Risk Factors for Falls in Community-dwelling Older People
A Systematic Review and Meta-analysis

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Background: Falls are the main cause of accidental death in persons aged 65 years or older.

Methods: Using MEDLINE and previous reviews, we searched for prospective studies investigating risk factors for falls among community-dwelling older people. For risk factors investigated by at least 5 studies in a comparable way, we computed pooled odds ratios (ORs) using random-effects models, with a test for heterogeneity.

Results: A total of 74 studies met the inclusion criteria and 31 risk factors were considered, including sociodemographic, mobility, sensory, psychologic, and medical factors and medication use. The strongest associations were found for history of falls (OR = 2.8 for all fallers; OR = 3.5 for recurrent fallers), gait problems (OR = 2.1; 2.2), walking aids use (OR = 2.2; 3.1), vertigo (OR = 1.8; 2.3), Parkinson disease (OR = 2.7; 2.8), and antiepileptic drug use (OR = 1.9; 2.7). For most other factors, the ORs were moderately above 1. ORs were generally higher for recurrent fallers than for all fallers. For some factors, there was substantial heterogeneity among studies. For some important factors (eg, balance and muscle weakness), we did not compute a summary estimate because the measures used in various studies were not comparable.

Conclusions: This meta-analysis provides comprehensive evidence-based assessment of risk factors for falls in older people, confirming their multifactorial etiology. Some nonspecific indicators of high baseline risk were also strong predictors of the risk of falling.

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Accidents are the fifth-leading cause of death in adults aged 65 years or older (after cardiovascular diseases, cancer, stroke, and respiratory causes). Falls account for two-thirds of these accidental deaths. Falls are very common, with about 30% of community-dwelling older adults falling every year in developed countries. The incidence among institutionalized older people is even higher, with a mean percentage of residents who fall each year of over 40%.[1] Most falls do not cause death, but 5%–10% of falls result in serious injuries such as head injuries or fractures.

Falls have a strong impact on health and quality of life of older people. In recent decades, several epidemiologic studies have investigated risk factors for falls. Although investigators have not used consistent classifications, risk factors for falls are generally categorized as intrinsic and extrinsic. Intrinsic factors are individual-specific and include advanced age, chronic disease, muscle weakness, gait and balance disorders, and cognitive impairment. Extrinsic factors generally include medication use, environmental hazards, and hazardous activities. Lord et al[2] proposed a more analytic classification, dividing risk factors into sociodemographic factors, balance and mobility factors, sensory and neuromuscular factors, psychologic factors, medical factors, medication use, and environmental factors. Except for 2 meta-analyses on drugs[3] and muscle weakness,[4] previous reviews of risk factors for falls[1,5–11] have not used standard meta-analytic techniques to summarize the evidence.

In 2003, the National Institute of Clinical Excellence[9] provided guidelines for the prevention of falls in older persons. These guidelines included a systematic review of prospective cohort studies published from 1998 through 2002. The mean odds ratio (OR) and relative risk (RR) for 16 risk factors extracted from 28 studies were computed. Factors predictive of falling for community-dwelling older people included history of falling, gait deficit, balance deficit, mobility impairment, fear of falling, visual impairment, cognitive impairment, urinary incontinence, and home hazards. Since then, several new studies have been published. Our objective is to provide an updated comprehensive systematic review of prospective studies on risk factors for falls in community-dwelling older people.

METHODS

Search Strategy and Selection Criteria

As the basis for our analysis, we used the systematic search of the relevant literature conducted in the review[9] of studies from 1998 to 2002, and previous reviews.[1,5–11] In addition to their search, we performed a MEDLINE search of the literature from 2002 to December 2008. Three search themes were combined using the Boolean operator "and." The first theme, "falls," combined in title/abstract *fall* or *falls* or *falling* or *faller** or *fallen* or *slip** or *trip** or Medical Subject Heading (MeSH) *accidental falls.* The second theme, "elderly," combined in title/abstract *old* or *older* or *senior** or *elder** or *aged* or *geriatric** or *middle?age**. The third theme, "risk," combined in title/abstract *risk** or *assess** or *predict** or *history** or *screen** or *probabilit** or Medical Subject Heading (MeSH) *risk*. This search strategy was derived from the one applied by previous reviewers.[9]

Two investigators (S.D., E.N.) independently reviewed titles and abstracts, and selected articles addressing falls in the elderly. Disagreements were resolved by discussion and consensus. We considered articles published in English, Italian, French, Spanish, Portuguese, and German. On a second sift, we selected original studies on risk factors for fall with the following inclusion criteria:

1. At least 80% of the sample aged 65 years or older.
2. Prospective study design.
3. Sample size greater than 200 subjects.
4. At least 80% of subjects living in the community.
5. Number of subjects experiencing one or more falls during follow-up as an outcome.

Additionally, the reference lists of the previous reviews were searched to identify studies that met the inclusion criteria and were published before 2002.

Data Extraction and Analysis

For each study included, the full text was retrieved and the following data were extracted: location, year of publication, size and mean age of the sample, outcome assessed, and method used to record falls.

We considered 2 outcomes:

1. All fallers: persons who fell at least once during the follow-up.
2. Recurrent fallers: persons who fell at least twice during the follow-up (within 6 months, or within 1 year, depending on the information given in the study).

The frequency of assessment was defined as follows:

1. High: when the fall was recorded on a calendar or persons were interviewed at least every 3 months.
2. Intermediate: when persons were interviewed less frequently than in (1) but at least every 6 months.
3. Low: when persons were interviewed only once a year.

For each risk factor, we extracted the OR or RR, together with CIs, and details about the statistical methodology (eg, confounders considered, analytic method used). When the OR or the RR was not provided, we computed a crude OR if possible.

We followed the risk-factors classification proposed by Lord et al.[2] Two investigators performed the extraction of the data in duplicate to avoid errors. Multivariate estimates were always selected when available, otherwise the unadjusted results were recorded. We pooled studies that presented ORs or RRs.

Given the high number of potential risk factors, we restricted our analysis to those for which an outcome was assessed by at least 5 studies. In some cases, the same risk factor was measured in different ways. For example, depression was diagnosed by 2 scales—the Center for Epidemiologic Studies Depression Scale (CES-D) and the Geriatric Depression Scale (GDS). Similarly, cognitive impairment was defined by a Mini Mental State Examination (MMSE) score <24 in some studies, and <18 in others. Because we did not have the original data, we used cutpoints given in the original studies. For body mass index, we used either <20 kg/m^2 or <25 kg/m^2 as the cutpoint, and for education we used the best proxy for a low grade (10, 11, or 12 years). However, when we judged that the measure used in a study was not comparable with ones used in other studies, we excluded that study when examining that risk factor.

