Chapter 10. Fall and Injury Prevention

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Background

Fall and injury prevention continues to be a considerable challenge across the care continuum. In the United States, unintentional falls are the most common cause of nonfatal injuries for people older than 65 years. Up to 32 percent of community-dwelling individuals over the age of 65 fall each year, and females fall more frequently than males in this age group.[1, 2] Fall-related injuries are the most common cause of accidental death in those over the age of 65, resulting in approximately 41 fall-related deaths per 100,000 people per year. In general, injury and mortality rates rise dramatically for both males and females across the races after the age of 85, but males older than 85 are more likely to die from a fall than females.[2-6] Unfortunately, fall-related death rates in the United States increased between 1999 and 2004, from 29 to 41 per 100,000 population.[2, 7] Sadly, these rates are moving away from the Healthy People 2010 fall-prevention goal, which specifically seeks to reduce the number of deaths resulting from falls among those age 65 or older from the 2003 baseline of 38 per 100,000 population to no more than 34 per 100,000.[8] Thus, falls are a growing public health problem that needs to be addressed.

The sequelae from falls are costly. Fall-related injuries account for up to 15 percent of rehospitalizations in the first month after discharge from hospital.[9] Based on data from 2000, total annual estimated costs were between $16 billion and $19 billion for nonfatal, fall-related injuries and approximately $170 million dollars for fall-related deaths across care settings in the community.[10, 11] Several factors have been implicated as causes of falls and injuries; to date, however, no definitive predictor profile has been identified. Although the underlying status of the individual who sustains a fall may contribute to the fall and subsequent injury, the trauma resulting from the fall itself is most often the cause of morbidity and mortality.

Over the past 20 years gerontology researchers, spearheaded by Mary Tinnetti from Yale University, have carried out a significant amount of research to address the problem of falls and injuries in the community. However, ubiquitous use of successful interventions is not yet in place in the community. As health care moves toward patient-centered care, and as a growing body of research provides guidance for widespread fall-prevention programs, fall- and fall-related-injury prevention now has the potential to be addressed across the care continuum.

Inpatient fall prevention has been an individual area of concern for nursing for almost 50 years.[12, 13] Traditional hospital-based incident reports deem all inpatient falls to be avoidable, and therefore falls are classified as adverse events. Indeed, falls are the most frequently reported adverse events in the adult inpatient setting. But underreporting of fall events is possible, so injury reporting is likely a more consistent quality measure over time and organizations should consider judging the effects of interventions based on injury rates, not only fall rates. Inpatient fall rates range from 1.7 to 25 falls per 1,000 patient days, depending on the care area, with geropsychiatric patients having the highest risk.[14-18] Extrapolated hospital fall statistics indicate that the overall risk of a patient falling in the acute care setting is approximately 1.9 to 3 percent of all hospitalizations.[16-18] In the United States, there are approximately 37 million hospitalizations each year;[19] therefore, the resultant number of falls in hospitals could reach more than 1 million per year.

Injuries are reported to occur in approximately 6 to 44 percent of acute inpatient falls.[5, 20-23] Serious injuries from falls, such as head injuries or fractures, occur less frequently, 2 to 8 percent, but result in approximately 90,000 serious injuries across the United States each year.[20] Fall-related deaths in the inpatient environment are a relatively rare occurrence. Although less than 1 percent of inpatient falls result in death, this translates to approximately 11,000 *fatal falls* in the hospital environment per year nationwide. Since falls are considered preventable, fatal fall-related injuries should *never* occur while a patient is under hospital care.

In the long-term care setting, 29 percent to 55 percent of residents are reported to fall during their stay.[24, 25] In this group, injury rates are reported to be up to 20 percent, twice that of community-dwelling elderly. The increase in injury rates is likely because long-term care residents are more vulnerable than those who can function in the community.[26] Rubenstein[27] reported 1,800 long-term care fatal falls in the United States during1988. The current number of long-term care fatal falls has not been estimated; however, there are 16,000 nursing homes in the United States caring for 1.5 million residents in 2004.[28] This population will likely grow in the coming years, thus fall and injury prevention remains of utmost concern.

Fall and Fall-Related Injury Reporting

Falls and related injuries have consistently been associated with the quality of nursing care in the acute care setting. They are included as a nursing-quality indicator monitored by the American Nurses Association, National Database of Nursing Quality Indicators (ANA–NDNQI) and by the National Quality Forum.[29, 30] Participation in the ANA–NDNQI provides hospitals with the ability to view their fall and injury rates in relation to other hospitals of similar type and size. However, participation in ANA–NDNQI is voluntary; despite a rapidly growing participation rate, it is not yet ubiquitous (1,089 hospitals as of June 2007, approximately 15 percent of U.S. hospitals). The National Quality Forum also advocates for voluntary reporting of quality indicators for acute care (falls prevalence and fall-related injuries) and ambulatory care (fall-risk screening for geriatrics).[31, 32]

The Maryland Quality Indicator Project is a second voluntary national repository that provides fall and fall-related injury benchmarks for the behavioral health, long-term care, and home care settings.[33] Unfortunately, this project has a participation level of approximately 1,000 hospitals (approximately 14 percent), making national benchmarking difficult. In the home care setting, the Centers for Medicare & Medicaid Service's Outcome and Assessment Information Set (CMS–OASIS) provides the reporting basis for the patients' physical functioning.[34] Growing efforts to expand patient safety initiatives to the home care setting seek to include falls as a quality indicator for patients who are cared for at home, but who are not completely bed bound.[35, 36] Collection of these data has the potential for organizations to track fall rates of vulnerable patients and to identify patients at risk for falls and injuries. However, further research is required to validate such screening and to examine which interventions are effective based on risk status.

In the nursing home setting, the long-term care minimum dataset (LTCMDS) is used for reporting all aspects of care. The LTCMDS captures fall and injury histories via assessments that are performed on admission and at regular intervals during a resident's stay.[37] In addition, residents are evaluated for balance and for the ability to perform activities of daily living (ADLs), with the goal to apply fall-prevention measures should the patient be deficient in these areas. Recent research by Hill-Westmoreland and Gruber-Baldini[38] indicated only a 75 percent

concordance between chart abstraction and minimum dataset reporting for a group of long-term care facilities. A more recent development in the long-term care setting, the Nursing Home Quality Initiative, promotes the collection of a list of enhanced quality indicators, including those that track declines in functional and cognitive status.[34, 37] The Agency for Healthcare Research and Quality (AHRQ) has elected to monitor only postoperative hip fracture as their fall-related preventive quality indicator, which is consistent with thinking that monitoring fall-related injuries is a more dependable measure of quality.[39, 40] However, tracking of all fractures would be of benefit. The Health Plan Employer Data and Information Set has recently added Fall Risk Assessment to its dataset, which will provide a method to benchmark the evaluation of fall risk between health insurance providers.[41] However, application of fall- and injury-prevention programs is not included as an indicator, which will make it difficult to benchmark these important measures. Increased and more accurate monitoring of these elements has the potential to reduce falls among nursing home residents; however, the effect of these efforts has yet to be established.

Definitions of Falls and Fall-Related Injuries

Falls and related injuries have had varying definitions.[42, 43] Falls may be precipitated by intrinsic or extrinsic factors. Intrinsic factors are those that have a physiologic origin, and extrinsic factors are those precipitating from environmental or other hazards. Distinguishing between intrinsic or extrinsic risk factors can facilitate identification of preventive strategies. According to Tinetti, Speechley, and Ginter,[44] a fall in the nonhospitalized geriatric population is defined as "an event which results in a person coming to rest unintentionally on the ground or lower level, not as a result of a major intrinsic event (such as a stroke) or overwhelming hazard." Agostini, Baker, and Bogardus[45] adapted this definition for the inpatient, acute, and long-term care areas to define a fall as "unintentionally coming to rest on the ground, floor, or other lower level, but not as a result of syncope or overwhelming external force."

Other definitions are broader and include falls related to intrinsic events such as syncope or stroke. For example, Nevitt's[46] definition of a fall is "falling all the way down to the floor or ground, or falling and hitting an object like a chair or stair." The ANA–NDNQI provides an all-inclusive definition[47] (p. 26):

> An unplanned descent to the floor (or extension of the floor, e.g., trash can or other equipment) with or without injury. All types of falls are included, whether they result from physiological reasons or environmental reasons.

The International Classification of Diseases 9 Clinical Modifications (ICD-9-CM) uses several codes to categorize falls, all of which have broad descriptions: Accidentally bumping against moving object caused by crowd with subsequent fall (E917.6); Fall on or from ladders or scaffolding (E881); Fall from or out of building or other structure (E882); Other fall from one level to another (E884); Fall on same level from slipping, tripping, or stumbling (E885); Fall on same level from collision, pushing, or shoving by or with another person (E886); and Other and unspecified fall (E888).[48] In the inpatient care setting, E888 is the code that is typically used to record a fall in a medical record. However, this ICD-9-CM code is not consistently used for reporting; therefore, institutions generally rely on incident reports as the method of counting fall events.[48]

Fall-related injuries in the community, home care, and long-term care areas are generally characterized by ICD-9-CM diagnoses for the related injured body part. In contrast, incident reports in the acute care setting use the following ANA–NDNQI fall-related injuries categories:

(1) *None* indicates that the patient did not sustain an injury secondary to the fall.
(2) *Minor* indicates those injuries requiring a simple intervention.
(3) *Moderate* indicates injuries requiring sutures or splints.
(4) *Major* injuries are those that require surgery, casting, further examination (e.g., for a neurological injury).
(5) *Deaths* refers to those that result from injuries sustained from the fall.[29]

According to Morse,[21] inpatient falls can be classified into three categories: accidental falls (derived from extrinsic factors, such as environmental considerations), anticipated physiologic falls (derived from intrinsic physiologic factors, such as confusion), and unanticipated physiologic falls (derived from unexpected intrinsic events, such as a new onset syncopal event or a major intrinsic event such as stroke). Morse asserts that using this classification, approximately 78 percent of the falls related to anticipated physiologic events can be identified early, and safety measures can be applied to prevent the fall. Research to identify precursors to unexpected intrinsic events, such as screening for predictors of syncopal events, might increase the early identification of anticipated physiologic falls, which could ultimately prevent more falls.[49-51]

Falls and Fall-Related Injuries as Medical Errors

The definition of a fall is consistent with that of a medical error: "the failure of a planned action to be completed as intended" (i.e., error of execution) or "the use of a wrong plan to achieve an aim" (i.e., error of planning).[52, 53] For example, an error of execution might be the failure to perform the planned action of placing a call light within the patient's reach, and an error in planning might be to provide aggressive physical therapy before a patient's balance has been established. An error of commission is "an error that occurs as a result of an action taken," for example, a fall that occurs subsequent to a behavioral health patient's electroconvulsive therapy. An error of omission, "an error which occurs as a result of an action not taken," might occur if the patient is not assessed for fall and injury risk, which prevents appropriate interventions from being applied. Latent errors related to fall and injury prevention are those in which an agency does not apply appropriate standards, training, or support for the practice-based fall- and injury-prevention processes. Recent efforts by the Joint Commission (formerly the Joint Commission on Accreditation of Healthcare Organizations [JCAHO]) in its National Patient Safety Goals advocate for institution-wide risk assessment for falls and documentation of a fall-prevention program.[54] These efforts have the potential to eliminate latent errors related to falls and injuries. Monitoring errors might occur if the patient is not monitored to identify fall risk, or if the patient is not monitored to identify a post-fall injury such as a subdural hematoma.

This review summarizes the current research related to fall and injury prevention. The chapter is organized to present research from two perspectives: (1) community setting, and (2) acute and long-term settings. For each setting, the research that addresses risk factors, risk assessment instruments, and fall- and injury-prevention interventions are reviewed. Reports on the outcomes of fall- and injury-prevention research using experimental or quasi-experimental research design is summarized in tables at the end of the chapter.

Research Evidence

Falls and Related Injuries in the Community

In the following section, research about falls and related injuries in the community were identified and categorized as follows: risk factor identification, risk assessment instruments, and prevention strategies.

Risk factors in the community. The pivotal research of Tinetti, Speechly and Ginter[44] related to fall and injury prevention in community-dwelling individuals older than 65 years identified the following risk factors for falling: (1) postural hypotension, (2) use of any benzodiazepine or sedative-hypnotics, (3) use of four or more prescription medications, (4) environmental hazards, and (5) muscular strength or range of motion impairments. Other researchers have identified additional patient or treatment risk factors: (1) comorbidities, including diabetes, diabetic foot ulcer,[55] stroke,[56] syncope,[57] anemia,[58, 59] Alzheimer's disease,[60] Parkinson's disease,[61] vitamin D deficiency,[62, 63] and vitamin D deficiency in combination with low creatinine clearance;[64] (2) patient characteristics, including fallophobia (also known as "fear of falling"),[65, 66] gait problems (e.g., weakness and impaired sensation),[67] postural hypotension, inability to get out of chair, impaired ability to perform ADLs, frailty,[68-70] inability to follow instructions,[71] and inability to adapt to changing environment;[72] and (3) other characteristics, including recent hospitalization,[9] nonsupportive footwear (e.g., slippers),[73] reckless wheelchair use,[74] environmental hazards, and use of psychotropic medication.[75, 76] Age and gender are also associated with falls and fall-related morbidity and mortality. Fall rates increase with age,[77] and in community-dwellers between 65 and 85 years of age, females are more likely to fall, but males are more likely to die from fall-related injuries than females in this group.[1, 2]

The roles of ethnicity and race in relation to falls and injury have also been studied. Reyes-Ortiz and colleagues[78] examined risk factors for Mexican-Americans and found that in the community, the risk factors are the same as for their White counterparts. Hanlon and colleagues[79] examined predictors of falls between Caucasians and African Americans and found that African Americans were 23 percent less likely to fall than Whites (odds ratio = 0.77). Faulkner and colleagues[80] explored this difference in women and found that Caucasian women were 50 percent more likely to fall than African American women, although this was not statistically significant (relative risk = 1.50, 95% confidence interval [95% CI] = 0.90–2.49). The researchers further examined situations leading to falls and found that circumstances differed by ethnicity: Caucasian women were more likely to fall outdoors versus indoors (odds ratio = 1.6, 95% CI = 1.0–2.7) and laterally versus forward (odds ratio = 2.0, 95% CI = 1.1–3.4), but less likely to fall on the hand or wrist (odds ratio = 0.6, 95% CI = 0.3–1.0). This research suggests that activities differ between older African American women and their Caucasian counterparts and should be considered when making fall- and injury-prevention plans.

