A RETROSPECTIVE COHORT STUDY OF INJURIOUS FALLS IN
COMMUNITY DWELLING OLDER PERSONS

by

Kathleen O'Malley

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ABSTRACT

This retrospective cohort study examines the risk factors associated with injurious falls requiring a visit to an emergency department in community dwelling persons 66 years and older residing in the province of Alberta. Data for this study is obtained from computerized administrative data sets that are linked deterministically using a unique personal identification number. The risk factors for injurious falls examined in the study include: age, gender, socioeconomic status (SES), location (rural and non-rural), 17 co-morbid disease classes, and 17 medication classes. Three series of logistic regression analysis are conducted. During the study year (1998/99 fiscal year), 8,534 persons 66 years and older presented to an emergency department in the province of Alberta because of a fall. Thirty-five percent of these persons required hospital admission. The most common type of injury found is fractures (56.4%). The results of this study indicate that fallers are more likely to be female, older, receiving subsidy or to have treaty status, residing in a rural location, taking more medications and living with more co-morbid diseases than non-fallers. After controlling for the confounding effects of age, gender, location, SES, and 17 co-morbid diseases, 8 medication classes remain significant predictors of sustaining an injurious fall. These medication classes include: narcotic pain killers, anti-convulsants, anti-depressants, sedatives, anti-parkinsonian agents, electrolytics, corticosteroids, and anti-coagulants.
# TABLE OF CONTENTS

Abstract.................................................................................................................................i

Table of Contents..................................................................................................................ii

List of Tables..........................................................................................................................iii

List of Figures.........................................................................................................................iv

Acknowledgement.................................................................................................................v

Introduction............................................................................................................................1

Literature Review...................................................................................................................3

Epidemiology of Falls............................................................................................................3

Consequences of Falls.........................................................................................................6

The Etiology of Falls.............................................................................................................10

Objectives of Study..............................................................................................................26

Methods and Data Analysis.................................................................................................27

Results.................................................................................................................................31

Discussion............................................................................................................................40

Limitations and Strengths....................................................................................................57

Conclusion............................................................................................................................59

Literature Cited......................................................................................................................62
LIST OF TABLES

Table 1. Description of the most common types of injuries sustained by fallers derived from ICD-9 codes. .................................................................32

Table 2. Description of the most common locations for injurious falls derived from ICD-9 codes. ..........................................................32

Table 3. Comparison of demographic variables, co-morbidities and medications between fallers and non-fallers. Un-adjusted and adjusted odds ratios for all demographic variables, co-morbidities and medications measured as risk factors for falling. .................................................................34
LIST OF FIGURES

Figure 1. Histogram displaying the number of injurious falls per month presenting to an emergency department in the province of Alberta in the 1998/99 fiscal year........33
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INTRODUCTION

Falls pose a very serious health threat to older community dwelling persons. Previous studies have indicated that more that 30% of community dwelling persons 65 years and older fall every year (Scott & Gallagher, 1999; O’Loughlin et al., 1993; Tinetti et al., 1988). Injuries sustained from falling are the sixth leading cause of death among people over sixty five years of age, and 70% of accidental deaths in persons seventy-five years of age and older are attributed to falls (Fuller, 2000; Sattin, 1992). Falls that do not result in immediate disability or death may still have serious consequences down the road. Fear of falling is a serious psychological problem that affects 29-92% of older adults who have experienced a fall and live independently (Legters, 2002; Yardley & Smith, 2002). Older persons suffering from an injurious fall are also more likely than non-fallers to be placed in a nursing home or a long term care facility (Alexander et al., 1992).

Falls are typically the result of complex interactions between combinations of factors. The factors that contribute to falls can be considered intrinsic (relating to the individual) and extrinsic (relating to the environment) (Tinetti, 2003; Mustard & Mayer, 1997). Intrinsic factors that are commonly cited as risk factors for falling include: age, gender, co-morbid diseases, and medication use (Kelly et al., 2003; Tinetti, 2003; Thapa et al., 1998). Extrinsic factors that are commonly found to be associated with falls include: temperature, stairs, cluttered living spaces, and icy or wet conditions (Hill et al., 2000; Parker et al., 1996). While programs have been developed to reduce the risks
associated with several of these extrinsic factors, many intrinsic risk factors are not modifiable.

Medications are a potentially modifiable risk factor for injurious falls. Before recommendations can be made about how to reduce the risk associated with medication use, a clear understanding of which medications pose a threat to older persons must be sought. The majority of studies that have examined the risks posed by certain medications have not controlled for the co-morbid diseases for which the medications are being prescribed. This results in confounding by indication because it is impossible to determine whether it is the medications that are causing an increased risk of falling or whether it is the underlying co-morbid diseases.

This study evaluates the risks associated with seventeen medication classes while controlling for the underlying effects of seventeen co-morbid diseases as well as age, gender, residence (rural and non-rural), and socioeconomic status. The entire population of community dwelling older persons residing in the province of Alberta are examined (N = 282,519) for the 1998/99 fiscal year. This greatly minimizes any threats to external validity that may occur in studies that limit the study population to single nursing homes or small communities. This is the first study to evaluate these risk factors using such a large comprehensive population of community dwelling older persons.
LITERATURE REVIEW

EPIDEMIOLOGY OF FALLS

Falls are a very serious health threat to older community dwelling persons. More than 30% of community dwelling persons over the age of sixty-five fall every year (Scott & Gallagher, 1999; O'Loughlin et al., 1993; Tinetti et al., 1988). This rate increases to between 40-50% among persons over the age of eighty (Dunn et al., 1992; Tinetti et al., 1988). Falls account for the most common cause of injury and hospital admission for trauma in persons sixty-five years and older (Wallace et al., 2002; Gallagher & Scott, 1997). Injuries sustained from falling are the sixth leading cause of death among people over sixty-five years of age, and 70% of accidental deaths in persons seventy-five years of age and older are attributed to falls (Fuller, 2000; Sattin, 1992).

Several studies have indicated that fall rates vary between males and females (Evans, 2003; Scott & Gallagher, 1999; Ruthazer & Lipsitz, 1993; Campbell et al., 1990). A population based study in British Columbia found that more women 65 years and older were hospitalized due to fall related injuries, but more men 65 years and older died from fall related injuries during the study years (Scott & Gallagher, 1999). In other studies, it has been reported that older women fall approximately twice as often as older men (O'Loughlin et al., 1993; Alexander et al., 1992; Ryynänen, et al., 1991). Tinetti et al. (1988) used a prospective study of community dwelling older adults to examine the risk factors for falls and also found that more women then men fell during the study period.

The majority of studies that examine the relationship between gender and falls have found that women fall more often than men, but a few studies have found opposite or equal fall rates (Bell et al., 2000; Rawsky, 1998; Sehested & Severin-Nielsen, 1977).
Bell et al. (2000) studied older patients presenting to an emergency department after a fall and found that the proportion of men and women presenting because of a fall was equal. The total number of women presenting was greater than the total number of men (450 vs. 283), but because the sex distribution in the community was not equal, they used the proportional rates rather than the crude rates (Bell et al., 2000). In the Canadian population of persons sixty-five years and older, the sex ratio of men to women is 75:100 (Statistics Canada, 2003). Fall rates in older persons must be reported as proportional rates to account for the skewed sex distribution in this population.

The circumstances and consequences of falling also vary between men and women. Berg et al. (1997) used a prospective study to examine falls in community dwelling older adults and found that falls among men most often resulted from slips, while falls among women most often resulted from trips. This study also revealed that while men were more likely to fall during the winter, no seasonal variation existed for fall rates in women (Berg et al., 1997). These results contradict those found by Campbell et al. (1990) where men showed seasonal variation in fall rates but women did not. In 1999, Scott and Gallagher demonstrated that mortality due to falls varies between men and women. These researchers found that while older women are hospitalized more often due to falls, more men die from fall related injuries.

The risk of falling in older persons greatly increases with age (Bell et al., 2000; Rothschild et al., 2000; Campbell et al., 1995). Kingma (1998) studied the age-specific rates of injurious falls from 1971 until 1995 and found that there was a dramatic increase in the incidence of falls in persons aged sixty-five years and older. In a similar study by Ryynänen et al. (1991), the incidence of fall injuries leading to medical treatment
increased steadily through the age groups from 1.3% in persons aged 65 to 69 to 12.4% in persons aged 85 and older. The frequency of hospitalization due to fall-related injuries in older adults was studied by Alexander et al. (1992) and these researchers also found that the incidence increased progressively with age. This age specific increase in the incidence of injurious falls poses an enormous health threat to Canadians because the population of persons aged 65 years and older is expected to increase by approximately forty-three percent over the next decade (Statistics Canada, 2003).

Studies that have investigated the location of falls have revealed that older community dwelling persons fall indoors more often than outdoors (Johansson, 1998; Carter et al., 1997; Campbell et al., 1990). The majority of indoor falls occur either in the individual's bedroom or hallways (Tideiksaar, 1992; Campbell et al., 1990). Researchers have also found that most falls occur during periods of maximum activity in the morning and afternoon, and it has been estimated that approximately 40% of falls in community dwelling older persons are associated with activities that are necessary for independent living (Johansson, 1998; Campbell et al., 1990).

A limited number of studies have examined seasonal and regional differences in fall rates, and the findings have been inconsistent (Johansson, 1998; Campbell et al., 1990; Grisso et al., 1990). Some studies suggest that seasonal variations are gender specific, while others have found a predominance of winter accidents in both sexes (Johansson, 1998; Campbell et al., 1990). Scott and Gallagher (1999) examined the distribution of falls throughout the province of British Columbia. These researchers found that the rates for falls in the Northern and Interior regions of the province were higher then those in the lower mainland and on Vancouver Island. These regional
differences could be a result of varying climates, differences in access to fall prevention clinics, or differences in the age structures of the populations.

CONSEQUENCES OF FALLS

The consequences of falls in older persons have been well documented (Bell et al., 2000; Berg et al., 1997; Gurwitz et al., 1994). The injuries sustained from falling range from minor bruising to fractures, immobility, psychosocial dysfunction, and premature death (Murphy et al., 2003). Studies have indicated that between 30-55% of falls lead to injuries requiring medical attention (Gallagher & Scott, 1997; Berg et al., 1997; Tideiksaar, 1992). Of those injuries, 15-30% can be classified as minor injuries such as bruising, cuts or gashes, and 5-25% can be considered major injuries such as fractures, dislocations, and head traumas (Tinetti, 2003; Johansson, 1998; Campbell et al., 1990). The classification of serious and minor injuries varies between authors so it is difficult to accurately assess the incidence of severe injuries. However, numerous studies have indicated that hip fractures are considered the most common of all serious fall related injuries in the elderly (Murphy et al., 2003; Hendrich et al., 1995).

Fractures are the most common type of serious injury sustained by falling (King & Tinetti, 1996). Johansson (1998) studied injurious falls in community dwelling persons sixty-five years and older and found that the most common types of fractures were hip fractures (11.6%), antebrachium fractures (9.9%), and brachium fractures (7%). In a similar study examining injurious falls, neck-of-femur fractures accounted for 36% of all fractures, while fractured wrists accounted for 16%, and humeral neck fractures for 12% (Bell et al., 2000). Both of these studies indicated that women sustained more
fractures than men (Bell et al., 2000; Johansson, 1998). These results are similar to a more recent study by Keegan et al. (2004) in that a greater percent of women fractured their feet, forearms, humerus, pelvis and tibia/fibula as a result of a fall. Nguyen et al. (2001) studied the risk factors for proximal humerus, forearm and wrist fractures and found that the risk of sustaining one of these fractures increased with age.

