connected to operate the FlexStep.

STEP 5

The FlexStep in the default mode

When the FlexStep is not in use as a lift, the device's default position is as a conventional flight of stairs.

STEP 6

The FlexStep in lift mode

When the FlexStep is used as a lift, the device engages the safety guard and an anti-roll guard on the lift to prevent a wheelchair from rolling off the lift.

STEP 7

Use the FlexStep

The user can test the FlexStep to ensure that it has been installed correctly and works well.

ADAPTING USER'S HOME

STEP 1

Measure key dimensions of stairway

This information must be provided to the manufacturer. It will be used to precut the AssiStep components.

STEP 2

Measure user's key dimensions

This biometric information will be used to custom-mount the AssiStep at the correct height for the user. The AssiStep can be adjusted vertically after it is installed.

STEP 3

Add structural support to mount AssiStep

The railing on the authors' test platform required additional structural support to install the AssiStep device.

STEP 4

Install the AssiStep rail system

The AssiStep has a double-track rail system that allows the support handle to be adjusted vertically to fit multiple users with different biometrics.

STEP 5

Install the AssiStep rail system

The double-track rail system allows the user to quickly release or lock the handle while providing support to the user as the person walks up and down the stairs.

STEP 6

Install the AssiStep handle

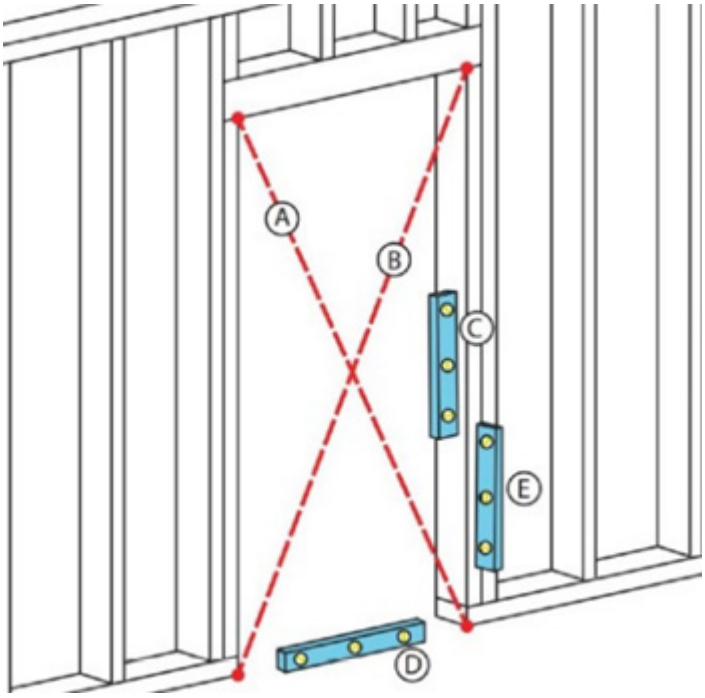
The AssiStep handle engages both the bottom and top rail system. It can be adjusted vertically, and the user can use the upper or lower support.

STEP 7

Use the AssiStep device

The user can test the AssiStep device to ensure that it has been installed correctly and works well.

ADAPTING USER'S HOME



STEP 1

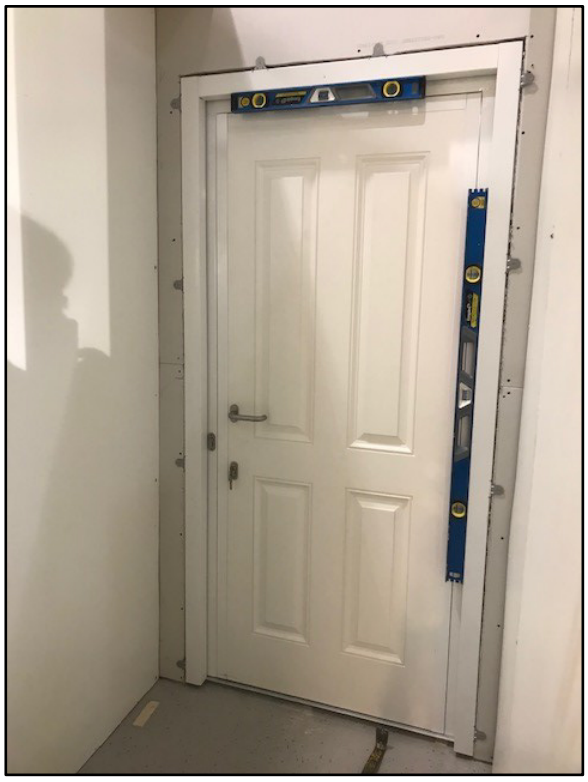
Measure the door opening

The door opening must be measured to determine if it is wide enough and level to install the All-Push Door. Modifications may be necessary if the opening is too narrow or if the wall jambs and threshold are not level.

STEP 2

Unpack the All-Push Door

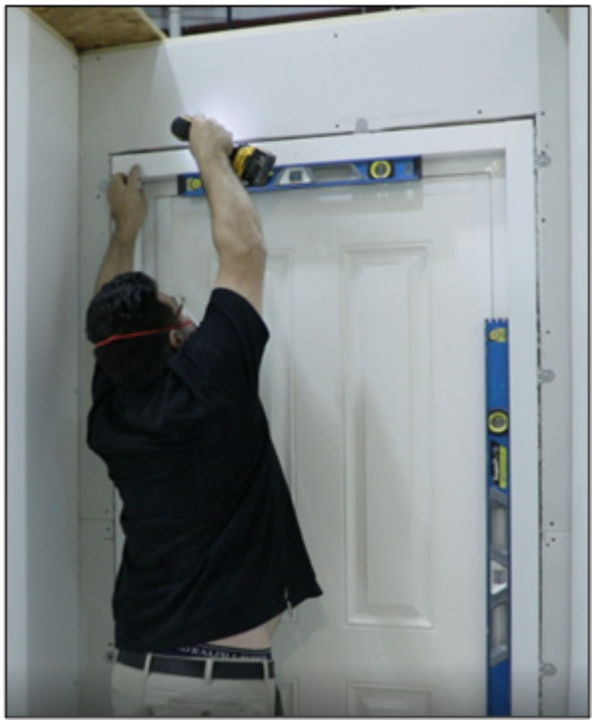
The All-Push Door is provided as a prehung door that is installed into the door opening.



STEP 3

Fit and adjust the All-Push Door

Place the All-Push Door into the opening, make adjustments to the clips, and ensure the All-Push Door is level before completing the installation.



STEP 4

Secure All-Push Door with clips

Use screws to install the clips of the All-Push Door to the door header and wall jambs. The clips are evenly spaced to anchor the door securely.

STEP 5

Anchor the hinges of the All-Push Door

The All-Push Door hinges must be screwed into the wall jamb to complete the door installation.

STEP 6

Install the trim to finish

Cover the clips and the rough edge of the door opening with a trim material.

STEP 7

Use the All-Push Door

The user can test the All-Push Door to ensure that it has been installed correctly and works well.

APPENDIX F:
EVALUATION OF ASSISTIVE DEVICES BY USERS, CAREGIVERS, AND PROFESSIONALS

Appendix F- Evaluation of Assistive Devices by Users, Caregivers, and Professionals

For U.S. Department of Housing and Urban Development

August 2022

Introduction – Mobility Assistive Devices Evaluated in this Phase

All-Push Door

StairSteady

FlexStep

AssiStep

Research Methodology

- In-person evaluations of the four mobility assistive devices were installed as they would be in homes on mock-ups of a stair, landing and doorway at Home Innovation Research Labs' Upper Marlboro, Maryland campus.

- Fifty-one participants arrived singly or in patient/caregiver pairs and were led through a process of evaluating each device by a marketing research professional.
  - Thirty-one (31) participants had a mobility issue OR were caregivers of people with mobility issues (in some cases, caregivers had mobility issues).
  - Twenty were professionals in the field of aging in place (physical and occupational therapists, architects, and designers).

Research Methodology

- After using each device, the research professional asked all participants a predetermined set of questions and recorded their responses.
  - Participants signed audio/video-recording release form with Home Innovation that provided consent to provide record their commentary during the device evaluations, such as their rationale for their response to the survey questions.

- Upon completion of the survey, participants were engaged in an open-ended discussion to gain further insight into their experience with the devices and recommendations for improvement.

Questionnaire Design

- Home Innovation evaluated each assistive device using an "agree/disagree" style questionnaire with 16 statements, organized into the following four categories:
  - Safety
  - Ease of Use
  - Appearance
  - Installation and Maintenance
- After each of the 16 statements was read to participants, each was asked to choose the answer that best suited their level of agreement/disagreement with the statement:
  - Strongly Agree (5)
  - Agree (4)
  - Neither agree nor disagree (3)
  - Disagree (2)
  - Strongly Disagree (1)
- Questions on acceptable pricing for each device were also included.

Safety Questions

Safety

- ❑ For me, using [name of device] made me worry a little bit for my safety
- ❑ I would like to have this product in my home now
- ❑ I would like to have this product in my home in the future

Ease of Use

- ❑ It is easy to understand how to use this device
- ❑ It takes more time to go up and down the stairs/go through the door than it should
- ❑ The device requires little physical effort to use it
- ❑ I needed assistance to use the device
- ❑ When I used it, I sometimes made mistakes that required me to re-do some steps
- ❑ I had problems using the device
- ❑ I think others would have problems using the device

Appearance Questions

Appearance

- ❑ Using this device could draw unwanted attention to me
- ❑ This device wouldn't get in the way of others using the area around it
- ❑ This device looks nice
- ❑ This device could be made to match my home décor

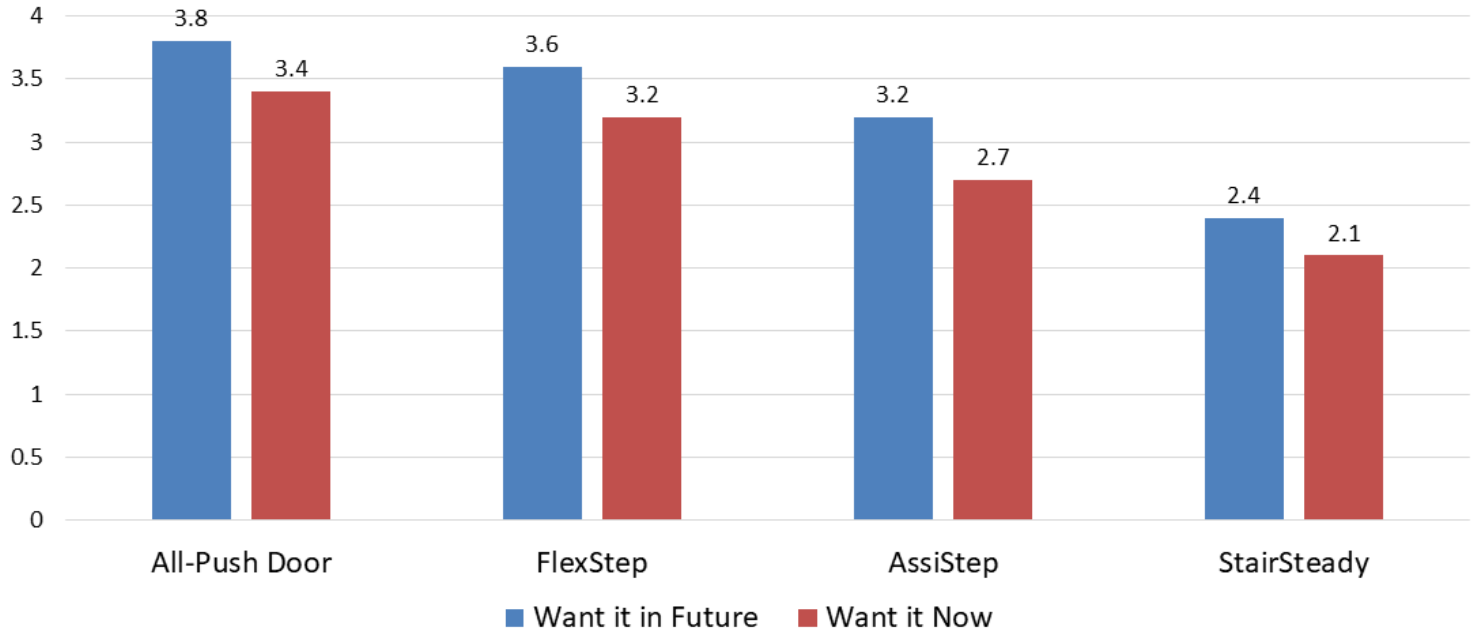
Installation and Maintenance Questions

Installation and Maintenance

- ❑ This device seems like it's easy to be installed for use
- ❑ This device seems like it's easy to clean and maintain

Desirability of Devices: Do Users Want It in Their Homes?

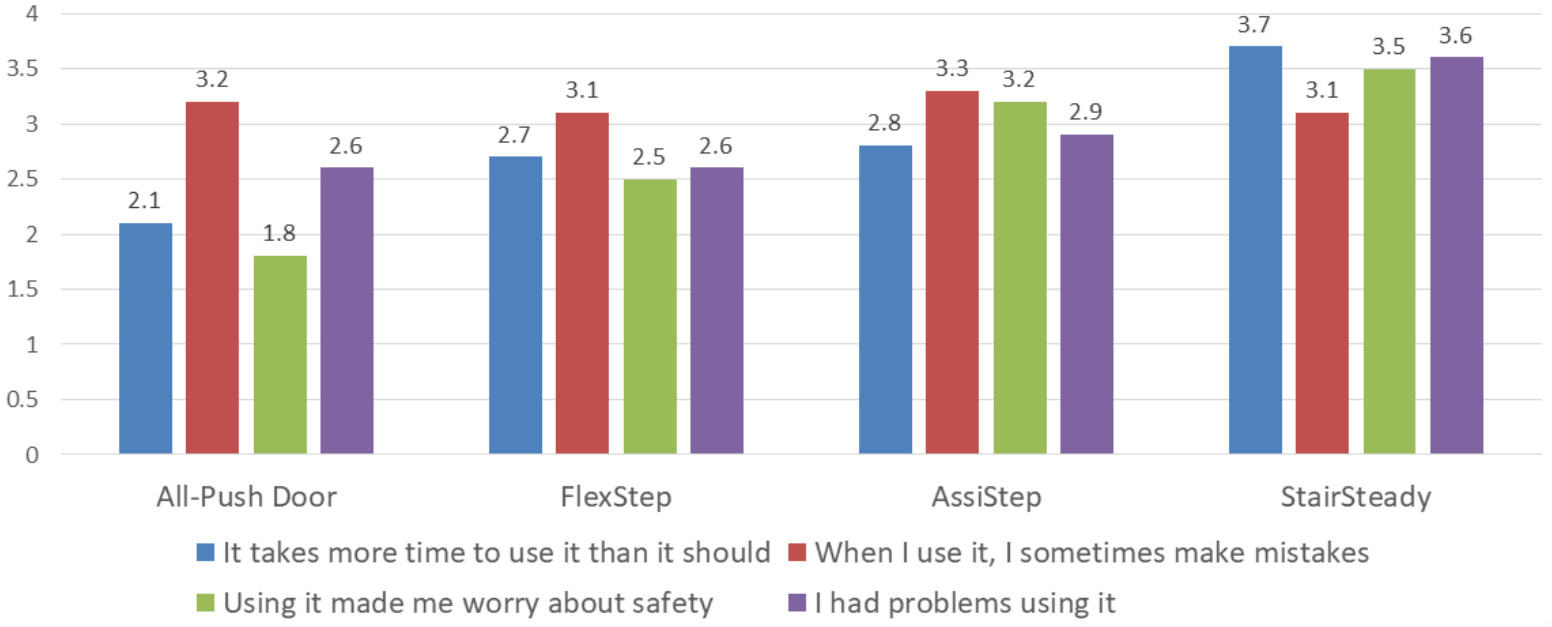
(5-point scale with 1= strongly disagree and 5= strongly agree)



Overall, participants thought they did not need the assistive devices yet, but in the future.

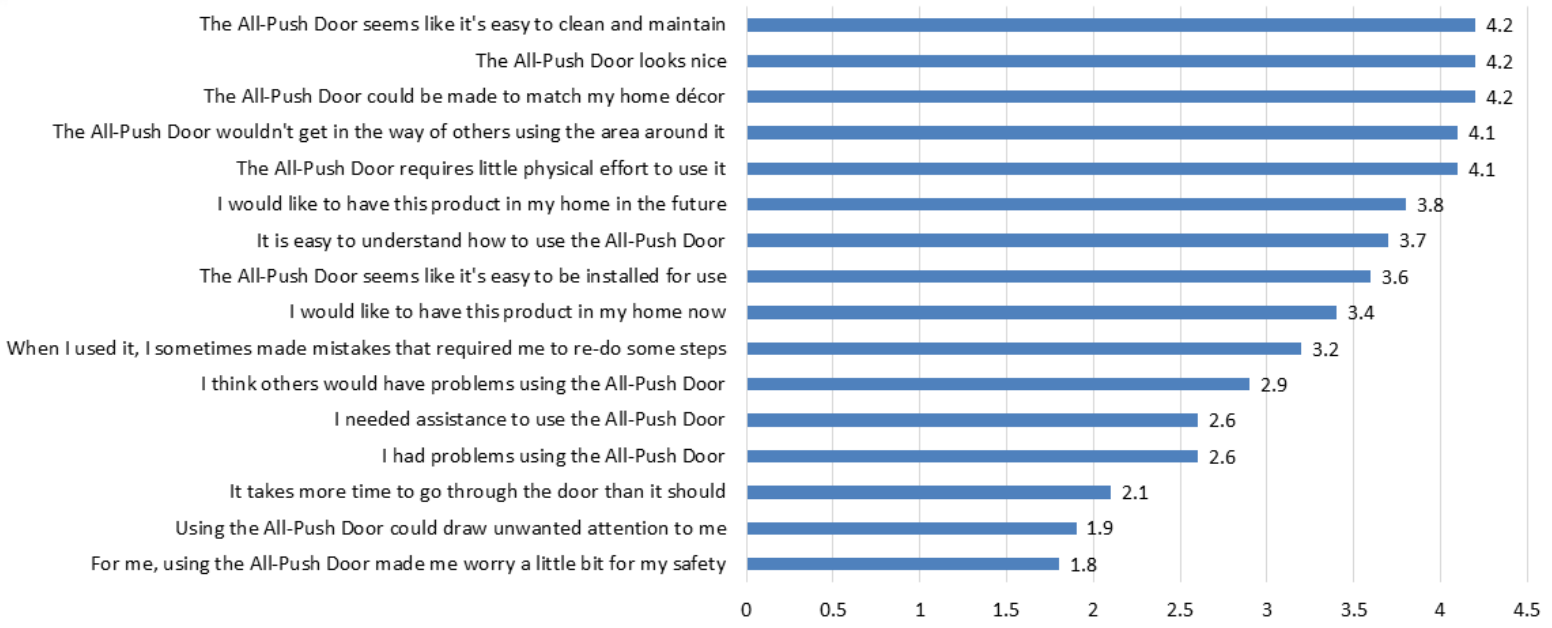
Concerns and Limitations When Using the Devices