Risk factors for injury in the community. Risk factors for injury in the community are increasingly well characterized. Porthouse and her research team[81] performed a comprehensive cohort study of almost 4,300 women older than 70 years and confirmed the following risk factors for various types of fall-related fractures: (1) fall in the past 12 months, (2) increasing age, (3) previous fracture, and (4) low body weight. This work also identified that smoking was not associated with fracture risk. A growing body of research is examining vitamin D deficiency as a risk factor for fracture; however, results are conflicting to date, but bear further research.[81, 82]

Colon-Emeric and colleagues[83] used data from a large community epidemiologic study to identify whether historical and functional information could help to predict fracture risk. The researchers identified nine characteristics that were predictors of fracture: (1) female sex, (2) age greater than 75 years, (3) White race, (4) body mass index (BMI) of less than 22.8 kg/m^2, (5) history of stroke, (6) cognitive impairment, (7) one or more ADL impairments, (8) one or more Rosow-Breslau impairments (e.g., perform heavy work, walk a mile, climb stairs), and (9) antiepileptic drug use. Ohm and colleagues[84] recently identified that elderly community-dwelling individuals with traumatic head injuries were more likely to die based on the use of antiplatelet therapy (relative risk = 2.5 for those taking antiplatelet therapies; $P = 0.016$). A similar body of research related to chronic subdural hematomas has identified that patients on anticoagulant or antiplatelet therapy are at higher risk for chronic subdural hematoma and that many of these are first identified when a patient is evaluated after a fall.[85] Many injury risk factors are consistent with fall risk factors, accentuating the need for effective screening of elderly community-dwelling individuals. However, factors that make people more susceptible to injury, such as antiplatelet therapy, establish the need for additional safety measures for individuals at risk for injury. Table 1 lists the intrinsic and extrinsic risk factors for falls, injuries, and fall-related deaths in the community.

Table 1. Risk Factors for Falls, Injuries, and Fall-Related Deaths in the Community

Intrinsic Risk Factors	Fall Risk	Injury Risk	Mortality Risk
Demographics			
• Age: Older Age (especially >70yrs)	Yes	Yes	Yes
• Gender	Female	Female	Male >85
• Race	Caucasian	Caucasian	Caucasian
Cognitive Function			
• Cognitive impairment	Yes	No data	No data
• Fallophobia (fear of falling)	Yes	Yes	No data
• Inability to follow instructions	Yes	No data	No data
• Inability to adapt to changing environment	Yes	No data	No data
Physical Function			
• Gait problems	Yes	No data	No data
• Impaired ability to perform ADLs	Yes	Yes	No data
• Impaired muscle strength or range of motion	Yes	Yes	No data
• Poor/fair self-reported health	Yes	Yes	No data
• Rosow-Breslau impairment	No data	Yes	No data
• Vision problems	Yes	No data	No data
Physical Status			
• BMI less than 22.8 kg/m^2	No data	Yes	Yes
• Frailty	No data	Yes	Yes
• Low body weight (<58 kg=BMI 23 if height 5'3")	Yes	Yes	No data
Comorbidities			
• Alzheimer disease	Yes	No data	No data
• Anemia (including mild anemia)	Yes	No data	No data
• Diabetes	Yes	No data	No data
• Diabetic foot ulcer	Yes	No data	No data
• Fall in the past 12 months	Yes	Yes	No data

Intrinsic Risk Factors	Fall Risk	Injury Risk	Mortality Risk
• Parkinson disease	Yes	No data	No data
• Postural hypotension	Yes	No data	No data
• Previous fracture	No data	Yes	No data
• Stroke	Yes	Yes	No data
• Subdural hematoma (chronic)	Yes	Yes	No data
• Syncope	Yes	No data	No data
• Vitamin D deficiency	Yes	Yes	No data
• Vitamin D deficient w/ low creatinine clearance	Yes	No data	No data
Medications			
• Use of 4 or more medications	Yes	No data	No data
• Anti-epileptics	No data	Yes	No data
• Antihypertensives	Yes	No data	No data
• Antiplatelet therapy	No data	No data	Yes
• Psychotropics	Yes	No data	No data
• Sedatives and hypnotics	Yes	No data	No data
Extrinsic Risk Factors	**Fall Risk**	**Injury Risk**	**Mortality Risk**
• Environmental hazards	Yes	No data	No data
• Footwear, non-supportive (e.g., slippers)	Yes	No data	No data
• Hospitalization, recent	Yes	No data	No data
• Wheelchair use, reckless wheelchair use	Yes	No data	No data

Risk assessment instruments for community dwellers. Tinetti[86] developed a fall risk assessment index based on the following nine risk factors: mobility, morale, mental status, distance vision, hearing, postural blood pressure, back examination, medications, and ability to perform ADLs. This instrument has been the most widely used and tested, with a reported sensitivity of 80 percent and specificity of 74 percent.[87] Other instruments used in the community include the following (with reported sensitivities and specificities in parentheses): (1) Berg Balance Test (sensitivity = 77 percent; specificity = 86 percent), (2) Elderly Fall Screening Test (sensitivity = 93 percent; specificity = 78 percent), (3) Dynamic Gait Index (sensitivity = 85 percent; specificity = 38 percent), and (4) Timed Get Up and Go test (sensitivity = 87 percent; specificity = 87 percent).[87] Aside from the Timed Get Up and Go test, which takes less than a minute for a health care provider to administer, these instruments generally take 15 to 20 minutes to complete.[87]

Lord and colleagues[88] recently evaluated the effect of an exercise-related fall-prevention program, but found that the intervention was not useful in community dwellers who were not screened for risk. The researchers concluded that screening to identify individuals at high risk for falls would be necessary for a successful fall-prevention program. Further research to identify the most accurate, yet easy-to-use risk assessment instrument would be necessary to move these efforts forward.

A recent systematic review by Scott and colleagues[89] examined fall risk assessment instruments in the community. The authors concluded that, in general, risk assessment instruments are available; however, most have been tested in only one setting. Therefore, further validation studies should be conducted on fall risk assessment instruments before any specific instrument can be recommended.

A potential time point for risk assessment is in the emergency department (ED). Several researchers have examined the effect of fall- and injury-prevention interventions applied to patients who are discharged from the ED after a noninjury or nonserious-injury fall. The overarching goal of these studies is to evaluate the ability of comprehensive risk assessment followed by targeted interventions to prevent future falls and fall-related injuries. Several studies have successfully shown that screening followed by tailored management can decrease repeat falls.[42, 90-94] Close and colleagues[42] found that fall rates were reduced by 61 percent and recurrent falls were reduced by 67 percent for patients who had comprehensive risk assessment after a fall, compared to individuals who received standard treatment. Davison and colleagues[90] found a 36 percent decrease in fall rates after 1 year for patients who received a multimodal intervention for fall prevention after being identified as a faller on admission to the ED. In addition, these researchers noted an increase in falls self-efficacy, which is a measure of an individual's perception of their ability to manage situations where they are at high risk for falling – the higher self-efficacy, the more able a person is able to manage high risk situations. In a related study, Lee, Hurley, and colleagues[91] conducted a randomized controlled trial to examine the impact of a personal emergency response system and found that there was no difference between treatment and control groups for self-efficacy or patient anxiety. The Lee and colleagues study is informative in that emergency contact alone was not sufficient to improve a patient's belief in their ability to manage fall risk situations. Although no standardized instrument has yet been developed for use in the ED environment, the potential for the prevention of falls and related injuries in the community would be increased with the accurate identification of patients at risk for falls while they are in the ED.

Automated risk assessment in the community setting. To date, a limited number of computer-based, community-based fall assessment instruments have been described. By far the most complex and integrated is the Fall Risk Assessment and Management System, which was developed by the Australia Family Practice Group for use in the community by family practice physicians.[95] Fall Risk Assessment and Management System includes automated recommendations after the clinician executes a thorough patient assessment. Although this system appears promising, its efficacy has not yet been reported.

Lord, Menz, and Tiedemann[96] describe an electronic fall risk assessment instrument that provides a method to measure several risk factors, including vision, peripheral sensation, muscle force, reaction time, and postural sway. Although this instrument is thorough, it is meant for use by a physical therapist or a physician, nurse practitioner, or physician assistant for a focused fall risk assessment, rather than as a triage or screening tool. The novel aspect of this instrument is the comparison of the individual's score to the normative scores for each of the assessments, which provides the clinician with an anchor and may facilitate improved screening over time. However, the predictive validity of this instrument has not been reported, and its use may be limited to a fall-prevention clinic.

Another electronic fall risk assessment instrument, described by Dyer and colleagues,[97] is an electronic checklist in a fall-prevention clinic. Unfortunately, the researchers concluded that the clinic itself was more successful than the instrument in identifying risk factors for falling, underscoring the reality that the implementation of an instrument without associated policy and procedure changes may have limited effect.

The presence of these automated systems indicates that there is movement toward computerized fall risk assessment. Indeed, many clinical information systems have adapted paper-based assessment instruments for use in the acute care setting. However, the efficacy of

these systems has not been reported, and their effectiveness is likely to be constrained by the limits of the original instrument, the system in which they are placed, and the design team in ensuring that the automated instrument accurately reflects the original instrument.

Prevention strategies in the community. To date, several reviews conducted to examine the evidence available to support practice in this area have identified the need for multimodal, interdisciplinary prevention programs; the need for more accurate risk assessment instruments; and the need for more research related to this complex and costly problem.[11, 98-107]

Cumming[100] reviewed 21 trials and concluded that exercise programs were the most promising, and reduction of antipsychotic medications should be considered. However, Cumming also concluded that none of the reviewed research studies provided a definitive prevention strategy. Chang and collaborators[99] conducted a similar review targeted at examining interventions for older adults in the community and found that multimodal assessments with targeted intervention reduced risk of falls by 37 percent, and that exercise interventions reduced fall risk by 14 percent. Hill-Westmoreland, Soeken, and Spellbring[38] conducted a recent meta-analysis, including a sensitivity analysis, which identified an improved effect on fall prevention in the community when individualized management was added to exercise interventions. They concluded that exercise interventions were not sufficient in and of themselves, and interventions needed to be tailored to address individual risk factors.

Researchers have explored several other individual prevention strategies, including fall prevention clinics, exercise interventions with leg strengthening (e.g., Tai Chi), vitamin D supplements, home visits for safety evaluations, cataract surgery, and cardiac pacing. Falls and balance clinics present a promising community-based solution to the problem of falls.[108] Perell and colleagues[109] found a 50 percent reduction in fall rates for patients who were screened at a clinic and who had tailored interventions applied; however, this study had no control group and the researchers did not report injury rates, so the results are tentative. Clinics such as these provide focused intervention planning for patients identified at risk for falling, but the success of such clinics is contingent upon accurate identification of high-risk patients.

Identification of recurrent fallers via comprehensive screening followed by tailored interventions has been successful at reducing recurrent falls. Screening and intervention done in the ED reduced recurrent falls by 36 percent in one study,[90] and a nurse-led intervention that provided home assessment and tailored interventions reduced recurrent falls by 38 percent in another study.[110] Hogan and colleagues[111] also evaluated tailored interventions for patients who had had a fall within the past 3 months. They found no significant differences between the intervention and control groups in fall rates or time to first fall; however, the intervention group had a longer time between falls ($P = 0.001$). However, the Hogan and colleagues study limited inclusion criteria to patients older than 65 years of age who had fallen in the past 3 months, and these two factors alone are likely insufficient to determine risk. These recent studies add to early work in the PROFET study, which found a 61 percent decrease in falls for patients who were identified in the ED and who had subsequent detailed risk assessment and tailored interventions.[42]

Exercise-related interventions are by far the most commonly studied individual community prevention strategy. Most of this research indicates that exercise is beneficial for patients, and some research demonstrates that exercise regimes that involve leg strengthening and balance training, such as Tai Chi, are most effective.[112-122] Robertson and colleagues[123] performed a meta-analysis of four studies that examined effects of home exercise programs. They found in the pooled effect analysis that both fall and injury rates decreased by 35 percent. Exercise in

conjunction with cognitive behavioral therapy, where patients are taught how to increase self-awareness about risky situations, has demonstrated promising results, including a longer time to first fall and decreased injuries.[124] Unfortunately, this work did not demonstrate an effect on falls efficacy, fear of falling, or actual fall rates. More recently, balance training has been compared to general exercise, and results show that balance training can prevent falls in the nonfrail elderly, but not in the frail elderly.[125] Lin and colleagues[126] found that deployment of large scale Tai Chi training to the general community had mixed results. Luukinen and colleagues[127] found a decrease in fall and injury rates with a targeted exercise program when compared to usual care, but the results were statistically significant only in a group that was not homebound—suggesting that early intervention may be more effective. Further research to explore interventions for homebound community dwellers, particularly for the very old and frail, will be important.

