

Industrial Revolution

Every home that is built is a representation of compromises made between different and often competing goals: comfort, convenience, durability, energy consumption, maintenance, construction costs, appearance, strength, community acceptance, and resale value. Consumers and developers tend to make tradeoffs among these goals with incomplete information which increases risks and slows the process of innovation in the housing industry. The slowing of innovation, in turn, negatively affects productivity, quality, performance, and value. This department features a few promising improvements to the U.S. housing stock, illustrating how advancements in housing technologies can play a vital role in transforming the industry in important ways.

A Study of Innovative Assistive Devices for Aging in Place

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The U.S. Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this article.

Abstract

Home Innovation Research Labs and the Center for Inclusive Design and Environmental Access (IDEA) partnered to study innovative, cost-effective assistive devices that improve accessibility in townhomes and row houses without requiring major renovations. Study participants include seniors, persons with disabilities, caregivers, and design professionals specializing in accessibility.

The U.S. Department of Housing and Urban Development (HUD) identified townhomes and row houses as needing innovative solutions to accommodate the growing population experiencing physical, mental, or sensory challenges. Several programs exist that provide retrofits to existing homes, but in many

Abstract (continued)

cases, the cost of renovating can be prohibitive due to narrow hallways, multilevel stairs, and the lack of bedrooms and full bathrooms on the first floor.

This study addresses three key issues: (1) identifying home improvements needed to make these homes more accessible for individuals with mobility-related limitations; (2) evaluating innovative assistive devices; and (3) determining the availability and cost of such devices.

Introduction

The United States has a large housing stock of attached and semi-attached residential buildings (townhomes and row houses). Narrow floor plans, functional areas spread among levels, and elevated entrances are particularly challenging for seniors and people with disabilities.

The U.S. Department of Housing and Urban Development (HUD) supports affordable housing through many programs, including *Section 202* Supportive Housing for the Elderly and *Section 811* Supportive Housing for Persons with Disabilities. HUD's Office of Lead Hazard Control and Healthy Homes also provides grants focused on low-cost, high-impact modifications through the Older Adult Home Modification Program (OAHMP). According to HUD (n.d.), examples include—

[I]nstallation of grab bars, railings, and lever-handled doorknobs and faucets . . . installation of adaptive equipment, such as temporary ramp, tub/shower transfer bench, handheld shower head, raised toilet seat, risers for chairs and sofas, and non-slip strips for tub/shower or stairs. The OAHMP model primarily relies on the expertise of a licensed Occupational Therapist (OT) to ensure that the home modification addresses the client's specific goals and needs and promotes their full participation in daily life activities.¹

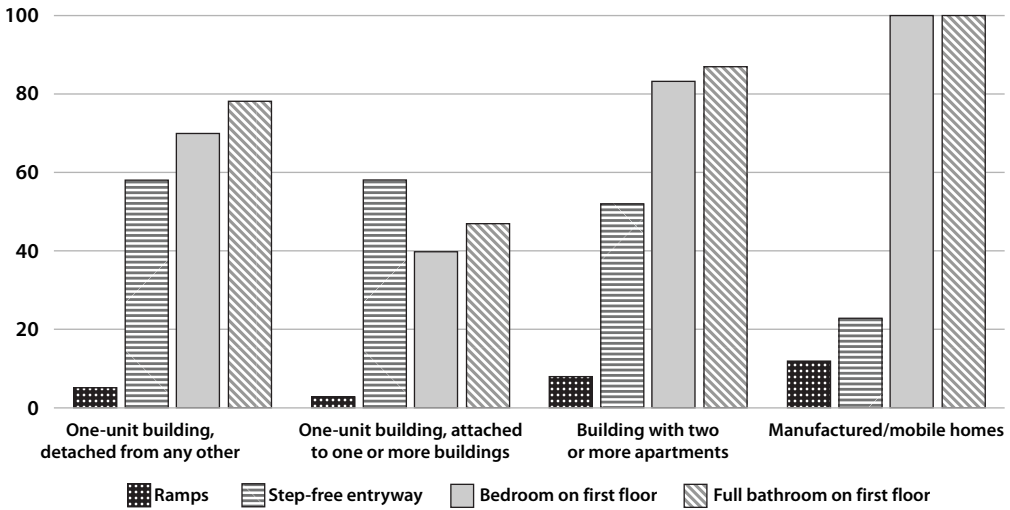
In fiscal year 2022, OAHMP received \$30 million in funding. To qualify for the program and receive benefits, applicants must be low-income homeowners who are at least 62 years old with a privately owned primary residence that needs repair or rehabilitation (beyond normal maintenance).

