Journal of Housing For the Elderly
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wjhe20

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Published online: 05 Mar 2014.

To cite this article: Susan Rodiek , Chanam Lee & Adeleh Nejati (2014) You Can't Get There From Here: Reaching the Outdoors in Senior Housing, Journal of Housing For the Elderly, 28:1, 63-84, DOI: 10.1080/02763893.2013.858093

To link to this article: http://dx.doi.org/10.1080/02763893.2013.858093

Journal of Housing for the Elderly, 28:63–84, 2014

ISSN: 0276-3893 print / 1540-353X online
DOI: 10.1080/02763893.2013.858093

Routledge
Taylor & Francis Group

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By providing access to outdoor environments, exterior doors can enhance the sense of freedom in residential environments for aging. However, doorways may also present barriers to outdoor access. Using environmental audits, this study examined doorway problems at 68 assisted living facilities in three geographic regions. Results were compared with resident surveys (n = 1,128), staff surveys (n = 432), and resident focus groups (n = 76). Specific doorway issues were found to be associated with residents' weekly minutes of walking, outdoor usage, and perceived ease of reaching outdoor areas. The main problems were door opening/closing, thresholds and landings, and self-locking doors. The findings indicate that exterior doorways often present barriers to assisted living residents, resulting in lower levels of walking and outdoor use. By discouraging these health-related behaviors, doorway problems may negatively affect residents' health and well-being. Practice implications suggest that many existing doorway problems, such as high thresholds or excessive opening force, are easily remedied.

Statistical analysis was provided by Tony Neumann, Department of Statistics, Texas A&M University.

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KEYWORDS exterior doorway, assisted living, therapeutic outdoor spaces, environmental barriers, older adults, aging

INTRODUCTION

Environments for older adults can be designed to provide increased levels of support for daily activities as functional limitations increase with aging (Lawton, 1980; Regnier, 2002). In long-term care settings, having well-planned outdoor space can encourage health-promoting activities such as walking, social interaction, and contact with nature, which can positively affect the health and well-being of residents (Chapman, Hazen, & Noell-Waggoner, 2007; Duggan, Blackman, Martyr, & Van Schaik, 2008; Gigliotti & Jarrott, 2005). Many factors impact the usability of outdoor space, such as staff policies, accessibility, environmental design, planned outdoor activities, and residents' physical and cognitive attributes (Cutler & Kane, 2006; Joseph, Zimring, Harris-Kojetin, & Kiefer, 2006; Zeisel et al., 2003). Issues such as wayfinding, safety concerns, and lack of awareness that outdoor spaces even exist can greatly reduce a resident's opportunities to spend time outdoors (Brawley, 2007; Kearney & Winterbottom, 2006; Sheehan, Burton, & Mitchell, 2006). Design that considers physical disabilities and cognitive impairment can support residents' freedom and autonomy by helping them access and navigate the outdoor environment (Day, Carreon, & Stump, 2000).

Exterior doors constitute the primary interface connecting residents with the world beyond the facility walls, allowing them to reach outdoor areas for walking, sitting, and contact with nature. Assisted living residents have reported a sense of freedom generated by spending time outdoors (Rodiek, 2006). Barriers preventing outdoor access can impact a resident's perception of self-reliance, autonomy, and independence (Kaup, 2011), all of which have been identified as important psychosocial goals for older adults (Regnier & Denton, 2009). Specifically, doors that are hard to open may undermine an individual's sense of mastery and control over the environment and increase feelings of helplessness, insecurity, alienation, and dependence on others, while reducing satisfaction (Regnier & Pynoos, 1992; Schwarz & Brent, 1999). Because spending time outdoors has been found to have multiple health benefits for older adults due to increased vitamin D absorption, physical activity, and social interaction (Bowling et al., 2003; Grant & Holick, 2005; Nezlek, Richardson, Green, & Schatten-Jones, 2002), doorway problems that impede access to outdoor areas can result in serious consequences for the health and well-being of elderly residents.

Doorway Problems Identified in Previous Studies

Experts on aging have identified doorways as an important concern in housing design for aging individuals (e.g., Hiatt, 1980; Kaup, 2011; Regnier, 1994).

Poorly designed doorways are a major barrier to seniors' outdoor access in congregate care facilities (Cooper Marcus & Barnes, 1999; Regnier, 2002). In describing various aspects of the built environment, Hiatt (1991) noted that exterior doors were often "difficult for residents or staff to negotiate. The doors are heavy or narrow; the entries have ramps or sills" (p. 110). However, few studies have focused specifically on doorways as a crucial aspect of environmental design for older adults, either in their individual homes or in senior housing settings. One study (N = 211) using surveys in 14 randomly selected assisted living facilities found that approximately 25% of all reported accessibility-related problems with outdoor usage were related to doorways (Rodiek, 2006). Another study used a participatory design model to engage older adults in designing doors that would satisfy their needs and preferences. Door handles, keys, and locking/unlocking systems emerged as the most important concerns of participants (Demirbilek & Demirkan, 2004).