Laboratory studies indicate that calcium and vitamin D reduce bone loss,[128] and a growing body of work is examining the ability for vitamin D supplementation to prevent fractures in individuals who are vitamin D deficient. A meta-analysis performed by Bischoff-Ferrari and team[129] revealed that larger doses of vitamin D supplementation (700–800 IU/deciliter) reduced the risk of fracture by up to 26 percent, whereas smaller doses of vitamin D (400 IU/deciliter) did not reduce fracture risk. However, research to date has been inconclusive, and larger, more recent studies have indicated that the use of vitamin D does not reduce fracture risk in the general community.[130] On the other hand, vitamin D supplementation may be integral in preventing falls themselves:[131] Recently, Latham and colleagues[132, 133] demonstrated that vitamin D intake is an individual predictor for fall reduction, primarily by improving muscle strength. Bischoff-Ferrari and colleagues[134] have also identified a reduction in fall risk for women, but not for men, using vitamin D supplementation. Although these results are promising, more research is required to identify best practice recommendations related to vitamin D deficiency screening and vitamin D supplementation or other bone-supporting medication regimes.

Other researchers are exploring the ability for osteoporosis-prevention medications to reduce fracture risk.[135] Sato and colleagues[136, 137] reported that risedronate, an oral bisphosphonate for osteoporosis prevention, was effective at preventing fracture in older females, older males who have had a stroke, and older females with Alzheimer's disease. A recent large study by McCloskey and colleagues[138] (N = 5579) demonstrated a 20–29 percent decrease in clinical fractures in community-dwelling females older than 75 years with and without osteoporosis who were prescribed clodronate 800 mg daily. However, this study did not find a decrease in hip fractures. Recent reports of adverse side effects of large doses of bisphosphonates, including osteonecrosis of the jaw, indicate that further research is warranted and that patients should be monitored for side effects of these drugs. Other related fall prevention efforts include home assessment for risk factors with the implementation of safety devices such as handrails, nonslip surfaces on stairs, and removal of throw rugs.[139-143] Researchers who conducted a recent randomized controlled trial found that thin-soled shoes were found to be the best type of shoe for patients, rather than running shoes, which have sticky soles.[144] Research addressing syncope-related falls indicate that cardiac pacing may be appropriate for individuals with syncope.[145]

Summary of community-based research on falls and related injuries. In summary, authors of several reviews have examined the efficacy of community-based fall- and injury-prevention programs. These reviewers have indicated that individualized multimodal interventions are effective at reducing falls and related injuries in the community setting.[105] However, multimodal interventions are not in place across primary care areas, which hinders their potential efficacy, and the aging community would likely benefit from large-scale

implementation of these proven preventive interventions. (See Evidence Tables 1 through 9 for individual study results.)

Falls and Related Injuries in the Acute and Long-Term Care Settings

Fall and related injury prevention is a major focus for both acute and long-term health care organizations. In 2005, the Joint Commission added the requirement for fall risk assessment and periodic reassessment as a National Patient Safety Goal in the acute care setting.[54] The goal of this requirement is to ensure that all patients are screened for falls and thus seeks to reduce harm from falls. However, the outcome is unpredictable because fall and injury risk assessment instruments have shown inconsistent reliability and validity A more promising extension of this goal starting in 2006 and continuing forward is the additional requisite of implementing and evaluating a fall-prevention program.[146] National compliance with these goals has the potential to significantly impact the problem of falls in the acute care setting. Efforts to enhance quality of care in the long-term care environment via improved reporting have the potential to reduce falls and related injuries in these particularly vulnerable patients; however, the successful implementation of fall-prevention programs will be necessary to improve the problem.

Falls in the acute and long-term care settings have several possible consequences. Recurrent falls have been identified as contributing to increases in the length of stay (LOS) in elderly psychiatric patients.[147] However, some research has suggested that LOS itself may be a predictor. A fall may also lead to a poorer quality of life because of fallophobia, a fear of future falls, which may itself contribute to fall risk.[148] Injuries occur in between 6 and 44 percent of falls in the acute care setting.[20, 21, 23] In the long-term care population, between 9 and 15 percent of falls result in injury, with approximately 4 percent of these falls resulting in fractures.[149] Additionally, patients who have underlying disease states are more susceptible to injuries; for example, osteoporosis can increase the risk for fracture, and bleeding disorders can increase the risk for subdural hematomas.[150] Moreover, fall-related injuries increase resource utilization: injuries from falls lead to increased LOS and an increased chance of unplanned readmission or of discharge to residential or nursing home care.[151] Furthermore, inpatients who have incurred an injury due to a fall have approximately 60 percent higher total charges than those who did not fall or those who fell and did not sustain an injury.[152]

Evans and colleagues,[153] via the Joanna Briggs Institute, performed a systematic review of the evidence up to 1997 for fall and injury prevention in the acute care setting. They examined 200 studies related to identification of predictors, risk assessment instrument development and testing, and fall- and injury-prevention interventions. Of these studies, only two were randomized controlled trials (RCTs). The trial by Tideiksaar and colleagues[154] examined the use of bed alarms to notify staff when patients at high risk for falls got out of bed; however, this study had a sample size that was too small to identify an effect from using bed alarms. The other RCT examined the use of colored bracelets to identify patients at high risk for falls. Again, the study results were inconclusive.[155] Evans and colleagues concluded that the fall risk assessment instruments available were not generalizable. However, they did not adequately compare the psychometric properties of the instruments in question; rather they evaluated research related to the implementation of such instruments, which was relatively weak up to that time. In addition, Evans and colleagues concluded that individual interventions were not more useful that any of the fall-prevention programs that might be developed at a particular institution for a specific subset of patients. However, recent research has seen a growing number of RCTs, which will

facilitate the ability to make stronger practice recommendations for this complex and challenging problem.

For this review, research related to falls and related injuries in the acute and long-term care settings were identified and categorized as follows: risk factor identification, risk assessment instruments, and prevention strategies. Each category of research is discussed below.

Acute care and long-term care risk factors. Factors associated with patients at risk of falling in the acute care setting have been explored extensively, particularly over the past two decades.[17, 87, 156-160] Evans and colleagues[161] conducted a systematic review of research and identified 28 risk factors for falling, including impaired mental status, special toileting needs, impaired physical status, and to some extent age and medications. Oliver and colleagues[159] reviewed risk factor and risk assessment literature and identified five risk factors consistent across studies: unsteady gait, increased toileting needs, confusion, sedative-hypnotics, and history of falling. In the long-term care environment, risk factors are largely the same, with the addition of inability to transfer effectively[162] and short-term memory loss.[163] Although ability to transfer and short-term memory function might be characterized by unsteady gait and confusion, these items are expressly captured via the LTCMDS.

Research has consistently demonstrated that multiple factors are associated with falling in elderly and hospitalized patients and that fall risk increases as the number of factors increases.[98, 153, 156-159, 164-166] Although increased age is a strong predictor of falling in the community, increased age has not always been identified as a predictor in the acute care setting. Some studies have found increased age to be a risk factor,[17, 165] but others have found that increased age is not a factor in acute care.[157, 167, 168] Comorbidities and impaired functional status may be more important predictors of falls and subsequent injury in this setting.[150, 157] Recent work by Hendrich[169] did not support the association between increasing age (older than 65 years) and increasing risk of falling in the inpatient environment. Instead, Hendrich and colleagues[169] found that confusion was the most important risk factor associated with the risk of falling. Nevertheless, age must be considered when discussing injury associated with falls because often with age comes frailty. Several researchers have identified gender as a risk factor, with female gender being a stronger risk factor in the older population[170] and male gender a stronger factor in the younger population.[167, 169, 171] A recent retrospective analysis by Krauss and colleagues[170] found that altered mental status was not a factor in falls, but that patients in academic medical centers were more likely to fall. This research was limited because it did not control for patient acuity or staffing levels.

Harwood and colleagues[172, 173] reviewed the literature related to visual problems and falls and found that uncorrected visual impairment nearly doubled the risk of falling. Cardiovascular causes of falls derive predominantly from neurally mediated disorders (e.g., vasovagal syncope) and cardiac abnormalities (e.g., arrhythmias, infarction, valvular stenosis).[174, 175] Time of day has also been implicated; Tutuarimia and colleagues[176] identified a higher rate of falls on the night shift, but this is inconsistent with other research and may in fact be explained by staffing patterns. Association of falls to the lunar cycle has also been explored, but no association was found.[177]

Vitamin D deficiency has been implicated as a risk factor for falls and fracture in the long-term care setting.[178] In addition, elevated alkaline phosphatase and low serum parathyroid hormone have been identified as predictors for falls,[179, 180] and anemia has also been implicated.[181]

A number of researchers are exploring the relationship between nurse-to-patient staffing ratios and an increase in the incidence of falls.[20, 176, 182-184] Some of this work has identified an

inverse association between licensed nurse staffing ratios and fall rates (i.e., a higher proportion of nurses is associated with lower fall rates);[176, 182, 184, 185] however, the overall the results are inconclusive.[186] In addition, a growing body of research related to failure to rescue, defined as being "based on the premise that although deaths in hospitals are sometimes unavoidable, many can be prevented,"[187-189] supports the inclusion of unanticipated physiologic events in the definition of falls since the patient's safety issues should be addressed at all times. Other researchers examining nurse staffing ratios and fall rates suggest that fall rates are reduced by increasing the number of nurse aids rather than licensed nursing staff.[190] This is potentially supported by recent work by Krauss and colleagues;[191] of the fallers in their case-control study, 85 percent of those in need of assistance or supervision with ambulation fell while not being supervised.

Certain subgroups of patients have been identified at higher risk because of the inherent characteristics of their disease process or treatment modalities. These groups include geriatric, behavioral health, oncology, rehabilitation, stroke, and multiple sclerosis patients. In the behavioral health setting, fall rates range from 4.5 to 25 falls per 1,000 patient days.[192, 193] Researchers have identified the typical faller in the behavioral health setting as a female with a history of falls; who was younger than 65 years of age; who was experiencing anxiety and agitation; and who was receiving a sedative, a tranquilizer, or a laxative.[194] Irvin[195] explored risk factors in the psychiatric setting and found that gait or balance problems and history of falls were the primary predictors. Although many of these characteristics are consistent with patients in the acute care setting, younger age and comorbidities such as depression and psychosis are often predictors in the behavioral health population.[196-199] In addition, treatments specific to behavioral health patients are different than those in the acute care setting. For example, patients being treated for late-life depression are at risk for falling in the first weeks of using a tricyclic antidepressant and should be monitored closely while they are adjusting to the new medication.[75] De Carle and Kohn[200, 201] have described risk factors in behavioral health patients and have identified electroconvulsive therapy as a predictor.

Patients in rehabilitation units are also at higher risk, likely because they have suffered neurological injuries such as stroke or head injury, which precipitate muscle weakness, impaired cognition, and impulsivity.[202-205] In addition, these patients are being physically challenged, which places them in higher-risk situations and thus at greater risk for falling.[206]

In the pediatric inpatient setting, fall rates range from 0 to 0.8 per 1,000 patient days.[207] These rates are very low compared to adult inpatient and long-term care rates. The factors that limit the number of falls in this population are unclear, but may be related to increased supervision of pediatric patients via higher nurse-to-patient staffing ratios and the common practice of parents staying with pediatric inpatients.

Injury risk factors in the acute and long-term care setting. In general, injury risk factors are similar across care areas. Vassallo and colleagues[208] examined the risk factors associated with injury in a group of inpatient fallers and found that three factors were associated with injuries related to falls: (1) history of falls, (2) confusion, and (3) unsafe gait. In addition to these, Rothschild and colleagues[134] identified physiological processes, such as increased bleeding tendencies and osteoporosis, as factors that increased risk for bleeding or fracture. The risk for medications or physiologic factors to precipitate injuries related to bleeding have been explored on a limited basis in the inpatient population. Contrary to results in the community,[84] Stein and team[209] found that hospitalized stroke patients who are anticoagulated are not at higher risk for injury than nonanticoagulated patients; however, this study was small and the issue warrants

further research. Bond and colleagues[210] examined over a 4-year period the risk for bleeding injury among 1,600 patients who fell while hospitalized. These researchers found that half of the patients were on thrombotic therapy and that the incidence of fall-related intracranial hemorrhage was low, even in persons taking warfarin. The authors suggested that selection bias may be a factor because physicians might withhold anticoagulant therapy for patients who have a higher fall risk. More recently, Spector and colleagues[211] performed a large study of nursing homes and found that 85 percent of fractures were caused by falls, and that those with epilepsy, those with agitation, and those taking anticonvulsants had the highest risk of sustaining a fracture if they fell.

Table 2. Risk Factors for Falls and Injuries in Acute and Long-Term Care

Intrinsic Risk Factors	Fall Risk	Injury Risk
Demographics		
• Age	Across ages	Older
• Gender	Male	Female
Cognitive Function		
• Agitation	Yes	Yes
• Anxiety	Yes	No data
• Cognitive impairment	Yes	No data
• Impulsivity	Yes	No data
• Inability to follow instructions	Yes	No data
• Short-term memory loss	Yes	No data
Physical Function		
• Fall history	Yes	Yes
• Fatigue	Yes	No data
• Gait problems	Yes	No data
• Impaired muscle strength	Yes	No data
• Impaired physical functioning	Yes	No data
• Toileting needs increased	Yes	No data
• Postural hypotension	Yes	No data
• Visual impairment	Yes	No data
Physiologic Status		
• Alkaline phosphatase level elevated	Yes	No data
• Anemia	Yes	No data
• Parathyroid hormone deficiency	Yes	Yes
• Prolonged bleeding time	No data	Yes
• Vitamin D deficiency	Yes	Yes
Comorbidities		
• Alzheimer's disease	Yes	No data
• Depression	Yes	No data
• Diabetes	Yes	No data
• Comorbidities in general	Yes	No data
• Multiple sclerosis	Yes	No data
• Parkinson disease	Yes	No data
• Stroke	Yes	No data
• Syncope	Yes	No data
Medications		
• Anticoagulants	No data	Yes
• Antiepileptics	Yes	No data
• Chemotherapeutics	Yes	No data

Intrinsic Risk Factors	Fall Risk	Injury Risk
• Laxatives	Yes	No data
• Psychotropics	Yes	No data
• Sedatives and hypnotics	Yes	No data
Extrinsic Risk Factors	**Fall Risk**	**Injury Risk**
Other Factors		
• Staffing	Yes	No data
• Time of day	Yes	No data
• Electroconvulsive therapy (in behavioral health)	Yes	No data
• Being physically challenged (in rehab)	Yes	No data

Acute care risk assessment instruments. Many tools have been developed to identify patients at highest risk for falling in the acute care setting.[21, 159, 167, 169, 212-215] Perell and colleagues[87] reviewed risk assessment tools and identified 6 functional assessment instruments and 15 fall risk assessment instruments developed by nursing. Vassallo and colleagues[216] concurrently examined the predictive validity in the acute care setting of four commonly used risk assessment instruments (STRATIFY, Downton, Tullamore, and Tinetti) and found that the STRATIFY instrument was the easiest to use, was most effective of the four at predicting falls in the first week of inpatient admission (total predictive accuracy of 66.6 percent), but had the poorest sensitivity (68.2 percent).

