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The epidemiology of falls and syncope

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Falls and syncope are two common and interrelated geriatric syndromes that cause considerable mortality and morbidity among older adults. Multiple causes and predisposing risk factors have been identified for both falls and syncope, which makes the diagnosis, treatment, and particularly prevention of these syndromes difficult clinical challenges. The most promising prevention strategies for falls and syncope involve the identification of individuals who are at increased risk and the implementation of appropriate interventions. This article provides an overview of the epidemiology of falls and syncope in both community-dwelling and institutionalized older adults and reviews the most common causes and risk factors.

Epidemiology of falls and syncope

Incidence of falls

Prospective studies have reported that 30% to 60% of community-dwelling older adults fall each year [6,11,47,52,62,92], with approximately half of them experiencing multiple falls. Fall incidence rates for community-dwelling older populations range from 0.2 to 1.6 falls per person per year, with a mean of approximately 0.7 falls per year (Table 1). The incidence rises steadily after middle age and tends to be highest among individuals 80 years of age and older [10]. These incidence rates are based on self-reported data, which not only may underestimate the true incidence of falls but also may overrepresent the proportion of individuals who report multiple falls.

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Table 1
Incidence of falls and fall-related injuries in prospective studies of community-based populations

Reference	Age	Sample size	% of population who fall/year	Annual fall incidence/1000 persons	% of falls with fracture	% of falls with other serious injury
Community-based surveys						
Sorock, [80]	≥ 60	169	34	609	NA	NA
Tinetti, [92]	≥ 75	336	32	809	6	4
Campbell, [11]	≥ 70	761	35	683	4	NA
Nevitt, [62]	≥ 60	325	57	1658	3	1
Hale, [27]	≥ 65	102	36	549	5	NA
Tinetti, [89]	≥ 72	1103	34	450	NA	10
O'Loughlin, [65]	≥ 65	409	29	482	3	1
Lord, [45]	≥ 65	341	39	842	NA	NA
Luukinen, [47]	≥ 70	M = 377 F = 602	30	M:368 F:611	NA	NA
Maki, [52]	≥ 62	96	61	1200	NA	NA
Studenski, [81]	≥ 70	306	33	1630	NA	NA
Tinetti, [91]	≥ 70	144	47	1100	NA	11
Davis, [16]	≥ 60	1073	M:9 F:16	M:139 F:276	M:0 F:12	M:9 F:NA
Berg, [6]	≥ 60	96	52	950	6	9
Simple mean of all surveys			34	772	6	6
Weighted mean of all surveys				653		

Summary of 14 studies [6,11,16,27,45,47,52,62,65,80,81,87,89,92].

The incidence among institutionalized elderly populations (Table 2) is considerably higher than that among community-dwelling elderly populations. Both the frailer nature of institutionalized populations and the more accurate reporting of falls in institutional settings cause this difference. In surveys of nursing home populations, the percentage of residents who fall each year ranges from 16% to 75%, with an overall mean of 43% [25,26,72,94]. The annual incidence of falls in long-term care facilities averages approximately 1.6 falls per bed (range 0.2–3.6 falls). Incidence rates from hospital-based surveys are somewhat lower, with a mean of 1.4 falls per bed per year (range 0.5–2.7 falls). In Tables 1 and 2, great variations in incidence rates exist between the prospective studies listed. This most likely reflects differences in case-mix, ambulation levels, reporting practices, and institutional falls-prevention policies and programs.

Fall-related mortality

Accidents are the fifth leading cause of death in older adults (after cardiovascular, cancer, stroke, and pulmonary causes), and falls constitute two thirds of these accidental deaths. Approximately three fourths of the deaths caused by falls in the United States occur in the 13% of the population that is aged 65 years and older [28]. Fall-related mortality increases dramatically with advancing age, especially in populations over 70 years of age. Older men have a higher mortality

Table 2
Incidence of falls and fall-related injuries in prospective studies of institutionalized populations

Reference	Age	Sample size	% of population who fall/year	Annual fall incidence/ 1000 persons	% of falls with fracture	% of falls with other serious injury
Hospital based surveys						
Pablo, [67]	72 (Mean)	186 beds	NA	790	0	17
Sehested, [75]	91% ≥ 60	97 beds	26	2700	4	1
Morris, [57]	99% ≥ 65	196 beds	NA	1500	2	0
Morgan, [56]	≥65	12,248	NA	1400	NA	NA
Morse, [58]	NA	1160 beds	NA	840	1	2
Simple mean of all surveys			26	1400	2	5
Weighted mean of all surveys				1350		
Long-term care based surveys						
Gryfe, [26]	81% ≥ 75	200 beds	45	650	6	17
Miller, [54]	82 (Mean)	139	50	1400	NA	NA
Colling, [14]	NA	129	NA	2600	2	5
Blake, [8]	≥60	59	NA	3600	NA	3
Gross, [25]	82 (Mean)	178 beds	16	220	10	15
Rubenstein, [72]	≥65	704	75	1200	2	1
Neufeld, [61]	84 (Mean)	514 beds	NA	630	NA	NA
Tinetti, [90]	84 (Mean)	397	54	1530	3	3
Lauritzen, [38]	66% ≥ 80	665	NA	1448	NA	NA
Luukinen, [47]	≥70	M = 28 F = 101	NA	M:2021 F:1423	NA	NA
Jantti, [30]	≥60	796	26	2800	NA	NA
Nurmi, [64]	≥60	440	36	1440	3	5
Simple mean of all surveys			43	1600	4	7
Weighted mean of all surveys				1550		

Summary of 17 studies [8,14,25,26,30,38,47,54,56–58,61,64,67,72,75,90].
Note: NA = data not available; M = male; F = female.

rate from falls than do older women, and nursing home residents 85 years and older account for one in five fatal falls [3]. The estimated 1% of people who fall and sustain a hip fracture had a mortality rate of 20% to 30% within 1 year of the fracture [50].

