Mortality, Disability, and Falls in Older Persons: The Role of Underlying Disease and Disability

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ABSTRACT

Background. Falls are prevalent in older persons and can have serious consequences.

Methods. Data from the Longitudinal Study on Aging were analyzed to study the relationship between falls and both mortality and functional status in 4270 respondents age 70 and over. The effects of demographic traits, chronic conditions, and disability present at baseline were controlled for by means of multivariable analyses.

Results. Risk of death within 2 years was greater for both single fallers (crude odds ratio [OR], 1.5; 95% confidence interval [CI], 1.1–2.0) and multiple fallers (crude OR, 2.2; 95% CI, 1.7–2.8). This excess risk was dissipated when selected covariates were added to the model. No crude or adjusted association was evident between single falls and functional impairment; however, multiple falls were an independent risk factor (adjusted OR, 1.6; 95% CI, 1.2–2.0).

Conclusions. Multiple falls in older persons increase risk of functional impairment and may indicate underlying conditions that increase risk of death. (*Am J Public Health.* 1992;82:395–400)

Introduction

Falls are prevalent in older persons, and the incidence of falls increases with age. Twenty-eight percent to 33% of those aged 65 and older report having fallen over a 1-year period, and the rates approach 50% in those over 80.[1–3]

Falls can have serious consequences in older persons. People over the age of 65 have the highest mortality rate from injuries, and the largest single cause of injury mortality in this group is falls.[4] A study using the Major Trauma Outcome Study database found an 11.7% case fatality rate for falls in geriatric patients,[5] and recent data from the Dade County, Fla, community-based Study to Assess Falls Among the Elderly[6] found 2.2 deaths per 100 fall injury events that came to medical attention, not including deaths that occurred after discharge from the hospital. There is some indication that longer-term outcomes of falls may be even more serious than the short-term outcome statistics would indicate. A British study of 125 people aged 65 and older who fell in the home reported a 1-year mortality rate of 26%, compared with 6% in a control group, although none of the deaths in those who fell were reported as being from fall-related causes.[7] Nonfatal falls can also have severe consequences in the aged: the Dade County study[6] found that about half of the fall injury events occurring at home and requiring hospitalization resulted in discharge to a nursing home.

These findings raise several questions: Are falls in older persons related to increased mortality and disability? If so, to what extent are these adverse outcomes due directly to falls, rather than to factors associated with both falling and mortality or disability outcomes?

Several studies[1–3,8] show the relationship between falling and mobility disorders, diseases, sensory losses, medication use, and limitations in activities of daily living (ADLs). It has been argued that the elevated mortality associated with falling is caused by conditions that predispose toward falling, rather than from resulting trauma.[7] Also, it has been suggested that a person who may already have compromised gait and balance systems may fall when a new illness or condition, even one that seems minor or unrelated to falling per se, occurs.[9] Tinetti[10] showed that a fall risk score, derived from the number of chronic diseases present, predicted risk of falling in older persons better than did a mobility score alone. She concluded that falling "appears to result from the accumulated effect of multiple specific debilities."

Researchers have found that those who experience repeated falls differ in some respects from those who have single or occasional falls. Risk factors for single falls appear to be less robust than those for multiple falls.[8] One suggestion is that occasional falls result primarily from extrinsic factors, such as environmental haz-

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TABLE 1—Covariates Used in Logistic Regression Analyses

Demographic	Chronic Condition	Disability
Age (1984)	Osteoporosis/hip fracture	Difficulty in
Sex	Arthritis	Bathing
Marital status	Hypertension	Dressing
Education	Heart disease	Eating
	Stroke	Transferring
	Vascular disease	Walking
	Diabetes	Going out
	Cancer	Toileting
	Visual deficit	
	Hearing deficit	
	Thinness	

ards, while repeated falls are the result of intrinsic factors, such as demographic factors, chronic disease, and disability.[9]

We have used data from the Longitudinal Study on Aging (LSOA) to examine the relationship between falls, chronic disease, disability, and mortality; the LSOA population is a larger and more diverse sample population than has been examined in previous studies of falling. Specifically, we determined the following:

1. Crude 2-year mortality rates in those who had and those who had not fallen in the year prior to the baseline (1984) LSOA survey
2. The extent to which history of falling in the past year predicts subsequent mortality, when demographic factors, chronic conditions, and functional disabilities present at baseline are controlled for
3. The extent to which history of falling predicts decreased functional ability after 2 years, when demographic variables, chronic conditions, and disabilities present at baseline are controlled for.

