Wheelchair Users Are Not Necessarily Wheelchair Bound

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OBJECTIVES: To determine the patterns of wheelchair use in terms of locations of use, whether wheelchair use in one location was related to wheelchair use in other locations, and factors associated with wheelchair use in different locations.

DESIGN: Longitudinal cohort study.

SETTING: Patients prescribed wheelchairs by clinicians at one of two teaching hospitals (one Veterans Affairs hospital and one private hospital).

PARTICIPANTS: One hundred fifty-three consecutive persons who were prescribed a new wheelchair, resided in the community, had a Short Portable Mental Status Questionnaire score of greater than six out of 10, and who could be interviewed within 7 to 21 days of receiving the wheelchair.

MEASUREMENTS: Patient, wheelchair, and environmental characteristics and self-reported wheelchair use in life spaces.

RESULTS: Wheelchair use in the 24 hours before the interview was inconsistent across life spaces. The correlation between wheelchair use in the bath and in the kitchen was 0.66, between locations near and far from home was −0.08, and between locations in the home and outside the home was 0.08. Predictors of wheelchair use in the home were using help from another person to propel the wheelchair (odds ratio (OR) = 0.14, 95% confidence interval (CI) = 0.04–0.45), the number of impairments (OR = 0.80, 95% CI = 0.67–0.96), a report that the wheelchair did not meet the subject's needs (OR = 3.71, 95% CI = 1.27–10.81), and having adapted the home to accommodate the wheelchair (OR = 3.75, 95% CI = 1.47–8.18). Having adapted the home was also positively associated with use of the wheelchair in areas near the home (OR = 4.77, 95% CI = 1.94–11.71). The only factor associated with wheelchair use in distant locations was older age (OR = 0.62, 95% CI = 0.46–0.83 per 10-year increment).

CONCLUSIONS: Personal factors (e.g., using help to propel the wheelchair) and environmental factors (e.g., home adaptations to accommodate the wheelchair) influenced wheelchair use. In addition, wheelchair use, and the factors influencing wheelchair use, differed by location. Wheelchair users appear to use their wheelchairs selectively, depending on their physical needs and the constraints of their environment. **J Am Geriatr Soc 50:645–654, 2002.**

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Problems with mobility are prevalent in the older population and are of special importance to community-dwelling older persons.[1–3] Interventions to cope with mobility disability are of three basic types: improve the individual's ability to perform the activity by mending the diseases or impairments causing the disability, eliminate the need to perform the activity or parts of the activity through use of personal assistance, or alter the way the activity is performed, for example through use of assistive technology such as a cane, walker, or wheelchair.[4] Use of assistive technology is an increasingly common way of coping with disability.[5] In 1995, requests to Medicare for reimbursement for durable medical equipment amounted to $6.27 million, an increase of 25.7% over the $4.99 billion requested in 1994.[6] The majority of assistive device users, particularly users of mobility aids, are aged 65 and older.[7] However, the aging of the U.S. population does not account for the increase in use of assistive technology. For example, although the U.S. population increased by 19.1% from 1980 to 1994, the age-adjusted use of leg braces increased by 52.1%, canes by 37.0%, walkers by 70.1%, and wheelchairs by 82.6%.[7] Part of the increase in use of assistive technology can be attributed to remarkable improvements in design, both in functionality and in appearance. For example, there has been an explosion in de-

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sign options in wheelchairs in the last 2 decades, including lighter-weight wheelchairs, motorized wheelchairs and scooters, and the ability to customize the fit of the seat and back to the wheelchair rider.[8,9]

However, despite their increasing popularity, there are few data on use of assistive technology or related outcomes. This is particularly notable when compared with the considerable body of work in the field of aging on the use of personal assistance and informal support.[3] To date, most studies of assistive technology have focused on utilization at very basic levels—predictors of overall use rather than use specific to the device or the activity.[10] What data exist show that there are problems; many severely disabled people lack potentially helpful devices, yet other reports show that many of the devices that are provided are not used. Moreover, problems with device utility appear to be common.[11–15] We have little understanding of why some devices prove useful and others are cast aside. The goal of this study was to examine in-depth the use of a single assistive device, with a goal of understanding the factors that facilitate or interfere with use. We selected wheelchairs for study because they are one of the more-expensive types of assistive devices commonly prescribed (and so disuse is of relatively greater importance) and because successful use of a wheelchair may be more susceptible to the influence of personal and environmental factors than other mobility aids (e.g., cane). Specifically, we focused on use of a wheelchair soon after provision, that is, wheelchair use 2 weeks after receipt, within and outside the home. We examined a variety of factors that might potentially affect wheelchair use to try to gain insight into factors that may act as barriers to or facilitators of being able to use a wheelchair in a given location. Our study questions were:

1. What are the patterns of wheelchair use in terms of locations of use?
2. Is wheelchair use in one location related to wheelchair use in other locations?
3. What factors are associated with wheelchair use in different locations?

METHODS

The study was approved by the Institutional Review Boards for the Durham Department of Veterans Affairs (VA) Medical Center (VAMC) and Duke University Medical Center.