Fall-related morbidity

A key issue of concern is not simply the high incidence of falls in elderly persons—young children and athletes certainly have an even higher incidence of falls—but rather the combination of this high incidence and a high susceptibility to injury. The propensity for fall-related injuries in elderly persons is caused by a high prevalence of clinical diseases (e.g., osteoporosis) and age-related physiologic changes (e.g., slowed protective reflexes) that make even a relatively mild fall particularly dangerous. Although most falls produce no serious injury,

community surveys reported over half of falls result in minor injuries that usually do not require medical treatment [66,88]. Nonetheless, between 5% and 10% of community-dwelling older adults who fall each year do sustain a serious injury, such as a fracture, head injury, or serious laceration [63,88]. The proportion of falls that result in serious injuries is roughly similar among community-dwelling and institutionalized populations, but the reported range is wide (1%–39%) because of differences in reporting practices (Tables 1 and 2), and these injuries are often associated with considerable long-term morbidity. Among community-dwelling individuals with fall-related hip fractures, studies have shown that between 25% and 75% do not recover their prefracture level of function in ambulation or activities of daily living [50].

In addition to physical injuries, falls can produce other serious consequences for the elderly person. Repeated falls are a common reason for the admission of previously independent elderly persons to long-term care institutions [79]. In one study, 50% of fall injuries that required hospital admission resulted in the elderly person being discharged to a nursing home [73]. In a prospective study of a community-dwelling older population, the risk of nursing home placement for individuals who had sustained at least one fall with a serious injury was three times greater than for individuals with only one noninjurious fall [93].

Fear of falling has been recognized as a negative consequence of falls. Surveys have reported 30%–73% of older persons, who have fallen acknowledge a fear of falling [37,91,96]. This post-fall anxiety syndrome can result in self-imposed activity restrictions among both home-living [91,99] and institutionalized [68] elderly individuals who have experienced a fall. Loss of confidence in the ability to ambulate safely can result in further functional decline, depression, feelings of helplessness, and social isolation.

Incidence and consequences of syncope

The epidemiology of syncope has not been documented well, owing in part to the paroxysmal nature of syncope, poor recall by patients, and inconsistent reporting methods. In studies that have tried to determine the most likely cause for falls, the percentage of falls attributed to syncope ranges only from 0.5% to 3.0%; however, because syncope is excluded in most studies of falls, these percentages are probably unrepresentatively low. Syncope was reported to account for approximately 3% of emergency department visits and 1% of medical admissions to a general hospital [18]. In a study of 188 older patients who sought care at an emergency department after a fall, 26% reported syncope [15]. In a prospective study of nursing home residents, the yearly incidence of syncope was 6%, and 30% of these patients had at least one recurrent episode [44].

There is some evidence that syncope is associated with a high risk of injury among older adults. In studies that evaluated elderly patients with syncope or unexplained falls, fractures and other major injuries were associated with 10% to 23% of syncopal episodes [34,53]. In another study, the risk of a major injury was 5.9 times greater for syncopal falls than for nonsyncopal falls [63]. Syncopal falls

also have been associated with a higher risk of having a long lie after a fall, [63] which in itself is a poor prognostic sign.

There is some debate over whether syncope itself causes increased mortality and sudden death or whether it is merely a marker for underlying pathophysiology. One-year mortality rates for patients with an episode of syncope range between 13% and 33% in studies of hospitalized patients [20,34], and a recent study reported that 4-year mortality rates for patients hospitalized with a diagnosis of syncope was 79% higher than expected [23]. Studies also have reported that elderly syncope patients have higher mortality rates than do younger patients [20,23,33] and that patients with a cardiac cause for syncope have higher mortality rates than those with a noncardiac cause [20,34,77]. In a recent large study of hospitalized syncope patients, however, 4-year mortality rates for patients with cardiovascular causes did not differ from that for patients with a noncardiovascular or unknown cause of syncope. Poorer survival was associated with higher comorbidity and age [23]. These data support the findings of a recent case-control study that compared outcomes for hospitalized patients with and without syncope [33]. In this study, syncope was not a predictor of 1-year mortality when other comorbid conditions were taken into account. The strongest risk factors for mortality in patients with and without syncope were comorbid cardiac diseases (specifically a history of congestive heart failure), male gender, and age over 55 years. Virtually all of these findings were based on hospitalized patients; individuals with syncope, who are not hospitalized, may have different outcomes.

Causes of falls

Determining the major causes of falls has been an objective of many studies; however, the comparability of findings has been limited by the following factors:

- Differences in diagnostic approaches used between studies
- Differences in study populations
- Differences in classification methods (e.g., single best diagnosis versus multiple diagnoses used for classifying each fall and varying importance placed on coexisting environmental hazards)
- Variable patient recall
- Multifactorial causality of many falls (e.g., a trip and fall caused by a gait disorder and poor vision, combined with an object on the floor)

Nonetheless, these studies provide useful general information about the reasons for falls among the elderly population.

Table 3 lists the major causes of falls and their relative frequencies based on the major published literature. Of the 12 studies reviewed, six were conducted among institutionalized populations [42,46,60,72,74,83], and six were conducted among community-dwelling populations [9,13,21,55,71,76]. Fall incidence and distribution of causes clearly differ among the populations

Table 3
Causes of falls in older persons: summary of 12 large studies

Cause	Mean (%)[a]	Range[b]
Accident and environment-related	31	1–53
Gait and balance disorders or weakness	17	4–39
Dizziness and vertigo	13	0–30
Drop attack	9	0–52
Confusion	5	0–14
Postural hypotension	3	0–24
Visual disorder	2	0–5
Syncope	0.3	0–3
Other specified causes[c]	15	2–39
Unknown	5	0–21

Summary of 12 studies [9,13,21,42,46,55,60,71,72,74,76,83].
[a] Mean percent calculated from the 3628 reported falls.
[b] Ranges indicate the percentage reported in each of the 12 studies.
[c] This category includes: arthritis, acute illness, drugs, alcohol, pain, epilepsy, and falling from bed.

studied. Frail, high-risk populations have higher incidence of all types of falls, particularly medically related falls, than do healthier populations. Environmentally related falls are more common in community-dwelling populations than in institutionalized populations.

