Outdoor Falls Among Middle-Aged and Older Adults: A Neglected Public Health Problem

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Objectives. Although risk factors for indoor falls among older individuals have been well studied, little is known about the etiology of outdoor falls. We examined risk factors for outdoor falls among middle-aged and older adults.

Methods. We analyzed data on the most recent fall during the past year among participants aged 45 years and older in the control group (N=2193) of a case–control study of fractures. The study was conducted at 5 Northern California Kaiser Permanente Medical Centers between 1996 and 2001.

Results. Falls occurred outdoors more often than indoors among most age groups. Study participants who reported more leisure-time physical activity had a higher risk for outdoor falls, and participants who were in poorer health had a greater risk for indoor falls. Most outdoor falls (73%) were precipitated by environmental factors, such as uneven surfaces and tripping or slipping on objects, and usually occurred on sidewalks, curbs, and streets. Walking (47.3%) was the most common fall-related activity.

Conclusions. Outdoor falls among adults aged 45 years and older were frequently attributable to modifiable environmental factors. With the widespread promotion of active lifestyles among older people, improvements in their outdoor environment are urgently needed. (*Am J Public Health.* 2006;96:1192–1200. doi:10.2105/AJPH.2005.083055)

Falls are the leading cause of injury-related deaths and hospital admissions among older adults. Each year, more than one third of the elderly persons in the United States fall,[1–3] and 10% of these falls result in injuries that require medical attention.[3–6] Fall-related injuries in the United States cost more than $20 billion each year, and by 2020, the total annual cost of these injuries is expected to reach $32.4 billion.[7]

Many studies have identified home hazards and personal risk factors for falls.[8–13] Northridge et al.[8] showed the importance of home hazards in falls among active versus inactive elderly persons, and they noted that measures are needed to prevent falls among the active elderly. To date, little research or public attention has been focused on outdoor falls; however, outdoor falls occur at least as often as indoor falls among older adults.[14–17] Indoor falls tend to occur among frail individuals,[15–17] but outdoor falls tend to occur among more active people and are heavily influenced by characteristics of the outdoor environment.[15–17]

In an era when active living is promoted by numerous international and national health agencies,[18–20] a better understanding of how the outdoor environment influences the risk for falls is important. Although increased physical activity is associated with decreased risk for chronic conditions such as obesity and cardiovascular disease, and although some national reports and guidelines suggest that physical activity may reduce an older person's risk for falling,[21,22] little empirical evidence exists about the association between physical activity, particularly outdoor activity, and the occurrence of falls.

Detailed data on falls and the people who experience them from the control group of a case–control study of fractures in Northern California provided an opportunity for examining this issue. We investigated the circumstances of outdoor falls, identified environmental and personal risk factors for outdoor falls, compared the frequency of self-reported outdoor and indoor falls among older adults, and examined differences in the characteristics of outdoor and indoor falls and the people who experienced them.

METHODS

Study Population

The study population for our analyses was the control group of a large community-based case–control study that identified risk factors for fractures of the distal forearm, foot, proximal humerus, pelvis, and shaft of the tibia/fibula among older persons. Details about the study design and the study population have been published elsewhere.[23–26] Briefly, the control group was selected between October 1996 and May 2001 from 5 Northern California Kaiser Permanente Medical Centers (Hayward, Oakland, San Francisco, Santa Clara, and South San Francisco) with a stratified random sampling scheme. Every 3 months, people who were enrolled at the 5 Kaiser centers were stratified by gender and age group (45–49 years, 50–54 years, 55–59 years, 60–64 years, 65–69 years, 70–74 years, 75–79 years, 80–84 years, and ≥85 years) and were randomly ordered within each gender/age group; the first 34 women and 7 men within each group were then selected. All who belonged to a minority group or were of unknown race/ethnicity, 39% of White women, and 78% of White men within each age group were randomly chosen. Sixty-five percent of those persons selected for the control group participated; study participants who required proxy respondents because they were unable to answer the questionnaire themselves (n=74) were excluded from our analyses. Persons in the control group who had a recent fracture or a previous fracture since age 45 years were included in our analyses.