Although hip fractures only occur in 1-2% of falls, they are considered the most serious fall related injury in older persons (Jordan et al., 2000; Dargent-Molina et al., 1996). It has been estimated that up to one third of older persons that suffer from a hip fracture die within one year (Keene et al., 1993; Gryfe et al., 1977). Researchers have found that older persons with hip fractures have a significantly elevated risk for subsequent hospitalization, mortality and functional decline (Wolinsky et al., 1997). Dirschl et al. (1997) used a prospective longitudinal study to determine the effects of hip fractures on bone mineral density in older adults and found that subjects that suffered a hip fracture had an accelerated loss in bone mineral density that was five times greater than the non-fractured subjects.

Head injuries, spinal cord injuries and maxillofacial injuries comprise a smaller group of fall related injuries, but the consequences of these injuries can be devastating. Luukinen et al. (1999) studied the relationship between head injuries caused by fall accidents and cognitive decline in a cohort of older adults and found that major head injuries increase the risk of cognitive decline. A recent Finnish study examining the number of fall-induced, fracture-associated, spinal cord injuries found that the number of these injuries has increased steadily from 1970 to 1995 (Niemi et al., 2000). Chew and Edmondson (1996) examined the incidence of maxillofacial injuries resulting from falls
in older persons, and determined that these types of injuries more often than not result in hospital admissions and surgery.

Admission to hospital after an injurious fall occurs in approximately 30-60% of cases (Bell et al., 2000; Mathers & Weiss, 1998; Grisso et al., 1990). Of the people admitted to the hospital, some experience secondary complications including: urinary tract infections, pneumonia and pressure sores (Lange, 1996). Fallers have almost twice the length of hospital stay compared to persons admitted for other reasons (Dunn et al., 1992). Older persons admitted to hospital have subsequent higher mortality rates than those individuals who were not admitted (Bell et al., 2000; Waller, 1977). The mortality rate associated with older persons seeking medical attention due to a fall increases substantially with age and with the number of falls sustained (King & Tinetti, 1995; Dunn et al., 1992). One study found that persons experiencing two or more falls have a significantly increased chance of dying within that year compared to persons experiencing one or no falls (Dunn et al., 1992).

Falls that do not result in immediate disability or death may still have serious consequences down the road. Hendrich et al. (1995) outlined a cascade of events that may occur as a result of a fall. This cascade begins with a reduction in activities of daily living which causes decreased body system functioning and organ system failure which may lead to an increased susceptibility to infection and disease and eventually death (Hendrich et al., 1995). Older persons suffering from an injurious fall are also more likely than non-fallers to be placed in a nursing home or a long term care facility (Alexander et al., 1992). Falls, as a risk factor for admission to a nursing home, was
studied by Tinetti and Williams (1997) and these researchers found that even after controlling for confounding factors, falls remained a strong predictor of admissions.

Fear of falling is a serious psychological problem that affects 29-92% of older adults who have experienced a fall and live independently (Legters, 2002; Yardley & Smith, 2002). This condition is defined as, ‘low perceived self efficacy at avoiding falls during essential, non-hazardous activities of daily living’ (Tinetti et al., 1990). This condition is problematic because it ultimately limits the performance of daily activities (Tinetti et al., 1989). Yardley and Smith (2002) identified the most common beliefs about the negative consequences of falling and found that these beliefs motivate older persons to avoid daily activities. Fear of falling may also result in elevated levels of depression and generalized anxiety (Legters, 2002; Chandler et al., 1996). It is conceivable that this psychological problem may contribute to the cascade of events previously described by Hendrich et al. (1995).

The economic cost to Canadians for fall related injuries in 1994 among persons sixty-five years and older was reported by Scott and Gallagher (1999) to be $2.8 billion. This estimate includes the direct cost of such things as institutional expenditures and professional services, and the indirect costs of lost productivity due to premature mortality and disability. This figure does not include the cost of medications or negligence claims (Scott & Gallagher, 1999). Another economic dimension that is not included in this estimate is the cost of nonprofessional caregivers. Family members and friends who care for older persons after a fall may need to take time off work to allow for the time needed to care for these people. Nonprofessional caregivers may also need
childcare services because they are not able to be at home while caring for their family member or friend.

THE ETIOLOGY OF FALLS

Falls are typically the result of complex interactions between combinations of factors. Several studies have indicated that the majority of falls cannot be attributed to a single medical problem or neurological disease, but are rather a result of the cumulative effect of multiple factors (Tinetti et al., 1988; Tinetti, 1989). These factors that contribute to falls can be considered intrinsic (relating to the individual) and extrinsic (relating to the environment) (Tinetti, 2003; Mustard & Mayer, 1997). Hindmarsh and Estes (1989) described a ‘threshold’ model to explain the etiology of falls in older persons. According to this model, a number of factors combine to limit the individual’s overall functional status, and any single problem can ‘tip the balance’ and lead to a fall (Hindmarsh & Estes, 1989).

There are several different ways to group the causes of falls. Rubenstein et al. (1988) observed that the same fall can be explained by a presenting symptom complex (e.g. dizziness, syncope), by a precipitating mechanism (e.g. environmental hazard, postural hypotension), or by underlying factors (medications, decreased vision). In 1995, Campbell et al. grouped falls into three categories. The first type of fall described is a fall with impairment or loss of consciousness, and these are likely due to hypotension, cardiac arrhythmias, epilepsy, aortic stenosis or vasovagal syncope. The second type of fall is a fall associated with acute illness, which may result from medications, postural hypotension, dehydration or environmental hazards. The third group of falls described by
these researchers is a fall associated with impairment of balance and gait. These falls are likely due to impaired sensory input, impaired motor function or impaired central nervous system processing (Campbell et al., 1995).

Falls occur in persons of all ages, but older persons are more susceptible to falling because of normal age related physical decline. Physiological impairments that are typically associated with normal aging include: decreased skeletal muscle strength, decreased coordination, abnormal blood pressure homeostasis, impaired gait and mobility, and visual and auditory deficits (Buchner, 1997; Vandervoort, 1992; Fleming et al., 1991; Lipsitz, 1985). These deficits are considered a normal part of aging, but many co-morbid diseases can exacerbate these impairments and essentially increase the risk of falling. Medications that are used to treat many diseases can also inadvertently impair physiological processes and increase the risk of falling in older persons. The intrinsic risk factors that will be reviewed include: age related physiological impairments, co-morbid diseases, and medications.

The association of age related physiologic changes in blood pressure homeostasis and falls was well reviewed by Lipsitz in 1985. This author highlights three physiological abnormalities in blood pressure that are age related. The first is a decline in baroreflex sensitivity which makes older persons more sensitive to everyday movements such as posture change and eating (Lipsitz, 1985). The second change is a progressive decline in cerebral blood flow which can be aggravated by the presence of cerebrovascular disease. The final abnormality is in extracellular volume regulation which is likely caused by impairments in sodium conservation and can lead to rapid volume depletion. Irregular blood pressure can also lead to other conditions that may
increase the risk of falls (Aronow, 1995). These conditions include: orthostatic hypotension, postprandial hypotension, carotid sinus hypersensitivity, and cardiac arrhythmias (Lipsitz, 1985).

Orthostatic hypotension has been linked to falls in several studies (Miller et al., 2000; Tinetti et al., 1994; Barbieri, 1983). This condition is defined as a drop of more than 20 mm of systolic blood pressure after standing (Josephson et al., 1991). Approximately 5% to 25% of community dwelling older persons suffer from orthostatic hypotension (Robbins & Rubenstein, 1984). Postprandial hypotension is a result of a reduction in systolic blood pressure after eating a meal (Aronow, 1995). This condition can lead to the development of symptomatic hypotension which may cause a person to fall (Aronow, 1995). In a study by Aronow and Ahn (1994), it was found that older persons with a history of falls had a significantly greater mean maximal reduction in postprandial systolic blood pressure compared to older persons with no history of falling.

Carotid sinus hypersensitivity has been identified as an important, but often overlooked, cause of falls in older persons (Ward et al., 1999; Davies & Kenny, 1996). This condition is diagnosed when a carotid sinus massage produces a fall in systolic blood pressure exceeding 50 mmHg and marked bradycardia (Ward et al., 1999). The relationship between carotid sinus hypersensitivity and falls resulting in fractures was examined and it was found that many accidental falls can be attributed to this condition (Davies & Kenny, 1996). Cardiac arrhythmias can cause impaired cardiac output and cerebrovascular insufficiency, and they are associated with falls and dizziness in older persons (Gordon, 1978). They are characterized by rapid supraventricular and ventricular arrhythmias and a reduction in cardiac output and blood pressure (Lipsitz, 1985).
Decreased skeletal strength in association with aging has been well established in the literature (Buchner, 1997; Chandler, 1996; Vandervoort, 1992). Aging causes the deterioration of isometric and dynamic strength and the speed of contraction (Chandler, 1996). The decline in strength associated with aging is due to a decrease in the number and size of alpha neurons, impaired excitation coupling, reduced muscle fiber size and reduced cross-sectional area of muscles (Chandler, 1996). A study by Fleming et al. (1991) used a muscle power test to evaluate the relationship between falling and strength in older persons and found that non-fallers were significantly stronger than fallers. Tinetti et al. (1995) examined a number of factors to determine if they predisposed older persons to falling and discovered that lower and upper extremity impairment acted as independent predictors of falls.

Healthy older persons score approximately 20-40% less on strength tests than younger adults (Vandervoort, 1992). Muscle strength deteriorates even more in unhealthy older adults because of inactivity. Buchner (1997) described a feedback loop in which inactivity leads to muscle fiber atrophy, which causes muscle weakness, leading to gait problems which may result in falls. After an injurious fall older persons are usually required to reduce their level of activity which could cause this cycle to be repeated. Muscle deterioration may also cause injuries to be more severe in older adults. This is possible because the most effective energy absorber in the human body is the musculature, which decreases with age, therefore reducing the body’s ability to withstand the effects of mechanical energy (Sattin, 1992).

Many older persons experience impairments in gait, balance and posture as a result of the aging process (Lajoie & Gallagher, 2004; Alexander, 1996; Judge et al.,
The causes of these impairments are deficits in the central integration of motor and sensory functions (Wolfson et al., 1985). Berg et al. (1996) broadly defined gait as “the means of locomotion achieved through alternating movements of the legs” (pg. 707). Neurological, musculoskeletal, and cardiovascular systems are all involved in controlling gait (Judge et al., 1996). In healthy older adults, gait speed declines with age at a rate of 1.6% per year after the age of sixty-three (Alexander, 1996). This decline in speed is associated with a decrease in step or stride length (Wolfson, 1985).

There is a lack of consensus between investigators as to which parameters of gait should be measured to predict falling (Eke-Okoro, 1999). Researchers have investigated walking speed, stride length, stride frequency, step symmetry, and stride-to-stride variability with conflicting results (Koski et al., 1998; Lord et al., 1996). In a study of community dwelling older women, Lord et al. (1996) measured several characteristics of gait and found that fallers had significantly reduced and more variable cadence than non-fallers. Tinetti et al. (1988) studied risk factors for falls in community dwelling older adults and found that increased trunk sway, inability to pick up walking pace, and increased path deviation significantly increased the risk of falling. In 1999, Eke-Okoro designed a study to explore the causes of falls using a velocity field diagram to assess the interaction of several gait parameters. The results of this pilot project indicate that fallers and non-fallers can be distinguished based upon their total use of the velocity field.

Several studies have examined the link between falls and the deterioration in postural stability as a result of aging (Rigler, 1996; Thornby, 1995; Lord et al., 1994; Maki et al., 1994). Posture is maintained by equally distributing the body’s center of
mass over a central area of the support base during moving and static situations (Maki et al., 1996; Thomby, 1995). Autonomic neuromuscular mechanisms are responsible for maintaining this equal distribution (Thomby, 1995). A fall occurs when a perturbation takes place and the posture control system fails to compensate for the perturbation (Maki et al., 1996). Age related changes in the sensory systems that allow individuals to correct for perturbations include: visual deterioration, vestibular disturbances, diminished proprioception, and central and peripheral nervous system damage (Maki et al., 1996).

