The Epidemiology And Health Services Utilization Of Spinal Cord Injury In British Columbia Seniors

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ABSTRACT

This study describes the incidence and pattern of traumatic spinal cord injury and spinal fracture and examines health services utilization of spinal cord injury in seniors of British Columbia. The study period was April 1, 1991 to March 31, 2002. Complete health system data have been obtained for the seniors from the Centre for Health Services and Policy Research (CHSPR) at the University of British Columbia. Population denominators from BC Health Insurance Registry are used to construct annual age-sex specific rates of injury for the fiscal years 1991/92 through 2001/02. Mechanism of injury and level of spinal cord injury and spinal fracture will be quantified by using descriptive statistics. The annual incidence rate for spinal cord injury is 8.4 per hundred thousand populations whereas incidence rate for spinal fracture is 65.9 per hundred thousand populations. Falls were leading cause followed by motor vehicle collisions for both events. Following initial discharge, individuals with SCI had 1.72 more hospital visits and 2.44 more physician visits than the control group.

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CHAPTER ONE

Background

The population of British Columbia (BC) has been steadily getting older since the 1970s. This trend will continue well into the future as the elderly population increases both in number and in terms of the percentage of the population. Currently, BC is home for about 600,000 seniors, which will more than double by 2031 (Ministry of Health Services, 2004). BC has one of the most rapidly aging populations in Canada; the population of seniors has been growing at an average rate of 2% over the past 10 years, twice the rate of the BC general population. According to BC population projections, by the year 2031 the population of BC residents over the age of 65 will increase from 10.7 percent in 1981 to 23.5 per cent. The Elderly Dependence Ratio (EDR) is increasing form 16.9 in 1981 to 39.0 in 2031(BC STAT, 2005). EDR is the number of persons aged 65+ per 100 persons aged 18 to 64.

This shifting age structure of the province will have serious impact on both the economy and its social organizations. Health care is one of the areas particularly affected by changing age structure of the population (Ministry of Health Services, 2004). It is more likely that seniors need more medical services. As the life expectancy continues to rise, the number of people in the higher age ranges also increases creating more pressure on our health care system (Gerontology Research Centre, 2006). As the demand for health care increases, so does its cost.

All health issues related to seniors are becoming increasingly important. Fractures are a common injury that occurs to older Canadians as a result of trauma. A specific

fracture that can have serious and irreversible consequences is the fracture of the spinal column that involves spinal cord injury (SCI). While there have been several studies of the epidemiology of spinal cord trauma associated with spinal fractures, only a few detailed studies of traumatic SCI in this growing population have been done (Chen et al., 1997; Kiwerski, 1992; Villanueva, 2000; Watson, 1976). However, evidence indicates that though the rate of traumatic SCI among younger adults is fairly static, it is rising among older persons. Kannus et al (2000) reported that between 1970 and 1995 the incidence of traumatic SCI in Finland increased from 5 to 29/100,000 in females and 7 to 17/100,000 in males. The authors attributed this increase to the survival into old age; of a frailer and a more osteoporosis prone population than in the past. This hypothesis is supported by longitudinal surveillance of spinal compression fractures that has found a parallel increase in their incidence over time (Bengner, Johnell, & Redlund-Johnell, 1988). Because there is currently no cure for SCI, prevention efforts are important. In order to identify risk factors and implement targeted prevention strategies, it is necessary to determine the incidence, cause and circumstances that resulted in the injury.

Objectives

The goal of this study is to define and understand the epidemiology of SCI in seniors in a Canadian province. It is hypothesized that there has been an increase in the rate of SCI in the BC senior's population. The objectives of the study are:

1. To describe the epidemiology of SCI and spinal fracture in seniors.
2. To compare seniors receiving health services for spinal fracture to seniors suffering SCI.
3. To examine the health system utilization outcomes of seniors with SCI.

Definition of SCI

SCI is defined as the occurrence of an acute traumatic lesion of neural elements in the spinal canal (spinal cord and cauda equina) resulting in resolving or permanent neurological deficit. Cases were identified by the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9) diagnostic codes for SCI: 806.x (fracture of the vertebral column with SCI) or 952.x (SCI without evidence of spinal bone injury). The use of these two ICD-9 codes was based on the "Uniform Data Systems Cases Definition" recommended by the U.S. Centers for Disease Control and Prevention (Thurman, 2005). This definition has been used extensively in trauma registries and surveillance systems to identify SCI (Burke, Linden, Zhang, Maiste, & Shields, 2001; Dryden et al., 2003; O'Connor & Murray, 2006; Pickett, Simpson, Walker, & Brison, 2003; Price, Makintubee, Herndon, & Istre, 1994; Surkin, Gilbert, Harkey, Sniezek, & Currier, 2000).

Definition of spinal fracture

Spinal fracture is a fracture of any of the vertebra of the spine; the spine is the backbone that protects the spinal cord. Spinal column fracture without SCI will be identified by 805.x (fracture of the vertebral column without SCI). Associated ICD-9 External Cause of Injury Codes (E-codes) will be used to provide information on the causes of SCI and non-SCI fractures.

Burden of SCI

The impact of traumatic SCI can be catastrophic, especially when accompanied by permanent loss of motor and sensory function. SCI is usually associated with high mortality (DeVivo, Stover, & Black, 1992; Kraus, Franti, Borhani, & Riggins, 1979),

severe disability and handicap (Dijlers, Abela, Gans, & Gordon, 1995; McColl, 1999; Trieschmann, 1988), and prolonged and costly treatment and rehabilitation (Berkowitz, O'Leary, Kruse, & Harvey, 1998; DeVivo, Whiteneck, & Chales, 1995; DeVivo, 1997; Price et al., 1994; Tyroch, Davis, Kaups, & Lorenzo, 1997) .

SCI has a tremendous burden on the injured person, family and society at large. The burden can be classified in two major categories: economic and social.

Economic burden consists of two costs: direct and indirect. Direct cost is the cost which is incurred by the SCI person throughout the lifetime as a direct result of injury. It includes the cost of medical care, expenses on mobility, aids, devices and hygiene, special equipment, physiotherapy, rehabilitation, transportation, environmental modification and personal assistance. These costs are not borne by the person only but are also borne by family members as well as by government. One study carried out in Canada found that the direct cost for post one year of injury is $151,600 per person for complete SCI and $42,100 per person for incomplete SCI for post one year of injury. The study also estimated annual cost for subsequent 5 years for complete SCI $5400 and for incomplete SCI $2800 (Dryden, Saunders, Jacobs et al., 2005).

Indirect cost is the value of potential output that is lost as a result of any reduction or elimination of work or other activity due to SCI. These costs are quite sizable because of long term loss of productivity and depend on several factors such as age, injury level, educational level (DeVivo et al., 1995). Often indirect cost exceeds the direct cost- Berkowitz et al. (1998) estimated that 65% of the total cost is indirect cost and only 35 % is direct.

Gill (1999) stated that "*SCI is a devastating event that has not only physical but also social and physiological ramifications for both the injured person and the family. Within one brief moment, a person's word will be changed forever. Like a ripple on the water, one injured family member affects the entire family system*".

Social burden cannot be quantified because of its nature; it is intangible. After an injury, the person as well as the family members has to change their life styles and attitude, and adjust to the new environment. An injured person can have access to limited activities due to the injury. All these sudden changes are hard to cope with and the injured person might lose self esteem and suffer from depression. A person who suffers with SCI has a high risk of dependency, depression, divorce and drug addiction (Gill, 1999). Dryden et al. conducted a cohort study and followed injured person for six years after the injury, found that depression is common and 30% of the SCI persons developed high level of depression post-injury (Dryden, Saunders, Rowe et al., 2005).

CHAPTER TWO

Spinal cord injury in international context

Incidence rate

The annual incidence rate of SCI around the world shows high variation. It is estimated to be between 10.4 and 83 cases per millions population per year (Wyndaele & Wyndaele, 2006). Studies in the USA show incidence rates from 27 – 83 per million per year (Burke et al., 2001; Jackson, Dijkers, Devivo, & Poczatek, 2004; Meyers, Bisbee, & Winter, 1999; National Spinal Cord Injury Statistical Center, 2005; Price et al., 1994; Sekhon & Fehlings, 2001; Surkin et al., 2000; Warren, Moore, & Johnson, 1995). In European countries, incidence rates range from 10 to 25 per million per year (Martins, Freitas, Martins, Dartigues, & Barat, 1998; O'Connor & Murray, 2006; van Asbeck, Post, & Pangalila, 2000). Rates are in between 17 and 21 per million per year for underdeveloped countries (Chen, Chiu et al., 1997; Hoque, Grangeon, & Reed, 1999; Karacan et al., 2000; Maharaj, 1996; Solagberu, 2002; Umaru & Ahidjo, 2005). In Australia the incidence rate was reported to be 15 per million per year (O'Connor, 2002).

International rates show variations because of three reasons: case definitions of SCI, data gathering methods and the social structure of countries (Ackery, Tator, & Krassioukov, 2004; Dahlberg, Kotila, Leppanen, Kautiainen, & Alaranta, 2005; Wyndaele & Wyndaele, 2006). Higher incidence rates were observed if studies included deaths before hospitalization (Dryden et al., 2003;

Martins et al., 1998; Surkin et al., 1998) whereas the rate is lower in cases when only hospitalization is included.

Age

Most of the studies report the mean age of injury as between 30- 39 years (Burke et al., 2001; Catz et al., 2002; Dahlberg et al., 2005; Jackson et al., 2004; Karamehmetoglu et al., 1997; Nobunaga, Go, & Karunas, 1999; Sekhon & Fehlings, 2001). One study in Ireland reports the median age of 37 years and highest mean age 50.5 years (O'Connor & Murray, 2006). Mean age at injury in Japan is 48.5 years (Shingu, Ohama, Ikata, Katoh, & Akatsu, 1995), and that in Taiwan is 46.1 years (Chen & Lien, 1985).

A few studies have found that distribution of age at injury is bimodal with one peak at the age group of 20-30 years and at 65+ years (Burt, 2004; O'Connor & Murray, 2006; van Asbeck et al., 2000).

The model spinal cord injury system of the USA reported an increase in the age at the time of injury. The average age at time of the injury increased from 28.7 years between 1973 and 1979 to 37.6 years between 2000 and 2003. The study also found that the proportion of injured persons of age 65+ increased from 4.7% to 10.9% during the same period of time (Jackson et al., 2004), which was supported by other study findings (National Spinal Cord Injury Statistical Center, 2005).

Gender

There is a global trend of prevalence of SCI: all studies show that it is more prevalent in males than in females (Acton et al., 1993; Catz et al., 2002;

Chen, Chiu et al., 1997; Dahlberg et al., 2005; Dincer et al., 1992; Hart & Williams, 1994; Jackson et al., 2004; Karamehmetoglu et al., 1997; Kuptniratsaikul, 2003; Martins et al., 1998; National Spinal Cord Injury Statistical Center, 2005; Nobunaga et al., 1999; O'Connor, 2006; O'Connor & Murray, 2006; Sekhon & Fehlings, 2001; Surkin et al., 2000; van Asbeck et al., 2000). A majority of the studies show the male to female prevalence ratio ranged from 3.0: 1 to 5.5:1. The ratio is higher in developing countries than in developed countries (Hoque et al., 1999; Igun, Obekpa, Ugwu, & Nwadiaro, 1999)

Etiology

Most of the studies have identified motor vehicles crash (MVC) as a major cause of incidence. MVC accounts for more than 50% of the causes of injury followed by falls and others (Ackery et al., 2004; Burke et al., 2001; Calancie, Molano, & Broton, 2005; Cardenas, Hoffman, Kirshblum, & McKinley, 2004; Jackson et al., 2004; Krassioukov, Furlan, & Fehlings, 2003; National Spinal Cord Injury Statistical Center, 2005; Nobunaga et al., 1999; O'Connor, 2002; O'Connor & Murray, 2006; Sekhon & Fehlings, 2001; van Asbeck et al., 2000). This has been consistent for last 30 years (Jackson et al., 2004). But the Model SCI system reports that the violence related SCI as second leading cause (Surkin et al., 2000). In some cases, falls from a height was reported as a main cause of the SCI (Hoque et al., 1999).

Several trends were identified in the etiology to SCI. In developed countries MVC was the leading cause of SCI followed by falls whereas in developing countries falls are the major cause of SCI followed by MVC and

violence (Ackery et al., 2004). MVC is the major cause of injury in younger population while falls is a major cause for older populations (Sekhon & Fehlings, 2001). As the percentage of older population is increasing rapidly, the number of falls is increasing, leading to a greater burden from falls related morbidity in the overall population.

Level of injury

Majority of the studies show that more than 50% of injuries occur at the cervical level (Burke et al., 2001; Burt, 2004; Hoque et al., 1999; Jackson et al., 2004; National Spinal Cord Injury Statistical Center, 2005; Nobunaga et al., 1999; O'Connor & Murray, 2006; Sekhon & Fehlings, 2001) and an increase in cervical level injuries has been observed over last 30 years.

Health services utilization

The epidemiologic reports published on spinal cord injury suggest that risks of both hospitalization and prolonged hospital stays for this component of severely disabled population are both relatively high. Re-hospitalizations of SCI patients results in high financial cost and workload in the hospital (Meyers et al., 1989; Paker et al., 2006). The risk of hospitalization was associated with both levels of injury and elapsed time, shorter time associated with higher risk (Cardenas et al., 2004; Davidoff et al., 1990; Ivie & DeVivo, 1994; Savic, Short, Weitzenkamp, Charlifue, & Gardner, 2000). Numbers of re-hospitalizations as well as the length of stay decreases while injury years increase (Ivie & DeVivo, 1994; Johnson, Gerhart, McCray, Menconi, & Whiteneck, 1998; Samsa, Landsman, & Hamilton, 1996). There is a high rate of re-hospitalization in the

first four years after the injury (Middleton, Lim, Taylor, Soden, & Rutkowski, 2004).

Frequent visits to the hospital and long stay at the hospital affect the person's family and social life. Disability followed by SCI can diminish the individual's personal control over his or her life and reliance on others. Understanding of hospital utilization pattern of SCI patients is important for further resources allocation, planning of health services and rehabilitation and targeting preventing measures.

Re-hospitalization

People with traumatic SCI are more than twice as likely to experience re-hospitalization for medical complication as the general population throughout their lifetime (Dryden et al., 2004; Johnson et al., 1998; Savic et al., 2000). Studies have shown that re-hospitalization rate ranges from 19 to 60 % (Ackery et al., 2004; Cardenas et al., 2004; Davidoff et al., 1990; Dryden et al., 2004; Ivie & DeVivo, 1994; Johnson et al., 1998; Krassioukov et al., 2003; Middleton et al., 2004; Noreau, Proulx, Gagnon, Drolet, & Laramee, 2000; Paker et al., 2006; Samsa, Patrick, & Feussner, 1993; Savic et al., 2000). In Canada Dryden et al. (2004) found that 57.3% of SCI persons were re-hospitalized for medical complications (Dryden et al., 2004).