Falls and Potential Risk Factors for Falls

Data about falls and possible risk factors for falls and fractures were obtained with a standardized structured questionnaire that was administered in either English or Spanish by trained interviewers. During the first 3 years of the study, most of the interviews were face-to-face; after November 15, 2000,

TABLE 1—Percentages of Self-Reported Outdoor Falls With Selected Characteristics by Gender and Age Group

Characteristic	Total (N = 297)	Men			Women		
		Middle-Aged (45–64 y) (n = 52)	Older (≥65) (n = 31)	Total (n = 83)	Middle-Aged (45–64 y) (n = 133)	Older (≥65) (n = 81)	Total (n = 214)
Place							
Sidewalk, curb, street	34.0	32.7	25.8	30.1	35.3	35.8	35.5
Garden, patio, porch, deck	23.6	5.8	48.4	21.7	20.3	30.8	24.3
Outdoor park, recreation area	14.5	23.1	6.5	16.9	17.3	7.4	13.6
Parking garage, parking lots	10.5	25.0	3.2	16.8	4.5	13.6	8.0
Outdoor stairs	8.8	1.9	3.2	2.4	14.3	6.2	11.2
Other outdoor place	8.8	11.5	12.9	12.0	8.3	6.2	7.5
Activity during fall							
Walking	47.3	30.8	48.4	37.4	54.9	45.0	51.2
Vigorous activity[a]	15.2	38.5	3.2	25.3	12.8	8.8	11.3
Walking up or down stairs	16.9	13.5	9.7	12.1	18.8	18.8	18.8
Other outside activity[b]	20.6	17.3	38.7	25.3	13.5	27.5	17.8
Environmental cause							
Uneven surface	47.6	36.0	45.2	39.5	56.2	42.0	50.7
Wet surface	21.0	13.7	30.0	19.8	27.5	12.3	21.7
Tripped on something	33.5	27.5	35.7	30.4	32.1	38.9	34.6
Slipped on something	20.2	19.6	9.7	15.9	28.7	13.6	22.9
Any of the above	73.4	61.5	74.2	66.3	78.9	71.6	76.2
Other							
On hard surface	71.3	70.6	58.1	65.9	72.2	75.3	73.4
From standing height or higher	95.2	96.0	100.0	97.5	95.4	92.5	94.3
Forward	46.8	36.3	48.4	41.5	46.6	52.6	48.8
Sideways	23.6	31.4	25.8	29.3	18.8	25.6	21.3
Backward	15.0	19.6	12.9	17.1	18.1	7.7	14.2
Straight down	12.0	5.9	9.7	7.3	13.5	14.1	13.7

[a]Vigorous activities include jogging, running, bicycling, dancing, and other activities.
[b]Other activities include turning around (n = 9), reaching up or down (n = 11), getting into or out of a chair (n = 1), sitting or lying down (n = 2), bending over (n = 4), getting into or out of a motor vehicle (n = 3), gardening or house repair (n = 4), climbing up or down a ladder or a stool or getting over a large object (n = 3), and other (n = 10).

most interviews were conducted by telephone to increase the response rate and the sample size. Mode of interview was controlled for in the multivariate analyses.

During the interview, all participants were asked how many times they had fallen during the past year. Those who had fallen at least once were asked for details about their most recent fall, including the place, circumstances, activity in which they were engaged, height from which they fell, direction in which they fell, type of surface on which they landed, whether they were wearing visual or hearing aids, and whether they took any medication or consumed alcohol before the fall.

Each respondent was classified as a nonfaller (did not fall during the past year), an indoor faller (most recent fall was indoors), or an outdoor faller (most recent fall was outdoors). An outdoor fall was defined as occurring outside a building or in a parking garage, and an indoor fall was defined as occurring inside any building other than a parking garage.

Potential risk factors for falls included demographic characteristics; weight and height, which were used to calculate body mass index (BMI); overall health status compared with others of similar age; history of practitioner-diagnosed medical conditions; self-reported foot problems; history of certain neuromuscular symptoms during the past year; history of using selected medications at least once a week for at least 1 year; recent use of medications for sleeping, calming nerves, or lifting mood; cigarette smoking; and alcohol consumption. To measure physical functioning, respondents were asked to report level of difficulty performing various tasks. Ability to perform activities of daily living during the past month was assessed with an approach similar to that used by Schwartz et al.[27]

Leisure-time physical activity was assessed with a modified Physical Activity History questionnaire,[28] which included questions about past-year frequency and duration of walking/hiking, gardening, exercise classes, swimming, bicycling, tennis, calisthenics/weight training, social dancing, jogging, bowling, golfing, stretching exercises/yoga, tai chi, and heavy housework. Each activity was assigned an appropriate metabolic equivalent value,[29] and a summary variable for total physical activity in metabolic equivalent hours of exercise per month was obtained by multiplying intensity by frequency by duration and then summing across all activities.

