www.medscape.com

Indoor and Outdoor Falls in Older Adults are Different: The Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston Study

WILEY-BLACKWELL

The Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston Study

Jennifer L. Kelsey, PhD; Sarah D. Berry, MD, MPH; Elizabeth Procter-Gray, PhD, MPH; Lien Quach, MS; Uyen-Sa D. T. Nguyen, DSc, MPH; Wenjun Li, PhD; Douglas P. Kiel, MD, MPH; Lewis A. Lipsitz, MD; Marian T. Hannan, DSc, MPH

Posted: 01/12/2011; J Am Geriatr Soc. 2010;58(11):2135-2141.

Abstract and Introduction

Abstract

Objectives: To identify risk factors for indoor and outdoor falls.
Design: Prospective cohort study.
Setting: The MOBILIZE Boston Study, a study of falls etiology in community-dwelling older individuals.
Participants: Seven hundred sixty-five women and men, mainly aged 70 and older, from randomly sampled households in the Boston, Massachusetts, area.
Measurements: Baseline data were collected by questionnaire and comprehensive clinic examination. During follow-up, participants recorded falls on daily calendars. The location and circumstances of each fall were asked during telephone interviews.
Results: Five hundred ninety-eight indoor and 524 outdoor falls were reported over a median follow-up of 21.7 months. Risk factors for indoor falls included older age, being female, and various indicators of poor health. Risk factors for outdoor falls included younger age, being male, and being relatively physically active and healthy. For instance, the age- and sex-adjusted rate ratio for having much difficulty or inability to perform activities of daily living relative to no difficulty was 2.57 (95% confidence interval (CI)=1.69–3.90) for indoor falls but 0.27 (95% CI=0.13–0.56) for outdoor falls. The rate ratio for gait speed of less than 0.68 m/s relative to a speed of greater than 1.33 m/s was 1.48 (95% CI=0.81–2.68) for indoor falls but 0.27 (95% CI=0.15–0.50) for outdoor falls.
Conclusion: Risk factors for indoor and outdoor falls differ. Combining these falls, as is done in many studies, masks important information. Prevention recommendations for noninstitutionalized older people would probably be more effective if targeted differently for frail, inactive older people at high risk for indoor falls and relatively active, healthy people at high risk for outdoor falls.

Introduction

Approximately 35% to 40% of community-dwelling adults aged 65 and older fall each year.[1] Falls are associated with reduced functioning, lack of self-confidence in ability to ambulate safely, hospitalization, premature nursing home admission, and excess mortality.[2] Frequently reported risk factors for falls include muscle weakness, a history of falls, gait and balance deficits, use of assistive devices, visual deficits, arthritis, impaired activities of daily living (ADLs), depression, cognitive impairment, polypharmacy, psychotropic medications, and age of 80 and older.[2,3] Most interventions have focused on trying to ameliorate these deficits and on making the home environment less hazardous.[4]

Even though most older people spend the vast majority of their time indoors,[5] most studies have found that at least 50% of falls in community-dwelling older people occur outdoors.[6–11] Previous reports, which have included only small numbers of risk factors, have suggested that, although indoor falls indeed tend to occur in frail people with compromised health, outdoor falls tend to occur in active people.[6–11] Nevertheless, most published studies of risk factors and interventions continue to combine all falls regardless of location. Failure to separate indoor and outdoor

falls can make it difficult to assess the magnitudes of associations between various risk factors and falls; in fact, associations may be completely missed when all falls are combined. The current study used data from the Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston Study (MOBILIZE Boston) to compare the associations of a large number of risk factors for falls when all falls are combined and when falls are divided into those occurring indoors and outdoors.

Methods

MOBILIZE Boston has been described in detail elsewhere.[12,13] Briefly, it is a prospective cohort study to identify risk factors and mechanisms of falls in 765 community-dwelling men and women, mainly aged 70 and older, who live in the Boston, Massachusetts, area. Other eligibility criteria included ability to read and speak English, ability to walk 20 feet without the assistance of another person, intention to stay in the Boston area for at least 2 years, and adequate cognition (score at least 18 points on the Mini-Mental State Examination (MMSE)).[14] Enrollment took place from September 2005 to December 2007 using door-to-door recruitment in randomly sampled households with at least one member aged 70 and older as recorded in annual town lists required in Massachusetts. From 5,655 sampled households, 4,303 people aged 70 and older were identified. Of the 4,303, 1,581 were not eligible, and 1,973 refused to participate or were unable to be contacted. An additional 16 persons aged 64 to 69 who were spouses or living with a participant were added to the cohort, for a total of 765 participants. The data presented here are based on follow-up through October 2008. The median length of follow-up was 21.7 months (range 0.5–38.4 months). The institutional review board of Hebrew SeniorLife approved this study, and all participants signed a consent form.

At baseline, participants underwent comprehensive assessments, including a home visit and clinic examination. Demographic characteristics included in these analyses were age, sex, self-reported race or ethnicity, and education. Among lifestyle factors, body mass index was derived from weight measured on a standard balance beam scale and stadiometer-measured height and categorized as normal (<25.0 kg/m^2), overweight (25.0–29.9 kg/m^2), or obese (≥30.0 kg/m^2). Typical physical activity level was estimated using the Physical Activity Scale for the Elderly questionnaire to measure physical activity in the previous week.[15] The number of stairs in a participant's home was observed during the home visit. Alcohol use was obtained according to self-report.

Balance was assessed using the Berg Balance Scale.[16] The Short Physical Performance Battery, which included tandem balance performance, timed chair stands, and gait speed, was used to measure lower extremity function.[17] Inability to perform the chair stands (unable or needed to use arms during the test) was also assessed. Gait speed (m/s) was the shortest time in two trials for a usual-paced 4-m walk.[18] The ADL scale[19,20] was scored according to ability to perform five activities (bathing, dressing, toileting, transferring, eating). Reduced activity because of illness was based on response to the question "In the past 12 months, did you cut down on the things you usually do, such as going to work or working around the house because of illness or injury?" Distance vision was tested at 10 feet (wearing corrective lenses, if used), with poor vision defined as vision worse than 40/100.