The U.S. Census Bureau and HUD (2021) published the 2019 American Housing Survey (AHS), which includes data concerning home accessibility. The AHS estimated 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. Of people living alone, approximately 35 percent have a disability, and 37 percent are aged 65 or older. The AHS estimated occupied housing units with accessibility features as a percentage of each structure type, demonstrated in exhibit 1.

¹ An overview of OAHMP is available at https://www.hud.gov/program_offices/spm/gmomgmt/grantsinfo/fundingopps/oahmp.

Exhibit 1

Occupied Housing Units with Accessibility Features as a Percentage of Each Building Structure Type



Source: U.S. Census Bureau

Exhibit 1 considers attached and semi-attached houses (townhomes and row houses) to be “One-unit building, attached to one or more buildings.” The research team could not identify a single “typical” design for these homes. Instead, the team identified several design types and developed lists of modifications needed to make the units accessible.

Existing Home Modifications Needed for Accessibility

The existing housing stock of attached and semi-attached houses has a wide variety of floor plans based on regional design differences and the age of the homes. The team identified three design features—elevated entryways, garages occupying most of the ground level, and stairs to access multiple floors—that make accessibility challenging.

Raised entryways may present a challenge to accessibility, especially when set-back space in the front of the property is limited. The space constraints in exhibits 2 and 3 make installing a conventional ramp impossible. In such cases, installing a stair lift may be necessary, or the resident may need to relocate if no retrofit solutions are viable. Exhibit 4 illustrates a common design feature of modern townhomes—a garage that occupies most of the ground floor space that requires livable space features, such as a full bedroom and bathroom, to be on the second and third floors of the residence.

Exhibit 2

Raised Entryway: Baltimore Rowhouse



Photo credit: Pinterest.

Exhibit 3

Raised Entryway: New York City Brownstone



Photo credit: Shutterstock.

Exhibit 4

Garage First Level: Virginia Townhouse



Photo credit: Pinterest.

As exhibit 1 shows, the Census Bureau and HUD identified and tracked four key accessibility features, which include ramps, step-free entryways, bedrooms on the first floor, and full bathrooms on the first floor. Exhibit 5 illustrates a typical floor design with the garage on the first floor.

If a resident has a mobility-related disability, three options must be considered. First, the homeowner may do a major renovation to create a bedroom and full bathroom on the first floor. Second, they may install a stair assistive device from the garage to the first floor and another 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 focuses on identifying and evaluating devices that make staying in the home both affordable and accessible.

Exhibit 5

Existing Garage on First Floor (No Bedroom or Full Bathroom)



Source: Home Innovation

Evaluating Innovative Assistive Devices

A large percentage of existing townhomes and rowhouses have bedrooms and bathrooms on the second or third level, making vertical navigation a daily challenge. With vertical mobility in mind, the Home Innovation research team evaluated innovative products that make stairways safer and easier to climb, including easier-to-grip railings and devices such as StairSteady and AssiStep. Initially, evaluating a new lift or elevator technology was expected to be outside the scope due to budget, time, and engineering constraints. However, the team identified a cost-effective option,

“FlexStep,” a lift product manufactured in Europe. The team also secured an easy-to-use door called “All-Push Door,” specifically designed for individuals with difficulty pulling open doors, a common difficulty of those in wheelchairs.

Using Focus Groups

Focus group discussions were conducted among three primary stakeholders—users, caregivers, and professionals. Each focus group discussion lasted approximately 2 hours, and each group had 8 to 10 participants, with 27 total participants.² Although extrapolation from this sample size may not be appropriate statistically, the findings from the focus groups corroborate the key findings from the literature search; for example, (1) the appearance of the assistive device is important and must fit with the home’s character; (2) assistive devices require a standard method of evaluation to increase trust of the device’s safety; and (3) affordability is a primary consideration.

Caregivers in the focus groups were more likely to report challenges than the users or people with disabilities. Caregivers tended to categorize an activity as challenging if they perceived any delay or difficulty, whereas users of the device resisted classifying an activity as a challenge as long as they could ultimately achieve the goal despite delay or difficulty. In every category, the caregivers consistently rated the activity more difficult than the users. Despite this difference, caregivers and users prioritized challenges the same.