Approximately 10% of participants (n = 198) agreed to a slightly abbreviated interview that did not include questions about some or all of the following variables: physical activity, cigarette smoking, and part of the medication history. Because of the reduction in number of respondents for these variables, analyses that included those variables were based on slightly smaller numbers than analyses that did not include them.

Statistical Analysis

Data were analyzed with Stata SE 9.0 software (Stata Corp, College Station, TX). Frequency and characteristics of falls were stratified by age and gender into the following categories: men aged 45 to 64 years (middle-aged men), men aged 65 years and older (older men), women aged 45 to 64 years (middle-aged women), and women aged 65 years and older (older women). Associations of indoor and outdoor falls with potential risk factors were assessed using unconditional multinomial logistic regression; nonfallers were the referent category, and indoor fallers and outdoor fallers were treated as mutually exclusive categories. For both types of falls, the same

TABLE 2—Percentages of Outdoor Fallers, Indoor Fallers, and Non-Fallers, by Selected Characteristics

Characteristic	Total (N = 2193)	Outdoor Fallers (n = 297)	Indoor Fallers (n = 215)	Non-Fallers (n = 1681)	Group Comparison (P^a)		
					Outdoor vs Indoor Fallers	Outdoor Fallers vs Non-Fallers	Indoor Fallers vs Non-Fallers
Metabolic equivalent hours per month of leisure-time physical activity in past year[b]					<.01	<.01	.57
1st quintile (0–12)	404	10.9	22.0	21.8			
2nd quintile (13–52)	397	12.6	22.5	20.9			
3rd quintile (53–98)	405	22.5	18.0	20.2			
4th quintile (99–184)	391	27.0	15.5	18.7			
5th quintile (≥185)	398	27.0	22.0	18.3			
Demographic characteristics							
Gender					.04	.01	.75
Women	1715	72.1	80.0	79.1			
Men	478	27.9	20.0	20.9			
Age, y					.05	.01	.63
45–64	1170	62.3	53.5	51.8			
≥65	1023	37.7	46.5	48.2			
Race/ethnicity					<.01	<.01	<.01
White, non-Hispanic	1101	63.6	55.8	47.1			
Black	391	11.8	22.8	18.3			
Hispanic	212	11.1	6.5	9.8			
Asian	447	12.1	14.0	22.7			
Other	42	1.4	0.9	2.1			
Education					<.05	<.01	.09
< High school	140	3.7	5.1	7.0			
High school	738	28.8	28.8	35.2			
College	951	43.1	51.2	42.4			
Postgraduate	364	24.6	14.9	15.4			
Health-related characteristics							
Number of self-reported practitioner-diagnosed diseases[c]					<.01	.20	<.01
None	777	40.4	21.9	36.3			
1	641	23.9	30.7	30.0			
2	406	19.5	18.6	18.3			
3 or more	369	16.2	28.8	15.4			
Number of daily living activities that require help or are unable to do[d]					<.01	.10	<.01
None	1634	79.1	63.7	75.1			
1	274	12.5	15.8	12.1			
2–3	164	6.1	10.7	7.3			
4 or more	121	2.4	9.8	5.5			

Continued

predictors were included in the models, making it possible for us to examine whether the risk factor profiles differed between those who fell outdoors and those who fell indoors. A risk factor was included in the model if it was statistically significant ($P<0.10$). Likelihood ratio tests evaluated the statistical significance of categorical risk factors. In all regression models, age in years, self-reported race/ethnicity (White, Native American, or other; Asian/Pacific Islander; Black; Hispanic), and mode of interview were included to account for possible confounding from these variables. The analysis was conducted with and without probability sampling weights. The impact of weighting was negligible; therefore, the unweighted results are presented.

RESULTS

The study population for our analyses comprised 2193 people: 78% of study participants were women, 47% were aged 65 years and older, 60% were college graduates, 50% were White, 18% were Black, 10% were Hispanic, 20% were Asian/Pacific Islander, and 2% were of other race/ethnicity. Five hundred twelve participants (23%) reported at least 1 fall during the previous year: 297 (58%) reported an outdoor fall as their most recent fall, and 215 (42%) reported an indoor fall. Outdoor falls accounted for 72% of the most recent falls among middle-aged men, 57% of the falls among older men, 58% of the falls among middle-aged women, and 51% of the falls among older women. Among men and women aged 80 years and older, outdoor falls accounted for 48% of their most recent falls.