(5-point scale with 1= strongly disagree and 5= strongly agree)



All-Push Door Ratings

(1= strongly disagree and 5= strongly agree)



Summary of Survey Findings and Feedback Responses from Interviews for the All-Push Door

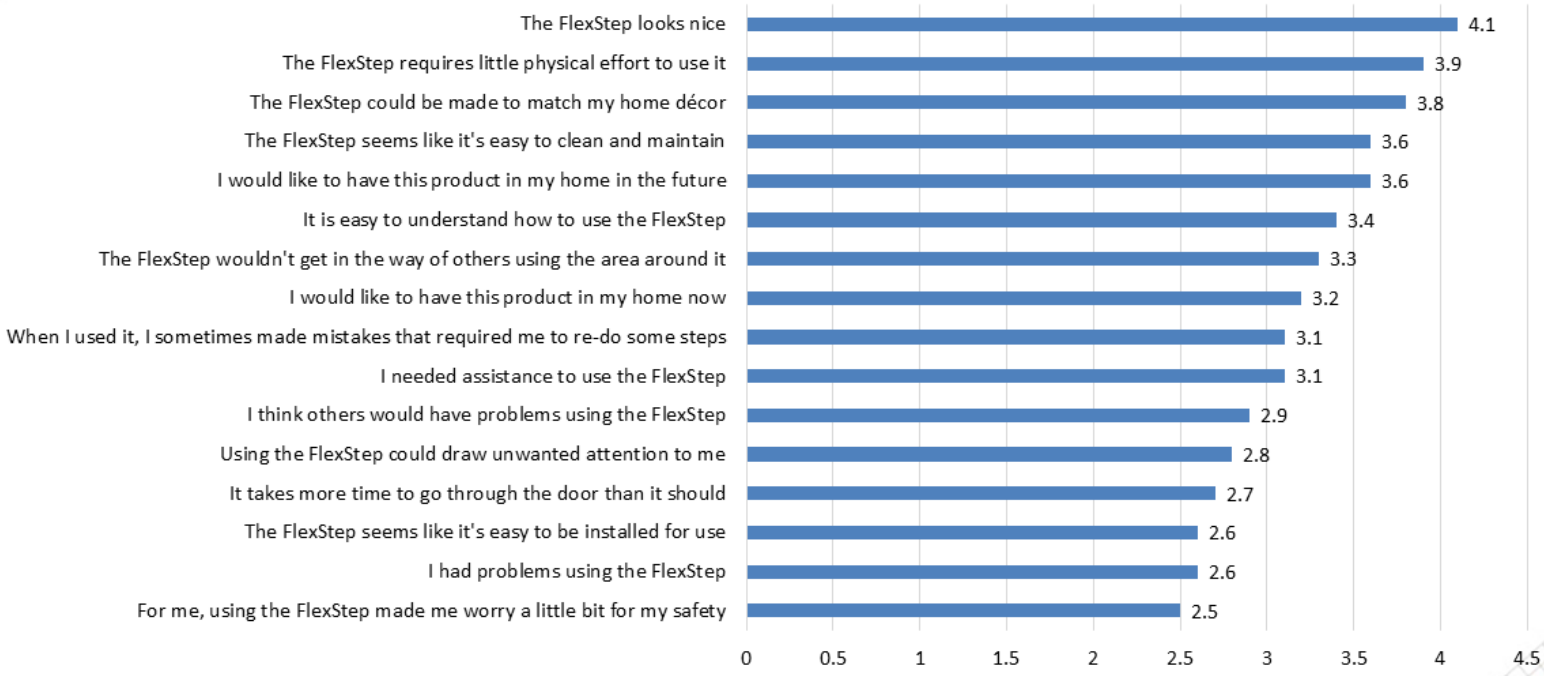
- The average "About Right" price for the All-Push Door was $1,243. This is the average price calculated from all respondents who answered the question.
- Overall, participants rated the All-Push Door positively compared with other devices.
- More details about the distribution of responses are in Appendix G.
- Whether one is in a wheelchair or walker, or simply having mobility issues, backing up is difficult when using passage doors

Summary of Survey Findings and Feedback Responses from Interviews for the All-Push Door (continued)

- Operating the door was not completely intuitive to all participants, but it required instruction and practice to internalize the operation.
- It's attractive, will fit most interior décor, and does not signal that it's an assistive device (which would be a big negative according to some respondents).
- Suggested improvements include a peephole or glass pane and a keypad instead of a lock-and-key set.

FlexStep Ratings

(1= strongly disagree and 5= strongly agree)



Summary of Survey Findings and Feedback Responses from Interviews for the FlexStep

- The average "About Right" price for the FlexStep was $7,675. This is the average price calculated from all respondents who answered the question.

- Overall, participants rated FlexStep from positive to neutral compared to other devices. The professionals believed it was hard to install the FlexStep, while the caregivers and users thought it would be easy to install the Flex Step.

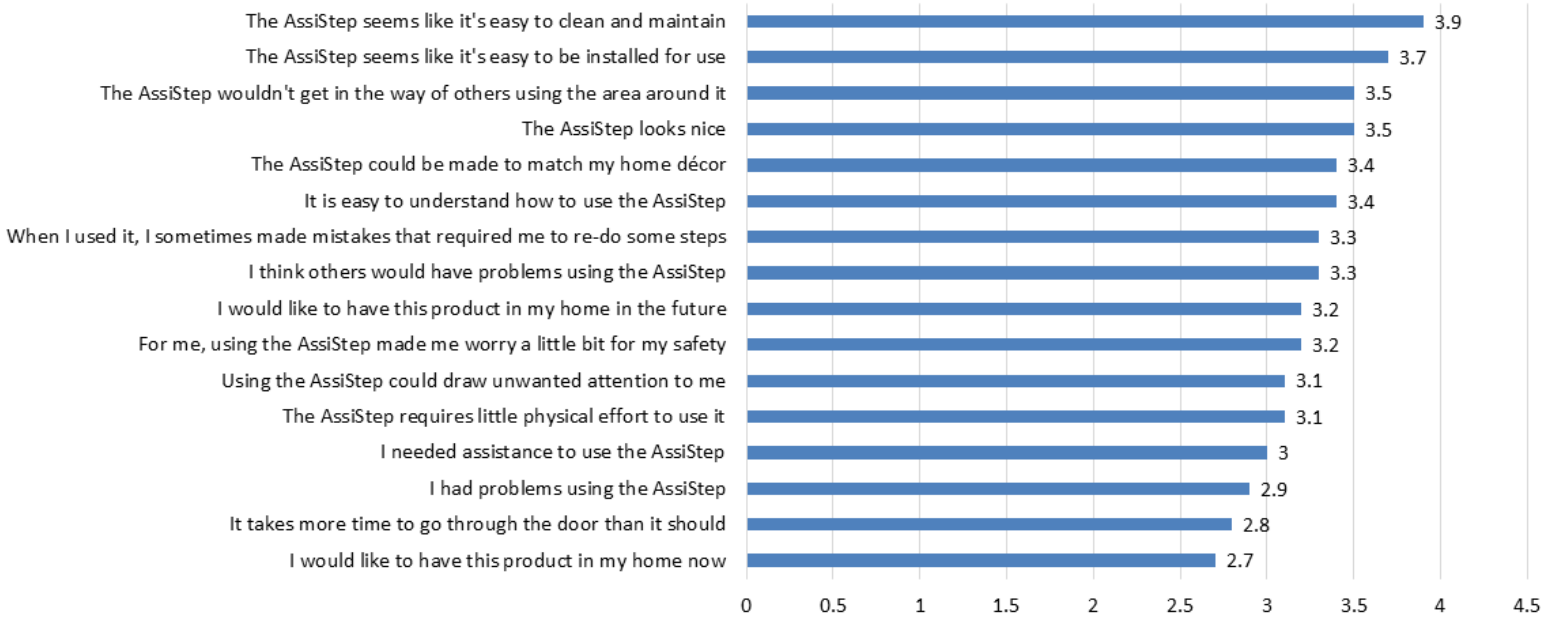
- More details about the distribution of the responses are in Appendix G.

Summary of Survey Findings and Feedback Responses from Interviews for the FlexStep (continued)

- Generally, the feedback on FlexStep was positive. Most respondents considered the FlexStep to be attractive and believed that it works with a wide variety of impairments (and for people without impairments).
- Some respondents were concerned with the FlexStep's noisy operation.
- Some respondents thought a pet or toy could get trapped under the stairs when it descends. (They were not convinced the safety sensors would work.)
- Recommendation for improvement included a voice to announce operations or verbal warnings instead of beeps.

AssiStep Ratings

(1= strongly disagree and 5= strongly agree)



Summary of Survey Findings and Feedback Responses from Interviews for the AssiStep

- The average "About Right" price for the AssiStep was $913. This is the average price calculated from all respondents who answered the question.
- Overall, participants rated the AssiStep from positive to neutral compared with other devices. The participants agreed that the AssiStep was attractive, easy to install, and did not get in the way of others trying to use the stairs.
- Users noted it is easier to use ascending stairs than descending the stairs.

Summary of Survey Findings and Feedback Responses from Interviews for the AssiStep (continued)

- Lifting the device to descend the stairs required an effort that would impede people with poor upper body strength.

- Respondents believed that when using the AssiStep, it would require some coordination and practice to be used skillfully; in addition, they expected that mistakes would be made by some while learning to use the AssiStep.

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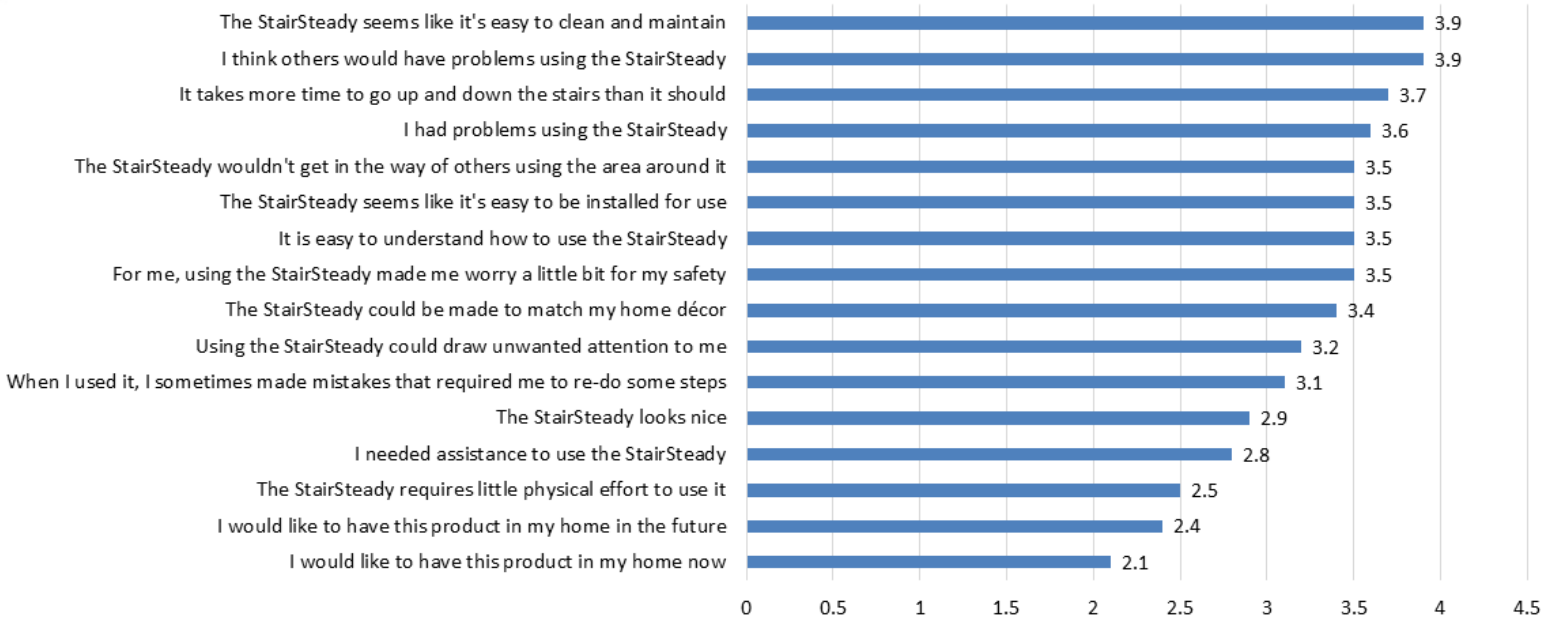
StairSteady Ratings

(1= strongly disagree and 5= strongly agree)



Summary of Survey Findings and Feedback Responses from Interviews for the StairSteady

- The average "About Right" price for the StairSteady was $598. This is the average price calculated from all respondents who answered the question.
- Overall, participants liked the StairSteady's simplicity and seeming ease of installation, cleaning, and maintenance. In addition, participants liked how the StairSteady stored because it was "out-of-the-way" when not in use.
- However, many participants had problems using it, which signals the potential need to improve design or better communicate how to use it.

Summary of Survey Findings and Feedback Responses from Interviews for the StairSteady (continued)

- Some were not able to satisfactorily make the device glide forward, requiring a "touch" that they may be able to develop with practice but not in the short time of the evaluation.

- Suggested improvements to the StairSteady include:
  - Adding padding to the handle.
  - Adjustability for different positions for ascending/descending the stairs.
  - Quick-release function to disengage bar at will.

General Findings from Post-Survey Discussions: Safety

- Users and caregivers are eager for improvements in assistive devices – to allow greater independence and use/enjoyment of homes.
- Interfaces with devices are important considerations that impact user experience and willingness to use – voice commands preferred over beeps and lights; high volumes can annoy or draw attention.
- Intuitive devices are highly preferred – for new users in home or for cognitively impaired users.

General Findings from Post-Survey Discussions: Safety (continued)

- Users want adjustable assistive devices to better suit their height, weight, vision, hearing and impairments.
- Manufacturers should consider that the construction of the device needs to inspire confidence; play-in components or odd noises should be designed out.

General Findings from Post-Survey Discussions: Ease of Use

- Assistive devices need to work easily, or users will abandon them – and unused devices are obstacles and can be a safety hazard.
- Assistive devices need a short learning curve, which can be aided by device simplicity and clear labeling of instructions, icons, and textured controls/braille.
- There is a higher preference for automated devices, operated with remote controls – particularly for those using wheelchairs whose approach to a device is limited by the chair.
- Manufacturers would help users and caregivers by making assistive devices smart – caregivers can check status of the device when not present, and automatic software updates can be implemented.

General Findings from Post-Survey Discussions: Appearance

- Assistive device appearance is nearly as important as functionality – they should appear as non-assistive devices so as not to draw attention to the user (based on focus group feedback).
- Assistive devices in homes should be customizable – colors and finishes. Personalization of homes is a universal desire, and owners/occupants of homes with assistive devices are more likely to have them if they fit the décor of the home and personality of the occupant.
- Manufacturers of devices should also design for use by family members and guests of the mobility-impaired occupant.
- When not permanently mounted, devices should be able to be readily stored when not in use or to keep out of reach of children or pets.

General Findings from Post-Survey Discussions: Installation and Maintenance

- Cost is important when deciding to purchase an assistive device – the cost of the device, its installation, and possible home remodeling or upgrading to accommodate the device.
- The fewer modifications required for an existing home, the greater the likelihood the device will be acquired – this is particularly true of older homes with narrow walkways and stairways.
- Certified trades or installers are preferred for greatest confidence in users – knowing the device may need to support a user's entire weight.

General Findings from Post-Survey Discussions: Installation and Maintenance (continued)

- New homes should be designed to accommodate assistive devices in the future – and architects and designers should have this training and awareness.

- Longer warranties for devices are desired – reflecting the big investment in the device, and if mounted permanently, they are expected to last many years.

Conclusions

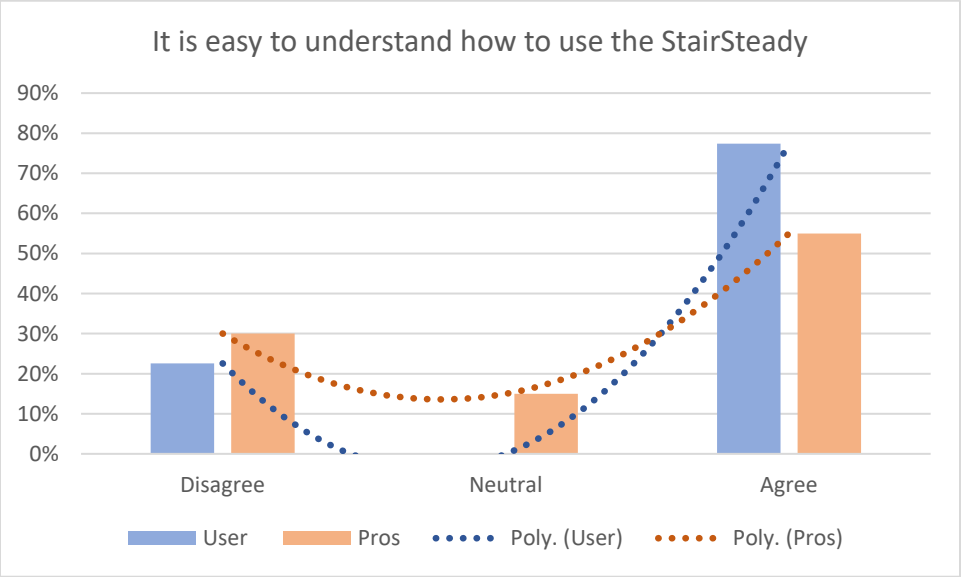
- The in-person evaluations conducted in this phase – including the survey and unstructured discussion which prove to be effective way to get insightful feedback on:
  - Use of specific devices
  - Mobility-assistive devices in general

The findings from this research can be used constructively by device manufacturers to:

- Improve existing products
- Better communicate the device's operating procedure to users
- Design and develop new assistive devices that meet user needs and expectations

APPENDIX G:
COHORT RESPONSE DISTRIBUTION GRAPHS FOR EACH DEVICE

STAIRSTEADY



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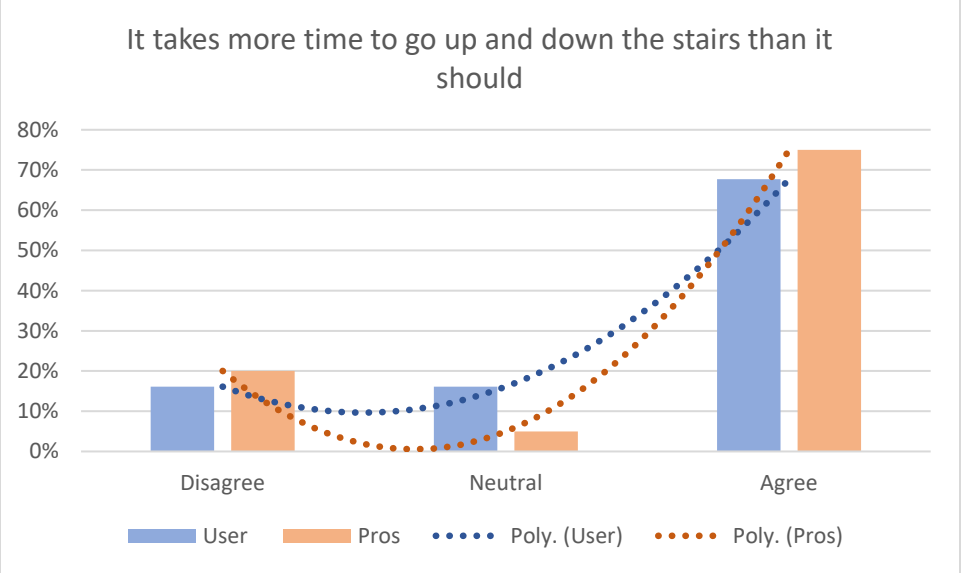
"Pros" is an abbreviation for the professional cohort.