Etiology of re-hospitalization

The primary reasons for re-hospitalizations are urinary tract infection, decubitus ulcers, respiratory complication and psychological disorders (Ackery et al., 2004; Anson & Shepherd, 1996; Cardenas et al., 2004; Davidoff et al., 1990;

Dryden et al., 2004; Johnson et al., 1998; Krassioukov et al., 2003; Paker et al., 2006; Savic et al., 2000). Respiratory complications cause proportionately more hospitalizations during initial years where as urinary tract and psychosocial problem cause proportionately more hospitalizations in later years.

Physician services

Persons with SCI have high rate of visits to family physicians, internists and psychiatrists. Main reasons for visits to physician are ill-defined symptoms, injuries, disorder of the genitourinary system and mental disorders (Dryden et al., 2004; Krassioukov et al., 2003).

Spinal cord injury in Canada

There have been a few studies on epidemiology of spinal cord injuries in Canada. (Table 1) Most of the studies were conducted in Ontario (Botterell et al., 1975; Krassioukov et al., 2003; G. E. Pickett, Campos-Benitez, Keller, & Duggal, 2006; W. Pickett et al., 2003; Tator & Edmonds, 1979; Tator, Duncan, Edmonds, Lapczak, & Andrews, 1993). One study was conducted on spinal fracture in Manitoba (Hu, Mustard, & Burns, 1996) and one in Alberta (Dryden et al., 2003).

Information on the epidemiology of SCI comes from four sources: chart review (Botterell et al., 1975; Krassioukov et al., 2003; Pickett et al., 2006; Tan, Don, & Balachandran, 1979; Tator et al., 1993), questionnaires (Canadian Paraplegic Association,), administrative datasets (Dryden et al., 2003; Hu et al., 1996), and trauma registries (Pickett et al., 2003).

A review of total care received by acute spinal cord injury patients in Ontario during 1969 and 1970 was conducted to propose a new model of care for the SCI patients

(Botterell et al., 1975). This study reviewed in detail hospital services and rehabilitation costs, secondary complications and geographical distribution of injury.

Table 1

Summary of Studies on the Epidemiology of Spinal Cord Injury (SCI) in Canada

Author, date	Study Population	Data Source	Study period	No of cases	Annual Incidence Rate/ Million	Male: female ratio	Age
Botterll, 1975	Admissions to hospital in Ontario	Chart review	1969/70	224	14 -16	4.6:1	Not given
Tator, 1979	Admissions to two hospitals in Ontario	Chart review	1948/73	358	Not given	4.5:1	Median 32 years
Tator, 1993	Admissions to SCI unit in Toronto	Chart review	1974/81	201	Not given	3.9:1	Mean 34.5 years
Hu, 1996	Admissions to hospitals in Manitoba	Administ rative data	Apr 1981 – Mar 1984	122	40	Not given	Not given
Candian Paraplegic Asosciation, 1997	Survey of Canadian injured for at least 5 years	Question naires	1995	966	35	4.3:1	Not given
Pickett, 2003	Admissions to hospitals in Ontario	Ontario trauma registry	1994/95 – 1998/99	2,385	46 (1994-95) 37 (1998-99)	Not given	Not given
Dryden, 2003	Population based study form the province of Alberta	Administ rative dataset	Apr 1997 – Mar 2000	450	52.5	2.52:1	Median 35 Years
Krassioukov 2003	Admissions to Toronto Western Hospital acute SCI unit	Chart review	Jan1997 – Jun 2001	58	Not given	2.9:1	55.4 years
Pickett, 2006	London health Sciences Centre Computerized medical records	Chart review	1998 - 2000	151	42.4 (age 15-64) 51.4 (age 65+)	Not given	Not given

Detailed information for each patient was compiled by using questionnaires from the day of injury to day of discharge from rehabilitation program into to the community or to a chronic care unit. The study estimated incidence rates of 15.9 per million for 1969 and 13.6 per million for 1970. The incidence rate was higher in males than females; and the ratio of male to female injury was 4.6: 1. The causes of SCI are MVC (43.3%) followed by industrial incidents (17.8%). The study also revealed that most of the patients returned home after hospitalization. Finally, the authors recommended a new model of treatment for SCI patients.

Another study by Tator & Edmonds, (1979) looked at the epidemiological aspects of spinal cord injury in two hospitals in Toronto to analyze the relationship between the age of the patients and the causes of injury. The study concluded that the most frequent causes of injury were MVC (34.4%) in young adults, incidents at work (29.3%) in young and middle aged persons, sports recreational injuries (15.4%) in young adults and falls (9.8%) in seniors.

Tator et al. looked at the changes in acute spinal cord injury during 1947 to 1981 in Ontario. The study compared patients injured between (a) 1947 and 1973 and (b) between 1974 and 1981(Tator et al., 1993). The study results show that there are some epidemiological changes in injury such as:

i. A slight increase in the number of females' injuries in the recent years, which decreased male to female ratio from 4.5:1 (Tator & Edmonds, 1979) to 3.9:1.

ii. An increase in injury in younger patients in the recent study.

iii. Few work related injuries and

iv. An increase in sports and recreational incidents with diving the most frequent cause of injury.

According to the study, major cause of injury is motor vehicles followed by work and sport recreational. There is a decreasing trend in work related injuries. Most of the injuries occurred near to the Toronto metro and the cervical injuries had increased slightly compared to previous study (Tator & Edmonds, 1979).

There is one cross sectional observational study conducted by (Hu et al., 1996) in Manitoba to identify incidence of spinal fractures within a complete population using an administrative data from Manitoba Health Services Insurance Plan database of all patients who have spinal fracture between April 1, 1981 and March 31, 1984. The annual incidence rate of spinal fracture was found 64 per 100,000 per year. Two peaks of incidence was observed; one in young men and second on elderly women. Accidental falls were major cause of the fractures and became more prevalent as age increased. The mean length of hospital stay was 38.5 days with standard deviation (SD) of 83 days.

The Paraplegia Association of Canada surveyed 966 Canadians who has been injured for at least 5 years and found the annual incidence rate to be 35 per million. The age ratio of male to female was 4.3:1, 80% of the patients were injured between ages of 15 – 34 years, 47.4% have quadriplegia and 46.7% have paraplegia type of injury (Canadian Paraplegic Association).

Pickett et al reviewed 2385 hospital admissions due to SCI during April 1, 1994 through March 31, 1999 from the Ontario trauma registry. The goal of the study was to identify groups at increased risk and provide insight into priorities for research and prevention. The study found that annual age standardized rates declined from 46.2 /

million in 1994/95 to 37.2 / million in 1998/99. Study analysis showed that male rates have been declining but female rates remained stable, highest rate were experienced by 70 years and older, modest peak among men of 20-29 years of age. The unintentional falls and transport incidents were leading cause of the injury. The median length of stay at hospital was 10 days with an IQR of 3-24 days (Pickett et al., 2003).

Dryden et al examined 450 SCI patients over three years period (1997 - 2000) from data combined from three sources: Alberta Ministry of health and wellness, the Alberta trauma registry and death reports from the office of the medical examiners. Persons with injury had median age of 35 years, and male-to female ratio of 2.5: 1. The authors calculated mean incidence rate of SCI of 52.5 per million. Incidence rate is higher in rural areas (72.6/million) compared to urban (32.0/million). Motor vehicle collision was major cause (56.4%) of injury, with the highest occurrence in the age group of 15 to 29; where as falls (19.1%) was the second major cause of SCI. The authors suggested that the prevention efforts should focus on males of all ages, female of age 19-29 years, with special emphasis on rural residents. In addition, fall prevention strategies should be targeted to seniors (Dryden et al., 2003).

A study conducted by Krassioukov et al. (2003) in Toronto with retrospective chart review of all 58 patients admitted to Toronto Western Hospital from January 1998 to December 2000. The mean age of SCI patients was 53.6 years, with half of the patients were 60 years or older. The authors found that falls were the leading cause of the injury (47%). The study was focused on the incidence of secondary complications in seniors and found pneumonia, urinary tract-infection, pressure sores and depression are the major

secondary complication in the SCI. The authors suggested a comprehensive care for seniors to minimize the complication due to age factor and improve their quality of life.

A recent retrospective review (Pickett et al., 2006) of all patients admitted to London Health Sciences Centre, Ontario with traumatic SCI between January 1997 and June 2001 to determine whether the elderly should be the focus for prevention efforts. There were 151 patients with mean age of 42.2 (SD 20.9) and male to female ratio of 3:1 in the study. The annual incidence rate was 42.4 per million for adults aged 15-64 years and 51.4 per million for 65 years and older. MVC (35%) was a major cause of SCI followed by falls (31%). The authors concluded that epidemiology of SCI is changing. People at highest risk of injury now include the elderly population too. The major cause of injury for the elderly population is falls.

None of these Canadian studies have focused on the older adult population, and as the longest period analyzed is five years, no temporal trends in SCI to seniors have been reported. Further, no studies have been conducted focusing on the specific health utilization issues of seniors with SCI.

This study presents the results of population based study from province of British Columbia, Canada. The study population includes seniors who had SCI or spinal fracture. The goal of the study was to fully describe the epidemiology of SCI and spinal fracture and health services utilization of the persons with SCI. Specific questions addressed were: 1) What was the incidence of SCI and spinal fracture between April 1, 1991 and March 31, 2002?; 2) what are the occurrences of SCI and spinal fracture by age, sex, level of injury and causes?: and 3) What are the pattern of health services utilization for person with SCI?

CHAPTER THREE

Study location

British Columbia (BC) is a pacific coast province in western Canada, the third largest province in area and population. More than fifty percent of the population lives in the south western corner of the province in an area of approximately 950, 000 square kilometers. In 2006, the population was estimated as 4.3 million, 14% of which was seniors. The population of the people aged 65 and over was substantially greater in BC compared to Canada as a whole (Gerontology Research Centre, 2006). The reasons behind this are mild climate, short winter and beautiful scenery, which attracts seniors to spend their retirement years in BC.

Data sources

Complete health system data have been obtained for the BC population aged 65 and older for an 11 year period beginning April 1, 1991 and ending March 31, 2002. These data include all hospitalizations, physician contacts, prescriptions, continuing/home care admissions, vital statistics, and causes of death linkable across all years of study. BC is a prime location for this research as administrative health data is readily available for a proportionally large population of seniors. A case was defined the ICD-9 diagnostic codes for SCI: 806.x or 952.x and spinal fracture identified by 805.x (fracture of the vertebral column without SCI). Cause of hospitalization was obtained from the diagnosis code of hospital separation data set. Up to 16 diagnoses were available using the ICD-9 codes to describe the nature and cause of a hospital admission. The

principal diagnosis for the patient's stay at hospital was used to designate to SCI and spinal fracture.

Hospital separation data consists of information of all separations (discharges, transfers and deaths) of in-patients and day surgery patients from acute care hospitals in BC. The hospital separation dataset used in this study comes from the British Columbia Linked Health Database (BCLHD). BCLHD is a health data resource for research purposes created and maintained by University of British Columbia's Centre for Health Services and Policy Research (CHSPR). CHSPR maintains computerized records of all physician visits, hospital discharges, deaths, births, extended health care, drug uses and worker's compensation claims in British Columbia from 1985 (Chamberlayne et al., 1998). The datasets are linked to a central registry file of all people in the province covered by the BC Medical Services Plan (MSP). This resource covers virtually all medical services encountered in these categories for almost every British Columbian during years of coverage. The reliability and utility of administrative health care data have been established for health and injury studies.

Moreover, these data have been used in a number of medication use and injury studies in Canada suggesting acceptance by the research community as legitimate data sources.

Records from four databases were used to compile information on individual encounters with the British Columbian health care system during the study period. The data sources were:

1. British Columbia Health Insurance Registry: This database contains demographic information about BC residents registered with the health care system.
2. Canadian Institute for Health Information (CIHI) Hospital Inpatient Database: Records of all hospitalizations in BC are collected in the inpatient database. Separation abstracts are completed for each admission by trained medical records technologists and contain admission and discharge dates, up to 16 ICD-9 diagnostic codes, up to 10 ICD-9 procedure codes, as well as associated ICD-9 E-codes.
3. Medical Services Plan Payment File: This is a database of fee-for-service claims submitted by physicians and other health service providers (e.g., optometrists and chiropractors) in BC for the provision of medically required services. For the purposes of this research only physician claims are reported and include medical, surgical, obstetric, anesthesia and diagnostic services. A three digit ICD-9 code is assigned to each medical encounter.
4. British Columbia Vital Statistics: This file includes the main cause of death for BC residents. It includes a three digit ICD-9 diagnostic code as well an ICD-9 External Cause of Injury Code (E-code).

Inclusion criteria

The inclusion criteria for the study were: 1) Spinal cord injuries or spinal fracture between April 1, 1991 to March 31, 2002 2) BC residency at the time of injury and 3)

65+ years of age at the time of injury. For health services utilization case were defined as spinal injuries during April 1, 1991 to March 31, 1994.

Exclusion criteria

The second injury was excluded if the person injured themselves within six months- the first injury was included.

Control group

For comparison with general population, each SCI case for health services utilization case was matched to five randomly selected from Medical Services Plan Payment File. Controls were matched with SCI cases for age, gender, and region of residence. Individuals were not eligible if they sustained SCI at any time during follow-up period.

Follow-up period

Data on health care utilization were collected form data of injury for each SCI cases to 7 years post injury. For each individual in the control group, data were collected from date of injury of their respective cases to 7 years after the date injury.

The reason for admission was determined by principal diagnosis for each hospitalization. For physician visits, the reason for the visit was determined by first diagnostic code for each physician claim. Reasons for admissions or visit were grouped into diagnostic categories according to ICD-9-CM.

A numbers of secondary complications were selected for examination. The presence of a complication was determined by ICD-9-CM code for the condition in any diagnostic field Medical Services Plan Payment File.

Data analyses

Objective 1: The epidemiology of spinal cord injury and spinal fracture will be described. The primary analysis will describe temporal trends, gender differences, cause of spinal cord injury and spinal fracture.