The most commonly reported risk assessment instrument is the Morse Falls Risk Assessment Tool.[217] In 2002, O'Connell and Myers[218] conducted psychometric testing with this tool on 1,059 patients admitted to an Australian hospital. In this study, the Morse Falls Risk tool had a sensitivity of 83 percent and a specificity of 29 percent, but a positive predictive value of only 18 percent. This resulted in a very high false-positive rate, with the tool identifying more than 70 percent of patients who did not fall at high risk for falling. This research was confounded by the fact that the interventions were applied based on the instrument's predictions; therefore, the predictive validity cannot be conclusively stated. The STRATIFY Falls Prediction tool also had a low positive predictive value (30 percent) and relatively low sensitivity (66 percent) and specificity (47 percent).[212]

The Heinrich Falls Risk Model I is reported to be more robust (sensitivity, 77 percent; specificity, 72 percent) than either of the others, and the Hendrich Falls Risk Model II demonstrated even more improvement (sensitivity, 74.9 percent; specificity 73.9, percent; positive predictive value, 75 percent).[169] The inclusion of a Get Up and Go test in the Heinrich II tool was the major change between version I and version II. The Get Up and Go test evaluates a person's ability to rise from a chair in a single movement, which is an assessment method that has been explored in earlier fall-prediction research. It is surprising that the sensitivity and specificity of the tool increases only slightly with the addition of this factor, underscoring the complexity of predicting patient falls. In addition, prospective evaluation of the use of the Hendrich II instrument has yet to be reported.

Several studies have tested the predictive validity of fall risk assessment instruments in relation to the judgment of nurses. Myers and Nikoletti[219] concluded that neither the fall risk assessment instrument nor nurses' clinical judgment acted as a reliable predictor. Eagle and colleagues[220] compared the Functional Reach test, the Morse Falls Scale, and nurses' clinical judgment in the rehabilitation and geriatric environment. This study also concluded that the two standardized assessment processes were no better at predicting falls than the clinical judgment of nurses. A limitation in both of these studies was that the evaluation occurred only at one time

point close to admission, which does not account for the variability of patient status throughout a patient's hospital stay.

In the domain of rehabilitation medicine, Ruchinskas[221] compared structured assessments—including the Mini-Mental State Exam, the Geriatric Depression Scale, the Functional Intervention Model, and the clinical judgment of physical and occupational therapists—on admission and discharge. This study concluded that the clinical judgment of therapists had a positive predictive power of 33 percent and a negative predictive power of 82 percent. However, the more accurate predictors of falling for the patients in their sample were a history of falls and presence of a neurological diagnosis. In the residential care environment, Lundin-Olson and colleagues[222] found that clinical judgment can contribute to the accurate prediction of fall risk, but is not sufficient on its own as a valid predictor.

Although fall-prediction research has been performed for two decades, it is clear that fall prevention is a complex problem that cannot be solved by risk assessment alone, hence the dissatisfaction with available risk assessment instruments.

Long-term care assessment instruments. Lundin-Olson and colleagues[223] developed the Mobility Interaction Fall Chart (MIF chart), which is an instrument based on a patients' ability to walk and talk at the same time, the ability to maintain pace while carrying a glass of water, visual impairment, and difficulty concentrating. When the predictive validity of the MIF chart was evaluated, the researchers found that the chart was helpful only when used in conjunction with clinical judgment and knowledge of a patient's history of falls, thus making the use of this instrument on its own limited.[222]

The Downton instrument, originally developed in the community setting, characterizes risk by five factors: (1) increased dependency, (2) cognitive impairment, (3) increased number of physical symptoms, (4) presence of anxiety, and (5) presence of depression.[224] This instrument has recently been prospectively evaluated in the long-term care setting with a reported sensitivity ranging from 81 to 95 percent and specificity ranging from 35 to 40 percent.[225] Although the specificity is low, this instrument might provide a standardized measure to identify those at risk in the long-term care environment.

Becker and colleagues[162] have recently described an algorithm to assess fall risk in the long-term care setting, categorizing long-term care residents into three subgroups: (1) residents requiring assistance to transfer, (2) residents able to transfer with history of falls and requiring the use of restraints, and (3) residents able to transfer and with no history of falls but with urinary incontinence and visual impairment. The researchers found that the residents with the history of falls were at highest risk for falls, which is consistent with other research in this domain, but might be useful to tailor interventions and would warrant prospective evaluation.

Acute care pediatric risk assessment instruments. Falls in the acute care pediatric setting are relatively rare; however, standardized assessment may be beneficial to reduce falls and injuries in this population. Graf[207] has recently developed an instrument for acute care pediatric risk assessment. According to Graf, factors associated with pediatric falls include (1) seizure medication (odds ratio 4.9), (2) orthopedic diagnosis, (3) not using an IV (odds ratio 3.6), (4) physical/occupational therapy ordered, and (5) LOS (odds ratio 1.84 for every 5 days). This model has a sensitivity and specificity of 69 percent and 84 percent, respectively, and is being prospectively evaluated by the investigator with the hope that standardized assessment will facilitate reduction in these already-low rates.

Automated risk assessment in the acute and long-term care settings. Recent national patient safety efforts highlight the promise of using informatics processes to manage patient

safety issues such as the management of patient falls. However, to date, most automated risk assessment techniques in the acute care setting are electronic versions of existing fall risk assessment instruments, with limited use of computerized decision support.[167, 226, 227] Promising new work in data mining for fall prediction has demonstrated that use of the LTCMDS has the potential to use existing data to generate risk models for patients in this setting. Volrathongchai[228] has recently explored the ability to use computerized data mining techniques to identify elderly residents of long-term care facilities who were at risk for falls. Although this work has not been prospectively evaluated, the research found that the use of these data mining techniques, in conjunction with nursing knowledge, had the potential to identify fallers.

Acute and long-term care prevention strategies. The goal of any fall- and injury-prevention effort is to decrease adverse outcomes for the patients who are most vulnerable to falling. A beneficial consequence of fall- and related-injury-prevention programs is the potential to streamline resource use, with the added potential for decreased costs associated with this problem.[229-231] To date, however, a ubiquitous fall- and injury-prevention strategy has not been identified for hospitalized patients, and implementation of multifaceted strategies is often difficult to introduce in the complex clinical environment.[232]

Several reviews have examined fall-prevention strategies in the acute and long-term care settings.[98, 99, 153, 159, 233] Oliver, Hopper, and Seed[234] examined 10 studies, including 3 RCTs and 7 prospective studies with historical controls. Oliver and colleagues found that the pooled effects ratio was 1.0 (95% CI = 0.60–1.68), indicating that overall the interventions were not able to prevent falls. More recently, Oliver and colleagues[235] have performed a meta-analysis of fall- and injury-prevention strategies and found a decrease in fall rates with multimodal intervention and a decrease in hip fractures with hip protectors in the long-term care setting. Agostini, Baker, and Bogardus[98] conducted a review of the literature related to fall prevention for hospitalized and institutionalized older adults. This review did not pool the results, but examined the literature related to the use of armbands, bed alarms, and restraints for fall prevention, all of which will be discussed individually below.

The use of physical restraints to prevent falls has been refuted because restraints limit mobility, contribute to injuries, and don't prevent falls.[236, 237] Agostini and colleagues[98] examined literature related to fall prevention via restraint and side rail use, as well as fall rates when restraints were removed. Six studies found that restraints were associated with increased injuries, and restraint and side rail removal did not increase fall rates. Evans, Wood, and Lambert[238] also examined the literature and found 16 studies that examined restraint minimization, concluding that restraint-minimization programs involving effective staff education can reduce injuries and do not increase fall rates.

Several individual fall-prevention interventions have been examined, including the use of armband identification bracelets, exercise regimen, postfall assessment, bed alarms, toileting regimen, and vitamin D supplementation. Mayo and colleagues[155] conducted a randomized controlled trial to examine if armbands would help identify high-risk patients in a rehabilitation unit and prevent falls in the high-risk group. The researchers, however, found that high-risk patients with a blue armband had higher fall rates than those without the armband. Despite widespread use, only one study from 1993 has examined bed alarms. Tideiksaar and colleagues[154] found that bed alarms were an effective method for fall prevention (relative risk = 0.32), but the intervention warrants further research. An associated intervention, a movement detector, has recently been developed. Kwok and colleagues[239] studied movement detectors and found no difference between intervention and control groups. However, a pilot study examined

the use of a movement detection patch attached to the thigh, which alerts clinicians when elderly long-term care residents are moving about.[240] Kelly and colleagues found a 91 percent decrease in falls during the 1-week testing period. Although this study quality was poor, the intervention might be suitable for select patients and bears further testing. Rask and colleagues[224] and Taylor and colleagues[225] evaluated the use of a fall-prevention program with a fall coordinator in the long-term care setting; they found that the control nursing homes had increases in fall rates over 4 years, whereas the intervention nursing homes had stable fall rates during the same time period.

Mulrow and colleagues[241] examined the effects of a physical therapy exercise intervention for frail long-term care residents and found that fall rates increased in the intervention group. However, the intervention group in this study also showed an increase in general strength and a decrease in the use of assistive devices, making one wonder if the physical therapy intervention sought to decrease the use of assistive devices in inappropriate situations. Rubenstein and colleagues[242] examined the ability for post-fall assessment to identify underlying factors that could be remedied to prevent further falls. Choi and colleagues[243] examined the effect of Tai Chi in the long-term care setting and found a 38 percent decrease in falls in the Tai Chi group, but this was not statistically significant (relative risk = 0.62; 95% CI = 0.32–1.19). A larger study may demonstrate statistical significance. A more recent study by Nowalk[244] reported no difference between groups who received strength training. The authors concluded that long term care residents may require individualized training, rather than group training.

Bakarich, McMillan, and Prosser[245] examined the impact of a toileting regimen for elderly confused patients with mobility problems in the acute care units of a large metropolitan teaching hospital. The researchers found that there were 53 percent fewer falls during shifts in which the risk assessment and toileting intervention was used, but that compliance with the assessment and intervention was difficult to maintain. More recently, Klay and Marfyak[246] found that a continence specialist in the long-term care environment reduced falls by 58 percent. Vitamin D has also reduced falls in elderly females in the long-term care setting by up to 49 percent, and in both males and females by 25 percent.[129, 134, 178, 247, 248] Further investigation of the use of vitamin D in the acute care and rehabilitation setting for fall and injury prevention is warranted. Jensen and colleagues[249] examined the effect of exercise training on elderly residential care patients and found an increase in strength and balance, and a nonstatistically significant decrease in falls. This study was limited by its small sample size and unequal distribution of important risk factors such as Mini-Mental State Exam scores across groups.

As with community interventions, tailored, multipronged prevention strategies are being shown to be more effective in acute and long-term care settings than individual interventions alone. Hofmann and colleagues[250] used three concurrent interventions—staff education, an exercise program, and environmental modifications—for a frail elderly population. The concurrent use of these interventions decreased the fall rate by 38 percent and decreased the fracture rate by 50 percent. Haines and colleagues[251] also examined a multipronged intervention involving staff and patient education, an exercise program, and the use of hip protectors. Researchers found a 22 percent decrease in falls and a 28 percent decrease in injuries in the intervention group.

One of the most promising studies by Jensen and her research team[252] investigated the effects of a comprehensive fall risk assessment and tailored intervention program in the long-term care setting. The intervention included assessment via the Mobility Interaction Fall Chart, visual evaluation, medication evaluation, and delirium screening by all members of the care team—physicians, nurses, and physical and occupational therapists. This research demonstrated that the

comprehensive assessment and tailored interventions reduced falls by 51 percent and injuries by 77 percent over a 34-week period. Healy and colleagues[253] also found a statistically significant reduction in falls (RR = 0.71) by applying a tailored plan of care to adult inpatients who were deemed at high risk for a fall based on having had a previous fall. In effect, this research used history of fall as a method to triage high-risk patients, who then received a comprehensive risk assessment with targeted interventions. This research did not demonstrate a decrease in injuries; however, further research using this technique will be useful. McMurdo, Millar, and Daly[254] found up to a 55-percent reduction in fall rates in a group of 133 nursing home residents with comprehensive risk assessment and balance training, but these results were not statistically significant. A larger sample size would provide a better understanding of the effect of the intervention.