Lord et al. (1994) examined measures of postural stability in community dwelling older persons in relation to falling and fracture prevalence. The results of this study indicate that falling can be predicted from tests of quadriceps strength, body sway, tactile sensitivity and visual field dependence (Lord et al., 1994). Maki et al. (1994) performed balance tests on older ambulatory and independent persons and found that the best predictor of future falls was the test of lateral spontaneous sway amplitude. These researchers concluded that this test performed the best because it acts as a marker of deteriorated neural and sensorimotor mechanisms that are involved in balance recovery (Maki et al., 1994). Four measures of balance (unsteady sitting down, unable to stand on one leg unsupported, unsteady turning, and unsteady after gentle push on sternum) used by Tinetti et al. (1988) were significantly associated with the risk of falling in older adults.

Vestibular disturbances that result from age related degenerative changes can cause impaired balance in older persons (Kristinsdottir et al., 2001; Brandt & Dieterich, 1993). Persons suffering from unilateral and bilateral vestibular loss may feel a sense of imbalance even while lying down (Sloane, 1996). Kristendottir et al. (2001) studied the
risk of falling associated with vestibular asymmetry in older persons and found that
fallers had a significantly higher frequency of signs of vestibular asymmetry than non-
fallers. Vestibular disturbances can result in two types of dizziness: vertigo and
disequilibrium (Sloane, 1996). Deficits in ankle proprioception contribute to falls in
older persons because of an increase in the activation threshold for cutaneous sensations
and joint proprioception (Anacker & Di Fabio, 1992). Age related changes affecting the
central and peripheral nervous systems include: loss of neurons, dendrite loss, reduced
branching, and irregular cerebral metabolism (Maki et al., 1996).

Visual deterioration is well established as a risk factor for imbalance and falling
in older adults (Maino, 1996; Cohn, 1985; Owen, 1985). Mobility is threatened by visual
field loss, impaired contrast sensitivity, loss of dark adaptation, and weakened stereopsis
(Maino, 1996; Owen, 1985). The quality of vision is reduced in older persons because of
normal age related changes in the tear film, cornea, pupil, lens and retina (Maino, 1996).
Aging is associated with a decrease in pupil size and an increase in the opaqueness of the
lens, which causes difficulties seeing at night (Maino, 1996). Jack et al. (1995) examined
the prevalence of visual impairments in older persons presenting to an emergency
department because of a fall, and found that 76% of the people admitted to the hospital
because of a fall had a visual impairment. Tinetti and Speechley (1989) also identified
visual impairment as a chronic risk factor for falling.

Many co-morbid diseases have also been associated with an increase risk of
falling in older persons (Schwartz et al., 2002; Wallace et al., 2002; Hendrich et al., 1995;
Tinetti et al., 1998). Diagnosis of cancer, depression, diabetes, dementia, osteoarthritis,
Parkinson’s disease, cognitive impairment, osteoporosis, cerebrovascular disease,
hypertension, cardiovascular disease, incontinence, malnutrition, and gait or balance disturbance are commonly cited as co-morbid conditions that increase the risk of falling (Wallace et al., 2002; Mustard & Mayer, 1997; Lilley et al., 1995; Thapa et al., 1995). These diseases and conditions contribute to the risk of falling for several reasons. Many of these conditions impair sensory, cognitive, neurologic and muscoskeletal functioning (Tinetti & Speechley, 1989).

The roles of dementia and depression in falling have been examined together because the deficits associated with these diseases are similar despite the different underlying mechanisms (Mossey, 1985). In 1985, Mossey hypothesized that while depression leads to distraction and psychomotor impairment, and dementia leads to gait and balance disorders, both these conditions cause impaired judgement. The cumulative effects of these impairments cause sufferers of both diseases to have an increased risk of falling (Mossey, 1985). Kip et al. (1999) used a prospective cohort study to examine the relationship between fractures in community dwelling women and depression. The findings of this study indicate that women with depression were more likely to experience falls than women without depression, and women with depression also had an increased rate of non-vertebral fractures (Kip et al., 1999). In an examination of the role of dementia in falls in community dwelling older persons, Asada et al. (1996) found that dementia was a significant risk factor for subsequent falls.

Diabetes and diabetes-related disorders are associated with an increase in fall risk (Schwartz et al., 2002; Wallace et al., 2002; Richardson & Ashton-Miller, 1996). Schwartz et al. (2002) used a prospective cohort study to investigate the relationship between falls and women with diabetes. The results of this study show that older women
with diabetes that use insulin have an increased risk of falling (Schwartz et al., 2002). In a similar study by Wallace et al. (2002), the frequency of fall related fractures in older persons with diabetes and a prior foot ulcer was examined. After one year, 54% of this cohort reported at least one fall, and insensate feet (as a result of diabetic peripheral neuropathy) was associated with an increased risk of two or more falls. Peripheral neuropathy, a diabetes related disorder, is found in approximately 50% of diabetic patients over the age of sixty (Richardson & Ashton-Miller, 1996). This condition impairs somatosensory function which can lead to imbalance and falls (Richardson & Ashton-Miller, 1996). In a recent study by Menz et al. (2004), it was found that persons diagnosed with peripheral neuropathy had an impaired ability to stabilize their body which can lead to more falls when walking on irregular surfaces.

Several studies examining the risk factors associated with falls in older persons have demonstrated that urinary incontinence, hypertension, cancer, cognitive impairment, and cerebrovascular disease are associated with an increase in the risk of falling (Miller et al., 2000; Suzuki et al., 1997; Tutuarima et al., 1997; Hendrich et al., 1995). Of these co-morbidities, urinary incontinence appears to be the most commonly cited risk factor for falls. Incontinence is estimated to occur in 17-55% of older women, and 11-34% of older men (Miller et al., 2000). Tinetti et al. (1995) examined shared risk factors for falls and incontinence and found an increase in these conditions as the number of predisposing factors increased. This led these researchers to conclude that a predisposition to geriatric syndromes, such as falls and incontinence, may occur because compensatory abilities are compromised by multiple impairments (Tinetti et al., 1995). Co-morbid diseases such as cognitive impairment, hypertension, cancer and cerebrovascular disease place older
persons at risk of falling because they further impair postural stability, blood pressure homeostasis, balance and coordination (Rawsky, 1998; Judge et al., 1996; Lipsitz, 1985).

Balance, coordination, muscle strength and gait are highly affected by Parkinson’s disease and malnutrition (Alexander, 1996; Rogers, 1996; Vellas et al., 1991).

Parkinson’s disease, a neurodegenerative condition that often results in small shuffling steps, forward-leaning posture and reduced movements in the limbs during walking, has been established as a risk factor for recurrent falls among older adults (Rogers, 1996; Nevitt et al., 1993). Malnutrition compromises the physiological systems that maintain balance and postural stability and it has been found to be a risk factor for falls in older persons (Stolz et al., 2002; Vellas et al., 1992; Vellas et al., 1991). Sufficient calcium and vitamin D intake has been established as a preventative measure to developing osteoporosis, and osteoporosis is considered a significant risk factor for fall related fractures (Prior et al., 1996; Wark, 1996; Nevitt et al., 1993).

The relationship between different medication classes and the risk of falling has been well documented (Kelly et al., 2003; Tinetti, 2003; Thapa et al., 1998; Mustard & Mayer, 1997; Thapa et al., 1995; Ruthazer & Lipsitz, 1993). Some of the findings are contradictory, but in many cases the same medication classes are consistently found to be risk factors for falls. The groups of drugs that have been associated with an increase in falls in older persons include: sedatives, antidepressants, anti-convulsants, anti-psychotics, anti-parkinsonian agents, anti-hypertensives, and anti-coagulants (Kelly et al., 2003; Thapa et al., 1998; Mustard & Meyer, 1997; Thapa et al, 1995). There have also been mixed results from studies that examine the risks associated with specific types of
drugs in these medication classes (Ensrud et al., 2002; Pierfitte et al., 2001; Ruthazer & Lipsitz, 1993).

Medications can have different effects on older persons compared to younger persons because of differential pharmacokinetic and pharmacodynamic properties (Monane & Avom, 1996). Pharmacokinetic properties refer to the relationship of the drug dosage and its concentration in the blood, whereas pharmacodynamic properties refer to how the drugs react in the body (Monane & Avom, 1996). While the absorption of drugs in essentially equivalent in older and younger persons, the distribution, metabolism and excretion is affected by normal aging processes (Monane & Avom, 1996). Reduced metabolic capacity and renal activity is an age related change that can result in an extended half life of a drug (Hanlon et al., 1996; Monane & Avom, 1996). Older persons may also be more sensitive to certain types of drugs because of pharmacodynamics (Hanlon et al., 1996). Increased sensitivity to drug effects in older persons has been found with benzodiazepines, opiates, anticholinergics, dopamine antagonists, and antihypertensives (Monane & Avom, 1996).

Benzodiazepines have been studied extensively and are continually associated with an increase in fall risk in older persons (Ensrud et al., 2002; Pierfitte et al., 2001; Wang et al., 2001; Herings et al., 1995). These types of drugs are commonly prescribed for the treatment of anxiety and insomnia (Shorr & Robin, 1994). Benzodiazepines are associated with impairments in cognition, memory, coordination and balance (Shorr & Robin, 1994). Ensrud et al. (2002) examined the association between medications and falling in community dwelling older persons and found that even after adjusting for potential confounders, benzodiazepines were associated with an increased risk for
frequent falls. In 1995, Herings et al. studied the risks of falling leading to femur fractures and found that falls were significantly associated with current use of benzodiazepines, sudden dose increases of benzodiazepines, use of short half-life benzodiazepines, and concomitant use of several benzodiazepines.

Other psychotrophic drugs have also been associated with an increase in the risk of falls in older persons (Ensrud et al., 2002; Weiner et al., 1998; Thapa et al., 1995; Hanlon et al., 1996). Aside from benzodiazepines, this class of drugs includes sedative-hypnotics, anti-depressants, and anti-psychotics (Hanlon et al., 1996). These drugs may contribute to falls by causing dizziness, sedation and increased postural sway (Weiner et al., 1998; Hanlon et al., 1996). Thapa et al. (1995) examined psychotrophic drugs and the risk of recurrent falls in older persons and found that even after controlling for the effects of dementia and depression, psychotropic drug users had a significantly higher risk of falling compared to non-users. In 1998, Weiner et al. studied the effects of using multiple central nervous system (CNS) active medications on community dwelling older persons. The results of this study indicate that the risk of falls was significantly greater in CNS active medication users than non-users, and the risk increased with the number of medications being used (Weiner et al., 1998).

Tricyclic and selective serotonin-reuptake inhibitors (SSRIs) are two types of commonly prescribed anti-depressants that have been studied extensively (Ensrud et al., 2002; Thapa et al., 1998; Ruthazer & Lipsitz, 1993). The rates of falls associated with these different anti-depressants have been compared to determine if one is safer than the other. Researchers expected that the newer SSRIs would not be associated with a risk of falling because they were designed to be free of the cardiovascular, anticholinergic and
antihistamine side effects associated with the older tricyclic antidepressants (Pacher & Ungvari, 2001). Ruthazer & Lipsitz (1993) found that older women taking antidepressants were more likely to fall than non-users, and that there was no difference in the rates of falls between women taking the two different types of anti-depressants. These results are similar to those reported by Thapa et al. (1998) in that there was no difference between the rates of falls between people taking the two medication types. However, Ensrud et al. (2002) did find an increased risk of falling in an older population with the use of SSRIs compared to tricyclics.