Outdoor falls occurred most often on sidewalks, curbs, and streets (Table 1). Gardens, patios, yards, decks or porches, parks and recreational areas, parking garages and parking lots, and outdoor stairs also were frequently cited. Among all groups except middle-aged men, the highest percentage of outdoor falls occurred when participants were walking (Table 1). Among middle-aged men, an outdoor fall was most likely to have occurred while engaging in a vigorous activity. Study participants reported that approximately three quarters of outdoor falls were precipitated by 1 or more (not mutually exclusive) environmental causes, including an uneven surface,

TABLE 2—*Continued*

Number of physical difficulties[e]					<.01	.32	<.01
None	923	47.5	30.2	42.7			
1	472	20.9	15.8	22.4			
2 or 3	435	18.5	22.3	19.8			
4 or 5	257	11.1	17.2	11.1			
6 or more	106	2.0	14.4	4.1			
Number of foot problems[f]					.45	.16	<.01
0	461	18.2	15.4	22.3			
1–2	995	45.1	42.8	45.8			
≥3	737	36.7	41.9	32.0			
Number of lower extremity neuromuscular symptoms[g]					.02	<.01	<.01
0	1,162	42.8	33.0	57.4			
1	526	31.3	30.2	21.9			
2–3	505	25.9	36.7	20.8			
Number of previous falls during past year					.99	–	–
None	1947	54.9	54.9	100.0			
1	111	21.6	21.4	–			
2–3	82	14.2	14.9	–			
≥4	53	8.4	8.8	–			
Self-reported health status					.01	.06	<.01
Excellent	693	38.5	27.0	31.1			
Good	1126	47.3	48.4	52.6			
Fair/poor	369	14.2	14.6	16.4			
Other lifestyle characteristics and body build							
Cigarette smoking[b]					.55	<.01	.02
Never	1130	47.7	50.7	59.1			
Current/past	865	52.3	49.3	40.9			
Alcohol consumption during past year							
No	1739	72.0	76.7	80.9	.23	<.01	.15
Yes	454	28.0	23.3	19.1			
Body mass index at the time of the interview							
Underweight (<18.5)	38	1.4	2.8	1.6	.14	.38	<.01
Normal (18.5–25)	966	41.6	35.8	45.6			
Overweight (25.1–30)	757	36.8	34.0	34.1			
Obese (≥30)	432	20.3	27.4	18.7			

[a]Pearson χ^2 tests for the equivalence in proportions between outdoor fallers vs indoor fallers, outdoor fallers vs nonfallers, and indoor fallers vs nonfallers.
[b]N = 1995 for this variable, mainly because of the abbreviated interviews. Of these, 1510 did not fall, 200 fell indoors, and 285 fell outdoors.
[c]Diseases queried were diabetes, angina, heart attack or heart failure, stroke or blood clot in the brain, epilepsy, seizures, convulsions or fits, kidney disease, cataracts, glaucoma, Parkinson's disease, arthritis, depression, cancer, hyperthyroidism, and hypothyroidism.
[d]Activities of daily living include using the telephone, getting groceries, getting to places outside of walking distance, preparing meals, doing chores around the house, taking medications, and handling finances.
[e]Inability to do or have difficulty with heavy housework; walking up and down stairs; walking half a mile without help; pushing/pulling a large object; stooping, crouching, or kneeling; lifting or carrying 10 pounds; reaching or extending arms above shoulder; and writing or handling small objects.
[f]Includes 14 foot problems: flat feet, high arches, lateral deviation of big toe, hammer toe or claw-like toe, bunions on feet, corns on feet, calluses on feet, Plantars warts on feet, ingrown toenails, painful toenails, cold feet most of time, arthritis of the toe, arthritis of feet, and other.
[g]Includes 3 neuromuscular symptoms: numbness or weakness in feet or leg; limping; and pain, numbness, burning, or tingling in legs or feet when not walking.

a wet surface, and tripping and/or slipping on an object (Table 1). Among those who fell outdoors, more than 70% landed on a hard surface (concrete, asphalt, tile, marble, stone, or a wood floor), and almost half fell forward. Falls on sidewalks, curbs, or streets were often attributed to 1 or more environmental causes, particularly uneven surfaces and tripping on something.

Table 2 compares characteristics of outdoor and indoor fallers. Outdoor fallers were more likely to be men, younger, White, and more educated compared with both indoor fallers and nonfallers. On average, outdoor fallers had a higher level of leisure-time physical activity during the past year compared with indoor fallers and nonfallers. Additionally, outdoor fallers had better health and a higher level of physical functioning. Outdoor fallers were less likely to be obese and more likely to smoke cigarettes and drink alcohol than nonfallers. Outdoor falls were more likely to have been precipitated by environmental causes compared with indoor falls. Higher proportions of outdoor fallers landed on a hard surface and fell in a forward direction.