Other research examining multimodal interventions have had mixed outcomes. A recent study by Vassallo and colleagues[255] in long-term care facilities found a decrease in falls was nullified when the results were controlled for LOS. However, controlling for LOS removes the ability for LOS to be identified as a predictor, which may be the case for patients who stay longer in a hospital setting. Kerse and colleagues[256] found that in a group of nursing homes, long-term care residents who were randomized to risk assessment followed by tailored interventions showed an increase in falls (incident rate ratio = 1.34; $P = 0.018$). Semin-Goossens, van der Helm, and Bossuyt[257] evaluated the effect of a guideline with semistructured interventions and found that fall rates in high-risk neurology and medical patients were not reduced. The researchers attributed the failure of the program to resistance by nurses to changing attitudes toward falls with the statement that nurses did not find falls troublesome enough. However, the failure was more likely due to system issues, such as ability to implement and agreement with the guideline, and training issues, which are common with guideline implementation failures.[258, 259] In addition, the Semin-Goossens guideline did not use a standardized risk assessment instrument, which might have made it difficult to identify patients at risk. Fonda and colleagues[260] studied a multimodal process-improvement plan and found that after 3 years, fall rates were decreased by 19 percent and injuries were decreased by 77 percent. Furthermore, this effect was sustained with continued use of the multimodal intervention. Schwendimann and others[261] found a moderate, but not statistically significant decrease in fall rates, and no change in injury rates after implementing an interdisciplinary fall-prevention program. Lane[262] found no decrease in patient fall rates before and after implementation of a fall-prevention program. Although the results of multimodal studies are conflicting, it is important to note that none of the studies of multimodal interventions—whether effective or ineffective results—controlled for staffing ratios or skill mix.

An increasing number of studies are examining the prevention of injury in the acute and long-term care settings. Hip protectors have been evaluated in the long-term care environment since the early 1990s. Although early work found that hip protectors were effective in reducing hip fractures in the frail or osteoporitic elderly,[263] more recent work indicates that compliance with using hip protectors is difficult to maintain, making recommendation for hip protector use conditional.[264, 265] Ray and colleagues[266] examined the ability of a 2-day staff safety education plan to reduce serious fall-related injuries and found that this intervention was not effective, but the result may have been confounded by lack of staff compliance with the safety plan. (See Evidence Tables 1 to 9 for individual study results.)

Summary of acute and long-term care falls and related injuries. In summary, fall prevention in the acute and long-term care settings is a complex and demanding problem with

multiple patient types and risk factors to manage. Standardized risk assessment with multimodal tailored interventions appears to be the most successful method of prevention; however, implementation of comprehensive interventions across care settings can be challenging. Further research toward overcoming barriers to implementation, guideline adherence, staffing ratios, and tailored interventions for newly identified risk factors such as vitamin D deficiency and anemia are warranted. Furthermore, research must be conducted on a larger scale to demonstrate generalizability and to be able to translate evidence into practice.

Evidence-Based Practice Implications

Screening for fall and injury risk should be performed across settings. In the community, all patients older than 65 years should be screened, and in the home care, acute care, and long-term care settings, patients of all ages should be screened. Screening needs to include injury risk, not just fall risk. The most effective interventions are multimodal ones that address specific areas of risk and work with interdisciplinary fall-prevention teams.

In the community, screening can take place with a general annual physical exam or other routine health care visit. A standardized risk assessment tool should be used, such as the Tinnetti screening tool, which has the highest sensitivity and specificity for use in the community, but screening for injury risk must be included. If a patient is seen in an emergency room because of a fall, evidence suggests that focused fall and injury risk evaluation is warranted, especially if the patient is to be discharged home, i.e., the discharge prescription should include a focused fall risk assessment by the primary care provider or by a fall-prevention clinic. Tailored interventions for elderly community dwellers can decrease fall rates. Interventions that have had the most success in the community include exercise interventions with leg strengthening and balance training (e.g., Tai Chi), medication adjustment, management of cardiac-related syncope, effective diabetes management, management of vitamin D deficiency, and home safety modifications. Interventions to prevent injury in the community include calcium with vitamin D for fracture prevention, and additional fall precautions and increased screening for patients on anticoagulant therapy.

In the acute and long-term care settings, screening should be carried out using a standardized assessment tool for all patients. The Morse tool is the most commonly used in the acute care setting, but it does not screen for injury risk. In the long-term care setting, the LTCMDS may be an effective screening tool. In both acute and long-term care, effective interventions are multimodal and include medication adjustment, environmental adjustment, alarm devices, staff safety education, calcium and vitamin D, exercise interventions, and treatment of other underlying disorders. Interventions to prevent injury in the acute and long-term care settings include limiting restraint use, lowering bedrails, using hip protectors in long-term care, calcium with vitamin D, and possibly bisphosphonates in long-term care. Across the health care continuum, effective interventions have been identified, but their use is not ubiquitous.

Research Implications

In the community setting, identification of the best timing for screening and reassessment is needed. Identification of methods to build fall- and injury-prevention programs in the community is needed to guide policymakers. In the acute and long-term care settings, large multisite intervention studies that use multimodal interventions tailored for individual risk factors and that control for comorbidities, acuity, staffing, and other environmental factors are needed. Cost-

effectiveness studies to characterize the impact of fall- and injury-prevention programs are needed in the acute and long-term care settings.

Recommendations From Evidence-Based Practice and Research Implications

1. Recommendations for screening and assessment

- Fall and injury risk screening should be performed in all settings.
- All patients who fall should receive a comprehensive postfall assessment.
- Methods for computerized screening and followup should be explored.

Table 3. Recommendations for Screening and Assessment

Evidence-Based Practice Recommendations	Research Implications
Community:	
• Screen all patients over 65 during routine or other visit.	• Examine risk factors related to race and gender.
• For patients who screen positive, refer to fall-injury prevention clinic for focused fall-injury risk assessment, if available.	• Identify barriers to widespread screening. • Examine barriers to establishment of fall-injury prevention clinics.
• Use a standardized risk assessment tool, such as Tinetti's 9-item screening tool for (1) mobility, (2) morale, (3) mental status, (4) distance vision, (5) hearing, (6) postural blood pressure, (7) back examination, (8) medications, and (9) ability to perform activities of daily living (ADLs). (*Note:* This tool does not overtly assess for injury risk.)	• Validate risk assessment instruments across culture, race, and language. • Examine predictive validity of injury risk factors such as antiplatelet therapy, bleeding disorders, vitamin D deficiency, and chronic subdural hematomas. • Develop instruments for patient self-assessment for fall and injury risk.
• For patients > 65 years who present to the emergency department (ED) with a fall, refer to primary care provider for focused fall-injury risk assessment.	• Examine the effect of identification in the ED using large, multicenter randomized controlled trials. • Identify barriers to widespread adoption.
Evidence-Based Practice Recommendations	**Research Implications**
Home Care and Long-Term Care:	
• Screen patients of all ages.	• Validate home care assessment instruments.
• Use a standardized risk assessment tool, such as Tinetti's 9-item screening tool.	• Examine predictive validity of Long Term Care Minimum Data Set.
• Reassess at regular intervals.	• Examine best timing for reassessment in home care and long-term care.
Evidence-Based Practice Recommendations	**Research Implications**
Acute Care Setting:	
• Screen patients of all ages.	• Develop and validate instruments for subgroups.
• Use a standardized risk assessment instrument such as the Morse, Hendrich II, or STRATIFY tools. (*Note:* These tools do not assess for injury risk.)	• Validate instruments in multiple settings. • Explore predictive validity of physiologic factors such as low creatinine clearance, vitamin D deficiency, and anemia.
• Assess for injury risk for patients with injury risk factors such as low BMI, frailty, osteoporosis, vitamin D deficiency, and antiplatelet therapy.	• Validate instruments that assess for injury risk.
• Reassess patients at regular intervals.	• Examine the best timing for reassessment.

2. Recommendations for interventions in the community setting

- Apply multimodal interventions as identified by risk assessment.
- Participate in national reporting activities such as ANA–NDNQI.
- Examine the use of computer-based guidelines in all settings.

Table 4. Recommendations for Community Setting

Evidence-Based Practice Recommendations	Research Implications
Fall Prevention:	
• Provide balance training with leg strengthening, such as Tai Chi.	• Examine effect of starting balance training at younger age (i.e., 50 years). • Examine barriers to establishment and use of balance training centers.
• Monitor medication side effects for patients older than 65.	• Identify medications with minimal side effect profiles for patients older than 65.
• Limit medications to fewer than four, if possible.	• Examine medication dosing for groups of medications.
• Monitor and treat calcium and vitamin D deficiency.	• Examine factors related to calcium and vitamin D metabolism in relation to muscle function.
• Manage underlying disorders such as cardiac-related syncope, diabetes, and vision problems (e.g., cataracts).	• Explore factors to manage groups of disorders. • Explore other diseases that may predict falls.
• Provide home safety modifications.	• Explore barriers to home safety modification.
• Educate about use of thin-soled shoes (not running shoes).	• Further explore shoe type for specific patient groups.
• Provide education about how to manage risky situations.	• Explore fall prevention self-management strategies.
Injury Prevention:	
• Monitor for calcium and vitamin D deficiency; provide supplements for fracture prevention.	• Conduct large studies that control for comorbidities, age, and other factors to explore efficacy of hip protectors in the community.
• Increase screening for patients on anticoagulant therapy, those with bleeding disorders, and for the frail and very old.	• Identify safety measures for bleeding-injury prevention. • Explore interventions for the very old and frail.
• Use bisphosphonates for patients with documented osteoporosis.	• Explore safety of long-term use of bisphosphonates.

3. Recommendations for interventions in the acute and long-term care settings

- Apply multimodal interventions as identified by risk assessment.
- Participate in national reporting activities such as ANA–NDNQI.
- Examine the use of computer-based guidelines in all settings.
- Large, multi-site randomized controlled trials that evaluate tailored interventions while controlling for organizational culture, staffing, comorbidities, acuity, and other factors are needed. Injury rates should be the primary outcome of interest, since fall-rate reporting may be an imprecise measure.
- Characterize the cost effectiveness of bundles of tailored interventions.

Table 5. Recommendations for Acute and Long-Term Care

Evidence-Based Practice Recommendations	Research Implications
Fall Prevention	
• Educate staff about safety care. • Train medical team, including students and residents, for fall-injury risk assessment and postfall assessment.	• Examine impact of safety education across interdisciplinary team.
• Use alarm devices.	• Examine impact of alarms on caregiver satisfaction.
• Monitor medication side effects and adjust as needed.	• Examine effect of computerized decision support for medication management.
• Adjust environment (e.g., design rooms to promote safe patient movement).	• Examine cost effectiveness of environmental adjustments.
• Provide exercise interventions (e.g., Tai Chi) for long-term care patients.	• Examine usefulness of exercise interventions for acute care patients.
• Provide toileting regimen for confused patients (e.g., check patients every 2 hours).	• Study barriers to maintaining and sustaining monitoring activities.
• Monitor and treat calcium and vitamin D levels for long-term care patients.	• Examine effects of calcium and vitamin D management for acute care patients.
• Treat underlying disorders such as syncope, diabetes, and anemia.	• Examine constellations of disorders that might precipitate falls.
Injury Prevention	
• Limit restraints use.	• Identify methods to overcome barriers to restraints reduction.
• Lower bedrails.	• Study efficacy of environmental changes.
• In addition to fall rates, monitor injury rates.	• Establish fatal fall rates across settings.
• Use hip protectors for geriatrics and long-term care.	• Identify methods to overcome barriers to use of hip protectors.
• Use floor mats.	• Examine effect of safety flooring.
• Monitor prothrombin time, international normalized ration (PT/INR) for patients at risk for falling.	• Identify safety measures for bleeding-injury prevention.
• Ensure postfall assessment.	• Examine barriers to postfall assessment.
• Use bisphosphonates for patients with documented osteoporosis.	• Explore safety of long-term use of bisphosphonates.

Conclusion

Falls and related injuries are an important issue across the care continuum. National efforts in the community via Healthy People 2010, in the acute care setting via the Joint Commission's National Patient Safety Goals, and in the long-term care setting via the Nursing Home Quality Initiative project have the potential to significantly reduce falls and related injuries. The growing number of randomized controlled trials related to fall-prevention efforts is promising. However, most of these studies have been carried out in the community and long-term care environments, with few randomized controlled trials evaluating fall- and injury-prevention measures in the acute care setting. As with other nursing-sensitive quality indicators, recent research demonstrating an association between fall rates and nurse staffing ratios needs to be more fully explored. In addition, further research needs to explore automated methods of assessing and communicating fall risk, better methods for risk identification, and the identification of

prevention measures. Indeed, with coordinated efforts to apply the evidence to practice, the problem of falls might be managed more effectively.

Search Strategy

MEDLINE,® the Cumulative Index to Nursing and Allied Health Literature (CINAHL®), and Cochrane databases from inception to March 2007 were searched for medical subject heading terms, both individual terms and combinations of the following: accidental falls, patient safety, medical errors, nursing-sensitive quality indicators, and fall prevention. In addition, references from relevant articles were searched using the snowball technique, as were archives of select nursing research and gerontology journals. The Related Links function in MEDLINE was also used to maximize the search strategy. Google, Google Scholar, and citations from identified articles were also searched for additional possible references. Articles related to occupational falls, sports-related falls, alcohol-related falls, and physical abuse-related falls were excluded. Articles that reported physiologic characteristics that are suspected to preclude falls but that did not examine falls or fall-related injuries as outcomes were also excluded because the causative effect on falls and fall-related injuries is, to date, inconclusive. Further, articles that were published in a foreign language were excluded. Two hundred and twenty seven articles were reviewed. Sixty-one of these were intervention research studies related to fall and injury prevention (32 from the community setting; 33 from the acute and long-term care setting).