Each outcome was analyzed separately. For dose–response analysis (ie, for age, number of drug prescriptions, etc) we used the method proposed by Greenland and Long-

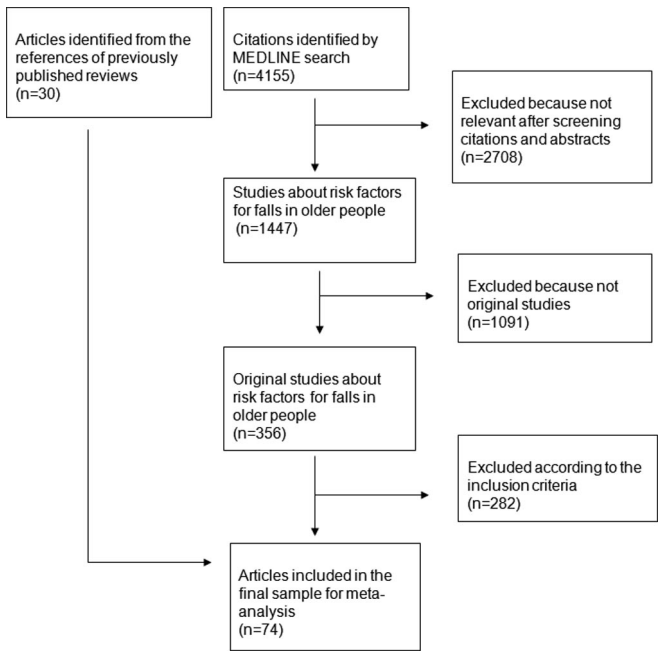

FIGURE. Flowchart of manuscript selection.

TABLE 1. Summary of 74 Prospective Studies Investigating Risk Factors for Falls in Community-dwelling Older People

Author, Reference	Year	Location	Sample Size Number	Women (%)	Frequency of Fall Assessment[a]	Mean or Median Age of Study Population (Years)	Duration of the Follow-up (Months)	Outcome[b]
Tinetti et al[56]	1988	USA	336	55	High	78	12	All
Nevitt et al[17]	1989	USA	325	82	High	73	12	All/recurrent
Teno et al[43]	1990	USA	586	68	Low	76	12	All
Duncan et al[52]	1992	USA	217	0	High	75	6	All/recurrent
Cauley et al[44]	1993	USA	9704	100	Intermediate	71	12	All/recurrent
O'Loughlin et al[27]	1993	Canada	409	63	High	74	11	All
Lord et al[58]	1994	Australia	341	100	High	74	12	Recurrent
Mahoney et al[51]	1994	USA	214	63	High	78	1	All
Luukinen et al[54]	1995	Finland	788	63	High	76	24	Recurrent
Northridge et al[18]	1995	USA	325	82	High	NR	12	All
Tinetti et al[25]	1995	USA	1103	73	High	80	12	All
Tinetti et al[28]	1995	USA	927	73	High	80	12	Recurrent
Graafmans et al[49]	1996	The Netherlands	354	85	High	83	7	All/recurrent
Luukinen et al[55]	1996	Finland	788	63	High	76	24	Recurrent
Northridge et al[26]	1996	USA	218	82	High	NR	12	All
Tromp et al[29]	1998	The Netherlands	1469	52	Low	73	12	All/recurrent
Vellas et al[19]	1998	USA	482	59	High	74	24	All
Weiner et al[57]	1998	USA	293	0	High	74	6	All
Arden et al[53]	1999	USA	5552	100	Intermediate	71	12	Recurrent
Brown et al[30]	2000	USA	6049	100	Intermediate	79	36	All
Cumming et al[22]	2000	Australia	418	57	High	77	12	All
Gill et al[23]	2000	USA	1084	73	High	80	36	All
Covinsky et al[21]	2001	USA	557	66	Low	82	12	All
Tromp et al[45]	2001	The Netherlands	1280	51	High	75	12	All/recurrent
Biderman et al[64]	2002	Israel	283	58	Low	71	12	Recurrent
Cesari et al[20]	2002	Italy	5570	58	Intermediate	77	3	All
Ensrud et al[32]	2002	USA	8127	100	Intermediate	77	12	All/recurrent
Friedman et al[31]	2002	USA	2211	59	Low	73	20	All
Hanlon et al[69]	2002	USA	2996	64	Low	72	36	All/recurrent
Leveille et al[24]	2002	USA	940	100	Intermediate	78	36	All/recurrent
Perracini and Ramos[34]	2002	Brazil	951	NR	Low	NR	24	All/recurrent
Schwartz et al[61]	2002	USA	9249	100	Intermediate	74	84	Recurrent
Stalenhoef et al[33]	2002	The Netherlands	287	60	High	78	8	Recurrent
van Schoor et al[46]	2002	The Netherlands	1437	51	High	76	36	Recurrent
Bergland et al[47]	2003	Norway	307	100	High	81	12	All
Bootsma-van der Wiel et al[50]	2003	The Netherlands	380	65	Low	>85	12	All/recurrent
Stel et al[60]	2003	The Netherlands	1365	51	High	75	36	Recurrent
Stel et al[41]	2003	The Netherlands	435	55	High	78	12	Recurrent
Visvanathan et al[59]	2003	Australia	240	69	Low	79	12	All
Coleman et al[16]	2004	USA	2002	100	Intermediate	76	72	Recurrent
Mukamal et al[63]	2004	USA	5473	58	Low	73	48	Recurrent
Reyes-Ortiz et al[71]	2004	USA	1391	61	Low	77	24	All
Salvà et al[38]	2004	Spain	448	59	High	75	12	All
Chu et al[15]	2005	Hong Kong	1516	49	High	73	12	All/recurrent
Fink et al[62]	2005	USA	5867	0	Intermediate	74	12	Recurrent
Gerdhem et al[68]	2005	Sweden	984	100	Low	75	12	All
Penninx et al[48]	2005	The Netherlands	394	50	High	75	36	Recurrent
Schaap et al[39]	2005	The Netherlands	608	0	High	NR	36	Recurrent
van Bemmel et al[72]	2005	The Netherlands	480	67	Low	85	12	All
Cawthon et al[14]	2006	USA	5689	0	Intermediate	74	12	Recurrent
Delbaere et al[65]	2006	Belgium	257	57	High	72	12	All/recurrent

(*Continued*)

TABLE 1. (*Continued*)

Author, Reference	Year	Location	Sample Size Number	Women (%)	Frequency of Fall Assessment[a]	Mean or Median Age of Study Population (Years)	Duration of the Follow-up (Months)	Outcome[b]
Delbaere et al[66]	2006	Belgium	257	58	High	72	12	Recurrent
Faulkner et al[35]	2006	USA	389	100	Intermediate	70	48	All
Orwoll et al[36]	2006	USA	2587	0	Intermediate	73	48	All
Pajala et al[37]	2006	Finland	428	100	High	69	12	All/recurrent
Pluijm et al[70]	2006	The Netherlands	1365	51	High	75	36	Recurrent
Snijder et al[40]	2006	The Netherlands	1231	51	High	75	12	Recurrent
Stone et al[42]	2006	USA	8101	100	High	77	12	Recurrent
Capon et al[73]	2007	Italy	559	NR	Intermediate	NR	12	All
Coleman et al[74]	2007	USA	4071	100	Intermediate	80	12	Recurrent
Gallagher et al[67]	2007	USA	415	100	Intermediate	72	36	All
van der Velde et al[76]	2007	The Netherlands	215	65	High	77	3	All
Bischoff-Ferrari et al[77]	2008	USA	446	55	High	71	36	All
Clough-Gorr et al[78]	2008	Europe (multicenter)	1644	56	Low	74	12	All
Ensrud[79]	2008	USA	6520	100	Intermediate	77	12	Recurrent
Gassmann et al[80]	2009	Germany	622	48	Intermediate	75	6	All/recurrent
Heesch et al[75]	2008	Australia	8188	100	Low	75	12	All
Iinattiniemi et al[85]	2009	Finland	555	76	High	88	11	All
Knudston et al[81]	2009	USA	2256	58	Low	75	12	Recurrent
Kulmala et al[86]	2009	Finland	428	100	High	69	12	All
Leclerc et al[82]	2008	Canada	549	76	High	80	12	All
Pajala et al[83]	2008	Finland	419	100	High	69	12	All
Stone et al[84]	2008	USA	2978	100	Intermediate	84	12	Recurrent
Srikanth et al[87]	2009	Australia	294	45	High	72	12	All