Table 3 shows adjusted odds ratios for several factors associated with falling outdoors or indoors compared with having not fallen. After adjusting for gender, age, race/ethnicity, education, and mode of interview, odds for outdoor falls—but not indoor falls—were strongly associated with more leisure-time physical activity. Cigarette smoking was associated with both outdoor and indoor falls, but the odds were lower and not statistically significant for indoor falls. Foot problems, lower-extremity neuromuscular symptoms, use of a walking aid, and alcohol consumption were associated with increased odds for both outdoor and indoor falls. Attributes associated with increased odds for an indoor fall—but only slightly or not at all associated with an outdoor fall—included various indicators of poor health, underweight (BMI<18.5) or obesity (BMI>30), and current use of sleep-inducing medications. Number of medications was somewhat associated with increased odds for both types of falls.

Table 4 shows multivariate adjusted odds ratios for falling both outdoors and indoors, with each variable adjusted for all other variables in the table. Differential risk factor profiles between those who fell outdoors and those who

TABLE 3—Adjusted Odds Ratios (95% Confidence Intervals [CI]) for Outdoor and Indoor Falls, by Selected Characteristics

Characteristic	Odds Ratio (95% CI)[a]		Indoor vs Outdoor Falls (*P*)
	Fell outdoors	Fell indoors	
Quintile of metabolic equivalent hours of leisure-time physical activity[a,b] per month during past year			<.01
1st quintile (0–12)	1.00	1.00	
2nd quintile (13–52)	1.04 (0.62, 1.73)	0.94 (0.60, 1.48)	
3rd quintile (53–98)	1.81 (1.13, 2.88)	0.79 (0.49, 1.27)	
4th quintile (99–184)	2.28 (1.44, 3.61)	0.72 (0.44, 1.19)	
5th quintile (≥185)	2.15 (1.36, 3.41)	1.01 (0.63, 1.61)	
Health-related characteristics[a]			
Number of self-reported practitioner-diagnosed diseases[c]			<.01
0	1.00	1.00	
1	0.82 (0.59, 1.14)	1.91 (1.28, 2.86)	
2	1.23 (0.85, 1.79)	2.13 (1.32, 3.42)	
3 or more	1.28 (0.85, 1.93)	4.16 (2.62, 6.60)	
Number of daily living activities that require help or are unable to do[d]			<.01
None	1.00	1.00	
1	1.26 (0.85, 1.87)	1.79 (1.17, 2.72)	
2–3	1.16 (0.67, 1.98)	2.30 (1.38, 3.85)	
≥4	0.67 (0.30, 1.51)	3.05 (1.73, 5.37)	
Number of physical difficulties[e]			<.01
0	1.00	1.00	
1	0.86 (0.61, 1.19)	1.03 (0.66, 1.59)	
2–3	1.03 (0.72, 1.46)	1.97 (1.30, 2.98)	
4–5	1.19 (0.77, 1.86)	2.89 (1.81, 4.62)	
≥6	0.68 (0.28, 1.64)	7.21 (4.14, 12.6)	
Number of foot problems[f]			.68
0	1.00	1.00	
1–2	1.17 (0.83, 1.66)	1.24 (0.82, 1.90)	
≥3	1.47 (1.02, 2.11)	1.79 (1.16, 2.76)	
Number of lower-extremity neuromuscular symptoms[g]			.04
0	1.00	1.00	
1	1.85 (1.37, 2.49)	2.30 (1.61, 3.30)	
2–3	1.76 (1.28, 2.42)	3.09 (2.18, 4.39)	
Number of medications[h]			.24
0	1.00	1.00	
1–5	1.50 (0.91, 2.46)	1.30 (0.70, 2.40)	
6–9	0.96 (0.67, 1.38)	1.52 (1.02, 2.28)	
≥10	1.34 (0.99, 1.82)	1.64 (1.14, 2.36)	

Continued

fell indoors remained evident. Higher level of leisure-time physical activity was still an independent predictor of outdoor but not indoor falls, whereas more health problems and more physical difficulties were independent predictors of indoor but not outdoor falls. Independent risk factors for both outdoor and indoor falls included lower-extremity neuromuscular symptoms, use of walking aids, cigarette smoking, and alcohol consumption during the past year.