Among illness- or symptom-related factors, bodily pain was assessed using the Medical Outcomes Study 36-item Short Form Survey.[21] Number of self-reported comorbid conditions (excluding depression) was summed from participants' response to whether a healthcare provider had told them that they had any of several specific major medical conditions.[22] Participants rated their health status as good to excellent or fair to poor. Peripheral neuropathy was assessed using Semmes-Weinstein monofilament testing.[23] Foot pain was based on report of pain, aching, or stiffness in one or both feet on most days. Trained nurses assessed the presence of knee osteoarthritis using the American College of Rheumatology clinical criteria for osteoarthritis of the knee.[24] Depression symptoms were assessed using a modification of the 20-item Centers for Epidemiologic Studies Depression Scale.[25,26]

Each participant's prescription and over-the-counter medications used during the previous 2 weeks were coded using the Iowa Drug Information System ingredient codes.[27] Topical medications, vitamins, and herbals were excluded.

The MMSE was used to assess cognitive function.[14]

Fall-related indicators included the number of self-reported falls in the past year and the Falls Efficacy Scale (FES), a summary measure of fear of falling that queries level of confidence in performing certain activities without falling on a scale of 1 to 10.[28]

A fall was defined as unintentionally coming to rest on the ground or other lower level. During the home visit, interviewers instructed participants on how to use a calendar during follow-up to record whether a fall occurred each day. At the end of each month, participants mailed their falls calendars to the study office. Study staff called those not returning calendars within 10 days of the end of a month or returning an incomplete calendar. Information on whether a fall had occurred was obtained for more than 99% of follow-up months.

When participants reported a fall, a structured telephone interview was conducted to determine the circumstances. An indoor fall was defined as one that occurred inside the participant's home, inside someone else's home, inside another building, or inside another location. Outdoor falls were those reported to have occurred anywhere outside. Location of the fall was reported for 1,122 (86.4%) of 1,299 falls. A fall was considered to have resulted in an injury if the participant answered yes to the question "Did you hurt yourself when you fell?" Fractures, sprains, dislocations, and pulled or torn muscles, ligaments, or tendons were classified as serious injuries.

In the statistical analysis, baseline characteristics of participants who fell indoors only, fell outdoors only, fell indoors and outdoors, and did not fall at all within a 2-year follow-up period were first compared. This particular analysis was limited to the 695 individuals (90.8%) who had at least 1 year of follow-up to minimize bias from the likelihood of fall frequency being greater in those with longer follow-up. *P*-values for differences between characteristics of those who fell only indoors and those who fell only outdoors were based on the Wilcoxon rank-sum test for quantitative variables and the chi-square test for categorized variables. Then rates of falls (average number of falls per person per year of follow-up) according to age and sex were computed for all falls, indoor falls, and outdoor falls for all participants through October 2008. Negative binomial regression models were used to estimate the effects of baseline characteristics on the rates of all falls, indoor falls, and outdoor falls, adjusting for age and sex. The effect of each characteristic or risk factor is expressed as a rate ratio, which is the average number of falls per person per year of follow-up in people with a characteristic (e.g., male sex), relative to the average number of falls per person per year of follow-up in a referent group (e.g., female sex). Thus, the referent group varies according to the characteristic or risk factor being considered.

The associations between each type of fall and quantitative risk factors were assessed for linearity and potential thresholds; variables with nonlinear associations or thresholds were categorized as needed. Potential interactions between selected combinations of risk factors and rate of falls were examined, but no interactions were evident.

Results

The median age at baseline of the 765 cohort members was 78 (range 64–97); 36% were male and 64% female. Of the 1,122 falls for which location was reported, 598 (53.3%) occurred indoors and 524 (46.7%) outdoors; 77% of indoor falls occurred inside the participant's own home. The locations of outdoor falls were more diverse but most commonly occurred on sidewalks (23%), yards or gardens (14%), streets or curbs (14%), outside stairs (13%), and parking lots (6%).

Table 1 presents baseline characteristics of those with at least 1 year of follow-up who fell indoors only, outdoors only, indoors and outdoors, and not at all during the first 2 years after baseline. Those who fell only outdoors were somewhat younger than those who fell only indoors, more likely to be male and better educated, and somewhat more likely to be white. Those who fell only outdoors had lifestyle characteristics indicative of better health, whereas those who fell only indoors had substantially more physical disabilities and were more likely to have characteristics classified as illness related. They were taking somewhat more medications, including psychotropic medications, and had somewhat lower cognitive function. They had fallen somewhat more in the previous year and were much more likely to have a low score on the FES than those who fell only outdoors. For many attributes, those who had fallen both indoors and outdoors during the 2-year period had values intermediate between those who fell indoors only and those who fell

outdoors only.

Table 1. Baseline Characteristics of People Who Fell Indoors Only, Outdoors Only, Outdoors and Indoors, and Not at All During the First 2 Years of Follow-Up