[a]High: when the fall event was ascertained with a fall calendar and/or the subjects were interviewed at least every 3 months; intermediate: when the subjects were interviewed less frequently than for "high" but at least every 6 months; low: when the subjects were interviewed only once a year.

[b]Any faller: subjects who fell at least once during the follow-up period; recurrent fallers: subject who fell at least twice during the follow-up period (within 6 months or within 1 year, depending on the information given in the study).

NR indicates not reported.

necker[12] that estimates study-specific slopes from the natural logarithm of the RR or OR across exposure categories, assigning to each class the dose corresponding to the midpoint of the range.

We used RevMan, version 4.3.2, for Windows by the Cochrane Collaboration (http://www.cc-ims.net/revman) to analyze data. We estimated pooled ORs and 95% confidence intervals (CIs) using random-effects models.[13] We assessed statistical heterogeneity among studies using the χ^2 test. The following additional subgroup analyses were performed: studies presenting multivariate ORs versus unadjusted ORs; studies where the mean or median age of subjects was >75 years versus studies where the mean age was 75 years or younger; follow-up longer than 1 year versus shorter; and high frequency of fall assessment versus low frequency.

RESULTS

The MEDLINE search produced 4155 citations. Review of titles and abstracts resulted in the selection of 1447 papers, among which 356 were original studies, and 44 met the inclusion criteria. An additional 30 studies were identified from the references of previously published reviews.[1,5–11] The flowchart of study selection is shown in the Figure. Selected characteristics of the 74 included articles14–87 are reported individually in Table 1 and summarized in Table 2. Most studies were conducted in the United States or Europe, with mean/median cohort age of 75 years or older, a sample size less than 500 (range: 211–9704), a duration of follow-up 1 year or less, and publication after 2000. A total of 31 risk factors were assessed by 5 or more studies in a comparable manner for at least 1 outcome.

Tables 3–6 provide the combined ORs and 95% CIs and heterogeneity test for each risk factor for 2 outcomes: all fallers and recurrent fallers. ORs are reported (1) for all studies, (2) only for studies reporting multivariate analysis, and (3) only for studies with a high frequency of fall assessment. eAppendix 1 (http://links.lww.com/EDE/A404) provides forest plots with results of individual studies, and eAppendix 2 (http://links.lww.com/EDE/A404) contains tables with other subgroup analyses.

Table 3 shows the results for sociodemographic factors. Advanced age and sex were the factors most frequently

TABLE 2. Characteristics of 74 Prospective Studies Investigating Risk Factors for Falls in Community-dwelling Older People

Characteristic	No. Studies[a]	
	All Fallers	Recurrent Fallers
Location		
Europe	18	18
USA	23	18
Other countries	8	4
No. of subjects included in the study		
200–500	25	12
501–1000	8	7
1001–2000	8	7
≥2001	8	14
Mean or median age of study population (years)[b]		
65–75	25	23
76–80	14	12
≥81	6	3
Duration of follow-up (months)		
1–12	37	27
13–24	4	3
≥25	8	10
Year of publication		
Prior to 1991	3	1
1991–1994	4	3
1995–1999	7	6
2000–2004	16	14
2005–2008	19	16
Frequency of fall assessment		
High	26	20
Intermediate	9	12
Low	14	8

[a]The sum does not add up to the total because some studies presented both outcomes.
[b]For 5 studies mean and median cohort age could not be determined.

investigated. For a 5-year increase in age, the OR was 1.12 (95% CI = 1.07–1.17) for all fallers and 1.12 (1.07–1.18) for recurrent fallers. Individual studies were heterogeneous for both outcomes ($P = <0.0001$ and 0.009, respectively). Nonetheless, all studies showed a consistent rise in risk with age. Female sex was associated with an increased risk of falling (OR = 1.3 for all fallers and OR = 1.3 for recurrent fallers), and again the results from individual studies were heterogeneous ($P = 0.004$ and $P = <0.0001$, respectively). Most studies found an increased risk for women, both for all fallers and recurrent fallers. Risks for living alone were OR = 1.3 for all fallers and OR = 1.3 for recurrent fallers, history of falls (OR = 2.8; 3.5), physical disability (OR = 1.6; 2.4), disability in instrumental activities of daily life (OR = 1.5; 2.0), and use of a walking aid (OR = 2.2; 3.1). Physical activity reduction, low education, and low body mass index were not associated with the risk of falling.

Table 4 shows the effects of psychologic and medical factors. All the medical conditions investigated showed a positive association with both outcomes. The strongest associations were with vertigo, Parkinson disease, and fear of falling: for recurrent fallers the ORs were 2.3 (1.9–2.8) for vertigo, 2.8 (1.8–4.6) for Parkinson disease, and 2.5 (1.8–3.5) for fear of falling. Comorbidity and self-perceived health status were also associated with falls: an increment of 1 medical condition resulted in a pooled overall OR of 1.2 (1.2–1.3) for any faller and 1.4 (1.2–1.6) for recurrent fallers.

Table 5 shows the relation with medication use. Use of sedatives, antihypertensives, and, in particular, antiepileptics (OR = 1.9 all fallers and 2.7 for recurrent fallers) were directly associated with risk of falling, as was number of medications used (OR = 1.06 for both outcomes with 1 drug increase).

Table 6 shows the effects of mobility and sensory factors. The high heterogeneity in methods used to assess muscle weakness and balance impairment did not allow results from different studies to be combined. Gait problems increased the risk of falls, with an overall OR of 2.1 (1.8–2.3) for all fallers and 2.2 (1.5–3.2) for recurrent fallers. Vision and hearing impairment also increased risk, especially vision problems (1.4 for all fallers and 1.6 for recurrent fallers).

DISCUSSION

This meta-analysis of risk factors for falls found ORs around 2–3 for history of falls, vertigo, Parkinson disease, fear of falling, gait problems, use of walking aids, and use of antiepileptic drugs. For most other factors considered, ORs were less than 2. ORs were generally higher for recurrent fallers than for all fallers.