The relationship between falls and cardiovascular medications has been evaluated in several studies (Koski et al., 1996; Lange, 1996; Monane & Avorn, 1996; Meredith, 1993). Anti-hypertensive agents have a potential for adverse effects because age-related irregularities in blood pressure homeostasis predispose older persons to hypotension (Monane & Avorn, 1996). Anti-hypertensive medications are also known to have anticholinergic side effects which can cause dizziness (Sloane, 1996). Diuretics may cause fatigue, volume depletion, orthostatic hypotension and electrolyte imbalance which could increase the risk of falling (Lange, 1996; Tinetti & Speechley, 1989). In a population based prospective study by Koski et al. (1996), the use of calcium channel blockers was found to be a risk factor for injurious falls in older persons. Conversely, O’Loughlin et al. (1993) found that blood pressure medications had no association with the risk of falls, and heart medications were found to have a protective effect.

One of the main problems with determining the risk of falls related to medication use is the difficulty in determining whether the falls occur because of the medication use or because of the condition for which the drug has been prescribed. In a recent study by
Kelly et al. (2003), the researchers examined the association between medication use and the risk of falls while controlling for the confounding effects of the underlying medical conditions. The results of this study indicate that narcotics, anti-convulsants and anti-depressants are independent risk factors for falls. Mustard and Mayer (1997) also conducted a study that controlled for the confounding effects of co-morbid diseases. According to this study, the medication classes anxiolytics/sedatives/hypnotics and anti-psychotic drugs were found to be associated with an elevated risk of an injurious fall.

Age related changes in older persons can result in a predisposition to falling, but many co-morbid conditions and medications can further exacerbate the risk of falling. From the literature, it is impossible to identify the most important risk factors for falling because no study has ever concurrently evaluated all of the known risk factors. However, many studies have consistently found that as the number of these risk factors increases, the risk of falling increases (Thapa et al., 1995; Tinetti & Speechley, 1989; Tinetti et al., 1988). In a study by Tinetti et al. (1988), the risk of falling increased linearly with the number of risk factors. These researchers suggest that this indicates that a predisposition to fall results from the accumulated effects of multiple risks. Thapa et al. (1995) saw a tenfold increase in the rates of falls in older persons as the number of risk factors increased from zero to five. This relationship indicates that all of these risk factors are associated and interrelated.

Extrinsic factors that are related to falls include precipitating features such as the individual’s environment, surroundings and support (O’Loughlin, 1993). The environment has been found to be a contributory factor in many falls (Carter et al., 1997; Parker et al., 1996; Josephson et al., 1991). Carter et al. (1997) examined the homes of
older persons for environmental hazards and found that 80% of the inspected homes had at least one known hazard. Home hazards include: poor lighting, clutter, rugs, chairs lacking arm rests, slippery floors, and poorly designed stairs (Hill et al., 2000; Carter et al., 1997; Connell, 1996; Waller, 1977). In a study of community dwelling older adults, Studenski et al. (1994) found that recurrent fallers had significantly more threatening environments than non-fallers. Barbieri (1983) found a higher incidence of falling in association with areas in an institution that had high gloss flooring.

Studies have also examined the environmental risk factors for falls occurring outdoors (Mamdani & Upshur, 2001; Luukinen et al., 1996; Parker et al., 1996). Items that have been identified as outdoor hazards include: stones, gravel, pot-holes, icy or wet surfaces, shoelaces, and grates (Parker et al., 1996; Waller, 1977). A Finnish study evaluated the relationship between outdoor temperature and the frequency of falls in older persons and found that there is little variation in the rates of falls in relation to temperature (Luukinen et al., 1996). A Canadian study that evaluated the seasonal patterns of hospitalizations associated with falls found that the peak in admissions for older persons occurred during the colder months (Mamdani & Upshur, 2001). The relative importance of these extrinsic factors generally depends on the individual's level of functioning (Northridge et al., 1995).

There have been numerous studies that have examined the relative risks of these intrinsic and extrinsic factors, but the majority of these studies have only examined a small population of subjects. A large population based study addressing several risk factors for falls in older community dwelling persons would allow researchers to get a better idea of which targeted prevention strategies would be most useful at reducing the
number of falls in older persons. The following is a study of the entire population of community-dwelling persons aged 66 years and older in Alberta during the 1998/99 fiscal year. Only community dwelling persons are being specified because they are considered a distinctly different population from long term care residents. Community dwelling persons typically have a lower prevalence of many of the risk factors mentioned, and they are more mobile than long term care residents (Tinetti et al., 1988). The goals of this current study are threefold. The first goal is to present a description of the age, gender, socioeconomic status (SES), residence (rural and non-rural), medication use and co-morbidities of fallers and non-fallers. The types of injuries sustained by fallers, the circumstances of the falls, the hospitalization rates, and the time of year of the falls will also be reported. The second goal of this research is to determine the independent risks of age, gender, SES, residence, medications and co-morbidities on falling. Thirdly, the effects of different medication classes on the incidence of injurious falls will be examined while controlling for other risk factors including: age, gender, SES, residence, and co-morbidities.
OBJECTIVES OF STUDY

1. To describe the demographics of the population of persons aged 66 and older experiencing injurious falls in the province of Alberta for the 1998-1999 fiscal year. This includes a comparison of their age, gender, SES, residence (rural and non-rural), medication use and co-morbidities with persons 66 years and older not experiencing an injurious fall in this time frame. The injuries sustained by fallers, the circumstances of the falls, the hospitalization rates, the mortality rates, and the month the falls occurred in will also be described.

2. To determine the independent effects of age, gender, SES, residence (rural and non-rural), medications and co-morbidities on falls.

3. To examine the influence of seventeen medication classes on the incidence of injurious falls in persons aged 66 and older while controlling for other risk factors. The risk factors that will be controlled for include: age, gender, SES, residence (rural and non-rural) and co-morbidities. The effects of the medication classes will first be analyzed while controlling for age, gender, SES, and residence (rural and non-rural). This analysis will be repeated but the additional effects of co-morbidities will be controlled for as well.
METHODS AND DATA ANALYSIS

Study Population: The study population is the entire population of community dwelling persons 66 years of age and older residing in the province of Alberta during the 1998-1999 fiscal year. During the time of data collection, the province of Alberta was divided into seventeen different health regions. The population of this province is approximately 3 million. Persons aged 66 years and older comprise approximately 10.2% of this population (Statistics Canada, 2003). There are 282,519 community dwelling persons included in this study.

Inclusion Criteria: Cases for this study are defined as all persons 66 years and older presenting to any of the emergency departments in the province with an injurious fall in the 1998-1999 fiscal year. An injurious fall is defined according to the International Classification of Diseases – Ninth Revision (ICD-9 Codes, 1989) as an unexpected event wherein a person fell to the ground from an upper level or from the same level, including falls up stairs and falls onto a piece of furniture. Exclusions of cases include any non-community-dwelling persons.

Data Collection: Data for this study were obtained from computerized administrative data sets that are linked deterministically using a unique personal identification number. Deterministic linking is used so that matched records for individuals can be brought together and assembled into one composite record for that individual. All personal identifiers that were used to assemble the data have been removed to ensure the privacy of all persons. Hospital emergency department data were used to collect information on persons 66 years and older presenting because of an injurious fall (as recorded by the
ICD-9 codes). Co-morbidity data was established using the Physicians Claims Files and medication use was determined from prescription billings available from the Blue Cross Insurance Plan. The seventeen co-morbid disease classes used in this study are as follows: eye disorders, incontinence or urinary tract disorders, nutritional deficiencies, Parkinson’s disease, osteoarthritis, dementia, depression/psychosis, neurosis, osteoporosis, cerebrovascular disease, hypertension, cardiovascular disease, diabetes, cancer, gait/balance disorders, seizures and injury trauma. Individuals were coded as having the co-morbidity if it was in their Physician Claim File within the study year. The medication classes included in the study include: anti-histamines, narcotic pain killers, non-steroidal anti-inflammatories (NSAIDS), anti-convulsants, anti-depressants, anti-psychotics, sedatives/anxiolytics/hypnotics, anti-parkisonian agents, electrolytics/water balance agents, visual impairment agents, anti-ulcer agents, corticosteroids, sex hormones, diabetes agents, thyroid agents, anti-coagulants, and anti-hypertensive agents. Fallers were coded as using the medication if it was purchased within 30 days prior to their fall. Non-fallers were matched to fallers using the date of the fall. The standard population was determined using the Alberta Health Registration file. The number of deaths occurring in the study year was also determined using the Alberta Health Registration file. The residence of individuals was determined using their postal codes. A zero in the second digit of the postal code indicates that the individual lives in a rural setting. Non-community dwelling persons were excluded using the Long Term Care file to establish residency.

Analysis: The complete data set was screened for outliers, missing values and miscoded information prior to performing any statistical analysis. The only variable with miscoded
values was age. Seven hundred and thirty-three persons (0.25%) had the value 999 as their age. Fourteen were fallers and 719 were non-fallers. These subjects were omitted from all analysis. A significance level of $p < 0.05$ was applied to all statistical tests. All statistical analysis was conducted using SPSS for Windows, version 11.0.

Objective One- The data collected regarding age, gender, socioeconomic status (SES), type of injury, location of fall, month of fall, hospitalization rates, co-morbidities, and medications was analyzed using descriptive statistics. Univariate analysis was conducted to compare fallers and non-fallers using the student's t-test and the chi-square test. The student's t-test was used to compare ages between fallers and non-fallers. Chi-square tests were used to compare gender, SES, residence, month of fall, mortality, all co-morbidities and all medication use 30 days prior to the incident between fallers and non-fallers.

Objective Two- The independent risks posed by age, gender, SES, residence, medications, and co-morbidities were examined using logistic regression. Each of these risk factors was examined independently of all other risk factors. For these logistic regressions, the dependent variable was an injurious fall requiring presentation to the emergency department.

Objective Three- Logistic regression was used to determine the effects of the different medication classes on fall incidence while controlling for age, gender, SES, and residence. This logistic regression was repeated but co-morbidities were included in the list of covariates. The dependent variable was an injurious fall requiring presentation to the emergency department, the independent variable was the different medication classes, and the covariates were age, gender, SES, residence and co-morbidities. This analysis
determined whether persons taking certain medication have a differential risk for falling compared to persons who are not taking these medications. By including co-morbidities in the analysis, it was possible to determine the fall risk associated with these medication classes above and beyond the risk associated with the diseases.
RESULTS

During the study period (1998/1999 fiscal year), 8,534 persons 66 years and older presented to an emergency department in the province of Alberta because of an injurious fall. Thirty-five percent of these injurious falls required hospital admittance. The majority of the injuries sustained were fractures (56.4%), followed by lacerations (11.7%), sprains and strains (10.2%), and abrasions (9.8%). A list of the most common injury diagnoses, according to ICD-9 coding, is found in Table 1. The majority of falls occurred at home (Table 2). A significant difference exists between the numbers of injurious falls occurring each month ($X^2 (11, N = 8,534) = 71.23, p < 0.000$). The greatest number of injurious falls occurred in the month of January ($n = 806$) and the fewest number of falls occurred in February ($n = 626$) (Figure 1). The number of fallers that died (7.1%) within the study year is significantly greater than the number of non-fallers who died (3.2%) within the study year ($Pearson's X^2 (1, N = 282,519) = 390.90, p < 0.000$).

A comparison of demographic variables between fallers and non-fallers is outlined in Table 3. Fallers are more likely to be female and older when compared to non-fallers ($Pearson's X^2 (1, N = 282,519) = 468.00, p < 0.00; Student's t-test, t = 40.22, df = 281,784, p < 0.00$). In the total population ($n = 282,519$) 55% of persons are female, while 67% of fallers are female and 55% of non-fallers are female. Fallers and non-fallers also differ when comparing their socioeconomic status ($Pearson's X^2 (3, N = 282,519) = 126.44, p < 0.000$). Fallers are more likely to be receiving subsidy or to have
Table 1. Description of the most common types of injuries sustained by fallers derived from ICD-9 codes.

