Biological, Medical and Behavioral Risk Factors on Falls

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The biological and medical risk factors

Introduction

Biological and medical risk factors fall along a continuum from effects of healthy aging to pathological conditions. Normal aging inevitably brings physical, cognitive and affective changes that may contribute to the risk of falls, including sensory, musculoskeletal, neurological, and metabolic changes. Gender is also a key factor as women fall more often than men and sustain more injuries when they fall.

Box: The biology of Ageing

- Loss of motor neurons + Decline in anabolic hormones
- Reduction in number and size of myocytes
- Loss of muscle mass (sarcopenia)
- Decline in locomotor power & strength
  Inability to perform work

With age, the % fat increases significantly, and this occurs at a fairly young age. It begins at about 40 and ends around 80. Body fat increases from 18% to 36% in men, and from 33% to 44% in women. Lean body mass, which includes muscle, vital organs, decreases by 10-15%.

Sarcopenia or muscle loss (Sarco= flesh; penia= lesser amount) is thought to have direct effects on performance and leads to disabilities, increased risk for falls, and increased vulnerability to injury. There is an increased fracture risk due to greater impact. Loss of muscle mass also has metabolic effects, including accelerated bone loss, lessened heat and cold intolerance, impaired glucose homeostasis, and obesity.

The direct sequelae of muscle loss is of course, loss of strength. In men, strength increases to age 30 and declines after 50, with a 24-36% decrease in strength between 50 and 70. Overall, cross sectional data indicate strength decline of 15% per decade in the 6th and 7th decades and 30 % per decade thereafter.

For 75-84 year olds, a large percentage has difficulty with minimal tasks of endurance or strength: 23% have difficulty with walking 1/2 mile; 24% with lifting 10 lb. And 55% with stoop, crouch, or kneel. The Framingham study demonstrated in a cross-sectional fashion the increase in

1 Thomas Hornick ;“Frailty and Muscle loss: Is exercise the panacea for ageing? (Can a Walk a day Keep the Doctor Away?)
incidence of weakness in women with age: the % women unable to lift 4.5 kg rises from 40% at ages 55-64 to 65% at 75-84 years old.

Functional consequences of weakness include diminished gait performance, falls, dependence in ADLs and IADLs. Leg power has been correlated with functional performance. There is a negative correlation between strength and walking speed:Quadriiceps strength and gait speed correlate in the old old. In older women, leg power is closely associated with walking speed and accounts for 86% of the variance in speed.

Risk Factors

Advanced age is associated with higher rates of falls. Seniors over 80 years of age are the most likely to fall and be injured. However, it is not age per se that increases the risk of falls – it is the co-morbidity of aging related to changes.

1. Muscle weakness and reduced physical fitness, particularly to the lower body, are one of the most common intrinsic risk factors for falling. A panel of the American Geriatrics Society, British Geriatrics Society and American Academy of Orthopedic Surgeons (1) found it to be the most important risk factor, increasing risk of a fall by four to five times. A loss of muscle strength, balance, flexibility and coordination can contribute to difficulty accomplishing activities of daily living (see below).

Related balance and gait disorders also have been shown to be closely linked to falls, creating a three-fold increase in the risk of falling. A recent Canadian study of veterans and their caregivers confirmed these findings (2).

2. Impaired control of balance and gait is a factor leading to instability and falls (3). In particular, age-related changes in the neural, sensory and musculoskeletal systems can lead to impaired ability to maintain upright stance or react to a sudden loss of balance (e.g., a slip, trip or push) (4).

Balancing reactions that involve rapidly taking a step or reaching to grasp an object for support play a critical role in preventing falls, but the ability to execute these reactions effectively can be impaired even in relatively young and healthy seniors (5,6). Neurologic disorders such as Parkinson’s disease or hemiparesis due to stroke can exacerbate these difficulties.

3. Vision changes can contribute to falls. Those with visual deficits such as reduced acuity or contrast sensitivity, declined accommodation to light and darkness, or altered depth perception are two and a half times more likely to have a fall (1). Visual deficits such as myopia, ulcerative scars, corneal pathology, cataracts or complications from cataract surgery and glare intolerance are also thought to increase the risk of falling. People may also experience problems with new glasses, particularly multi-focal lenses that distort depth perception (7).