Although many studies have investigated risk factors for falls, a comprehensive and quantitative summary has been lacking. We included only studies with a prospective design to avoid problems of reverse causality, given that some factors (eg, fear of falling) are consequences as well as risk factors for falls. A prospective design ensures that the exposure was measured before the occurrence of the outcome. We excluded cohorts with fewer than 200 subjects to avoid studies based only on a small number of outcomes or very few exposed subjects.

Several of the studies presented crude ORs only. To investigate the role of possible confounders on the association between each factor and the risk of falling, we also calculated pooled ORs based on studies in which the OR was adjusted at least for age and sex, and other potential confounders when possible. In the 2003 review of risk factors,[9] studies presenting adjusted ORs were given greater consideration. Given the strong possibility of confounding by age and sex, as well as by other correlated factors, adjusted ORs are clearly more reliable. The use of adequate statistical techniques is a further

TABLE 3. Association of Sociodemographic Risk Factors With Falls in Community-dwelling Older People

	All Studies			Multivariate Analysis Only			High Frequency of Fall Assessment Only		
Characteristic	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**
Age (5-year increase)									
All fallers	18	<0.0001	1.12 (1.07–1.17)	8	0.0002	1.12 (1.05–1.19)	8	0.007	1.11 (1.05–1.17)
Recurrent fallers	15	0.009	1.12 (1.07–1.18)	6	0.0007	1.15 (1.00–1.32)	9	0.10	1.12 (1.07–1.18)
Sex (women vs. men)									
All fallers	22	0.004	1.30 (1.18–1.42)	7	0.003	1.28 (1.06–1.54)	12	0.22	1.37 (1.21–1.55)
Recurrent fallers	18	<0.0001	1.34 (1.12–1.60)	6	0.0002	1.68 (0.97–2.89)	12	0.0002	1.34 (1.08–1.68)
Living situation (alone vs. not alone)									
All fallers	11	0.44	1.33 (1.21–1.45)	1	NA	1.20 (0.69–2.08)	3	0.52	1.26 (1.04–1.53)
Recurrent fallers	9	0.43	1.25 (1.10–1.43)	1	NA	1.59 (1.00–2.52)	4	0.79	1.16 (0.98–1.38)
History of falls (yes vs. no)									
All fallers	18	<0.0001	2.77 (2.37–3.25)	12	0.002	2.92 (2.50–3.40)	9	0.35	2.79 (2.43–3.20)
Recurrent fallers	12	0.04	3.46 (2.85–4.22)	7	0.04	3.07 (2.31–4.08)	9	0.54	3.09 (2.63–3.63)
Physical activity (limitation vs. no limitation)									
All fallers	10	0.01	1.20 (1.04–1.38)	1	NA	0.70 (0.40–1.21)	7	0.008	1.22 (1.00–1.50)
Recurrent fallers									
Physical disability (yes vs. no)									
All fallers	9	<0.0001	1.56 (1.22–1.99)	4	0.0001	1.46 (0.85–2.52)	4	0.20	2.30 (1.55–3.43)
Recurrent fallers	8	<0.0001	2.42 (1.80–3.26)	2	0.02	2.63 (1.06–6.51)	6	0.22	2.24 (1.81–2.77)
Instrumental disability (yes vs. no)									
All fallers	6	0.03	1.46 (1.20–1.77)	2	0.70	1.25 (1.02–1.53)	1	NA	1.40 (0.92–2.14)
Recurrent fallers	4	0.002	2.04 (1.41–2.95)	0			1	NA	2.00 (1.35–2.96)
Body mass index (low vs. intermediate/high)									
All fallers	3	0.64	1.17 (0.93–1.46)	1	NA	1.04 (0.73–1.48)	1	NA	1.20 (0.85–1.70)
Recurrent fallers	6	0.55	1.03 (0.86–1.23)	1	NA	0.88 (0.59–1.31)	4	0.73	1.03 (0.84–1.27)
Education (low vs. intermediate/high)									
All fallers	7	0.01	1.01 (0.88–1.16)	1	NA	0.93 (0.76–1.13)	3	0.03	0.91 (0.62–1.32)
Recurrent fallers	8	0.001	0.81 (0.62–1.05)	2	0.66	0.87 (0.71–1.08)	4	0.47	0.71 (0.59–0.86)
Walking aid use (yes vs. no)									
All fallers	11	0.006	2.18 (1.79–2.65)	3	0.80	2.50 (1.80–3.47)	6	0.12	2.46 (1.91–3.15)
Recurrent fallers	6	0.009	3.09 (2.10–4.53)	1	NA	3.20 (1.70–6.01)	4	0.01	3.05 (1.87–4.95)

NA indicates not applicable.

indicator of better quality of the study. However, it is also possible that in some studies a number of risk factors were investigated, and that the ones included in the multivariate analyses were only those significantly associated in the univariate ones. Considering only studies presenting adjusted ORs may thus lead to an overestimation of the overall OR. Moreover, in some instances, there were only 1 or 2 studies presenting multivariate results. In any case, the difference between the pooled estimate based on all individual ORs and the one based only on adjusted ORs was not substantial for most factors, although the pooled adjusted estimates tended to have wider confidence intervals, given that these were generally based on fewer studies. A notable exception was cognition impairment, for which multivariate ORs were higher than univariate ones for both outcomes.

Falls are often underreported, and particularly falls without injury.[88] For this reason, we also estimated pooled ORs including only studies in which the fall event had been recorded on a fall calendar or ascertained with an interview at least every 3 months. This also can be considered as an indicator of better quality. Again, no major differences were observed for most factors when the analysis was restricted to studies with better outcome assessment.

When interpreting the results from this meta-analysis, one must consider the issue of heterogeneity among studies, which was substantial for some—but not all—factors. A higher heterogeneity leads to wider confidence intervals, since a random-effects model was used. For this reason, in evaluating the strength of the association of each factor with the risk of falling, one should consider the whole confidence interval of the summary OR, rather than the point estimate only. From the 31 risk factors considered, the *P* value of the heterogeneity test in the overall analysis was <0.10 in 23 cases for all fallers and in 19 cases for recurrent fallers. In

TABLE 4. Association of Medical and Psychological Risk Factors With Falls in Community-dwelling Older People