Population denominators from the BC Health Insurance Registry will be used to construct annual age-gender specific rates of injury for the fiscal years 1991/92 through 2001/02 (11 years in total). Geriatric SCI prevention efforts require information on mechanism (i.e. fall, MVC, etc). The database will be rigorously interrogated to obtain the most highly specific data possible regarding the injury mechanisms stratified by both SCI in the presence and in the absence of bony canal fracture. Mechanisms of injury and level of spinal cord injury will be quantified using frequency tables and cross tabulations. Continuous variables such as age will be presented as means and standard deviations. Statistical analyses included Student's *t* test and chi-square testing, where appropriate (alpha level set at .05).

Objective 2: Health system utilization outcomes of seniors with spinal cord injury will be examined. Those with spinal column fracture will be compared to age, gender and co-morbidity matched controls to estimate the health impact of spinal column fracture.

A case-comparison design will be used to accomplish this objective. Data on health care utilization will be collected from date of injury for each SCI case to eight years post-injury. Cases will be selected from the fiscal years 1991/92 through 1994/95 (three years). For comparison with the general seniors' population, each SCI case will be matched to five comparison subjects randomly selected from the BC Health Insurance Registry (individuals must be continuously enrolled during the study period to be eligible

for selection). Comparison subjects will be matched with SCI cases for age, gender and health service delivery area (to control for distance and access to health services). For each individual in the control group, data will be collected from the date of injury of their respective matched cases to seven years post date of injury. For the case and comparison groups, the types of diagnoses as well as the numbers of services provided over the study period will be quantified.

Objective 3: Seniors diagnosed with spinal fracture but no spinal cord injury will be compared to seniors suffering spinal cord injury. The primary comparison for this objective will be to determine if similar mechanisms result in both types of injury. Cross tabulations of injury causes will be produced to examine the patterns of injury. Characteristics of injured seniors such as age, gender, health region, and socio-economic status will also be compared. Temporal trending of spinal fracture with no spinal cord injury will also be conducted. Population denominators from the BC Health Insurance Registry will be used to construct annual age-gender specific rates of injury for the fiscal years 1991/92 through 2001/02 (11 years in total). Statistical analyses included Student's *t* test and chi-square testing, where appropriate (alpha level set at .05).

CHAPTER FOUR

Spinal cord injury

Between 1991-92 and 2001-02, there were 441 cases of spinal cord injury of which 262 (59.41%) were male. Overall mean age at injury was 76.15 years; male mean age was 74.77 years (SD = 6.91) whereas female mean age was 78.16 Years (SD = 7.90). The mean incidence rate was 8.48 / 100,000 population per year (95% confidence interval (CI 7.69, 9.27). During the same period 283 injuries were by the cause of falls, which is about 65% of the total incidence. Table 2 also showed that about the half of the injuries were at cervical level.

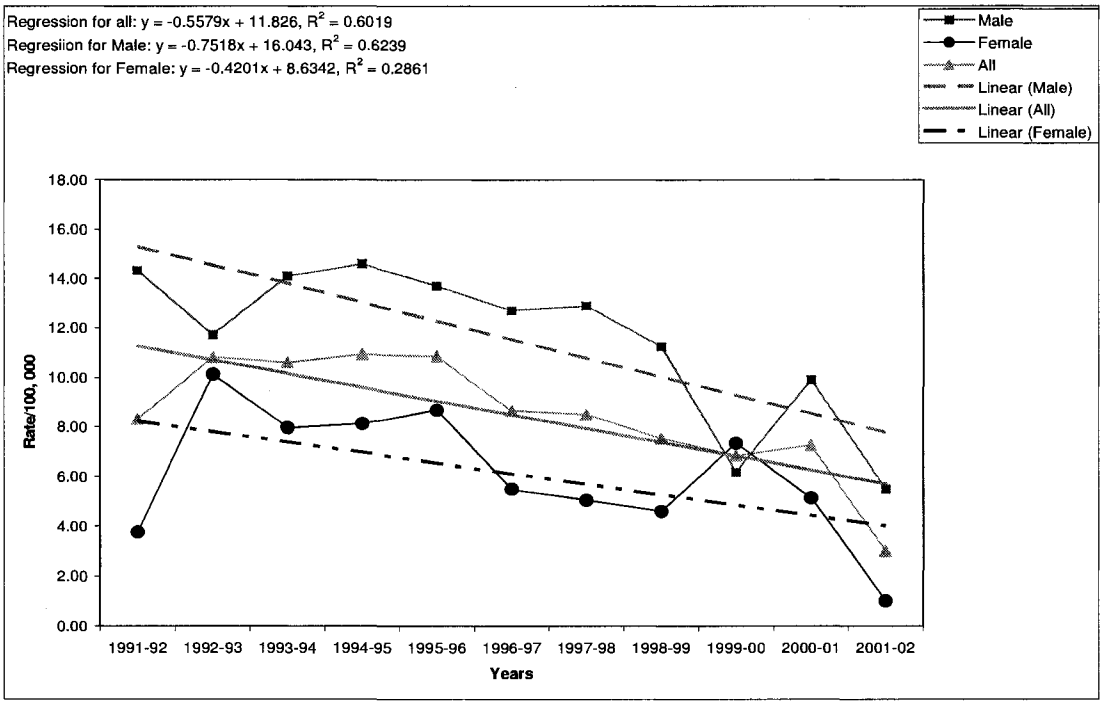

Figure1. Annual incidence rates for SCI by gender.

Figure 1 shows the annual incidence rates, males had higher incidence rates than female. Incidence rates shows decreasing for both genders. There was a significant decline in incidence rates over the study period.

Table 2

Demographics of Spinal Cord Injury in Seniors in BC, Canada, 1991-2002 (N= 441)

Years	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	Total
Number of cases	35	47	47	50	51	42	42	38	35	38	16	441
Annual Incidence per 100,000/Year	8.32	10.82	10.60	10.93	10.86	8.64	8.49	7.53	6.82	7.25	3.00	8.48
95 % Confidence Interval	5.56, 11.08	7.73, 13.91	7.57, 13.63	7.90, 13.96	7.88, 13.84	6.03, 11.25	5.92, 11.06	5.14, 9.92	4.56, 9.08	4.94, 9.56	1.53, 4.47	7.69, 9.27
Gender (Male (%))	26 (74.3%)	22 (43.5%)	27 (58.7%)	29 (57.1%)	28 (56.0%)	27 (64.3%)	28 (66.7%)	25 (65.8%)	14 (40.5%)	23 (62.2%)	13 (81.3%)	262 (59.4%)
Etiology (no. (%))												
Falls	20 (57.1%)	31 (65.9%)	27 (57.4%)	35 (70.0%)	31 (60.8%)	33 (78.6%)	28 (66.7%)	24 (63.2%)	25 (71.4%)	26 (70.3%)	4 (25.0%)	283 (64.2%)
Motor Vehicle Collision (MVC)	13 (37.1%)	10 (21.3%)	15 (31.9%)	12 (24.0%)	16 (31.8%)	9 (21.4%)	7 (16.7%)	11 (28.9%)	9 (25.7%)	10 (26.3%)	8 (50.0%)	120 (27.2%)
Others	2 (5.7%)	6 (12.8%)	5 (10.6%)	3 (6.0%)	4 (7.8%)	0 (0.0%)	7 (16.7%)	3 (7.9%)	1 (2.8%)	2 (5.3%)	4 (25.0%)	38 (8.6%)
Level (no (%))												
Cervical	22 (62.9%)	19 (40.4%)	24 (51.1%)	27 (54.0%)	27 (52.9%)	22 (52.4%)	18 (42.8%)	19 (50.0%)	14 (40.0%)	26 (68.4%)	14 (87.5%)	232 (52.6%)
Dorsal	8 (22.9%)	12 (25.5%)	12 (25.5%)	9 (18.0%)	7 (13.7%)	10 (23.8%)	11 (26.2%)	8 (21.0%)	4 (11.4%)	5 (13.2%)	0 (0.0%)	86 (19.5%)
Lumbar	3 (8.6%)	13 (27.7%)	8 (17.0%)	8 (16.0%)	10 (19.2%)	9 (21.4%)	10 (23.8%)	7 (18.4%)	9 (25.7%)	4 (10.5%)	0 (0.0%)	81 (18.4%)
Sacrum	2 (5.7%)	1 (2.1%)	0 (0.0%)	0 (0.0%)	1 (2.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.9%)	2 (5.3%)	0 (0.0%)	7 (1.6%)
Unspecified	0 (0.0%)	2 (4.3%)	3 (6.4%)	6 (12.0%)	6 (11.8%)	1 (2.4%)	3 (7.2%)	4 (10.5%)	7 (20.0%)	1 (2.6%)	1 (12.5%)	35 (7.9%)

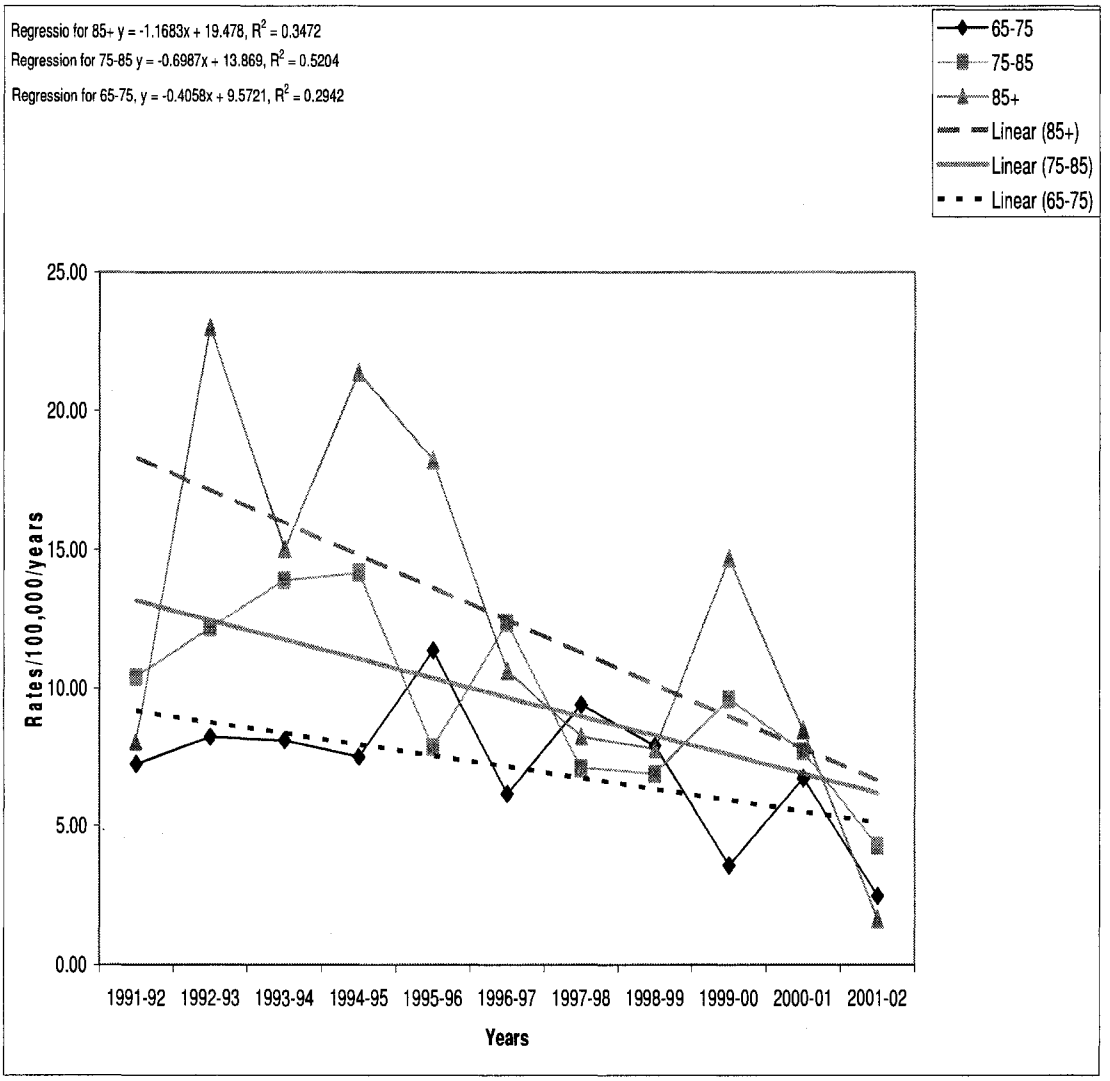

Figure 2. Annual age specific incidence rates for SCI.

Figure 2 indicates that incidence rates were higher in the 85+ age group. All age group shows decreasing trends. Greatest decline is observed for the oldest age group.

When stratified by gender there were no specific trends in male incidence rates with respect to age. Female incidence rate show relationship between age and incidence rates, it is higher in the age group 85+ almost every year. Figures are in Appendix A.

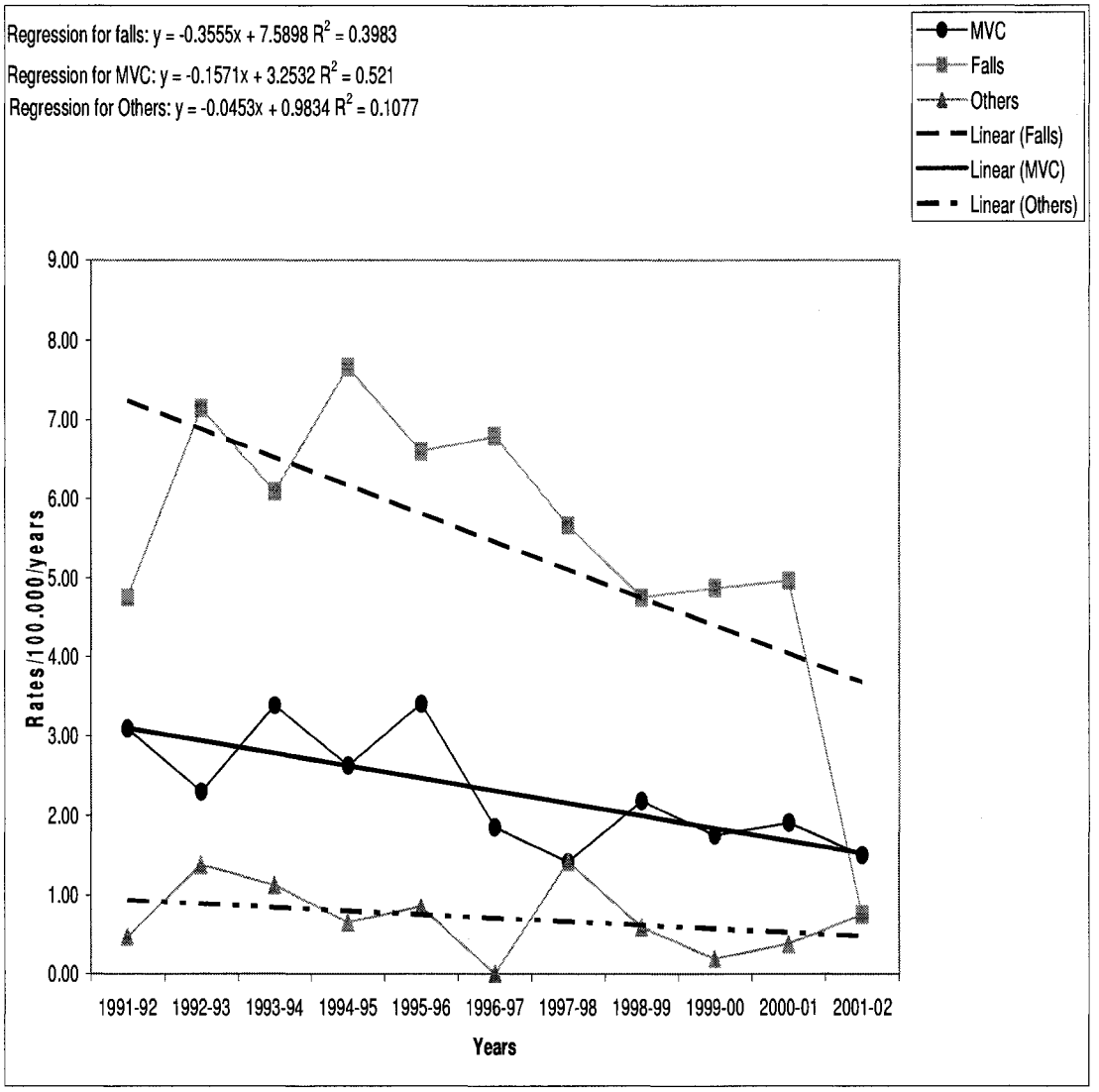

Figure 3. Annual incidence rates for SCI by etiology.