Methods

The LSOA Population

For this analysis we used data from the 1986 longitudinal follow-up of persons 70 years of age and older from the Supplement on Aging to the 1984 National Health Interview Survey (NHIS) conducted by the National Center for Health Statistics. The purpose and design of this survey is described elsewhere.[11,12]

Of the persons selected for reinterview in 1986, 4270 met our criteria: they had had a follow-up interview or their vital status was known, and complete information was available for them on variables germane to this study.

Those who had died prior to follow-up and those who were missing pertinent follow-up information were deleted from disability outcome analyses; thus the sample size for this outcome was 3706.

The 1984 baseline interview included self-reported data on demographic variables, health conditions (including history of falls in the past year), and functional status; the 1986 follow-up reported vital status and functional status but did not obtain additional information about health conditions or falls.

Outcome Variables

Mortality. Mortality at follow-up was defined as death validated through a match with the National Death Index (NDI), or report of death for those for whom no NDI match was found. Five hundred twenty-five of the 4270 individuals used in this analysis had died during the 2-year follow-up period; cause of death was not available at the time of this analysis.

Disability. Functional disability at both baseline and follow-up was determined by reported difficulty with a modified selection of ADLs: bathing, dressing, eating, transferring from bed or chair, walking, going out, and toileting. Individuals were coded as having difficulty with an activity if they responded "yes" when asked if they had difficulty accomplishing that activity. Missing responses were deleted, as were those from individuals who reported that they did not perform the activity for reasons unrelated to health or physical ability. "Don't do" responses constituted less than 0.5% of responses for each individual ADL.

The dichotomous disability outcome variable was defined as having difficulty with a greater number of ADLs in 1986 than in 1984. Individuals having difficulty with fewer ADLs at follow-up (884, or 20.7%), as well as those whose functional ability had not changed, were defined as not having decreased functional ability.

Further multivariate analysis of the association of falls and subsequent disability was carried out with a categorical disability outcome variable: the number of ADLs reported at follow-up.

Exposure Variables

Respondents to the 1984 interview were asked if they had fallen in the past 12 months. If they answered "yes" they were asked if they had fallen once, or more than once; 401 individuals reported one fall and 405 reported more than one. Single and multiple fallers were compared separately to the reference group (those who had not fallen). In the multivariable analyses this comparison was accomplished with two dummy variables.

Covariates

Covariates used in the multivariable logistic regression models are listed in Table 1.

Because 14% of the baseline responses and 33% of the follow-up responses were completed by proxy respondents, and proxy status was significantly associated with multiple falls at baseline, a variable was included in each multivariable model to indicate proxy status of the respondent.

Other covariates were included in the models if they had been shown to be associated with falls in the LSOA population or in previous studies or (2) if they had been shown to be associated with mortality or disability in the LSOA population or in previous studies, and (3) if, in addition, the variable had sufficient responses for meaningful analysis.

Covariates were categorized as demographic, chronic condition, or disability variables. To examine the effect of specific covariates, we added all variables in a given category to the model as a block. Additionally, because our primary interest was to examine the effect of controlling for multiple chronic conditions and disabilities rather than to examine the effects of specific covariates upon the outcomes, we created two ordinal variables to represent the numbers of reported chronic conditions (0–11) and disabilities (0–7).