Characteristic	Fell Indoors Only (n=135)	Fell Outdoors Only (n=129)	*P*-Value for Indoor Only Versus Outdoor Only†	Fell Indoor and Outdoors (n=113)	Did Not Fall (n=318)
Demographic					
Age, mean ± SD	79.9 ± 5.5	77.7 ± 4.9	.002	77.9 ± 6.1	77.5 ± 5.2
Male, n (%)	31 (23.0)	59 (45.7)	<.001	41 (36.3)	114 (35.8)
Education, n (%)			.03		
≤High school graduate	47 (34.8)	33 (25.6)		31 (27.4)	129 (40.7)
Some college or college graduate	54 (40.0)	44 (34.1)		34 (30.1)	113 (35.6)
>Graduate studies	34 (25.2)	52 (40.3)		48 (42.5)	75 (23.7)
White, n (%)	106 (78.5)	111 (86.7)	.08	95 (84.1)	226 (71.1)
Lifestyle, n (%)					
Body mass index, kg/m^2					
<25.0	33 (25.2)	38 (30.2)	.001	46 (40.7)	95 (30.4)
25.0–29.9	46 (35.1)	65 (51.6)		45 (39.8)	127 (40.7)
≥30.0	52 (39.7)	23 (18.2)		22 (19.5)	90 (28.9)
Bottom quartile of physical activity, Physical Activity Scale for the Elderly score<55	37 (28.0)	22 (17.0)	.03	31 (27.9)	71 (22.3)
≥Three flights stairs in home	12 (8.9)	19 (14.7)	.14	21 (18.6)	26 (8.2)
Use of alcohol, drinks			.10		
None	60 (44.4)	40 (31.0)		43 (38.1)	133 (41.8)
1–3 drinks/month	28 (20.7)	26 (20.2)		24 (21.2)	73 (23.0)
1–6 drinks/wk	33 (24.4)	44 (34.1)		30 (26.6)	73 (23.0)
≥7 drinks/wk	14 (10.4)	19 (14.7)		16 (14.2)	39 (12.3)
Physical disability					
Berg Balance Scale score, n (%)			<.001		
≥51	48 (35.6)	83 (64.3)		56 (49.6)	190 (59.8)
48–51	34 (25.2)	29 (22.5)		34 (30.1)	71 (22.3)

<48	53 (39.3)	17 (13.2)		23 (20.3)	57 (17.9)
Unable to do chair-stand test without using arms, n (%)	22 (16.3)	6 (4.6)	.002	5 (4.4)	17 (5.3)
Gait speed, m/s, n (%)			.005		
>1.33	7 (5.2)	11 (8.5)		12 (10.6)	17 (5.3)
0.68–1.33	97 (71.8)	107 (83.0)		89 (78.8)	267 (84.0)
<0.68	31 (23.0)	11 (8.5)		12 (10.6)	34 (10.7)
Activities of daily living, n (%)			<.001		
No difficulty	83 (61.5)	109 (84.5)		83 (73.5)	267 (84.0)
A little or some difficulty	26 (19.3)	17 (13.2)		25 (22.1)	36 (11.3)
Much difficulty or inability	26 (19.3)	3 (2.3)		5 (4.4)	15 (4.7)
Short Physical Performance Battery score <10, n (%)	80 (59.3)	38 (29.5)	<.001	45 (39.8)	116 (36.5)
Reduced activity because of illness, n (%)	47 (34.8)	39 (30.2)	.43	45 (39.8)	60 (18.9)
Poor vision (worse than 40/100), n (%)	11 (8.2)	8 (6.2)	.54	7 (6.2)	31 (9.7)
Illness-related					
Moderate to severe bodily pain, n (%)	78 (57.8)	38 (29.7)	<.001	46 (40.7)	106 (33.4)
Number of comorbid conditions, mean ± SD	3.2 ± 1.4	2.7 ± 1.5	.002	3.0 ± 1.4	2.8 ± 1.4
Fair to poor self-rated health, n (%)	28 (20.7)	14 (10.8)	.03	16 (14.2)	36 (11.3)
Peripheral neuropathy, n (%)	19 (14.3)	16 (12.4)	.65	16 (14.3)	24 (7.6)
Foot pain, n (%)	47 (34.8)	30 (23.3)	.04	31 (27.4)	51 (16.0)
Knee osteoarthritis, n (%)	40 (29.6)	31 (24.0)	.31	32 (28.3)	73 (23.0)
Depression, n (%)	17 (12.6)	10 (7.8)	.19	14 (12.4)	8 (2.5)
Medication use, n (%)					
Number of medications			.10		
0–4	37 (27.4)	45 (34.9)		44 (38.9)	112 (35.2)
5–8	57 (42.2)	59 (45.7)		49 (43.4)	158 (49.7)
≥9	41 (30.4)	25 (19.4)		20 (17.7)	48 (15.1)
Uses psychotropic medication ‡	39 (28.9)	26 (20.2)	.10	27 (24.1)	49 (15.6)

Impaired cognition (Mini-Mental State Examination score 18–24), n (%)	19 (14.1)	10 (7.8)	.10	10 (8.8)	41 (12.9)
Fall related					
Number of falls in year before baseline, mean ± SD	1.1 ± 1.7	0.9 ± 2.4	.08	1.7 ± 5.0	0.3 ± 0.8
Falls Efficacy Scale score<90, n (%)	34 (25.2)	14 (10.9)	.003	15 (13.4)	30 (9.5)
Follow-up time, months, mean ± SD	20.3 ± 4.2	21.1 ± 4.0	.10	21.5 ± 3.6	20.0 ± 4.3

Participants with at least 1 year of follow-up are included. All variables had a sample size of 95–100% of full N shown.
†Wilcoxon rank-sum test was used for age, number of comorbid conditions, falls before baseline and follow-up time; chi-square was used for all other variables.
‡Includes antidepressants, benzodiazepines, antipsychotics, and other sedatives.
SD=standard deviation.

In addition, those who fell outdoors only were generally at least as healthy, if not more so, than those who did not fall at all, whereas those who fell indoors only were less healthy and more disabled than those who did not fall at all (Table 1).

Table 1. Baseline Characteristics of People Who Fell Indoors Only, Outdoors Only, Outdoors and Indoors, and Not at All During the First 2 Years of Follow-Up

Characteristic	Fell Indoors Only (n=135)	Fell Outdoors Only (n=129)	*P*-Value for Indoor Only Versus Outdoor Only†	Fell Indoor and Outdoors (n=113)	Did Not Fall (n=318)
Demographic					
Age, mean ± SD	79.9 ± 5.5	77.7 ± 4.9	.002	77.9 ± 6.1	77.5 ± 5.2
Male, n (%)	31 (23.0)	59 (45.7)	<.001	41 (36.3)	114 (35.8)
Education, n (%)			.03		
≤High school graduate	47 (34.8)	33 (25.6)		31 (27.4)	129 (40.7)
Some college or college graduate	54 (40.0)	44 (34.1)		34 (30.1)	113 (35.6)
>Graduate studies	34 (25.2)	52 (40.3)		48 (42.5)	75 (23.7)
White, n (%)	106 (78.5)	111 (86.7)	.08	95 (84.1)	226 (71.1)
Lifestyle, n (%)					
Body mass index, kg/m^2					
<25.0	33 (25.2)	38 (30.2)	.001	46 (40.7)	95 (30.4)