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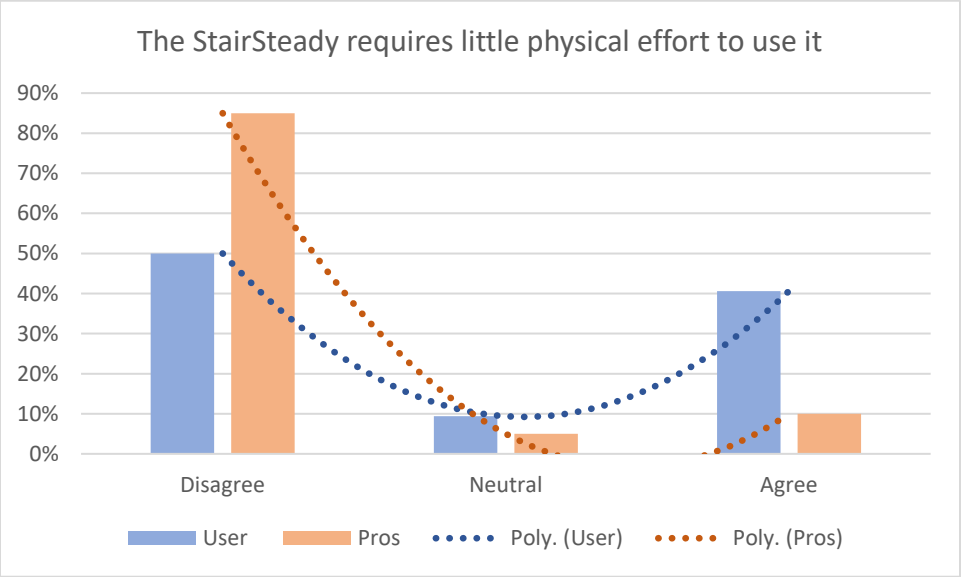

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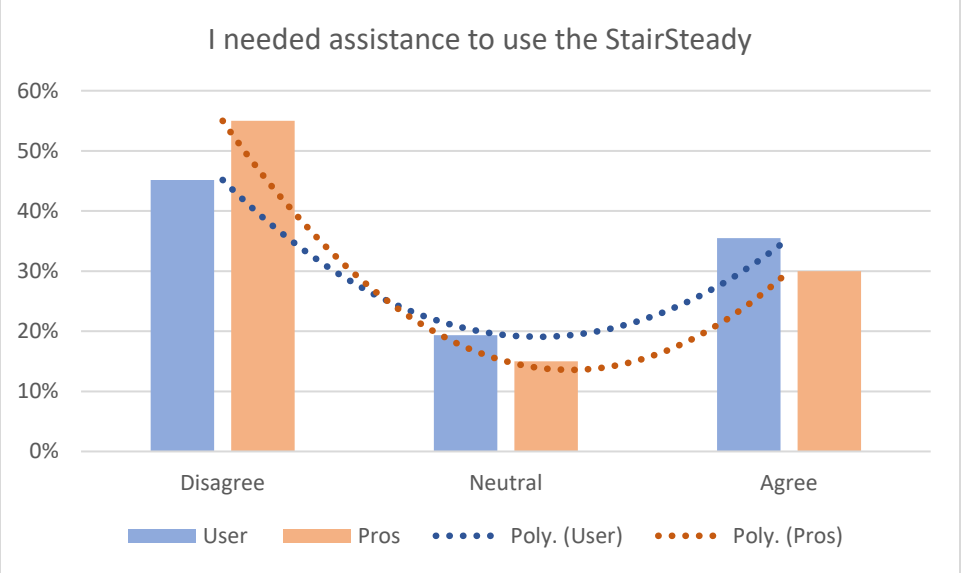

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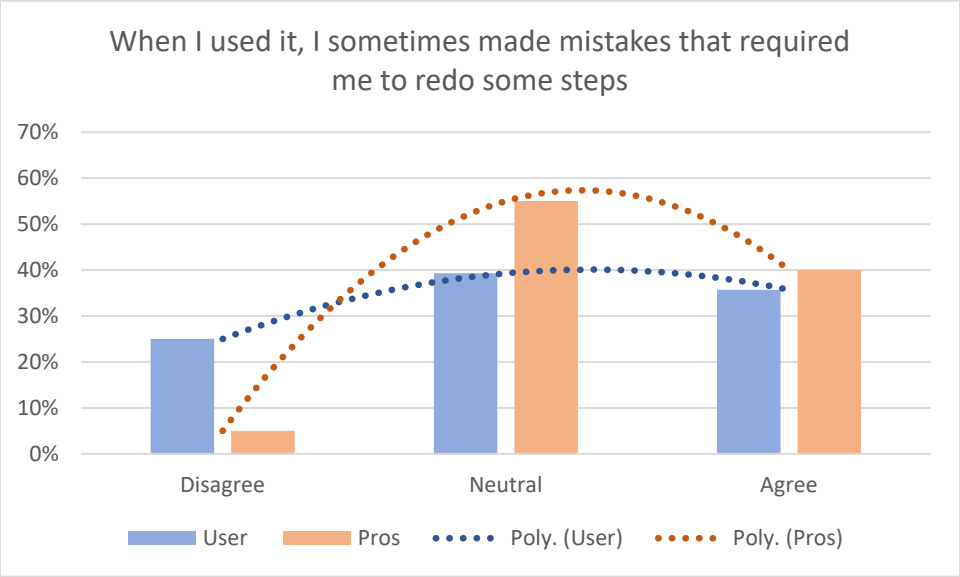

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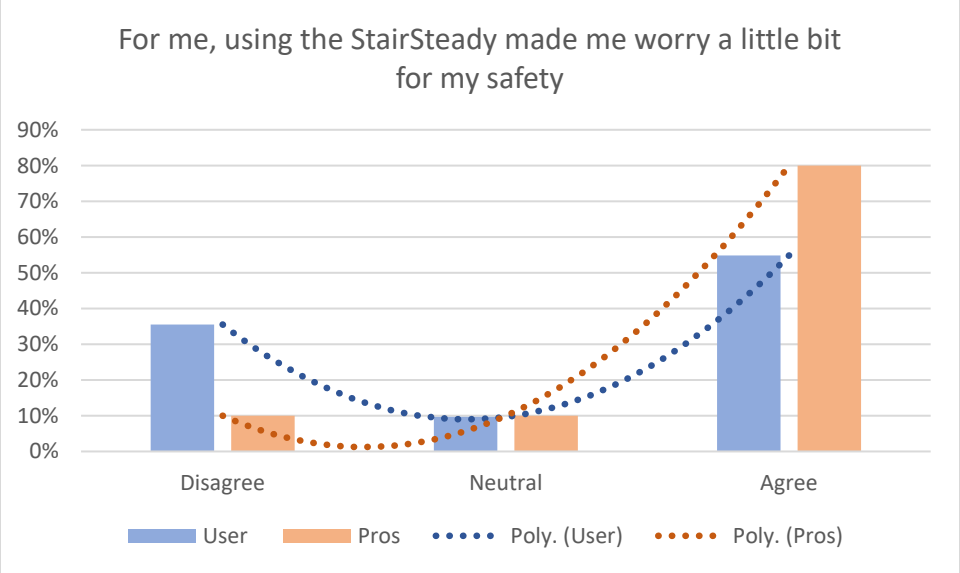

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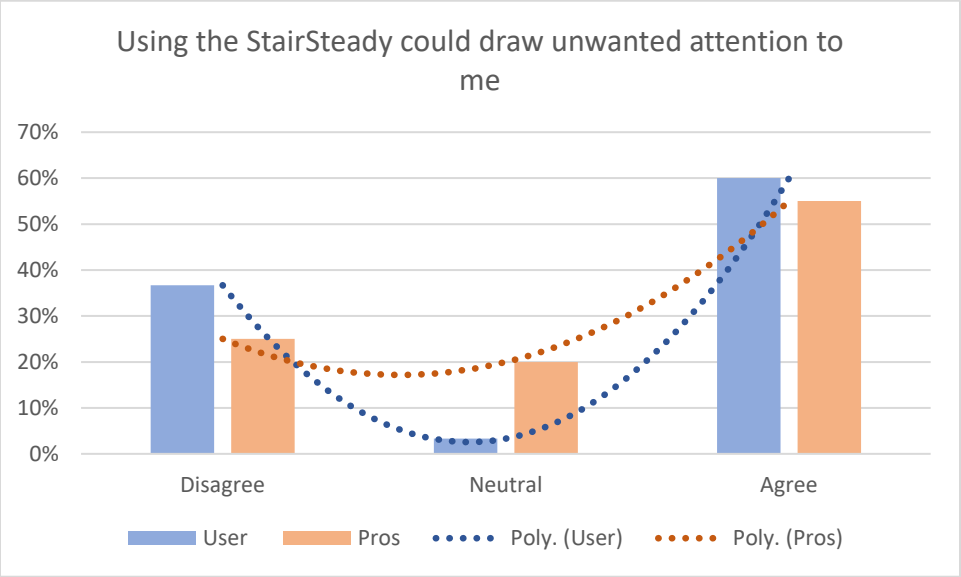

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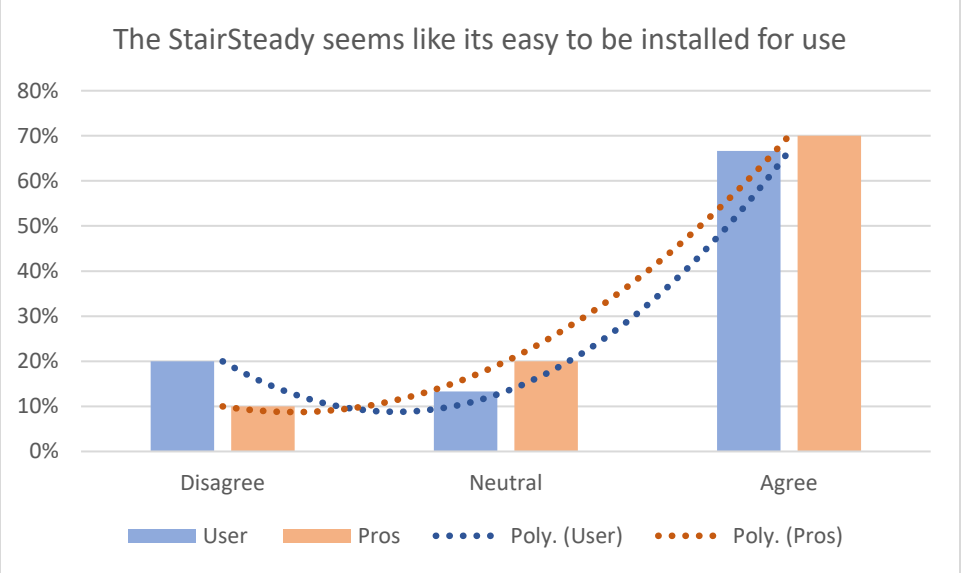

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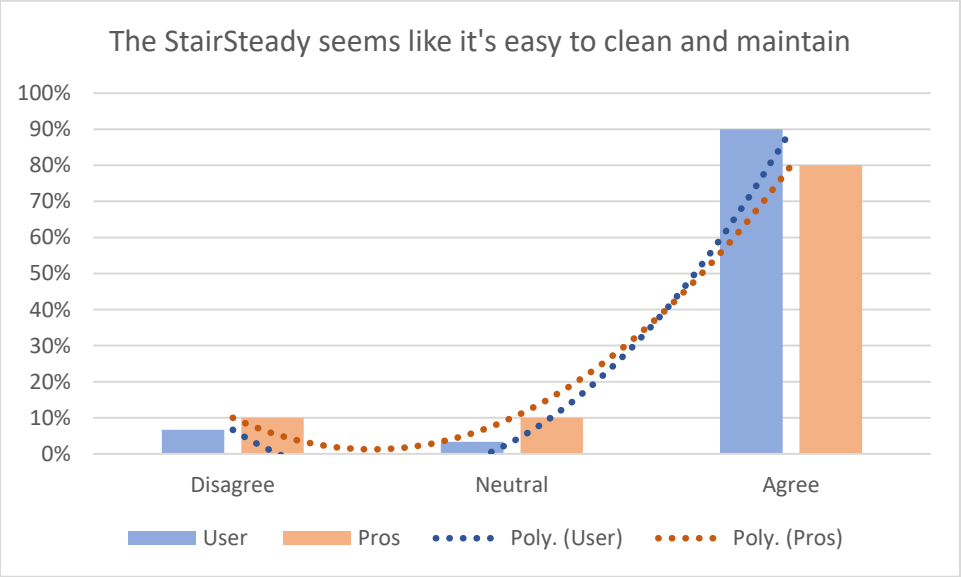

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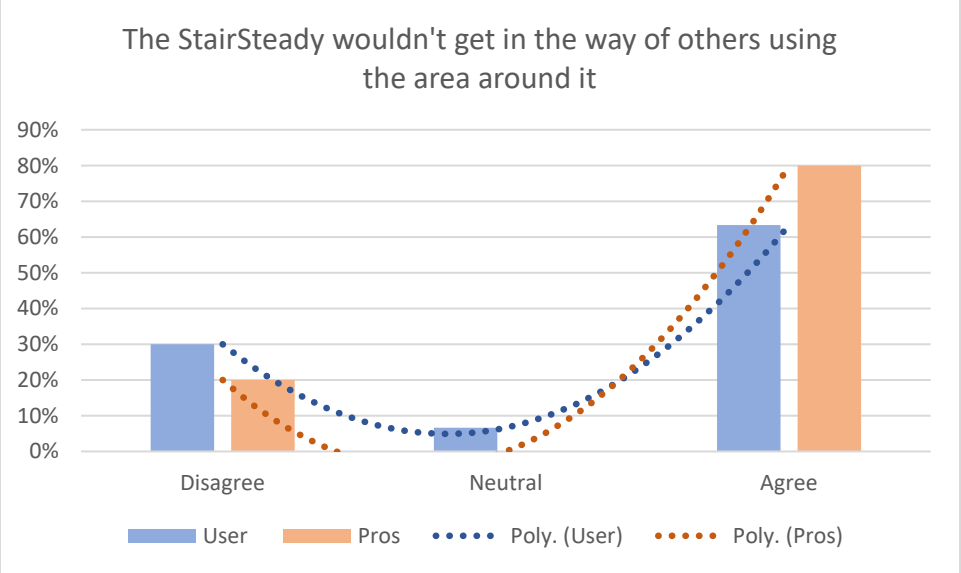

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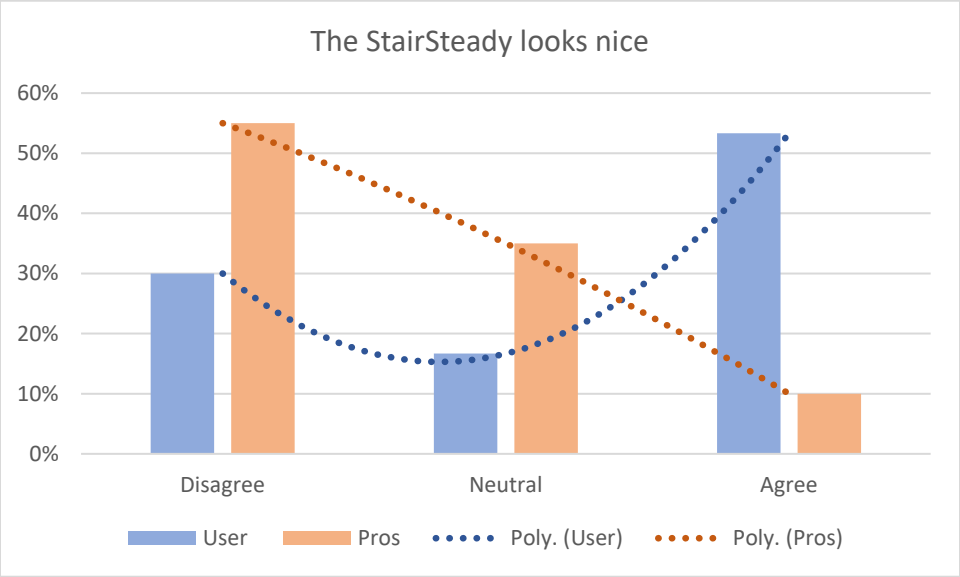

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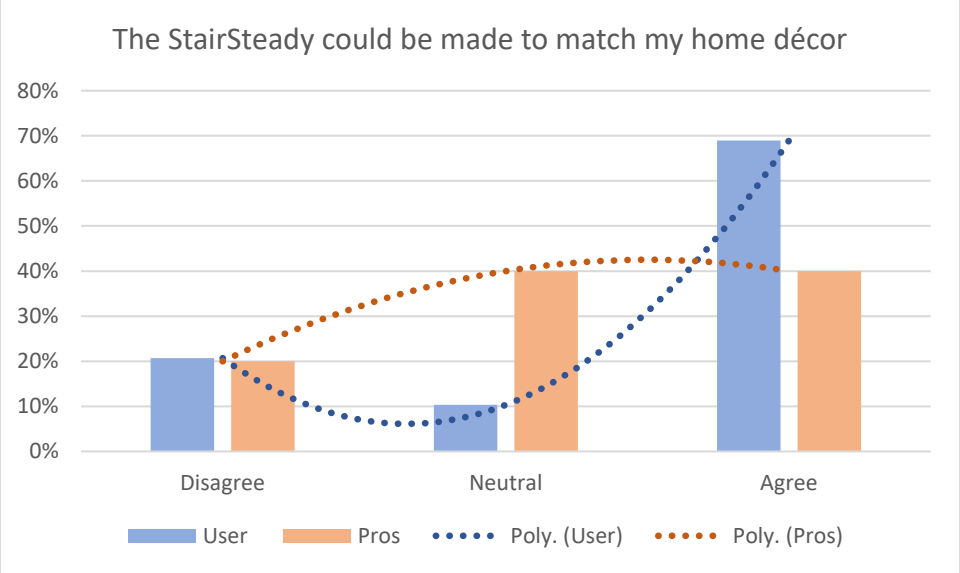