Demographic covariates were age in 1984, sex, marital status, and education (two dummy variables were used to describe "low" and "high" education, compared with the reference category of 9–12 years). Those missing data for education were assigned mean values (9.56 years for males, 9.99 for females). Education was included both as a surrogate for socioeconomic status (because 20% of the respondents had not answered the question about income) and because there appears to be an inverse relation between educational attainment and mortality in middle-aged and older Americans.[13]

Chronic condition variables included osteoporosis/hip fracture, arthritis, hypertension, heart disease (myocardial infarction, rheumatic heart disease, coronary heart disease, and "other heart attack"), stroke, diabetes, vascular disease, cancer, visual deficits, hearing deficits, and thinness (body mass index < 21 kg/m^2). Low body mass index was included because the body weight at which minimal mortality occurs increases with advancing age[14] and the curve of mortality risk versus declining body mass index rises steeply for body mass indexes of 21 and less in middle-aged and older females.[15]

Disability covariates consisted of reported difficulty with individual ADLs at baseline (1984), as described above.

Analytical Methods

Our analytic strategy was to determine risks for 2-year mortality and functional decline in those with and without a history of falling, and then to examine the same questions in multivariable models, controlling for demographic characteristics, preexisting health conditions, and disabilities that could be related to an individual's propensity to fall as well as to risk of death or future disability.

Statistical analyses were performed with the SAS package.[16] All univariate and multivariate analyses were weighted; the results are thus applicable to the US population age 70 and over.

Multiple logistic regressions were performed with the LOGIST procedure.[17] The RTILOGIT procedure[18] was used with mortality and dichotomous disability outcome models to generate variances incorporating the weighting system used to compensate for the complex sampling design of the survey. RTILOGIT could not be used in models with an ordinal outcome variable; however, because the weighted variances generated in the dichotomous outcome model were so close to those obtained with the LOGIST procedure (within .0001 in all cases), we used standard deviations generated from the LOGIST procedure to calculate confidence intervals for the ordinal outcome models. Before ordinal outcome regressions were run, the partial proportional odds model[19] was used to test for nonproportionality of increasing response (number of ADLs) with exposure (falls); because this was nonsignificant, proportionality, or a common odds ratio between any dichotomous division in the outcome variable scale, could be assumed.

All multivariable models included the block of demographic covariates and a variable indicating the proxy status of the respondent.

Results

Descriptive and Cross-sectional Statistics

Unweighted descriptive statistics for the LSOA subpopulation used in this analysis are shown in Table 2. The extent to which the covariates used in the multivariable analyses are associated with having fallen is shown in Table 3. Compared with those who had not fallen, those who had fallen once in the year prior to baseline interview were significantly more likely to be female, age 80 or over, thin (BMI < 21), and unmarried, and to report the presence of visual or hearing difficulties, osteoporosis/hip fracture, arthritis, vascular disease, and difficulty with each of the ADLs. Those who had fallen more than once had characteristics similar to those listed above, and in addition were more likely to have less than 9 years of formal education, to have had the baseline questionnaire completed by a proxy, and to report the presence of hypertension, heart disease, stroke, diabetes, and cancer.

Mortality Outcome

Of those who reported no falls in the year prior to their 1984 interview, 11.9% were deceased by 1986, compared with 18% of those reporting one fall and 25.4% of those reporting two or more falls. The corresponding crude odds ratios were 1.5 (95% confidence interval [CI], 1.1–2.0) for single falls and 2.2 (95% CI, 1.7–2.8) for multiple falls (Table 4).

In the multivariable analysis, the odds ratios for single and multiple falls decreased slightly in magnitude, to 1.4 and 2.0, respectively, but remained significant at $P < .05$ when demographic variables and proxy status were controlled for (Table 5). When the block of chronic conditions was added to the model, the mortality odds ratios decreased further. With disability at baseline added to the model with demographic and proxy variables, the odds ratio for death decreased even more, losing significance for single falls, and when chronic conditions and disabilities were added together, the mortality odds ratios for single and multiple falls converged at 1.3 (95% CIs, 0.9–1.7 and 0.9–1.8, respectively). Substituting number of chronic conditions or disabilities for the individual conditions had almost no effect on these results.