4. Chronic illness has been associated with an increased risk of falling. Arthritis is a major contributor (osteoarthritis being the most common form), increasing the risk of a fall by 2.4 times (1). Senior women experience more arthritis than men (58% vs. 42%, CCHS 2003). Other chronic illnesses such as stroke and Parkinson’s disease increase the risk of falls. Hypotension (low blood pressure) affects 15% of all seniors and has been associated with as many as 20% of all falls (8). Osteoporosis, characterized by low bone mass and the deterioration of bone tissue, does not affect the risk of falling per se, but does increase the risk of fractures from a fall, particularly those of the hip, spine and wrist. Other chronic conditions frequently implicated in falls include urinary incontinence and cardiovascular conditions including arrhythmias.
5. Physical disability can increase the risk of falls. Physical disabilities linked to aging include gait disorders, diminished touch and sensation in limbs and feet, hearing loss, poor balance, dizziness, postural hypotension, sore feet and other feet problems, and injuries from a previous fall (9).

6. Acute illness may be responsible for between 10% to 20% of falls (9). One example is acute infection. A Canadian study found that anti-infective medications were highly associated with fall-related hospital admissions, strongly suggesting that people with acute infectious disease are at a high risk for falls and injuries as a result of weakness, fatigue or dizziness (10). Even the short periods of immobility often associated with an acute illness are known to contribute to reduced bone density and muscle mass.

7. Cognitive impairment, such as confusion due to dementia and delirium, can also increase the risk of a fall. The Rand researchers reported an increased risk of 1.8 times for persons with cognitive impairment (1). The Canadian study of veterans and caregivers also found that worsening memory was associated with more frequent falling (2).

8. Depression has been reported by many researchers as having a relationship to falls, but such studies are often retrospective and the depression could well result from the fall, rather than be a causal or risk factor (11).

9. Sarcopenia. Ageing is associated with sarcopenia that is characterised by loss of muscle mass and strength. Multiple factors underlie this process. Loss of motoneurons and decrease of myofibrillar protein synthesis appear to be major contributing factors. The role of other factors as decreased anabolic hormone production, mitochondrial DNA alteration, or inflammatory mediators remain to be more clearly defined.

The influence of sarcopenia on disability and events as falls in the elderly is now well established. Resistance exercise programs have clearly shown benefits to potentially reverse sarcopenia. However the lack of motivation remains a limiting factor to generalize those programs especially in frail elderly. Protein and caloric intake plays a major role in the prevention of sarcopenia (12).

A study that investigated the association of the amount of skeletal muscle mass in a person's legs with the relative risk of falling in 121 elderly men (average age: 76.4 years) and women (average age: 75.7 years) concluded that sarcopenia, the loss of muscle mass due to aging, is a risk factor for injurious falls in the elderly (13).

Variables included body fat, balance and gait, physical activity and medication use. Age was significantly associated with falls in men but not in women. The risk of falling had a 'u-shaped' association with muscle mass in each sex; the risk of falling was increased significantly in the lowest and highest tertiles of muscle mass, compared with the middle tertile.

The relative risk of falls in women was significantly increased in those whose leg muscle mass fell in the first (relative risk: 1.629) and third (relative risk: 1.546) tertiles, in those with gait abnormalities (relative risk: 1.880) and in those who used medication (1.643). Increased body fat was protective against injuries due to falls in men but not in women.

The investigators believe that the risk of falls in those with high muscle mass may be a result of increased activity and exposure to falls. Men who had low leg muscle mass, gait abnormalities, were taking more than three medications or were more physically active had more falls with
injuries. Women who had low leg mass, balance abnormalities or were taking more than three medications had an increased risk of falls with injuries.