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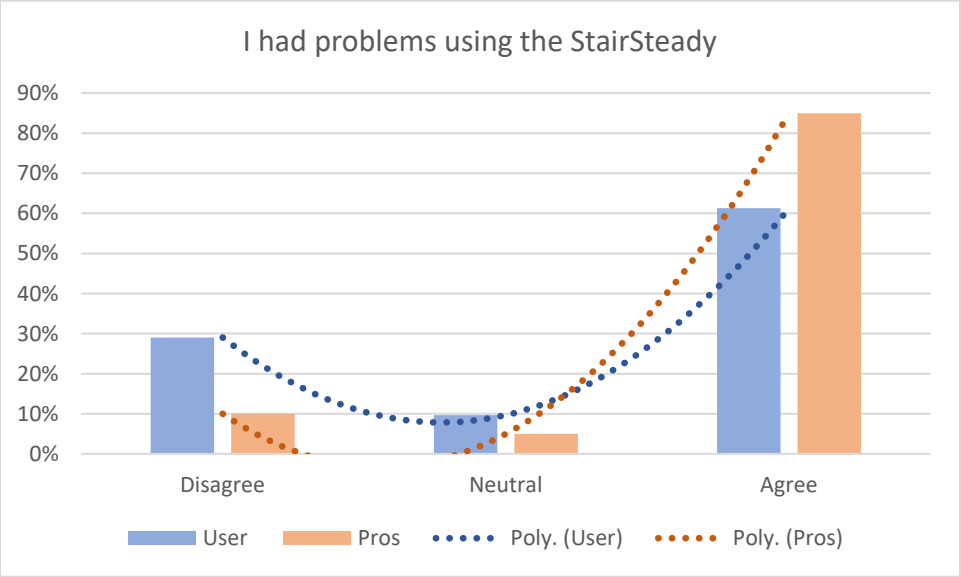

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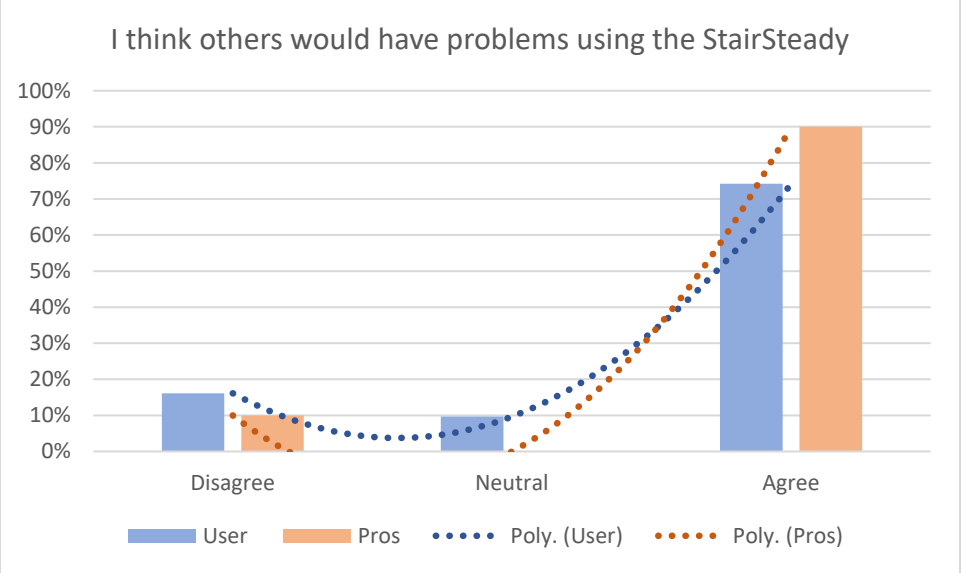

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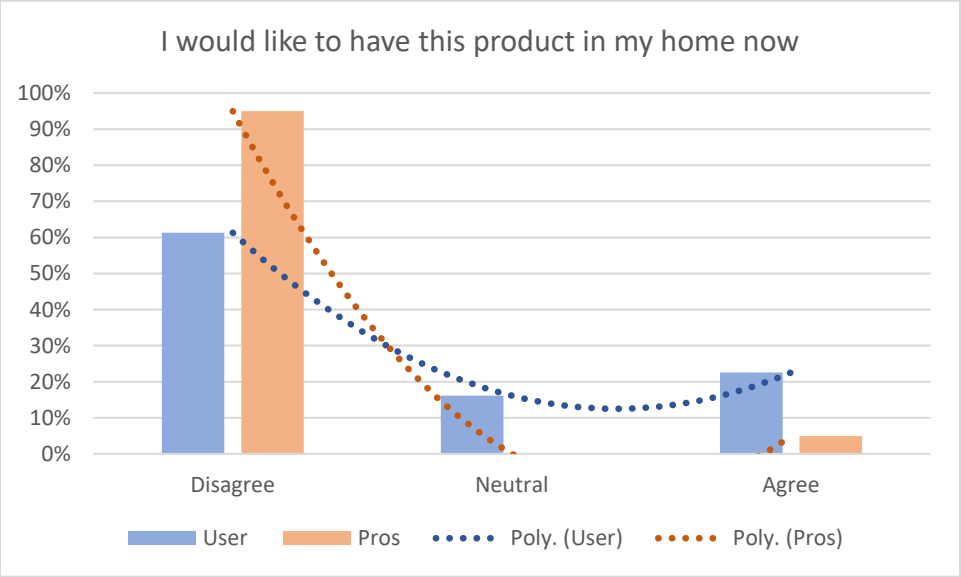

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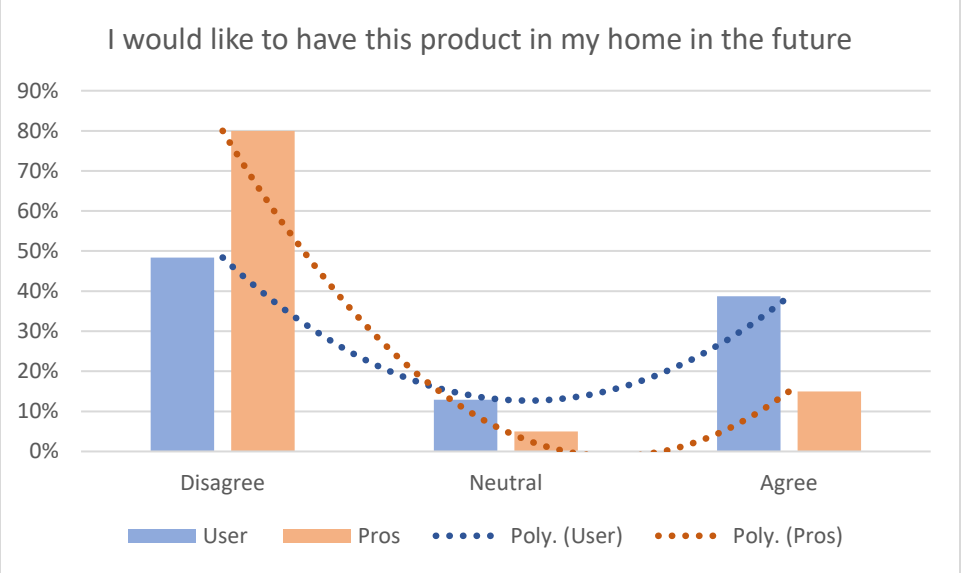

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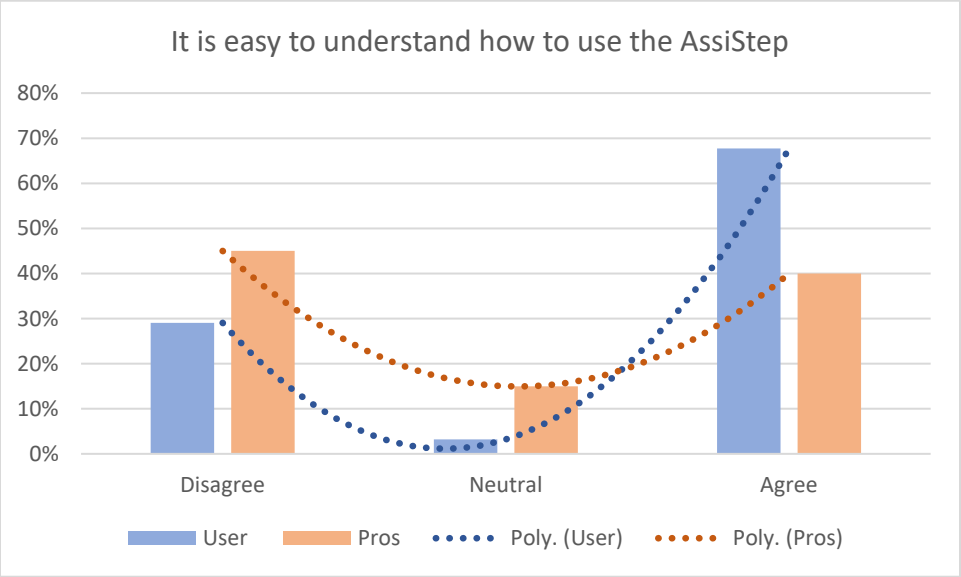
ASSISTEP



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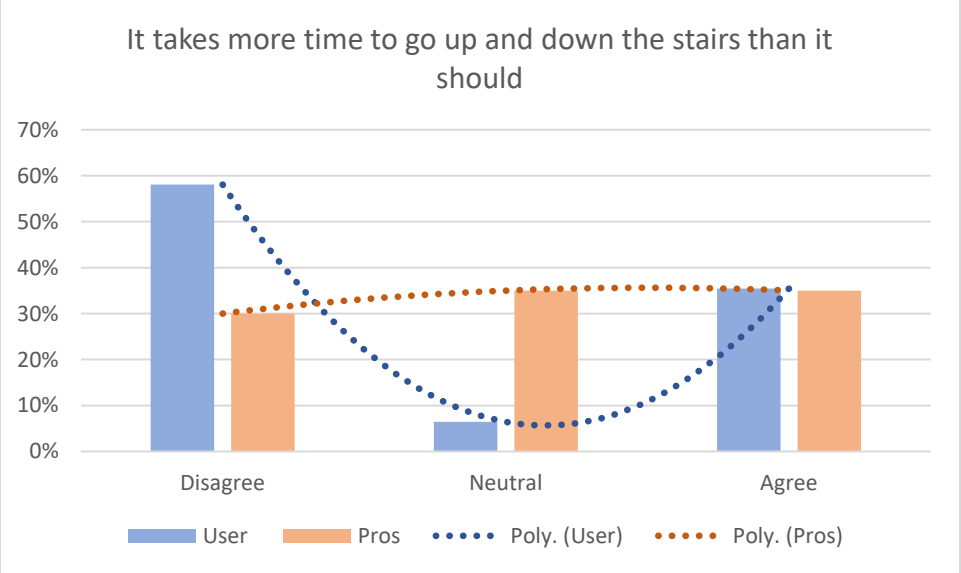

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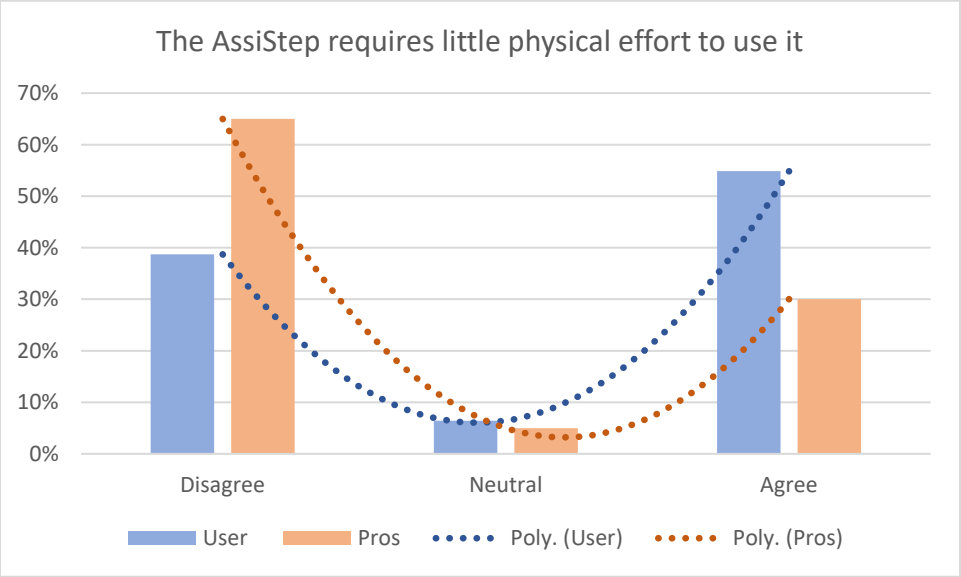

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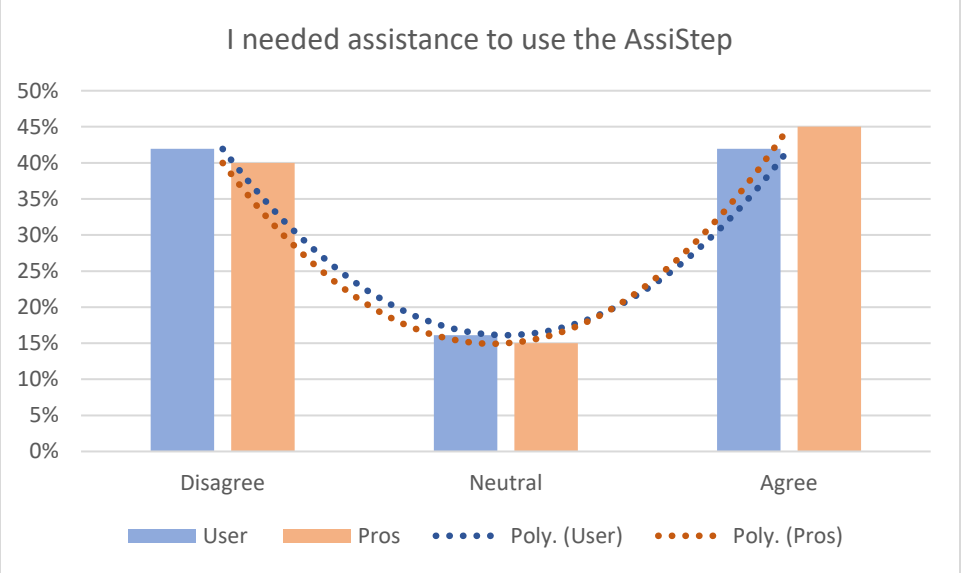

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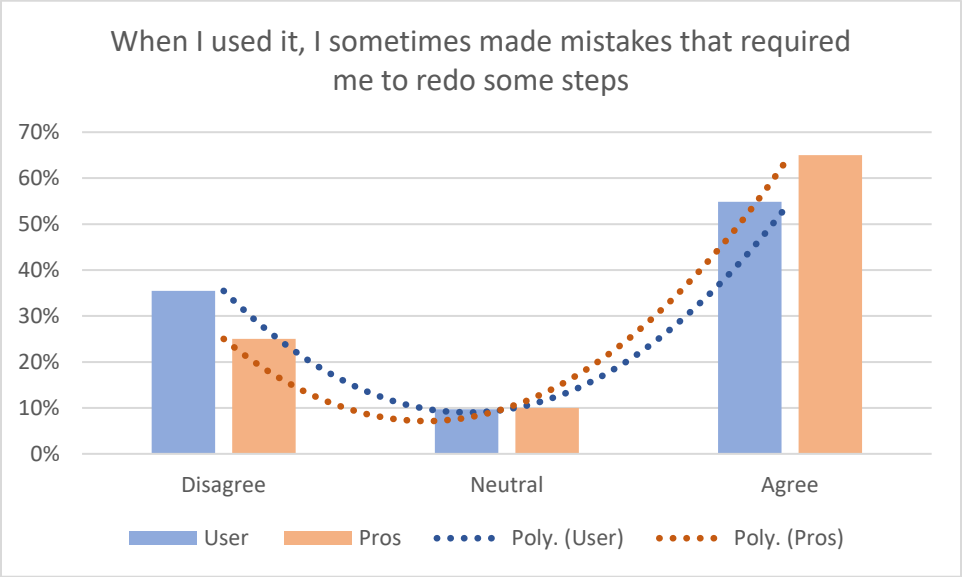

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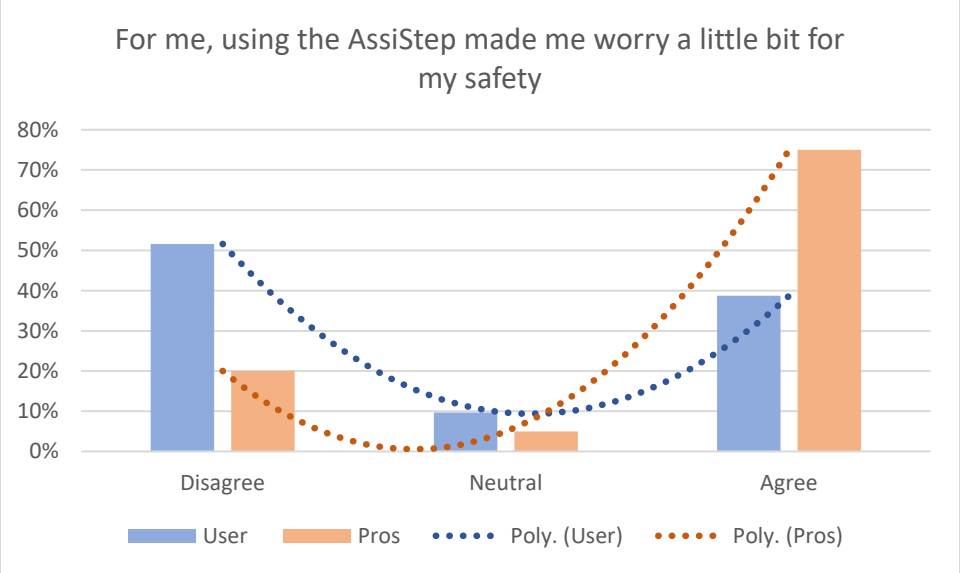