Safety/Security Issues with Doorways

Older adults have a much higher rate of accidents associated with doorways and of serious injuries resulting from those accidents compared with younger adults. In 2002, the U.S. Consumer Product Safety Commission estimated there were more than 300,000 door-related injuries, in which approximately 14% of people 65 years or older had injuries more severe than "treat and release" compared with less than 1% of people younger than 65 years (Chang & Drury, 2007; CPSC, 2002). This suggests that problems with doorways become increasingly serious as people grow older and have implications for those in long-term care, such as assisted living, where the mean age is approximately 86.9 years (Byala, 2009). Because doorways constitute an integral part of the residential environment, it is important that they be designed to reduce hazards and risks for seniors as much as possible.

DOORWAY PROBLEMS IDENTIFIED IN THIS STUDY

This study compared environmental audits with survey findings to identify the primary exterior doorway problems at 68 assisted living facilities; these results were then compared with previous focus group findings to better understand the implications. Although surveys and focus groups gathered information from self-reported perceptions, the environmental audits provided more objective, reliable, and systematic assessments of specific environmental features rated by trained auditors. Therefore, audit data offer additional insights into the evidence-based environmental interventions that can lead to more effective outcomes. This article focuses on the three doorway problems most commonly reported in the surveys and focus groups: (1) the door was

difficult to open or it closed too rapidly; (2) thresholds and landings were difficult to cross; and (3) self-locking doors made it difficult or impossible to reenter the facility after going outdoors. A few additional doorway problems reported less frequently are briefly discussed here to be more inclusive but are not included in the analysis.

Door Opening/Closing

This is a major issue in any setting where users may lack strength or balance. As Covington and Hannah (1997) noted, "Getting to the door is one thing, opening it is quite another" (p. 37). In a recent survey (Rodiek, Nejati, Bardenhagen, Lee, & Senes, 2013), 53 subject matter experts on design for aging rated "doors open with little effort" as the most important environmental feature influencing outdoor usage in long-term care settings for older adults; it was also the only environmental feature rated as "highly important" by all the experts surveyed. Nearly all exterior doors in senior communities have closing devices to prevent the door from being opened by differential indoor-outdoor air pressure; these devices tend to make the door harder to open due to resistance from the door closing mechanism. Standards set by the Americans with Disabilities Act (ADA) specify that accessible doors require no more than five pounds of force to open (ADA, n.d.). However, due to limited upper-body strength, it is suggested that five pounds of force may still be too high for older people (Hoglund, 1985; Sanford, Echt, & Malassigne, 1991). Although advocates have not determined a maximum recommended opening force for seniors, experts report that additional assistance is frequently needed for older people to operate a standard exterior door requiring five pounds of force. Steinfeld and Danford (1993) described a power-assist door that automatically "reduces the resistance of a manual closer so that the door can be opened more easily." Most door closers can be adjusted to require less force to open, but facility staff may not be aware of door opening force as a significant problem for residents. Door closing speed is also important because a rapidly closing door can adversely affect older adults' sense of balance and equilibrium, potentially resulting in falls or injuries (Goldsmith, 1976).

Thresholds and Landings

Problems with the doorway threshold, such as the lack of a paved landing and a flat door frame, may also discourage older adults from going outdoors to experience the full range of their environment (Peloquin, 1994). Because a large percentage of older adults use assistive mobility devices (e.g., canes, walkers, wheelchairs, and power scooters), doorway thresholds may be substantially more difficult for them to navigate compared with younger individuals' ability to navigate thresholds. The *2009 Overview*

of Assisted Living (Byala, 2009) reported that only 23% of residents could walk unaided, whereas 54% used a walking device (e.g., cane, crutch, walker) and 22% used a wheelchair or power scooter all or part of the time. Level and smooth paved landings are specified in ADA standards, but they may be poorly constructed or maintained, posing substantial barriers for mobility-compromised older adults and increasing the risk of falling at doorways.

Self-Locking Doors

Because of security issues, some residential facilities for seniors use self-locking doors to provide additional security for residents. However, the fear of being accidentally locked outside is likely to deter residents from using outdoor areas and could undermine their feelings of independence. Hiatt (1991) noted that outdoor areas were often underused and recommended that staff find ways to address issues such as locked doors. Cooper Marcus and Barnes (1999) reported that self-locking doors can create a frustrating outdoor experience for seniors who face denial of access back into the building. They reported that, in some places, doors were routinely propped open by staff, who might have been aware of the problems these locked-door policies created for residents. Demirbilek and Demirkan (2004) noted that older adults had problems in operating different types of locking systems.