So-called accidents, or falls stemming from environmental hazards, comprise the largest fall cause category, accounting for 25% to 45% in most series. However, falls in this category stem from interactions between environmental hazards, or hazardous activities, and increased individual susceptibility to these hazards from the accumulated effects of age and disease. Among impaired patients, even normal activities of daily living may be considered hazardous if they are performed without assistance or modification. Most healthy older people have stiffer, less-coordinated, and more-precarious gaits than do younger people. Posture control, speed of body-orienting reflexes, muscle strength and tone, and stepping height all decrease with aging and impair an individual's ability to avoid a fall after an unexpected trip or while reaching or bending. Age-associated impairments of vision, hearing, and memory also tend to increase the number of trips and stumbles. A person's physiologic strategy for adjusting to slips, trips, and other sudden horizontal displacements is altered with aging and can range from being unable to adjust rapidly at the hip or ankle without taking a step, to compensating by rapidly stepping backward or forward, to not being able to compensate at all without falling [29].

Although the environment outside the home certainly contains many fall hazards, impaired older adults are most likely to fall inside their own homes, perhaps because they spend more time inside and may be more careless there [62,78,92]. These in-home falls generally occur on a level surface [4,78,92] during activities that require only low to moderate displacement of the individual's center of gravity (e.g., standing, walking, transferring, bending, reaching) [92]. In nursing homes, most falls occur in the bedroom at the bedside or in the bathroom [7,19,32]. Certain activities that are associated with falls in these

locations commonly include arising from bed, ambulating to and from the bathroom, and transferring to a bed, chair, or toilet [7,26,32], which are activities known to be associated with intrinsic fall risks from postural changes and vasovagal reflexes. Environmental hazards that frequently contribute to these falls include wet floors (caused by spills or episodes of incontinence), poor lighting, bedrails, and improper bed height. Falls also have been reported to increase when nurse staffing is low [8], during shift changes (presumably because of a lack of staff supervision) [19], and after meals (which likely is related to the phenomenon of postprandial orthostatic hypotension) [41].

The broad category of gait problems and muscle weakness is the second most common cause for falls. In addition to the age-related changes mentioned previously, gait problems and weakness can stem from specific dysfunctions of the nervous, muscular, skeletal, circulatory, and respiratory systems (e.g., stroke, parkinsonism, and arthritis) and from simple deconditioning after inactivity. Muscle weakness is extremely common among the aged population and studies have reported the prevalence of grossly detectable lower extremity weakness ranging from 48% among community-dwelling older persons [10], to 57% among residents of an intermediate-care facility [94], and to over 80% among nursing home residents [71]. Muscle weakness, especially plantarflexor and dorsiflexor weakness, is a common cause of gait disorders, which affect 20%–50% of the elderly population [82]. Case-control studies reported that over two thirds of individuals who have fallen have substantial gait disorders, considerably higher than control subjects who have not experienced a fall [62,71,92,94]. Although there is general agreement that a reduction in muscle strength accompanies the aging process, much of this reduction stems from disease and inactivity rather than aging per se.

Dizziness is an extremely common complaint among elderly people who have fallen and requires a careful history for clarification, because the description of dizziness means different things to different people and arises from diverse causes. True vertigo, a sensation of rotational movement, may indicate a disorder of the vestibular apparatus (e.g., benign positional vertigo, acute labyrinthitis, and Meniere's disease). Symptoms described as imbalance when walking often reflect a gait disorder. Many patients describe a vague lightheadedness, which may reflect cardiovascular problems (e.g., arrhythmia and heart failure) hyperventilation, orthostatic hypotension, drug side-effects, anxiety, or depression. Because this category is 50 heterogeneous, referring to it as the third leading cause of falls may be misleading.

Drop attacks are defined as falls that are associated with sudden leg weakness, but without dizziness or loss of consciousness. A sudden change in head position is often the precipitating event. This syndrome has been attributed to transient vertebrobasilar insufficiency but probably is caused by more diverse pathophysiologic mechanisms, including knee instability. Leg weakness is usually transient but can persist for hours. Recent studies have found substantially fewer falls from true drop attacks than did earlier studies, probably because of better documentation and diagnostic precision. Most researchers believe that the 9%

mean figure shown in Table 3 is still too high an estimate, reflecting an earlier time when drop attacks were an ill-defined wastebasket category.

Confusion and cognitive impairment frequently is cited as a cause of falls and may reflect an underlying systemic or metabolic process that causes both the confusion and the fall itself, such as electrolyte imbalance and fever. Dementia can increase falls by impairing judgment, visuospatial perception, and the ability to orient one's self geographically. The wandering activities of demented patients often are associated with falls.

Orthostatic hypotension, defined as a drop of over 20 mm Hg in systolic blood pressure after standing, has a 5%–25% prevalence among normal elderly people living at home [70]. It is even more common among individuals with certain predisposing risk factors, including autonomic dysfunction, hypovolemia, low cardiac output, parkinsonism, metabolic and endocrine disorders, and medications (particularly sedatives, antihypertensives, vasodilators, and antidepressants) [31,49]. The orthostatic drop may be more pronounced on arising in the morning, and after meals, the former occurring because of diminished baroreceptor response following prolonged recumbency [41]. Although orthostatic hypotension clearly can cause falls, most people with this syndrome can adjust to the symptoms without falling; thus, it is not as common a cause for falls as its high prevalence might suggest.

Syncope is a serious but somewhat less common cause of falls in most studies; however, the low percentage of falls attributed to syncope in Table 3 is probably an underestimation, because many of the fall studies specifically excluded patients with syncope. Even the studies that did not specifically exclude syncope probably still underestimated the importance of syncope among those who have fallen, because syncope patients were disproportionately more likely to have been hospitalized immediately and not be included in the study. Moreover, a history of syncope is more difficult to obtain than that of most other causes of falls, because many syncope patients have retrograde amnesia and do not remember exactly how the fall occurred. Patients often confuse symptoms of drop attacks or dizziness with those of syncope. Although falls are much more frequent than episodes of syncope, the clinical spectrums of falls and syncope clearly overlap: Most episodes of syncope cause falls (certainly when occurring in the upright position), and a small but significant proportion of all falls are caused by syncope. To further complicate this overlap, the syndrome of near-syncope, or presyncope, which arises from transient arrhythmias, orthostatic hypotension, hypoglycemia, or other causes of true syncope, could cause falls and herald the onset of later syncope.