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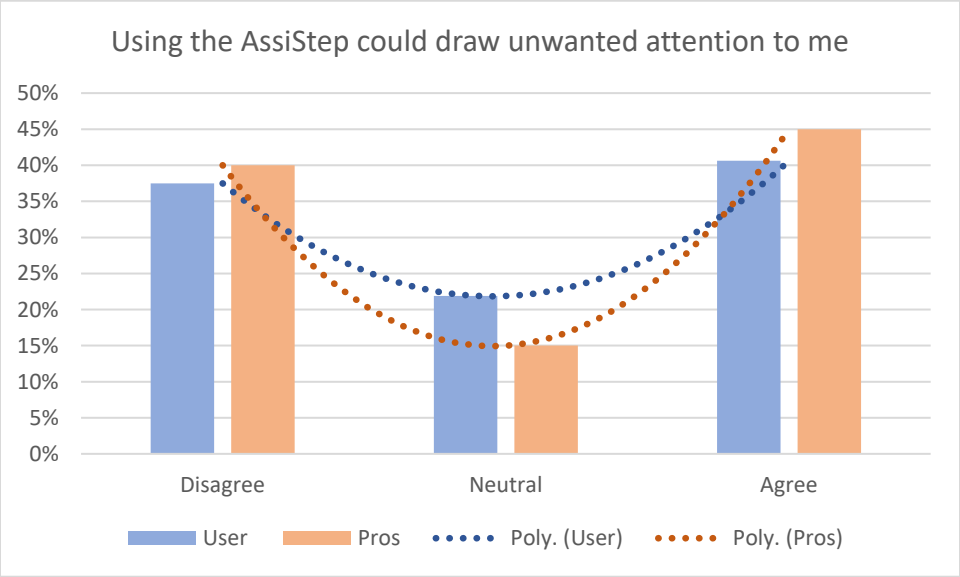

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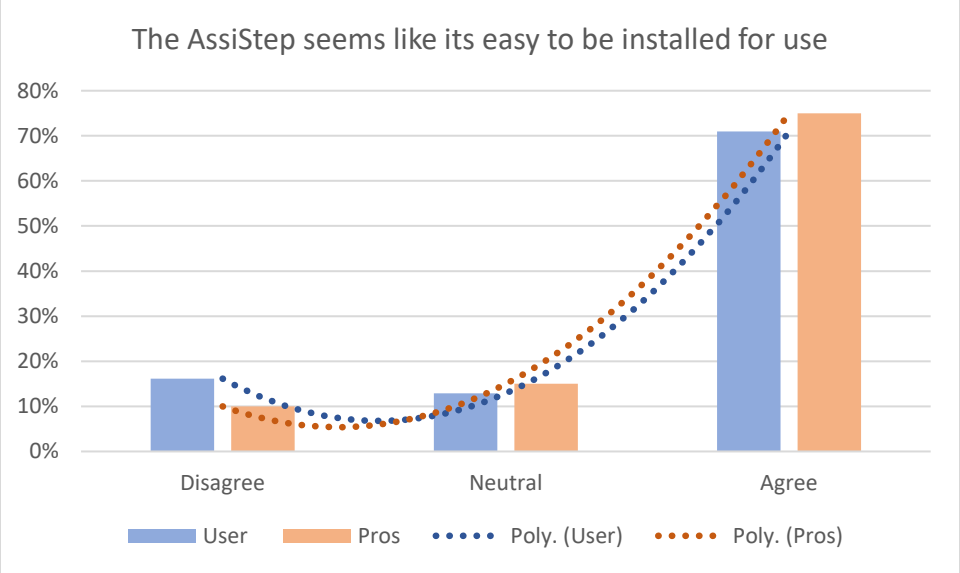

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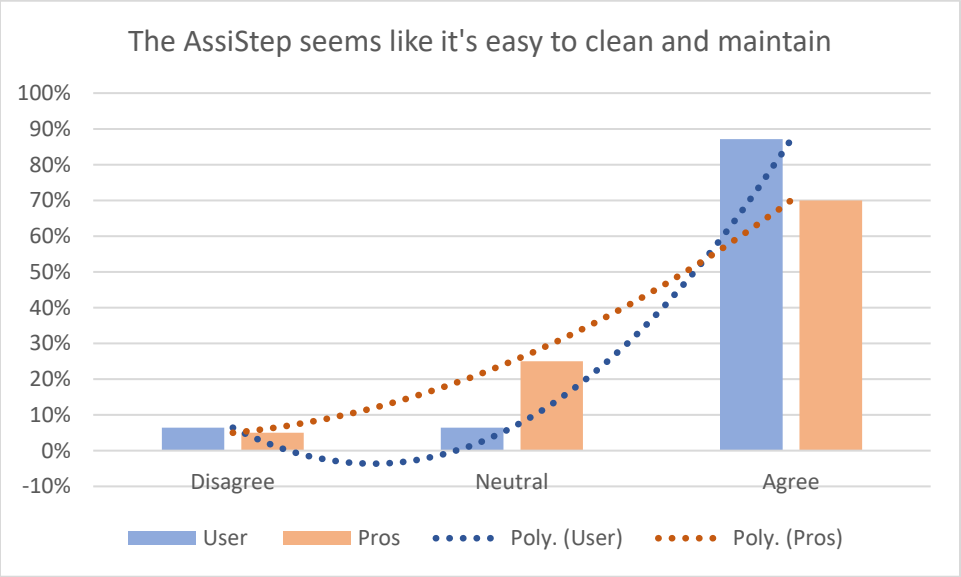

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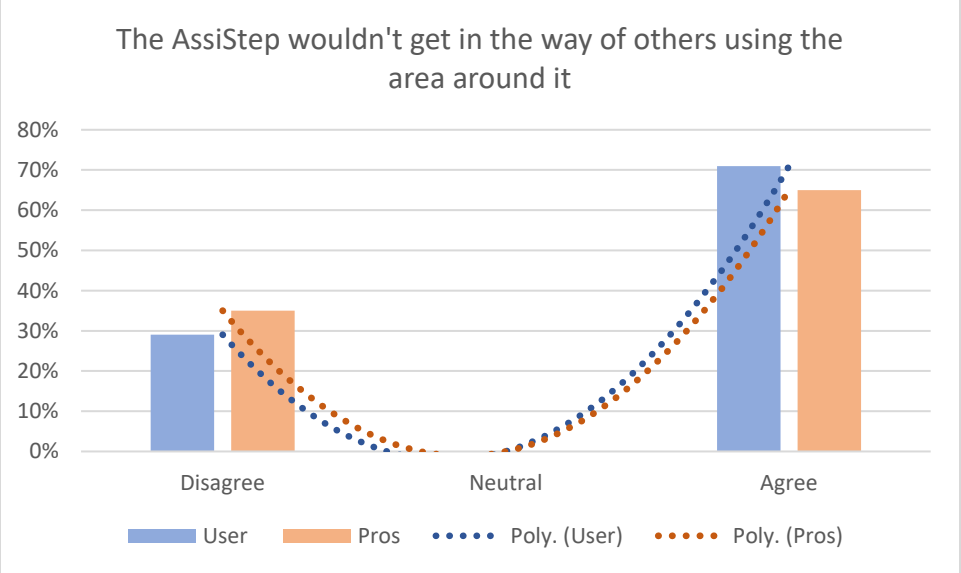

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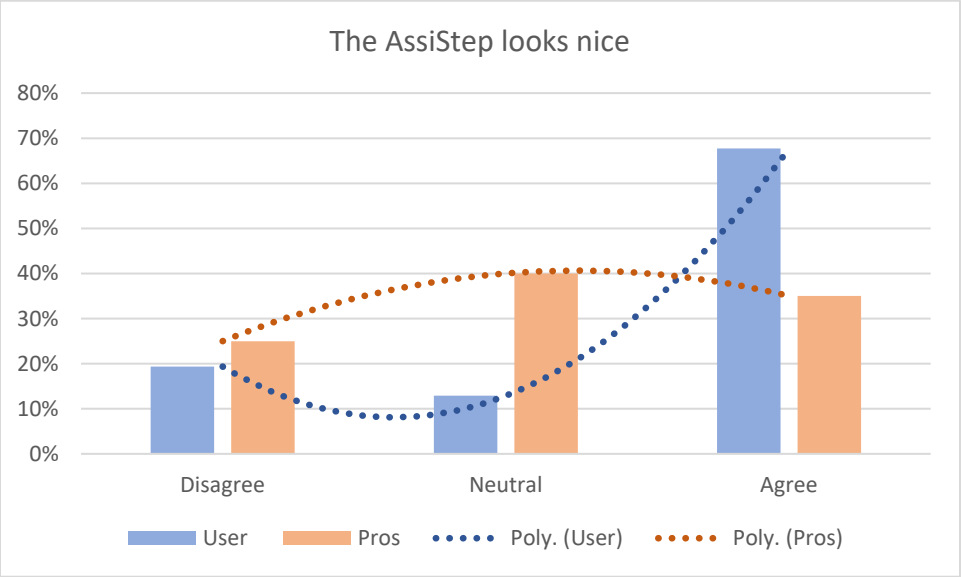

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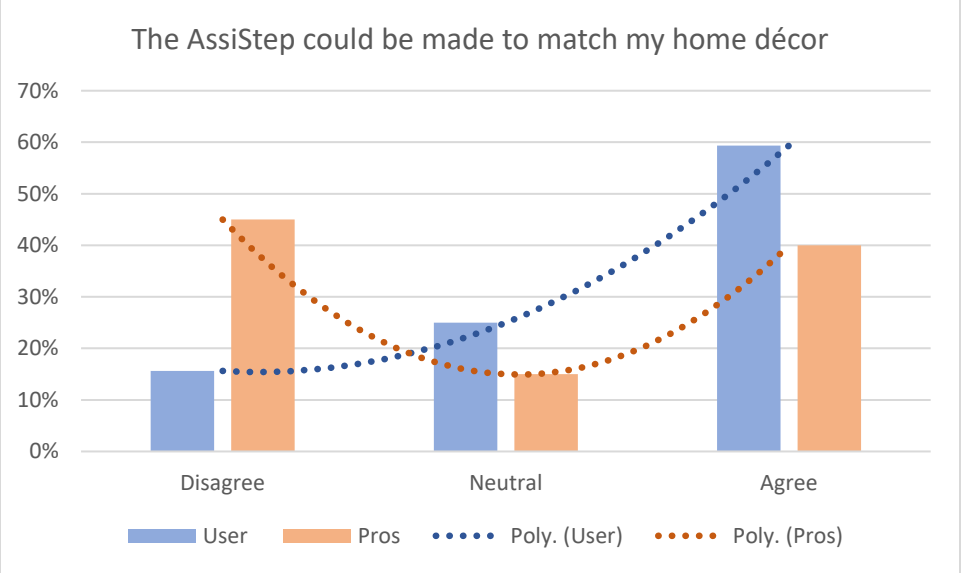

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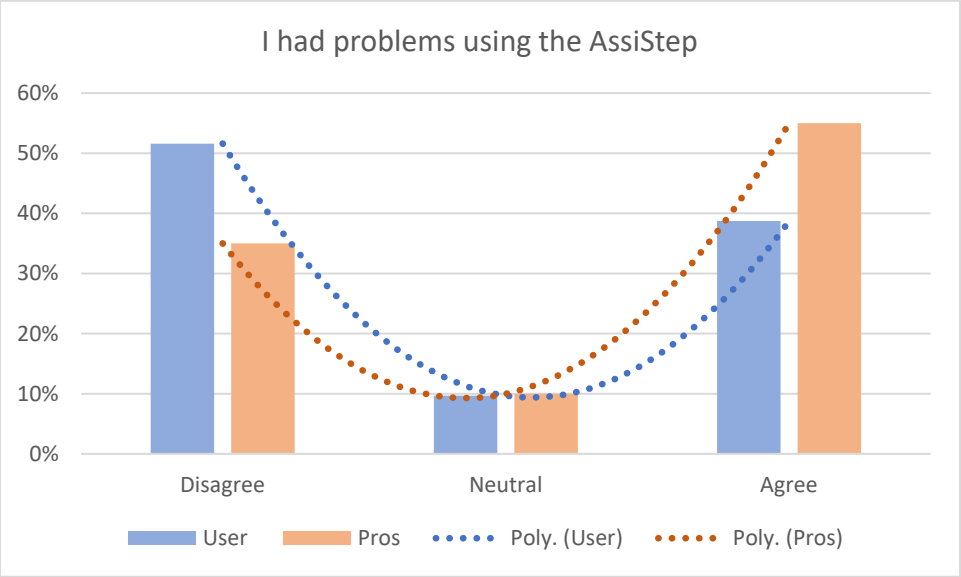

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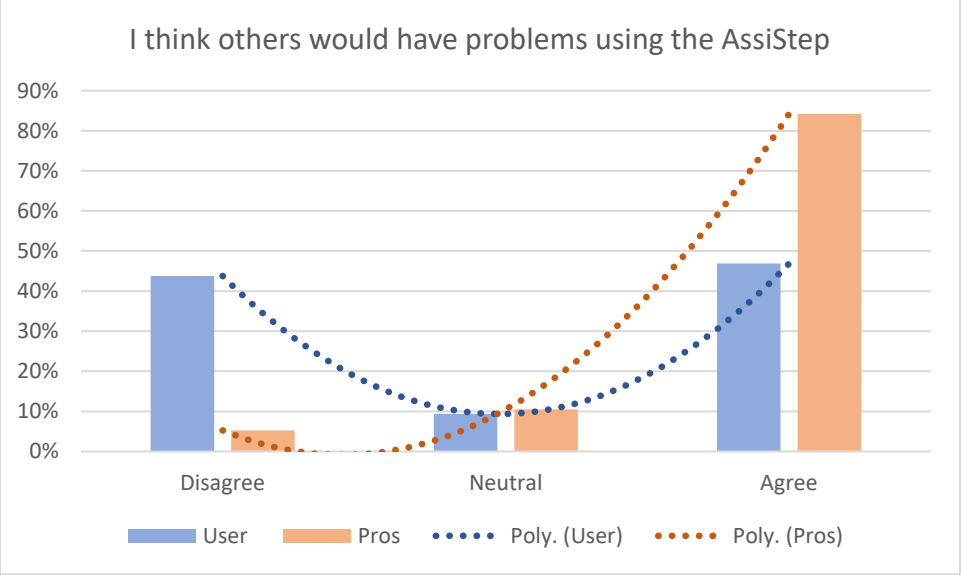

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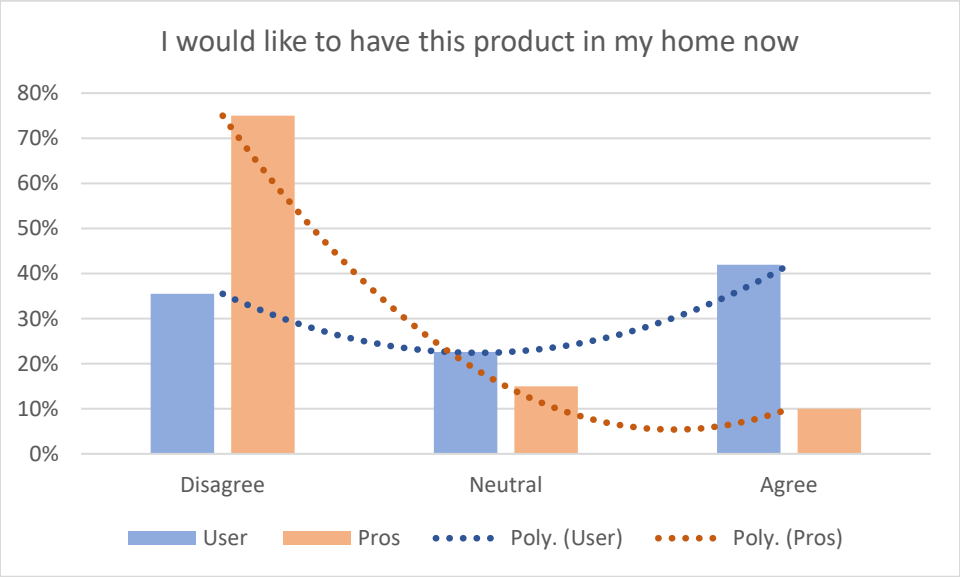

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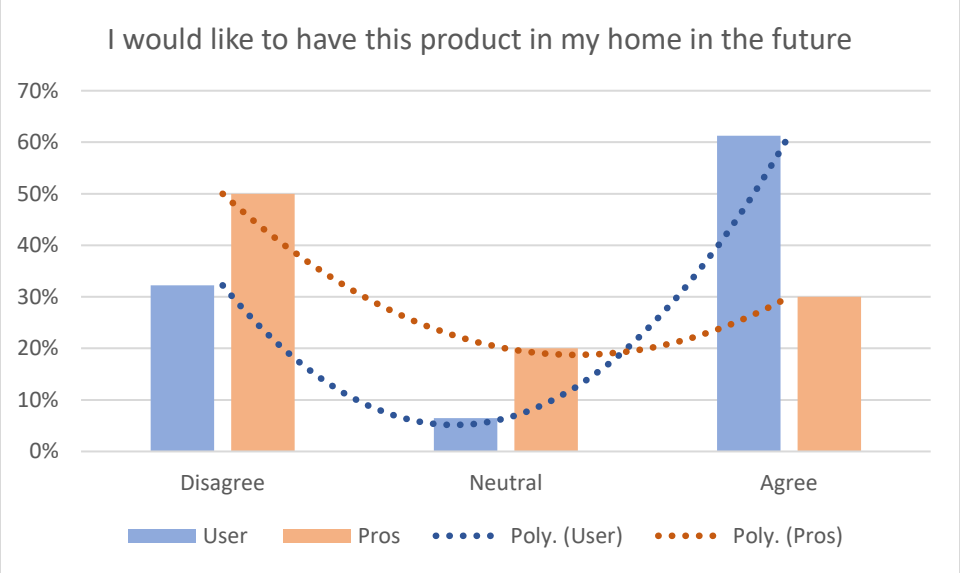

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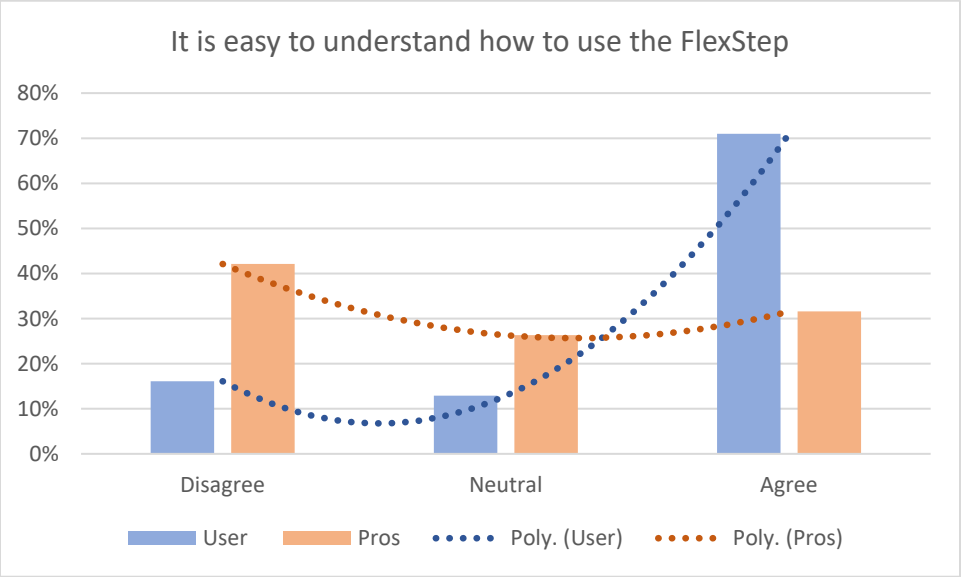
ALL-PUSH DOOR