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Evidence Table 1. Reviews Examining Fall-Prevention Interventions in the Community

Source	Safety Issue Related to Clinical Practice	Design Type*	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Weigand 2001[93]	Fall and injury prevention in the community	Literature Review	**Design:** Review **Outcomes:** Fall rates	**Setting:** Community **Population:** Emergency patients	Assessment of fallers & targeted interventions	*Falls:* No definitive evidence to support ED assessment followed by targeted interventions is effective for preventing falls. More research required.
Cumming 2002[100]	Fall and injury prevention in the community	Literature Review	**Design:** Review **Outcomes:** Fall rates	**Setting:** Community **Population:** Older adults	Multiple interventions; 21 trials reviewed	*Falls:* • Exercise programs most promising. • Reduction of antipsychotic medications should be considered. • No definitive prevention strategy.
Gillespie 2003[104]	Fall and injury prevention in the community	Meta-analysis	**Design:** Systematic Review **Outcomes:** Fall rates	**Setting:** Community **Population:** 21,668 people	Multiple interventions; 62 trials reviewed	*Falls:* Multimodal, interdisciplinary prevention programs are most successful. *Risk Assessment:* Need more accurate risk assessment instruments.
Chang 2004[99]	Fall and injury prevention in the community	Meta-analysis	**Design:** Review **Outcomes:** Fall rates	**Setting:** Community **Population:** Older adults	Multiple interventions; 40 trials reviewed	*Falls:* Multimodal assessments with targeted intervention reduced risk of falls by 37 percent, and exercise interventions reduced fall risk by 14 percent.
Hill-Westmore-land 2005[38]	Fall and injury prevention in the community	Meta-analysis	**Design:** Meta-analysis **Outcomes:** Fall rates	**Setting:** Community **Population:** Older adults in long-term care setting	Multiple interventions; 12 studies reviewed	*Falls:* Decrease in fall rates when individualized management added to exercise interventions.
Stevenson 2005[135]	Fall and injury prevention in the community	Systematic Review	**Design:** Systematic review **Outcomes:** Fracture, vertebral and nonvertebral	**Setting:** Community **Population:** Older women at risk for fracture	Review of calcium, vitamin D, and bisphosphonates	*Fractures:* • Calcium, with or without vitamin D, reduces fractures in patients with high risk for fracture. • Calcium with vitamin D can prevent fractures in women not at risk for fractures.

* Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.

Source	Safety Issue Related to Clinical Practice	Design Type*	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Shekele 2003[11]	Fall and injury prevention in the community	Meta-analysis	**Design:** Meta-analysis **Outcomes:** Fall and injury rates	**Setting:** Community **Population:** Medicare recipients	Mulriple interventions	*Falls:* Multifactorial fall prevention programs decrease fall rates

Evidence Table 2. Studies on Community-Based Fall-Prevention Screening with Tailored Interventions (listed chronologically)

Source	Safety Issue Related to Clinical Practice	Design Type†	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Close 1999[42]	Tailored interventions for falls in the community	RCT	**Design:** RCT **Outcomes:** Fall rates, repeat fall rates, hospital admissions, Barthel Score (Max 100; higher score = higher functioning)	**Setting:** Community **Population:** 397 patients ≥ 65 years who presented to an accident and emergency department with a fall	Detailed medical and occupational-therapy assessment with referral to relevant services if indicated with 1 year followup.	*Falls:* Decreased by 61 percent for patients who were identified in the emergency department and who had subsequent detailed risk assessment and tailored interventions (odds ratio = 0.39, 95% CI = 0.23–0.66; *P* = 0.0002). *Recurrent falls:* Decreased by 67 percent (odds ratio = 0.33, 95% CI = 0.16–0.68). *Hospital admissions*: Decreased by 39 percent (odds ratio = 0.61, 95% CI = 0.35–1.05). *Barthel score:* Decline in score with time greater in the control group (*P* < 0.00001).
Hogan 2001[111]	Tailored interventions for falls in the community	RCT	**Design:** Randomized controlled trial **Outcomes:** Fall rates, repeat fall rates, time between falls, emergency department visits, hospital admissions	**Setting:** Community **Population:** 152 patients ≥ 65 years who had fallen within the previous 3 months	In-home assessment in conjunction with the development of an individualized treatment plan, including an exercise program for those deemed likely to benefit.	*Cumulative number falls:* No significant differences (311 v. 241, *P* = 0.34) *One or more falls*: No significant difference (79.2 percent v. 72.0 percent, *P* = 0.30) *Mean number of falls:* 4.0 v. 3.2, *P* = 0.43. *Repeat fall rates*: No significant difference *Time between falls*: Longer time between falls in intervention group (*P* < 0.001) *For multiple fallers at baseline:* • Intervention group less likely to fall (*P* = 0.046) • Time between falls longer for intervention group (*P* < 0.001) *Emergency department visits:* No significant difference *Hospital admissions:* No significant difference

† Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.

Source	Safety Issue Related to Clinical Practice	Design Type†	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Lightbody 2002[110]	Tailored interventions for falls in the community	RCT	**Design:** RCT **Outcomes:** Falls, functional ability, emergency department visits, admission to hospital	**Setting:** Community **Population:** 348 consecutive patients ≥ 65 years who were discharged from emergency room after sustaining a fall	Home assessment for medication, ECG, blood pressure, cognition, visual acuity, hearing, vestibular dysfunction, balance, mobility, feet and footwear	*Recurrent Falls:* Reduced by 38 percent *Falls:* Decreased falls in intervention group, but not statistically significant. *Admissions and bed days:* Fewer fall-related admissions and bed days in intervention group (8 and 69, respectively) than the control group (10 and 233, respectively).
Nikolaus 2003[141]	Tailored interventions for falls in the community	RCT	**Design:** RCT **Outcomes:** Number of falls, compliance with recommendations	**Setting:** Patients identified in university-affiliated geriatric hospital; intervention carried out in patients' homes **Population:** 360 patients showing functional decline, especially in mobility, admitted to a geriatric hospital (mean age 81.5 years)	Comprehensive geriatric assessment followed by diagnostic home visit and home intervention or a comprehensive geriatric assessment with recommendations	*Falls:* Intervention group had 31 percent fewer falls than control group (incidence rate ratio = 0.69, 95% CI = 0.51–0.97). *Falls:* For subgroup with ≥2 falls during previous year, there was a 37 percent decrease in falls (incident rate ratio = 0.63, 95% CI = 0.43–0.94).
Nitz 2004[108]	Tailored interventions for falls in the community	RCT	**Design:** pilot RCT **Outcomes:** Fall rates, balance measures	**Setting:** Australia; academic medical center **Population:** 73 adults (92 percent female) ≥ 65 yrs	Balance training sessions once a week for 10 weeks	*Falls:* Intervention and control groups both showed reduction in fall rates, but no differences between groups. *Balance measures:* Improved for intervention group.

Source	Safety Issue Related to Clinical Practice	Design Type†	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Davison 2005[90]	Tailored interventions for falls in the community	RCT	**Design:** RCT **Outcomes:** Fall rates, number of fall-related admissions, LOS, balance	**Setting:** Accident & emergency departments in a teaching hospital and associated general hospital in the United Kingdom **Population:** 313 cognitively intact patients ≥ 65 years with fall or fall-related injury and at least one additional fall in preceding year	Multimodal postfall assessment, including medical, physiotherapy, and occupational therapy evaluation	*Falls:* 36 percent fewer falls in the intervention group (relative risk = 0.64, 95% CI = 0.46–0.90). *Proportion of fallers:* 65 percent of subjects in the intervention group continued to fall compared with 68 percent in the control group (relative risk = 0.95, 95% CI = 0.81–1.12). *Hospital admissions*: Number of fall-related visits and hospital admissions was not different between groups. *Hospitalization:* Duration of hospital admission was reduced (mean difference admission 3.6 days, 95% CI = 0.1–7.6). *Activities-specific balance confidence score:* Improved in the intervention group.
Perell 2006[109]	Tailored interventions for falls in the community	Pretest post-test design	**Design:** Pretest, post-test **Outcomes:** Falls, repeat falls	**Setting:** Urban Los Angeles – Veterans Affairs System **Population:** 120 elders referred to the clinic. Gender not reported.	Screening following by tailored interventions at falls clinic	*Falls:* Reduction of total falls (pre = 297; post = 141; *P* = 0.0002). Increase in falls reported by 12.5 percent patients. *Mean fall rates:* Reduction in mean falls (pre = 4.1;post = 2.0). *Repeat falls:* Reduction in repeat falls (pre = 86 percent; post = 51 percent).

EvidenceTable 3. Studies Examining Exercise-Related Interventions in the Community (listed chronologically)

Source	Safety Issue Related to Clinical Practice	Design Type‡	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Reinsch 1992[124]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** Four-arm RCT **Outcomes:** Fall rates, time to first fall, injury rates	**Setting:** 16 senior centers in Orange County, California **Population:** 230 older adults who were participants at senior centers	Exercise in conjunction with cognitive behavioral therapy for safety self-awareness	*Falls:* No effect on fall rates, falls efficacy, or fear of falling. *Time to first fall:* Longer time to first fall. *Injuries:* Decreased injuries. Even though a relatively high percentage (38.6 percent) suffered at least one fall, only 7.8 percent of these community-residing elderly required medical attention.
Province 1995[115]	Exercise-related interventions for fall prevention in the community	Meta-analysis	**Design:** Preplanned meta-analysis of 7 RCTs **Outcomes:** Time to each fall (fall-related injury) by self-report and/or medical records	**Setting:** Two nursing homes and five community sites **Population:** Patients ages 60–75, ambulatory, cognitively intact	Exercise training one area or more of endurance, flexibility, balance platform, Tai Chi (dynamic balance), and resistance	*Falls:* • Fall rates decreased in group with general exercise (odds ratio = 0.90, 95% CI = 0.81–0.99). • Fall rates decreased for those with exercise plus balance training (odds ratio = 0.83, 95% CI = 0.70–0.98). *Injuries:* Patients who did not exercise had an increase in injurious falls, but power was low to detect this outcome.
Wolf 1997[120]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Frailty indicators, occurrence of falls	**Setting:** Community **Population:** 200 men and women ≥ 70 years	Tai Chi, computerized balance training, or education	*Multiple falls:* Risk of multiple falls decreased by 47.5 percent

‡ Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.

Source	Safety Issue Related to Clinical Practice	Design Type‡	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Steinberg 2000[143]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT with four arms **Outcomes:** Self-reported slips, trips, or falls	**Setting:** Community, Australia **Population:** 252 active, community-dwelling Australians ≥ 50 yrs.	Education re: fall risk factors, strength/balance exercises, home safety advice, medical evaluation	*Falls:* 30 percent reduction in falls; hazard ratio 0.70 (95% CI = 0.48–1.01). *Slips:* 58 percent reduction in slips; hazard ratio 0.42 (95% CI = 0.29–0.69). *Trips:* 64 percent reduction in trips; hazard ratio 0.36 (95% CI = 0.26–0.66).
Rubenstein 2000[116]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Muscle strength, endurance, mobility, balance, fall rates	**Setting:** Community-living men **Population:** 59 men ≥ 65 years with specific fall risk factors	90 min. exercise sessions 3x/week Focus on increased strength and endurance, improving mobility and balance	*Falls:* • Exercise group had lower fall rates than nonexercisers when adjusted for baseline activity level (6 falls/1,000 hours of activity vs 16.2 falls/1,000 hours, $P < 0.05$). • Total number of falls not decreased. *Strength:* Exercise achieved no significant effect on hip or ankle strength, balance, self-reported physical functioning.
Robertson 2002[123]	Exercise-related interventions for fall prevention in the community	Meta-analysis	**Design:** Meta-analysis of four studies **Outcomes:** Fall rates, injury rates	**Setting:** Community setting: nine cities and towns in New Zealand **Population:** 1,016 women and men ages 65 to 97	Muscle strengthening and balance retraining exercises designed specifically to prevent falls	*Falls and injuries:* Fall and injury rates decreased by 35 percent; no difference between genders. • Fall rate incidence rate ratio (IRR) = 0.65, 95% CI = 0.57–0.75 • Participants reporting a fall in the previous year had a higher fall rate (IRR = 2.34, 95% CI = 1.64–3.34). • Injury rate IRR = 0.65, 95% CI = 0.53–0.81.
Barnett 2003 [113]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Fall rates, balance, muscle strength, fear of falling	**Setting:** Community, South Western Sydney, Australia. **Population:** 163 subjects ≥ 65 years identified as at risk of falling using a standardized assessment screen by general practitioner or physical therapist	Weekly group exercise program with ancillary home exercises over 1 year	*Falls:* Fall rates decreased by 40 percent in the exercise group (IRR = 0.60, 95% CI = 0.36–0.99). *Balance measures*: Improved in exercise group. *Other measures:* No difference between groups in strength, reaction time, and walking speed or on Short-Form 36, Physical Activity Scale for the Elderly or fear of falling.

Source	Safety Issue Related to Clinical Practice	Design Type‡	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Wolf 2003[122]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Time to first fall, fall rates, balance	**Setting:** 20 congregate living facilities in the greater Atlanta area **Population:** 291 women and 20 men ages 70 to 97 who were transitioning to frailty	Intense Tai Chi exercise program or wellness education program	*Falls:* Fall rates decreased in Tai Chi group, but no statistical difference between groups (relative risk = 0.75, 95% CI = 0.52–1.08).
Clemson 2004 [114]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Fall rates	**Setting:** Community **Population:** 310 men and women ≥ 70 years who had had a fall in the previous 12 months or were concerned about falling	Occupational therapy home visits, lower-limb balance and strength training, environmental safety education	*Falls:* • 31 percent reduction in falls for both genders (relative risk = 0.69, 95% CI = 0.50–0.96; *P* = 0.025). • For men alone, 68 percent reduction in falls (relative risk = 0.32, 95% CI = 0.17–0.59).
Morgan 2004[140]	Exercise-related interventions for fall prevention in the community	RCT	**Design**: RCT **Outcomes:** Falls	**Setting:** Community **Population:** 294 men and women ≥ 60 years who had either a hospital admission or bed rest for 2 days or more within the previous month	Exercise sessions lasting 45 minutes, including warm-up and cool-down, 3 times a week for 8 weeks (24 sessions)	*Falls:* • 49 percent reduction in falls for patients with low baseline physical functioning. • 3.5 times increase in falls for patients with high baseline physical functioning.
Suzuki 2004[118]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Fall rates	**Setting:** Community, Japan **Population:** 52 elderly Japanese women	Exercise intervention—home and community center	*Falls:* Fall rates decreased in intervention group (13.6 percent v. 54.5 percent; *P* = 0.0097).