	All Studies			Multivariate Analysis Only			High Frequency of Fall Assessment Only		
Characteristic	No. Studies	Heterogeneity *P*	OR (95% CI)	No. Studies	Heterogeneity *P*	OR (95% CI)	No. Studies	Heterogeneity *P*	OR (95% CI)
Cognition impairment (yes vs. no)									
All fallers	10	0.06	1.36 (1.12–1.65)	4	0.07	2.24 (1.25–4.03)	4	0.07	2.21 (1.18–4.14)
Recurrent fallers	12	0.02	1.56 (1.26–1.94)	2	0.40	3.65 (1.71–7.79)	12	0.02	1.56 (1.26–1.94)
Depression (yes vs. no)									
All fallers	17	<0.0001	1.63 (1.36–1.94)	6	<0.0001	1.44 (1.11–1.86)	8	0.88	1.70 (1.46–1.97)
Recurrent fallers	14	<0.0001	1.86 (1.45–2.38)	3	0.01	1.59 (0.87–2.88)	8	0.98	1.79 (1.53–2.09)
History of stroke (yes vs. no)									
All fallers	5	0.90	1.61 (1.31–1.98)	2	0.7	1.65 (1.22–2.22)	4	0.81	1.59 (1.28–1.98)
Recurrent fallers	7	0.52	1.79 (1.51–2.13)	2	0.60	2.94 (1.77–4.87)	2	0.72	2.35 (1.51–3.66)
Urinary incontinence (yes vs. no)									
All fallers	13	0.0005	1.40 (1.26–1.57)	6	0.001	1.33 (1.11–1.61)	3	0.17	1.74 (1.32–2.28)
Recurrent fallers	11	0.10	1.67 (1.45–1.92)	4	0.009	1.71 (1.17–2.49)	7	0.34	1.75 (1.53–2.01)
Rheumatic disease (yes vs. no)									
All fallers	9	0.02	1.47 (1.28–1.70)	4	0.03	1.41 (1.09–1.81)	4	0.24	1.76 (1.44–2.16)
Recurrent fallers	10	0.50	1.57 (1.42–1.73)	4	0.12	1.91 (1.43–2.56)	6	0.58	1.54 (1.34–1.77)
Dizziness and vertigo (yes vs. no)									
All fallers	6	0.01	1.80 (1.39–2.33)	1	NA	2.30 (1.35–3.93)	4	0.26	1.50 (1.23–1.82)
Recurrent fallers	8	0.21	2.28 (1.90–2.75)	2	0.94	2.14 (1.54–2.99)	6	0.18	2.18 (1.77–2.68)
Hypotension (yes vs. no)									
All fallers	4	0.18	1.24 (0.90–1.71)	1	NA	1.40 (0.57–3.43)	4	0.18	1.24 (0.90–1.71)
Recurrent fallers	6	0.05	1.31 (0.95–1.81)	2	0.27	1.55 (0.82–2.91)	6	0.05	1.31 (0.95–1.81)
Diabetes (yes vs. no)									
All fallers	8	0.70	1.19 (1.08–1.31)	3	0.99	1.36 (1.15–1.61)	2	0.58	1.04 (0.73–1.48)
Recurrent fallers	7	0.17	1.28 (1.09–1.50)	2	0.88	1.43 (1.15–1.77)	2	0.31	1.48 (1.06–2.07)
Comorbidity (increment of 1 condition)									
All fallers	10	<0.0001	1.23 (1.16–1.30)	2	0.02	1.09 (0.96–1.25)	3	0.54	1.18 (1.13–1.23)
Recurrent fallers	8	0.003	1.48 (1.25–1.74)	0			3	0.52	1.25 (1.12–1.40)
Self perceived health status (poor vs. good)									
All fallers	6	0.004	1.50 (1.15–1.96)	1	NA	1.00 (0.68–1.46)	2	0.94	1.32 (1.08–1.61)
Recurrent fallers	8	<0.0001	1.82 (1.26–2.61)	1	NA	1.05 (0.74–1.48)	3	0.02	1.65 (0.90–3.03)
Pain (yes vs. no)									
All fallers	2	0.60	1.39 (1.19–1.62)	1	NA	1.41 (1.20–1.66)	0		
Recurrent fallers	6	0.80	1.60 (1.44–1.78)	3	0.64	1.55 (1.38–1.75)	3	0.94	1.78 (1.49–2.13)
Fear of falling (yes vs. no)									
All fallers	9	<0.0001	1.55 (1.14–2.09)	3	0.0001	1.27 (0.86–1.87)	5	<0.0001	1.57 (1.03–2.40)
Recurrent fallers	7	0.002	2.51 (1.78–3.54)	3	0.12	1.88 (1.24–2.85)	5	0.02	2.21 (1.55–3.15)
Parkinson disease (yes vs. no)									
All fallers	5	<0.0001	2.71 (1.08–6.84)	4	0.0001	2.73 (1.00–7.45)	2	0.79	3.89 (3.88–3.90)
Recurrent fallers	5	0.56	2.84 (1.77–4.58)	2	0.12	3.79 (1.00–14.30)	2	0.55	6.57 (2.11–20.44)

NA indicates not applicable.

most instances, however, results were fairly consistent in the direction of the effect (ie, pointing toward an increase or decrease in risk), even though studies differed in the estimation of the effect size. (See forest plots in eAppendix 1 [http://links.lww.com/EDE/A404]). The subgroup analyses in eAppendix 2 (http://links.lww.com/EDE/A404) explored the role of some characteristics of studies in explaining heterogeneous results. Other characteristics (eg, other design or population issues, including methodologic limitations and biases) may further explain differences in results.

Despite these potential limitations, some clear associations emerged from this analysis.

This review underscores the plethora of factors that affect the risk of falling, with a weak or moderate OR for most (generally below 2). Although most associations are not large, these factors are common in the older population, and

TABLE 5. Association of Medication Risk Factors With Falls in Community-dwelling Older People

	All Studies			Multivariate Analysis Only			High Frequency of Fall Assessment Only		
Characteristic	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**
No. medications (for 1-drug increase)									
All fallers	10	0.86	1.06 (1.04–1.08)	4	1.00	1.05 (1.01–1.09)	2	0.80	1.05 (1.00–1.10)
Recurrent fallers	11	0.38	1.06 (1.04–1.08)	3	0.62	1.04 (1.01–1.07)	5	0.37	1.05 (1.03–1.07)
Use of sedatives (use vs. no use)									
All fallers	10	0.06	1.38 (1.15–1.66)	6	0.30	1.38 (1.18–1.62)	5	0.05	1.65 (1.06–2.57)
Recurrent fallers	10	0.78	1.53 (1.34–1.75)	3	0.65	1.44 (1.16–1.78)	4	0.58	1.53 (1.21–1.93)
Use of antihypertensives (use vs. no use)									
All fallers	7	0.03	1.25 (1.06–1.48)	4	0.11	1.25 (1.02–1.54)	3	0.003	1.40 (0.89–2.22)
Recurrent fallers	7	0.05	1.23 (1.05–1.44)	3	0.03	1.19 (0.79–1.77)	4	0.15	1.32 (1.07–1.64)
Use of antiepileptics (use vs. no use)									
All fallers	4	0.09	1.88 (1.02–3.49)	2	0.22	1.45 (0.84–2.52)	1	NA	1.70 (0.58–5.00)
Recurrent fallers	5	0.69	2.68 (1.83–3.92)	3	0.38	2.52 (1.61–3.93)	2	0.84	3.19 (1.53–6.66)

NA indicates not applicable.