**Why do we lose muscle mass?**
Several theories attempt to explain this phenomenon.

a) Muscle loss due to nutritional deficiency: Could the loss of muscle with ageing be due to inadequate intake over a long period of time? Protein calorie malnutrition has an incidence among institutionalized of 30-50%, and is associated with premature death, micronutrient deficiency, increased risk of disability from falls. Low dietary intake is common in healthy elderly adults and can be due to a number of things, among which are decreased smell, taste, poor dentition, depression. Additionally, over the long haul of years, it may be difficult for old people to compensate for day-day fluctuations in food intake.

b) Energy expenditure declines progressively throughout life. In sedentary individuals, the major determinant of energy expenditure is fat free mass, which declines by about 15% between 20 and 80. Therefore there is a lower metabolic rate in the elderly. Experimentally, body composition correlates with energy expenditure: in endurance trained men 20-60 consuming a high caloric diet body fat was related to the number of hours spent exercising. In young and old sedentary men: the energy expenditure accounted for 73% of the variability of body fat content.

Therefore, it is possible that as a consequence of low protein/calorie intake over time in combination with increasing disuse that there may be a reduction in total muscle mass. However, in addition, age-related decline in muscle strength is seen in highly motivated and trained athletes. Top running speeds of running events are 1/2 of those over 75. Thus, disuse and nutrition may not be the entire reason athletes who regularly train and eat well do not have the muscle mass of younger athletes.

c) Thus it is postulated that there are changes in the nervous system. In autopsies of older subjects it has been shown that the number of motor neurons in the spine is reduced: 50% loss seen at age 60. In many ways, skeletal muscle can be considered an extension of the nervous system, without nervous innervation, the muscle tissue atrophies rapidly. Biopsy specimens from old subjects show that there is a decrease in the functioning motor units in the old, supporting the results of the autopsies. Larger motor units remain, and it is Type 2 units most often lost. Remodeling of the motor end plates (where nerves attach to muscle) occurs, and when denervation occurs it is likely that another neuron will reform an attachment. However, axons lifting from viable fibers can cause them to become permanently denervated. If full return to previous mass does not occur after injury (including denervation), then there would be permanent loss of volume. Old muscle regenerates less successfully than young, and if ongoing damage to muscle occurs with time, one can postulate a gradual decrease in amount, much in the same way there is a gradual loss of bone in osteoporosis through inefficient repair mechanisms.

In summary, there are many distinct causes for falls in the older population. Data from 12 of the largest retrospective studies of falls reveal the following (18):

<table>
<thead>
<tr>
<th>Cause of falls</th>
<th>Average</th>
<th>Range %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident/Environment-related</td>
<td>31</td>
<td>1-53</td>
</tr>
<tr>
<td>Gait/Balance disorders or weakness</td>
<td>17</td>
<td>4-39</td>
</tr>
<tr>
<td>Dizziness/Vertigo</td>
<td>13</td>
<td>0-30</td>
</tr>
<tr>
<td>Drop attack</td>
<td>9</td>
<td>0-52</td>
</tr>
</tbody>
</table>
Confusion 5 0-14
Postural hypotension 3 0-24
Visual disorder 2 0-5
Syncope 0.3 0-3
Others 15 2-39
Unknown 5 0-21

Others include arthritis, acute illness, medications, alcohol, pain, epilepsy, falling from bed
Average calculated from the 3,268 falls in the 12 studies
Range indicates the percentage reported in each of the 12 studies

Risk factors reported from a 16 studies indicate the following (18):

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Significant/Total</th>
<th>Mean RR-OR</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weakness</td>
<td>11/11</td>
<td>4.9 (8)</td>
<td>1.9-10.3</td>
</tr>
<tr>
<td>Balance deficit</td>
<td>9/9</td>
<td>3.2 (5)</td>
<td>1.6-5.4</td>
</tr>
<tr>
<td>Gait deficit</td>
<td>8/9</td>
<td>3.0 (5)</td>
<td>1.7-4.8</td>
</tr>
<tr>
<td>Visual deficit</td>
<td>5/9</td>
<td>2.8 (9)</td>
<td>1.1-7.4</td>
</tr>
<tr>
<td>Mobility limitation</td>
<td>9/9</td>
<td>2.5 (8)</td>
<td>1.0-5.3</td>
</tr>
<tr>
<td>Cognitive impairment</td>
<td>4/8</td>
<td>2.4 (5)</td>
<td>2.0-4.7</td>
</tr>
<tr>
<td>Impaired functional status</td>
<td>5/6</td>
<td>2.0 (4)</td>
<td>1.0-3.1</td>
</tr>
<tr>
<td>Postural hypotension</td>
<td>2/7</td>
<td>1.9 (5)</td>
<td>1.0-3.4</td>
</tr>
</tbody>
</table>

Significant/Total: Number of studies with significant association/Total number of studies looking at each factor
RR: Relative risk (Prospective studies) and OR: Odds ratios (Retrospective studies)
Number in parenthesis indicates the number of studies that reported relative risks or odds ratios.