Other specified causes of falls include visual problems, arthritis, acute illnesses, disorders of the central nervous system, drug side effects, and alcohol intake. Drugs frequently have side effects that result in impaired mentation, stability, and gait. Especially important are those agents with sedative, antidepressant, and antihypertensive effects, particularly diuretics, vasodilators, and beta-blockers [24,80]. Other, less-common causes of falls include seizures, carotid sinus hypersensitivity syndrome [53], anemia, hypothyroidism, unstable joints, foot problems, and severe osteoporosis with spontaneous fracture.

Causes of syncope

As with falls, syncope can be caused by a multitude of different conditions, some of which are relatively benign and others potentially life threatening. A number of studies have evaluated patients carefully after a syncopal episode to determine the most likely cause. Table 4 lists those studies that included primarily elderly patients. The study populations range from outpatients evaluated in a clinic setting to patients admitted to hospital intensive care units. Consequently, the causes identified in each setting vary in severity.

Overall, when these studies are combined, noncardiovascular causes account for the largest category of syncopal episodes for which a cause could be determined (38% of all syncope cases). The most common causes included in this category are orthostatic hypotension, vasovagal response, and drug-induced syncope. Cardiovascular causes accounted for almost a quarter of syncopal events, with arrhythmias and heart block being the most common mechanisms. Not surprisingly, cardiac causes for syncope comprise a larger proportion in studies of patients who were admitted to intensive care units. In spite of extensive evaluations, the cause of syncope was not identified in 39% of patients overall. This high rate probably was caused by the transient nature of symptoms, the precipitating events associated with syncope, and the possibility that some episodes may not have been actual syncopal events.

Risk factors

Because a single specific cause for falling often cannot be identified and because falls are usually multifactorial in their origin, many investigators have performed epidemiologic case-control studies to identify specific risk factors, the presence of which places individuals at an increased likelihood of falling. The idea behind these studies is that, by identifying risk factors early, preventive strategies can be devised and instituted. Table 5 lists the major fall risk factors that were identified in a univariate analysis of multiple risk factors from 16 studies, which examined and compared individuals who experienced a fall with those who did not. Eight of these studies were conducted in community-dwelling populations [6,10,17,51,62,71,92,95] and eight were conducted in nursing home populations [36,42,48,59,66,71,85,94].

In all but one of the studies that evaluated muscle strength, lower-extremity weakness (detected by either functional testing or manual muscle examination) was identified as a significant risk factor, increasing the odds of falling over 4-fold on average (1.5–10.3). Gait and balance impairments and having a previous history of falls also were found to be significant risk factors in many studies, being associated with an approximately 3-fold increased risk of falling. Using an assistive device, visual deficits and arthritis were associated with an approximately 2.5-fold increased risk of falling. Depression, cognitive impairment, the inability to perform basic activities of daily living, and an age of

Table 4
Frequency of syncope etiologies in 6 studies in primarily elderly patients[a]

Symptoms	Kapoor 1986 ER, Hospital, Clinic $n = 210$	Getchell 1999 Hospital $n = 1516$	Silverstein 1982 ICU $n = 108$	Dougnac 1991 ICU $n = 91$[c]	Lipsitz 1986 NH $n = 97$	Allcock[b] 2000 Clinic $n = 120$	Total $n = 2142$
Arrhythmias	47	169	23	18	4	1	262 (12.2)
Heart block	7	48	6	24	2	0	87 (4.1)
Aortic stenosis	8	14	4	5	5	1	37 (1.7)
Myocardial infarction	4	16	6	5	6	0	37 (1.7)
Carotid sinus syndrome	5	0	0	1	1	44	51 (2.4)
Cardiac ischemia	0	0	0	0	3	0	3 (0.1)
Miscellaneous cardiac[d]	0	37	3	0	0	0	40 (1.9)
Orthostatic hypotension	18	166	4	3	6	35	232 (10.8)
Vasovagal response	3	175	1	0	0	4	183 (8.5)
Drug-induced	7	55	4	7	11	0	84 (3.9)
Situational[e]	15	18	1	4	13	0	51 (2.4)
Cerebrovascular event	7	31	5	1	3	0	47 (2.2)
Seizure disorder	3	29	0	0	3	1	36 (1.7)
Postprandial hypotension	0	0	0	0	8	0	8 (0.4)
Miscellaneous[f]	3	128	0	3	7	29	170 (7.9)
Unknown etiology	83 (39.5)	630 (41.6)	51 (47.2)	33 (36.3)	25 (25.8)	17 (14)	839 (39.2)

Note: ER = emergency room; ICU = intensive care unit; NH = nursing home.

[a] [1,20,23,34,43,77].

[b] 20% had more than one cause.

[c] 3 patients had more than one cause identified.

[d] Includes cough, micturition, and defecation syncope.

[e] Includes pulmonary embolus, pulmonary hypertension, aortic aneurysm.

[f] Includes psychiatric causes, bleeding or anemia, subclavian steal, trigeminal neuralgia, vertigo, drop attack, volume depletion.

Table 5
Risk factors for falls identified in 16 studies that examined multiple risk factors: Summary of univariate analysis

Risk factor	Significant/total[a]	Mean RR, OR[b]	Range
Muscle weakness	10/11	4.4	1.5–10.3
History of falls	12/13	3.0	1.7–7.0
Gait deficit	10/12	2.9	1.3–5.6
Balance deficit	8/11	2.9	1.6–5.4
Use assistive device	8/8	2.6	1.2–4.6
Visual deficit	6/12	2.5	1.6–3.5
Arthritis	3/7	2.4	1.9–2.9
Impaired ADL	8/9	2.3	1.5–3.1
Depression	3/6	2.2	1.7–2.5
Cognitive impairment	4/11	1.8	1.0–2.3
Age >80 years	5/8	1.7	1.1–2.5

[a] Number of studies with significant odds ratio or relative risk ratio in univariate analysis/total number of studies that included each factor

[b] RR = relative risk ratio; OR = odds ratio. RR calculated for prospective studies; OR calculated for retrospective studies. *Data from* references [6,10,17,36,42,48,51,59,62,66,71,85,92,94,95].

over 80 years were associated with approximately a 2-fold increased risk of falling.