Areas of the home such as bathrooms, stairs, laundry rooms, and entryways or entrances were commonly cited as presenting the greatest challenges. Among caregivers and users, the fear of falling was a primary safety concern associated with the bathroom and stairs. Users thought that these areas needed to be modified for them to remain in their homes long term, and caregivers stressed the importance of having good retrofit solutions for these spaces. Caregivers prioritized stairway solutions because they improved mobility inside the house, prevented users from feeling isolated or confined to one part of the house, and allowed mobility-facilitated social interaction.

Occupational therapists in the focus groups stated that individuals who stayed in their homes saw greater benefits in terms of quality of life and added value to their homes 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.³

Remodelers, builders, and architects participating in the research project claimed to encourage their clients to proactively plan for future needs when planning general remodels or designing new homes.⁴ Those professionals have found that their clients were more accepting of solutions that highlight empowerment and improve quality of life.

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. An occupational therapist in the group confirmed this challenge, sharing an example of a client who needed a ramp

² The focus group participants were paid an honorarium of \$150 in the form of a gift card.

³ *Aging in place* refers to people remaining in their homes without losing their quality of life as they age.

⁴ 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.

or lift to access their home, but the entryway did not have space for a ramp, and the cost of a lift was prohibitive (from \$15,000 to \$20,000). The issue ultimately forced the individual to move.

Professionals agreed safety was a fundamental consideration for all home modifications. Fall prevention was the primary concern, and bathrooms, stairs, door thresholds, and floor material transitions were identified as the areas with the highest probability of falls.

Professionals believed that aesthetics were very important to encourage proactive planning with their clients. Although everyone valued safety and ease of use, 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 performance, clients preferred the best-looking device.

Across the focus groups, affordability was perceived as the number one barrier to retrofits and renovations. Despite available grant money, rebates, and other funding sources, residents often struggled to get financial assistance. Income or asset thresholds, lack of homeownership—generally a requirement for many of the programs—or a complex application process can prevent residents from qualifying for funding. Even when funding is secured, it may not be enough to cover the total cost. For townhomes and row houses, various space limitations complicate retrofits and renovations. To address those constraints, professionals have proposed complex design solutions that include more expensive devices such as elevators or major renovations.

Selecting the Assistive Devices

Based on the focus group discussions, Home Innovation and Inclusive Design and Environmental Access (IDEA) conducted several brainstorming sessions to identify innovative product solutions that could address the following accessibility challenges typical of townhomes and row houses:

- Limited 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 property line.

From the brainstorming sessions, the team considered four assistive devices (StairSteady, AssiStep, FlexStep, and All-Push Door). StairSteady was selected because it offers a simple, relatively inexpensive assistive device for climbing stairs. It is compact and easy to install but requires some upper body strength to use the manual device. The device is affordable, low maintenance, and compact enough to be concealed when not in use. Because the product can be painted any color,

it can easily match the surrounding decor of virtually any home. It is manufactured in Canada and must be special ordered because no U.S. distributors carry it.

AssiStep (similar to the StairSteady device) was chosen as an alternative manual stair-assistive device. It has an adjustable handle and can be installed on stairways with limited space. AssiStep 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. It is manufactured in Europe and must be special ordered because no U.S. distributors carry it.

FlexStep was selected because it converts from a lift to a staircase, making it a potential solution for limited space at the main entrance. The product is also well suited for interior doors that enter the house from the garage. It received a high ranking due to its potential to address stairs, entryways, and limited spaces. However, a preliminary review of its cost revealed that it may not be affordable. The product is manufactured in Europe but is readily available for purchase in the United States through distributors.

The All-Push Door was selected 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 plans to have products available to meet anticipated future demand.

In-Person Evaluations of Assistive Devices

Home Innovation recruited 51 participants—users, caregivers, and professionals—to evaluate the assistive 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 specializing in accessibility renovations.

Participants were given a short orientation that included a review of the evaluation process and a demonstration of how to use each device (exhibits 6 and 7). Participants were instructed to evaluate each device and complete a survey. Next, participants engaged in open-ended discussions with Home Innovation staff, which led to further insight into participants' experiences.

Exhibit 6

StairSteady, AssiStep, and FlexStep Product Test Platform



Photo credit: Home Innovation.