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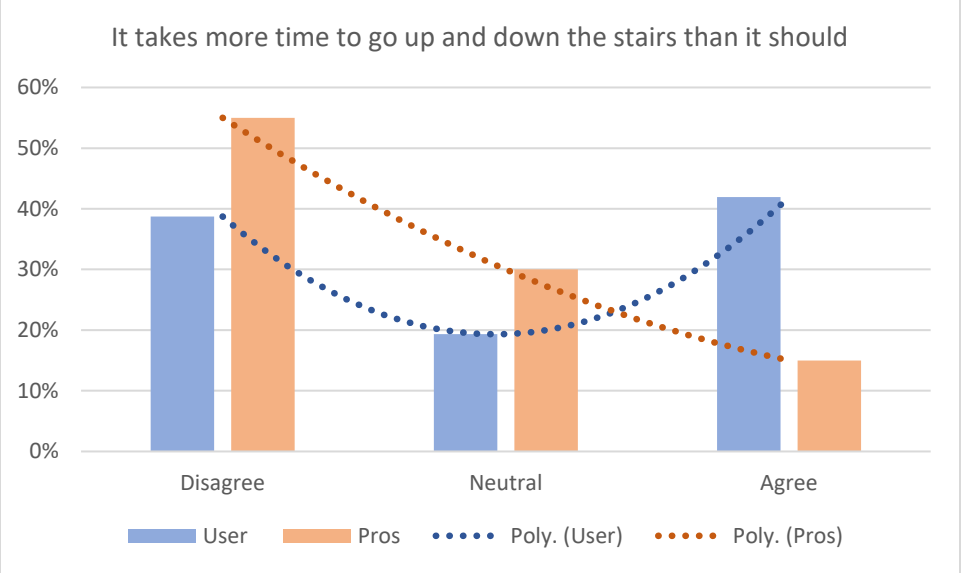

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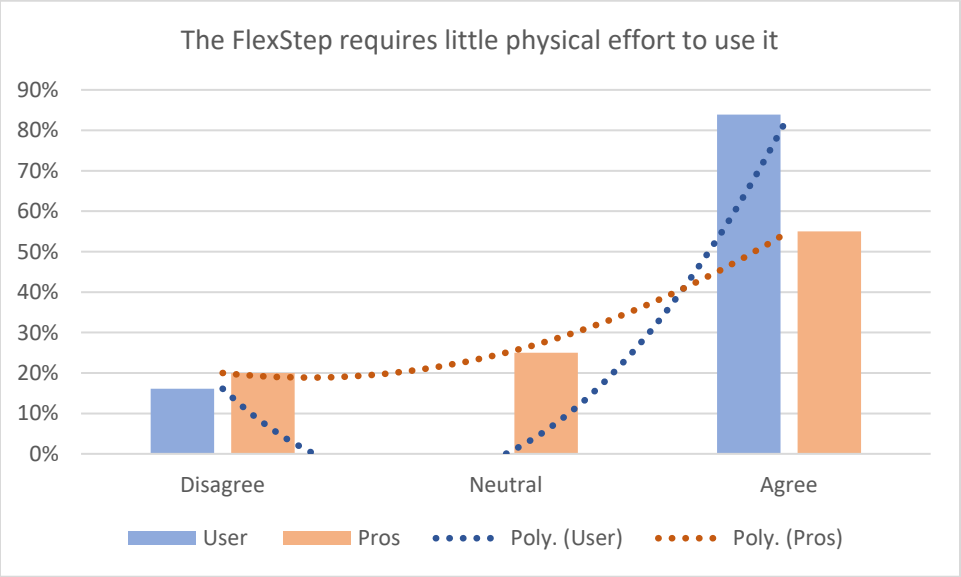

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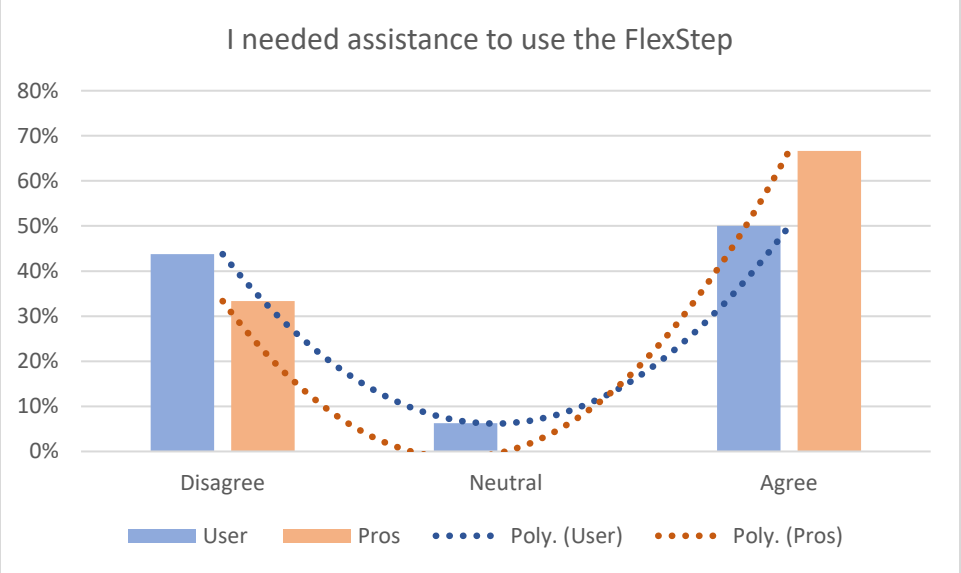

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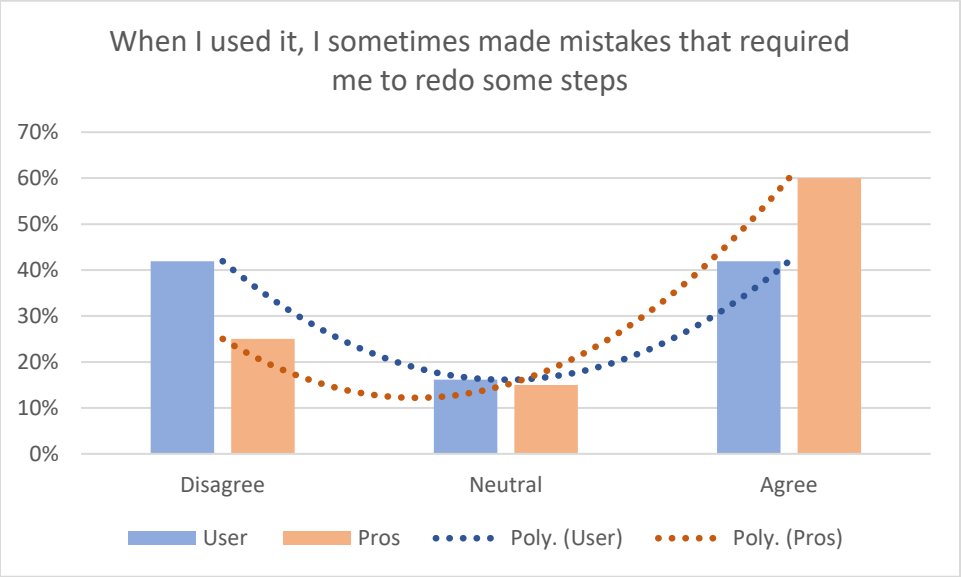

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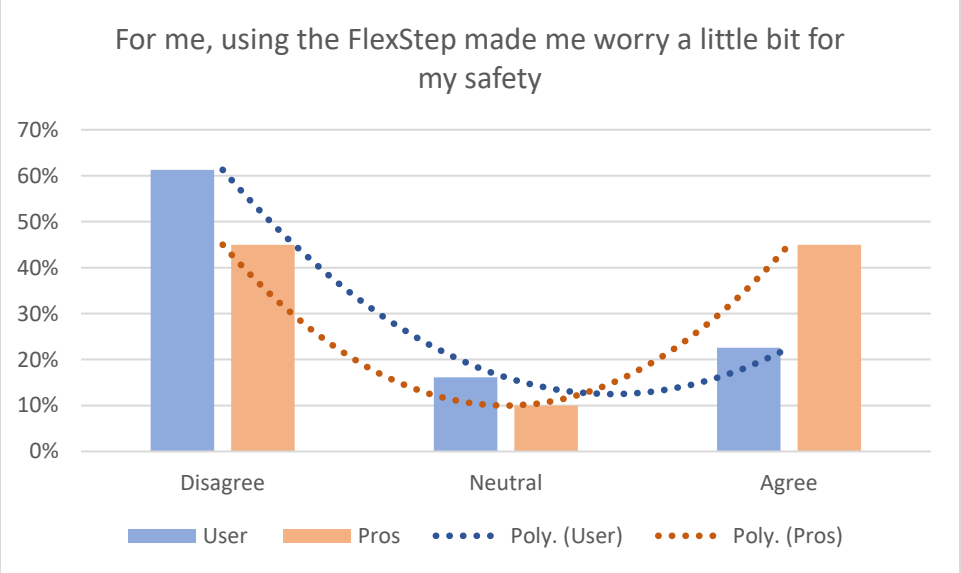

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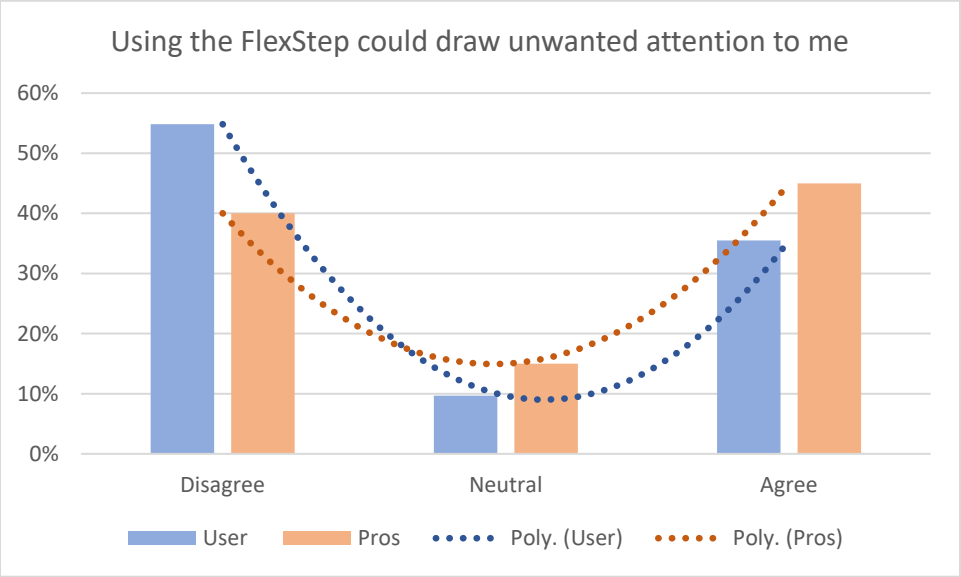

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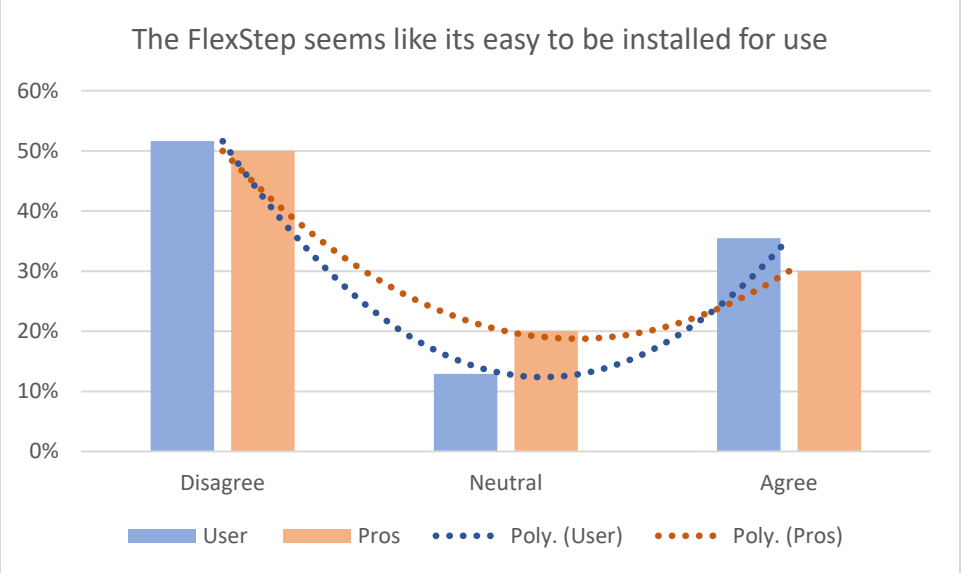

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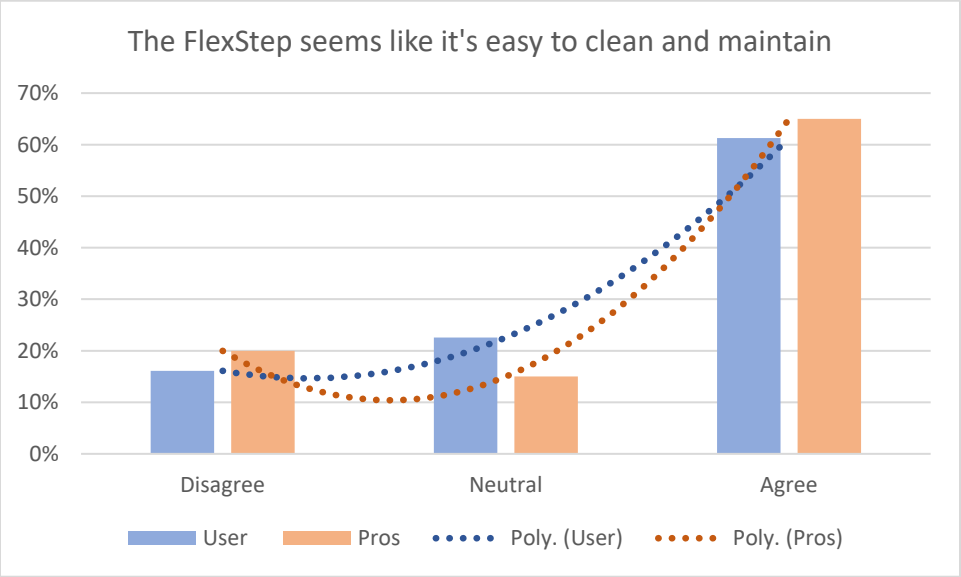

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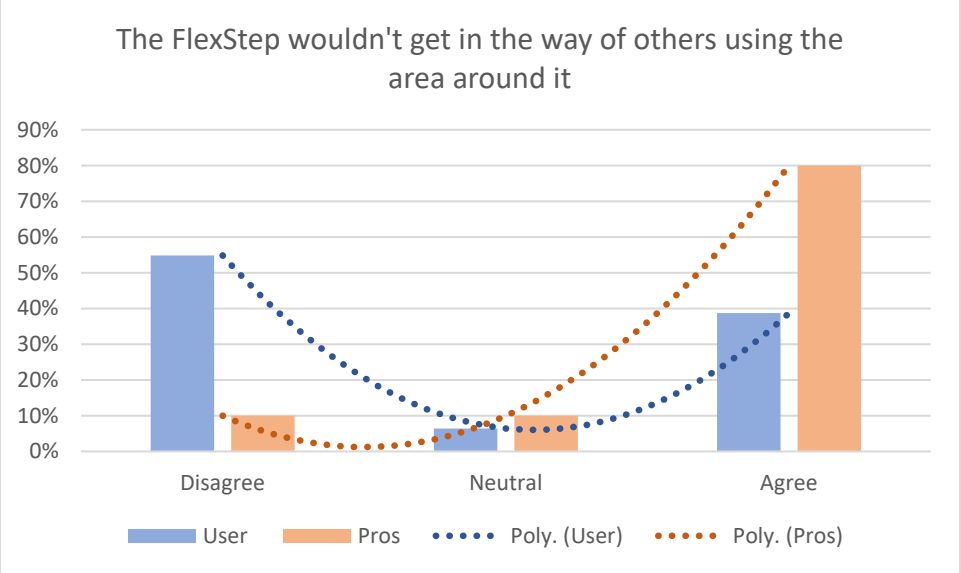

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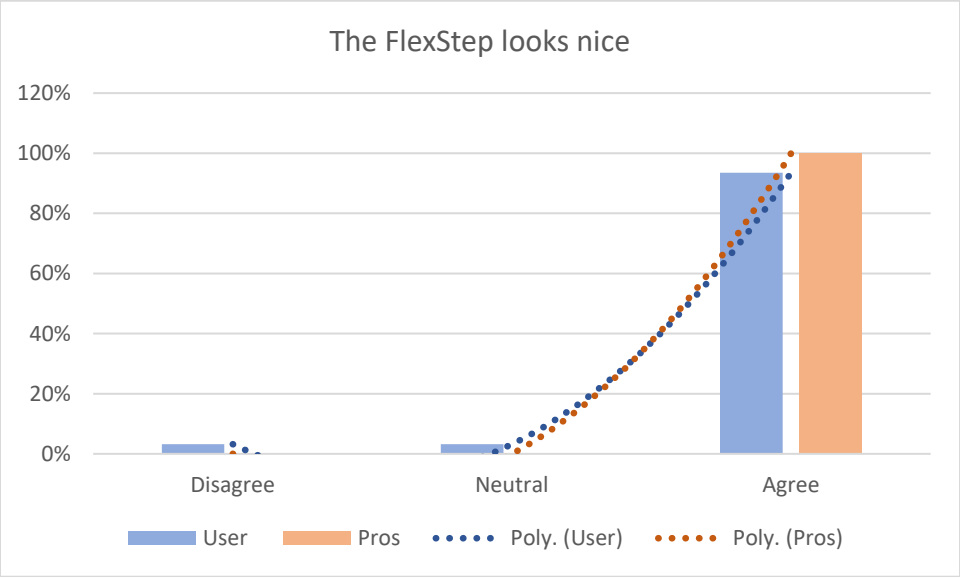