The relationship between medication use and falls also has been examined in many studies. A recent meta-analysis [39] that pooled data from 40 studies found that the odds ratio (OR) for one or more falls was 1.7 for psychotropic drug use. Use of sedatives, hypnotics, antidepressants, benzodiazepines, and neuroleptics each were associated with a pooled OR of approximately 1.5. A second meta-analysis, which included data from 29 studies that examined the use of cardiac and analgesic drugs and falls, found somewhat weaker associations between falls and the use of digoxin (OR = 1.2), type Ia antiarrhythmics (OR = 1.6), and diuretics (OR = 1.1) [40]. Associations were not found for other classes of cardiac or analgesic drugs. In addition, several studies implicate strong relationships between the risk of falls and the use of three or more medications [10,42,59,81].

Eleven of the studies shown in Table 5 used multivariate analysis to better understand possible interactions between the individual risk factors and to rank their relative importance [10,17,36,42,48,51,59,62,92,94,95]. The risk factors that emerge from these analyses were similar to the univariate factors; however, the size of risk was altered for some of them. Muscle weakness remained the dominant risk factor with a 4-fold increased risk of falls (3.0–5.9). Balance deficits and history of falls were still associated with an approximately 3-fold increased risk of falls. Cognitive impairment, age over 80 years, and visual impairments also increased fall risk approximately 3-fold; however, gait deficits declined to a 2-fold increased risk of falls in the multivariate analyses.

Many other case-control studies have examined the relationship between falls and single possible risk factors. Several studies examined the relationship of leg strength and fall status. Gehlson and Whaley [22] reported healthy older persons with a history of falling had significantly lower leg strength than did those

without a history of falling. Whipple et al. [101] examined knee and ankle strength among institutionalized individuals and reported that weakness at both joints was found to be significantly more common among those who experienced a fall than among those who did not. The authors also performed a gait analysis of 49 nursing home patients and found that those who had fallen had significantly slower gait speed and shorter stride length than did those who had not experienced a fall [102]. Studenski et al. [81] found that outpatients with impaired mobility had a significantly higher rate of recurrent falls over a 6-month period. Other studies have compared the measures of dynamic balance in older adults who have and have not fallen. Deficits in the ability to control lateral stability were associated with increased risk of falling in healthy ambulatory population [52]. Other single-variable risk-factor studies have documented significant relationships between falls and psychotropic medications and sedatives [69,80], cardiac medications [35,100], postprandial hypotension [31], and constricted visual fields [5].

Possibly even more important than identifying risk factors for falling is identifying risk factors for injurious falls, because most falls do not result in injury. Several research groups have identified risk factors that are associated with injurious falls. Among nursing home residents, lower-extremity weakness, female gender, poor vision and hearing, disorientation, number of falls, impaired balance, dizziness, low body mass, and use of mechanical restraints have been identified as factors that increase the risk of an injurious fall [83,84,86,90]. Surprisingly, patients who are functionally independent and not depressed also have a greater risk of injury [86], probably because they are more active. Risk factors identified as increasing the likelihood of an injurious fall among community-dwelling individuals include a previous fall with a resultant fracture, Caucasian race, impaired cognitive function, and impaired balance (i.e., unable to stand unsupported on one leg for 5 seconds) [63,97]. A survey of elderly Medicaid enrollees revealed that the risk of hip fracture increased 2-fold for both nursing home residents and community-dwelling elderly persons who were taking psychotropic medications [69]. All in all injurious falls have the same risk factors as for falls in general, with the additional factors of female gender, low body mass (both of which probably are related largely to osteoporosis), and higher physical activity.

An appreciation of the interactions and probable synergism among multiple risk factors is just as important as the identification of individual risk factors. Several studies have shown that the risk of falling increases dramatically in relation to increases in the number of risk factors [62,71,92,94]. In a survey of community-dwelling elderly persons, Tinetti et al. [92] reported the percentage of people who fell increased from 27% among those with none or one risk factor to 78% among those with four or more risk factors. Identified risk factors include sedative use, decreased cognition, leg and foot disabilities, gait and balance impairments, and the presence of a palmomental reflex. Similar results were found among an institutionalized population [94]. Nevitt et al. [62] reported that the percentage of community-dwelling individuals with recurrent falls increased from 10% to 69% as the number of risk factors increased from one to four or

more. The identified risk factors included white race, a history of previous falls, arthritis, parkinsonism, difficulty rising, and poor tandem gait.

In a study by Robbins et al. [71] that involved both an institutionalized and outpatient population, many individual risk factors were significantly connected to falls. Multivariate analysis enabled simplification of the model so that maximum predictive accuracy could be obtained by using only 3 risk factors (e.g., manually assessed hip weakness, unstable balance, and the use of 4 or more prescribed medications) in a branching-logic, algorithmic fashion. With this model, the predicted 1-year risk of falling ranged from 12% for people with none of the 3 risk factors to 100% for people with all 3 risk factors. From this review, the ability to identify those who are at substantially increased risk of falling by detecting the presence of risk factors is clearly possible.

Two recent, controlled-intervention trials demonstrated that a program of risk-factor identification and targeted interventions reduced 1-year fall rates among community-dwelling older adults [87,98]. Consequently, risk-factor identification seems to be a promising first step in developing effective falls-prevention programs for high-risk patients. Many institutional settings have designed ongoing fall-prevention programs that identify high-risk individuals and provide multifaceted prevention and monitoring interventions; however, these strategies have not been tested in controlled trials.

Risk factors for syncope

Fewer studies have reported risk factors associated with syncope. As evidenced by the research on syncope causes, the presence of cardiac disease is undoubtedly an important underlying risk factor, as are any conditions or medications that cause orthostatic hypotension. In a prospective study of 97 nursing home residents, multivariate analysis identified five independent risk factors for syncope: coronary artery disease, functional impairment, postural hypotension, aortic stenosis, and insulin therapy [43]. Patients with syncope also were twice as likely as controls to have two or more of these risk factors. In another nursing home study, postprandial hypotension, male gender, and a previous syncopal episode were identified as independent risk factors for syncope [2]. Medications identified as increasing the risk of syncope in elderly hospitalized patients included fluoxetine, acepromethazine, haloperidol, and L-dopa [12]. Each of these drugs had an OR of 2.0–2.8. Further case-control studies are needed in order to better understand the mechanisms of syncope, and to identify the risk factors amenable to intervention.