<table>
<thead>
<tr>
<th>Code</th>
<th>n</th>
<th>%</th>
<th>Description of Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>8208</td>
<td>623</td>
<td>7.3</td>
<td>Closed fracture of unspecified part of neck of femur</td>
</tr>
<tr>
<td>81341</td>
<td>347</td>
<td>4.1</td>
<td>Closed colles' fracture</td>
</tr>
<tr>
<td>9221</td>
<td>326</td>
<td>3.8</td>
<td>Contusion of chest wall</td>
</tr>
<tr>
<td>8730</td>
<td>298</td>
<td>3.5</td>
<td>Open wound of scalp without mention of complication</td>
</tr>
<tr>
<td>87342</td>
<td>275</td>
<td>3.2</td>
<td>Open wound of forehead without mention of complication</td>
</tr>
<tr>
<td>920</td>
<td>267</td>
<td>3.1</td>
<td>Contusion of face, scalp and neck except for eye(s)</td>
</tr>
<tr>
<td>81342</td>
<td>260</td>
<td>3.0</td>
<td>Closed fracture of distal end of radius</td>
</tr>
<tr>
<td>82021</td>
<td>236</td>
<td>2.8</td>
<td>Closed fracture of intertrochanteric section of neck of femur</td>
</tr>
<tr>
<td>84500</td>
<td>185</td>
<td>2.2</td>
<td>Sprain and strain of unspecified site of ankle</td>
</tr>
<tr>
<td>82009</td>
<td>160</td>
<td>1.9</td>
<td>Closed fracture of neck of femur</td>
</tr>
<tr>
<td>80700</td>
<td>123</td>
<td>1.4</td>
<td>Closed fracture of ribs, unspecified</td>
</tr>
<tr>
<td>81201</td>
<td>120</td>
<td>1.4</td>
<td>Closed fracture of surgical neck of humerus</td>
</tr>
</tbody>
</table>

Table 2. Description of the most common locations for injurious falls derived from ICD-9 codes.

<table>
<thead>
<tr>
<th>Code</th>
<th>n</th>
<th>%</th>
<th>Description of Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>E888</td>
<td>3209</td>
<td>37.6</td>
<td>Other and unspecified accidental fall at home.</td>
</tr>
<tr>
<td>E885</td>
<td>2679</td>
<td>31.4</td>
<td>Fall on same level from tripping, slipping or stumbling.</td>
</tr>
<tr>
<td>E8809</td>
<td>751</td>
<td>8.8</td>
<td>Accidental fall on or from stairs or steps at home.</td>
</tr>
<tr>
<td>E8849</td>
<td>176</td>
<td>2.1</td>
<td>Accidental fall from one level to another at home.</td>
</tr>
<tr>
<td>E8842</td>
<td>171</td>
<td>2.0</td>
<td>Accidental fall from chair or bed at home.</td>
</tr>
</tbody>
</table>
Figure 1. Histogram displaying the number of injurious falls per month presenting to an emergency department in the province of Alberta in the 1998/99 fiscal year.
Table 3. Comparison of demographic variables, co-morbidities, and medications between fallers and non-fallers. Un-adjusted and adjusted odds ratios for all demographic variables, co-morbidities and medications measured as risk factors for falling.

<table>
<thead>
<tr>
<th></th>
<th>Fallers (n = 8,534)</th>
<th>Non-Fallers (n = 273,985)</th>
<th>Un-adjusted OR (95% CI)</th>
<th>Adjusted** OR (95% CI)</th>
<th>Adjusted*** OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (Female)</td>
<td>67%</td>
<td>55%*</td>
<td>1.65 (1.58, 1.73)</td>
<td>1.47 (1.40, 1.54)</td>
<td>1.48 (1.41, 1.55)</td>
</tr>
<tr>
<td>Age: mean (SD)</td>
<td>77.9 (8.1)</td>
<td>74.8 (6.8)*</td>
<td>1.06 (1.05, 1.06)</td>
<td>1.05 (1.05, 1.06)</td>
<td>1.05 (1.05, 1.05)</td>
</tr>
<tr>
<td>SES:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Subsidy</td>
<td>33.1%</td>
<td>*</td>
<td>1.23 (1.17, 1.29)</td>
<td>1.03 (0.98, 1.08)</td>
<td>1.03 (0.98, 1.08)</td>
</tr>
<tr>
<td>Subsidy</td>
<td>65.2%</td>
<td>60.7%</td>
<td>0.65 (0.44, 0.97)</td>
<td>0.77 (0.52, 1.14)</td>
<td>0.78 (0.52, 1.16)</td>
</tr>
<tr>
<td>Social Services</td>
<td>0.3%</td>
<td>0.5%</td>
<td>2.10 (1.74, 2.54)</td>
<td>2.25 (1.85, 2.73)</td>
<td>2.03 (1.67, 2.47)</td>
</tr>
<tr>
<td>Treaty</td>
<td>1.3%</td>
<td>0.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>24.4%</td>
<td>22.1%*</td>
<td>1.14 (1.08, 1.19)</td>
<td>1.12 (1.06, 1.18)</td>
<td>1.13 (1.08, 1.19)</td>
</tr>
<tr>
<td>Co-morbidities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye Disorders</td>
<td>36.7%</td>
<td>32.4%*</td>
<td>1.21 (1.16, 1.27)</td>
<td>1.04 (0.99, 1.09)</td>
<td></td>
</tr>
<tr>
<td>Incontinence or Urinary tract disorders</td>
<td>5.2%</td>
<td>3.9%*</td>
<td>1.34 (1.22, 1.48)</td>
<td>1.18 (1.07, 1.31)</td>
<td></td>
</tr>
<tr>
<td>Nutritional Deficiencies</td>
<td>0.3%</td>
<td>0.2%</td>
<td>1.25 (0.83, 1.88)</td>
<td>0.93 (0.61, 1.40)</td>
<td></td>
</tr>
<tr>
<td>Parkinson’s Disease</td>
<td>1.5%</td>
<td>0.7%*</td>
<td>2.13 (1.78, 2.54)</td>
<td>1.35 (1.08, 1.69)</td>
<td></td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>20.5%</td>
<td>15.8%*</td>
<td>1.38 (1.30, 1.45)</td>
<td>1.05 (0.99, 1.11)</td>
<td></td>
</tr>
<tr>
<td>Dementia</td>
<td>4.5%</td>
<td>1.8%*</td>
<td>2.58 (2.32, 2.87)</td>
<td>1.43 (1.28, 1.60)</td>
<td></td>
</tr>
<tr>
<td>Depression/ Psychosis</td>
<td>10.4%</td>
<td>5.8%*</td>
<td>1.98 (1.84, 2.12)</td>
<td>1.30 (1.20, 1.41)</td>
<td></td>
</tr>
<tr>
<td>Neurosis</td>
<td>16.9%</td>
<td>12.6%*</td>
<td>1.41 (1.33, 1.49)</td>
<td>1.12 (1.06, 1.20)</td>
<td></td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>5.1%</td>
<td>3.9%*</td>
<td>1.33 (1.20, 1.46)</td>
<td>1.08 (0.97, 1.19)</td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular Disease</td>
<td>5.5%</td>
<td>3.0%*</td>
<td>1.89 (1.72, 2.08)</td>
<td>1.35 (1.23, 1.50)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>31.9%</td>
<td>32.2%</td>
<td>0.98 (0.94, 1.04)</td>
<td>0.90 (0.86, 1.01)</td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>1.03</td>
<td>0.94</td>
<td>1.07</td>
<td>1.13</td>
<td>1.15</td>
</tr>
<tr>
<td>---------------------------------</td>
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<td>------</td>
</tr>
<tr>
<td>Cardiovascular Disease</td>
<td>23.8</td>
<td>18.8</td>
<td>1.35</td>
<td>1.28</td>
<td>1.07</td>
</tr>
<tr>
<td>Diabetes</td>
<td>10.2</td>
<td>8.9</td>
<td>1.15</td>
<td>1.08</td>
<td>1.15</td>
</tr>
<tr>
<td>Cancer</td>
<td>13.9</td>
<td>13.4</td>
<td>1.04</td>
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<td>Gait/Balance Disorders</td>
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<td>1.50</td>
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<td>Seizures</td>
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<td>15.4</td>
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<td>2.58</td>
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<td>2.81</td>
<td>2.51</td>
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<tr>
<td>9</td>
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**Medications**

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<tr>
<th>Medications</th>
<th>Anti-histamines</th>
<th>Narcotic Pain Killers</th>
<th>NSAIDS</th>
<th>Anti-convulsants</th>
<th>Anti-depressants</th>
<th>Anti-psychotics</th>
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<tr>
<td></td>
<td>0%</td>
<td>7.9%</td>
<td>7.6%</td>
<td>2.7%</td>
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<td>1.6%</td>
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<tr>
<td></td>
<td>0%</td>
<td>4.4%</td>
<td>5.7%</td>
<td>1.2%</td>
<td>4.0%</td>
<td>0.8%</td>
</tr>
<tr>
<td></td>
<td>0.00 (0.00,-)</td>
<td>1.88 (1.74, 2.04)</td>
<td>1.35 (1.24, 1.46)</td>
<td>2.19 (1.91, 2.51)</td>
<td>2.22 (2.05, 2.40)</td>
<td>2.05 (1.72, 2.44)</td>
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<tr>
<td></td>
<td></td>
<td>1.47 (1.35, 1.60)</td>
<td>1.11 (1.02, 1.21)</td>
<td>1.63 (1.42, 1.88)</td>
<td>1.60 (1.47, 1.74)</td>
<td>1.29 (1.08, 1.54)</td>
</tr>
<tr>
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<td>1.36 (1.24, 1.48)</td>
<td>1.06 (0.98, 1.16)</td>
<td>1.34 (1.16, 1.55)</td>
<td>1.38 (1.26, 1.51)</td>
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<tr>
<td>Category</td>
<td>Prevalence</td>
<td>Significance</td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
<td></td>
</tr>
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<td>--------------</td>
<td>-------------</td>
<td>-------------</td>
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</tr>
<tr>
<td>Sedatives, Anxiolytics, Hypnotics</td>
<td>11.4%</td>
<td>6.8%*</td>
<td>1.75 (1.63, 1.87)</td>
<td>1.21 (1.13, 1.31)</td>
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<tr>
<td>Anti-parkinsonian Agents</td>
<td>1.3%</td>
<td>0.5%*</td>
<td>2.43 (2.00, 2.95)</td>
<td>1.87 (1.53, 2.28)</td>
<td>1.47 (1.15, 1.88)</td>
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<tr>
<td>Electrolytic, Water Balance agents</td>
<td>13.1%</td>
<td>8.6%*</td>
<td>1.59 (1.49, 1.69)</td>
<td>1.10 (1.02, 1.18)</td>
<td>1.11 (1.03, 1.19)</td>
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<tr>
<td>Visual Impairment Agents</td>
<td>2.6%</td>
<td>1.9%*</td>
<td>1.34 (1.17, 1.54)</td>
<td>1.10 (0.96, 1.26)</td>
<td>1.09 (0.95, 1.26)</td>
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</tr>
<tr>
<td>Anti-ulcer agents</td>
<td>10.5%</td>
<td>7.1%*</td>
<td>1.53 (1.43, 1.64)</td>
<td>1.13 (1.04, 1.22)</td>
<td>1.08 (1.00, 1.17)</td>
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</tr>
<tr>
<td>Corticosteroids</td>
<td>4.8%</td>
<td>3.1%*</td>
<td>1.61 (1.46, 1.78)</td>
<td>1.37 (1.24, 1.52)</td>
<td>1.34 (1.22, 1.50)</td>
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</tr>
<tr>
<td>Sex Hormones</td>
<td>0.3%</td>
<td>0.3%</td>
<td>1.12 (0.99, 1.27)</td>
<td>1.00 (0.88, 1.13)</td>
<td>0.97 (0.85, 1.10)</td>
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<tr>
<td>Diabetes Agents</td>
<td>5.3%</td>
<td>4.6%*</td>
<td>1.19 (1.08, 1.31)</td>
<td>1.10 (1.00, 1.21)</td>
<td>1.00 (0.89, 1.13)</td>
<td></td>
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<tr>
<td>Thyroid Agents</td>
<td>5.7%</td>
<td>4.0%*</td>
<td>1.44 (1.32, 1.58)</td>
<td>1.05 (0.95, 1.15)</td>
<td>1.02 (0.93, 1.13)</td>
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<tr>
<td>Anti-coagulants</td>
<td>3.3%</td>
<td>2.1%*</td>
<td>1.63 (1.44, 1.84)</td>
<td>1.28 (1.13, 1.45)</td>
<td>1.19 (1.05, 1.35)</td>
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<tr>
<td>Anti-hypertensive Agents</td>
<td>16.2%</td>
<td>13.5%*</td>
<td>1.24 (1.17, 1.31)</td>
<td>0.96 (0.90, 1.02)</td>
<td>0.98 (0.92, 1.05)</td>
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</tr>
<tr>
<td>Number of Medications</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>21.4%</td>
<td>19.9%</td>
<td>1.31 (1.24, 1.39)</td>
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<tr>
<td>2</td>
<td>13.5%</td>
<td>10.6%</td>
<td>1.56 (1.46, 1.66)</td>
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<td>3</td>
<td>8.2%</td>
<td>5.0%</td>
<td>2.00 (1.84, 2.17)</td>
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</tr>
<tr>
<td>4</td>
<td>4.0%</td>
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</tr>
<tr>
<td>5</td>
<td>2.1%</td>
<td>0.8%</td>
<td>3.15 (2.69, 3.68)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>0.6%</td>
<td>0.2%</td>
<td>3.24 (2.46, 4.26)</td>
<td></td>
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</tr>
<tr>
<td>7</td>
<td>0.3%</td>
<td>0.08%</td>
<td>4.10 (2.69, 6.26)</td>
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</tr>
<tr>
<td>8</td>
<td>0.08%</td>
<td>0.02%</td>
<td>4.83 (2.20, 10.60)</td>
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<td></td>
</tr>
</tbody>
</table>