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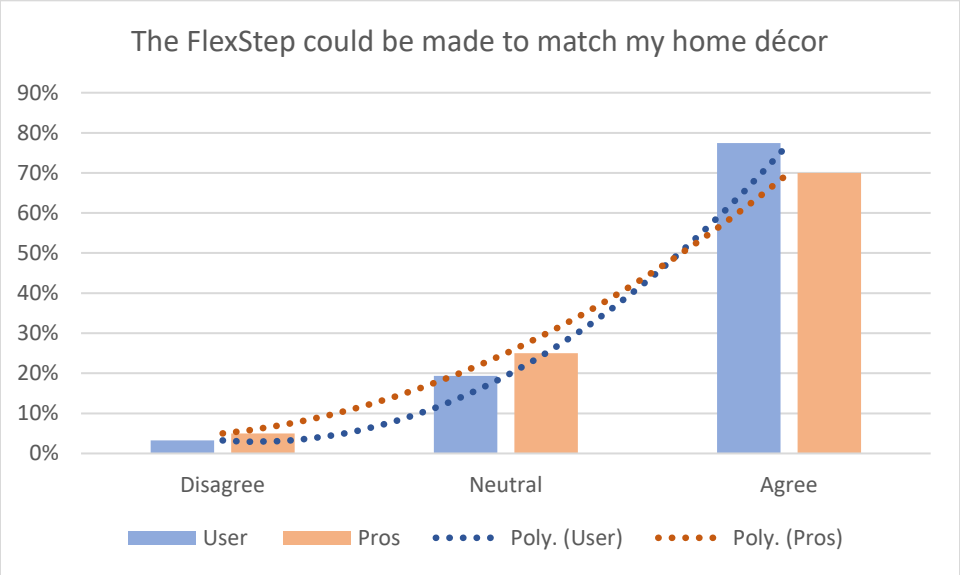

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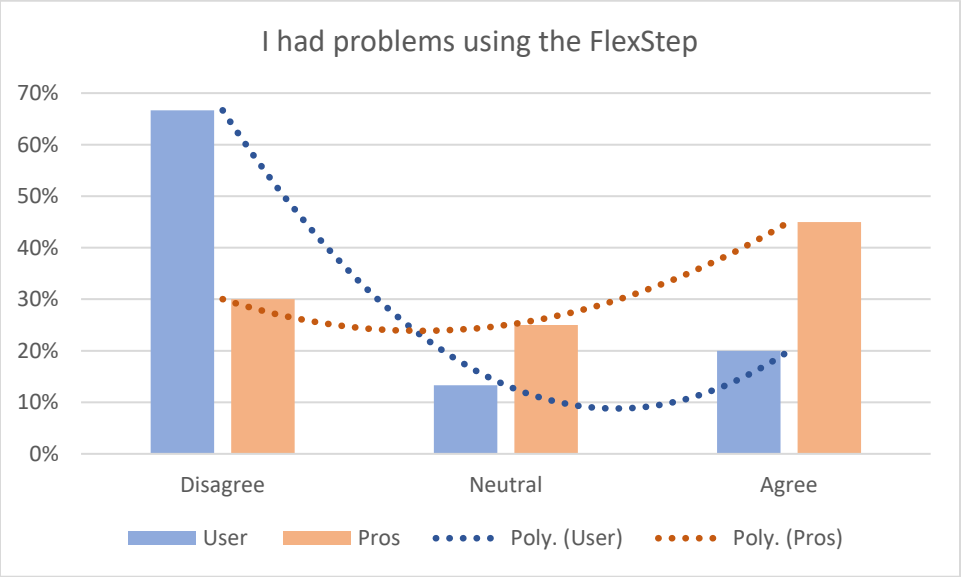

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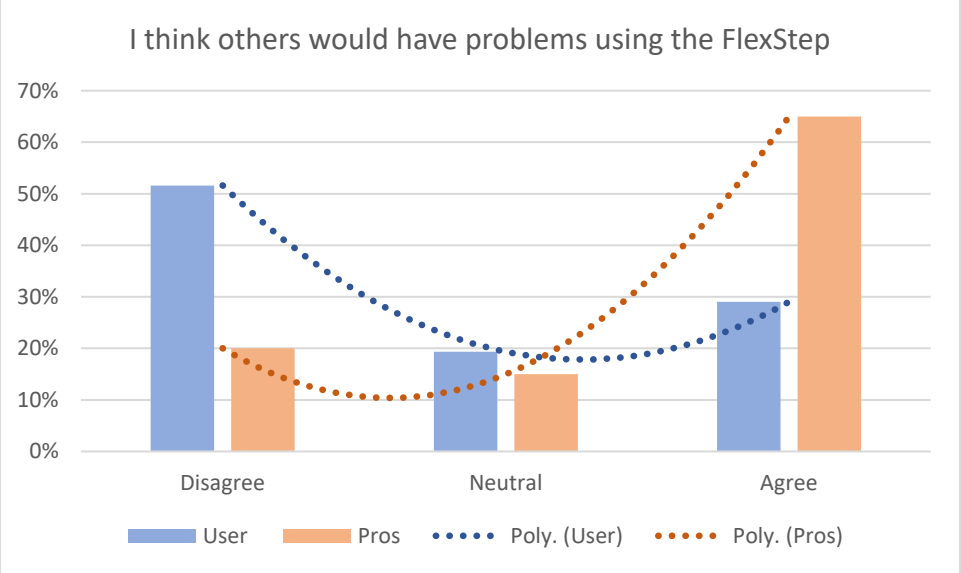

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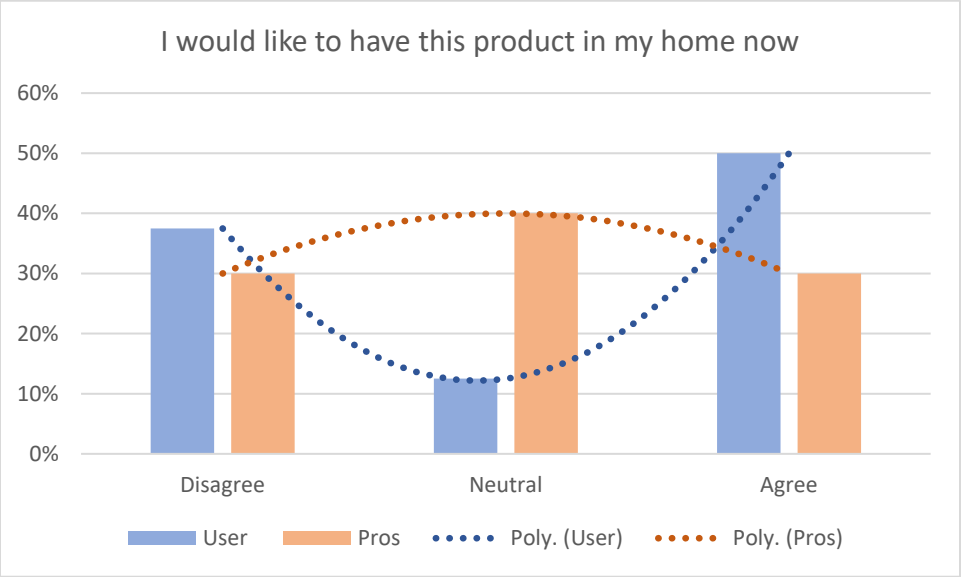

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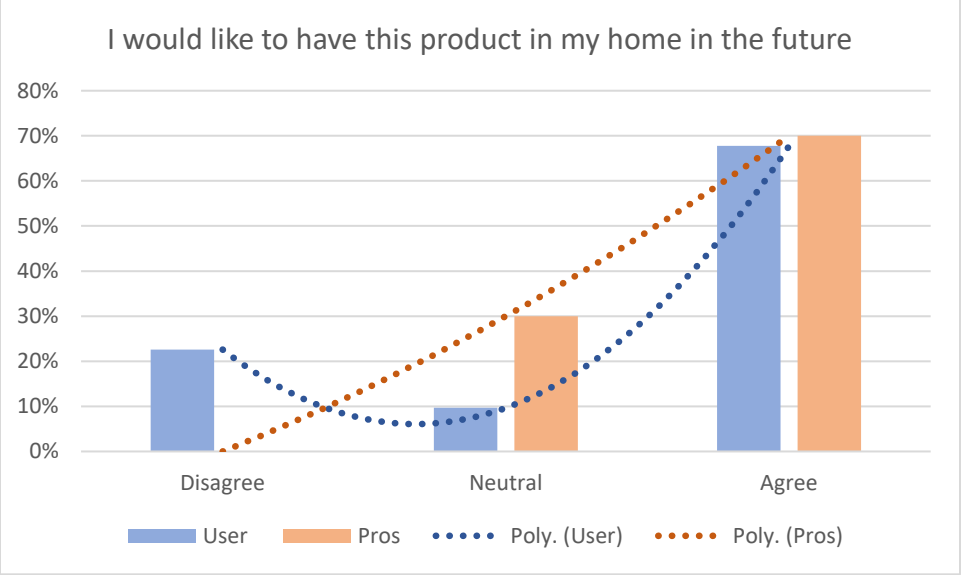

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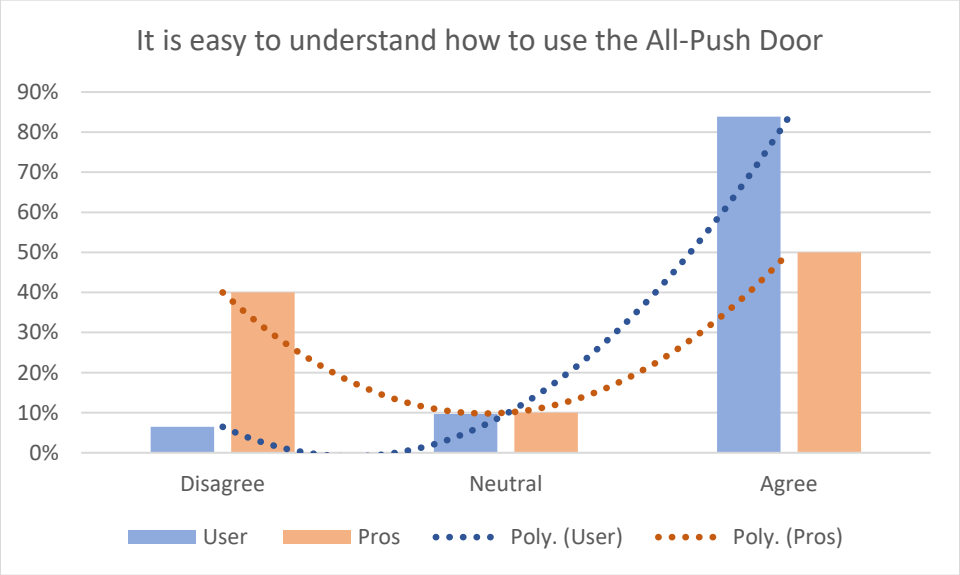

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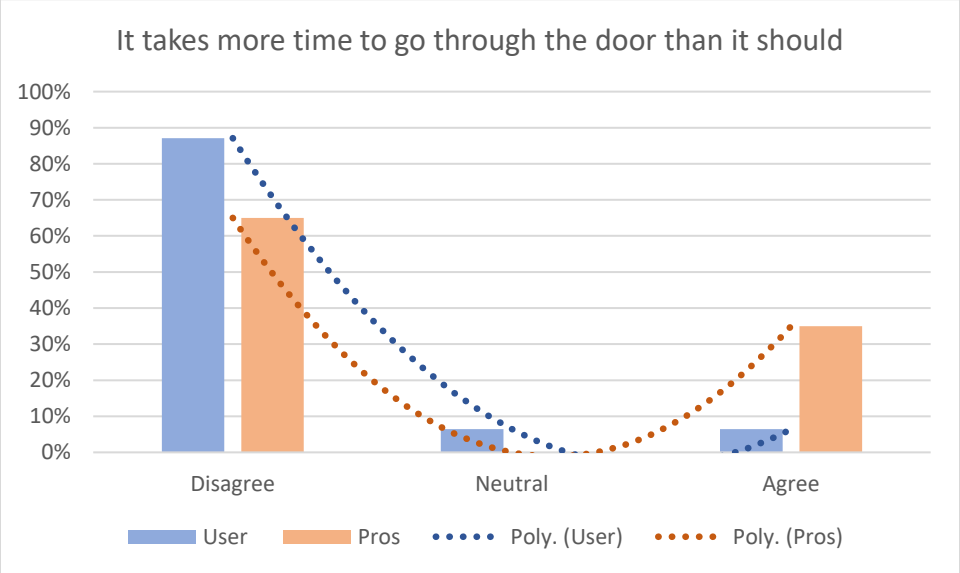

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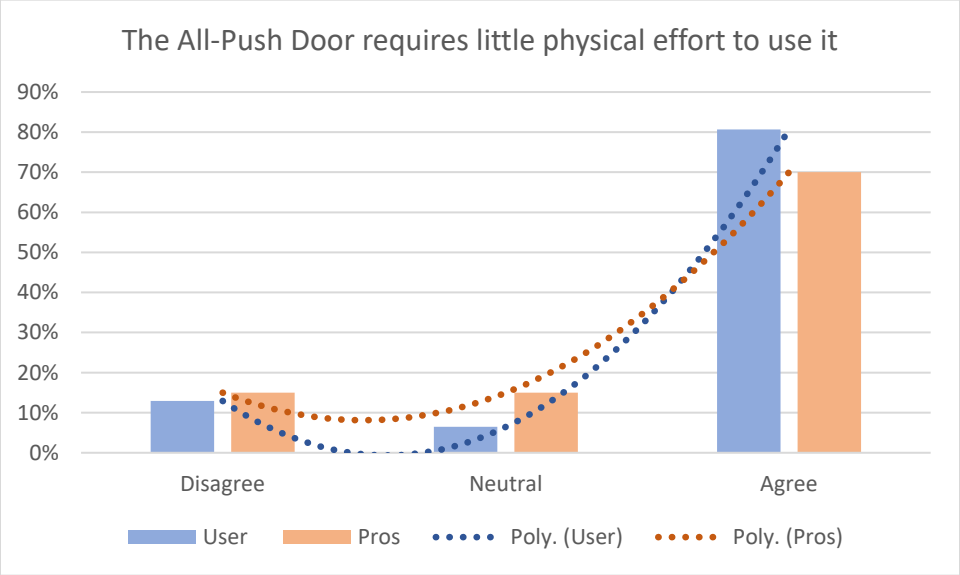

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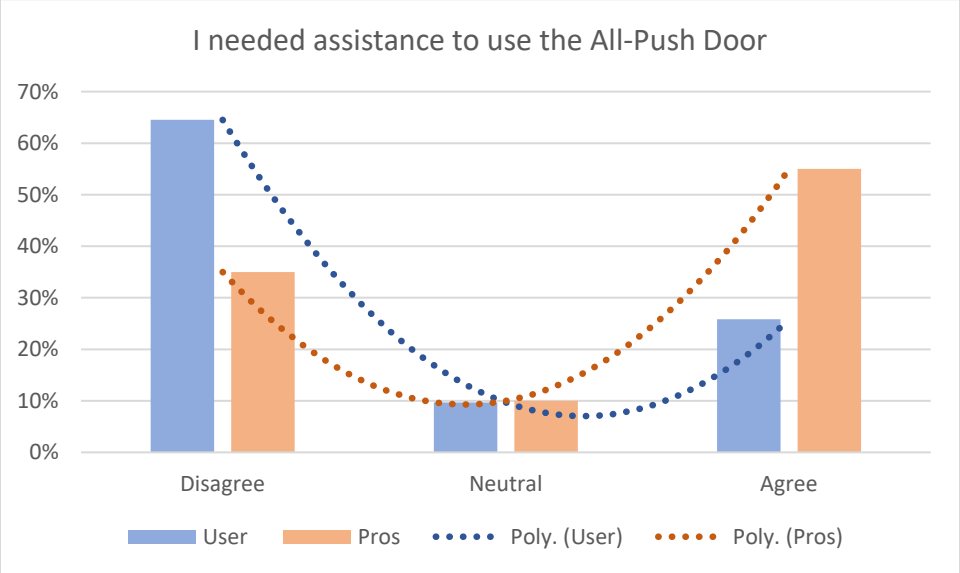

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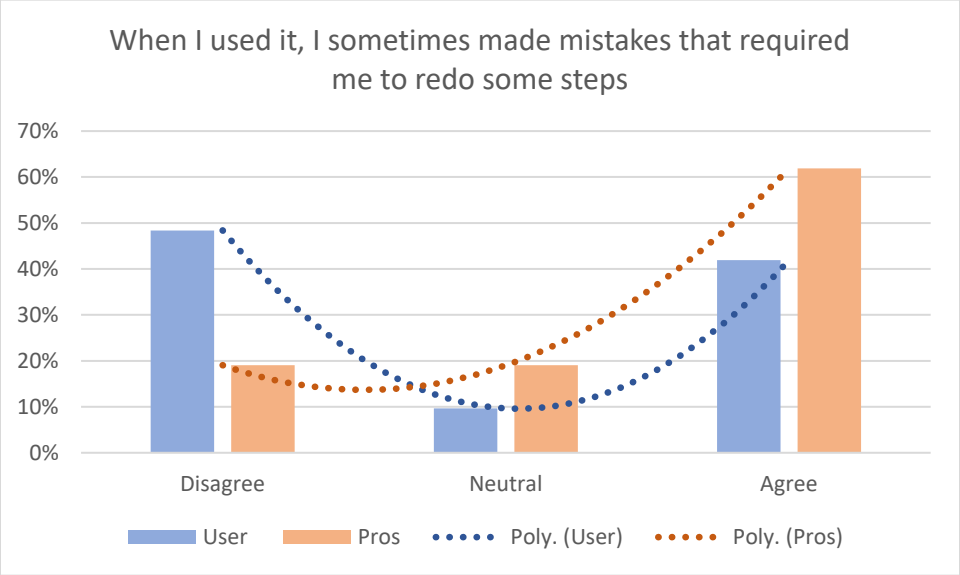

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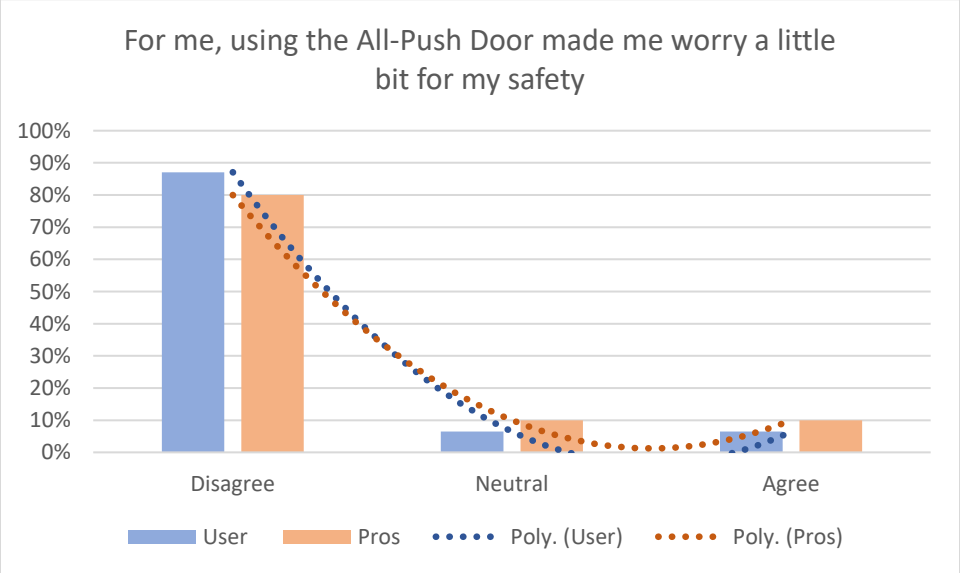