Additional Doorway Problems

Aside from the primary issues of door opening/closing, thresholds/landings, and self-locking doors, there are additional doorway problems related to the door handle and to having windows near doorways for viewing the outdoor areas. The manual dexterity needed to operate door handles is especially important for people with arthritis and other functional impairments of the hand, wrist, and arm. Lever handles with curved edges are more comfortable to operate than round doorknobs for most people, especially older adults, and elbow-operated handles can be used in some circumstances (Demirbilek & Demirkan, 2004; Peloquin, 1994). Another aspect of exterior doors identified as important by gerontological designers is the transparency of the doorway and surrounding areas, which allows residents to preview weather conditions and see what is happening outdoors before deciding to go outside (Carstens, 1993; Regnier, 1994, 2002; Rodiek & Fried, 2005). Although these additional doorway issues are indicated in the literature and recognized in this study, this article is focused mainly on the three doorway problems most commonly reported by older residents: door opening/closing, thresholds and landings, and self-locking doors.

METHODS

This study used qualitative and quantitative methods to ensure the depth and breadth needed to comprehensively identify problems seniors encounter with exterior doorways in their living environment and understand how these problems affect their outdoor usage and walking. The data used in this study came from focus groups, resident and staff surveys, and environmental audits. All study instruments and protocols were approved by the Texas A&M University Institutional Review Board.

Qualitative Method

Data Collection

Five focus groups were conducted in 2003 at residential facilities for seniors in a single, urbanized area in south-central Texas to gather information on residents' experiences with their living environments, particularly their access to the outdoors. Although this study did not specifically target doorway issues, doorway-related issues emerged spontaneously from the focus group discussions as important determinants of outdoor access. At five facilities, ranging from independent housing where seniors lived in detached fourplexes to congregate facilities providing assistance with daily activities, a total of 76 residents participated in 1-hour focus group discussions. Facilities were selected based on proximity to the study center, and residents were selected based on their availability and willingness to participate. All residents deemed by administrators as capable of giving meaningful answers were eligible for inclusion. Approximately 80% of participants were older than 75 years, and more than 40% were older than 85 years; 92% were women. Staff members were not present at these discussions to encourage participants to discuss their feelings more freely. All sessions were facilitated by S.R. the primary investigator, recorded, and transcribed. Before engaging in the focus group discussions, participants had completed a brief written survey on outdoor usage and environmental features.

Data Preparation and Analysis

Transcripts of focus group responses and associated written comments were searched both visually and digitally for terminology relating to doors, doorways, thresholds, open, opening, lock, locked, locking, handle(s), knob(s), automatic door(s), reach, and access. Major themes that emerged were analyzed and categorized using the content analysis method (Holsti, 1969; Krippendorff, 2003).

Quantitative Method

Data Collection

The data used for the quantitative analyses came from the resident and staff surveys and environmental audits from a larger-scale study conducted in 2007. This study was conducted in three regions in the United States at 68 assisted living facilities, which are congregate residential settings that provide help with the activities of daily living (Regnier, 2002) and where a high percentage of residents are able to access outdoor areas without staff assistance.

Written surveys were developed to assess attitudes, behavior, and preferences regarding outdoor access and usage, with separate instruments for residents and staff (44 items for residents; 40 items for staff). Formats were slightly different and tailored to each age group based on extensive pretesting with resident and staff representatives. Overlapping items were included to allow for comparison between the two user groups, and some of the staff items were intended to make it possible to confirm resident's responses (e.g., staff were asked to estimate how much time residents spent outdoors). Almost all questions were multiple choice, with additional write-in responses accompanying some items.

Data collection was conducted in 3 of the 10 major emerging megapolitan areas identified in the United States (Lang & Dhavale, 2005), which were selected to ensure a wide geographic dispersion with diverse climatic conditions (Fovell & Fovell, 1993). In each region, the sample frame consisted of a 2-hour driving diameter around the geographic center of each region's primary city: Houston, Texas; Chicago, Illinois; and Seattle, Washington. Data collection occurred during the months of the year identified by recent national weather records as most likely to have optimally comfortable outdoor conditions in each of the regions (National Oceanic and Atmospheric Administration, 1997-2006). Thus, data collection occurred in late May to early June in Houston, late June to early July in Chicago, and late July to early August in Seattle.

From all assisted living facilities located within the sample frame that met the 50+ licensed capacity criterions, approximately 22 to 23 facilities were randomly selected from each of the three regions. The locations of selected sites ranged from dense urban contexts to outlying suburbs and small towns. Some of the facilities were single story and others were multistory (range, 1–11 stories); the average building height was 2 stories in Houston, 3.5 stories in Seattle, and 4 stories in Chicago. The mean overall facility size was 94 residents (range, 39 to 274 residents); the mean size was 84 residents in Houston, 94 residents in Seattle, and 104 residents in Chicago. Participating residents ($n = 1,128$) were recruited by invitations from facility administrators and completed the surveys in small group sessions working independently or with assistance from staff/researchers if requested. Residents with advanced

cognitive impairment were not within the scope of this study, so those residents in memory care units were excluded. Staff (n = 432) also completed surveys independently and in some cases returned them by mail.