Significant covariates in the full model (containing demographics, proxy status, individual chronic conditions, and individual disabilities) were age, male sex, high education (protective), thinness, arthritis (protective), stroke, cancer, difficulty bathing, and difficulty toileting. In the model with number of chronic condi-

TABLE 2—Characteristics of the Study Population

	n	%
Age in 1984, y		
70–74	1497	35.1
75–79	1082	25.3
80–84	1040	24.4
85+	651	15.2
Sex		
Female	2715	63.6
Male	1555	36.4
Race		
White	3799	88.8
Non-White	471	11.2
Marital status		
Unmarried	2286	53.5
Married	1984	46.5
Education, y		
0–8	1733	40.6
9–12	1788	41.9
13+	749	17.5
Body mass index (kg/m^2)		
<21	843	19.7
21–29	2986	69.9
30+	441	10.3
Falls in year prior to 1984		
None	3289	77.0
One	473	11.1
Two or more	508	11.9
Chronic conditions in 1984		
None	338	7.9
1–2	1782	41.7
3–4	1604	37.6
5+	546	12.8
ADL difficulties in 1984		
None	3111	72.9
1–2	682	16.0
3–4	263	6.2
5+	214	5.0
ADL difficulties in 1986		
None	2226	60.1
1–2	828	22.3
3–4	325	8.8
5+	327	8.8
Vital status in 1986		
Alive	3745	87.7
Deceased	525	12.3
Change in number of ADL difficulties 1984–1986		
Decrease	884	20.7
No change	2251	52.7
Increase	1135	26.6

Note. ADLs = activities of daily living.

TABLE 3—Weighted Cross-sectional Associations of Demographic Variables, Chronic Conditions, and Activities of Daily Living with Falls

	OR, One Fall vs No Falls (95% CI) (n = 3762)	OR, Two or More Falls vs No Falls (95% CI) (n = 3797)
Demographics		
Age (80+ vs 70–79)	1.7 (1.4–2.1)	2.2 (1.8–2.6)
Sex (male vs female)	0.6 (0.5–0.8)	0.7 (0.6–0.9)
Marital status (Married vs unmarried)	0.6 (0.5–0.7)	0.6 (0.5–0.8)
Education		
(<9 vs ≥9 years)	1.1 (0.9–1.3)	1.4 (1.2–1.7)
(>12 vs ≤12 years)	1.1 (0.8–1.4)	0.9 (0.7–1.2)
Chronic Conditions		
Body mass index (<21 vs ≥21)	1.5 (1.2–1.9)	1.4 (1.1–1.8)
Visual deficit	1.5 (1.2–1.8)	2.4 (1.9–2.8)
Hearing deficit	1.3 (1.1–1.6)	2.0 (1.7–2.4)
Osteoporosis/hip fracture	1.8 (1.3–2.5)	1.6 (1.1–2.2)
Arthritis	1.6 (1.3–1.9)	2.4 (1.9–2.9)
Hypertension	1.2 (1.0–1.5)	1.6 (1.3–1.9)
Heart disease	1.0 (0.8–1.3)	2.3 (1.8–2.8)
Stroke	1.4 (1.0–2.1)	3.6 (2.8–4.7)
Vascular disease	1.5 (1.1–1.9)	2.0 (1.5–2.6)
Diabetes	1.1 (0.8–1.5)	2.1 (1.6–2.7)
Cancer	1.1 (0.8–1.5)	1.9 (1.5–2.5)
Disabilities		
Difficulty bathing	2.2 (1.7–2.9)	4.9 (3.9–6.1)
Difficulty dressing	2.0 (1.4–2.8)	4.7 (3.6–6.1)
Difficulty eating	3.5 (1.8–6.7)	9.8 (6.4–15.0)
Difficulty walking	2.1 (1.6–2.6)	4.8 (3.9–5.8)
Difficulty transferring	2.3 (1.7–3.1)	4.5 (3.5–5.7)
Difficulty going out	2.1 (1.6–2.8)	5.2 (4.2–6.4)
Difficulty toileting	2.1 (1.4–3.2)	4.5 (3.3–6.1)
Self vs proxy	0.9 (0.6–1.2)	1.4 (1.1–1.8)

Note. OR = odds ratio; CI = confidence interval.

TABLE 4—Mortality Rates and Crude Mortality Odds Ratios

Falls in 1984	Alive in 1986	Deceased in 1986 (%)	Odds Ratio (95% CI)
None	2939	350 (11.9)	—
One (n = 3762)	401	72 (18.0)	1.5 (1.1–2.0)
Two or more (n = 3797)	405	103 (25.4)	2.2 (1.7–2.8)

Note. CI = confidence interval.

tions and disabilities, the same demographic covariates were significant, along with the number of chronic conditions and number of disabilities.