DISCUSSION

We found that the frequency of outdoor falls was higher compared with indoor falls among middle-aged and older men and women in Northern California. This is consistent with findings from several other studies of middle-aged and older persons in Canada,[14] England,[16] Norway,[15,17] Finland,[30] Israel[31,32] and Japan,[33] suggesting that outdoor falls among older adults occur more frequently than indoor falls across geographic regions. The predominance of outdoor falls is particularly striking because of the small amount of time most middle-aged and older adults spend outdoors compared with time spent indoors. For instance, Robinson and Silvers[34] reported that in a random sample of middle-aged and older men in the United States, the average time spent outdoors was 78 minutes per day,[34] and in the far western part of the country, the average was less than 90 minutes per day.

We also found that the risk profile for outdoor falls differed from indoor falls. Higher leisure-time physical activity was associated with outdoor but not indoor falls, and a greater number of physical difficulties and indicators of poor health were associated with indoor but not outdoor falls. These findings are consistent with results from other studies.[14–17] As noted by Northridge et al.,[8] fall prevention programs should not overlook the active elderly population, whose risk factors for falls may differ from those of the frail elderly population.

Our study adds to the results of the few previous studies on outdoor falls by providing more information about specific outdoor hazards. Sidewalks, curbs, and streets were the most frequent site of outdoor falls. Simple yet effective preventive measures include cleaning sidewalks and streets frequently, installing ramps at intersections, painting/

TABLE 3—*Continued*

Use of medication to help with sleep			.27
No	1.00	1.00	
Yes	1.19 (0.92, 1.54)	1.46 (1.09, 1.96)	
Use of walking aids[i]			
None	1.00	1.00	
Any	1.70 (1.04, 2.78)	3.38 (2.17, 5.27)	.02
Self-reported health status			.01
Excellent	1.00	1.00	
Good	0.84 (0.64, 1.11)	1.18 (0.84, 1.66)	
Fair	0.82 (0.54, 1.25)	1.66 (1.06, 2.59)	
Poor	1.20 (0.54, 2.69)	4.25 (2.12, 8.49)	
Lifestyle factors and body build[b]			
Cigarette smoking[c]			.64
Never	1.00	1.00	
Current/past	1.37 (1.05, 1.79)	1.27 (0.93, 1.72)	
Alcohol consumption in past year			.17
No	1.00	1.00	
Yes	1.89 (1.42, 2.52)	1.43 (1.05, 1.95)	
Body mass index			0.29
Normal (18.5–25.0)	1.00	1.00	
Underweight (< 18.5)	1.16 (0.39, 3.43)	2.20 (0.87, 5.58)	
Overweight (25.1–30)	1.10 (0.82, 1.47)	1.22 (0.86, 1.73)	
Obese (> 30.0)	1.12 (0.78, 1.59)	1.71 (1.16, 2.52)	

[a]Adjusted by a multinomial logistic regression model for gender, age, Kaiser-reported race/ethnicity, college education, and mode of interview.
[b]N = 1995 for this variable, mainly because of the abbreviated interviews. Of these, 1510 did not fall, 285 fell outdoors, and 200 fell indoors.
[c]Diseases queried were diabetes, angina, heart attack or heart failure, stroke or blood clot in the brain, epilepsy, seizures, convulsions or fits, kidney disease, cataracts, glaucoma, Parkinson's disease, arthritis, depression, cancer, hyperthyroidism, and hypothyroidism.
[d]Activities of daily living include using the telephone, getting groceries, getting to places outside of walking distance, preparing meals, doing chores around the house, taking medications, and handling finances.
[e]Inability to do or have difficulty with heavy housework; walking up and down stairs; walking half a mile without help; pushing/pulling a large object; stooping, crouching, or kneeling; lifting or carrying 10 pounds; reaching or extending arms above shoulder; and writing or handling small objects.
[f]Includes 14 foot problems: flat feet, high arches, lateral deviation of big toe, hammer toe or claw-like toe, bunions on feet, corns on feet, calluses on feet, Plantars warts on feet, ingrown toenails, painful toenails, cold feet most of time, arthritis of the toe, arthritis of feet, and other.
[g]Includes 3 neuromuscular symptoms: numbness or weakness in feet or leg; limping; and pain, numbness, burning, or tingling in legs or feet when not walking.
[h]A history of use of selected medications (thiazide diuretics, water pills, Tums, other calcium supplements, multivitamins, melatonin, steroid pills, and seizure medications) at least once per week for at least 1 year.
[i]Includes cane, walker, wheelchair, artificial leg, and brace.

marking curbs, fixing cracks or removing bumps, providing better lighting, and timely removal of construction debris and snow. Public works departments can implement these measures, which should be given high priority in areas where there are high concentrations of older people. A sizable proportion of outdoor falls occurred in parking lots and garages, particularly from tripping over the short curbs often placed at the end of parking spaces (data not shown). Despite the limited time older adults spend in these facilities, the relatively high frequency of falls shows that these settings need to be built and maintained not only for the benefit of motor vehicle drivers but also for pedestrians. Lack of designated walkways in parking lots and garages also may contribute to the increased risk for falls.