Falls were the dominant mechanism of injury during the study period. There was a sudden drop in incidence for falls in year 2001 - 02, this might be because of changes in ICD 9 to ICD 10 on 2001(Figure 3). Regression equations shows that there is high drop in rates of the falls of the three categories. Similar trends were observed for both genders (see Appendix B)

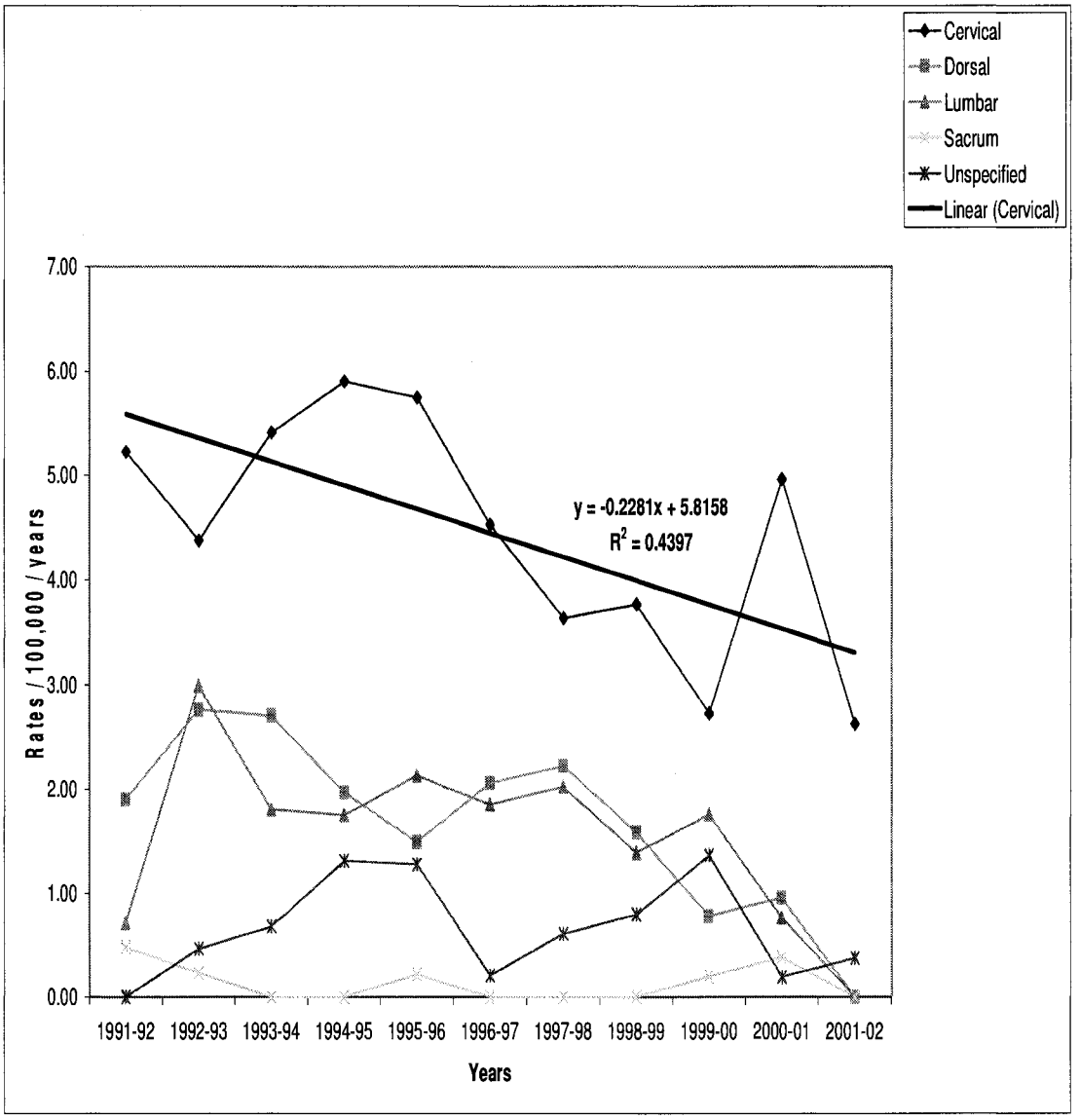

Figure 4. Annual incidence rates for level of injury of SCI.

Incidence rates for cervical level injury were high for all years and there is a decreasing trend. Incidence rates for dorsal and lumbar shows similar trends over study years (Figure 4). In contract sacrum and unspecified categories shows no pattern.

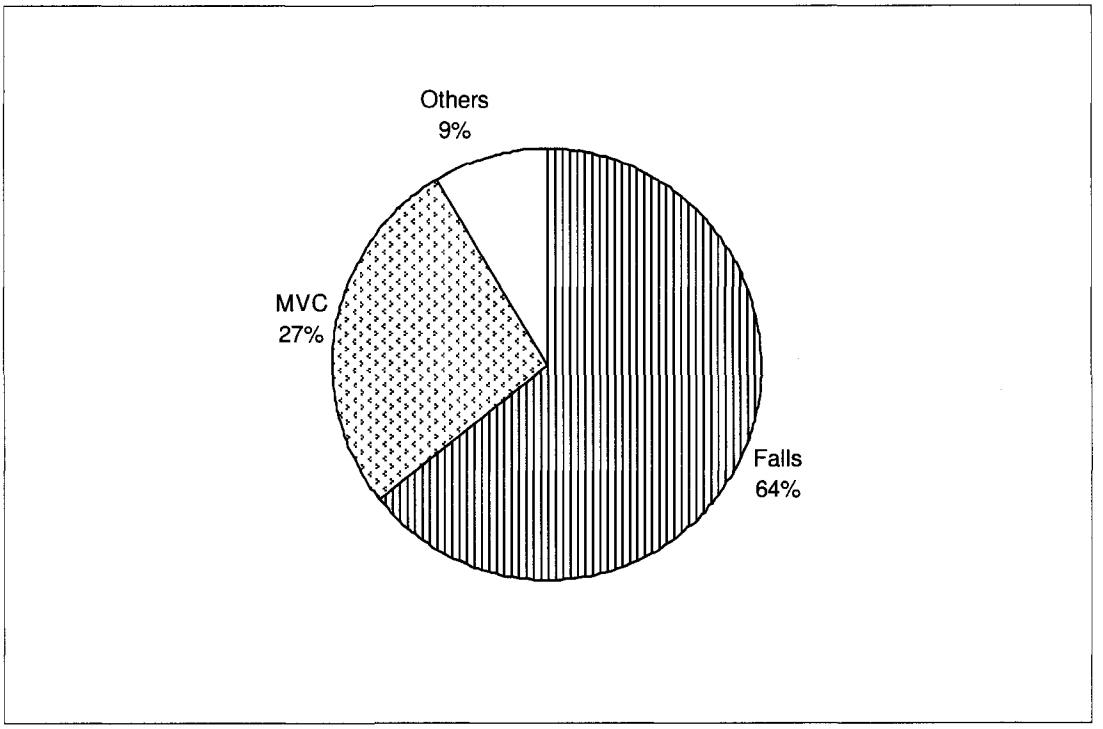

Figure 5. Etiology of SCI.

Overall, falls were the leading cause of spinal cord injury in BC for seniors between 1991 and 2002 (64.2%), followed by MVC (27.2%). Table 3 indicates that the same etiological trends were found in both genders but the falls incidence was higher in females (70.4%) than the males (59.9%), where as MVC was higher (30.9%) in the male population than the female population (21.8%).

Table 3

Etiology of Spinal Cord Injury (SCI) by gender

	Male		Female	
	Number	Percent	Number	Percent
Fall	157	59.9%	126	70.4%
MVC	81	30.9%	39	21.8%
Others	24	9.2%	14	7.8%
Total	262		179	

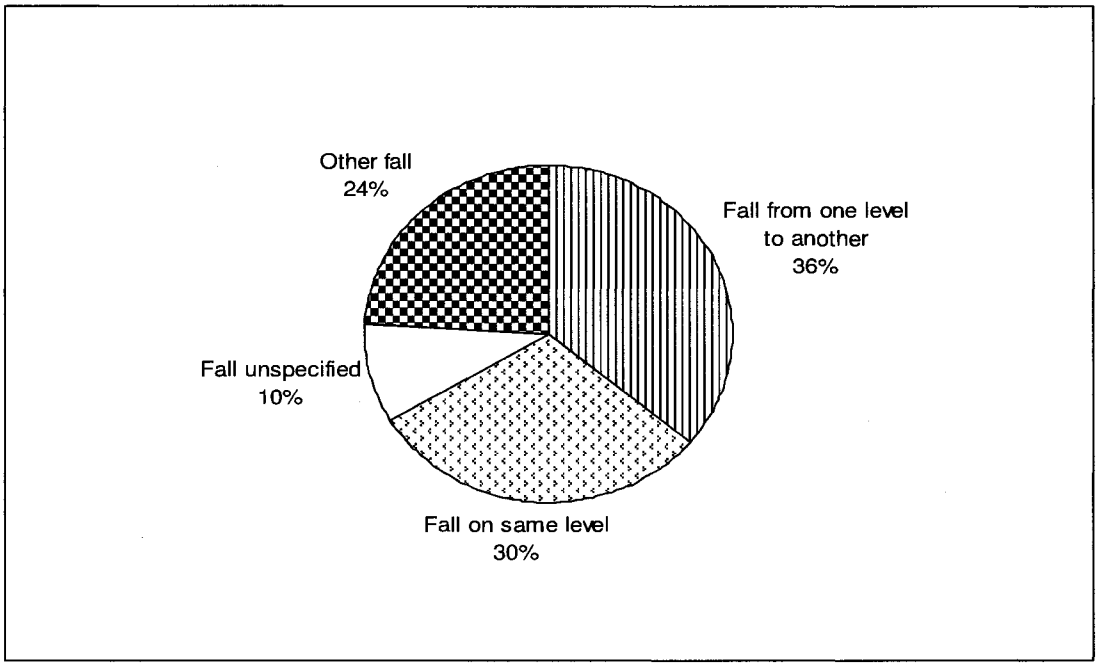

Figure 6. Fall-related SCI by fall type.

There were 284 falls resulting in senior's SCI from 1991 to 2002. Falls from one level to another accounted for 36% followed by falls on same level (30%). Different etiology of falls was observed between genders. Males had more than twice (47.1% vs. 22.7%) falls from one level to another whereas females had a higher but similar percentage (32.8%) of falls in the same level (Table 4).

Table 4

Etiology of falls related SCI by gender

	Male		Female	
	Number	Percent	Number	Percent
Fall from one level to another	73	47.1%	29	22.7%
Fall on same level	44	28.4%	42	32.8%
Fall unspecified	8	5.2%	19	14.8%
Other fall	30	19.4%	38	29.7%
Total	155		128	

Among the seniors sustaining a vehicle crash related SCI, most of them (90.8%) were due to MVC, which is defined as any MVC occurring on a public highway.

Incidents involving motor vehicles being used in recreational activities and non- collision motor vehicle accident entirely off the highway are classified as motor vehicle non traffic accidents contributes 5.8% of injuries and, rest 3.3% were due to other vehicle accidents. Table 5 shows that male and female had similar trends for MVC-related SCI.

Table 5

Etiology of MVC related SCI by gender

	Male		Female	
	Number	Percent	Number	Percent
MV traffic accident	73	90.1%	36	92.3%
MV non-traffic accident	5	6.2%	2	5.1%
Other vehicle traffic accident	3	3.7%	1	2.6%
Total	81		39	

Spinal Fracture

There were 3462 cases of spinal fractures during 1991-92 and 2001-02, the majority of which (37.6%) were female. Overall mean age at the time of injury is 78.98 years; male mean age was 77.60 years (SD = 7.71) and mean age at the time of injury for female is 79.81(SD = 7.31). The average annual incidence rate of spinal fracture was 65.91/100,000 (CI: 63.73, 68.11). During the same period 2744 fractures were caused by falls, which is about 80% of the total incidence (Table 2). Table 2 also showed that about half of the fractures were at lumbar level.