*P < 0.05
**Adjusted for age, gender, socioeconomic status (SES), rural residence, and all medication classes.

***Adjusted for age, gender, socioeconomic status (SES), rural residence, all medication classes and all co-morbid diseases.
treaty status, whereas non-fallers are more likely to be receiving social services or to have no subsidy. A larger percent of fallers (24.4%) live in a rural area compared to non-fallers (22.1%) (Pearson’s $X^2(1, N = 282,519) = 25.31, p < 0.000$).

Falers have significantly more co-morbid diseases than non-fallers (Table 3). When comparing fallers and non-fallers, 79.4% of non-fallers have at least one co-morbid disease compared to 87.3% of fallers. In every category of disease, except for nutritional deficiencies, hypertension and cancer, a significantly larger percent of fallers have the disease than non-fallers (Pearson’s $X^2(1, N = 282,519) = 15.63 - 364.16, p < 0.000$).

Similarly, fallers are taking significantly more medications than non-fallers (Pearson’s $X^2(1, N = 282,519) = 12.85- 415.96, p < 0.000$) (Table 3). This is the case for every medication class except for anti-histamines and sex hormones. Approximately 39% of non-fallers are taking at least one medication, while 50% of fallers are taking at least one medication.

Un-adjusted odds ratios (OR) for the demographic variables are listed in Table 3. Every demographic variable measured, aside from receiving social services, is a significant predictor of falling (Table 3). All co-morbid diseases apart from nutritional deficiencies, hypertension and cancer are significant predictors of falling when evaluated individually (Table 3). The largest magnitudes of increased risk are found with seizures (OR: 2.68, 95% CI: 2.17, 3.31) and dementia (OR: 2.58, 95% CI: 2.32, 2.87). The OR’s for falling increase linearly with the number of co-morbid diseases diagnosed. All medication classes, aside from anti-histamines and sex hormones, are associated with an increase risk of falling when measured independently of all other risk factors (Table 3). The medications with the greatest risks are anti-parkinsonian agents (OR: 2.43, 95% CI:
2.00, 2.95) and anti-depressants (OR: 2.22, 95% CI: 2.05, 2.40). The risk of falling also increases linearly with the number of medications prescribed.

Column 5 of Table 3 lists the adjusted odds ratios associated with the demographic variables and medications. These odds ratios are calculated after adjusting for age, gender, SES, residence and all medication classes. After these adjustments, the only SES variable that is still associated with a significant risk of falling is having treaty status. The other demographic variables remained independent risk factors for falling. The magnitudes of risk associated with medication classes also changed after these adjustments. Visual impairment agents, diabetes agents, thyroid agents and anti-hypertensive agents are no longer related to an increase risk of falling.

Column 6 of Table 3 lists the results of the final logistic regression whereby the additional effects of co-morbid diseases are controlled for. After this adjustment, only eight of the seventeen medication classes remained to be significant predictors of an injurious fall. The largest magnitudes of increased risk are found with anti-parkinsonian agents (OR: 1.47, 95% CI: 1.15, 1.88), anti-depressants (OR: 1.38, 95% CI: 1.26, 1.51), and narcotic pain killers (OR: 1.36, 95% CI: 1.24, 1.48). Being female, older, having treaty status and living in a rural residence all remained significant predictors of injurious falls. Ten of the seventeen co-morbid diseases also remained positively associated with injurious falls (Table 3).
DISCUSSION

The results of this study demonstrate that falls are a serious health threat to older community dwelling persons. Thirty-five percent of fallers suffered injuries serious enough to require hospital admission. This rate is within the wide range of hospital admission rates reported in other studies. Other researchers have found that between 20-60% of injurious falls require hospital admissions (Kelly et al., 2003; Bell et al., 2000; Scott & Gallagher, 1999; Mathers & Weiss, 1998). The hospital admission rate in this study is higher than the hospitalization rates reported by two other Canadian studies (21.6% and 24.8%) (Kelly et al., 2003; Scott & Gallagher, 1999). The population examined in this study is larger and more comprehensive compared to these other two Canadian studies. Kelly et al. (2003) examined a smaller, primarily urban, sample of community dwelling persons. Scott & Gallagher (1999) calculated a different type of hospitalization rate which was based on hospital separation records, and it did not take into account the number of persons presenting because of an injurious fall.

The most common type of injury found in this study is fractures. They accounted for 56.4% of all injuries reported. These results are consistent with those found in other studies (Kelly et al., 2003; Bell et al., 2000; Johansson, 1998). Older persons have a higher risk of sustaining a fracture after a fall because of bone loss that occurs with advancing age (Francis, 2001). Older persons also have an increased risk of suffering from a fracture because of decreased bone strength and reduced padding on areas of their bodies that come in contact with the floor when they fall (O'Reilly, 1995). According to the descriptions of injuries in Table 1, the most common specific types of fractures are
'closed fracture of unspecified neck of femur', 'closed colles’ fracture’, and ‘closed fracture of distal end of radius’.

Fractures occurring in the neck of femur are the most commonly found fractures in this study (Table 1). They account for 24.5% of all fractures in this study. In a similar study examining injurious falls, neck of femur fractures accounted for 36% of all fractures (Bell et al., 2000). Aside from the immediate health threat that hip fractures pose, they can have detrimental long term effects on the health of older persons. Approximately one third of older persons suffering from a hip fracture die within one year (Keene et al., 1993; Gryfe et al., 1977). Of the persons that survive a hip fracture, between 40-70% are likely to move to a long term care facility (Wolinsky et al., 1997; Armstrong & Wallace, 1994). In a study by Wolinsky et al. (1997), the effect of hip fractures on functional status was measured and persons suffering from a hip fracture were significantly more likely to have a decrease in their functional abilities.

Lacerations, sprains and strains, and abrasions accounted for 31.7% of the injuries sustained. Berg et al. (1997), in a study of the circumstances and consequences of falling, also found similar rates of soft tissue damage in older persons. While these injuries do not cause immediate death or disability, they may still have devastating consequences in the future. Between 29-92% of older persons who have fallen experience a ‘fear of falling’ (Legters, 2002; Yardley & Smith, 2002). This psychological problem can cause persons to limit their activities of daily living, to avoid daily activities, and to develop depression or generalized anxiety (Yardley & Smith, 2002; Chandler et al., 1996; Tinetti et al., 1989). Tinetti and Williams (1997) studied the relationship between falls in older persons and placement in nursing homes and found
that falls are a strong predictor of nursing home placement in older community dwelling persons.

The majority of injurious falls that are reported in this study occurred at home (Table 2). Several other studies have also found that the majority of falls occur at home (Berg et al., 1997; Tideiksaar, 1992; Grisso et al., 1990). Tripping, slipping or stumbling accounted for 31.4% of the falls that occurred. In a prospective study by Campbell et al. (1990), trips or slips accounted for only 20% of falls. This difference may have arisen because the method of ascertaining fall information was different in the study by Campbell et al. (1990). The focus of their study was to determine the circumstances of falls so these researchers relied on detailed self reports by older persons to determine why falls occurred. The specifics of how falls occurred were not captured in the external cause of injury codes (E-codes) used in this study. This is particularly evident in the most commonly reported type of fall found in this study which is ‘other and unspecified accidental fall at home’. Accidental falls on stairs at home accounted for 8.8% of the falls. This is very similar to the results of a Swedish study in which 8% of all falls occurred on stairs (Johansson, 1998).

While a significant difference exists in the number of falls occurring each month, it is difficult to determine whether a trend exists (Figure 1). The months with the most number of falls are January (806), July (750), May (749), and December (746). It appears as though there is a peak in the number of falls in the winter over January and December and in the summer over May and July. However, February, which is also a very cold winter month has the lowest recorded number of falls (626) and June has the second lowest number of falls (673). Seasonal variations have been examined in several
studies, but the results have been inconsistent (Johansson, 1998; Niino et al., 1995; Campbell et al., 1990). It is difficult to compare seasonal variations between studies because the climates of the study regions may be quite diverse. Studies that took place in regions with similar climates to the province of Alberta have found that more falls occur in the winter months (Mamdani & Upshur, 2001; Johansson, 1998; Grisso et al., 1990). More falls may occur during the colder winter months because outdoor walking conditions may be more of a hazard, and indoor heating may not be adequate leading to mild hypothermia (Luukinen et al., 1996). It is also probable that more falls may occur in the summer because older persons may be performing more activities in these months that put them at a risk for falling.

During the study year, 604 (7.1%) fallers died compared to 8,742 (3.2%) non-fallers. These results indicate that the adverse effects of falling may include a decline in overall health and well-being over time. In 1995, Hendrich et al. outlined a probable scenario of how falling can indirectly lead to mortality over time. According to this scenario, fallers reduce their activities of daily living which causes a decrease in body system functioning and organ system failure which may lead to an increased susceptibility to infection and disease and eventually death (Hendrich et al., 1995). It is also probable that prior to the fall incident fallers were less healthy compared to non-fallers. The results of this study indicate that fallers were taking significantly more medications than non-fallers, and fallers had significantly more co-morbid diseases than non-fallers. Dunn et al. (1992) also found that a larger number of fallers died within the study year compared to non-fallers. The actual number of fallers that died may actually
be higher because persons that fell and died before ever making it to an emergency
department are not included in these numbers.