25.0–29.9	46 (35.1)	65 (51.6)		45 (39.8)	127 (40.7)
≥30.0	52 (39.7)	23 (18.2)		22 (19.5)	90 (28.9)
Bottom quartile of physical activity, Physical Activity Scale for the Elderly score<55	37 (28.0)	22 (17.0)	.03	31 (27.9)	71 (22.3)
≥Three flights stairs in home	12 (8.9)	19 (14.7)	.14	21 (18.6)	26 (8.2)
Use of alcohol, drinks			.10		
None	60 (44.4)	40 (31.0)		43 (38.1)	133 (41.8)
1–3 drinks/month	28 (20.7)	26 (20.2)		24 (21.2)	73 (23.0)
1–6 drinks/wk	33 (24.4)	44 (34.1)		30 (26.6)	73 (23.0)
≥7 drinks/wk	14 (10.4)	19 (14.7)		16 (14.2)	39 (12.3)
Physical disability					
Berg Balance Scale score, n (%)			<.001		
≥51	48 (35.6)	83 (64.3)		56 (49.6)	190 (59.8)
48–51	34 (25.2)	29 (22.5)		34 (30.1)	71 (22.3)
<48	53 (39.3)	17 (13.2)		23 (20.3)	57 (17.9)
Unable to do chair-stand test without using arms, n (%)	22 (16.3)	6 (4.6)	.002	5 (4.4)	17 (5.3)
Gait speed, m/s, n (%)			.005		
>1.33	7 (5.2)	11 (8.5)		12 (10.6)	17 (5.3)
0.68–1.33	97 (71.8)	107 (83.0)		89 (78.8)	267 (84.0)
<0.68	31 (23.0)	11 (8.5)		12 (10.6)	34 (10.7)
Activities of daily living, n (%)			<.001		
No difficulty	83 (61.5)	109 (84.5)		83 (73.5)	267 (84.0)
A little or some difficulty	26 (19.3)	17 (13.2)		25 (22.1)	36 (11.3)
Much difficulty or inability	26 (19.3)	3 (2.3)		5 (4.4)	15 (4.7)
Short Physical Performance Battery score <10, n (%)	80 (59.3)	38 (29.5)	<.001	45 (39.8)	116 (36.5)
Reduced activity because of illness, n (%)	47 (34.8)	39 (30.2)	.43	45 (39.8)	60 (18.9)
Poor vision (worse than 40/100), n (%)	11 (8.2)	8 (6.2)	.54	7 (6.2)	31 (9.7)
Illness-related					
Moderate to severe bodily pain, n (%)	78 (57.8)	38 (29.7)	<.001	46 (40.7)	106 (33.4)

Number of comorbid conditions, mean ± SD	3.2 ± 1.4	2.7 ± 1.5	.002	3.0 ± 1.4	2.8 ± 1.4
Fair to poor self-rated health, n (%)	28 (20.7)	14 (10.8)	.03	16 (14.2)	36 (11.3)
Peripheral neuropathy, n (%)	19 (14.3)	16 (12.4)	.65	16 (14.3)	24 (7.6)
Foot pain, n (%)	47 (34.8)	30 (23.3)	.04	31 (27.4)	51 (16.0)
Knee osteoarthritis, n (%)	40 (29.6)	31 (24.0)	.31	32 (28.3)	73 (23.0)
Depression, n (%)	17 (12.6)	10 (7.8)	.19	14 (12.4)	8 (2.5)
Medication use, n (%)					
Number of medications			.10		
0–4	37 (27.4)	45 (34.9)		44 (38.9)	112 (35.2)
5–8	57 (42.2)	59 (45.7)		49 (43.4)	158 (49.7)
≥9	41 (30.4)	25 (19.4)		20 (17.7)	48 (15.1)
Uses psychotropic medication‡	39 (28.9)	26 (20.2)	.10	27 (24.1)	49 (15.6)
Impaired cognition (Mini-Mental State Examination score 18–24), n (%)	19 (14.1)	10 (7.8)	.10	10 (8.8)	41 (12.9)
Fall related					
Number of falls in year before baseline, mean ± SD	1.1 ± 1.7	0.9 ± 2.4	.08	1.7 ± 5.0	0.3 ± 0.8
Falls Efficacy Scale score<90, n (%)	34 (25.2)	14 (10.9)	.003	15 (13.4)	30 (9.5)
Follow-up time, months, mean ± SD	20.3 ± 4.2	21.1 ± 4.0	.10	21.5 ± 3.6	20.0 ± 4.3

Participants with at least 1 year of follow-up are included. All variables had a sample size of 95–100% of full N shown.
†Wilcoxon rank-sum test was used for age, number of comorbid conditions, falls before baseline and follow-up time; chi-square was used for all other variables.
‡Includes antidepressants, benzodiazepines, antipsychotics, and other sedatives.
SD=standard deviation.

Table 2 gives rates of falls (average number of falls per person per year) according to age and sex for the entire cohort. If all falls are considered, a slight increase in rate of falls with age and a somewhat higher rate of falls in men than women were seen, although the increase in fall rates with age was limited to indoor falls; outdoor fall rates decreased with age. Also, there was a higher rate of indoor falls in women than men and a markedly higher rate of outdoor falls in men than women.