Disability Outcome

In the univariate analysis (Table 6), single falls were not significantly associated with subsequent increased disability, but those who had fallen more than once were more than twice as likely to report difficulty with additional ADLs as were those who had fallen once.

Single falls did not predict increased disability in any of the multivariate models, whereas multiple falls were significant predictors in all models, both dichotomous and ordinal (Tables 7 and 8). As with the mortality outcome models, the addition of successive groups of covariates caused a decrease in the magnitude of the disability odds ratios for multiple falls. Substitution of numbers of chronic conditions or ADL difficulties present at baseline for the groups of individual conditions had little effect on the odds ratios.

A similar trend was seen in the categorical outcome models, with the disability odds ratio for multiple falls decreasing in magnitude but remaining significantly greater than 1.0 as successive blocks of covariates were added (Table 8).

Significant covariates in the categorical full model with individual chronic conditions were age, being married (protective), osteoporosis/hip fracture, arthritis, hypertension, heart disease, stroke, diabetes, proxy status, and number of functional disabilities at baseline. In the model with number of chronic conditions rather than individual chronic conditions, there was a significant association between this variable and decreased functional ability.

Discussion

Although the univariate analysis demonstrated a significant association between falls and 2-year mortality in this nationally representative population, the results of the multivariable analyses support the hypothesis that elevated mortality associated with falling in older persons is largely due to the presence of multiple chronic diseases and disabilities in those who are prone to fall. Falling is not an independent predictor of mortality when chronic disease and functional disability are controlled for, but it tends to be associated with these conditions in our baseline data. Our findings are consistent with other studies implicating underlying disease and disability as possible causal factors in falling.

Single falls do not appear to be associated with increased functional disability over a 2-year follow-up, but multiple falls are, and they remain significant, if not independent, predictors even when chronic conditions and functional disabilities present at baseline are controlled for. This could be due to injuries not included in the model, to other chronic diseases associated with both falls and disability that we were not able to control for (e.g., parkinsonism, Alzheimer's disease), or to these and other chronic diseases that might be undiagnosed and thus unreported. It has also been noted that fear of falling can cause people to restrict their normal activities[8]; it is possible that a repeat faller might limit his or her activities to the point where ADLs are affected. Although a relatively small proportion of falls result in serious injury (such as fractures or severe soft tissue trauma), it is possible that less serious injuries (as well as outcomes such as anxiety about further falls and loss of confidence) may disproportionately affect older persons.

In light of Tinetti's findings implicating number of conditions as one of the most important risk factors for falls, it is

TABLE 5—Odds Ratios (and 95% Confidence Intervals) from Multiple Logistic Regression Analysis: Falls as Predictors of 2-Year Mortality, when Demographic (DM), Chronic Condition (CC), and Disability (DB) Covariates Are Controlled For (n = 4270)

	Covariates						
Falls in 1984	DM	DM, CC	DM, DB	DM, CC, DB	DM, No. CC	DM, No. DB	DM, No. CC, No. DB
One	1.4 (1.1–1.9)	1.4 (1.0–1.9)	1.3 (0.9–1.8)	1.3 (0.9–1.8)	1.3 (1.0–1.8)	1.3 (0.9–1.7)	1.2 (0.9–1.7)
Two or more	2.0 (1.5–2.6)	1.6 (1.2–2.1)	1.4 (1.1–1.9)	1.3 (0.9–1.7)	1.6 (1.2–2.1)	1.4 (1.1–1.9)	1.3 (1.0–1.7)

Note. All models are weighted and control for proxy responses.