Table 6

Demographics of Spinal Fracture in Seniors in BC, Canada, 1991-2002 (N= 3462)

Years	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	Total
Number of cases	306	324	309	309	290	324	307	303	320	305	365	3462
Annual Incidence per 100,000/Year	72.70	74.59	69.72	67.57	61.95	66.69	62.07	60.24	61.75	58.20	68.71	65.91
95 % Confidence Interval	64.10, 80.34	66.47, 82.72	62.80, 78.44	60.45, 75.56	54.83, 69.07	59.43, 73.95	55.13, 69.02	53.47, 67.02	54.95, 68.55	51.67, 64.73	61.67, 75.75	63.72, 68.11
Gender (Male (%))	120 (39.5%)	108 (33.3%)	111 (35.5%)	115 (37.0%)	110 (37.8%)	120 (37.0%)	109 (35.5%)	116 (38.1%)	114 (36.0%)	117 (38.4%)	155 (42.3%)	1295 (37.4%)
Etiology no ((%))												
Falls	223 (73.4%)	254 (78.4%)	252 (80.5%)	243 (78.1%)	233 (80.1%)	251 (77.5%)	246 (80.1%)	238 (78.3%)	265 (83.6%)	251 (82.3%)	288 (78.7%)	2744 (79.2%)
MVC	36 (11.8%)	29 (8.9%)	34 (10.9%)	45 (14.5%)	37 (12.7%)	35 (10.8%)	38 (12.4%)	36 (11.8%)	30 (9.5%)	30 (9.8%)	40 (10.9%)	390 (11.2%)
Others	45 (14.8%)	41 (12.6%)	27 (8.6%)	23 (7.4%)	21 (7.2%)	38 (11.7%)	23 (7.5%)	30 (9.9%)	22 (6.9%)	24 (7.9%)	38 (10.4%)	332 (9.6%)
Level (no (%))												
Cervical	35 (11.4%)	30 (9.2 %)	28 (9.1%)	37 (12.0%)	36 (12.4%)	41 (12.6%)	43 (14.0%)	40 (13.2%)	38 (11.9%)	37 (12.1%)	66 (18.1%)	431 (12.4%)
Dorsal	97 (31.7%)	102 (31.5%)	99 (32.04%)	96 (31.1%)	98 (33.8%)	90 (27.8%)	94 (30.6%)	95 (31.3%)	86 (26.9%)	91 (29.8%)	105 (28.8%)	1053 (30.4%)
Lumbar	169 (55.2%)	183 (56.5%)	166 (53.7%)	154 (49.8%)	143 (49.3%)	179 (55.2%)	151 (49.2%)	155 (51.2%)	169 (52.8%)	159 (52.1%)	176 (48.2%)	1804 (52.1%)
Sacrum	4 (1.3%)	6 (1.8%)	11 (3.6%)	17 (5.5%)	9 (3.1%)	10 (3.1%)	14 (4.6%)	11 (3.6%)	16 (5.0%)	10 (3.3%)	18 (4.9%)	126 (3.6%)
Unspecified	1 (0.3%)	3 (0.9%)	5 (1.6%)	5 (1.4%)	4 (1.2%)	4 (1.6%)	5 (1.3%)	2 (0.7%)	11 (3.4%)	8 (2.6%)	0 (0.0%)	48 (1.4%)

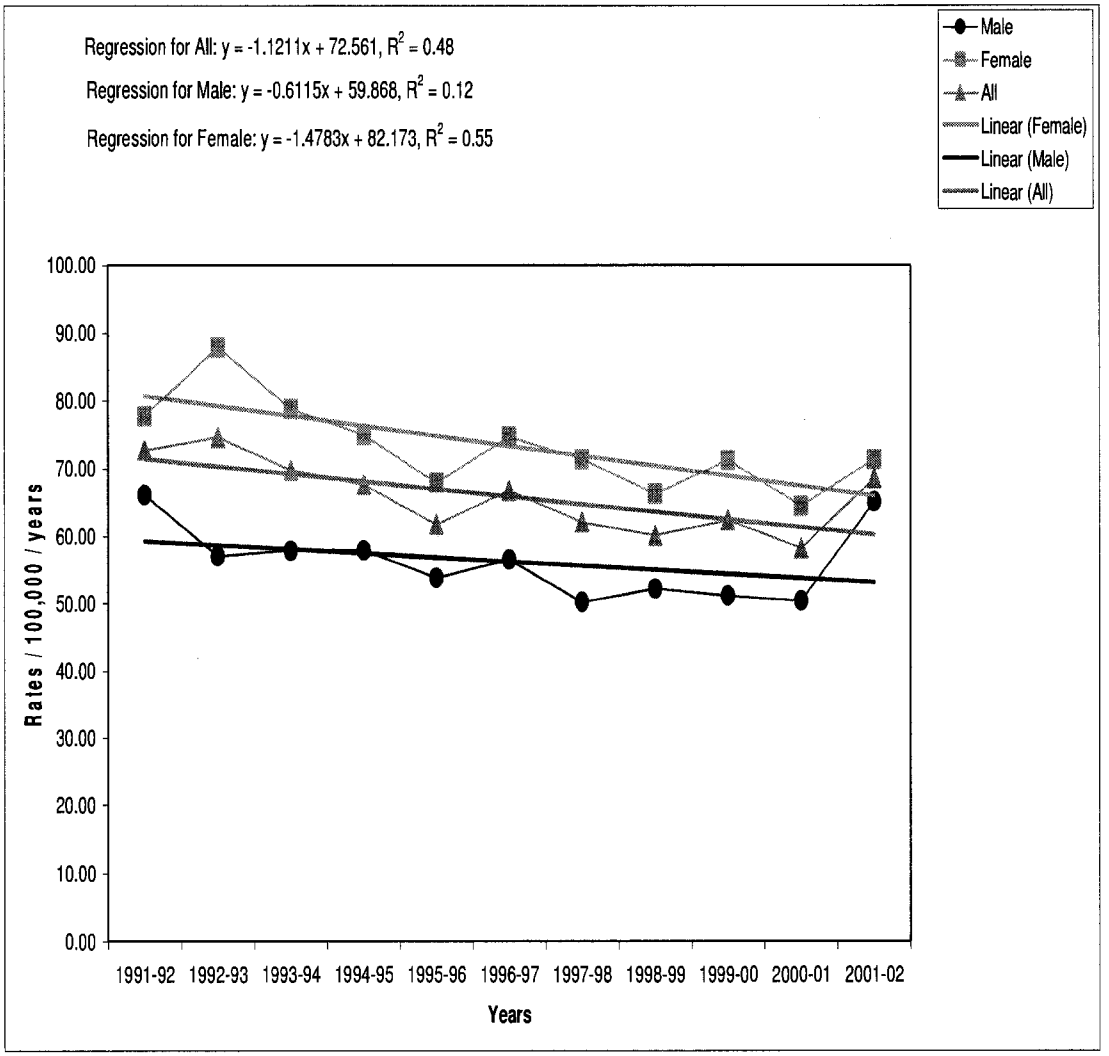

Figure 7. Annual incidence rates for spinal fracture by gender.

Female incidence rate was higher throughout the study period (Figure 7). The overall trend indicates that spinal fracture is decreasing.

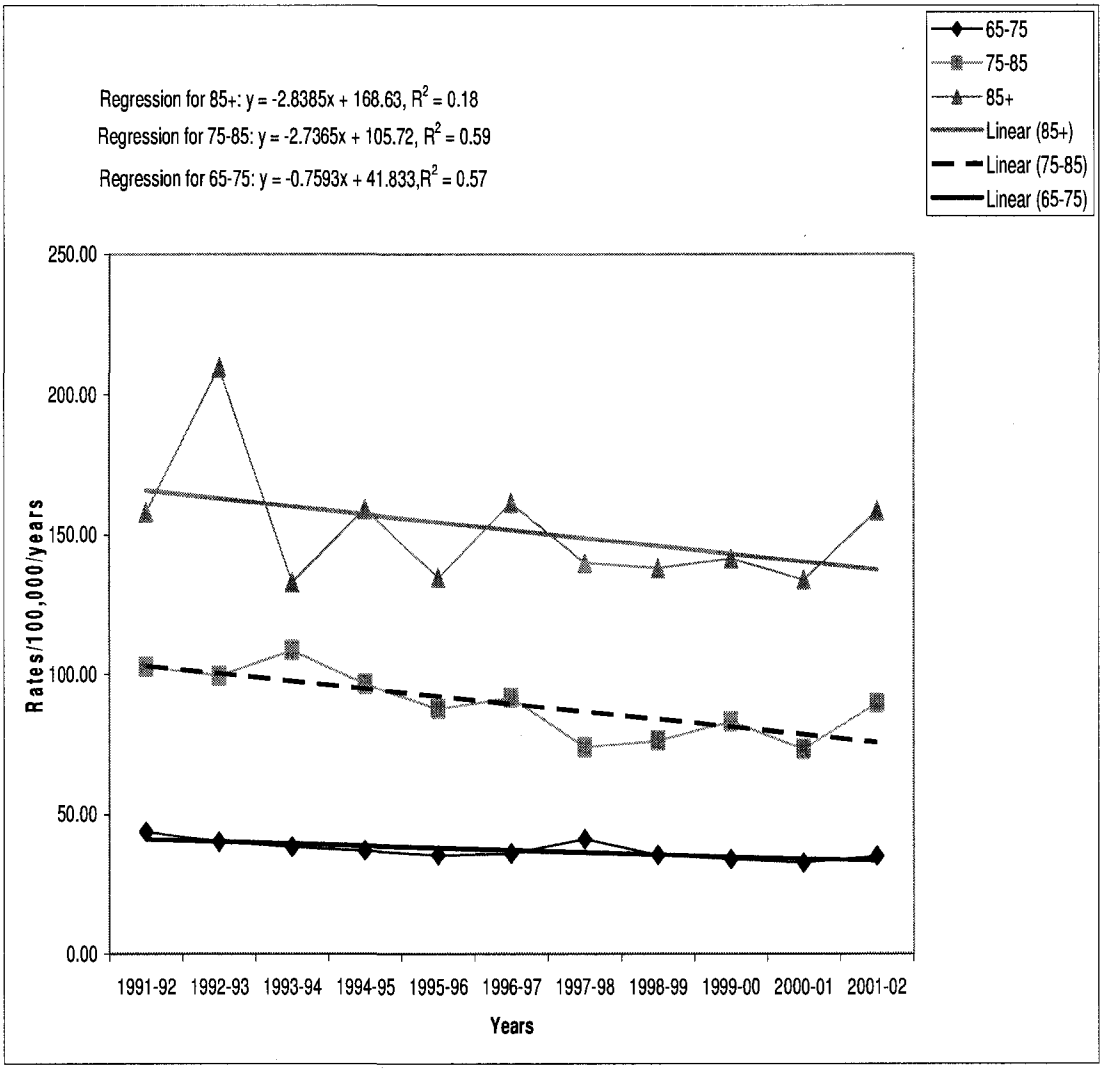

Figure 8. Annual age-specific incidence rates for spinal fracture.

Figure 8 shows age-specific incidence rates. Age group 85+ shows higher incidence rate, almost double compared to age group 65-75. Incidence rates for age group 65-75 shows constant for both genders in all years. Gender and age specific figures are shown in Appendix C.

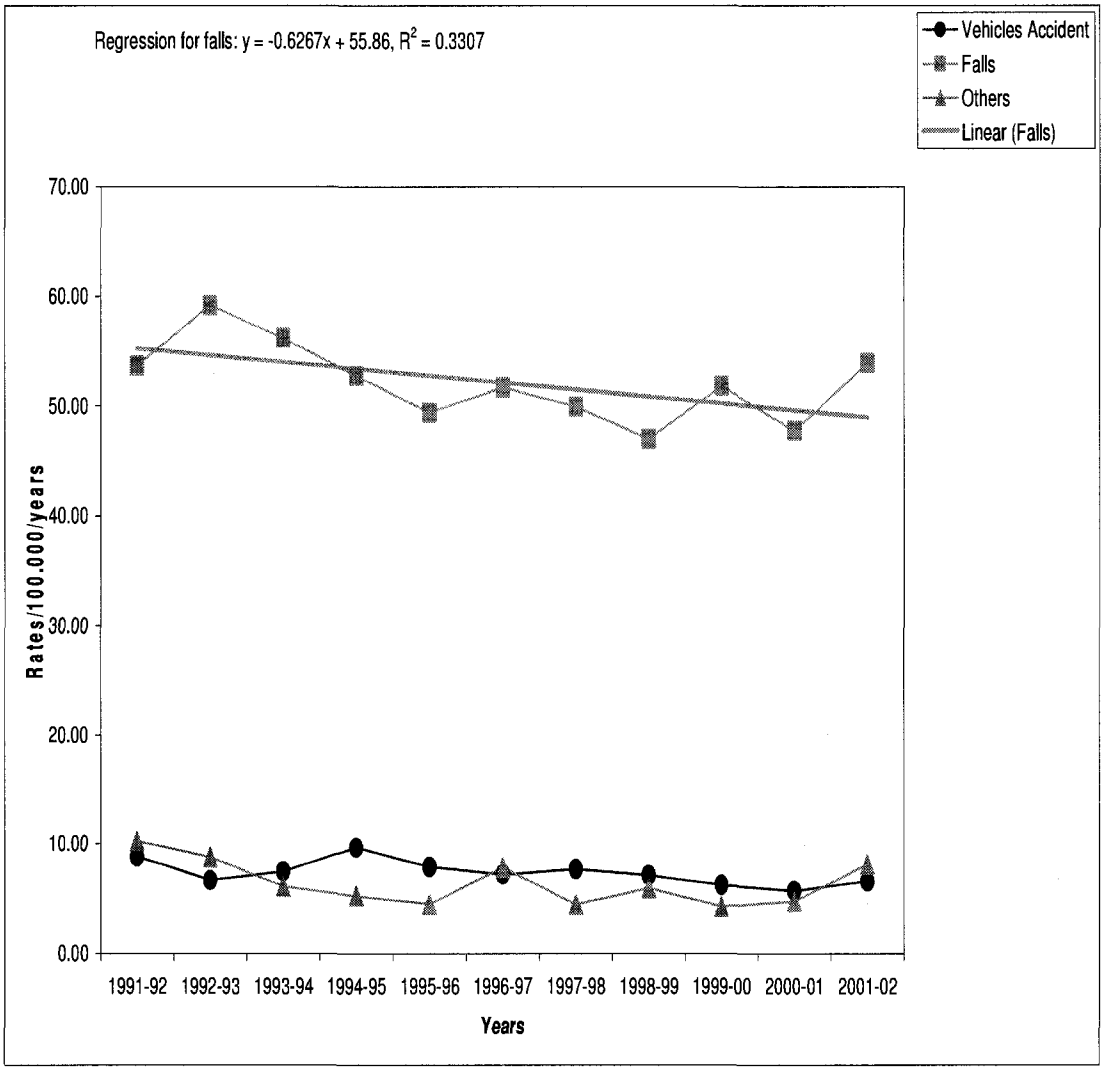

Figure 9. Annual incidence rates for spinal fracture by etiology.

An annual incidence rate for spinal fracture by falls was consistent. It shows that rates were higher than 50/100,000 per year, whereas rates for vehicle accident and others were less than 10/100,000 for this study population (Figure 9). Female incidence rate by falls was consistent but it was 20% higher than male rates (Appendix D).