Table 2. Annualized Fall Rates and Rate Ratios According to Age and Sex: All Falls, Indoor Falls, and Outdoor Falls

Age and Sex	All Falls	Indoor Falls	Outdoor Falls
Mean fall rate (95% CI) according to age			
65–69	0.69 (0.43–1.10)	0.28 (0.14–0.53)	0.40 (0.23–0.69)
70–79	0.79 (0.69–0.91)	0.39 (0.33–0.47)	0.40 (0.34–0.48)
80–89	0.85 (0.73–0.99)	0.50 (0.42–0.61)	0.34 (0.28–0.43)
90–99	0.96 (0.57–1.62)	0.80 (0.43–1.48)	0.15 (0.06–0.37)
Rate ratio per 5 years of age	1.06 (0.97–1.16)	1.20 (1.07–1.34)	0.90 (0.79–1.01)
Mean fall rate (95% CI) according to sex			
Male	0.87 (0.73–1.04)	0.38 (0.30–0.48)	0.49 (0.40–0.60)
Female	0.79 (0.70–0.89)	0.47 (0.41–0.55)	0.32 (0.27–0.37)
Rate ratio male versus female	1.11 (0.90–1.36)	0.81 (0.62–1.05)	1.55 (1.19–2.02)

Fall rates (mean number of falls per person per year) and rate ratios were estimated using negative binomial regression models. The rate ratio is the average number of falls per person per year of follow-up in one group (e.g., men) divided by the average number of falls per person per year of follow-up in a referent group (e.g., women). The referent group is specific for each potential risk factor.
CI=confidence interval.

Table 3 shows age- and sex-adjusted rate ratios for all falls, indoor falls, and outdoor falls according to the other attributes in Table 1. For all falls, rate ratios greater than 1.50 occurred for white race, being highly educated, having three or more flights of stairs in the home, having little or some difficulty with ADLs, having recently reduced activity because of illness, and being depressed. Also, the greater the number of falls in the year before baseline, the higher the rate ratio. All other attributes had low levels of association with all falls combined.

Table 3. Age- and Sex-Adjusted Associations Between Baseline Characteristics and All Falls, Indoor Falls, and Outdoor Falls

Characteristic	Rate Ratio (95% Confidence Interval)		
	All Falls	Indoor Falls	Outdoor Falls
Demographic			
White	1.53 (1.19–1.98)	1.23 (0.90–1.68)	2.08 (1.46–2.96)
Education level (reference ≤high school graduate)			
Some college or college graduate	1.22 (0.96–1.56)	1.19 (0.88–1.61)	1.33 (0.97–1.84)
Graduate studies	1.76 (1.37–2.25)	1.53 (1.12–2.09)	2.08 (1.51–2.87)
Lifestyle			
Body mass index, kg/m^2 (reference <25.0)			

25.0–29.9	0.99 (0.78–1.25)	1.12 (0.83–1.50)	0.87 (0.65–1.16)
≥30.0	0.79 (0.60–1.03)	1.14 (0.82–1.59)	0.47 (0.32–0.67)
Bottom quartile of physical activity (Physical Activity Scale for the Elderly score<55)	1.03 (0.81–1.31)	1.43 (1.07–1.90)	0.67 (0.48–0.92)
≥Three flights stairs in home	1.58 (1.17–2.13)	1.17 (0.80–1.72)	1.98 (1.38–2.83)
Use of alcohol (reference none)			
1–3 drinks/month	1.05 (0.80–1.38)	1.05 (0.75–1.46)	1.04 (0.72–1.51)
1–6 drinks/wk	1.16 (0.89–1.50)	0.89 (0.64–1.23)	1.53 (1.10–2.12)
≥7 drinks/wk	1.39 (1.01–1.91)	1.08 (0.73–1.61)	1.80 (1.21–2.67)
Physical disability			
Berg Balance Scale score (reference ≥51)			
48–50	1.33 (1.04–1.69)	1.56 (1.16–2.11)	1.18 (0.87–1.60)
<48	1.44 (1.10–1.89)	2.33 (1.70–3.19)	0.66 (0.45–0.98)
Unable to do chair-stand test unless using arms	1.34 (0.92–1.95)	1.85 (1.20–2.86)	0.68 (0.38–1.21)
Gait speed, m/s (reference >1.33 m/s)			
0.68–1.33	0.59 (0.41–0.87)	0.95 (0.57–1.57)	0.43 (0.28–0.67)
<0.68	0.69 (0.43–1.10)	1.48 (0.81–2.68)	0.27 (0.15–0.50)
Activities of daily living (reference no difficulty)			
Little to some difficulty	1.59 (1.21–2.10)	1.98 (1.43–2.74)	1.18 (0.82–1.69)
Much difficulty to inability	1.42 (0.97–2.06)	2.57 (1.69–3.90)	0.27 (0.13–0.56)
Short Physical Performance Battery score <10	1.15 (0.93–1.42)	1.69 (1.30–2.18)	0.68 (0.51–0.90)
Reduced activity due to illness	1.57 (1.27–1.95)	1.75 (1.34–2.28)	1.37 (1.03–1.82)
Poor vision (worse than 40/100)	0.80 (0.55–1.16)	0.79 (0.50–1.27)	0.86 (0.53–1.40)

Illness related			
Moderate to severe bodily pain	1.02 (0.83–1.26)	1.37 (1.07–1.77)	0.72 (0.54–0.94)
Number of comorbid conditions (per condition)	1.05 (0.99–1.13)	1.17 (1.08–1.27)	0.93 (0.85–1.02)
Fair to poor self-rated health	1.29 (0.97–1.71)	1.77 (1.28–2.46)	0.77 (0.52–1.15)
Peripheral neuropathy	1.32 (0.97–1.80)	1.51 (1.04–2.19)	1.17 (0.78–1.76)
Foot pain	1.34 (1.06–1.69)	1.56 (1.17–2.06)	1.08 (0.79–1.46)
Knee osteoarthritis	1.30 (1.03–1.62)	1.28 (0.97–1.70)	1.31 (0.98–1.76)
Depression	1.96 (1.37–2.80)	1.81 (1.17–2.82)	2.07 (1.32–3.26)
Medication use			
Number of medications (reference 0–4)			
5–8	0.77 (0.61–0.96)	0.90 (0.68–1.20)	0.66 (0.50–0.88)
≥9	1.14 (0.86–1.49)	1.86 (1.34–2.57)	0.60 (0.41–0.87)
Uses psychotropic medication	1.36 (1.07–1.74)	1.53 (1.14–2.06)	1.19 (0.86–1.64)
Impaired cognition (Mini-Mental State Examination score 18–24)	1.02 (0.74–1.39)	1.24 (0.85–1.81)	0.77 (0.50–1.18)
Fall-related			
Number of falls in past year (per fall)	1.30 (1.21–1.39)	1.31 (1.21–1.42)	1.23 (1.13–1.34)
Falls Efficacy Scale score<90	1.33 (0.99–1.77)	1.73 (1.23–2.43)	0.83 (0.55–1.25)

Rate ratios were estimated using negative binomial regression models. The rate ratio is the average number of falls per person per year of follow-up in one group (e.g., white race) divided by the average number of falls per person per year of follow-up in a referent group (e.g., nonwhite race). The reference group is specific for each potential risk factor.