Summary

Falls, syncope, and the associated complications are among the most serious problems that face the elderly population. The most common underlying causes

and risk factors for falls include muscle weakness, gait and balance problems, visual impairment, cognitive impairment, depression, functional decline, and particular medications (especially in the presence of environmental hazards). Studies have identified the relative risks for these factors that enable a fairly accurate prediction of who is at high risk for falls and what areas to target for falls-prevention activity. Causes and risk factors for syncope have not been studied as well in the older population. The most serious types of syncope have underlying cardiac etiologies but they cause less than 25% of the reported cases. The largest category of syncope (approximately 40%) is syncope of unknown etiology, which defies careful diagnostic evaluation but seems to be fairly benign. The epidemiology of these syndromes can provide extremely helpful insights for developing falls-prevention strategies.

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References

[1] Allcock L, O'Shea D, Kenny RA. Outcome of neurocardiovascular investigation of dizziness, falls, and syncope in elderly patients at a district hospital. J Am Geriatr Soc. In press.
[2] Aronow W, Ahn C. Association of postprandial hypotension with incidence of falls, syncope, coronary events, stroke, and total mortality at 29-month follow-up in 499 older nursing home residents. J Am Geriat Soc 1997;45:1051–3.
[3] Baker S, Harvey A. Fall injuries in the elderly. Clin Geriatr Med 1985;1:501–12.
[4] Baker S, O'Neill B, Karpf R. Falls the injury fact book. Lexington (MA): Lexington Books; 1984. p. 113–26.
[5] Berg W, Alessio H, Mills E, Tong C. Correlates of recurrent falling in independent community-dwelling older adults. J Motor Behav 1997;29:5–16.
[6] Berg W, Alessio H, Mills E, Tong C. Circumstances and consequences of falls in independent community-dwelling older adults. Age Ageing 1997;26:261–8.
[7] Berry G, Fisher RH, Lang S. Detrimental incidents, including falls, in an elderly institutional population. J Am Geriatr Soc 1981;29:322–4.
[8] Blake C, Morfitt JM. Falls and staffing in a residential home for elderly people. Public Health 1986;100:385–91.
[9] Brocklehurst JC, Exton-Smith AN, Lempert-Barber SM, Hunt LP, Palmer MK. Fractures of the femur in old age: A two-centre study of associated clinical factors and the cause of the fall. Age Ageing 1978;7:7–15.
[10] Campbell AJ, Borrie MJ, Spears GF. Risk factors for falls in a community-based prospective study of people 70 years and older. J Gerontol 1989;44:M112–7.
[11] Campbell AJ, Borrie MJ, Spears GF, Jackson SL, Brown JS, Fitzgerald JL. Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. Age Ageing 1990;19:136–41.
[12] Cherin P, Colvez A, Deville de Periere G, Sereni D. Risk of syncope in the elderly and consumption of drugs: A case-control study. J Clin Epidemiol 1997;50:313–20.

[13] Clark ANG. Factors in fracture of the female femur: a clinical study of the environmental, physical, medical, and preventative aspects of this injury. Gerontol Clin 1968;10:257–70.
[14] Colling J, Park D. Home, safe home. J Gerontol Nurs 1983;9:175–9.
[15] Davies AJ, Kenny RA. Falls presenting to the accident and emergency department: Types of presentation and risk factor profile. Age Ageing 1996;25:362–6.
[16] Davis J, Ross P, Nevitt M, Wasnich RD. Incidence rates of falls among Japanese men and women living in Hawaii. J Epidemol 1997;50:589–94.
[17] Davis J, Ross P, Nevitt M, Wasnich RD. Risk factors for falls and for serious injuries on falling among older Japanese women in Hawaii. J Am Geriatr Soc 1999;47:792–8.
[18] Day SC, Cook EF, Funkenstein H, Goldman L. Evaluation and outcome of emergency room patients with transient loss of consciousness. Am J Med 1982;72:15–23.
[19] Dimant J. Accidents in the skilled nursing facility. N Y State J Med 1985;85:202–5.
[20] Dougnac A, Gonzalez R, Kychenthal A, Loyola MS, Rubio R, Rubenstein LZ. Syncope: Etiology, prognosis, and relationship to age. Aging 1991;3:63–72.
[21] Exton-Smith AN. Functional consequences of aging: Clinical manifestations. In: Exton-Smith AN, Grimley Evans J, editors. Care of the elderly: meeting the challenge of dependency. London: Academic Press; 1977. p. 41–53.
[22] Gehlson GM, Whaley MH. Falls in the elderly: Balance, strength, and flexibility. Arch Phys Med Rehabil 1990;71(Part II):739–41.
[23] Getchell WS, Larsen GC, Morris CD, McAnulty JH. Epidemiology of syncope in hospitalized patients. J Gen Intern Med 1999;14:677–87.
[24] Granek E, Baker SP, Abbey H. Medications and diagnoses in relation to falls in a long-term care facility. J Am Geriatr Soc 1987;35:503–11.
[25] Gross YT, Shimamoto Y, Rose CL, Frank B. Monitoring risk factors in nursing homes. J Gerontol Nurs 1990;16:20–5.
[26] Gryfe CI, Amies A, Ashley M. A longitudinal study of falls in an elderly population: incidence and morbidity. Age Ageing 1977;6(Part I):201–10.
[27] Hale WA, Delaney MJ, McGaghie WC. Characteristics and predictors of falls in elderly patients. J Fam Pract 1992;34:577–81.
[28] Hogue C. Injury in late life: I. Epidemiology. II. Prevention. J Am Geriatr Soc 1982;30:183–90.
[29] Horak FB. Effects of neurological disorders on postural movement strategies in the elderly. In: Vellas B, Toupet M, Rubenstein L, et al, editors. Falls, balance, and gait disorders in the elderly. Paris: Elsevier; 1992. p. 137–51.
[30] Janitti PO, Pyykko I, Laippala P. Prognosis of falls among elderly nursing home residents. Aging Clin Exp Res 1995;7:23–7.
[31] Jonsson PV, Lipsitz LA, Kelley M, Koestner J. Hypotensive responses to common daily activities in institutionalized elderly: a potential risk for recurrent falls. Arch Intern Med 1990;150:1518–24.
[32] Kalchthaler T, Bascon RA, Quintos V. Falls in the institutionalized elderly. J Am Geriatr Soc 1978;26:424–8.
[33] Kapoor WN, Hanusa BH. Is syncope a risk factor for poor outcomes? Comparison of patients with and without syncope. Am J Med 1996;100:646–55.
[34] Kapoor WN, Snustad D, Peterson J, et al. Syncope in the elderly. Am J Med 1986;80:419–28.
[35] Kerman M, Mulvihill M. The role of medication in falls among the elderly in a long-term care facility. Mt Sinai J Med 1990;57:343–7.
[36] Kiely D, Kiel D, Burrows A, Lipsitz LA. Identifying nursing home residents at risk for falling. J Am Geriatr Soc 1998;46:551–5.
[37] King MB, Tinetti ME. Falls in community-dwelling older persons. J Am Geriatr Soc 1995; 43:1146–54.
[38] Lauritzen JB, Petersen MM, Lund B. Effect of external hip protectors on hip fractures. Lancet 1993;341:11–3.
[39] Leipzig RM, Cumming RG. Tinetti ME. Drugs and falls in older people: a systematic review and meta-analysis. Psychotropic drugs. J Am Geriatr Soc 1999;47(Part I):30–9.