Source	Safety Issue Related to Clinical Practice	Design Type‡	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Li 2005[112]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcome:** Fall rates, functional balance, physical performance, fear of falling	**Setting:** Community in Portland, Oregon **Population:** 256 physically inactive elders ages 70 to 92	Tai Chi or stretching 3x/week for 6 months	*Falls:* 55 percent reduction in falls in Tai Chi group (relative risk = 0.45, 95% CI = 0.30–0.70). Fewer falls in the Tai Chi group (Tai Chi = 38 vs. stretch = 73; *P* = 0.007), (Tai Chi = 28 percent vs. stretching = 46 percent; *P* = 0.01). *Injuries:* Fewer injurious falls (Tai chi = 7 percent vs. stretching = 18 percent; *P* = 0.03).
Lord 2005[88]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcome:** Fall rates	**Setting:** Community in Australia **Population:** 620 people ≥ 75 years	Interventions to maximize vision and sensation or brief advice or usual care	*Falls:* The rate of falls during the trial period were similar in the three groups. *Injuries:* The rate of injurious falls during the trial period were similar in the three groups.
Faber 2006[125]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Falls, mobility, physical performance, and self-reported disability	**Setting**: 15 homes for the elderly in Amsterdam, The Netherlands **Population:** 287 elderly men and women (mean age +/- standard deviation, 85+/-6yrs)	20-week exercise program of balance training inspired by Tai Chi or daily mobility activities or control	*Falls:* Fall incidence rate lower in balance training group (2.4 falls/yr) compared to the mobility activities group (3.3 falls/yr) and control (2.5 falls/yr), but not statistically significant. *For frail subjects:* Risk of becoming a faller in the exercise groups increased almost 3 times (hazard ratio = 2.95; 95% CI = 1.64-5.32). *For pre-frail subjects:* Risk of becoming a faller decreased by 61 percent (hazard ratio = 0.39; 95% CI = 0.18–0.88).
Lin 2006[126]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Falls, fall-related injuries, related functional outcomes	**Setting:** 6 rural villages in Taiwan: 2 villages received intervention, 4 villages acted as controls **Population:** 1,200 men and women ≥ 65 years screened; 88 participants	Tai Chi training plus fall-prevention education or fall-prevention education alone	*Falls:* 50 percent greater decrease in fall rates among the Tai Chi practitioners (relative risk = 0.5; 95% CI = 0.11–2.17), but not statistically significant. *Tinetti Balance Scale*: Tai Chi practitioners increased by 1.8 points (95% CI = 0.2–3.4). *Tinetti Gait Scale:* Tai Chi practitioners increased by 0.9 point (95% CI = 0.1–1.8). *Fear of Falling:* No significant changes in the fear of falling.

Source	Safety Issue Related to Clinical Practice	Design Type‡	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Luukinen 2007[127]	Exercise-related interventions for fall prevention in the community	RCT	**Design:** RCT **Outcomes:** Fall rates, time to first fall	**Setting:** Community, home-dwelling Finnish **Population:** 555 older men and women (67 percent ≥ 85 years), most with history of recurrent falls or at least one mobility risk factor	Suggestions for a program consisting of home exercise, walking exercise, group activities, self-care exercise, or routine care	**For all subjects:** *Falls:* • 12 percent decrease in falls from baseline for intervention group (hazard ratio = 0.88, 95% CI = 0.74–1.04). • 7 percent decrease in all falls, but not statistically significantly (hazard ratio = 0.93, 95% CI = 0.80–1.09). **For subjects not homebound:** *Falls:* • 22 percent decrease in falls (hazard ratio = 0.78, 95% CI = 0.64–0.94). • 12 percent decrease in first four falls (hazard ratio = 0.88, 95% CI = 0.74–1.05).

Evidence Table 4. Studies examining physiologic interventions in the community (listed chronologically)

Source	Safety Issue Related to Clinical Practice	Design Type[§]	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Latham 2003[132]	Physiologic interventions to prevent falls in patients discharged from acute care to the community	RCT	**Design:** RCT **Outcomes:** Falls over 6 months	**Setting:** Five hospitals in Auckland, New Zealand, and Sydney, Australia **Population:** 243 frail older people (53 percent female)	One dose vitamin D 300,000 IU versus placebo OR 10 weeks of high-intensity home-based exercise versus attention lessons	*Falls:* • Increase in falls for patients receiving vitamin D as compared to placebo, but not statistically significant (relative risk = 1.12, 95% CI = 0.79–1.59). • Decrease in falls for patients in exercise group compared to attention group, but not statistically significant (relative risk = 0.96, 95% CI = 0.67–1.36). *Injury:* Patients in the exercise group were at increased risk of musculoskeletal injury (risk ratio = 3.6, 95% CI = 1.5–8.0).
Bischoff-Ferrari 2004[178]	Physiologic interventions to prevent falls and fall-related injuries in the community	Meta-analysis	**Design:** Meta-analysis of five RCTs **Outcomes:** Fracture	**Setting:** Community **Population:** 1,237 participant in the five studies	Vitamin D: Large dose = 700–800IU/d Small dose = 400 IU/d	*Falls:* Compared with patients receiving calcium or placebo, vitamin D reduced risk of falling by 22 percent (corrected odds ratio = 0.78, 95% CI = 0.64–0.92). *Fracture:* • Vitamin D 700–800IU/d reduced the risk of fracture by up to 26 percent. • Vitamin D 400 IU/d did not reduce fracture risk. *Numbers needed to treat:* 15 patients would need to be treated with vitamin D to prevent 1 person from falling. *Sensitivity analysis of 5 additional studies:* Total sample 10,001 – smaller effect size (corrected relative risk = 0.87, 95% CI = 0.80–0.96).

[§] Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.

Source	Safety Issue Related to Clinical Practice	Design Type[§]	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Avenell 2005[107]		Meta-analysis	**Design:** Metanalysis of RCTs or quasi-randomized trials **Outcomes:** Fractures	**Setting:** Community **Poplulation:** 7 trials; 18,668 participants	Vitamin D or an analogue alone, or vitamin D with calcium, or Placebo, no intervention, or calcium	**Vitamin D or analogue alone:** • No effect on hip fracture (relative risk = 1.17; 95% CI = 0.98–1.41). • No effect on vertebral fracture (relative risk = 1.13; 95% CI = 0.50–2.55). • Any new fracture (relative risk = 0.99; 95% CI = 0.91–1.09). **Vitamin D or analogue with calcium:** • Marginal reduction in hip fractures (relative risk = 0.81; 95% CI = 0.68–0.96). • Marginal reduction in nonvertebral fractures (relative risk = 0.87; 95% CI = 0.78–0.97). • No effect on vertebral fractures. • Calcitriol may be associated with an increased incidence of adverse effects.
Grant 2005[130]	Physiologic interventions to prevent falls and fall-related injuries in the community	RCT	**Design:** Factorial-design trial **Outcomes:** New low-energy fractures	**Setting:** Patients identified in 21 UK hospitals then treated at home after discharge **Population:** 5,292 people ≥ 70 years (85 percent female) with new low-trauma fracture, and who were mobile before that fracture	800 IU vitamin D daily or 1,000 mg calcium daily or 800 IU vitamin D plus 1,000mg calcium daily or placebo	*Falls:* No differences between groups (hazard ratio = 0.94; 95% CI = 0.81–1.09). *Fractures:* • No difference between vitamin D and placebo (hazard ratio = 1.02; 95% CI = 0.88–1.19). • No difference between combination treatment and placebo.
Sato 2005[137]	Physiologic interventions to prevent fall-related injuries in acute care	RCT	**Design:** RCT **Outcomes:** Vertebral factures, hip fractures	**Setting:** Community in Japan **Population:** 500 women ≥ 70 years with Alzheimer's disease, vitamin D deficiency, and hyperparathyroidism	Risedronate 2.5 with 1,000 IU vitamin D plus 1,200 mg calcium or placebo with 1,000 IU vitamin D plus 1,200 mg calcium	*Fractures:* 72 percent decrease in fractures in the risedronate group (relative risk = 0.28; 95% CI = 0.13–0.59).

Source	Safety Issue Related to Clinical Practice	Design Type[§]	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Bischoff-Ferrari 2006[134]	Physiologic interventions to prevent falls and fall-related injuries in the community	RCT	**Design:** RCT **Outcomes:** Fall rates	**Setting:** Community **Population:** 199 men and 246 women ≥ 65 years living at home	700 IU of vitamin D plus 500 mg of calcium citrate malate per day or placebo	*Falls:* • Vitamin D plus calcium reduced the odds of falling in women by 46 percent (odds ratio = 0.54, 95% CI = 0.30–0.97). • Vitamin D plus calcium reduced the odds of falling in women by 65 percent in less active women (odds ratio = 0.35; 95% CI = 0.15–0.81). • Vitamin D plus calcium did not significantly reduced the odds of falling in men (odds ratio = 0.93, 95 percent CI, 0.50-1.72)
McCloskey 2007[138]	Physiologic interventions to prevent falls and fall-related injuries in the community	RCT	**Design: RCT** (double-blind) **Outcomes:** Hip and any clinical fracture	**Setting:** General community in South Yorkshire and North Derbyshire **Population:** 5,579 women ≥ 75 years	800 mg oral clodronate (Bonefos) or placebo	*Hip fracture:* Slight increase in risk for hip fracture in placebo group (hazard ratio = 1.02, 95% CI = 0.71–1.47). *Any fracture:* 20 percent decrease in risk for any clinical fracture for patients in clodronate group (hazard ratio = 0.80, 95% CI = 0.68–0.94). *Osteoporosis-associated nonhip fractures:* 29 percent decrease in clodronate group (hazard ratio = 0.71; 95% CI = 0.57–0.87).

Evidence Table 5. Reviews Examining Fall Prevention Interventions in Acute and Long-Term Care (listed chronologically)

Source	Safety Issue Related to Clinical Practice	Design Type**	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Evans 1998[153]	Fall and injury prevention in the acute care setting	Literature Review	**Design:** Review **Outcomes:** Fall rates	**Setting:** Acute care **Population:** Patients in acute care setting	Multiple interventions; 200 studies reviewed	*Falls:* Across settings, individual interventions are not more useful than fall-prevention programs for a specific subset of patients.
Oliver 2000[234]	Fall and injury prevention in the acute care setting	Meta-analysis	**Design:** Systematic review **Outcomes:** Fall rates	**Setting:** Acute care **Population:** Patients in acute care setting	Multiple interventions; 10 studies reviewed	*Falls:* Overall the interventions studied did not prevent falls (pooled effects ratio = 1.0; 95% CI = 0.60–1.68).
Agostini 2001[98]	Fall and injury prevention in the acute care setting	Review	**Design:** Review **Outcomes:** Fall rates	**Setting:** Acute care **Population:** Patients in acute care setting	Multiple interventions; two studies and one systematic review reviewed	*Falls:* Interventions with potential to decrease falls include identification bracelets, bed alarms, special flooring, and hip protectors.
Oliver 2007[235]	Fall and injury prevention in the acute care setting	Meta-analysis	**Design:** Systematic review **Outcomes:** Fall rates, fall-related fracture rate	**Setting:** Acute care **Population:** Patients in acute and long-term care setting	Multiple interventions; 43 studies included in meta-analysis	*Falls:* • Multimodal interventions in hospitals showed 18 percent decrease in fall rates (rate ratio = 0.82; 95% CI = 0.68–0.997). • Multimodal interventions in hospitals showed no significant effect on the number of fallers. *Injuries:* • Hip protectors in long-term care homes showed a 33 percent decrease in hip fractures (rate ratio = 0.67; 95% CI = 0.46–0.98). • Multimodal interventions in hospitals showed no significant effect on the number of fractures. *Other interventions:* Insufficient evidence to recommend other interventions.

** Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.

Evidence Table 6. Studies Examining Environmental Interventions in Acute and Long-Term Care (listed chronologically)

Source	Safety Issue Related to Clinical Practice	Design Type††	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Tideiksaar 1993[154]	Environmental interventions for fall prevention in acute and long-term care	RCT	**Design:** RCT **Outcomes:** Bed falls, staff attitudes toward the use of the system	**Setting:** Geriatric evaluation and treatment unit **Population:** 70 patients (86 percent female), avg. age 84 years, at risk for falls	Bed alarm system	*Falls:* Bed alarms reduced falls by 68 percent, but this was not statistically significant (odds ratio = 0.32; 95% CI = 0.10–1.03). The bed alarm system was well accepted by patients, families, and nurses.
Mayo 1994[155]	Environmental interventions for fall prevention in acute and long-term care	RCT	**Design:** Blinded RCT **Outcomes:** Fall rates	**Setting:** Geriatric care unit at university hospital **Population:** 70 patients at risk for falls	Identification bracelet for patients at high risk for falls	*Falls:* Identification bracelets increase fall risk in high-risk patients (hazard ratio = 1.3, 95% CI = 0.8–2.4), but this was not statistically significant.
Kelly 2002[240]	Environmental interventions for fall prevention in acute and long-term care	Pretest and post-test study	**Design:** Crossover design for 1 week **Outcomes:** Fall rates	**Setting:** Medicare unit of a skilled nursing facility **Population:** 47 patients at high risk for falls	Movement detection patch attached to the thigh	*Falls:* Fall rates decreased from 4.0 falls per 100 patient days to 3.4 falls per 100 days for patients with movement detection patches.
Kwok 2006[222]	Environmental interventions for fall prevention in acute and long-term care	RCT	**Design:** RCT **Outcomes:** Physical restraints use, fall rates	**Setting:** Two geriatric stroke rehabilitation wards in a convalescent hospital in Hong Kong **Population:** 180 geriatric patients perceived by nurses to be at risk of falls	Bed-chair pressure sensor or control	*Falls:* No difference in fall rates between chair alarm group and control group. *Restraints:* No difference in physical restraint use between chair alarm group and control group.

†† Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.

Evidence Table 7. Studies Examining Physical Activity Interventions in Acute and Long-Term Care (listed chronologically)

Source	Safety Issue Related to Clinical Practice	Design Type‡‡	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Mulrow 1994[241]	Physical activity interventions for fall prevention in acute and long-term care	RCT	**Design:** RCT **Outcomes:** Fall rates	**Setting:** 1academic nursing home and 8 community nursing homes **Population:** 194 frail long-term care residents	Individually tailored one-on-one physical therapy sessions or Friendly visits	*Falls:* Fall rates increased in the intervention group (79 versus 60; *P* = 0.11).
Nowalk 2001[244]	Physical activity interventions for fall prevention in acute and long-term care	RCT	**Design:** RCT **Outcomes:** Fall rates	**Setting:** 2 long-term care facilities **Population:** 110 elderly men and women (avg. age 84), capable of ambulating and able to follow simple directions	Resistance-endurance with enhanced exercise or Tai Chi with enhanced exercise or enhanced exercise	*Falls and other outcomes:* Time to first fall, time to death, number of days hospitalized, and incidence of falls did not differ among the treatment and control groups (*P* > 0.05).
Choi 2005[243]	Physical activity interventions for fall prevention in acute and long-term care	Non-randomized trial	**Design:** A quasi-experimental design with a nonequivalent control group **Outcomes:** Fall rates	**Setting:** Residential care facilities **Population:** 68 fall-prone older adults, avg. age 77.8 years	12-week Sun-style Tai Chi exercise program	*Falls:* 38 percent decrease in falls in the Tai Chi group, but not statistically significant (relative risk = 0.62; 95% CI = 0.32–1.19).

‡‡ Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.

Evidence Table 8. Studies Examining Multimodal Interventions in Acute and Long-Term Care (listed chronologically)

Source	Safety Issue Related to Clinical Practice	Design Type[§§]	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Rubenstein 1990[242]	Multimodal interventions in acute and long-term care	RCT	**Design:** RCT with 2-year followup **Outcomes:** Fall rates	**Setting:** Long-term residential care facility **Population:** 160 ambulatory subjects (avg. age, 87 years)	Tailored interventions based on fall risk factors	*Falls:* Patients in the intervention group had 9 percent fewer falls. *Fall-related deaths:* 17 percent fewer deaths than controls by 2 years, but these trends were not statistically significant.
Bakarich 1997[245]	Multimodal interventions in acute and long-term care	Pretest, post-test	**Design:** Pretest, post-test **Outcomes:** Fall rates	**Setting:** 450-bed metropolitan teaching hospital **Population:** 2,023 patients ≥ 70 years	Toileting regimen for at-risk patients (confused and having mobility problems)	*Falls:* 53 percent less falls during shifts in which the risk assessment and toileting intervention was used.
Lane 1999[262]	Multimodal interventions in acute and long-term care	Pretest, post-test	**Design:** Pre-post and comparative, descriptive design **Outcomes:** Fall rates	**Setting:** Medical-surgical/critical care unit; large community hospital system **Population:** 292 older patients	Fall-prevention program	*Falls:* No decrease in patient fall rate was found between patients who fell before and after implementation of the program.
McMurdo 2000[254]	Multimodal interventions in acute and long-term care	RCT	**Design:** RCT **Outcomes:** Falls and fractures	**Setting:** Nursing home residents **Population:** 133 residents ≥ 84 years	Assessment/ modification and seated balance exercise training program or reminiscence therapy	*Falls:* 55 percent reduction in fall rates for group with exercise training, but not statistically significant (odds ratio = 0.45; 95% CI = 0.19–1.14).

[§§] Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.

Source	Safety Issue Related to Clinical Practice	Design Type[§§]	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Jensen 2002[249]	Multimodal interventions in acute and long-term care	RCT	**Design:** cluster RCT **Outcomes:** Fall rates, time to first fall, fall-related injuries	**Setting:** 9 residential care facilities located in northern Sweden **Population:** 439 residential care residents ≥ 65 years	Comprehensive fall risk assessment and tailored interventions	*Falls:* 51 percent reduction in falls (adjusted odds ratio = 0.49; 95% CI = 0.37–0.65). *Injuries:* 77 percent reduction in fall-related injuries (adjusted odds ratio = 0.23; 95% CI = 0.06–0.94).
Bischoff 2003[247]	Multimodal interventions in acute and long-term care	RCT	**Design:** Double-blind RCT **Outcomes:** Fall rates	**Setting:** Long-stay geriatric care **Population:** 122 elderly women (mean age, 85.3 years; range, 63–99 years)	1,200 mg calcium plus 800 IU vitamin D daily or 1,200 mg calcium daily	*Falls:* 49 percent reduction of falls in the group that received calcium plus vitamin D (95% CI = 14–71; $P < 0.01$).
Hofmann 2003[250]	Multimodal interventions in acute and long-term care	Pretest, post-test	**Design:** Pretest, post-test **Outcomes:** Falls, fall-related fractures	**Setting:** 120-bed nursing home **Population:** Frail elderly population	Concurrent: Staff education, exercise, and environmental modifications	*Falls:* 38 percent reduction in fall rates ($P = 0.0003$). *Injuries:* 50 percent reduction in injury rates ($P > 0.05$).
Semin-Goossens 2003[257]	Multimodal interventions in acute and long-term care	Pretest, post-test	**Design:** Pretest, post-test pilot study **Outcomes:** Fall rates	**Setting:** Academic medical center, 2 medical-surgical units **Population:** 2,670 patients	Fall prevention guideline with semistructured interventions	*Falls:* Fall rates in high-risk neurology and medical patients were not reduced.
Haines 2004[251]	Multimodal interventions in acute and long-term care	RCT	**Design:** RCT **Outcomes:** Fall rates, fall-related injury rates, repeat fallers	**Setting:** 3 subacute wards in rehabilitation and elder care hospital **Population:** 626 men and women ages 38 to 99 years (avg. 80 years)	Falls risk alert card, exercise, education program, and hip protectors or usual care	*Falls:* 22 percent decrease in falls (relative risk = 0.78; 95% CI = 0.56–1.06). *Injuries:* 28 percent decrease in injuries in the intervention group, but not statistically significant ($P = 0.20$).

Source	Safety Issue Related to Clinical Practice	Design Type[§§]	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Healey 2004[253]	Multimodal interventions in acute and long-term care	RCT	**Design:** Cluster randomized trial **Outcomes:** Fall rates	**Setting:** Elder care units and associated community units of a district general hospital in England **Population:** Patients deemed at high risk for falls received intervention	Preprinted care plan for patients identified as at risk of falling and introduced appropriate remedial measures	*Falls:* 29 percent decrease in falls in the intervention group (relative risk = 0.71; 95% CI = 0.55–0.90, *P* = 0.006). *Injuries:* No reduction in injuries.
Jensen 2004[249]	Multimodal interventions in acute and long-term care	RCT	**Design:** Cluster-randomized trial **Outcomes:** Fall rates	**Setting:** 9 residential care facilities in Sweden **Population:** 187 residents at high risk for falling ≥ 65 years	Education, environment, exercise, drug review, postfall assessments, hip protectors	*Falls:* Intervention had no effect on fall rates.
Kerse 2004[256]	Multimodal interventions in acute and long-term care	RCT	**Design:** Cluster RCT **Outcomes:** Fall rates	**Setting:** Residential care homes **Population:** 628 residents	Risk assessment followed by tailored interventions	*Falls:* 34 percent increase in falls (incident rate ratio = 1.34; 95% CI = 1.06–1.72).
Vassallo 2004[208]	Multimodal interventions in acute and long-term care	Non-randomized trial	**Design:** Quasi-experimental **Outcomes:** Fall rates, injury rates, repeat fall rates	**Setting:** 3 geriatric wards **Population:** 825 consecutive geriatric patients	Medication adjustment, environmental assessment, wristbands	*Falls:* • 25 percent decrease in falls in the intervention group, but not statistically significant (relative risk = 0.75; 95% CI = 0.53–1.05). • No reduction in recurrent fallers. *Injuries:* No reduction in injuries.
Flicker 2005[248]	Multimodal interventions in acute and long-term care	RCT	**Design:** Randomized, placebo-controlled, double-blind trial **Outcomes:** Falls and fall-related fractures	**Setting:** Multicenter study in 60 assisted living facilities and 89 nursing homes across Australia **Population:** 625 residents (avg. age 83 years) with vitamin D deficiency	Vitamin D 10,000 IU once, then 1,000 IU daily plus 600 mg calcium or placebo plus 600 mg calcium	*Falls:* 27 percent decrease in falls in intervention group (incident rate ratio = 0.73; 95% CI = 0.57–0.95). *Injuries:* 31 percent decrease in injuries, but not statistically significant (odds ratio = 0.69; 95% CI = 0.40–1.18).

Source	Safety Issue Related to Clinical Practice	Design Type[§§]	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Klay 2005[246]	Multimodal interventions in acute and long-term care	Pretest, post-test study	**Design:** Pretest, post-test **Outcomes:** Urinary tract infections, pressure ulcers, and falls	**Setting:** Connecticut long-term care center **Population:** 42 female residents who were incontinent or had urgency related to overactive bladder	Individualized continence program	*Falls:* 58 percent reduction in falls after treatment with individual continence program.
Fonda 2006[260]	Multimodal interventions in acute and long-term care	Pretest, post-test study	**Design:** Pretest, post-test **Outcomes:** Fall rates, fall-related injuries	**Setting:** Long-term care setting, Australia **Population:** All patients admitted to the unit	Multistrategy approach: work practice changes, environmental/ equipment changes, staff education	*Falls:* 19 percent reduction in the number of falls per 1,000 patient days (12.5 v 10.1; P = 0.001). *Falls:* 77 percent reduction in the number of falls resulting in serious injuries per 1,000 patient days (0.73 v 0.17; P < 0.001).
Schwendi-mann 2006[261]	Multimodal interventions in acute and long-term care		**Design:** Serial survey design **Outcomes:** Fall rates, fall-related injuries	**Setting:** 300-bed urban public hospital **Population:** Adult patients in internal medicine, geriatrics, and surgery	Interdisciplinary falls-prevention program	*Falls:* Decrease in fall rates, but not statistically significant (pre-9.0, post-7.8; P = 0.086). *Injuries:* No change in injury rate.

Evidence Table 9. Studies Examining Interventions to Prevent Injury in Acute and Long-Term Care (listed chronologically)

Source	Safety Issue Related to Clinical Practice	Design Type***	Study Design, Study Outcome Measure(s)	Study Setting & Study Population	Study Intervention	Key Finding(s)
Lauritzen 1993[263]	Physical interventions to prevent fall-related injuries in acute care	RCT	**Design:** RCT **Outcomes:** Hip fractures	**Setting:** 10 of the 28 wards in a nursing home **Population:** 665 older patients (67 percent female)	External hip protectors	*Fractures:* 56 percent decrease in hip fractures for patients wearing hip protectors (relative risk = 0.44; 95% CI = 0.21–0.94).
O'Halloran 2004[264]	Physical interventions to prevent fall-related injuries in acute care	RCT	**Design:** Cluster RCT **Outcomes:** Hip fracture	**Setting:** 127 nursing and residential homes in Northern Ireland **Population:** 4,117 elderly residents	Hip protectors, staff education	*Fractures*: Slight increase in hip fractures in the intervention group (adjusted rate ratio = 1.05; 95% CI = 0.77–1.43).
Ray 2005[266]	Multimodal interventions to prevent fall-related injuries in acute care	RCT	**Design:** Cluster RCT **Outcomes:** Serious fall-related injuries	**Setting:** 112 long-term care facilities **Population:** 10,558 residents ≥ 65 years, not bedridden	Staff safety education plan with tailored interventions	*Injuries:* • No difference in injury rates (adjusted rate ratio = 0.98; 95% CI = 0.83–1.16). • 21 percent decrease in injury rates for patients with prior fall in facilities with the best compliance, but not statistically significant (adjusted rate ratio = 0.79; 95% CI = 0.57–1.10).
Sato 2005[136]	Physiologic interventions to prevent fall-related injuries in acute care	RCT	**Design:** Double blind RCT **Outcomes:** Hip fractures	**Setting:** Stroke unit at hospital in Japan **Population:** 280 male poststroke patients ≥ 65 years	Risedronate 2.5 mg or placebo	*Fractures*: 81 percent decrease in hip fractures in risedronate group (relative risk = 0.19, 95% CI = 0.04–0.89).
Sato 2005[137]	Physiologic interventions to prevent fall-related injuries in acute care	RCT	**Design:** Double blind RCT **Outcomes:** Hip fractures	**Setting:** Stroke unit at hospital in Japan **Population:** 187 female poststroke patients ≥ 65 years	Risedronate 2.5 mg or placebo	*Fractures*: 86 percent decrease in hip fractures in the risedronate group, but this was not statistically significant (relative risk = 0.14; 95% CI = 0.02–1.2).

*** Study Design Type: (1) Meta-analysis, (2) Randomized controlled trials, (3) Nonrandomized trials, (4) Cross-sectional studies, (5) Case control studies, (6) Pretest and post-test (before and after) studies, (7) Time series studies, (8) Noncomparative studies, (9) Retrospective cohort studies, (10) Prospective cohort studies, (11) Systematic literature reviews, (12) Literature reviews, nonsystematic/narrative, (13) Quality-improvement projects/research, (14) Changing-practice projects/research, (15) Case series, (16) Consensus reports, (17) Published guidelines, (18) Unpublished research, reviews, etc.