Table 1. Baseline Characteristics of People Who Fell Indoors Only, Outdoors Only, Outdoors and Indoors, and Not at All During the First 2 Years of Follow-Up

Characteristic	Fell Indoors Only	Fell Outdoors Only (n=129)	*P*-Value for Indoor Only	Fell Indoor and Outdoors	Did Not Fall

	(n=135)		Versus Outdoor Only†	(n=113)	(n=318)
Demographic					
Age, mean ± SD	79.9 ± 5.5	77.7 ± 4.9	.002	77.9 ± 6.1	77.5 ± 5.2
Male, n (%)	31 (23.0)	59 (45.7)	<.001	41 (36.3)	114 (35.8)
Education, n (%)			.03		
≤High school graduate	47 (34.8)	33 (25.6)		31 (27.4)	129 (40.7)
Some college or college graduate	54 (40.0)	44 (34.1)		34 (30.1)	113 (35.6)
>Graduate studies	34 (25.2)	52 (40.3)		48 (42.5)	75 (23.7)
White, n (%)	106 (78.5)	111 (86.7)	.08	95 (84.1)	226 (71.1)
Lifestyle, n (%)					
Body mass index, kg/m^2					
<25.0	33 (25.2)	38 (30.2)	.001	46 (40.7)	95 (30.4)
25.0–29.9	46 (35.1)	65 (51.6)		45 (39.8)	127 (40.7)
≥30.0	52 (39.7)	23 (18.2)		22 (19.5)	90 (28.9)
Bottom quartile of physical activity, Physical Activity Scale for the Elderly score<55	37 (28.0)	22 (17.0)	.03	31 (27.9)	71 (22.3)
≥Three flights stairs in home	12 (8.9)	19 (14.7)	.14	21 (18.6)	26 (8.2)
Use of alcohol, drinks			.10		
None	60 (44.4)	40 (31.0)		43 (38.1)	133 (41.8)
1–3 drinks/month	28 (20.7)	26 (20.2)		24 (21.2)	73 (23.0)
1–6 drinks/wk	33 (24.4)	44 (34.1)		30 (26.6)	73 (23.0)
≥7 drinks/wk	14 (10.4)	19 (14.7)		16 (14.2)	39 (12.3)
Physical disability					
Berg Balance Scale score, n (%)			<.001		
≥51	48 (35.6)	83 (64.3)		56 (49.6)	190 (59.8)
48–51	34 (25.2)	29 (22.5)		34 (30.1)	71 (22.3)
<48	53 (39.3)	17 (13.2)		23 (20.3)	57 (17.9)
Unable to do chair-stand test without using arms, n (%)	22 (16.3)	6 (4.6)	.002	5 (4.4)	17 (5.3)
Gait speed, m/s, n (%)			.005		
>1.33	7 (5.2)	11 (8.5)		12 (10.6)	17 (5.3)

0.68–1.33	97 (71.8)	107 (83.0)		89 (78.8)	267 (84.0)
<0.68	31 (23.0)	11 (8.5)		12 (10.6)	34 (10.7)
Activities of daily living, n (%)			<.001		
No difficulty	83 (61.5)	109 (84.5)		83 (73.5)	267 (84.0)
A little or some difficulty	26 (19.3)	17 (13.2)		25 (22.1)	36 (11.3)
Much difficulty or inability	26 (19.3)	3 (2.3)		5 (4.4)	15 (4.7)
Short Physical Performance Battery score <10, n (%)	80 (59.3)	38 (29.5)	<.001	45 (39.8)	116 (36.5)
Reduced activity because of illness, n (%)	47 (34.8)	39 (30.2)	.43	45 (39.8)	60 (18.9)
Poor vision (worse than 40/100), n (%)	11 (8.2)	8 (6.2)	.54	7 (6.2)	31 (9.7)
Illness-related					
Moderate to severe bodily pain, n (%)	78 (57.8)	38 (29.7)	<.001	46 (40.7)	106 (33.4)
Number of comorbid conditions, mean ± SD	3.2 ± 1.4	2.7 ± 1.5	.002	3.0 ± 1.4	2.8 ± 1.4
Fair to poor self-rated health, n (%)	28 (20.7)	14 (10.8)	.03	16 (14.2)	36 (11.3)
Peripheral neuropathy, n (%)	19 (14.3)	16 (12.4)	.65	16 (14.3)	24 (7.6)
Foot pain, n (%)	47 (34.8)	30 (23.3)	.04	31 (27.4)	51 (16.0)
Knee osteoarthritis, n (%)	40 (29.6)	31 (24.0)	.31	32 (28.3)	73 (23.0)
Depression, n (%)	17 (12.6)	10 (7.8)	.19	14 (12.4)	8 (2.5)
Medication use, n (%)					
Number of medications			.10		
0–4	37 (27.4)	45 (34.9)		44 (38.9)	112 (35.2)
5–8	57 (42.2)	59 (45.7)		49 (43.4)	158 (49.7)
≥9	41 (30.4)	25 (19.4)		20 (17.7)	48 (15.1)
‡ Uses psychotropic medication	39 (28.9)	26 (20.2)	.10	27 (24.1)	49 (15.6)
Impaired cognition (Mini-Mental State Examination score 18–24), n (%)	19 (14.1)	10 (7.8)	.10	10 (8.8)	41 (12.9)
Fall related					
Number of falls in year before baseline, mean ± SD	1.1 ± 1.7	0.9 ± 2.4	.08	1.7 ± 5.0	0.3 ± 0.8

Falls Efficacy Scale score<90, n (%)	34 (25.2)	14 (10.9)	.003	15 (13.4)	30 (9.5)
Follow-up time, months, mean ± SD	20.3 ± 4.2	21.1 ± 4.0	.10	21.5 ± 3.6	20.0 ± 4.3

Participants with at least 1 year of follow-up are included. All variables had a sample size of 95–100% of full N shown.
†Wilcoxon rank-sum test was used for age, number of comorbid conditions, falls before baseline and follow-up time; chi-square was used for all other variables.
‡Includes antidepressants, benzodiazepines, antipsychotics, and other sedatives.
SD=standard deviation.