As noted in other studies,[15,17,30] the highest proportion of outdoor falls occurred while walking. Walking is the most common type of reported physical activity across all racial/ethnic, income, and age groups[35–39]: 45% of older adults report walking for leisure-time physical activity,[38] and nearly 70% of physically active older adults report walking as their predominant choice of physical activity. Increased walking has been promoted by various health organizations as an important way of lowering risk for chronic diseases,[7] yet little has been done to make walking safe for older adults. Streets, roads, and sidewalks are most often used by older adults for leisure-time physical activity,[40,41] but our results suggest that walking on sidewalks or roads may be dangerous because of uneven surfaces, litter, and other hazards. Elevated risk for falls associated with increasing physical activity may in part offset the lowered risk for chronic diseases, because the consequences of falls may result in older adults becoming homebound or institutionalized. Furthermore, fear of falling can become a significant barrier to physical activity[42,43] and thus lead to decreased independence and mobility.[44] Activity-related risk for falls among older adults is therefore a timely public health concern and should be thoroughly evaluated, because relatively easy environmental modifications can substantially reduce the risk for falls. We recommend that future trials evaluate the effectiveness of such environmental improvements as a means of reducing the occurrence of falls and fractures.

In a 2005 comprehensive review of intervention trials for preventing falls among the elderly, Gillespie et al.[45] reported that none of the 62 intervention trials included modification to or maintenance of the outdoor environment as an intervention component. The only published study on modifications to the outdoor environment for preventing falls among older adults, including lighting in public spaces and the conditions of roads and walkways, was conducted in Motala, Sweden, 20 years ago.[46] The lack of studies on outdoor falls may be the result of a common perception that the elderly spend little time

TABLE 4—Multivariable-Adjusted Odds Ratios (95% Confidence Intervals [CI] for Indoor and Outdoor Fallers

Risk factors	Odds Ratio (95% CI)[a]		Indoor vs Outdoor Falls[b] (*P*)
	Fell outdoors	Fell indoors	
Quintile of metabolic equivalent hours of leisure-time physical activity per month during past year			.02
1st quintile (0–12)	1.00	1.00	
2nd quintile (13–52)	1.08 (0.64, 1.81)	1.18 (0.73, 1.91)	
3rd quintile (53–98)	1.88 (1.16, 3.04)	1.00 (0.60, 1.67)	
4th quintile (99–184)	2.43 (1.51, 3.92)	1.04 (0.61, 1.77)	
5th quintile (≥185)	2.33 (1.44, 3.78)	1.54 (0.92, 2.55)	
Health-related characteristics			
Number of self-reported practitioner-diagnosed diseases[c]			<.01
0	1.00	1.00	
1	0.76 (0.53, 1.08)	1.80 (1.18, 2.77)	
2	1.11 (0.74, 1.67)	1.49 (0.87, 2.54)	
≥3	1.00 (0.62, 1.61)	2.35 (1.38, 4.03)	
Number of physical difficulties[d]			.01
0	1.00	1.00	
1	0.79 (0.55, 1.13)	0.80 (0.50, 1.28)	
2–3	0.85 (0.57, 1.28)	1.31 (0.82, 2.08)	
4–5	1.11 (0.66, 1.89)	1.70 (0.97, 2.98)	
≥6	0.57 (0.20, 1.59)	4.23 (2.14, 8.38)	
Number of lower-extremity neuromuscular symptoms[e]			.85
0	1.00	1.00	
1	1.90 (1.37, 2.62)	1.96 (1.31, 2.91)	
2–3	1.74 (1.20, 2.53)	2.01 (1.32, 3.06)	
Use of walking aid [f]			.95
None	1.00	1.00	
Any	1.63 (0.94, 2.83)	1.60 (0.95, 2.69)	
Lifestyle factors			
Cigarette smoking			.29
Never	1.00	1.00	
Current/past	1.35 (1.03, 1.78)	1.10 (0.79, 1.51)	
Alcohol consumption during past year			.91
No	1.00	1.00	
Yes	1.65 (1.20, 2.26)	1.69 (1.18, 2.42)	