Older age has consistently been found to be a risk factor for falling (Stolze et al.,
2004; Bell et al., 2000; Rothchild et al., 2000; Campbell et al., 1995). Fallers in this
study are significantly older than non-fallers (Table 3). Age is a significant predictor of
falling even after taking in to account the effects of all other demographic variables, co-
morbid diseases, and medications used (OR 1.05, 95% CI 1.05, 1.05). This implies that
even after controlling for age related impairments (co-morbid diseases) and the effects of
medications used to treat the co-morbid diseases, the oldest older persons still have a
higher risk of falling compared to the younger elderly persons. This is most likely due to
the fact that older persons experience normal age related physiological impairments that
may not manifest as specific co-morbid diseases. Normal age related impairments
include: decreased skeletal muscle strength, decreased coordination, abnormal blood
pressure homeostasis, impaired gait and mobility, and auditory deficits (Buchner, 1997;

The results of this study indicate that being female is a significant risk factor for
falling (Table 3). Sixty-seven percent of fallers are females compared to only 55% of
non-fallers. Several other studies have also found that females fall more often than males
(O’Loughlin et al., 1993; Alexander et al., 1992; Ryynänen et al., 1991). When gender is
examined as a risk factor for falling, independently of all other risk factors, females have
a 65% greater chance of experiencing an injurious fall than males. Females may have an
increased risk because they live longer, they have a higher incidence of diseases known
to be risk factors for falling such as osteoporosis, and they are more likely to live alone
However, after controlling for all other demographic variables, medication use and co-morbid diseases, females still have a 48% greater chance of suffering from an injurious fall compared to males. This increased risk may be in part due to possible risk factors not measured in this study such as fitness level, ability to perform activities of daily living, and living alone (Langlois et al., 1995; Northridge et al., 1995; O’Loughlin et al., 1993).

The results of this study indicate that the socioeconomic status (SES) of fallers differs from that of non-fallers (Table 3). Fallers are more likely to be receiving a health care premium subsidy or to have treaty status, while non-fallers are more likely to be receiving social services or to have no subsidy. These SES measures are related to the premiums that older persons pay for their health care. Individuals receiving subsidy have part of their premiums covered by the provincial health care budget because they do not have the means to cover the full cost. Persons receiving social services are also receiving financial aid to help cover the cost of their premiums, but they are being subsidized by the Ministry of Social Services. The difference between these two types of subsidy is related to the reasons why these persons do not have the financial means to cover the cost of their premiums. In the context of this study, it is difficult to distinguish between these two forms of subsidy because the incomes of these persons are not known. Persons with treaty status have the entire premium covered by Health Canada, which is the part of the federal health budget. Individuals with no subsidy have the means to pay for their health premiums so they are not subsidized by any level of government.

Based on these measures of SES, the results of this study indicate that fallers may have a lower annual income compared to non-fallers. In a similar study by Kelly et al.
(2003), fallers were found to have a lower annual income compared to non-fallers. Dunn et al. (1992) measured total years of education as a proxy measure of SES. They did this because there appears to be an inverse relationship between education level and mortality in older persons (Dunn et al., 1992). These researchers found that fallers were more likely to have received fewer years of education compared to non-fallers. In a recent study by Pearson et al. (2004), the relationship between social deprivation, osteoporosis and falls was examined. These researchers found that women that were the most socially deprived had a significantly higher likelihood of having osteoporosis, which is a well documented risk factor for fall related fractures (Pearson et al., 2004; Wark, 1996). It is not entirely clear why persons with lower incomes are more likely to suffer from a fall related injury. It is possible that these people have a higher likelihood of having other risk factors for falls and fractures. Examples of risk factors for injurious falls that may be more prevalent in groups with lower incomes include: malnutrition, inadequate corrective eyewear or auditory equipment, and insufficient walking aids (Kristinsdottir et al., 2001; Maino, 1996; Maki et al., 1996; Vellas et al., 1992).

The results from the first logistic regression indicate that receiving subsidy and having treaty status are independent predictors of sustaining an injurious fall (Table 3). After controlling for all other demographic variables and medication use, only having treaty status remains a significant predictor of suffering from an injurious fall. In fact, in the final logistic regression, having treaty status has the largest magnitude of increased risk compared to all other variables (OR 2.03, 95% CI 1.67, 2.47). It is difficult to determine why having treaty status would be associated with an increased risk of
experiencing an injurious fall. This variable has not been measured in any other studies focusing on falls in older persons.

A significantly larger percent of fallers live in a rural area compared to non-fallers (Table 3). Living in a rural area is also significantly associated with sustaining an injurious fall, even after controlling for all other demographic variables, co-morbid diseases and medications. Postal codes were used to determine whether a person lives in a rural area or non-rural area. A zero in the second position of a person’s postal code signifies a rural postal code. There are no letter carriers in these areas, and residents must go to the postal office or to a corner postal box to receive their mail (du Plessis et al., 2001). The health status of older persons living in rural areas compared to urban areas has been studied by several researchers (Chevalley et al., 2002; Dansky et al., 1998; Clayton et al., 1994; Shapiro & Roos, 1984). Studies examining health differences between rural and urban older persons have found that these populations differ in their age structure, gender ratio, income, nutrition, hospitalizations rates, physician visits, and home health care use (Morgan et al., 2002; Vitolins et al., 2002; Andrews, 2001; Kinsella, 2001; Dansky et al., 1998; Shapiro & Roos, 1984).

Several studies have indicated that rural populations tend to be older than their urban counterparts (Coburn et al., 2003; Kinsella, 2001; Shapiro & Roos, 1984). This may be in part due to a trend known as ‘reverse migration’. According to this theory, while younger people tend to move to urban areas, older people tend to return to rural areas (Andrews, 2001; Kinsella, 2001). The net effect is that rural areas have a disproportionally higher percent of older persons compared to urban areas. It has also been observed that the gender ratio differs in these two areas in that more men are found
living in rural areas compared to urban areas (Andrews, 2001; Shapiro & Roos, 1984). Blazer et al. (1995) compared several socio-demographic variables between urban and rural older persons and found that rural residents have significantly lower incomes compared to urban residents. As mentioned earlier, having a lower income can be a risk factor for falling.

A study conducted in a rural community evaluating the quality of diets consumed by older persons revealed that none of the participants met the minimum dietary recommendations (Vitolins et al., 2002). Malnutrition has been linked to falls in older persons as a lack in essential nutrients can jeopardize posture stability and balance (Stolz et al., 2002; Vellas et al., 1991). Arcury et al. (1998) studied barriers to nutritional well-being in older rural residents and identified several reasons why these residents have a higher risk of malnutrition. The list of causes includes: transportation barriers, financial strains, and inadequate knowledge of dietary needs (Arcury et al., 1998).

Studies examining differences between rural and urban older people with regards to hospitalization rates, use of home health care services, and number of physician visits have found mixed results (Coburn et al., 2003; Schlenker et al., 2002; Dansky et al., 1998). Some studies indicate that older persons living in a rural setting use less home health services and have fewer physician visits (Coburn et al., 2003; Schlenker, 2002). Other studies have found that there are very few or no differences in these measures between rural and urban older persons (Dansky et al., 1998; Shapiro & Roos, 1984). Mixed results also exist regarding hospitalization rates between rural and urban older persons (Dansky et al., 1998; Blazer et al., 1995; Shapiro & Roos, 1989).
The results of this study indicate that fallers have significantly more co-morbid diseases than non-fallers. In fact, while 87.3% of fallers have at least one co-morbid disease only 79.4% of non-fallers have one or more co-morbid diseases. This implies that fallers have a greater number of risk factors for falling compared to non-fallers. The risk of falling increases linearly with the number of co-morbid diseases diagnosed. In fact, persons diagnosed with four or more co-morbidities have at minimum double the risk of falling compared to persons with no co-morbidities. Twelve percent of older persons in this entire population have four or more co-morbid diseases. Several studies have found that as the number of risk factors increases so does the risk of falling (Thapa et al., 1995; Tinetti & Speechley, 1989; Tinetti et al., 1988). The rational for this observation as explained by Tinetti et al. (1995) is that as older persons develop multiple diseases their ability to respond to challenges diminishes, thus making it more likely that they will fall. In a study by Thapa et al. (1995), as the number of risk factors increased from zero to five the risk of falling increased tenfold.

All co-morbid diseases measured in this study, except for cancer, nutritional deficiencies and hypertension, are associated with an increased risk for falling when measured independently of all other risk factors. The greatest risks are associated with dementia and seizures. Dementia is a well documented risk factor for falling (Asada et al., 1996; Mossey, 1985; Tinetti et al., 1988). Older persons suffering from dementia and dementia related disorders often have gait and balance problems (Mossey, 1985). Dementia can also cause slowed reaction time because of its effect on the central nervous system which may increase the likelihood of falling (Mossey, 1985). Persons suffering from seizures have a higher risk of falling because the majority of seizures result in a loss
of consciousness (Principles of Internal Medicine, 1992, pg. 139). Injuries resulting from seizures are common because during a seizure an individual’s protective reflexes fail to work (Principles of Internal Medicine, 1992, pg. 139).

In the final logistic model, after controlling for all demographic variables, all other co-morbidities and medications, ten of the seventeen co-morbid diseases remain significantly associated with an increased risk of falling. These co-morbid diseases include: incontinence or urinary tract disorders, Parkinson’s disease, dementia, depression/psychosis, neurosis, cerebrovascular disease, cardiovascular disease, diabetes, seizures and injury trauma. Seizures still have the strongest association with injurious falls. Several other studies have also mentioned these co-morbid diseases as risk factors for falling in older persons (Kelly et al., 2003; Shaw et al., 2003; Schwartz et al., 2002; Wallace et al., 2002; Tinetti et al., 1998; Lipsitz, 1989). These conditions are commonly associated with falling because they impair sensory, cognitive, neurologic, and musculoskeletal functioning (Tinetti & Speechley, 1989).

Urinary incontinence is commonly cited as a risk factor for falling (de Rekeneire et al., 2003; Lange, 1996; Lilley et al. 1995). Tinetti et al. (1995) studied the risk factors for urinary incontinence and falling together because they often occur concurrently in older persons making up a part of what these researchers refer to as ‘frail geriatric syndrome’. This condition may also be linked to an increased risk of falling because the associated urgency to eliminate may cause older persons to trip, slip or stumble. Older persons living with Parkinson’s disease often have impaired balance, coordination, muscle strength and gait, all of which are risk factors for falling (Stolze et al., 2004; Alexander, 1996; Rogers, 1996). Depression has been linked to falls in older persons
because it can cause distraction and psychomotor impairment (Mossey, 1985). Other researchers have found anxiety to be associated with an increased risk of falling by other researchers (Bosma, et al., 2004; Tinetti et al., 1995). Falling can actually result in a heightened degree of anxiety if persons develop a subsequent fear of falling. This may result in what Hindmarsh (1989) described as a cycle of events that begin with a fall which causes the person to become inactive because they fear they will fall again. This inactivity results in deconditioning further increasing the risk of falling (Vellas et al., 1992; Hindmarsh, 1989).

Cerebrovascular diseases can result in falls because they often cause a decline in cerebral blood flow (Lipsitz, 1989). Strokes are often cited as a risk factor for falling (Sherrington & Lord, 1998; Dunn et al., 1992; Vlahov, et al., 1990). Cardiovascular diseases such as postural hypotension, postprandial hypotension and syncope have been identified by several researchers as significant predictors of injurious falls in older persons (Miller et al., 2000; Aronow, 1995; Tinetti et al., 1994). Several studies have linked diabetes to an increased risk of falling (Schwartz et al., 2002; Wallace et al., 2002; Richardson & Ashton-Miller, 1996). This is probably due to the high prevalence of peripheral neuropathy associated with diabetes. This condition impedes somatosensory function often leading to imbalance and falls (Richardson & Aston-Miller, 1996). Injury trauma includes previous falls and several reports on injurious falls have found that falling within the previous year predicts subsequent falls (Krueger et al., 2001; Tinetti et al., 1995; Dunn et al., 1992).