TABLE 6. Association of Mobility and Sensory Risk Factors With Falls in Community-dwelling Older People

	All Studies			Multivariate Analysis Only			High Frequency of Fall Assessment Only		
Characteristic	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**	**No. Studies**	**Heterogeneity *P***	**OR (95% CI)**
Gait problems (yes vs. no)									
All fallers	5	0.54	2.06 (1.82–2.33)	3	0.32	2.06 (1.76–2.41)	2	0.17	2.02 (1.39–2.93)
Recurrent fallers	6	<0.0001	2.16 (1.47–3.19)	2	0.11	3.68 (1.87–7.22)	4	0.04	2.58 (1.79–3.74)
Vision impairment (yes vs. no)									
All fallers	15	<0.0001	1.35 (1.18–1.54)	6	0.01	1.21 (0.92–1.58)	7	0.61	1.51 (1.29–1.78)
Recurrent fallers	13	<0.0001	1.60 (1.28–2.00)	4	<0.0001	1.45 (0.83–2.53)	8	0.50	1.81 (1.58–2.08)
Hearing impairment (yes vs. no)									
All fallers	7	0.13	1.21 (1.05–1.39)	0			4	0.15	1.25 (1.03–1.51)
Recurrent fallers	8	0.36	1.53 (1.33–1.76)	0			5	0.28	1.50 (1.27–1.78)

NA indicates not applicable.

often a person presents several factors, thus being at considerable risk of falling.

The estimated ORs were generally higher for "recurrent fallers" than for "all fallers," indicating that the subjects who experience more than one fall are a distinct risk group. Although one fall may occur by chance alone, the repetition of the event suggests an underlying high-risk state.

Some nonspecific indicators of a high baseline risk (history of falls, fear of falling, and use of walking aids) were associated with about a 3-fold risk of falling. These factors cannot be prevented, but they may help identify persons at high risk of falling and thus likely to benefit most from preventive interventions.

Other factors showing ORs around 2 were dizziness and vertigo, gait problems, and antiepileptic drug use, plus cognition impairment when adjusted ORs only were considered. Prescriptions of newer antiepileptic drugs have been increasing in recent years in several countries, particularly for the treatment of pain.[89] There is a need to explore the increased risk of falls by type of drug, given that falls may be an important adverse event that must be considered when deciding the treatment of pain in older people.

Several potentially relevant factors were not addressed in this study, either because they were considered by too few studies (eg, anemia, hypovitaminosis D, use of antidepressants, antipsychotics or insulin, footwear, use of bifocal lenses) or because the risk factor was measured in noncomparable ways (eg, muscle weakness, balance impairment, environmental hazards). For the first group of factors, there is a need for further studies to explore these associations. In the second group, there is a need for consensus on measures to evaluate the factor, to improve comparability among studies.

For example, the Prevention of Falls Network Europe identified over 30 different measures of balance within the European Union (http://www.profane.eu.org/eu_map/index.php). The same problem was raised by a recent review on exercise for improving balance in older people performed within the framework of the Cochrane Collaboration.[90] The authors recommended "a consensus of outcome measures for evaluating the effects of interventions of balance ability" and, we add, for the evaluation of balance ability in older people in general. With regard to muscle weakness, some studies measured upper-limb muscle strength and others lower-limb strength, using different methods, with none of the measures used in at least 5 studies.

This meta-analysis provides the first comprehensive evidence-based assessment of risk factors in community-dwelling older people. It shows the need for improved quality in reporting studies on risk factors in older people, as well as for further research on potentially important neglected factors, and for improvements in comparability of risk-factor measurement.

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REFERENCES

1. Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. *Clin Geriatr Med*. 2002;18:141–158.
2. Lord SR, Sherrington C, Menz HB. *Falls in Older People: Risk Factors and Strategies for Prevention*. 2nd ed. Cambridge, MA: Cambridge University Press; 2007.
3. Leipzig RM, Cumming RG, Tinetti ME. Drugs and falls in older people: a systematic review and meta-analysis: part I. Psychotropic drugs. *J Am Geriatr Soc*. 1999;47:30–39.
4. Moreland JD, Richardson JA, Goldsmith CH, Clase CM. Muscle weakness and falls in older adults: a systematic review and meta-analysis. *J Am Geriatr Soc*. 2004;52:1121–1129.
5. American Geriatrics Society, British Geriatrics Society, American Academy of Orthopaedic Surgeons Panel on Falls Prevention. Guideline for the prevention of falls in older persons. *J Am Geriatr Soc.* 2001;49:664–672.
6. Connell BR. Role of the environment in falls prevention. *Clin Geriatr Med*. 1996;12:859–880.
7. Ganz DA, Bao Y, Shekelle PG, Rubenstein LZ. Will my patient fall? *JAMA*. 2007;297:77–86.
8. Hartikainen S, Lonnroos E, Louhivuori K. Medication as a risk factor for falls: critical systematic review. *J Gerontol A Biol Sci Med Sci*. 2007; 62:1172–1181.
9. NICE. *The Assessment and Prevention of Falls in Older People Clinical Practice Guideline*. London: Royal College of Nursing; 2004.
10. Perell KL, Nelson A, Goldman RL, Luther SL, Prieto-Lewis N, Rubenstein LZ. Fall risk assessment measures: an analytic review. *J Gerontol A Biol Sci Med Sci*. 2001;56:M761–M766.
11. Rawsky E. Review of the literature on falls among the elderly. *Image J Nurs Sch*. 1998;30:47–52.
12. Greenland S, Longnecker MP. Methods for trend estimation from summarized dose-response data, with applications to meta-analysis. *Am J Epidemiol*. 1992;135:1301–1309.
13. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*. 1986;7:177–188.
14. Cawthon PM, Harrison SL, Barrett-Connor E, et al. Alcohol intake and its relationship with bone mineral density, falls, and fracture risk in older men. *J Am Geriatr Soc*. 2006;54:1649–1657.
15. Chu LW, Chi I, Chiu AY. Incidence and predictors of falls in the Chinese elderly. *Ann Acad Med Singapore*. 2005;34:60–72.
16. Coleman AL, Stone K, Ewing SK, et al. Higher risk of multiple falls among elderly women who lose visual acuity. *Ophthalmology*. 2004; 111:857–862.
17. Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent nonsyncopal falls: a prospective study. *JAMA*. 1989;261:2663–2668.
18. Northridge ME, Nevitt MC, Kelsey JL, Link B. Home hazards and falls in the elderly: the role of health and functional status. *Am J Public Health*. 1995;85:509–515.
19. Vellas BJ, Wayne SJ, Garry PJ, Baumgartner RN. A two-year longitudinal study of falls in 482 community-dwelling elderly adults. *J Gerontol A Biol Sci Med Sci*. 1998;53:M264–M274.
20. Cesari M, Landi F, Torre S, Onder G, Lattanzio F, Bernabei R. Prevalence and risk factors for falls in an older community-dwelling population. *J Gerontol A Biol Sci Med Sci*. 2002;57:M722–M726.
21. Covinsky KE, Kahana E, Kahana B, Kercher K, Schumacher JG, Justice AC. History and mobility exam index to identify community-dwelling elderly persons at risk of falling. *J Gerontol A Biol Sci Med Sci*. 2001;56:M253–M259.
22. Cumming RG, Salkeld G, Thomas M, Szonyi G. Prospective study of the impact of fear of falling on activities of daily living, SF-36 scores, and nursing home admission. *J Gerontol A Biol Sci Med Sci*. 2000;55: M299–M305.
23. Gill TM, Williams CS, Tinetti ME. Environmental hazards and the risk of nonsyncopal falls in the homes of community-living older persons. *Med Care*. 2000;38:1174–1183.
24. Leveille SG, Bean J, Bandeen-Roche K, Jones R, Hochberg M, Guralnik JM. Musculoskeletal pain and risk for falls in older disabled women living in the community. *J Am Geriatr Soc*. 2002;50:671–678.
25. Tinetti ME, Doucette J, Claus E, Marottoli R. Risk factors for serious injury during falls by older persons in the community. *J Am Geriatr Soc*. 1995;43:1214–1221.
26. Northridge ME, Nevitt MC, Kelsey JL. Non-syncopal falls in the elderly in relation to home environments. *Osteoporos Int*. 1996;6:249–255.
27. O'Loughlin JL, Robitaille Y, Boivin JF, Suissa S. Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. *Am J Epidemiol*. 1993;137:342–354.
28. Tinetti ME, Inouye SK, Gill TM, Doucette JT. Shared risk factors for falls, incontinence, and functional dependence. Unifying the approach to geriatric syndromes. *JAMA*. 1995;273:1348–1353.
29. Tromp AM, Smit JH, Deeg DJ, Bouter LM, Lips P. Predictors for falls and fractures in the Longitudinal Aging Study Amsterdam. *J Bone Miner Res*. 1998;13:1932–1939.
30. Brown JS, Vittinghoff E, Wyman JF, et al. Study of Osteoporotic Fractures Research Group. Urinary incontinence: does it increase risk for falls and fractures? *J Am Geriatr Soc*. 2000;48:721–725.
31. Friedman SM, Munoz B, West SK, Rubin GS, Fried LP. Falls and fear of falling: which comes first? A longitudinal prediction model suggests strategies for primary and secondary prevention. *J Am Geriatr Soc*. 2002;50:1329–1335.
32. Ensrud KE, Blackwell TL, Mangione CM, et al. Central nervous system-active medications and risk for falls in older women. *J Am Geriatr Soc*. 2002;50:1629–1637.
33. Stalenhoef PA, Diederiks JP, Knottnerus JA, Kester AD, Crebolder HF. A risk model for the prediction of recurrent falls in community-dwelling elderly: a prospective cohort study. *J Clin Epidemiol*. 2002;55:1088–1094.
34. Perracini MR, Ramos LR. Fall-related factors in a cohort of elderly community residents [in Portuguese]. *Rev Saude Publica*. 2002;36:709–716.
35. Faulkner KA, Cauley JA, Zmuda JM, et al. Higher 1,25-dihydroxyvitamin D3 concentrations associated with lower fall rates in older community-dwelling women. *Osteoporos Int*. 2006;17:1318–1328.
36. Orwoll E, Lambert LC, Marshall LM, et al. Endogenous testosterone levels, physical performance, and fall risk in older men. *Arch Intern Med*. 2006;166:2124–2131.
37. Pajala S, Era P, Koskenvuo M, Kaprio J, Viljanen A, Rantanen T. Genetic factors and susceptibility to falls in older women. *J Am Geriatr Soc*. 2006;54:613–618.
38. Salva A, Bolibar I, Pera G, Arias C. Incidence and consequences of falls among elderly people living in the community. *Med Clin (Barc)*. 2004;122:172–176.