Patient Sample

We enrolled a convenience sample of consecutive wheelchair recipients at the Durham VAMC and Duke University Medical Center if they met the following inclusion criteria: received a manual or motorized wheelchair, were older than 21, lived within a 65-mile radius of the Durham VAMC, had a phone, had a Short Portable Mental Status Questionnaire score of six out of 10 or higher, and gave informed consent. Subjects were excluded if the wheelchair was an exact replacement of a wheelchair they already owned or if we were unable to contact them within 7 to 21 days of obtaining the wheelchair. Potential study subjects were identified through billing logs at Duke University Medical Center Social Work Service, referrals from Duke University Medical Center Physical/Occupational Therapy, and through the computerized database maintained by the prosthetics service at the Durham VAMC. The VA database allowed us to identify all wheelchair recipients, whereas at Duke we were able to identify only those patients whose wheelchair was obtained with the assistance of Social Work Service (which included solely inpatients electing to order a wheelchair before discharge). We included the Duke patients because it allowed us to expand the diversity of our convenience sample (e.g., to include more women), with the recognition that we had no way of identifying definitively the base population of wheelchair recipients at Duke University Medical Center. For purposes of the current analyses, we further limited the study population to persons residing in the community (n = 153).

Data Collection

Data were obtained by interview (telephone or in-person, whichever was most convenient for the subject) after obtaining informed consent. Interviews were performed within 7 to 21 days of wheelchair receipt. Interrater reliability and quality control was assured by periodic (approximately every 3–4 months) mutual observation during patient interviews.

Study Variables

Dependent Variables

Outcomes of interest were self-reported wheelchair use in different life spaces. Life spaces were selected for measurement in this study based on the conceptual model for mobility in the life space diameter of older persons, with life spaces identified as concentric rings moving from the home to areas near to the home to areas distant from home.[16,17] Life spaces measured included two life spaces within the home (the kitchen and bathroom) and two life spaces outside the home (nearby locations such as the yard/garden/sidewalk and far away locations such as locations outside the neighborhood). We chose to study the bathroom and kitchen as examples within home life spaces because they are easily identifiable, they often present problems for wheelchair use due to narrow confines and high counters, and they are generally used on a daily basis. Each subject was queried as to the mobility method used during the prior 24 hours within each life space according to whether or not they went to the life space and the main method used to reach and move about in the life space (if more than one method was used), defined as walked, wheeled with or without assistance of another person, did not go, or missing. For the bivariate and multivariate analyses, wheeled (with or without assistance) in a given life space was compared with walked, did not go, and missing. Use of the wheelchair in the bathroom or the kitchen was examined jointly because of the relatively high correlation between wheelchair use in the bath and the kitchen ($\kappa = 0.65$). There was essentially no correlation between wheeling in locations near the home (yard/garden/street) and locations far from home (outside the neighborhood) ($\kappa = 0.08$) or between wheeling in the life spaces in the home and the life spaces outside the home ($\kappa = -0.08$).

Independent Variables

We classified independent variables as patient characteristics, wheelchair-related characteristics, and environmental characteristics.

1. Patient characteristics. Sociodemographic characteristics included age, sex, race (white race vs all others), education (high school graduate vs all others), income (<$15,000 per year vs all others), whether the subject lived alone, use of paid personal assistance (none vs any), and total hours of paid and unpaid personal assistance. Medical characteristics measured diseases and impairments. Diseases were summed in an additive scale based on self-reports by the subjects that physicians had told them they had heart disease, lung disease, stroke, parkinsonism, broken bones, joint fusion or replacement, arthritis, osteoporosis, amputation, diabetes mellitus, pressure ulcers, eye disease, falls, cancer, or psychiatric problems. Similarly, impairments were summed and included self-reported chest pain, shortness of breath, weakness, poor balance, dizziness, fear of falling, pain, or confusion. We also used the number of hours the subject reported spending out of bed per day as a measure of overall frailty.
2. Wheelchair-related characteristics. Subjects were asked about their usual method of wheelchair propulsion: self-propelled, propelled by another, and motorized. For analytic purposes we defined three variables: self-propelled vs all others, propelled by another vs all others, and motorized vs all others. Subjects also reported difficulty transferring to the wheelchair using a four-level Likert scale, which we summarized as any vs no difficulty, and they reported whether the wheelchair met their needs (needs met vs any unmet needs) and whether they had regularly used a wheelchair in the past year other than the wheelchair they had just received (any vs none).
3. Environmental characteristics. We ascertained by self-report whether there were steps to enter the home, whether the home was single story (bathroom, kitchen, and sleeping area on one level vs multiple levels), whether the home had been adapted to accommodate the wheelchair, presence or absence of unused rooms in the home, and the primary mode of transportation (wheelchair van/bus vs all others).

Data Analysis

Use of the wheelchair in various life spaces and other patient and environmental characteristics were summarized by percentages and means. The relationship between wheelchair use in one life space and wheelchair use in another life space was assessed with the kappa statistic. The lack of prior studies in this area precluded definitive a priori hypotheses for our predictive analyses. Rather, we chose to take an exploratory approach to describe the factors that may influence wheelchair use, with the knowledge that this analytic approach would have substantial risk of Type 1 error. Demographic, wheelchair, and environmental variables were associated with wheelchair use by bivariate logistic regression. We examined correlations between independent variables using the Spearman coefficient. We used stepwise logistic regression to develop our final multivariable models separately for each outcome.