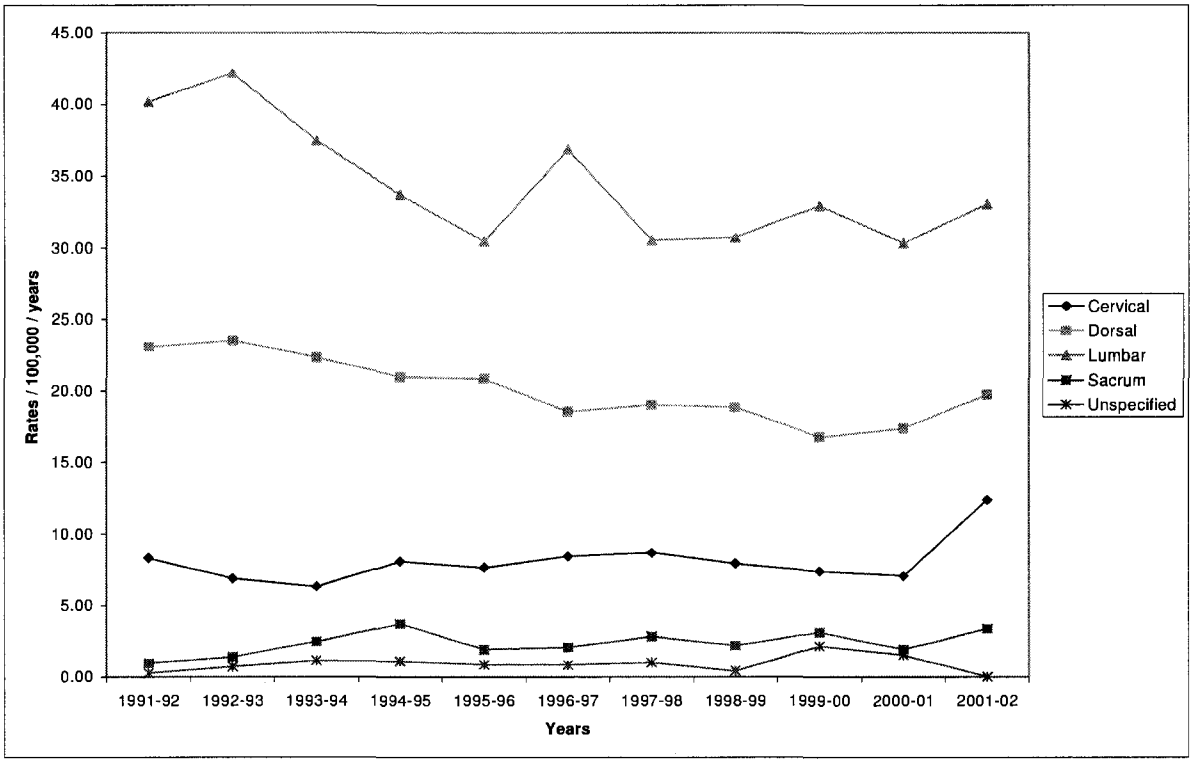

Figure 10. Annual incidence rates for level of injury for spinal fracture

Incidence rates for level of injury for spinal fracture (Figure 10) shows that the injury in lumbar region had the highest incidence rates for entire study period followed by the dorsal region.

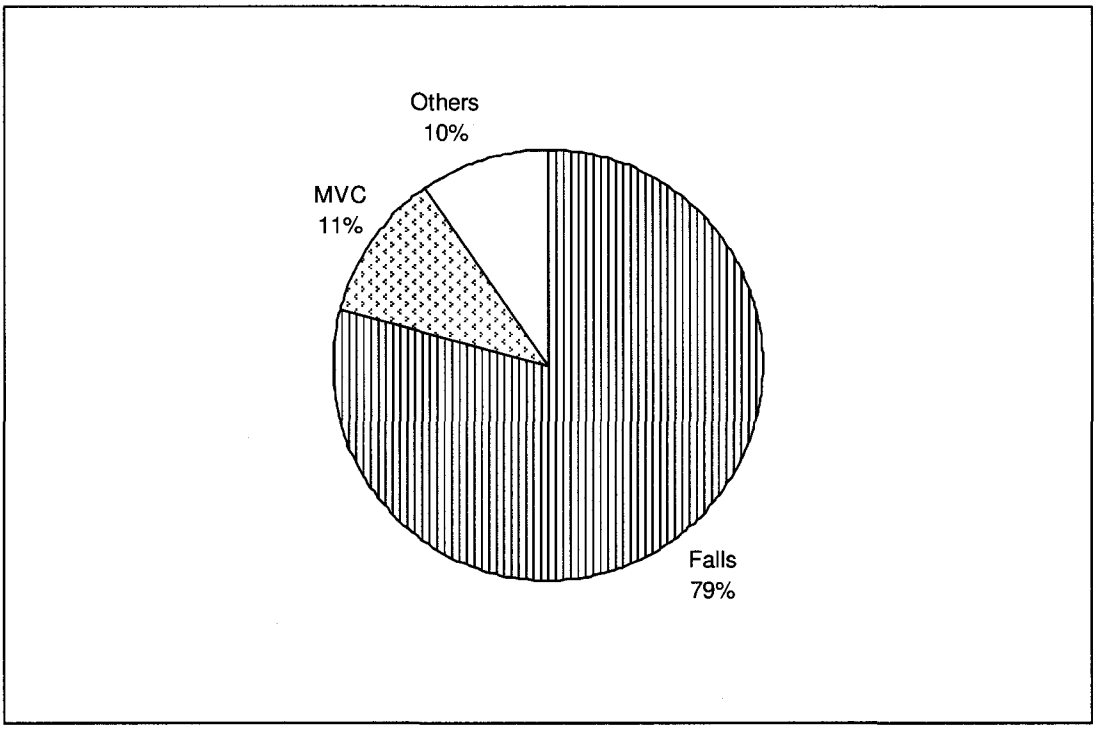

Figure 11. Etiology of spinal fracture.

Falls were the leading cause of spinal fractures (79.2%) followed by vehicle accidents (11.1%) and (9.6%) accounted for others. Rates by category were similar for males and females

Table 7

Etiology of Spinal Fracture by Gender

	Male		Female	
	Number	Percent	Number	Percent
Falls	1,017	78.35%	1,726	79.76%
Vehicle Accident	174	13.41%	212	9.80%
Others	107	8.35%	226	10.44%
Total	1298		2164	

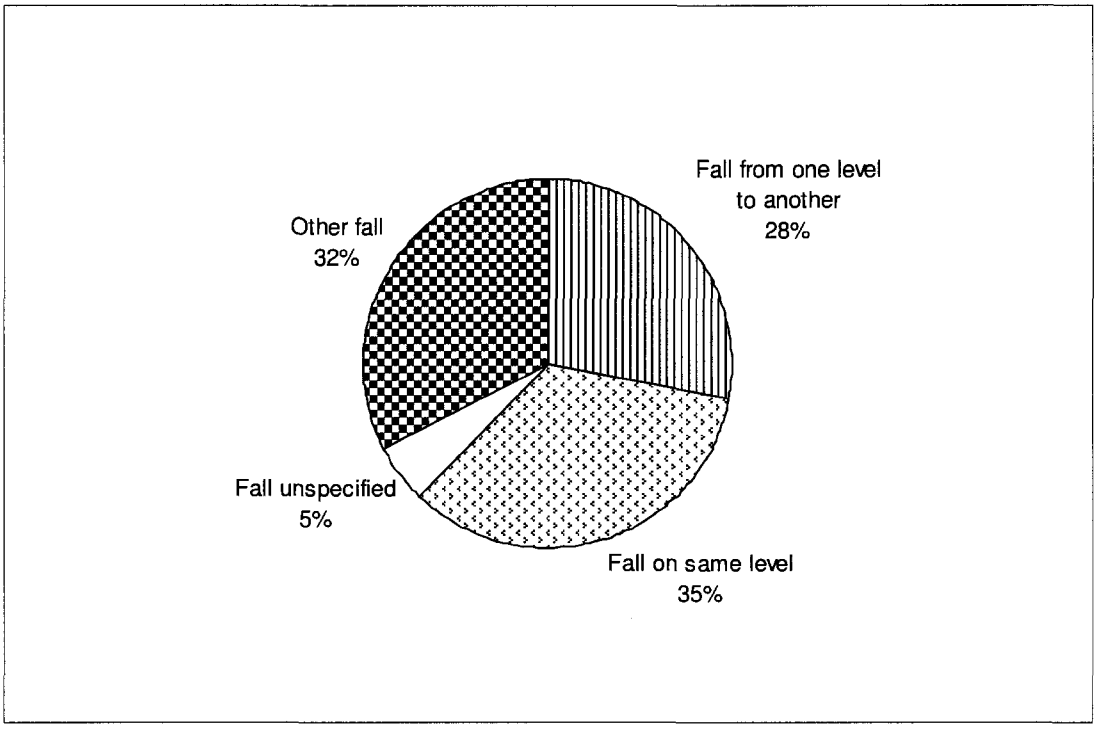

Figure 12. Fall-related spinal fracture by fall type.

About thirty five percent of fall-related spinal fractures were due to falls on same level followed by other falls (32%). Falls from one level to another accounted for (28%) and finally unspecified falls contributed 5%. Males had 38.6% falls from one level to another where as female had high percentages of falls in same level (37.7%). (Table 8)

Table 8

Etiology of Falls Related Fracture by Gender

	Male		Female	
	Number	Percent	Number	Percent
Fall from one level to another	392	38.6%	376	21.8%
Fall on same level	286	28.1%	651	37.7%
Fall unspecified	52	5.1%	97	5.6%
Other fall	287	28.2%	602	34.8%
Total	1,017		1,726	

Of those seniors sustaining a vehicle crash related spinal fracture, most of them (84%) was due to MVC, 9% by other vehicle accident and rest 7% were due to motor vehicle non-traffic accident. Among vehicle related fractures, females had a higher proportion than males. (Table 9)

Table 9

Etiology of Motor Vehicle Related Fracture by Gender

	Male		Female	
	Number	Percent	Number	Percent
MV traffic accident	130	74.7%	193	91.4%
MV non-traffic Accident	22	12.6%	7	3.3%
Other vehicle traffic accident	22	12.6%	12	5.7%
Total	174		212	

Comparison between spinal cord injury and spinal fracture

During the years 1991-2002, there were 441 cases of SCI and 3462 spinal fracture in seniors of BC. Annual incident rate for spinal fracture was 8 times higher than SCI. The majority of spinal fractures were more likely to occurs to female (62.6%) compared to SCI (40.6%), and had a less length of stay at hospital (10 days vs. 13 days, respectively) (Table 10).

Table10

Characteristics of Spinal Cord Injury and Spinal Fracture

Characteristics	Spinal Cord Injury	Spinal fracture
Numbers	441	3462
Gender		
Male (%)	262(59.4%)	1295 (37.4%)
Age Group		
65-75	213 (48.3%)	1110 (32.0%)
75-85	166 (37.6%)	1564 (45.2%)
85+	62 (14.0%)	788 (14.0%)
Incidence rates /100,00/Year	8.48	69.72
Confidence interval	(7.69 – 9.27)	(63.72 – 68.11)
Etiology		
Falls (%)	283 (64.2%)	2744 (79.2%)
Motor Vehicle Collisions (%)	120 (27.2%)	390 (11.2%)
Others (%)	38 (8.6%)	332 (9.6%)
Length of stay (median)	13 Days	10 Days
Admission Category		
Urgent (%)	199 (45.1%)	2262 (65.3%)
Emergency (%)	182 (41.3%)	1121 (32.4%)
Elective (%)	58 (13.2%)	79 (2.3%)
Others	2 (0. 5%)	
Level of Care		
Acute	395 (89.6%)	3457 (99.9%)
Extended Care/ CBD Units	15 (3.4%)	5 (0.1%)
Rehabilitation	29 (6.6%)	0 (0.0%)
Others	2 (0.4%)	0 (0.0%)
Entry through		
Direct	136 (30.8%)	495 (14.3%)
Emergency	303 (38.7%)	2967 (85.7%)
Others	2 (0.5%)	0 (0.0%)
Heath Authorities		
Vancouver Coastal	204 (46.3%)	765 (22.1%)
Interior	98 (22.2%)	950 (27.4%)
Fraser	77 (17.5%)	997 (28.8%)
Vancouver Island	41 (9.3%)	574 (16.6%)
Northern	16 (3.6%)	165 (4.8%)
Others	5 (1.1%)	11 (0.3%)

Age group distribution of incidence table shows highest occurrence of SCI falls on the age group of 65-75 years (48.3%) followed by 75 -85 years (37.6%) and 85+ years (14.0%) whereas in spinal fracture, highest percentage falls was in the age group 75- 85 years (45.2%) followed by 65 -75 years (32.0%) and 85+ (14.0%). The proportion was same for people in age group 85+ in both SCI and spinal fracture (Table 10).

As shown in Table 10, the leading cause of both spinal fracture and SCI was fall (79.2% and 64.2%, respectively). Second leading cause for both cases was motor vehicle accident (11.2% and 27.2% respectively) followed by others (9.6% and 8.6%, respectively). Majority of incidence for both spinal fracture and SCI entered hospital system through emergency (85.7% and 68.7%, respectively) and received acute care (99.9% and 89.6% respectively).

Fraser Health Authority had the highest percent of spinal fracture (28.8%) followed by Interior (27.4%), Vancouver Coastal (22.1%), Vancouver Island (16.6%) and Northern Health Authorities (4.8%) whereas for SCI, Vancouver Coastal Health Authority had highest percentage of incidence (46.3%) followed by Interior (22.0%), Fraser (17.5%), Vancouver Island (9.3%) and Northern Health Authorities (3.6%).

Health services utilization

From the Medical Services Plan Payment File, a total 121 patients who met the inclusive criteria for SCI and were included in the Health services utilization follow-up study. A total 605 persons were selected from the general population to form the matched control group. Controls were matched with SCI cases for age, gender, and region of residence.

There were 129 cases of SCI during the study period. Six cases have repeated occurrences in the defined period, only first occurrences was considered and two cases have no follow-up information. Hence, the number of cases for follow-up became 121, where number of male cases was 67 (55.4%).The mean age for SCI cases was 76.55 years (SD=7.46) (Table 11) .The mean age for male cases is 75.05 years (SD= 7.02), whereas mean age for the females was 78.41 years (SD=7.63). Distribution of age and gender of SCI group was considered during matching to make control group similar to the case group.

Table 11

Demographic and Injury Characteristics of Seniors SCI Patients Injured in BC, April 1. 1991 – March 31, 1994.