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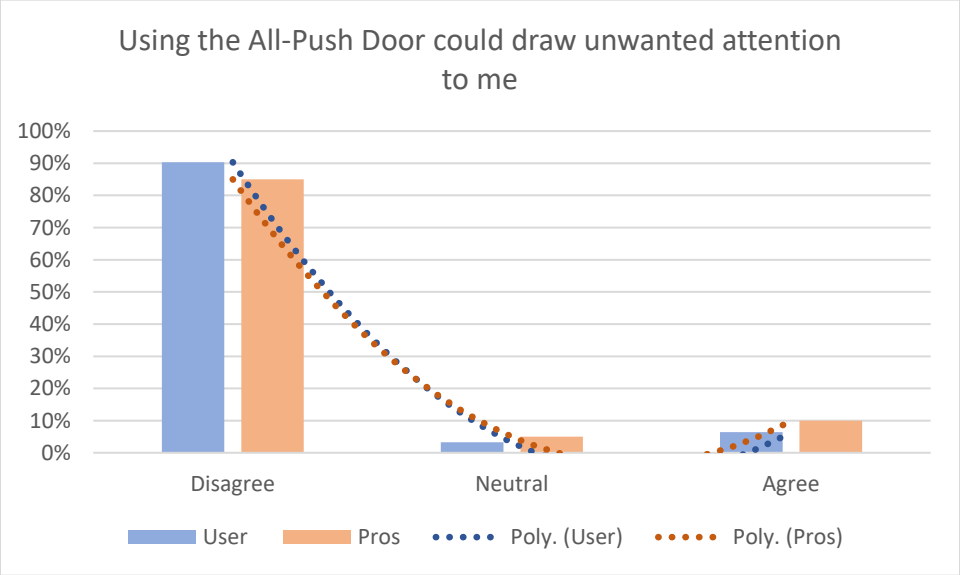

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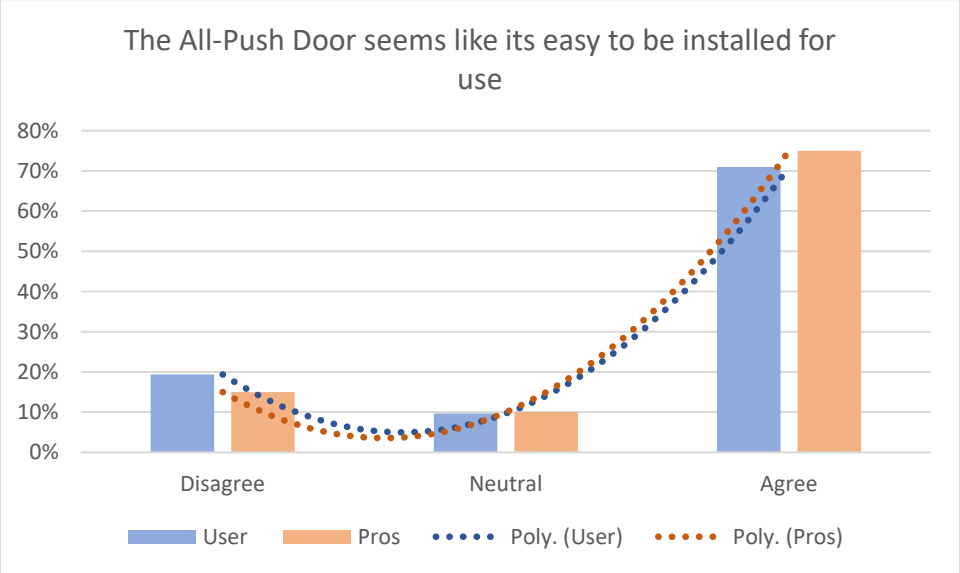

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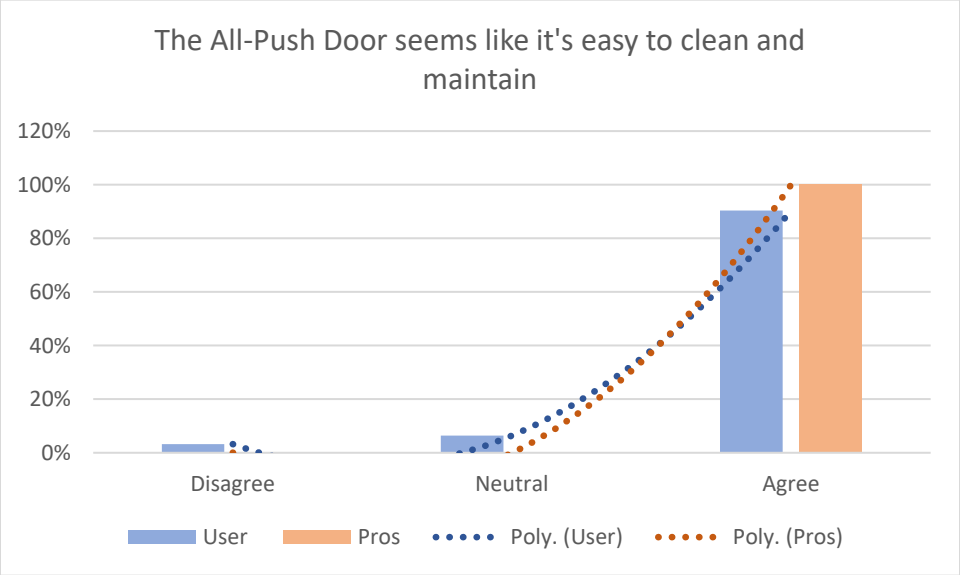

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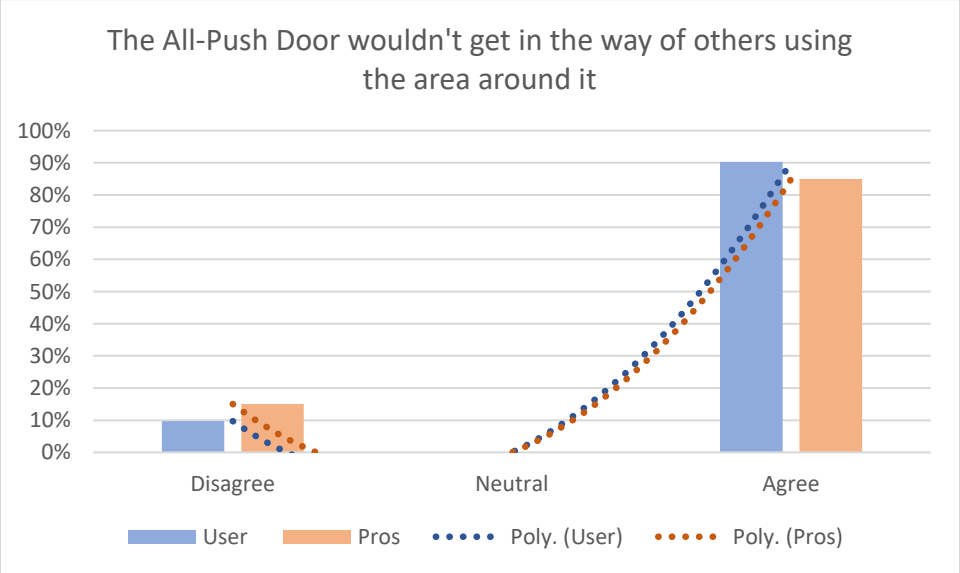

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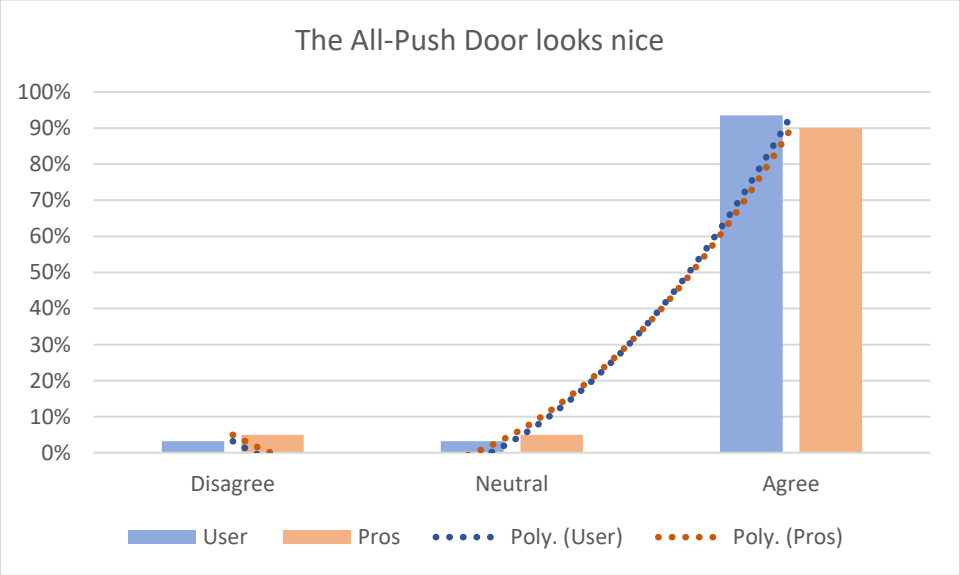

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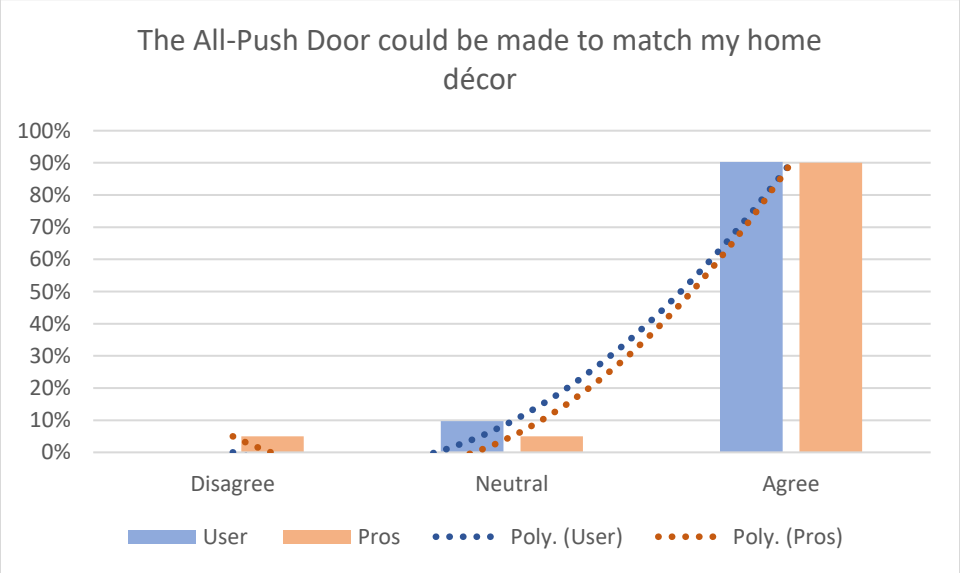

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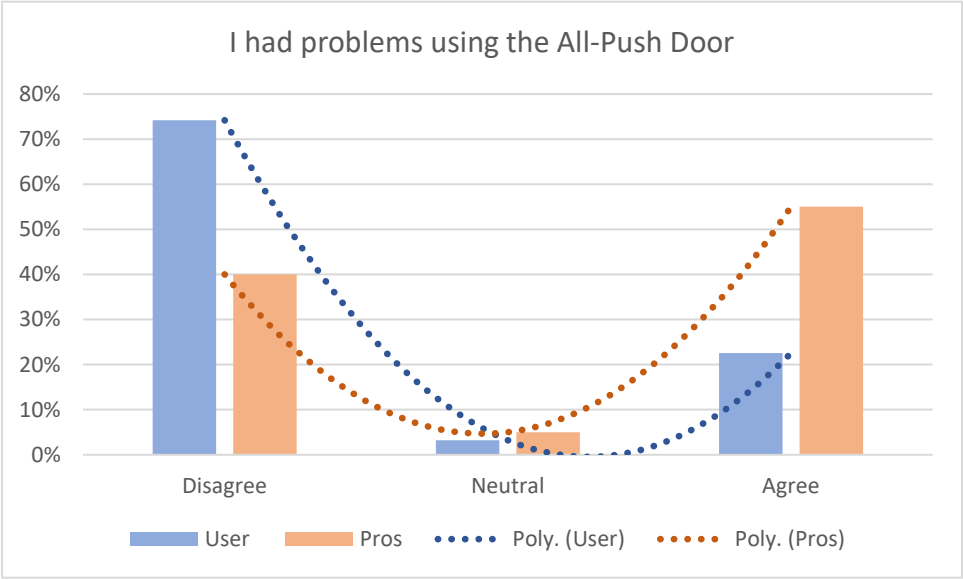

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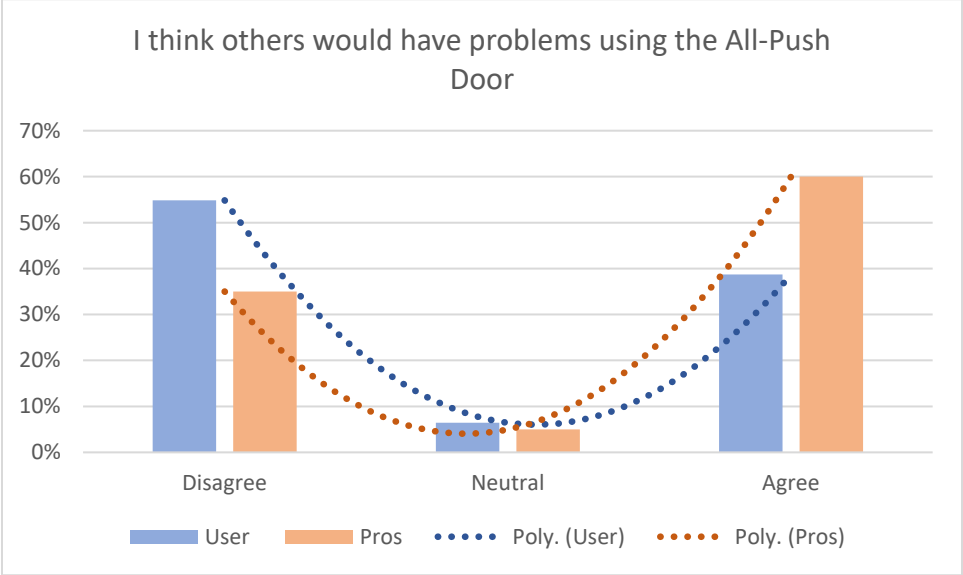

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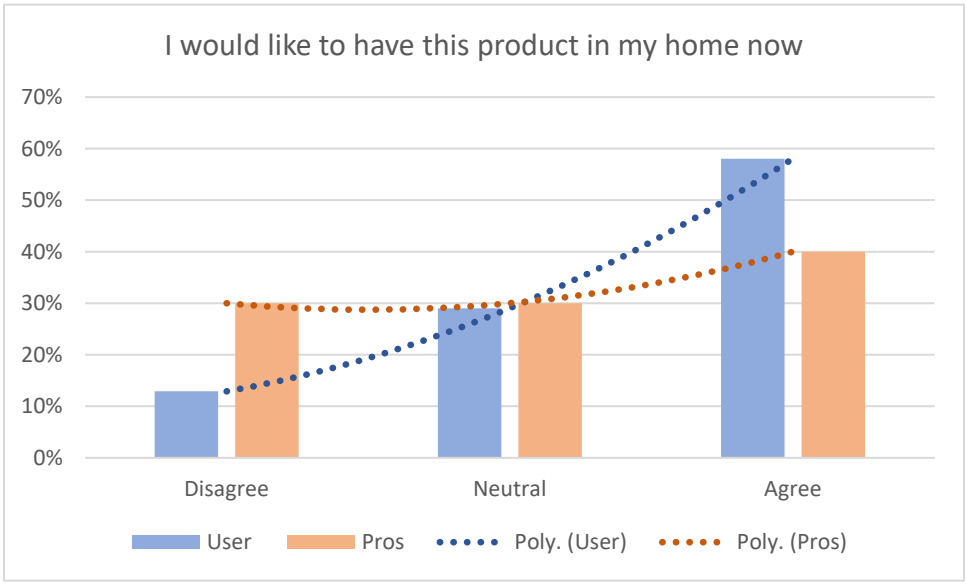

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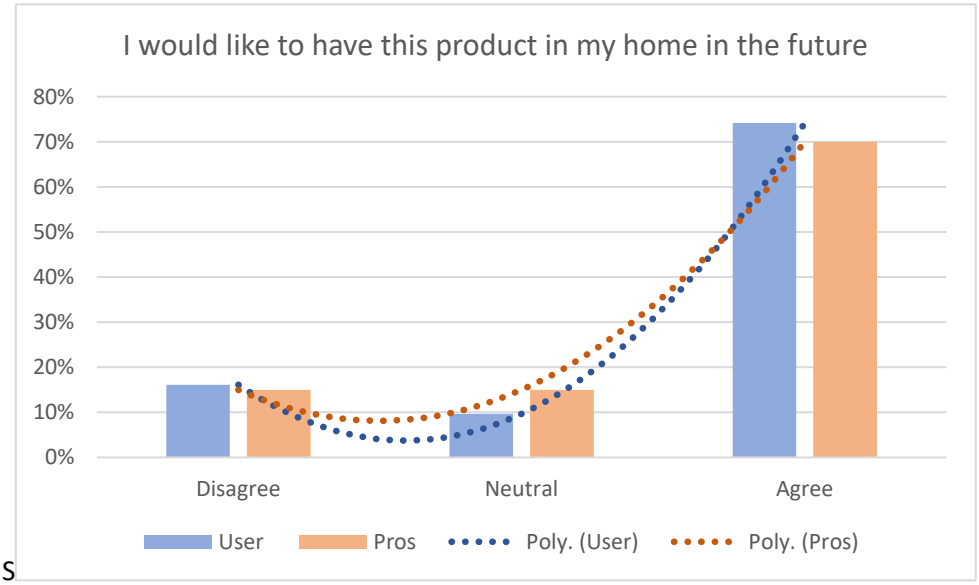

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EQUAL HOUSING OPPORTUNITY

June 2024