References on biological determinants

14. F/P/T Ministers Responsible for Seniors. A best practices guide for the prevention of falls among seniors living in the community. 2001. The review conducted for the Best practices guide of the F/P/T Ministers Responsible for Seniors screened 674 studies, ultimately reviewing 34 that evaluated fall prevention interventions designed to reduce falls or fall-related injuries among community-dwelling seniors.
The behavioral risk factors

Examples of behavioral risk factors may be as simple as the choice of footwear, or attempts to prune a tree or reach an object on a high shelf. These risks also include lifestyle factors such as alcohol use, poor diet and lack of exercise, or the use of high-risk medication or multiple medications that predispose some seniors to falling. It can be difficult for seniors, who may feel no different than they felt in younger years, to realize that the seemingly ordinary choices they make and the actions they take may greatly increase their chance of falling (1).

Several studies have indicated that the social background, family disposition, health factors, limitations in activities of daily living, insufficient intake of certain dietary products, drinking tea, improper footwear, and vinyl on the floor seem to be of importance, as shown herewith.

1- Activities of daily living

Elderly people with reduced walking skills and those that need help for activities of daily living show a strong association to the risk of falling. Studies have shown an association between fall injuries in elderly people and dependence in activities of daily living (2), as well as poor mobility (3) and physical inactivity (4).

1. A history of previous falls is one of the best predictors of a future fall. Any previous fall increases the risk for another fall threefold (5). A previous fall may reduce mobility in older people, resulting in loss of strength, balance and reflexes. Feelings of fear and helplessness may also ensue, further adding to restrictions on activity and participation and reduced quality of life (6).

2. Fear of falling has been identified relatively recently as a risk factor in the fall prevention literature. Fear of falling is widespread and has been reported as the most common fear of older adults (7). It is an important aspect to consider, particularly for those who develop fear after having fallen (8). Fear of falling is reported by a significant number of older persons (8). Specific fears vary but often include fear of falling again, being hurt or hospitalized, not being able to get up after a fall, social embarrassment, loss of independence, and having to move from home(9,10, 11,12).

Fear can positively motivate some seniors to take precautions against falls and can lead to gait adaptations that increase stability (13). For others, fear can lead to a decline in overall quality of life and increase the risk of falls through a reduction in the activities needed to maintain self-esteem, confidence, strength and balance (14,15,16). In addition, fear can lead to maladaptive changes in balance control (e.g., “stiffening”) that may increase the risk of falling (17). People who are fearful of falling also tend to lack confidence in their ability to prevent or manage falls, which increases the risk of falling again (18).

3. Risk-taking behavior as a factor associated with falls has not been studied scientifically. The risk associated with participation in activities is influenced by individual, behavioral and situational factors. For example, an older adult’s vision and strength, awareness of the environment, and protective behaviors, such as using a handrail, influence the risk of falls (19). Risk behaviors may include climbing, reaching, or bending while performing activities of daily living (20). Reviews of cases presenting in the emergency department have shown that many falls result from seniors climbing ladders, standing on unsteady chairs, and even participating in vigorous sports such as skiing or tennis. Many seniors report that their fall occurred when they
were rushing, not paying attention or not using mobility devices prescribed for them such as a cane or walker (21).

4. **Footwear, clothing and handbags** can contribute to falls, although clear research evidence is lacking. Footwear that fits poorly, has worn soles, is not laced or buckled when worn, or is of an unusual heel height for the individual, can contribute to falls. As people age, their height and posture change and long dressing gowns or trousers, which may have fit well at one time, can cause tripping hazards resulting in a fall and related injury (21). Many older people report falling or sustaining a fall-related injury, as a result of carrying an object such as a handbag, laundry basket or grocery bag (21). Suspected mechanisms relate to altered balance, altered recovery mechanisms upon a trip or stumble, and altered means of protection as the senior lands on the ground or floor (21). Holding an object, for example, has been shown to impede ability to recover balance as it prevents one from rapidly grasping a handrail or other object for support (22).