RESULTS

Eight hundred thirteen persons received 815 new manual or motorized wheelchairs from January 14, 1998, to February 9, 1999; of these, 51 subjects served as pilot subjects and were not included in this analysis. There were 444 subjects who were ineligible because of residence outside a 65-mile radius of the Durham VAMC (n = 250), Short Portable Mental Status Questionnaire score less than six out of 10 (n = 67), refused (n = 66), no phone (n = 29), wheelchair was an exact replacement (n = 21), or age less than 21 (n = 11). Of the 318 eligible subjects, 116 (36%) were not enrolled because of inability to contact the subject within 2 weeks of receiving the wheelchair for the following reasons: unable to establish contact in person, by telephone, or mail (n = 63), death before initial interview (n = 20), readmitted to the hospital before initial interview (n = 19), lost their wheelchair before initial interview (n = 4), no longer using wheelchair at the time of initial interview (n = 5), initial interview more than 2 weeks after wheelchair delivery (n = 4), and other (n = 1). The remaining 202 subjects were enrolled in the study (173 VA, 29 Duke). Of these, 153 were community dwelling and constitute the sample for this analysis.

Table 1 shows characteristics of the analytic sample. The mean age of the study sample was 64.8 years; the study sample was predominantly male (92%), racially mixed (62% white), and poor (51% reported <$15,000 per year income). The sample reported relatively poor health, with a median of 4.8 chronic conditions and 4.7 physical impairments. They averaged 11.2 hours out of bed per day. In addition, 25% reported they usually needed help from another person to propel their wheelchair, 54% usually propelled their wheelchair themselves, 12% used a motorized wheelchair, and 8% had missing data on wheelchair propulsion. One-third (33.6%) reported regularly using a wheelchair before receiving this wheelchair, 59% had adapted their home for the wheelchair, and 63% reported they had to negotiate steps to enter their home. Compared with the Duke subjects, the VA subjects were significantly older; less educated; and more likely to be male, to use a motorized wheelchair, to have used a wheelchair before, and to have a one-level house (data not shown).

Tables 2a and 2b show reasons why a wheelchair was needed. We addressed this question in two ways. In Table 2a, we show data on whether subjects reported ever being told they had any of a variety of specific diseases or had been hospitalized and then whether they thought that that disease or event had contributed to needing a wheelchair. For example, although only 27.4% of subjects had been hospitalized in the preceding 6 months, 52.9% of them thought their hospitalization had contributed to needing a wheelchair. The most common conditions reported as contributing to the need for a wheelchair were recent hospitalization, arthritis, and falls, which were cited by over 30% of the population. Ten percent or more of the population cited recent surgery, stroke, lung disease, heart disease, diabetes mellitus, fracture, amputation, joint fusion/replacement, and cancer. In addition, we asked subjects an open-

Table 1. Sample Characteristics (N = 153)

Characteristic	Mean ± standard deviation or % with characteristic	Coding
Sociodemographic characteristics		
Age in years	64.8 ± 13.0	
Female	7.8	1 = yes; 0 = no
White	62.0	1 = yes; 0 = no
High school graduate	61.4	1 = yes; 0 = no
Poor	51.6	1 = <$15,000; 0 = ≥15,000
Lives alone	15.7	1 = yes; 0 = no
No paid assistance	82.3	1 = yes; 0 = no
# hours paid + unpaid assistance	9.1 ± 11.5	0–24 hours
Medical/health characteristics		
# medical conditions, range 0–11	4.8 ± 2.05	0–11 conditions
# impairments, range 0–8	4.7 ± 2.16	0–8 conditions
# of hours out of bed per day	11.2 ± 5.02	0–24 hours
Subject's hospital = VA	81.05	1 = VA Hospital; 2 = Duke Hospital
Wheelchair characteristics		
Method of wheelchair propulsion		
Usually is pushed	25.5	1 = yes; 0 = no
Usually pushes	54.2	1 = yes; 0 = no
Usually motorized	11.8	1 = yes; 0 = no
Missing/don't know/refused	8.5	1 = yes; 0 = no
Difficulty transferring	43.8	1 = yes; 0 = no
Wheelchair does not meet needs	15.7	1 = yes; 0 = no
Prior wheelchair use	33.3	1 = yes; 0 = no
Environmental characteristics		
Steps in/out of house	62.7	1 = yes; 0 = no
Bed/bath/kitchen not on same level	11.8	1 = yes; 0 = no
House adapted for wheelchair use	41.2	1 = yes; 0 = no
Unused rooms in house	22.9	1 = yes; 0 = no
Type of transportation	8.5	1 = wheelchair van; 0 = all others

VA = Department of Veterans Affairs.

ended question about the problem(s) that led to needing a new wheelchair; their responses are shown in Table 2b. Subjects reported specific diseases, impairments, functional limitations, and equipment-related reasons for needing a wheelchair. Many subjects reported more than one reason for needing the new wheelchair. The most commonly reported reason was disability, specifically difficulty walking long distances or difficulty with community mobility, cited by 18.3% of the population; another 13.1% said they had difficulty walking but did not specify that it was limited to long distances or the community. The most commonly reported impairment was weakness, by 14.4% of the population, followed by shortness of breath, by 7.8%. The most commonly reported type of disease was neurological disease of one sort or another, by 11.1% of the population, followed by acute orthopedic problems, by 9.8%. The most common equipment-related reason was need for a replacement wheelchair due to wear and tear. reported by 5.9% of the subjects, followed by specific problems with the existing wheelchair. by 3.9%.