At the 68 facilities in which resident and staff surveys were conducted, a 63-item environmental audit tool was completed by trained researchers, under the supervision of S.R. and C.L. This tool was used to evaluate the qualities of outdoor spaces and indoor-outdoor connections. A 10-point scale was used to rate each specific feature or quality from 1 to 10, with 1 being an "extremely poor example," 5 being "average," and 10 being "the best that could be expected in this type of setting." The specific items to evaluate were developed based on widely cited publications in the recent literature and the best-practice guidelines developed by design practitioners, gerontologists, and care providers, which were generally in agreement with existing empirical studies. A team of the same two researchers completed the environmental audits at all participating facilities, working independently, and averaging their ratings afterward. Up to three of most-used outdoor areas were selected for the audit at each facility based on physical traces and observations of usage. The perspective of the audit was based on the affordance theory of Gibson (1979), in that it focused on the action possibilities that environmental features could be expected to provide from the viewpoint and capabilities of elderly residents. This approach generated a rating for each item that was both user-oriented and relevant to the desired behavioral outcomes. For example, instead of a door threshold being rated as a physical object, it was rated according to how easily a resident could negotiate the threshold. In pretesting, the audit tool was found to have high inter-rater reliability, with intra-class correlation coefficients ranging from 0.92 to 0.95 (Rodiek, 2008). Most environmental features were rated on the 10-point scale, but a few were measured directly, such as the pounds of force needed to open a nonautomatic door.

Data Preparation

Data collected from the surveys and environmental audits were entered and quality checked to ensure accuracy. Multiple outdoor areas were rated at most facilities (overall mean = 2.24 areas per facility). The ratings for environmental variables at different outdoor areas were weighted according to the relative level of usage of each outdoor area, as reported by residents. In a few cases, the audit ratings and survey responses required additional interpretation. For example, of the automatic doors surveyed, one was found to operate automatically only part of the time and was not included in the analysis. At facilities where staff responses about self-locking doors were in agreement with each other, they were accepted at face value. Where multiple-choice staff responses about self-locking doors contradicted each other at the same facility, they were compared with the consistency, intensity,

and specificity of written comments to arrive at an estimate of the relative prevalence and difficulty of self-locking doors. Staff comments also suggested that different methods of reentering the building from outdoor areas (e.g., key card, physical key, or numerical keypad requiring a code) presented different degrees of difficulty to residents. Therefore, the exterior doorways at each facility were categorized as problematic, partly problematic, or not problematic in terms of how difficult it was for residents to reenter the building from outdoor usage areas.

Study Variables

The two main outcome variables for this study are weekly minutes of walking and outdoor usage (Table 1). Each of these variables was computed from two survey questions asking the frequency and the duration, which were combined to estimate the total weekly minutes. A secondary outcome variable, perceived ease of reaching the outdoors, was considered as an intermediate outcome variable that may be associated with both the main outcome and the independent variables. Independent variables included those survey and audit items related to doorway problems, including how hard it was to see and reach the outdoors and whether locked doors ever discouraged their outdoor access. The staff survey item used in the study was whether exterior doors were typically locked during daytime hours. A total of five audit items were selected as independent variables based on their relevance to the three major doorway problems that this study focuses on: door opening/closing, thresholds and landings, and self-locking doors. Table 1 summarizes the survey and environmental audit items used as the dependent and independent variables in the analysis.

Statistical Analysis

All statistical analyses were performed in STATA. Variables were first examined for distribution, and continuous variables were categorized when necessary to ensure feasible distributions for statistical analyses. Kendall's tau-a correlations were used to test bivariate associations between the dependent and independent variables because of the categorical nature of many study variables. Those variables showing a p-value of 0.1 or less are considered significant in this paper.

RESULTS

The response rates were 30.8% for the resident survey. The final resident sample size was 906 selected out of 1,128 survey respondents after excluding