**II- Medications**

1. **Certain medications and multiple prescriptions** are a significant factor in many falls. Older people tend to take more drugs than younger people and, with age, they develop altered mechanisms for digesting and metabolizing drugs. Both the half-life and the active levels of a given dose increase with age, making the cumulative effects of medication use unpredictable. Medications can affect one’s risk of falling in several ways. They can affect alertness, judgment, and coordination. Certain drugs increase postural hypotension – a significant drop in blood pressure with a change in position (lie to sit or stand) – resulting in dizziness. Drugs can also alter the balance mechanism and the ability to recognize and adapt to obstacles. Finally, drugs may impair mobility by causing increased stiffness or weakness (23).

2. **Polypharmacy**, defined as taking five or more prescribed medications, is shown to be a significant factor in many falls (23). The variety of prescription medications is increasing and they are used in greater numbers and in new combinations. Drug herb interactions may also be implicated in falls as supplements, herbs and vitamins can react with each other or with prescription medications (24). The effects of various drug combinations are not yet clearly understood, especially the possible risks for falls in elderly individuals.

3. **Benzodiazepines**, such as alprazolam (Xanax) and diazepam (Valium), are often prescribed to treat sleep problems and anxiety. Even the use of short-acting benzodiazepines has a greater association with falls and hip fractures (25).

4. Patients taking **psychotropic medications**, such as paroxetine (Paxil) and sertraline (Zoloft) prescribed for depression, appear to have about a two-fold increased risk of falls and fractures, compared with individuals not taking these drugs. Some studies have also found that use of non-steroidal anti-inflammatory drugs is associated with falling. However, current evidence suggests that diuretics, in general, do not cause falls and that thiazide diuretics may help prevent fractures by slowing the development of osteoporosis (28).

It seems difficult to distinguish the effect of medication from the effect of the medical condition treated (27). There may be an increased risk of falling caused by sedation and postural hypotension when using hypnotics (28), sedatives, antipsychotics, and antidepressants (29). Antipsychotics (28) may increase the risk of falling because of sedation, but extrapyramidal side effects may further impair gait and balance. Diuretics may increase the risk of hypotension, but (as noted above) thiazide diuretics also seem to cause a reduction in calcium excretion(30,31).
5. Previous use of thyroxin seemed to be associated with falling in both genders. In some studies, patients treated for hyperthyroidism and hypothyroidism were found to have increased fracture risk (32,33). However, former hyperthyroid patients treated by combined medical therapy had normal bone mass, bone turnover, and calcium homeostasis (34). An explanation for the increased fracture risk might be that the patients were over-substituted with thyroxin, that thyroxin increased the tendency to fall, or that the altered thyroid function had induced more permanent structural skeletal changes.

6. Use of analgesics was associated with falling. Previous researches have shown an association with falls and the use of sedatives and hypnotics. Use of vitamin D among females was associated with an increased risk of falling. The explanation may be that fall prone elderly with fractures have been considered at risk of osteoporosis and therefore treated with vitamin D.

7. The risks associated with anticoagulant therapy, especially the risk of falls-related injury, are greater in the elderly. A fall may result in head trauma but go undiagnosed because patients are confused, do not remember falling, or fail to report the fall. This is especially risky in patients on anticoagulant therapy since a fall with head trauma may result in bleeding in the brain. Blunt head trauma may cause behavioral and neurological abnormalities and may be a sign of bleeding in the brain or brain cavity (35).

III- Diet

1. The association between poor nutrition status and falls among the elderly has not been studied extensively (36). Patients with hip fractures are often malnourished (37,38) with low intake of protein from animal sources (39).

2. Inactivity and inadequate diet may be important factors in both falls and related injuries. Again, while clear research evidence is lacking, people who are hospitalized 19 days or more have been shown to have an increased risk of a fall (40). Undoubtedly, inactivity will result in reduced muscle mass, decreased bone density and poor balance.