Table 3a presents the primary mobility method reportedly used in each of four life spaces. We had little missing data, with missing value rates ranging from 1.3% to 4.6% (the latter for locations far from home). Use of the in-home life spaces was common during the preceding 24 hours. Only 8.5% of subjects reported that they did not go to their bathroom and 8.5% that they did not go to their kitchen in the preceding 24 hours. However, use of the life spaces away from home was much less common; 50.3% of subjects reported they did not go to the yard, garden, or sidewalk in the preceding 24 hours (locations near to home), and 62.1% reported they did not go to any locations outside their immediate neighborhood (locations far from home). Use of wheeling as a mode of transport in a given life space varied from 18.3% of the total sample wheeling in locations near home to 30.7% of the total sample wheeling in the kitchen. When examined relative to the subset that actually went to the life space, walking was the predominant mobility method inside the home and in the near outdoors. Wheeling was the predominant mobility method far from home. For example, wheeling was used by only 34.1% (47/138 persons) of people who went to the kitchen compared with use of wheeling by 62.7% (32/51 persons) of those who went to locations far from home.

Table 3b summarizes mobility methods across life spaces. These data show that 99.4% of study subjects reported some form of mobility (wheeling or walking) in at least one of the measured life spaces during the preceding 24 hours, and 57.5% reported using their wheelchair in

Table 2a. Percentage of Subjects Who Reported the Presence or Absence of Selected Medical Conditions and Who Reported That the Condition Contributed to Needing a Wheelchair (N = 153)

Medical Condition	Condition Present	Condition Contributed to Need for Wheelchair
	%	
Hospitalized in last 6 months	27.4	52.9
Surgery in last 6 months	34.0	24.2
Heart disease	49.0	18.3
Lung disease	37.2	19.6
Stroke	34.6	20.9
Parkinsonism	2.6	1.3
Falls	51.0	30.7
Fracture (ever)	39.2	15.7
Joint fusion/replacement	20.1	14.4
Arthritis	60.1	35.6
Osteoporosis	9.1	6.5
Amputation	22.2	15.7
Diabetes mellitus	33.3	17.0
Pressure ulcer	7.8	3.9
Eye disease	45.7	7.2
Cancer	29.1	12.4
Depression/ emotional problem	25.5	5.9

Table 2b. Subject Reports of Reasons Why a Wheelchair Was Needed

Reason for Wheelchair	Percentage of Subjects
Disease	
Neurological (stroke, spinal cord disease, neuropathy, etc.)	11.1
Orthopedic (surgery, fracture, injury)	9.8
Peripheral vascular disease and/or amputation	9.1
Arthritic/musculoskeletal	7.8
Cardiopulmonary	6.5
Surgery (cardiac, plastic, etc.)	4.6
Other (pressure ulcer, burns, cancer)	7.8
Impairment	
Weakness	14.4
Shortness of breath	7.8
Dizzy, poor balance, falls	4.6
Pain	3.9
Leg swelling	2.0
Other (insensate, spasms, etc.)	5.9
Disability	
Can't walk long distance or community mobility	18.3
Can't walk or difficult walking	13.1
Can't push manual wheelchair	4.6
Equipment-related	
Replacement wheelchair	5.9
Problem with existing wheelchair (e.g., too narrow)	3.9
Needs motorized wheelchair	2.6
Don't know	3.0

Note: Totals add up to more than 100% because subjects may have cited more than one reason.

one or another of the life spaces. Only 4% of the population walked in all of the measured life spaces, and none of the subjects wheeled in all four life spaces (data not shown). Jointly, Tables 3a and 3b show differential use of the wheelchair across life spaces, with no more than 30.9% of the subjects reporting wheelchair use in any given life space and 57.9% reporting wheelchair use in at least one of the life spaces. When we examined correlations between wheeling in the different life spaces, we found that wheeling in the kitchen and wheeling in the bathroom showed a moderate correlation with one another ($\kappa = 0.65$). However, there was essentially no correlation between wheeling in locations near the home (yard/garden/street) and locations far from home (outside the neighborhood) ($\kappa = 0.08$) or between wheeling in the life spaces in the home and in the life spaces outside the home ($\kappa = -0.08$).

Table 4 shows bivariate analyses comparing wheeling with walking or not going to that life space with potential barriers and facilitators that might account for some of the differences in wheelchair use across life spaces. People with income less than $15,000 per year were less likely to report using their wheelchair in the bath or kitchen (odds ratio (OR) = 0.38, 95% confidence interval (CI) = 0.19–0.75), as were those who had more physical impairments (OR = 0.83, 95% CI = 0.70–0.96), who reported that they used help from another person to propel the wheelchair (OR = 0.14, 95% CI = 0.05–0.42), or who had to negotiate steps to enter the home (OR = 0.40, 95% CI = 0.20–0.80). Subjects were more likely to report using their wheelchair in the bathroom or kitchen if they had prior experience using a wheelchair (OR = 3.38, 95% CI = 1.67–6.85), had adapted the home for the wheelchair (OR = 4.38, 95% CI = 2.17–8.84), or reported that the wheelchair did not meet their needs (OR = 3.71, 95% CI = 1.50–9.18).