[40] Leipzig RM, Cumming RG, Tinetti ME. Drugs and falls in older people: A systematic review and meta-analysis: Cardiac and analgesic drugs. J Am Geriatr Soc 1999;47(Part II):40–50.
[41] Lipsitz LA, Fullerton KJ. Postprandial blood pressure reduction in healthy elderly. J Am Geriatr Soc 1986;34:267–70.
[42] Lipsitz LA, Jonsson PV, Kelley MM, Koestner JS. Causes and correlates of recurrent falls in ambulatory frail elderly. J Gerontol 1991;46:M114–22.
[43] Lipsitz LA, Pluchino FC, Wei JY, Rowe JW. Syncope in institutionalized elderly: The impact of multiple pathological conditions and situational stress. J Chron Dis 1986;39:619–30.
[44] Lipsitz LA, Wei JY, Rowe JW. Syncope in an elderly, institutionalized population: Prevalence, incidence, and associated risk. Q J Med 1985;54:45–54.
[45] Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated with falls in older community-dwelling women. J Am Geriatr Soc 1994;42:1110–7.
[46] Lucht U. A prospective study of accidental falls and injuries at home among elderly people. Acta Sociomed Scand 1971;2:105–20.
[47] Luukinen H, Koski K, Hiltunen L, Kivelä SL. Incidence rate of falls in an aged population in northern Finland. J Clin Epidemiol 1994;47:843–50.
[48] Luukinen H, Koski K, Laippala P, Kivelä SL. Risk factors for recurrent falls in the elderly in long-term institutional care. Public Health 1995;109:57–65.
[49] Mader SL, Josephson KR, Rubenstein LZ. Low prevalence of postural hypotension among community-dwelling elderly. JAMA 1987;258:1511–4.
[50] Magaziner J, Simonsick EM, Kashner TM, Hebel JR, Kenzora JE. Predictors of functional recovery one year following hospital discharge for hip fracture: a prospective study. J Gerontol Med Sci 1990;45:M101–7.
[51] Mahoney J, Sager M, Dunham NC, Johnson J. Risk of falls after hospital discharge. J Am Geriatr Soc 1994;42:269–74.
[52] Maki BE, Holliday PJ, Topper AK. A prospective study of postural balance and risk of falling in an ambulatory and independent elderly population. J Gerontol 1994;49:M72–84.
[53] McIntosh SJ, Lawson J, Kenny RA. Clinical characteristics of vasodepressor, cardioinhibitory, and mixed carotid sinus syndrome in the elderly. Am J Med 1993;95:203–8.
[54] Miller MB, Elliott DF. Accidents in nursing homes: implications for patients and administrators. In: Miller MB, editor. Current issues in clinical geriatrics. New York: Tiresias Press; 1979. p. 97–137.
[55] Morfitt JM. Falls in old people at home: intrinsic versus environmental factors in causation. Public Health 1983;97:115–20.
[56] Morgan VR, Mathison JH, Rice JC, Clemmer DI. Hospital falls: a persistent problem. Am J Public Health 1985;75:775–7.
[57] Morris EV, Issacs B. The prevention of falls in a geriatric hospital. Age Ageing 1980;9:181–5.
[58] Morse JM, Prowse MD, Morrow N, Federspeil G. A retrospective analysis of patient falls. Can J Public Health 1985;76:116–8.
[59] Myers AH, Baker SP, Van Natta ML, Abbey H, Robinson EG. Risk factors associated with falls and injuries among elderly institutionalized persons. Am J Epidemiol 1991;133:1179–90.
[60] Naylor R, Rosin AJ. Falling as a cause of admission to a geriatric unit. Practitioner 1970; 205:327–30.
[61] Neufeld RR, Tideiksaar R, Yew E, Brooks F, Young J, Browne G, et al. A multidisciplinary falls consultation service in a nursing home. Gerontologist 1991;31:120–3.
[62] Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent nonsyncopal falls: a prospective study. JAMA 1989;261:2663–8.
[63] Nevitt MC, Cummings SR, Hudes ES. Risk factors for injurious falls: a prospective study. J Gerontol 1991;46:M164–70.
[64] Nurmi I, Sihvonen M, Kataja M, Lüthje P. Falls among institutionalized elderly: a prospective study in four institutions in Finland. Scand J Caring Sci 1996;10:212–20.
[65] O'Loughlin J, Robitaille Y, Boivin J, Suissa S. Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. Am J Epidemiol 1993;137:342–54.