interesting that controlling for number of chronic diseases or functional disabilities present at baseline had an effect on the mortality and disability odds ratios for falls almost identical to the effect of controlling for the individual conditions. An examination of this LSOA subpopulation suggests a possible explanation with regard to chronic condition variables in the mortality outcome models. As shown in Table 1, the majority of individuals (nearly 80%) reported having from one to four of the chronic conditions we examined in our models. The most prevalent chronic conditions reported were arthritis (55.2%), hypertension (46.1%), hearing deficits (39.7%), and visual deficits (37.0%), none of which was a significant risk factor for mortality in the full model. An assumption that the majority of people reporting chronic conditions at baseline suffer from more than one of these prevalent but nonfatal conditions could explain the similar effect of controlling for number of conditions as opposed to individual conditions. In support of this assumption, a recent analysis of comorbidities in respondents aged 60 and older to the National Health Interview Survey and the Supplement on Aging found that arthritis and hypertension were the most common comorbid conditions, reported by 24.1% of that population, followed by arthritis and cataract (11.7%).[20]

These data provide an interesting note on the relationship between single and multiple falls. Although the crude mortality odds ratio was much higher for multiple than for single falls, the difference between the two decreased as covariates representing "intrinsic" characteristics were added to the model. When demographic, chronic condition, and disability variables were controlled for simultaneously, the odds ratios and test-based confidence intervals were nearly identical for single and multiple falls, and neither were significant predictors of mortality. On the other hand, multiple falls predicted increased disability and single falls did not, even when all covariates were added to the model. The most likely source of bias in comparisons of single and multiple falls—that a substantial number of single-fallers had additional falls prior to follow-up—would tend to obscure this difference. Perhaps there is a temporal difference; those experiencing multiple falls earlier in time may be more likely to become disabled sooner.

TABLE 6—Functional Ability Status and Crude Disability Odds Ratios

Falls in 1984	No Additional Disability in 1986[a]	Additional Disability in 1986	Odds Ratio (95% CI)
None	2090	819	—
One (n = 3306)	271	126	1.2 (0.9–1.5)
Two or more (n = 3309)	210	190	2.2 (1.8–2.7)

Note. CI = confidence interval.
[a]Includes those reporting difficulty with fewer activities of daily living (ADLs) in 1986 than in 1984.

There are also implications for caregivers and clinicians in the interrelationships of mortality, disability, chronic conditions, and falls. As individuals accumulate larger numbers of chronic conditions and disabilities—even those that are individually relatively benign—their potential for experiencing adverse outcomes from falls increases substantially. These individuals may be most in need of interventions to reduce both the risk and the severity of falls. Likewise, multiple falls in older persons should be taken seriously by physicians and other caregivers as indicators of possible underlying conditions that could increase risk for functional dependency or death within the next few years. □

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TABLE 7—Odds Ratios (and 95% Confidence Intervals) from Multiple Logistic Regression Analysis: Falls as Predictors of Additional Disability, Dichotomous Outcome, when Demographic (DM), Chronic Condition (CC), and Disability (DB) Covariates Are Controlled For (n = 3706)

	Covariates						
Falls in 1984	DM	DM, CC	DM, DB	DM, CC, DB	DM, No. CC	DM, No. DB	DM, No. CC, No. DB
One	1.1 (0.9–1.4)	1.0 (0.8–1.3)	1.1 (0.9–1.4)	1.0 (0.8–1.3)	1.0 (0.8–1.3)	1.1 (0.9–1.4)	1.0 (0.8–1.3)
Two or more	1.9 (1.5–2.3)	1.4 (1.1–1.8)	1.9 (1.5–2.4)	1.6 (1.2–2.0)	1.5 (1.2–1.9)	2.0 (1.5–2.5)	1.6 (1.3–2.0)

Note. All models control for proxy responses.

TABLE 8—Odds Ratios (and 95% Confidence Intervals) from Ordinal Outcome Multiple Logistic Regression Analysis: Falls as Predictors of Increase of One Difficult Activity of Daily Living Between 1984 and 1986, when Demographic (DM) and Chronic Condition (CC) Covariates Are Controlled For (n = 3706)

	Covariates		
Falls in 1984	DM	DM, CC	DM, No. CC
One	1.1 (0.9–1.4)	1.0 (0.8–1.3)	1.0 (0.8–1.3)
Two or more	2.1 (1.7–2.5)	1.7 (1.4–2.1)	1.8 (1.4–2.2)

Note. All models control for proxy responses and number of activities of daily living (ADLs) at baseline.

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