3. Dietary relationships to falls are less clear. However, adequate protein, essential vitamins and water are believed to be essential for optimum health. If deficiencies do exist, it is reasonable to expect that weakness, poor fall recovery and increased injury will ensue. Bone health is affected by intakes of vitamin D and calcium and deficiencies in these two nutrients have been associated with increased risk of fracture from a fall.

4. Information on amount of dairy consumption and fish consumption were assessed and analyzed. Women who did not have fish for lunch or dinner at least once per month showed an increased tendency to fall. All types of fish tested revealed non-significant odds ratios higher than one, independently of presumed differences in vitamin D content. A certain lifestyle associated with eating fish seems to influence the tendency of falling among elderly women. It was also found that women not eating sour dairy products were associated with a higher risk of falling, which was even more significant in the final analyses (OR 3.0; P < 0.005).

5. Elderly with low dietary intake of calcium and vitamin D, a low cutaneous production of vitamin D, and decreasing renal function may be at risk for falls and fractures because of myopathy caused by vitamin D deficiency and secondary hyper-parathyroidism, which is not
compensated for by an enhanced renal production of 1,25-dihydroxyvitamin D (41). There may be a direct effect of vitamin D status on muscle function (42,43,44,45) as vitamin D or its active metabolites seem to improve muscle function (46,47). Vitamin D receptors have been identified in cultured myoblasts (48) and in cloned human skeletal muscle cells (49), permitting vitamin D protein synthesis through transcription. Vitamin D seems to stimulate the uptake of Ca++ in the chick sarcoplasmatic reticulum by increased Ca++-ATPase activity (50). The effect is an increased intracellular calcium pool needed for muscle contractions. Furthermore, vitamin D is required for the intracellular uptake of inorganic phosphate in myoblasts leading to accumulation of energy rich phosphate compounds like ATP and creatine phosphate (51). In elderly in a long-stay geriatric care in Switzerland, vitamin D in combination with calcium supplementation reduced the risk of falling with 49% (44).

6. Excessive alcohol has been shown to be a factor in increased rates of falling. Consumption of 14 or more drinks per week is associated with an increased risk of falls in older adults (52). Cross-sectional studies may fail to identify this risk of heavier drinking, perhaps because older adults at risk for falls decrease their alcohol use over time or because heavier drinkers at risk for falls tend not to enroll in studies. Alcohol may also interact with certain drugs to increase the risk of falls by producing changes in awareness, balance and gait. Alcohol used in moderation has not been associated with increased fall rates (52).

Use of alcohol has been considered a risk factor of falls. However, most studies have not found an association (53,54). One obvious explanation may be that elderly with a higher tendency of falling refrain from alcohol. Besides, moderate alcohol consumption may have a protective effect against total and ischemic stroke that may reduce the risk of falling (55). Furthermore, no association was reported between the amount of alcohol consumed and the risk of falling (56). To improve the analyses, it seems relevant to consider the patterns of drinking in addition to average volume of alcohol consumption (57). Furthermore, heavy drinkers may not have wanted to participate in the study or may have died at an earlier age, which may underestimate the effect of heavy alcohol consumption.

7. Interestingly, drinking tea was in elderly females associated with an increased risk of falling (OR 6.1). Few studies have investigated the effect of tea consumption and health, and the results are conflicting. One study showed an increased risk of hip fractures in male tea drinkers from southern Europe (58). Another study showed a higher bone mineral density among female tea drinkers (59). Tea drinking seems to be associated with other dietary and lifestyle factors (60). One explanation may be that tea drinking is associated with an increased physical activity, whereas coffee drinking seems to be associated with a higher cigarette consumption (61). Tea drinking was relatively frequent in nonsmokers (72.8% in nonsmokers versus 27.2% in smokers; OR 0.6). Furthermore, tea drinking may be associated with female urinary incontinence increasing the risk of falling (62).