39. Schaap LA, Pluijm SM, Smit JH, et al. The association of sex hormone levels with poor mobility, low muscle strength and incidence of falls among older men and women. *Clin Endocrinol (Oxf)*. 2005;63:152–160.
40. Snijder MB, van Schoor NM, Pluijm SM, van Dam RM, Visser M, Lips P. Vitamin D status in relation to one-year risk of recurrent falling in older men and women. *J Clin Endocrinol Metab*. 2006;91:2980–2985.
41. Stel VS, Smit JH, Pluijm SM, Lips P. Balance and mobility performance as treatable risk factors for recurrent falling in older persons. *J Clin Epidemiol*. 2003;56:659–668.
42. Stone KL, Ewing SK, Lui LY, et al. Self-reported sleep and nap habits and risk of falls and fractures in older women: the study of osteoporotic fractures. *J Am Geriatr Soc*. 2006;54:1177–1183.
43. Teno J, Kiel DP, Mor V. Multiple stumbles: a risk factor for falls in community-dwelling elderly: a prospective study. *J Am Geriatr Soc*. 1990;38:1321–1325.
44. Cauley JA, Cummings SR, Seeley DG, et al. The Study of Osteoporotic Fractures Research Group. Effects of thiazide diuretic therapy on bone mass, fractures, and falls. *Ann Intern Med*. 1993;118:666–673.
45. Tromp AM, Pluijm SM, Smit JH, Deeg DJ, Bouter LM, Lips P. Fall-risk screening test: a prospective study on predictors for falls in community-dwelling elderly. *J Clin Epidemiol*. 2001;54:837–844.
46. van Schoor NM, Smit JH, Pluijm SM, Jonker C, Lips P. Different cognitive functions in relation to falls among older persons. Immediate memory as an independent risk factor for falls. *J Clin Epidemiol*. 2002;55:855–862.
47. Bergland A, Jarnlo GB, Laake K. Predictors of falls in the elderly by location. *Aging Clin Exp Res*. 2003;15:43–50.
48. Penninx BW, Pluijm SM, Lips P, et al. Late-life anemia is associated with increased risk of recurrent falls. *J Am Geriatr Soc*. 2005;53:2106–2111.
49. Graafmans WC, Ooms ME, Hofstee HM, Bezemer PD, Bouter LM, Lips P. Falls in the elderly: a prospective study of risk factors and risk profiles. *Am J Epidemiol*. 1996;143:1129–1136.
50. Bootsma-van der Wiel A, Gussekloo J, de Craen AJ, van Exel E, Bloem BR, Westendorp RG. Walking and talking as predictors of falls in the general population: the Leiden 85-Plus Study. *J Am Geriatr Soc.* 2003;51:1466–1471.
51. Mahoney J, Sager M, Dunham NC, Johnson J. Risk of falls after hospital discharge. *J Am Geriatr Soc*. 1994;42:269–274.
52. Duncan PW, Studenski S, Chandler J, Prescott B. Functional reach: predictive validity in a sample of elderly male veterans. *J Gerontol*. 1992;47:M93–M98.
53. Arden NK, Nevitt MC, Lane NE, et al. Study of Osteoporotic Fractures Research Group. Osteoarthritis and risk of falls, rates of bone loss, and osteoporotic fractures. *Arthritis Rheum*. 1999;42:1378–1385.
54. Luukinen H, Koski K, Laippala P, Kivela SL. Predictors for recurrent falls among the home-dwelling elderly. *Scand J Prim Health Care*. 1995;13:294–299.
55. Luukinen H, Koski K, Kivela SL, Laippala P. Social status, life changes, housing conditions, health, functional abilities and life-style as risk factors for recurrent falls among the home-dwelling elderly. *Public Health*. 1996;110:115–118.
56. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med*. 1988;319:1701–1707.
57. Weiner DK, Hanlon JT, Studenski SA. Effects of central nervous system polypharmacy on falls liability in community-dwelling elderly. *Gerontology*. 1998;44:217–221.
58. Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated with falls in older community-dwelling women. *J Am Geriatr Soc*. 1994;42:1110–1117.
59. Visvanathan R, Macintosh C, Callary M, Penhall R, Horowitz M, Chapman I. The nutritional status of 250 older Australian recipients of domiciliary care services and its association with outcomes at 12 months. *J Am Geriatr Soc*. 2003;51:1007–1011.
60. Stel VS, Pluijm SM, Deeg DJ, Smit JH, Bouter LM, Lips P. A classification tree for predicting recurrent falling in community-dwelling older persons. *J Am Geriatr Soc*. 2003;51:1356–1364.
61. Schwartz AV, Hillier TA, Sellmeyer DE, et al. Older women with diabetes have a higher risk of falls: a prospective study. *Diabetes Care*. 2002;25:1749–1754.
62. Fink HA, Kuskowski MA, Orwoll ES, Cauley JA, Ensrud KE. Association between Parkinson's disease and low bone density and falls in older men: the osteoporotic fractures in men study. *J Am Geriatr Soc*. 2005;53:1559–1564.
63. Mukamal KJ, Mittleman MA, Longstreth WT Jr, Newman AB, Fried LP, Siscovick DS. Self-reported alcohol consumption and falls in older adults: cross-sectional and longitudinal analyses of the cardiovascular health study. *J Am Geriatr Soc*. 2004;52:1174–1179.
64. Biderman A, Cwikel J, Fried AV, Galinsky D. Depression and falls among community dwelling elderly people: a search for common risk factors. *J Epidemiol Community Health*. 2002;56:631–636.
65. Delbaere K, Crombez G, Van Den Noortgate N, Willems T, Cambier D. The risk of being fearful or fearless of falls in older people: an empirical validation. *Disabil Rehabil*. 2006;28:751–756.
66. Delbaere K, Van den Noortgate N, Bourgois J, Vanderstraeten G, Tine W, Cambier D. The Physical Performance Test as a predictor of frequent fallers: a prospective community-based cohort study. *Clin Rehabil*. 2006;20:83–90.
67. Gallagher JC, Rapuri PB, Smith LM. An age-related decrease in creatinine clearance is associated with an increase in number of falls in untreated women but not in women receiving calcitriol treatment. *J Clin Endocrinol Metab*. 2007;92:51–58.
68. Gerdhem P, Ringsberg KA, Akesson K, Obrant KJ. Clinical history and biologic age predicted falls better than objective functional tests. *J Clin Epidemiol*. 2005;58:226–232.
69. Hanlon JT, Landerman LR, Fillenbaum GG, Studenski S. Falls in African American and white community-dwelling elderly residents. *J Gerontol A Biol Sci Med Sci*. 2002;57:M473–M478.
70. Pluijm SM, Smit JH, Tromp EA, et al. A risk profile for identifying community-dwelling elderly with a high risk of recurrent falling: results of a 3-year prospective study. *Osteoporos Int*. 2006;17:417–425.
71. Reyes-Ortiz CA, Al Snih S, Loera J, Ray LA, Markides K. Risk factors for falling in older Mexican Americans. *Ethn Dis*. 2004;14:417–422.
72. van Bemmel T, Vandenbroucke JP, Westendorp RG, Gussekloo J. In an observational study elderly patients had an increased risk of falling due to home hazards. *J Clin Epidemiol.* 2005;58:63–67.
73. Capon A, Di Lallo D, Mastromattei A, Pavoni N, Simeoni S. Incidence and risk factors for accidental falls among general practice elderly patients in Latina, Central Italy [in Italian]. *Epidemiol Prev*. 2007;31:204–211.
74. Coleman AL, Cummings SR, Yu F, et al. Binocular visual-field loss increases the risk of future falls in older white women. *J Am Geriatr Soc*. 2007;55:357–364.
75. Heesch KC, Byles JE, Brown WJ. Prospective association between physical activity and falls in community-dwelling older women. *J Epidemiol Community Health*. 2008;62:421–426.
76. van der Velde N, Stricker BH, Roelandt JR, Ten Cate FJ, van der Cammen TJ. Can echocardiographic findings predict falls in older persons? *PLoS ONE.* 2007;2:e654.
77. Bischoff-Ferrari HA, Orav EJ, Dawson-Hughes B. Additive benefit of higher testosterone levels and vitamin D plus calcium supplementation in regard to fall risk reduction among older men and women. *Osteoporos Int*. 2008;19:1307–1314.
78. Clough-Gorr KM, Erpen T, Gillmann G, et al. Preclinical disability as a risk factor for falls in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci*. 2008;63:314–320.
79. Ensrud KE, Ewing SK, Taylor BC, et al. Frailty and risk of falls, fracture, and mortality in older women: the study of osteoporotic fractures. *J Gerontol A Biol Sci Med Sci*. 2007;62:744–751.
80. Gassmann KG, Rupprecht R, Freiberger E. Predictors for occasional and recurrent falls in community-dwelling older people. *Z Gerontol Geriatr*. 2009;42:3–10.
81. Knudtson MD, Klein BE, Klein R. Biomarkers of aging and falling: The Beaver Dam eye study. *Arch Gerontol Geriatr*. 2009;49:22–26.
82. Leclerc BS, Begin C, Cadieux E, et al. Risk factors for falling among community-dwelling seniors using home-care services: an extended hazards model with time-dependent covariates and multiple events. *Chronic Dis Can*. 2008;28:111–120.
83. Pajala S, Era P, Koskenvuo M, Kaprio J, Tormakangas T, Rantanen T. Force platform balance measures as predictors of indoor and outdoor