Fifty percent of fallers are taking at least one medication compared to only 39% of non-fallers. As with co-morbid diseases, the risk of falling increases linearly with the
number of medications prescribed. Older persons taking three or more medications have, at minimum, a twofold increase in the risk of falling compared to persons not taking any medications. In this entire population of older persons 8.6% are taking three or more medications. It is often found that an increase in the number of risk factors is associated with an increase in the likelihood of falling (Thapa et al., 1995; Tinetti & Speechley, 1989; Tinetti et al., 1988). The rational for this occurring with medications is the same as it is for co-morbid diseases. As older persons take more medications, the adverse side effects of the medications compound, therefore increasing the likelihood that these people will suffer from an injurious fall.

When measured independently of all other risk factors, fifteen of the seventeen medication classes are associated with an increased risk of falling. The fifteen medication classes include: narcotic pain killers, NSAIDS, anti-convulsants, anti-depressants, anti-psychotics, sedatives/anxiolytics/hypnotics, anti-parkinsonian agents, electrolytic/water balance agents, visual impairment agents, anti-ulcer agents, corticosteroids, diabetes agents, thyroid agents, anti-coagulants, and anti-hypertensives. The two medications with the largest risks are anti-parkinsonian agents and anti-depressants. After controlling for all demographic variables and all other medications, visual impairment agents, diabetes agents, thyroid agents, and anti-hypertensive agents are no longer associated with an increased risk of falling.

When the effects of co-morbid diseases are controlled for as well as all demographic variables and all other medication classes, eight medication classes remain significant predictors of injurious falls. This implies that persons taking narcotic pain killers, anti-convulsants, anti-depressants, sedatives/anxiolytics/hypnotics, anti-
parkinsonian agents, electrolytic/water balance agents, corticosteroids, and anti-coagulants have an increased risk of suffering from an injurious fall that is solely associated with these medications. This risk is not related to their age, gender, SES, location, or any of the co-morbid diseases that they are taking the medications for. The greatest risks are associated with anti-parkinsonian agents, anti-depressants and narcotic pain killers. Persons taking anti-parkinsonian agents have a 47% greater chance of suffering from an injurious fall compared to persons not taking these medications. In a similar study by Kelly et al. (2003), anti-depressants, narcotic pain killers and anti-convulsants were also found to be significantly associated with an increased risk of sustaining an injurious fall after controlling for the underlying co-morbid diseases and several demographic variables.

Many of these medication classes have been found to be linked to falls in older persons by other researchers (Kelly et al., 2003; Tinetti, 2003; Thapa et al., 1998; Mustard & Mayer, 1997; Thapa et al., 1995). However, an extensive literature search revealed that aside from the recent study conducted by Kelly et al. (2003), no other study has examined so many medication classes and co-morbid diseases concurrently. Older persons taking narcotic pain killers have a 36% greater chance of suffering from an injurious fall compared to persons not taking these medications. In a study by Mustard and Mayer (1997), narcotics were also associated with a greater risk of suffering from a fall, but the associated risk diminished after co-morbid diseases were controlled for. It is biologically plausible that taking these medications could cause falls because they can cause sedation and postural instability (Hanlon et al., 1996). Anti-convulsant medications are not often studied as a risk factor for falling, but they are associated with
an increased risk in a few studies (Ensrud et al., 2002; Koski et al., 1996). Taking anti-convulsant medications has been linked to the development of osteoporosis, which is a commonly cited risk factor for sustaining an injury from falling (Lappe, 1998).

Anti-depressants are associated with a 38% greater chance of suffering from an injurious fall. These results are consistent with other studies examining this medication class (Ensrud et al., 2002; Thapa et al., 1998; Avorn, 1998; Ruthazer & Lipsitz, 1993). The process whereby these medications increase the risk of falling is multifaceted and it may include orthostatic hypotension, arrhythmias, sedation and confusion (Pacher & Ungvari, 2001). Several studies have examined the effects of sedatives/anxiolytics/hypnotics on the risk of falling (Ensrud et al., 2002; Pierfitte et al., 2001; Wang et al., 2001; Herings et al., 1995). These types of medications are often found to be associated with an increased risk of falling because they may cause impairments in cognition, memory, coordination and balance (Weiner et al., 1998; Shorr & Robin, 1994). Anti-parkinsonian agents are not often included in studies evaluating the risks of medications on falls. They are evaluated in a study by Kelly et al. (2003) whereby they were found to increase the likelihood of sustaining an injurious fall, but only prior to controlling for co-morbid diseases.

Electrolytic and water balance agents are associated with an increased risk of falling because they may cause fatigue, volume depletion, and orthostatic hypotension (Lange, 1996; Tinetti & Speechley, 1989). Corticosteroids are linked to an increased risk of falling because they have the ability to impair mobility (Hanlon et al., 1996). The results of this study indicate that persons taking corticosteroids have a 34% greater chance of suffering from an injurious fall. While anti-coagulants are not often studied in
relation to falls, the results of this study indicate that they are responsible for a 19% greater chance of falling. A study by Gurwitz et al. (2000) examined the incidence of adverse drug events and found that the second most common type of adverse event was a fall. These researchers found that the second most common drug implicated in these falls was anti-coagulants (Gurwitz et al., 2000).

Side effects of prescription medications are common in all age groups, but older persons are more susceptible to experiencing certain detrimental elements of medications because of differential pharmacokinetic and pharmacodynamic properties (Monane & Avorn, 1996). The distribution, metabolism and excretion of many medications are altered by normal age related changes (Monane & Avorn, 1996). Older persons are often not part of the clinical trials that test the safety and efficacy of medications (Avorn, 1998). This makes it difficult for care givers to accurately assess the negative side effects of certain medications that are commonly prescribed to older persons. As indicated in this study, older persons are often taking more than one medication and yet the interactions between medications are often not studied in older persons.

The key finding in this study is that older community dwelling persons taking medications from any one of eight medication classes have an increased chance of sustaining a fall related injury above and beyond the risk posed by the co-morbid disease for which the medications are being prescribed. To summarize, these medication classes include: narcotic pain killers, anti-convulsants, anti-depressants, sedatives/anxiolytics/hypnotics, anti-parkinsonian agents, electrolytic/water balance agents, corticosteroids, and anti-coagulants. Aside from a recent study by Kelly et al. (2003), no other study has evaluated the effects of this many medication classes on the
risk of sustaining an injurious fall while controlling for demographic variables and seventeen underlying co-morbid diseases. The majority of studies that have examined the risks posed by certain medications have not controlled for the co-morbid diseases for which the medications are being prescribed. This results in confounding by indication because it is impossible to determine whether it is the medications that are causing an increased risk of falling or whether it is the underlying co-morbid diseases. The current study is also the largest study of its kind with 282,519 community dwelling older persons included.
LIMITATIONS AND STRENGTHS

The limitations of this study are similar to those outlined by Kelly et al. (2003). The first of these limitations has to do with the fact that only falls related to emergency room visits are examined. This potentially excludes falls that occur in hospitals and other care settings that would not result in a visit to the emergency room. As noted earlier, this study is intended to examine only community-dwelling persons because older persons in long term care are considered to be a distinct population. This inclusion criterion also ignores all non-injurious falls and those falls that are treated at home. Another limitation of this study is that medication use is ascertained from prescription billings. This makes it impossible to determine precisely the amount and frequency of medication use in this population. This study also does not measure the amount of non-prescription medication use, alcohol or illicit drug use. Other studies that have examined the role of alcohol in falls have found that intoxication was responsible for between 4.2-10.0% of falls in older persons (Bell et al., 2000: Berry et al., 1981). The residence (rural and non-rural) of individuals was ascertained from postal codes, which may not accurately reflect growing populations because this system adds codes based on population density. Areas that were traditionally rural may have grown in population, but original postal codes may not be updated to reflect these changes. It is also possible that co-morbid diseases are misclassified or under reported because of the use of administrative health sources. The accuracy and reliability of this data depends on the consistency and precision of the medical professionals coding. Persons taking certain medication classes, or with certain co-morbid diseases, may be over represented in the emergency department because they
were advised to seek medical treatment in the event of any accident. The example of this used by Kelly et al. (2003) is that older persons taking anti-coagulants may have been advised to consult a physician if they are bleeding because there is a chance that uncontrolled blood loss may occur. This would result in persons taking these medications seeking care at the emergency department for falls that would normally not require medical attention.

There are also several strengths of this study. The study used the entire population of persons 66 years and older residing in the province of Alberta. This greatly minimizes any threats to external validity that may occur in studies that limit the study population to single nursing homes or small communities. The threat of selection biases in the Canadian health care system are minimal because the health care system is universally provided and all persons 65 years and older are covered by the Blue Cross Insurance Plan. An entire fiscal year of data is analyzed which minimizes any seasonal variability in falls in the regions, and it also allowed for the examination of seasonal variability. Measurement biases are also minimized because all of the data is collected from one uniform health care system. Complete case coverage will occur because all emergency departments in the province are included in the study.
CONCLUSION

This study examined risk factors associated with injurious falls requiring a visit to an emergency department in community dwelling older persons in the entire province of Alberta. The risk factors examined in this study include: age, gender, residence (rural and non-rural), SES, 17 medication classes and 17 co-morbid disease classes. Three series of logistic regression analysis were conducted. This study used a very large cohort of community dwelling persons (N = 282,519) which greatly reduces any threats to external validity. The results of this study are useful to persons interested in reducing the number of injurious falls occurring in this older population.

This study confirms that older age and being female are significant predictors of sustaining an injurious fall. These results indicate that high risk groups should be targeted for intervention. The results of this study indicate that even after controlling for SES, residence, 17 co-morbid diseases and 17 medication classes, being older and female are still independent predictors of falling. Fall prevention initiatives should place a high priority on reducing the number of falls occurring in these populations.

An interesting finding in this study is that older persons categorized as having treaty status are significantly more likely to suffer from an injurious fall compared to older person receiving subsidy, social services or no subsidy. The rational for this finding is not clear. Future research evaluating risk factors for falls should focus on determining why this particular group of older individuals has an increased risk of falling. Fall prevention initiatives should make an effort to provide this group of older persons with mechanisms to reduce their risk of falling.
Another risk factor for falling that emerged from this study is residing in a rural residence. While several studies have demonstrated that differences exist between rural and urban elderly, no other study has compared injurious falls in these populations. Further research examining the health differences between these populations is necessary to determine why older rural residents have a higher risk of sustaining an injurious fall compared to non-rural residents. This will make it possible to develop programs for reducing the number of falls in rural residents.

Ten co-morbid diseases remained positively associated with injurious falls after controlling for age, gender, SES, residence and 17 medication classes. Medical research has not yet determined how to prevent many of these co-morbid diseases. In these cases, fall prevention must focus on helping persons living with these conditions avoid falls. This study identified 10 co-morbid disease classes that should be acknowledged by fall prevention strategists as significant risk factors for falling.

Older community dwelling persons taking medications from any one of eight medication classes have an increased chance of sustaining a fall related injury above and beyond the risk posed by the co-morbid disease for which the medications are being prescribed. These medication classes include: narcotic pain killers, anti-convulsants, anti-depressants, sedatives, anti-parkinsonian agents, electrolytic agents, corticosteroids, and anti-coagulants. While it is not always feasible to discontinue the use of these medications, it is important for health care professionals to recognize that these medications may pose a very serious threat. Older persons taking these medications should be referred to a falls clinic to reduce the risk of falling associated with the use of these medications.
The results of this study also indicate that persons taking more than one type of medication have an increased risk of sustaining an injurious fall. Health care professionals should be made aware of the linear increase in risk associated with an increase in the number of medications prescribed. Older persons taking four or more types of medications should have their medical profiles reviewed to determine if it is possible to discontinue the use of any of the medications. Other researchers have also indicated that switching older persons to lower doses and shorter acting medications may reduce the risk of falling (Monane & Avorn, 1996; Tinetti et al., 1996; Herings et al., 1995). It is also recommended that older persons taking more than one type of medication for any one of the eight medication classes associated with an increase risk of falling be informed of strategies to prevent falls.