Fewer variables were associated with wheelchair use outside the home than inside the home on bivariate analysis (Table 4). Use of the wheelchair in locations near the home was negatively associated with having to negotiate steps (OR = 0.30, 95% CI = 0.13–0.71); it was positively associated with prior wheelchair experience (OR = 2.34, 95% CI = 1.04–5.48) and with having adapted the home (OR = 4.77, 95% CI = 1.94–11.71). Use of the wheelchair in far locations was negatively associated with older age (OR = 0.62, 95% CI = 0.46–0.83 per 10-year increment) and income less than $15,000 per year (OR = 0.34, 95% CI = 0.15–0.79). Overall wheelchair use (use of the wheelchair in any of the measured locations) was reflective of the setting-specific findings with several exceptions.

Because the number of physical impairments was associated with less use of the wheelchair inside the home, we examined the relationship between individual impairments and use of the wheelchair inside the home to identify which specific impairment might be responsible. Impairments that had a significant negative association with

Table 3a. Mobility in Specific Life Spaces, According to Mobility Method, in the Preceding 24 Hours (N = 153)

Location	Did Not Go	Wheeled	Walked	Missing
	%			
Bath	8.5	26.8	62.8	2.0
Kitchen	8.5	30.7	59.5	1.3
Near to home	50.3	18.3	29.4	2.0
Far from home	62.1	20.9	12.4	4.6

Table 3b. Mobility (Any Wheeling, Any Mobility), According to Life Space, in the Preceding 24 Hours (N = 153)

Mobility Method	Bath or Kitchen	Near or Far from Home	Any Location†
	%		
Any wheeling	36.0	36.6	57.5
Any mobility*	98.0	69.9	99.4

*Wheeled or walked.
†Any of the measured locations.

wheelchair use in the home were shortness of breath with exertion (OR = 0.27, 95% CI = 0.14–0.55), chest pain with exertion (OR = 0.48, 95% CI = 0.24–0.98), and poor balance (OR = 0.37, 95% CI = 0.18–0.76). Weakness, dizziness, fear of falling, pain, and confusion were not associated with wheelchair use.

We examined correlation coefficients between the independent variables to shed light on results of the subsequent stepwise logistic regression, with the following key findings (data not shown). We found a negative correlation between income less than $15,000 and having adapted the home for the wheelchair ($r = -0.20$, $P < .05$). Prior wheelchair use was negatively correlated ($r = -0.20$, $P < .01$) with having to negotiate steps to enter the home.

Table 4. Bivariate Relationship of Predictors to Wheeling in Different Life Spaces

Characteristic	Any Wheeling in Bath or Kitchen	Any Wheeling in Yard/Street	Any Wheeling Far from Home	Any Wheeling in Any Location*
	OR (95% CI)			
Patient characteristic				
Age (per 10-year increment)	0.88 (0.68–1.13)	0.91 (0.67–1.23)	0.62 (0.46–0.83)†	0.70 (0.53–0.92)†
Female sex	0.88 (0.25–3.07)	0.88 (0.18–4.28)	1.29 (0.32–5.06)	1.52 (0.44–5.30)
White race	0.77 (0.39–1.52)	0.93 (0.40–2.16)	1.45 (0.63–3.32)	1.31 (0.68–2.53)
Income <$15,000	0.38 (0.19–0.75)†	0.45 (0.19–1.05)	0.34 (0.15–0.79)†	0.25 (0.13–0.49)†
Lives alone	1.33 (0.55–3.24)	1.62 (0.58–4.55)	0.30 (0.07–1.35)	1.27 (0.52–3.13)
No paid assistance	0.54 (0.23–1.25)	0.98 (0.34–2.87)	1.20 (0.42–3.46)	0.76 (0.32–1.79)
Number of hours paid + unpaid assistance (per hour)	0.99 (0.96–1.02)	1.02 (0.98–1.05)	0.99 (0.96–1.03)	1.00 (0.97–1.03)
High school graduate	1.02 (0.52–2.02)	1.16 (0.50–2.72)	2.19 (0.91–5.26)	1.11 (0.58–2.14)
Number of medical diseases (per disease)	1.01 (0.86–1.18)	1.03 (0.85–1.26)	0.83 (0.68–1.01)	0.95 (0.81–1.11)
Number of impairments (per impairment)	0.83 (0.70–0.96)†	0.92 (0.76–1.11)	0.91 (0.76–1.09)	0.87 (0.75–1.02)
Number of hours out of bed per day (per hour)	1.03 (0.96–1.10)	1.02 (0.94–1.11)	1.04 (0.96–1.12)	1.03 (0.97–1.10)
Wheelchair characteristics				
Method of propulsion				
Usually is pushed	0.14 (0.05–0.42)†	0.29 (0.08–1.04)	0.97 (0.39–2.38)	0.30 (0.14–0.65)†
Usually pushes	3.41 (1.67–6.97)†	1.38 (0.60–3.19)	1.10 (0.50–2.43)	3.09 (1.59–6.02)†
Usually motorized	1.50 (0.55–4.05)	1.87 (0.61–5.77)	2.10 (0.70–6.11)	1.55 (0.55–4.38)
Difficulty transferring into wheelchair	0.55 (0.28–1.09)	1.14 (0.50–2.60)	1.37 (0.63–3.00)	0.85 (0.44–1.61)
Wheelchair does not meet needs	3.71 (1.50–9.18)	2.12 (0.78–5.74)	1.71 (0.64–4.58)	2.52 (0.94–6.78)
Prior experience with wheelchair	3.38 (1.67–6.85)†	2.34 (1.04–5.48)†	0.74 (0.31–1.73)	2.31 (1.13–4.72)†
Environmental characteristics				
Steps to enter/exit house	0.40 (0.20–0.80)†	0.30 (0.13–0.71)†	1.17 (0.52–2.65)	0.54 (0.28–1.07)
One-story house	0.67 (0.24–1.81)	1.14 (0.31–4.23)	2.29 (0.50–10.50)	1.41 (0.53–3.78)
Adapted house for wheelchair	4.38 (2.17–8.84)†	4.77 (1.94–11.71)†	1.14 (0.51–2.51)	3.51 (1.74–7.09)†
Unused rooms in house	1.46 (0.68–3.16)	0.50 (0.16–1.57)	0.73 (0.28–1.95)	0.96 (0.46–2.10)
Type of transportation = wheelchair van/bus	1.59 (0.51–5.00)	1.38 (0.35–5.38)	1.15 (0.30–4.44)	1.20 (0.37–3.85)