TABLE 1 Survey and Environmental Audit Items Included in Analysis

Variable	Source	Item	Coding and Descriptive Statistics
Dependent variables			
Walking	Resident survey[a]	r_1. Do you ever take walks, indoors or outdoors, just to get your exercise?	Never, Seldom, Once a month, Twice a month, Once a week, Every day, More than once a day
	Resident survey	r_2. If you walk for exercise, about how long do you usually walk each time?	5 minutes or less, About 15 minutes, About 30 minutes, About 45 minutes, About 1 hour, About 1–1/2 hours, 2 hours or more
Outdoor usage	Resident survey	r_3. How often do you typically use the outdoor areas, here at this senior community, when the weather is nice?	Never, Seldom, Once a month, Twice a month, Once a week, Every day, More than once a day
	Resident survey	r_4. If you use the outdoor areas here at this senior community, about how long do you usually stay outdoors, on average, when the weather is nice?	5 minutes or less, About 15 minutes, About 30 minutes, About 45 minutes, About 1 hour, About 1–1/2 hours, 2 hours or more
Ease of reaching outdoors	Resident survey	r_7. How hard is it for seniors to see and reach the outdoor areas here at this senior community?	Very hard, Somewhat hard, Somewhat easy, Very easy
Independent variables			
Door opening/closing	Audit[b]	a_1. The doors are very easy for residents to open.	1–10 Mean = 7.376, SD = 2.173
	Audit	a_3. There is an automatic door opener to reach this area.	No (no automatic) = 58.4% Yes (have automatic door) = 41.6%
	Direct measure	(Used portable hanging scale to measure force of pull.)	Pounds, Ounces Mean = 4.097, SD = 2.962
Thresholds and landings	Audit	a_2. The doors are easy for residents to pass through, and do not close too quickly.	1–10 Mean = 8.772, SD = 1.682
	Audit	a_4. Residents using walkers or wheelchairs can easily navigate the door threshold.	1–10 Mean = 7.616, SD = 2.299
	Audit	a_5. There is a wide and level paved landing on both sides of the door threshold.	1–10 Mean = 7.219, SD = 1.452
Self-locking doors	Resident survey	r_5. Have locked doors or alarms ever kept you from going outside when you want to?	Often = 2.0% Sometimes = 10.7% Seldom or never = 87.3%
	Resident survey	r_6. Have you ever been accidentally locked outside, even for a little while?	Yes, No No = 90.7%, Yes = 9.3%
	Staff survey[c]	s_1. Are the doors to usable outside areas usually locked during daytime hours? (staff-reported self-locking door problems for their residents)[d]	(Independent re-entry for residents assessed as): Very problematic = 21.8% Partly problematic = 10.9% Not problematic = 67.1%

[a]Resident sample = 906.
[b]Audit sample = 68 facilities, with scoring range of 1–10 (1 = low, 10 = high).
[c]Staff sample = 431.
[d]Categorization of self-locking door problems is described in data preparation.

TABLE 2 User Characteristics

Characteristic	Resident (n = 906)	Staff (n = 431)
Age		
Mean (SD)	84.0 (8.4)	43.4 (13.4)
Range	42 to 104	27 to 62
Gender, No. (%)		
Female	706 (77.9%)	382 (88.6%)
Male	200 (22.1%)	49 (11.4%)
Outdoor minutes per week		
Mean (SD)	239.8 (354.5)	90.3 (159.3)
Range	0 to 1680	0 to 1200
Walking minutes per week		
Mean (SD)	111.1 (122.7)	N/A
Range	0 to 420	N/A

Abbreviation: N/A = not applicable.

those who did not complete all survey questions (N = 165) and those avid walkers who walked 10+ hours per week (N = 57). Avid walkers were excluded because their walking behaviors appeared to be determined primarily by their prior habits and personal characteristics, regardless of environmental supports or barriers; in contrast, residents who did little walking appeared to be susceptible to environmental conditions. The mean age of residents was 84.0 years; 77.9% were women and 22.1% were men. The staff sample size was 431 respondents with a mean age of 43.4 years; 88.6% were women and 11.4% were men. On average, residents spent approximately 111 minutes per week walking and 240 minutes per week outdoors (see Table 2).

When asked how hard it was to see and reach the outdoor environment, 45.5% of residents reported at least some difficulties reaching the outdoors. Of the written comments on problems seeing and reaching outdoor areas, 57.5% mentioned doorways and several residents reported it was difficult to access the outdoors using a walker, wheelchair, or power scooter. Of the written comments specifying problematic aspects of the doorway, 80% cited door opening force, 15% mentioned thresholds, and 5% described self-locking doors as the most important problems in reaching the outdoors.

Focus group participants also brought up many issues related to doorways, making the following comments: "I have trouble with the doors" and "I don't go out as much as I would like, because I can't handle the doors." The importance of walkers and wheelchairs to this study population was confirmed by several focus group members, making the following comments: "...the doors are not compatible with walkers and wheelchairs...," "...because when you walk up to the screen door you have to back (up) and when you are in the walker, that is difficult to do," and "These lovely wide doors we have, we can go in and out, with a wheelchair, or whatever..." It was noted in this and previous studies that residents frequently referred to themselves as "walking" and "taking walks" even when permanently consigned to a wheelchair or power scooter

TABLE 3 Doorway Related Comments from Residents

Theme	Examples of Comments	Source
Door opening/ closing	"By the time I get through the door, my energy's gone."	Focus group
	"... and that door, I have back trouble, and if I have to open that, it nearly kills me."	
	"The doors are hard to push open."	
	"I mean it's hard. I have learned, but then sometimes I have to go through the living room because these doors are heavy."	
	"You're right. I have trouble with my shoulder to open, push, and pull the doors. I find that I have difficulties going through the doors."	
	"It is hard to get through it. They need some that opens, you know, when you get to it."	
	"One thing I find is with the common room doors – it would be helpful if they would open automatically. And it's really important, particularly if you're going to have wheelchairs and walkers."	
	"You have to push the button and then you have to get out right away. I don't think, just from observation, that she would be able to do that – because you would have to be in front of the door, to be able to reach over to push the button."	
Thresholds and landings	"Going through doors - door frames are high."	Resident survey
	"Going over the door frame on floor hard to cross over."	
Self-locking doors	"There is something that I think a lot of us talk about missing is the freedom to be outside. At present here, all of our doors are locked except that front one. The first year that we were here the back door out onto the porch was unlocked, and we could go out there. Everybody liked that. I know we need the security but we need something to be done where, you know, we're not locked in."	Focus group

(Lu, Rodiek, Shepley, & Duffy, 2010; Rodiek, 2006). Although moving about in a wheelchair or scooter does not afford the physical exercise of walking on foot, it does allow residents the autonomy and freedom to navigate their physical environment. The following sections discuss findings from both the qualitative and the quantitative methods related to each of the three independent variables; Table 3 shows example comments from residents related to doorway issues.