falls in community-dwelling women aged 63–76 years. *J Gerontol A Biol Sci Med Sci*. 2008;63:171–178.
84. Stone KL, Ancoli-Israel S, Blackwell T, et al. Actigraphy-measured sleep characteristics and risk of falls in older women. *Arch Intern Med*. 2008;168:1768–1775.
85. Iinattiniemi S, Jokelainen J, Luukinen H. Falls risk among a very old home-dwelling population. *Scand J Prim Health Care*. 2009;27:25–30.
86. Kulmala J, Viljanen A, Sipila S, et al. Poor vision accompanied with other sensory impairments as a predictor of falls in older women. *Age Ageing*. 2009;38:162–167.
87. Srikanth V, Beare R, Blizzard L, et al. Cerebral white matter lesions, gait, and the risk of incident falls: a prospective population-based study. *Stroke*. 2009;40:175–180.
88. Cummings SR, Nevitt MC, Kidd S. Forgetting falls: the limited accuracy of recall of falls in the elderly. *J Am Geriatr Soc*. 1988;36:613–616.
89. Savica R, Beghi E, Mazzaglia G, et al. Prescribing patterns of antiepileptic drugs in Italy: a nationwide population-based study in the years 2000–2005. *Eur J Neurol*. 2007;14:1317–1321.
90. Howe TE, Rochester L, Jackson A, Banks PM, Blair VA. Exercise for improving balance in older people. *Cochrane Database Syst Rev*. 2007;4:CD004693.