Exhibit 7

All-Push Door Product Test Doorway



Photo credit: Home Innovation.

None of the equipment evaluated are considered do-it-yourself devices. Manufacturers recommend using a remodeler or contractor to ensure correct installation. The StairSteady, AssiStep, and FlexStep devices were installed on the demonstration platform in exhibit 6. A separate doorway mock-up structure was built to install the *All-Push Door* in exhibit 7.

Home Innovation did not conduct performance testing on the accessibility devices and does not endorse or debunk any manufacturer's claims. Instead, Home Innovation captured the participants' perceptions and comments through observational research.

Observational Research Findings for Assistive Devices

The observational research conducted in Home Innovation's laboratory allows large-scale field studies of people interacting with tools, materials, products, or other people while maintaining control and predictability only possible in a structured setting. The product test platforms created for this study are a "true-to-life mock" scenario of a home interior in which participants are led through activities and discussions under the discrete observation of market research professionals. This set-up provides the authenticity and deep insight of ethnographic research with an efficient use of time and resources.

StairSteady Evaluation Results

Participants considered StairSteady easy to install, clean, maintain, and match with any home decor—provided the device was painted. All found the 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 shift from one position to the next. As a result, most participants "had problems using the device" and believed that others would have the same problems.

The professionals and the users and caregivers disagreed about the physical effort needed to use StairSteady. Nearly all professionals thought that the upper body strength needed would make the device difficult to use for most frail senior users or any client recovering from a stroke. When answering this question, the physical and occupational therapists considered a wider range of potential users, not only those individuals with mobility-related disabilities. The users and caregivers were divided about the physical effort necessary. Some believed it would be easier with practice, and others thought the device was not positioned correctly for their body size and stature.

The 51 participants for the in-person evaluation varied in size and stature. StairSteady was installed according to the manufacturer's instructions but could not be adjusted for each participant and is not designed to be adjusted after installation. The in-person evaluations proved that the device must be installed based on each user's physical measurements. Users and caregivers who required little effort to use the device were simply fortunate enough to fit the installation of StairSteady. For taller users, the handle did not line up at 90 degrees with the person's elbow (exhibits 8 and 9), causing the user to push the handle at an angle that kept it from moving smoothly. Furthermore, the person's center of gravity was typically over the handle coming down the stairs (exhibit 10), making it less safe.

Exhibit 8

Height of Handle:
Starting Position



Photo credit: Home Innovation.

Exhibit 9

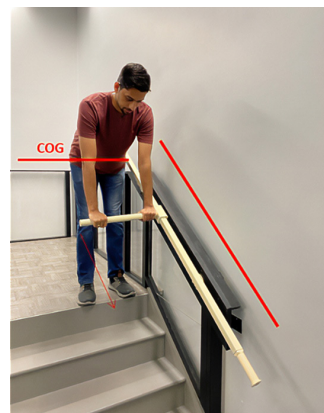
Adjust to 90 Degrees:
Ascending Stairs



Photo credit: Home Innovation.

Exhibit 10

Handle Too Low:
Descending Stairs



COG = center of gravity.
Photo credit: Home Innovation.

The device was determined to be too low for many participants who tried to use it—an unavoidable outcome given the random nature of recruiting participants—and may partially explain some of the poor ratings StairSteady received.

Although StairSteady is straightforward to install, it must be mounted at the correct height for the user. One physical therapist regarded StairSteady as a quasi-medical device that a trained professional should install to ensure that the consumer can use it correctly. One design 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.

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 it 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 Results

Participants' thoughts on AssiStep were similar to those provided for StairSteady. They considered AssiStep easy to install and clean but not easy to match with any home decor. Most participants believed that AssiStep required little maintenance, even though the rail has a sophisticated metal track with special gears inside. All found 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, participants were divided about whether they "had problems using the device."

Nearly all professionals thought that others would have problems with AssiStep, even when they did not have difficulty using the device. However, the users and caregivers typically supposed, "If I can do it, anyone can," or "If I had a problem, someone else will have a problem too."

AssiStep was installed according to the manufacturer's instructions. The device's handle can be adjusted vertically after installation 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.

Participants could hold one of two locations (the upper bar or lower bar) of the handle while allowing the standing user's elbow to be at a 90-degree angle (exhibits 11 and 12).