Door Opening/Closing

Qualitative Findings

In focus group and written survey comments, residents reported door-opening force as an important problem, with comments such as the following: "doors are hard to open" or "doors are heavy." One resident said that "By the time I get through the door, my energy's gone." Another said

that "I have trouble with my shoulder to open, push, and pull the doors. I find that I have difficulties going through the doors." Other comments such as, "The door doesn't stay open that long," suggested that door closing speed was important for older adults, who might need more time to navigate through a doorway.

Quantitative Findings

The force needed to open a door was measured using a small portable hanging scale that could be hooked around the door handle and pulled in the direction of opening. Perceived door opening force was also estimated with an environmental audit item (Table 1, a_1). The mean measured door opening force was 4.1 pounds, as shown in Table 1. Although current ADA standards mandate that accessible doors should require no more than five pounds of force to open, 46.7% of the manual doors tested in this study failed to meet these standards and the hardest to open door required 13.4 pounds of force to operate. Table 4 shows that lower measured door opening force was moderately associated with higher levels of outdoor usage ($T_a = -0.044$, $p = 0.053$). The audit-rated "ease of opening" was also moderately associated with outdoor usage ($T_a = 0.043$, $p = 0.064$), as well as with residents' reported ease of reaching the outdoors ($T_a = 0.038$, $p = 0.065$). Automatic doors were significantly associated with increased outdoor usage and residents' reported ease of outdoor access but not with walking. Slower door closing speed was also shown to be significantly associated with higher levels of outdoor usage, walking, and residents' reported ease of access (see Table 4).

Thresholds and Landings

Qualitative Findings

The threshold and landing were also found to be important aspects of the doorway interface for residents. When residents were asked why it was hard to reach the outdoor environments in their senior community, written comments included: "Going through doors - door frames are high," and "Going over the door frame on floor hard to cross over." (Residents commonly referred to the door thresholds as door frames.)

Quantitative Findings

Outdoor usage and walking were not significantly associated with audit measures of thresholds and landings, but residents' self-reported ease of reaching the outdoors was significantly and positively correlated with thresholds audit ratings (Table 4). These findings suggest that audit measures of doorway

TABLE 4 Association of Environmental Variables with Walking, Outdoor Usage, and Residents' Reported Ease of Reaching the Outdoors

		Increased Outdoor Minutes per Week[r3×r4]		Increased Walking Minutes per Week [r1×r2]		Reported Ease of Reaching Outdoors [r7]	
Theme	Variable	τ	p-value	τ	p-value	τ	p-value
Door opening/ closing	a. Measured opening force (lbs.)	−0.044	0.053*	−0.019	0.382	−0.025	0.220
	a_1. Door overall easy to open	0.043	0.064*	0.030	0.186	0.038	0.065*
	a_2. Door closes slowly enough	0.062	0.007***	0.049	0.027**	0.041	0.045**
	a_3. Door has automatic opener	0.060	0.009***	0.014	0.516	0.044	0.031**
Thresholds and landings	a_4. Threshold easy to cross	0.017	0.466	0.003	0.904	0.053	0.001***
	a_5. Adequate paved landing	0.010	0.672	−0.003	0.905	−0.013	0.526
Self-locking doors	r_5. Resident reports that self-locking doors were not a concern	0.028	0.044**	0.033	0.017**	0.049	< 0.001***
	s_1. Facilities where staff reported self-locking doors were not problematic	0.035	0.073*	0.035	0.065*	0.045	0.009***

Significance level: *p<.10. **p<.05. ***p<.01. τ = Kendall's Tau-a Correlations.
[a]This item was measured directly; other environmental variables were from the audit ratings.
Note: Variable r_6 was tested but was not significant. Superscript designations refer to items in Table 1.

thresholds and landings are only indirectly related to walking and outdoor usage by being associated with residents' perceived ease of reaching the outdoors. The perceived ease of reaching outdoors measure was significantly correlated with outdoor usage (T_a = 0.0997, p<0.001) and walking (T_a = 0.0698, p<0.001).

Self-Locking Doors

Qualitative Findings

Resident comments indicated that locked or alarmed exterior doors adversely impacted their usage of outdoor areas. For example, a staff member reported that a resident said it was hard for him to reach the outdoors because "he thinks the doors will lock behind him and he will be stuck outside." One resident in the focus group described her feeling about locked doors very explicitly: "There is something that I think a lot of us talk about missing is the freedom to be outside. At present here, all of our doors are locked except

that front one. I know we need the security but we need something to be done where, you know, we're not locked in." These comments suggest that self-locking doors impact residents' perception of freedom to use outdoor areas.