[66] Oliver D, Britton M, Seed P, Martin FC, Hopper AH. Development and evaluation of evidence-based risk assessment tool (STRATIFY) to predict which elderly inpatients will fall: case-control and cohort studies. BMJ 1997;315:1049–53.
[67] Pablo RY. Patient accidents in a long-term care facility. Can J Pub Health 1977;68:237–46.
[68] Pawlson LF, Goodwin M, Keith K. Wheelchair use by ambulatory nursing home residents. J Am Geriatr Soc 1986;34:860–4.
[69] Ray WA, Griffin MR, Schaffner W. Psychotropic drug use and the risk of hip fracture. N Engl J Med 1987;316:363–9.
[70] Robbins AS, Rubenstein LZ. Postural hypotension in the elderly. J Am Geriatr Soc 1984; 32:769–74.
[71] Robbins AS, Rubenstein LZ, Josephson KR, Schulman BL, Osterweil D, Fine G. Predictors of falls among elderly people: results of two population-based studies. Arch Intern Med 1989; 149:1628–33.
[72] Rubenstein LZ, Robbins AS, Josephson KR, Schulman BL, Osterweil D. The value of assessing falls in an elderly population: a randomized clinical trial. Ann Intern Med 1990; 113:308–16.
[73] Sattin RW, Huber DAL, DeVito CA, Rodriguez JG, Ros A, Bacchelli S. The incidence of fall-injury events among the elderly in a defined population. Am J Epidemiol 1990;131: 1028–37.
[74] Scott CJ. Accidents in hospital with special reference to old people. Health Bull (Edinb) 1976; 34:330–5.
[75] Sehested P, Severin-Nielsen T. Falls by hospitalized elderly patients: Causes, prevention. Geriatrics 1977;32:101–8.
[76] Sheldon JH. On the natural history of falls in old age. BMJ 1960;2:1685–90.
[77] Silverstein MD, Singer DE, Mulley AG, Thibault GE, Barnett GO. Patients with syncope admitted to medical intensive care units. JAMA 1982;248:1185–9.
[78] Sjörgen H, Björnstig U. Injuries among the elderly in the home environment. J Aging Health 1991;3:107–25.
[79] Smallegan M. How families decide on nursing-home admission. Geriatr Consult 1983;2:21–4.
[80] Sorock GS, Shimkin EE. Benzodiazepine sedatives and the risk of falling in a community-dwelling elderly cohort. Arch Intern Med 1988;148:2441–4.
[81] Studenski S, Duncan PW, Chandler J, Samsa G, Prescott B, Hogue C, et al. Predicting falls: the role of mobility and nonphysical factors. J Am Geriatr Soc 1994;42:297–302.
[82] Sudarsky L. Geriatrics: gait disorders in the elderly. N Engl J Med 1990;322:1441–6.
[83] Svensson ML, Rundgren A, Larsson M, Odén A, Sund V, Landahl S. Accidents in the institutionalized elderly: a risk analysis. Aging 1991;3:181–92.
[84] Thapa P, Brockman K, Gideon P, Fought RL, Ray WA. Injurious falls in nonambulatory nursing home residents: a comparative study of circumstances, incidence, and risk factors. J Am Geriat Soc 1996;44:273–6.
[85] Thapa PB, Gideon P, Fought RL, Ray WA. Psychotropic drugs and risk of recurrent falls in ambulatory nursing home residents. Am J Epidemiol 1995;142:202–11.
[86] Tinetti ME. Factors associated with serious injury during falls by ambulatory nursing home residents. J Am Geriatr Soc 1987;35:644–8.
[87] Tinetti ME, Baker DI, McAvay G, Claus EB, Garrett P, Gottschalk M, et al. A multifactorial intervention to reduce the risk of falling among elderly people living in the community. N Engl J Med 1994;331:821–7.
[88] Tinetti M, Doucette J, Claus E, Marottoli R. Risk factors for serious injury during falls by older persons in the community. J Am Geriatr Soc 1995;43:1214–21.
[89] Tinetti ME, Liu WL, Claus EB. Predictors and prognosis of inability to get up after falls among elderly persons. JAMA 1993;269:65–70.
[90] Tinetti ME, Liu WL, Ginter SF. Mechanical restraint use and fall-related injuries among residents of skilled nursing facilities. Ann Intern Med 1992;116:369–74.
[91] Tinetti ME, Mendes de Leon CF, Doucette JT, Baker DI. Fear of falling and fall-related efficacy

in relationship to functioning among community-dwelling elders. J Gerontol Med Sci 1994; 49:M140–7.
[92] Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988;319:1701–7.
[93] Tinetti ME, Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. N Engl J Med 1997;337:1279–84.
[94] Tinetti ME, Williams TF, Mayewski R. Fall risk index for elderly patients based on number of chronic disabilities. Am J Med 1986;80:429–34.
[95] Vellas B, Wayne S, Garry P, Baumgartner RN. A two-year longitudinal study of falls in 482 community-dwelling elderly adults. J Gerontol 1998;53A:M264–74.
[96] Vellas BJ, Wayne SH, Romero LJ, Baumgartner RN, Garry PJ. Fear of falling and restriction of mobility in elderly fallers. Age Ageing 1997;26:189–93.
[97] Vellas BJ, Wayne SH, Romero LJ, Baumgartner RN, Rubenstein LZ, Garry PJ. One-leg balance is an important predictor of injurious falls in older persons. J Am Geriatr Soc 1997;45:735–8.
[98] Wagner EH, LaCroix AZ, Grothaus L, Leveille SG, Hecht JA, Artz K, et al. Preventing disability and falls in older adults: a population-based randomized trial. Am J Public Health 1994;84:1800–6.
[99] Walker JE, Howland J. Falls and fear of falling among elderly persons living in the community: occupational therapy interventions. Am J Occup Ther 1991;45:119–22.
[100] Wells BG, Middleton B, Lawrence G, Lillard D, Safari KJ. Factors associated with the elderly falling in intermediate care facilities. Drug Int Clin Pharm 1985;19:142–5.
[101] Whipple RH, Wolfson LI, Amerman PM. The relationship of knee and ankle weakness to falls in nursing home residents: An isokinetic study. J Am Geriatr Soc 1987;35:13–20.
[102] Wolfson L, Whipple R, Amerman P, Tobin JN. Gait assessment in the elderly: A gait abnormality rating scale and its relation to falls. J Gerontol 1990;45:M12–9.