When indoor falls were considered separately, rate ratios greater than 1.50 were seen for a high level of education, most indicators of physical disability and illness, medication use, and low FES score. There were fairly strong associations with number of comorbid conditions and number of falls in the year before baseline. Rate ratios were also computed for indoor falls that occurred specifically in a participant's own home. These results (not shown) were similar to those for all indoor falls, except that several of the rate ratios were slightly higher than for all indoor falls.

When outdoor falls were considered, a different outcome emerged. Rate ratios greater than 1.50 were seen for white race, high educational level, having three or more flights of stairs in the home, high or moderately high alcohol consumption, and being depressed. Rate ratios of 0.67 or less were found for high body mass index, physical inactivity, poor balance score, slow or moderate gait speed, much difficulty with or inability to perform ADLs, and taking five or more medications. Each additional fall during the year before baseline was associated with a higher rate ratio.

Approximately 9.5% of all falls were classified as resulting in serious injury, including 10.2% of indoor falls and 9.0% of outdoor falls (*P*=.46). Because the numbers of serious fall injuries were much smaller than numbers of all falls, confidence intervals were much wider and conclusions therefore less certain, although the same overall picture emerged of physical disability, illness, medication use, and low FES score being predictors of higher rates of serious injurious indoor falls and, with a few exceptions, predictors of lower rates of serious injurious outdoor falls (data not shown). When all injurious falls were considered, the same trends were seen.

Discussion

Older people at high risk for indoor falls were different from older people at high risk for outdoor falls. Indoor falls were associated with disability, indicators of poor health, and an inactive lifestyle. Outdoor falls were associated with an active lifestyle and average or better-than-average health. Only a few attributes, including history of falls in the past year, depression, and high educational level, were associated with both indoor and outdoor falls.

These findings of numerous differences between risk factors for indoor and outdoor falls are consistent with the few other studies that have examined this question.[6–11] Most of these studies considered only a small number of risk factors. In the current study, a large number of potential risk factors were examined, and falls were ascertained using fall calendars, providing more-definitive evidence that risk factors for indoor and outdoor falls are different in many ways.

There are at least four important implications of these results. First, a fall is not necessarily a marker of existing or impending poor health. Almost half of all falls in this study occurred outdoors, and people who fell outdoors tended to have the same as or better health than those who did not fall at all. A previous study[10] reported an approximately 70% higher 8-year mortality rate after indoor falls compared to those who did not fall but no greater mortality after outdoor falls. Another study[11] found that indoor falls were predictive of future mobility limitation in Finnish women, whereas outdoor falls were not. Second, epidemiological studies aimed at identifying risk factors for falls in older

people will be hampered when all falls are combined. Associations between risk factors and either indoor or outdoor falls may be missed or the magnitudes of associations considerably diluted. Third, study populations consisting of people who stay indoors most of the time will have different associations between risk factors and falls than will study populations with people who spend more time outdoors. Fourth, intervention programs to prevent falls need to be targeted and evaluated differently for people likely to fall indoors and outdoors.

Most fall prevention programs have emphasized prevention of indoor falls, particularly through strength, balance, and gait training; use of assistive devices; treatment of medical conditions; reduction in use of certain medications; improvement in vision; and elimination of home hazards.[2,3]] Recent systematic reviews of fall interventions have grouped interventions into those in community-dwelling persons and those in institutions.[29,30] The findings of the current study suggest that, in addition, interventions in community-dwelling individuals should take into account the health status, activity level, and other characteristics of those for whom the interventions are planned. Healthy, active older people should be cautious, especially when walking outdoors.[9] More attention needs to be paid to the elimination of outdoor environmental hazards involving sidewalks, curbs, and streets, such as by repairing uneven surfaces, removing debris, installing ramps at intersections, and painting curbs.[8–10]

Strengths of this study include its longitudinal design, its sampling from the general population, its relatively large sample size, its careful measurement of many risk factors for falls, and detailed documentation of where falls occurred. Nevertheless, although most older people spend only a small amount of time outdoors,[5] individual participants in this study were not asked how much time they spent indoors and outdoors. Future studies should find out how much time each participant spends indoors and outdoors so that rates for indoor and outdoor falls can take time at risk into account. Some of the data, including the occurrence of falls, is based on self-report, and undoubtedly some inaccuracy is present. For instance, it is possible that the higher fall rates in better-educated participants are partly the result of better reporting. Results of other studies suggest that these findings are generalizable to a variety of geographic areas, but this study was conducted in only one area (Boston, MA). Finally, it will be important to examine risk factors for falls resulting in serious injury when larger numbers of these events have occurred, as well as in other studies.

In conclusion, indoor and outdoor falls are both important, but people at high risk for indoor falls are different in many ways from those at high risk for outdoor falls. Failure to separate indoor and outdoor falls can mask important information on risk factors. Prevention programs and studies of risk factors in noninstitutionalized older people are likely to be more effective if they are targeted differently for frail, inactive older people who are at high risk for indoor falls and for active, relatively healthy older people who are at high risk for outdoor falls.