**IV- Environment**

1. Among environmental items tested, few were found to have significant associations to falling. A strong association to the risk of falling was found among elderly with vinyl or linoleum on the floors. A previous study of flooring type has shown that a high proportion of elderly sustained injuries when falling on vinyl as compared to carpet (63). A high tendency to fall was found in homes with irregular sidewalks to the residence, loose carpets on the kitchen floor, loose electrical wires on the bedroom floor, and inconvenient doorsteps.
2. Among females, a significant association of falls was walking in socks without shoes or slippers without a sole. Previous studies have shown that shoes with thin, hard soles are preferable to achieve optimal stability for elderly individuals (64). An effect of footwear on postural stability has been proposed (65). Analyses suggest that among elderly males, it is especially important that slippers are of suitable size and that they stick closely to the feet. In a previous study enrolling elderly who had fallen while hospitalized, it was found that 51% had poorly fitting shoes (66).

More studies are needed to test the impact of environmental modifications on fall occurrence, but results hitherto published indicate that a modest reduction of falls (7%) may actually be achieved by environmental change (67). One study reported that in a group of elderly, as a whole falls were not associated with the presence of home hazards (68). However, it seemed that vigorous older persons living with more home hazards were more likely to fall, as compared to vigorous older persons without home hazards.

In conclusion, the present analyses suggest that several factors work together to establish the risk of falling among elderly community residents. It appears relevant for further studies to test if modifications of the potential risk factors identified may reduce falls among community dwelling older persons.

A multivariate analysis of the variables that determined falling in the last twelve months, in a population-based survey of factors relating to the prevalence of falls in the older people (69), conducted in South Australia, deemed the following factors to be significant:

<table>
<thead>
<tr>
<th>Variables</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
</tr>
<tr>
<td>65-69</td>
<td>1.00</td>
</tr>
<tr>
<td>70-74</td>
<td>1.23 (0.96-1.57)</td>
</tr>
<tr>
<td>75-79</td>
<td>1.36 (1.05-1.76)*</td>
</tr>
<tr>
<td>80+</td>
<td>1.46 (1.11-1.90)*</td>
</tr>
<tr>
<td>Country of birth</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>1.00</td>
</tr>
<tr>
<td>English-speaking country</td>
<td>1.03 (0.83-1.29)</td>
</tr>
<tr>
<td>Non-English speaking country</td>
<td>0.59 (0.43-0.82)*</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>1.00</td>
</tr>
<tr>
<td>Trade/Apprenticeship</td>
<td>0.99 (0.81-1.21)</td>
</tr>
<tr>
<td>Degree or Higher</td>
<td>0.63 (0.43-0.94)*</td>
</tr>
<tr>
<td>Income (AUD)</td>
<td></td>
</tr>
<tr>
<td>Up to 20,000</td>
<td>1.00</td>
</tr>
<tr>
<td>20,000-80,000</td>
<td>1.27 (1.00-1.61)</td>
</tr>
<tr>
<td>80,000 +</td>
<td>1.10 (0.45-2.70)</td>
</tr>
<tr>
<td>Refused to state</td>
<td>1.54 (1.19-2.00)*</td>
</tr>
<tr>
<td>Living arrangements</td>
<td></td>
</tr>
<tr>
<td>Living alone</td>
<td>1.00</td>
</tr>
<tr>
<td>Living with someone</td>
<td>0.77 (0.63-0.94)*</td>
</tr>
<tr>
<td>Not stated</td>
<td>1.27 (0.20-8.09)</td>
</tr>
<tr>
<td>Health improvement in last 12 months</td>
<td></td>
</tr>
</tbody>
</table>
Better, about the same 1.00
Not as good now 1.63 (1.31-2.04)*
Don’t know 5.54 (0.46-66.55)

General Health
Excellent, Very Good, Good 1.00
Fair, Poor 1.34 (1.09-1.67)*

Do you still drive?
Yes 1.00
No 0.69 (0.57-0.83)*

Is your house in need of maintenance?
Yes 1.00
No 0.76 (.63-0.92)*

Receive assistance for daily tasks
Yes 1.00
No 0.56 (0.40-0.80)*

Significant at p<0.05 level

References on Behavioral factors

69. Gill, T; Taylor, A; Pengelly, A; “A population-based survey of factors relating to the prevalence of falls in the older people”, Gerontology 2005; 51; 340-345