Quantitative Findings

Analysis of staff surveys indicated that self-locking doors were "very problematic" at 21.8% of facilities and "somewhat problematic" at 10.9% of facilities (Table 1). When asked whether locked doors or alarms ever kept them from going outside, 12.7% of residents said they "sometimes" or "often" were deterred from going outside because of locked or alarmed exterior doors. Several residents (9.3%) had also experienced being accidentally locked outside at their residential facility. Resident-reported concerns regarding self-locking doors were highly correlated with staff reports ($T_a = 0.049$, $p<0.001$), and both variables were also moderately associated with lower weekly minutes of walking and outdoor usage ($T_a = 0.033$, $T_a = 0.028$, $p<0.05$; $T_a = 0.035$, $T_a = 0.035$, $p<0.1$). Furthermore, residents who expressed concerns about self-locking and alarmed doors ($T_a = 0.049$, $p<0.001$) and those who had previously experienced being locked out ($T_a = 0.024$, $p = 0.024$) were more likely to report that it was hard to see and reach the outdoor areas.

Additional Doorway Issues

In addition to the main doorway problems of opening/closing, thresholds/landings, and self-locking doors, residents described additional difficulties related to manual dexterity and the ability to preview outdoor areas from indoors. The manual dexterity needed to operate door handles was mentioned in a few comments: "...and handles instead of knobs. This place has handles—yes, lever handles." The outdoor preview availability (measured by audit) was moderately associated with walking only ($T_a = 0.0544$, $p = 0.014$) and with the reported ease of reaching outdoors ($T_a = 0.0382$, $p = 0.062$). Although this study did not focus on these issues, the findings suggest that they are important factors in outdoor usage and perceived ease of access.

DISCUSSION

Discussion of Findings

Although many factors can impact outdoor usage, such as residents' cognitive and physical abilities, staff policies, and the overall quality of the outdoor space, the findings from this multi-method study suggest that the doorway interface is an important environmental feature for older adults and has a

substantial impact on residents' walking behavior and the amount of time spent in outdoor areas. The qualitative results of this study confirmed that doorway problems are major barriers to walking and outdoor usage among older adults (independent and assisted living residents) and identified specific problem areas. The intensity and specificity of focus group and written comments helped confirm and clarify the quantitative findings regarding the features that were found to be most important. The results from quantitative analysis showed that the most significant barriers to assisted living residents' perceived ease of access to the outdoors were self-locking doors, followed by problems related to thresholds and door opening/closing. The four measures related to door opening/closing (pounds of opening force, presence of automatic opener, and two audit items assessing ease of opening and speed of closing (Table 4) were all significantly associated with outdoor usage, but only door closing speed was significantly associated with walking.

Interestingly, the only variable not associated with perceived ease of access was the measured force needed to open the door, suggesting that multiple factors can influence residents' perceptions of outdoor accessibility. These findings suggest that automatic doors, easily opened manual doors, and slow-closing doors are effective ways to remove environmental barriers for older adults, especially those who use a mobility device such as a walker, cane, or wheelchair. Thresholds were found to be associated only with perceived ease of reaching the outdoors and not with walking or outdoor usage. This finding is different from a previous analysis of the same survey data using multivariate statistical models accounting for the facility-level data clustering, where easy-to-cross thresholds were significant for outdoor usage (Rodiek & Lee, 2009). Audit ratings of landings were not associated with the outcome variables. In facilities where self-locking doors were reported as problematic by residents or staff (i.e., where it was difficult for residents to reenter the building after being outdoors), they spent significantly less time in outdoor environments, less time walking, and perceived the outdoors as being more difficult to reach.

Implications

Behavioral Implications

The doorway problems explored in this study have the potential to reduce residents' feelings of freedom and autonomy by making them feel spatially restricted due to lack of control over environmental features (Cohen & Weisman, 1991). At the same time, this may reduce their feelings of functional competence, by discouraging independent movement through their environment (Kane, Giles, Lawton, & Kane, 1999). Residents' feelings of safety and security may also be negatively impacted due to fear of being injured, and anxiety about potentially being locked out (Cooper Marcus & Barnes, 1999; Hiatt, 1991). The focus group and survey comments in this study help

confirm that the exterior doorway may be associated with a sense of freedom; many residents indicated that after spending time outdoors they felt "more free" or "more alive." One resident said that after being outdoors he felt "Not locked in." Another resident commented, "When I close my door, I feel very hemmed in." Comments suggested that the exterior doorway is an important connection to the world beyond the facility; as one person said, "You could let the outside in, and you don't really get that as much with a window open, as you do a door that has the whole area where you can have a screen." Another resident remarked, "I lived at one retirement complex, where your door, when you left your apartment, you went into a corridor. And I felt like I was in a nursing home. Because I didn't open the door and I wasn't outside. Some of the apartments did have an outside door, but not all of them. I felt like I'd be confined." This study also showed that locked or alarmed exterior doors adversely affected residents' perceptions of "ease of reaching the outdoors" and resulted in them spending significantly less time outdoors and less time walking. By curtailing access to the outdoors and by preventing access back into the building, these doorway problems can undermine residents' trust in their residential environment and make them feel restricted and imprisoned.