*Any of the measured locations.
†Statistically significant.
OR = odds ratio; CI = confidence interval.

Presence of steps and having adapted the home were negatively correlated with one another ($r = -0.37$, $P < .0001$). Use of a motorized wheelchair/scooter was correlated with prior wheelchair use ($r = 0.39$, $P < .0001$) and with using a wheelchair van or bus ($r = 0.32$, $P < .0001$).

Multivariate stepwise logistic regression showed that several factors remained significant predictors of wheelchair use in the bathroom/kitchen, and one factor each was associated with wheelchair use in locations near home and far from home (Table 5). Independent predictors of wheelchair use in the home included the number of impairments (OR = 0.80, 95% CI = 0.67–0.96), a report that the wheelchair did not meet the subjects needs (OR = 3.71, 95% CI = 1.27–10.87), using help from another person to propel the wheelchair (OR = 0.14, 95% CI = 0.04–0.45), and having adapted the home to accommodate the wheelchair (OR = 3.75, 95% CI = 1.72–8.18). Having adapted the home was also positively associated with use of the wheelchair in areas near the home (OR = 4.77, 95% CI = 1.94–11.71). The only factor associated with wheelchair use in distant locations was older age, which was negatively associated with wheelchair use (OR = 0.62, 95% CI = 0.46–0.83 per 10-year increment). Independent predictors of overall wheelchair use (use in any of the measured locations) differed from the life-space-specific models in several respects. Usually being pushed in the wheelchair was associated with lower wheelchair use in the bathroom or kitchen but was not a predictor of use of the wheelchair across life spaces (overall use). Instead, pushing the wheelchair oneself was usually an independent predictor in the model for overall use but was not an independent predictor in any of the life-space-specific models. Similarly, poverty was an independent predictor in the overall-use model but not in the life-space-specific multivariate models. Indeed, the only variable that was present in the model for wheelchair use across life spaces and in one or more of the life-space-specific models was having adapted the home to accommodate the wheelchair.

DISCUSSION

We found that wheelchair use varies considerably both among users and across life spaces. Although the majority (nearly 60%) of wheelchair recipients used their wheelchairs during the 24 hours measured by this study, they did not use the wheelchair in all of the locations to which they went. A variety of potential barriers to and facilitators of wheelchair use were associated with actual wheelchair use. Most notably, wheelchair use inside the home was higher among people who had adapted their home for the wheelchair and lower among people who were dependent on another person to propel the wheelchair. Examination of use within specific life spaces was more illuminating than examining overall use (any use in any of the measured life spaces), revealing that different factors predicted wheelchair use in the various life spaces. Overall, our data are most consistent with the thesis that people with wheelchairs use them selectively, depending on their needs and the constraints of their environment.

Two of our findings are surprising at first glance—wheelchair use in the home was lower among people with more impairments, and wheelchair use in far locations outside the home was lower among older subjects. However, the specific impairments associated with lower wheelchair use were chest pain or shortness of breath with ambulation and poor balance. Studies comparing the work of walking with the work of propelling a wheelchair are limited to persons with conditions such as an amputation or stroke that are known to increase the work of walking.[18] It seems likely that, for persons with otherwise normal gait, propelling a wheelchair may require nearly as much effort as walking. Thus, for someone with cardiopulmonary disease, it may be as easy to walk a short distance inside the home as to push the wheelchair or to ask for help to push the wheelchair. Similarly, subjects with poor balance may be able to accommodate for their poor balance in the familiar environment inside the home, especially if they have modified their home so that frequent supports are available. Lower wheelchair use by older subjects in locations far from home may reflect a greater tendency toward home confinement in the geriatric population noted in other studies, rather than differential use of wheelchairs per se.[19–21]