	Died during Hospitalization (N=17)	Survival initial Hospitalization (N=114)	Total (N=121)
Gender			
Male (%))	12 (70.6%)	55 (52.9%)	67 (55.4%)
Age (Years)			
Mean	79.65	76.04	76.55
Standard deviation	6.29	7.54	7.46
Cause of injury (no (%))			
Motor Vehicle	8 (47.1%)	28 (26.9%)	36 (29.8%)
Falls	6 (35.3%)	68 (65.4%)	74 (61.2%)
Others	3 (17.1%)	8 (7.7%)	11 (9.1%)
Level of injury (no (%))			
Cervical	13 (76.5%)	49 (47.1%)	62 (51.2%)
Dorsal	2 (11.8%)	26 (25.0%)	28 (23.1%)
Lumbar	-	23 (22.1%)	23 (19.0%)
Sacrum	-	3 (2.9%)	3 (2.5%)
Unspecified	2 (11.8%)	3 (2.9%)	5 (4.1%)

Most of the injuries were by falls with 74 (61.16%) people, including falls from one level to another, falls on the same level and other falls. Motor vehicle collisions were

the second most common cause of injury, 36 people (29.8%) and other causes with 11 incidents (9.1%).

Table 11 shows 62 (51.2%) individuals sustained their injuries at the cervical level, while 28 (23.14%) sustained their injury at dorsal level followed by 23 (19.01%) had injury at lumbar level. In total, 17 (14.05%), SCI patients died during their initial hospitalization. Seventy Five percent of the deaths were occurred for patients with cervical even though those patients comprised only half of the sample.

During the initial hospitalization, the SCI group was hospitalized for total of 5301 days (Table 12). The median length of stay (LOS) was 17 days (IQR 4.0 – 59.0). The length of stay ranged from 1 to 348 days.

Table 12

Hospital Utilization for SCI Patients in British Columbia: Initial Hospitalization and Re-Hospitalizations over 7 years

	Total
Initial hospitalization	(N=121)
Length of stay	
Total bed-days	5301
Median (days)	17
Inter-quartile range	4.0 - 59.0
Death during initial hospitalization	17
Re-hospitalizations	
Numbers of people admitted	98
Numbers of re-hospitalizations	492
Length of stay	
Total bed-days	26213
Median (days)	8
Inter-quartile range	2.0 – 32.0
Death during re-hospitalizations	50

There were 492 re-hospitalizations during the follow-up period and 98 patients had at least one hospitalization over the period. Over the 7-year follow-up, the median LOS was 8 days (IQR 2 – 32) per hospitalization and ranged from 1- 2195 days. The number of hospitalizations per person ranged from 1 to 24. Considering all cases, 17.35% of people were hospitalized once, 14.29% were hospitalized twice, 32.65% were admitted three to five times, 28.57% were hospitalized for six to nine times and 7.14% for 10 times or more. Figure 13 Shows the trend of hospitalization pattern of the SCI patients and their control over the period of seven years.

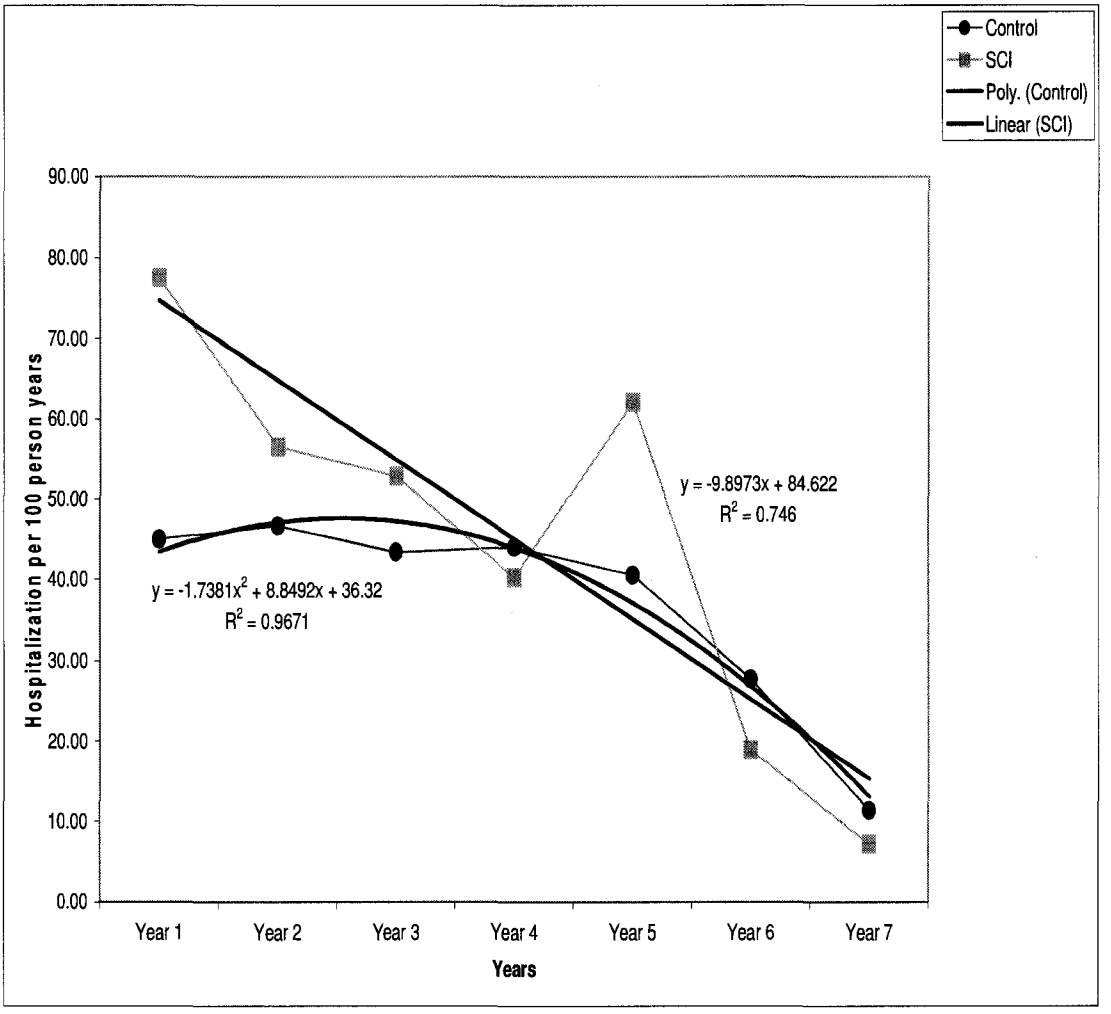

Figure 13. Hospitalization for persons with SCI and their matched controls.

Following initial discharge, individuals with SCI had 1.72 more hospital visits in year one and subsequent steady decreases with post years of injury, equal after four years. SCI shows linear trend with $R^2 = 0.7$, whereas control shows polynomial trend with $R^2 = 0.9$ (Figure 13). The control group shows no decrease in rate until after four years.

Following figure shows the trend of physicians' visits of SCI and control during the follow-up period

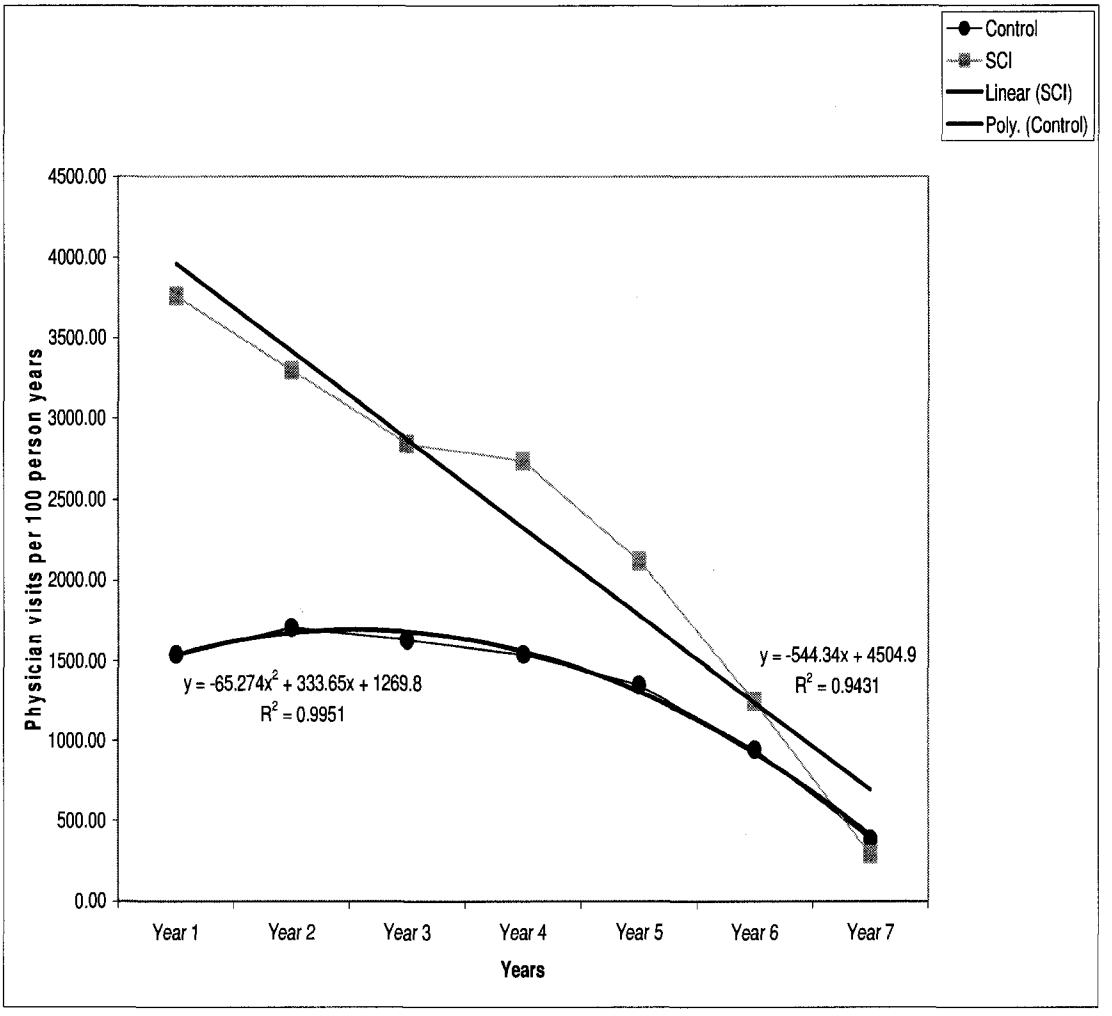

Figure 14. Physician visits for persons with SCI and their matched controls.

Similarly the physician visits trends shows the same pattern as the hospitalization. Following initial discharge, individuals with SCI had 2.44 more physician visit than the control group. Individuals with SCI had greater physician contact through observed periods and follow linear trend with $R^2 = 0.9$, whereas controls show a polynomial trend with $R^2 = 1$(Figure 14).

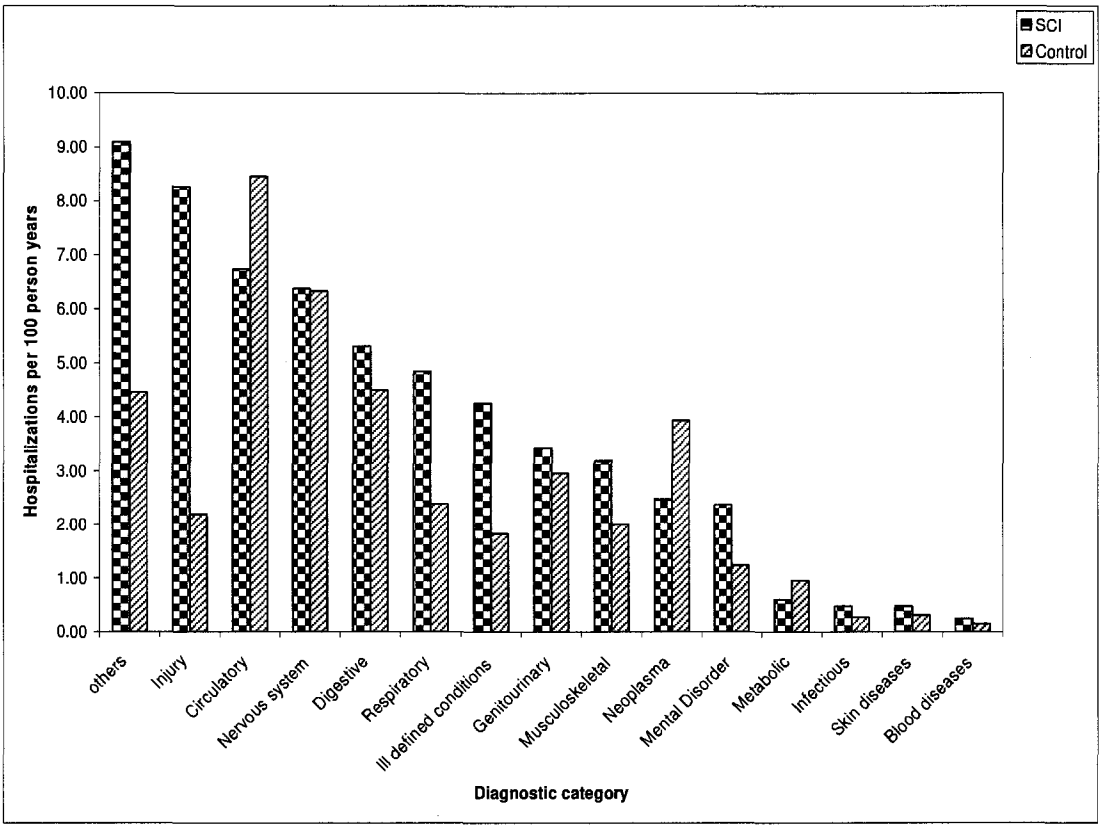

Figure 15. Hospitalization by diagnostic category for SCI patients and their matched control group.

Figure 15 illustrates the distribution of hospitalization by diagnostic category. Injury, circulatory system diseases, nervous system diseases, digestive system diseases and respiratory diseases were five major categories for SCI, while circulatory diseases, nervous system diseases, digestive diseases and neoplasm were the five major categories for control group hospitalization. Circulatory system diseases and neoplasm had the highest hospitalization for control group rest of the categories had a similar hospitalization for SCI group.