Physical Health Implications

This study found that problematic doorway elements may reduce outdoor usage and walking, especially for residents using mobility devices. Well-designed exterior doorways can potentially contribute to health by increasing outdoor usage and walking. Because calcium and vitamin D absorption are increased by physical activity and exposure to sunlight, enhanced outdoor access may be protective against osteoporosis and bone fractures (Chapuy et al., 1992; Nguyen, Center, & Eisman, 2000; Reid, Gallagher, & Bosworth, 1986; Tang, Eslick, Nowson, Smith, & Bensoussan, 2007). This is especially important because of the large number of falls that occur annually in long-term care settings, where 30% to 50% of assisted living residents and 45% to 61% of skilled nursing residents experience a fall each year (Carroll, Delafuente, Cox, & Narayanan, 2008; Tideiksaar, 2007). Aside from the health-promoting value of spending time outdoors, well-designed doorways may help prevent injuries from door-related falls caused by inappropriate opening force, closing speed, thresholds, and landings.

Implications for Practice

Improvements to exterior doorways may be surprisingly cost-effective and possibilities range from merely adjusting existing door closing mechanisms to replacing thresholds and installing new automatic doors. An evidence-based

guide on outdoor design for older adults illustrates several important improvements that can be made to exterior doorways, such as threshold modifications, adding automatic doors, and improving previewing at the doorway interface (Rodiek, 2009). In discussing how to adapt housing for older people with disabilities, Steinfeld (1987) noted that although most wheelchair users can negotiate thresholds up to half an inch in height, it is preferable to eliminate level changes at the threshold wherever possible. Although raised thresholds are typically used at exterior doors to prevent wind-driven rain from entering the building, threshold height can be reduced or eliminated by appropriate design detailing (Marx, 2007). In senior facilities where the majority of residents use mobility devices such as canes, walkers, wheelchairs, and power scooters, it is clearly an essential goal to provide thresholds that do not pose barriers or risks.

Regarding automatic doors, although they are substantially more expensive than manual doors, it may be possible to retrofit existing doors with low-cost automatic openers, thereby reducing the need to replace the entire door and frame: "...rehabilitation engineers have devised several inexpensive ways to automate existing manual doors using off the shelf products" (Steinfeld & Danford, 1993). Assisted living facility administrators may not be aware of the different doorway technologies or may not know how much the automatic doors can contribute to residents' health and well-being (Peloquin, 1994). Regarding self-locking doors, facilities may be able to modify their locking system by replacing keypads that require residents to memorize a numeric code with ergonomically designed locks that open with the same key as the resident's room or apartment. Before making renovations, it is important to assess existing doorway problems thoroughly and identify all relevant issues related to residents' usage and perception of the experience of passing through the doorway.

Study Limitations

This study was limited by not having behavioral observation or additional in-depth interviews to help confirm the findings. Although the surveys were conducted in multiple regions in the United States, focus groups were conducted in a single geographic region; it would have been more consistent if both qualitative and quantitative data came from the same settings. Because participants volunteered for this study, they likely were in the top percentiles of those residents who were most the healthy and spent the most time outdoors; this may account for the unexpectedly high levels of outdoor usage. Although residents with physical disabilities were included, those with substantial cognitive impairment were not included in this study, making the findings less representative of the assisted living population. In addition, survey responses may reflect fear-of-retribution bias, leading participants to

depict conditions as somewhat better than they actually were. The statistical analysis was limited to bivariate tests, and the potential roles of confounding variables and facility-level clustering were not assessed. Further studies could use behavior-mapping and quasi-experimental techniques to test specific hypotheses related to doorway issues and more deeply explore the complex interactions of older adults with the various components of doorways.

CONCLUSION

Despite the fact that exterior doors are intended to support access to outdoor environments, this study found that many existing doors in senior communities present barriers to residents' outdoor usage and walking. The design and maintenance of exterior doorways can have a major impact on residents' perception and usage of outdoor areas, with substantial effects on their physical and psychological health and well-being. In addition to discouraging use of outdoor areas, poorly designed doorways may also present safety hazards for frail residents. Because doorway elements are relatively simple and inexpensive to modify or replace, improving exterior doorways can be a practical and cost-effective way to reduce the barriers that prevent older adults from accessing the full range of their residential environments.

FUNDING

Funding for this study was provided by the National Institute on Aging, SBIR #R44 AG024786, and by the Ronald L. Skaggs Endowed Professorship in Health Facilities Design, College of Architecture, Texas A&M University.

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