We know of only one other study comparing mobility methods across life spaces. York found that physically disabled college students used various mobility methods in different types of locations, with wheeled mobility being more common among subjects traveling longer distances outdoors.[22] Use of multiple methods for mobility may be relatively common among disabled persons, both older

Table 5. Multivariable Stepwise Backwards Logistic Regression Predicting Wheelchair Use (Versus Walked or Did Not Go) in Various Locations

Characteristic	Bath or Kitchen	Near to Home	Far from Home	Any Wheeling in Any Location*
	OR (95% CI)			
Age			0.62 (0.46–0.83)	
Poor				0.29 (0.14–0.60)
Number of Impairments	0.80 (0.67–0.96)			
Unmet needs	3.71 (1.27–10.87)			
Usually is pushed (vs all others)	0.14 (0.04–0.45)			
Usually pushes (vs all others)				2.65 (1.29–5.44)
Adapted house	3.75 (1.72–8.18)	4.77 (1.94–11.71)		2.73 (1.28–5.81)

*Any reported use of the wheelchair during the preceding 24 hours in any of the measured locations.
OR = odds ratio; CI = confidence interval.

and younger. For example, Pawlson et al. found that 25% of nursing home residents both used a wheelchair and walked.[23] Moreover, when older persons use wheelchairs, independent use may not be the norm. Simmons et al. showed that nursing home residents were observed propelling their wheelchairs less than 4% of the time.[24] Thus, the inconsistent use of wheelchairs across locations seen in our study may reflect reality for disabled persons coping with a multiplicity of environments and environmental constraints.

Several studies provide insight into factors that may adversely affect use of wheelchairs by older persons. Redford reviewed studies specifically concerned with seating and wheeled mobility for older people; he commented on the paucity of data but concluded that two major barriers to greater use of optimal seating/wheelchair technology were the high cost of durable medical equipment and the failure of most clinicians and institutional administrators to recognize the importance of posture and comfort in providing functional independence in wheelchair users.[25] Simmons et al. found mechanical problems in 46% of wheelchairs used by nursing home residents and that 100% of wheelchair users in the nursing home were unable to unlock the brakes on their wheelchairs.[24] Similarly, Mann et al. found that 40% of community-dwelling older wheelchair users reported problems with their wheelchairs and that 41% of the problems related to the fit between the user and the wheelchair (e.g., uncomfortable to sit in), 33% of the problems were mechanical, and 26% of the problems related to the physical characteristics of the wheelchair (e.g., too heavy to push, too wide to use inside the home).[11] Perks et al. found that significant numbers of wheelchair users experience difficulties with propulsion because of impaired upper limb function.[15] Meyers et al. examined mobility in a convenience sample of chronic wheelchair users, old and young, using daily interviews.[26] They found that the wheelchair users reported encountering a wide variety of environmental and personal barriers, some of which they reported that they were able to overcome and others that they were unable to overcome. None of these studies simultaneously examined the relationship of personal, wheelchair-related, and environmental factors to actual wheelchair use. Our study provides evidence that personal, wheelchair, and environmental factors all may play important and independent roles. Providing a wheelchair that fits well and is easy to operate without addressing environmental access may limit the benefit from the equipment. Similarly, an accessible environment is of no benefit if the equipment is difficult for the user to operate.

Although there are relatively few studies of wheelchair use, the problems seen in our study appear emblematic of the overall situation with provision and use of assistive technology. Substantial unmet needs for equipment are reported among disabled older people. In addition, there are reports that the devices owned by older subjects are frequently in disrepair or are ill fitting (including half of the mobility aids), and up to half of the devices owned were not in use.[12,13,27] Some of the variance in use may be due to personal preferences and improvement in health. For example, there is some evidence of gender-related differences in use of technology,[12] and two studies found improvement in health to be the main reason cited by patients for discarding aids.[28,29] However, there also appear to be substantial problems with the provision of assistive technology. O'Day et al. report that acquisition of assistive technology presents many problems for disabled persons, including lack of funds to purchase the most suitable equipment, fraud and abuse by providers, and denials of needed equipment by third-party payors.[30] Moreover, one study showed that an improved process for provision of bath aids resulted in improved utilization and greater patient safety compared with the usual process.[31]

Most studies of outcomes from assistive technology have focused on any versus no use,[10] which may be overly simplistic. Results of studies may be confounded by extraneous factors that might influence device availability irrespective of potential use were the device owned, such as lack of finances or awareness about potentially useful devices. Moreover, overly simplistic studies may miss important findings caused by differential benefits from different devices and differential effects across settings. Therefore, we simplified several confounding constructs; we examined only a single type of device, a wheelchair, among persons who had the device and then examined its use within specific settings. Indeed, our findings support the notion that assistive technology use is far more complex than simply whether or not the device is used at all. Noteworthy findings would have been missed by not examining location-specific wheelchair use.