[a]Each odds ratio was adjusted by a multinomial logistic regression model for all other variables presented in this table and for gender, age, Kaiser-reported race/ethnicity, and college education. N = 1995, of whom 285 fell indoors, 200 fell indoors, and 1510 did not fall.
[b]Wald tests for equivalence of odds ratios between risk factors for outdoor and indoor falls.
[c]Diseases queried were diabetes, angina, heart attack or heart failure, stroke or blood clot in the brain, epilepsy, seizures, convulsions or fits, kidney disease, cataracts, glaucoma, Parkinson's disease, arthritis, depression, cancer, hyperthyroidism, and hypothyroidism.
[d]Activities of daily living include using the telephone, getting groceries, getting to places outside of walking distance, preparing meals, doing chores around the house, taking medications, and handling finances.
[e]Inability to do or have difficulty with heavy housework; walking up and down stairs; walking half a mile without help; pushing/pulling a large object; stooping, crouching, or kneeling; lifting or carrying 10 pounds; reaching or extending arms above shoulder; and writing or handling small objects.
[f]Includes 14 foot problems: flat feet, high arches, lateral deviation of big toe, hammer toe or claw-like toe, bunions on feet, corns on feet, calluses on feet, Plantars warts on feet, ingrown toenails, painful toenails, cold feet most of time, arthritis of the toe, arthritis of feet, and other.

outdoors, and therefore outdoor falls are less important than indoor falls. However, as documented in our study and several other reports,[14,16,17,33,47] outdoor falls are more common than indoor falls in almost all age groups, despite the limited amount of time most people spend outdoors.

Experts on fall-related research have long recognized the lack of studies on outdoor environmental hazards.[1,4,5,48,49] As they have noted, assessing environmental influences is problematic because of a lack of standardized methods for evaluating environmental hazards and because of the difficulty associating falls with specific environmental hazards that are dynamic over space and time. During the past 20 years, several techniques have been developed for studying the health impact of the built environment on falls. Such studies are possible because of the fast growth of spatial statistics, geographic information systems (GIS), and public databases. The knowledge accumulated in this research area should be applied to studies on falls among the elderly. For example, municipal GIS units and public works or transportation departments can develop spatial databases that monitor environmental changes, identify high-risk locales, and prioritize maintenance in neighborhoods where there are high concentrations of older people. Research into the impact of the built environment on falls requires multidisciplinary efforts and a joint framework that connects public health, behavioral research, health economics, transportation, and urban design. Several recent publications provide stepping-stones in this emerging field.[50–55]

Our study has strengths and limitations. The data came from a large probability sample that was drawn from a defined community-based population. Data about falls includes place, circumstance, direction, and activity at the time of fall. Many known and potential risk factors for falls and fractures were collected during the study, enabling us to control for many potentially confounding variables. On the other hand, the study was conducted in 1 geographic area, Northern California, where people may spend more time outdoors compared with other geographic areas. Although the sociodemographic characteristics of Kaiser patients were generally similar to those of the general population,

except for underrepresentation of the very rich and the very poor,[56] participants in our study tended to be well-educated and relatively active. People who were recovering from previous serious injuries were probably less likely to participate. The focus of the original study was on the etiology of fractures rather than falls and the study was conducted on the basis of self-reported data on falls and potential risk factors for falls. It is likely that the frequency of falls was underreported, because the data were obtained on the basis of past-year recall, and only the most recent fall was queried in detail. Previous studies have shown that past-year falls are likely to be underreported by 13% to 32%.[57] After we accounted for this extent of underreporting, the frequency of falls in our control group was consistent with other studies. However, there are no data to show whether recall error differs between outdoor and indoor falls. Some errors also may have occurred when reporting the circumstance of the fall. Our findings need to be replicated by other investigators.

Outdoor falls are an important but neglected public health problem. Many of the environmental risk factors associated with outdoor falls appear to be preventable through better design and maintenance of sidewalks, curbs, walkways, streets, outdoor parks and recreational places, and parking lots and garages. In this decade of worldwide promotion of Active Living and Active Aging,[19,58] efforts have begun at the national, state, municipal, and community levels to improve the built environment, including making neighborhoods more walkable. Preventing falls among older persons should be included in these efforts. ■

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Contributors

J.L. Kelsey originated the study, W. Li conducted the data analysis, and W. Li and J.L. Kelsey led the writing. J.L. Kelsey was the principal investigator of the study from which from these data were obtained. T.H.M. Keegan assisted with preparation of the analytic data set, data analysis, and writing the article. B. Sternfeld had primary responsibility for measuring physical activity on the questionnaire and assisted with writing the article. S. Sidney and C.P. Quesenberry assisted with the study design, and S. Sidney was the principal investigator of the Kaiser Permanente component of the study.

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