References

1. CDC. Self-reported falls and fall-related injuries among persons ages > = 65 years - United States, 2006. MMWR Morb Mortal Wkly Rep 2008;57:225–229.
2. AGS. Guideline for the prevention of falls in older persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. J Am Geriatr Soc 2001;49:664–672.
3. Close JC, Lord SL, Menz HB et al. What is the role of falls? Best Pract Res Clin Rheumatol 2005;19:913–935.
4. Chang JT, Morton SC, Rubenstein LZ et al. Interventions for the prevention of falls in older adults: Systematic review and meta-analysis of randomized clinical trials. BMJ 2004;328:680.
5. Robinson JP, Silvers A. Measuring potential exposure to environmental pollutants: Time spent with soil and time spent outdoors. J Expo Anal Environ Epidemiol 2000;10:341–354.
6. Bergland A, Jarnlo GB, Laake K. Predictors of falls in the elderly by location. Aging Clin Exp Res 2003;15:43–50.
7. Bergland A, Pettersen AM, Laake K. Falls reported among elderly Norwegians living at home. Physiother Res Int 1998;3:164–174.
8. O'Loughlin JL, Boivin JF, Robitaille Y et al. Falls among the elderly: Distinguishing indoor and outdoor risk factors in Canada. J Epidemiol Commun Health 1994;48:488–489.
9. Li W, Keegan TH, Sternfeld B et al. Outdoor falls among middle-aged and older adults: A neglected public

health problem. Am J Public Health 2006;96:1192–1200.
10. Bath PA, Morgan K. Differential risk factor profiles for indoor and outdoor falls in older people living at home in Nottingham, UK. Eur J Epidemiol 1999;15:65–73.
11. Manty M, Heinonen A, Viljanen A et al. Outdoor and indoor falls as predictors of mobility limitation in older women. Age Ageing 2009;38:757–761.
12. Samelson EJ, Kelsey JL, Kiel DP et al. Issues in conducting epidemiologic research among elders: Lessons from the MOBILIZE Boston Study. Am J Epidemiol 2008;168:1444–1451.
13. Leveille SG, Kiel DP, Jones RN et al. The MOBILIZE Boston Study: Design and methods of a prospective cohort study of novel risk factors for falls in an older population. BMC Geriatr 2008;8:16.
14. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189–198.
15. Washburn RA, Smith KW, Jette AM et al. The Physical Activity Scale for the Elderly (PASE): Development and evaluation. J Clin Epidemiol 1993;46:153–162.
16. Berg KO, Wood-Dauphinee SL, Williams JI et al. Measuring balance in the elderly: Validation of an instrument. Can J Public Health 1992;83(Suppl 2):S7–S11.
17. Guralnik JM, Ferrucci L, Simonsick EM et al. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. N Engl J Med 1995;332:556–561.
18. Guralnik JM, Ferrucci L, Pieper CF et al. Lower extremity function and subsequent disability: Consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci 2000;55A:M221–M231.
19. Lawton MP, Brody EM. Assessment of older people: Self-maintaining and instrumental activities of daily living. Gerontologist 1969;9:179–186.
20. Katz S, Ford AB, Moskowitz AW et al. The Index of ADL: A standardized measure of biological and psychosocial function. JAMA 1963;185:914–919.
21. Stewart AL, Hays RD, Ware JE Jr. The MOS short-form general health survey. Reliability and validity in a patient population. Med Care 1988;26:724–735.
22. Sangha O, Stucki G, Liang MH et al. The Self-Administered Comorbidity Questionnaire: A new method to assess comorbidity for clinical and health services research. Arthritis Rheum 2003;49:156–163.
23. Perkins BA, Olaleye D, Zinman B et al. Simple screening tests for peripheral neuropathy in the diabetes clinic. Diabetes Care 2001;24:250–256.
24. Altman R, Asch E, Bloch D et al. Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Diagnostic and Therapeutic Criteria Committee of the American Rheumatism Association. Arthritis Rheum 1986;29:1039–1049.
25. Radloff L. The CES-D scale: A self-report depression scale for research in general population. Appl Psychol Measure 1977;1:385–401.
26. Eaton WW, Muntaner C, Smith C et al. Center for Epidemiologic Studies Depression Scale: Review and Revision (CESD and CESD-R). Mahway, NJ: Lawrence Erlbaum Assoc Inc., 2004.
27. Pahor M, Chrischilles EA, Guralnik JM et al. Drug data coding and analysis in epidemiologic studies. Eur J Epidemiol 1994;10:405–411.
28. Tinetti ME, Richman D, Powell L. Falls efficacy as a measure of fear of falling. J Gerontol 1990;45:239–243.
29. Gillespie LD, Robertson MC, Gillespie WJ et al. Interventions for preventing falls in older people living in the community. Cochrane Database Syst Rev 2009:CD007146.
30. Coussement J, De Paepe L, Schwendimann R et al. Interventions for preventing falls in acute- and chronic-care hospitals: A systematic review and metaanalysis. J Am Geriatr Soc 2008;56:29–36.

Acknowledgments
The authors acknowledge the MOBILIZE Boston research team and study participants for the contribution of their time, effort, and dedication.

Conflict of Interest
The authors have no conflicts of interest to report. Dr. Hannan had full access to all of the data in the study and takes responsibility for the

integrity of the data and the accuracy of the data analysis.

The study was funded by Grant AG026316 from the National Institutes of Health (NIH), and the research was supported in part by Grants 3R01AG026316-03S1, AG028738, R37-AG25037, and AG004390 from the National Institute on Aging, NIH.

Author Contributions
JLK helped conceive and design the study and led the data analyses and the preparation of the manuscript. SDB and MTH helped conceive and design the study and contributed to the analyses and preparation of the manuscript. EP-G contributed to the data preparation and analyses and preparation of the manuscript. LQ and UN contributed to statistical analyses and preparation of the manuscript. WL led the statistical analytic work and contributed to the preparation of the manuscript. DPK contributed to the operation of the study and study data collection and contributed to the preparation of the manuscript. LAL contributed to analytic interpretations and contributed to the preparation of the manuscript preparation. All authors read and approved the final manuscript.

Sponsor's Role
The NIH played no role in the design or conduct of the study; the collection, management, analysis, or interpretation of the data; or the preparation, review, or approval of the manuscript.

J Am Geriatr Soc. 2010;58(11):2135-2141.