Exhibit 11

Upper and Lower Bars: Select Bar Position



Photo credit: Home Innovation.

Exhibit 12

Correct Position of Handle: Ready to Ascend Stairs



Photo credit: Home Innovation.

AssiStep's handle can be adjusted up and down, as exhibit 13 shows. When walking down the stairs, the device's handle must be lifted to disengage the metal track, which some professionals thought would be difficult for senior users. Users and caregivers were less concerned, believing that, with practice, a person could safely disengage the handle from the track. As exhibit 14 shows, the person's center of gravity is not over the handle.

Exhibit 13

Adjusting the Handle and Disengaging the Track: Highly Adjustable Design

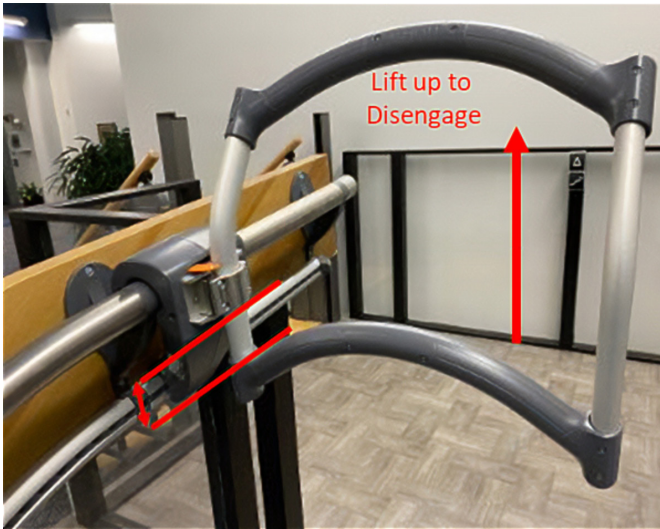


Photo credit: Home Innovation.

Exhibit 14

Descending the Stairs: Can Adjust Without Remounting



COG = center of gravity.
Photo credit: Home Innovation.

The professionals were less likely to believe that the device was needed than the users and caregivers. In some cases, users thought it was not necessary because they could still navigate the stairs using canes. Some professionals said that the device needed an additional safety mechanism to lock in an emergency—in case the handle was disengaged from the track—before they would recommend it.

FlexStep Evaluation Results

Participants considered FlexStep easy to clean, nice-looking, and easy to match with any home decor. All participants found the 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 their operation. As a result, most “needed assistance to use FlexStep.” They believed that others would need formal training to remember what buttons to push and what to do in a power outage. FlexStep comes with a backup battery, but many participants worried that power would go out and they would be trapped on an upper floor in the house if they depended solely on FlexStep.

All participants agreed that installing 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. In addition, all participants were concerned about maintenance and repair options for the FlexStep. Users and caregivers thought that finding service for general maintenance would be difficult. Some respondents also expressed concern about maintenance and repair costs. Many thought that if the purchase of FlexStep was expensive, then maintenance and repair would likely be equally expensive. The manufacturer stated that authorized dealers throughout the United States offer maintenance plans and that FlexStep would not need annual maintenance. The company recommends maintenance every 5 years.

Some participants complained about the noisy operation and audible safety warnings from FlexStep. When in operation, the device made multiple “beeping” noises and flashed lights. The manufacturer stated that many warning cues can be disabled, and the volume can be adjusted. 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 to a lift (exhibits 15 through 17).

Exhibit 15

Stair Mode: Starting Position



Photo credit: Home Innovation.

Exhibit 16

Lifting Mode:
Intermediate Position



Photo credit: Home Innovation.

Exhibit 17

Final Landing Position:
Finished Position



Photo credit: Home Innovation.

Most users and caregivers who did not want FlexStep thought it would not fit in their house due to the layout of their exterior or interior stairs, and they were concerned about the cost of a major renovation to use the device. Many participants thought that FlexStep would be impractical for interior floor spaces but that it could work at entryways where short flights of steps were common.

FlexStep can accommodate a wide range of individuals, including users with moderate mobility limitations and those who use wheelchairs. Participants liked that people of different sizes and statures could use FlexStep without special configurations.