Our study has a number of important limitations. We were best able to predict use of the wheelchair at home. This may be because nearly everyone went to the life spaces we measured in the home, whereas less than 50% of the sample went to measured life spaces outside their home. For life spaces visited infrequently, the associations may reflect associations with mobility rather than wheelchair use per se because our comparison group with wheeling was walking or not going to the life space at all. For the in-home life spaces, nearly everyone went to the life space; thus the odds ratio compares wheeling with walking. For the life spaces outside the home, substantial numbers of subjects did not go to the life space at all; thus the odds ratio reflects in part the odds of wheeling in the life space versus not going there at all. For example, the inverse relationship of age to wheelchair use in far locations may reflect decreased mobility in the oldest subjects rather than a propensity for lower wheelchair use. In point of fact, several investigators have found a relationship between older age and home confinement.[19–21] In addition, type 2 statistical error may have affected our ability to detect the effect of factors that occurred infrequently on events that also occurred infrequently. For example, only 18 subjects used a motorized wheelchair; this small sample size and the relative infrequency of mobility outside the home may have prevented us from detecting benefits of motorized wheelchairs/scooters on community mobility. The important question of benefit from custom or motorized wheelchairs requires further study.

A second important limitation relates to the longitudinal cohort study design. Although most of our findings make intuitive sense, causality cannot be inferred. For example, people who reported that their wheelchair did not meet their needs were more likely to report actually using their wheelchair in the preceding 24 hours. Probably this is because people who frequently use their wheelchair have

more opportunity to discover ways in which the wheelchair does not meet their needs rather than because poorly fitting or poorly designed wheelchairs are more likely to be used. Our analysis used stepwise logistic regression, which is an exploratory analytic approach, appropriate to a study such as this. However, use of this technique may account for some of the differences in our life-space-specific models versus the overall-use model, in that, with stepwise logistic regression, the computer program selected the best variable from a set of colinear variables. Alternatively, it makes intuitive sense that a life-space-specific analysis might reveal findings that were missed in a more global analysis.

Yet another concern relates to the generalizability of our findings. We were able to enroll 64% of eligible patients, so our findings should generalize to the entire population of wheelchair recipients who were eligible for the study. However, we have no way to verify the true base population at Duke University Medical Center (i.e., inpatients for whom wheelchairs were ordered but were not logged by social work service), so we may have overestimated the degree to which we were able to capture eligible patients at Duke University Medical Center. Moreover, eligible patients at Duke University were limited to inpatients. In addition, despite the addition of subjects from a private hospital, the majority of subjects in our study were veterans, so our findings may not generalize to other populations where limitations in insurance coverage or difference in prescribing patterns may affect which types of patients receive wheelchairs or the kinds of wheelchairs they receive. Although our sample represents a convenience sample in which we explored important factors influencing use of a commonly described assistive device, the factors we identified (e.g., use of help propelling the wheelchair, home adaptations) are likely to affect benefit from a wheelchair irrespective of the user's demographics. Finally, the point at which we measured wheelchair use must be considered. Two weeks after receiving the wheelchair, users may still be too ill to use it outside the home, and they may not have had time to modify their home to accommodate the wheelchair. Alternatively, 2 weeks after receipt is too early for devices to have been abandoned on the basis of recovery from illness. These considerations must be kept in mind when interpreting our results.

In general, our findings should be reassuring to practitioners fearful of prescribing a wheelchair lest the recipient become dependent on it. Our sample clearly used their wheelchairs in a selective fashion. However, our findings also serve as an alarm call as to problems with common practices in wheelchair prescription. The most consistent predictor of wheelchair use, seen both in the life-space-specific models and the overall-use models was having adapted the home. This finding is particularly interesting because many healthcare insurance plans do not pay for environmental modifications such as a ramp, even though they may cover the wheelchair itself, nor is reimbursement readily available for specially adapted wheelchairs that might be easier to propel. Recent data from the National Health Interview Survey show that accessibility problems are substantially more common among wheelchair users than among the rest of the U.S. population.[32] For example, in the National Health Interview Survey, 52.1% of wheelchair users report difficulty entering or leaving their home, compared with 6.8% of the nondisabled adult population. Prospective studies are needed to investigate whether benefit from a wheelchair is increased by interventions such as providing a ramp, widening doorways, and providing a special wheelchair for people with difficulty propelling the wheelchair.

Like much research, this study raises as many questions as it answers. For example, we saw intriguing associations between specific patient characteristics (e.g., chest pain with exertion, age) and wheelchair use in specific locations. Although we were unable to explore interactions between such variables because of sample size limitations, one wonders about such interactions. For example, do younger patients, highly disabled but primarily with neurological disease, use their wheelchairs differently than do older adults with multiple medical problems or cardiopulmonary impairments? Because our study showed that wheelchairs were selectively used according to life space, perhaps other mobility aids that were better suited to a given life space were used instead of the wheelchair. Thus, another question that arises out of our study is whether mobility-impaired subjects commonly use multiple mobility aids and whether use of different mobility aids according to the environment is of benefit. Because some third-party payors limit payment to one mobility aid per year, this is a question of substantial importance. As yet another example, because wheelchair use was higher among those who were able to propel their wheelchairs independently, this would support the need for research into use of lightweight and other specialized wheelchairs that facilitate independent propulsion. Fuhrer recently called for an investment in systematic research to assess the outcomes of assistive technology.[33] He emphasizes, and our study underscores, that dependable information on which devices work and for which people is indispensable for charting future research and development to improve those technologies and their efficacy in ameliorating disability.

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