All-Push Door Evaluation Results

Participants considered the All-Push Door easy to install, clean, and match to any home decor. Most participants believed that it required little maintenance. All found the instructions easy to understand but also thought the locking mechanism on the door should be easier to operate. Some

participants thought the multiple locks made it difficult to know whether the door was locked. Most participants had to try the locking sequence several times to understand how to operate it. Therefore, most professionals “needed assistance to use the All Push Door.” In addition, many respondents “made mistakes that required them to redo some steps.” Participants believed that others would need some practice using the double set of locks.

Participants disagreed about how much assistance was needed to operate the All-Push Door. Users and caregivers appeared to make fewer mistakes operating the door than did the professionals. In fact, most users and caregivers did not need much assistance to use 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. Many professionals also thought that some senior clients or patients could accidentally leave one of the multiple locks open.

The All-Push Door has a double-hinge mechanism, allowing the door to be pushed from either direction. In exhibit 18, the door is being pushed from the inside. In exhibit 19, the door is being pushed from the outside.

Exhibit 18

Outer Door Frame Operation: Exiting the House

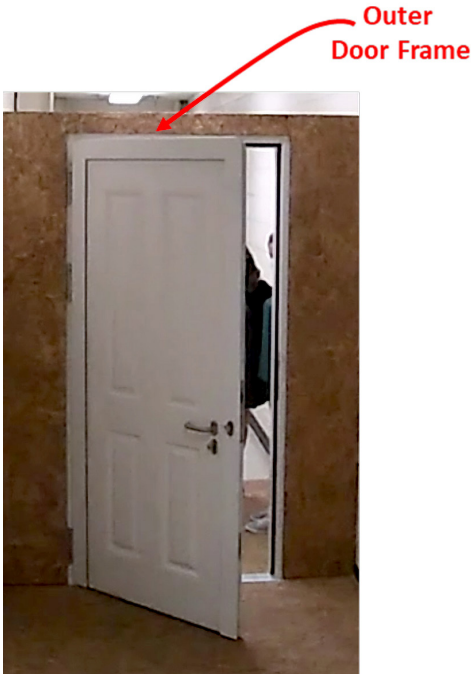


Photo credit: Home Innovation.

Exhibit 19

Inner Door Frame Operation: Entering the House



Photo credit: Home Innovation.

Participants believed that the All-Push Door addresses the problem of having to back up in a wheelchair when approaching a door that opens toward the person. 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 is believed to be a “great benefit.”

Although operating the door was not completely intuitive due to the double set of locks (best seen in exhibit 18 near the door handle), participants saw it as a minor issue that could be overcome with some instruction and practice.

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 soon.

Availability and Costs of Innovative Assistive Devices

All four assistive devices in this study were manufactured outside the United States, meaning their availability was limited, and additional costs may be associated with shipping. European countries and Canada have developed assistive devices that install on stairs and doors at a much greater frequency than the United States. Most products in this study must be purchased directly through the manufacturers’ websites, with turnaround times of several weeks. Purchasers of StairSteady, AssiStep, and All-Push Door must hire a remodeler to install the products. FlexStep distributors are in the United States, so the product can be readily found, and the distributor can provide installation, maintenance, and warranty services. The All-Push Door manufacturer is interested in making the product in the United States, which may lead to lower costs and wider availability in the long term.

StairSteady costs less than a conventional stair lift product, and AssiStep is similar in cost to a conventional stair lift product. FlexStep is more expensive than a similarly sized wheelchair lift device but has the added benefit of converting into a flight of stairs and superior aesthetics, which users of accessibility devices prefer. The All-Push Door is comparable in cost to an automatic door opener, but it can easily exceed that cost if installation requires a major door frame modification.

Conclusion

Study participants expressed a strong willingness to adapt their homes to meet their needs. An inherent value is associated with staying in one’s home. It provides a sense of independence and well-being. The accessibility devices evaluated in this study offer some new options, but in terms of performance, the manual devices are not “game changers.” Nonetheless, StairSteady is the most affordable option, but only individuals with some remaining upper body strength can use it. If the person suffers from a degenerative disease or osteoarthritis, using a manual stair-assistive device may cause the person’s joints to deteriorate faster. AssiStep is also a manual device for stairs, and it is somewhat easier to use, requiring less upper body strength. 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 because it eliminates the need for 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 opening device.

In closing, the four innovative products in this study show that many opportunities exist for further innovation. They also demonstrate the economic value of government support for home modification services. Such support may spur further innovation, improve product quality, and reduce the cost of retrofits and adaptations.

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