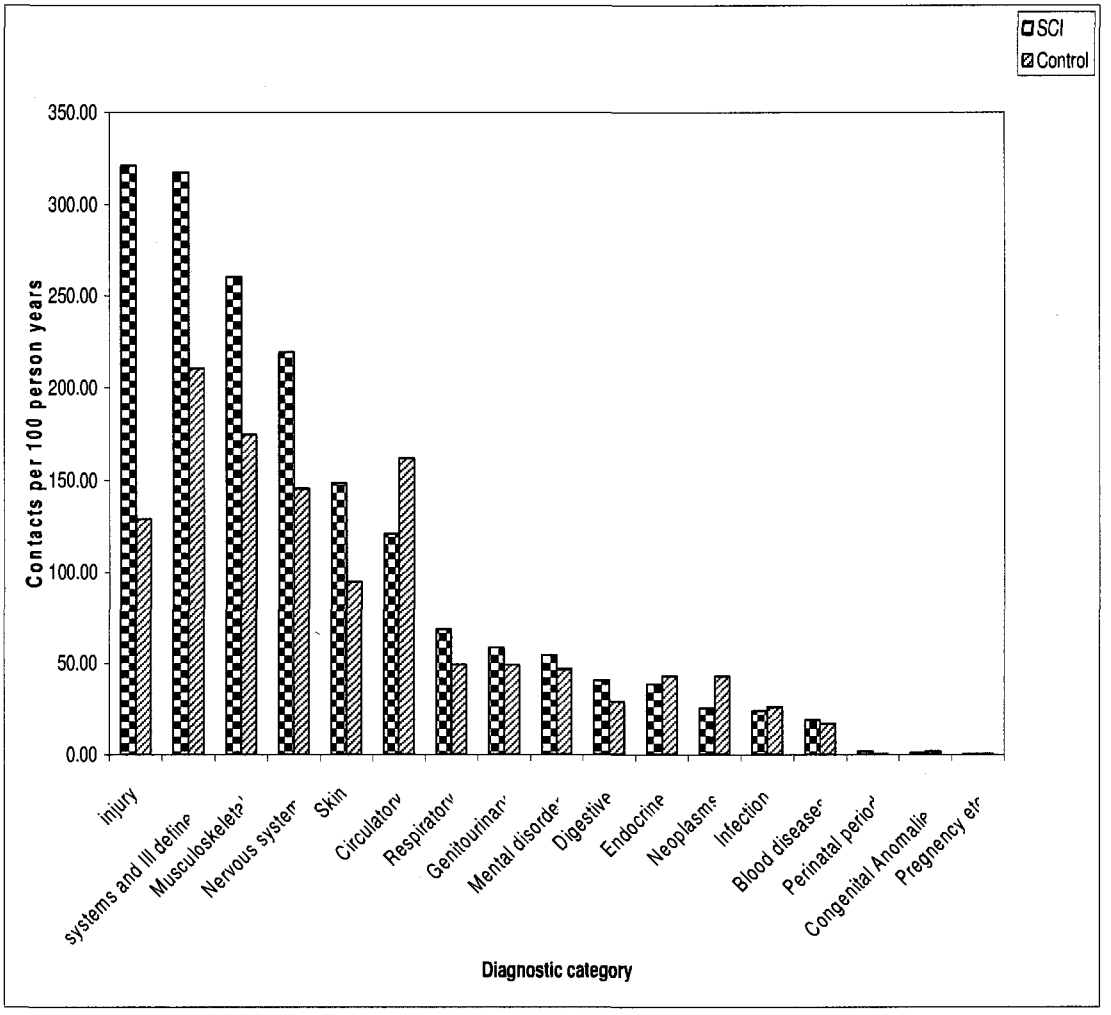

Figure 16. Physician contacts by diagnostic category for persons with SCI and their matched controls.

Figure 16 shows the distribution of physician contacts by diagnostic categories. Injury, ill defined system, musculoskeletal, nervous system and skin diseases were five major categories for both groups. Rate of physician visit was high for control group in circulatory, endocrine, neoplasm categories while rest of the categories had a high rate for SCI group.

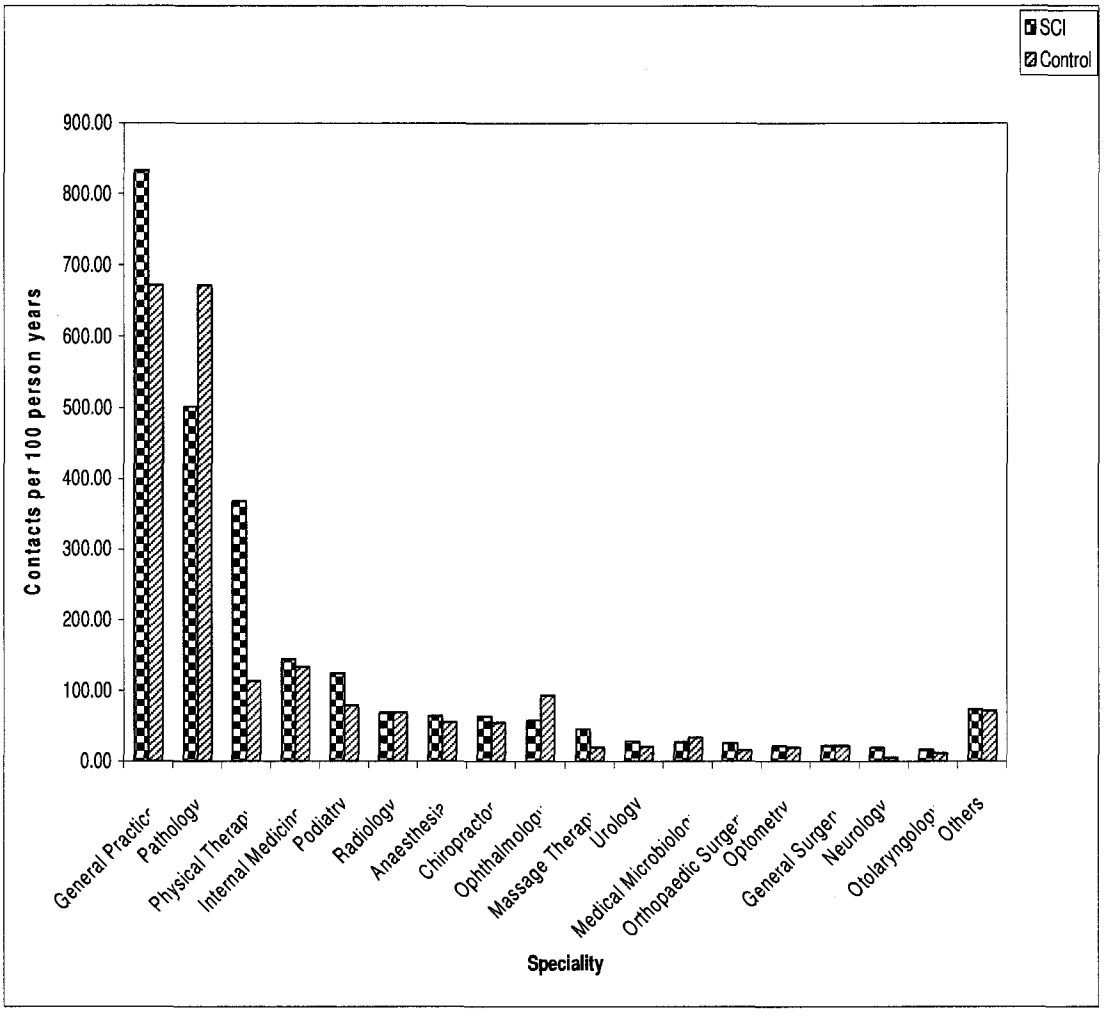

Figure 17. Physician contacts by specialty for persons with SCI and their matched controls.

During the follow up period, the SCI group visited family physicians, physiotherapists, internal medicine, podiatry, chiropractors, and massage therapists more often than the control group. Whereas the control group visited pathology, ophthalmology more often than the SCI group (Figure 17).

Table 13

Distribution of the Medical Co-morbidities in Patients with SCI and their Matching Controls in 7 years.

Categories	Medical Co-morbidities	Cases	Control	pvalues[1]
Cardiovascular Diseases	Hypertension	21	143	0.13
	Ischemic Heart Diseases	16	69	0.57
	Arrhythmia	11	35	0.17
	Heart Failure	9	28	0.19
	Stroke	8	14	0.01
Psychiatric Disorder	Depression	11	45	0.50
	Dementia	2	7	*
	Schizophrenia	1	1	*
	Others	4	4	*
Rheumatologic Diseases	Dorsopathies	54	81	0.00
	Osteoarthritis	26	63	0.00
Respiratory Diseases	Asthma	6	16	0.17
	Bronchitis	14	66	0.83
	Pneumonia	14	17	0.00
Others	Diabetes mellitus	14	46	0.15

[1]. Chi Square test is performed.
* Chi Square test is not performed because of observation are smaller than 5.

The most common medical co-morbidities in both groups are summarized in Table13. Stroke, rheumatic disease and pneumonia are statistically significant, while rest of the diseases: diabetes, respiratory diseases, psychiatric disorder, hyper-tension, ischemic heart diseases Arrhythmia and heart failure were not statistically significance. Over the 7- year follow-up, 18% people with SCI were treated for urinary tract infection, followed by pneumonia, heart disease, ulcer of skin and depression. For each complication, proportion of treatment received for SCI group was higher compared with the control group (Figure 18).

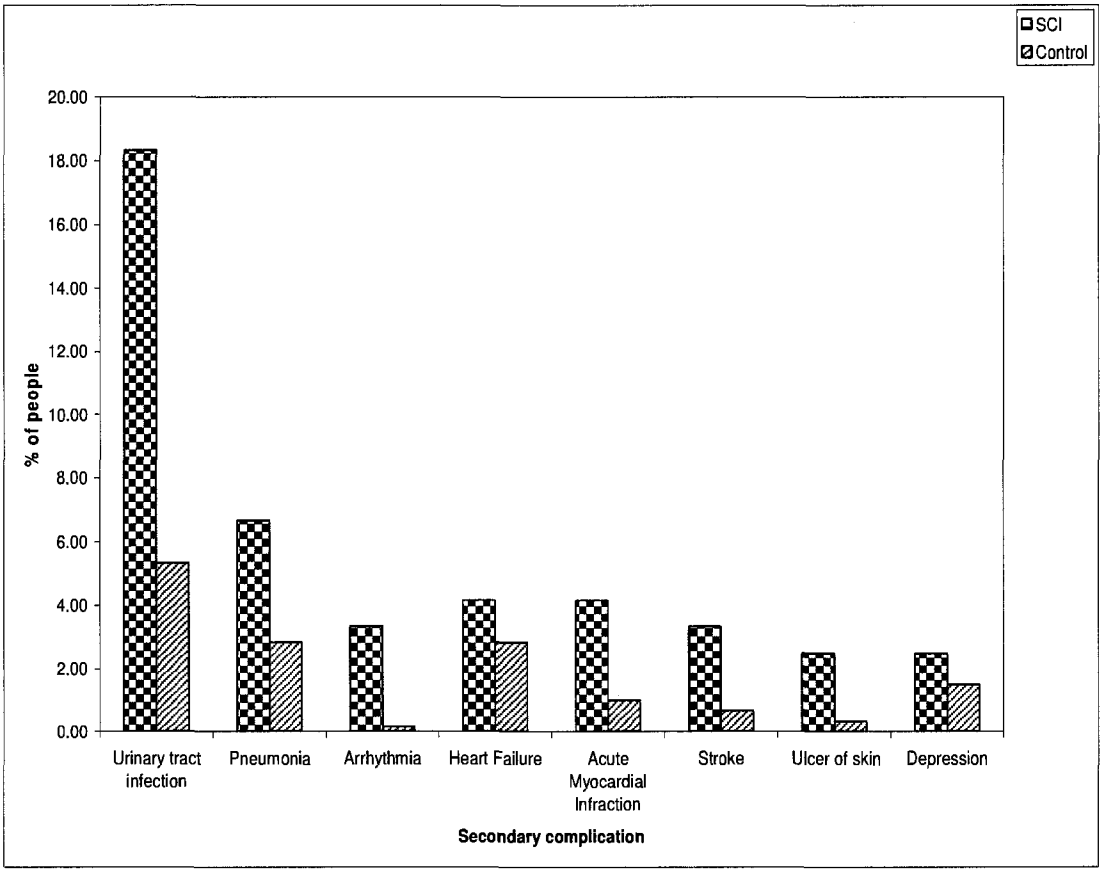

Figure 18. Proportion of the SCI group and control group diagnosed with secondary complication over the follow-up period.

CHAPTER FIVE

Overview

The population of seniors in British Columbia (BC) is aging rapidly compared to other provinces in Canada. This is primarily because of two reasons. First, the mild weather and beautiful landscape makes southern Vancouver Island and the Okanagan valley a very popular destination for retired life. As a result, Kelowna and Victoria are among the top two urban areas with highest percentage of seniors in Canada (Northcott & Milliken, 1998). Secondly many young people have left BC for other provinces for employment opportunities (BC STAT, 2005). As seniors are moving in from other provinces and the young and professionals are moving out of the province then the province develops more senior population than the other provinces. This trend will likely continue with the aging of baby boomers.

There are physiological changes that occur in the system of the body with aging. Seniors are more vulnerable and susceptible to acute and chronic diseases and may recovery more slowly from these illnesses (Lin & Armour, 2004). An added vulnerability exists in special populations that are both old and dealing with other debilitating conditions. They will also face many secondary complication and medical problems. Thus, increasing incidence of SCI in seniors creates concerns for the health care system and is a big challenge going forward (Krassioukov et al., 2003; Sekhon & Fehlings, 2001).

Spinal Cord injuries have a substantial economic cost to society although it is not that frequent (Dryden, Saunders, Jacobs et al., 2005). It has high level of personal and bio-psychological impact on the injured person. Since there is no treatment for spinal cord injury, prevention is the only way to reduce the burden on the health care system. Multidisciplinary healthcare professionals are needed to mange the injury and potential secondary complication. It is imperative to know the epidemiology of SCI in elderly population, in order to plan health services, rehabilitation and preventive strategies (Dahlberg et al., 2005; O'Connor, 2005; O'Connor & Murray, 2006).

This study has examined the incidence and the pattern of SCI and spinal fractures in seniors over a ten year period in British Columbia and also examined the utilization of health services following SCI over a 7-years period.

Spinal cord injury

The mean annual incidence is found to be 8.48 per hundred thousand populations. This is close to previous studies (Villanueva, 2000; Watson, 1976). It is more than double than the average annual estimate in USA (3.1 per 100,000) (National Spinal Cord Injury Statistical Center, 2005), a Canadian study (Pickett et al., 2006), and a study from Taiwan (Chen et al., 1997). This suggests that the seniors in Canada have a higher incidence rate of SCI.

Incidence rates for cervical level injury are high through out study period. This supports the previous findings as well (Jackson et al., 2004; Spivak, Weiss, Cotler, & Call, 1994). There was a sharp decrease noted in the 2001-02 year. This may be because of changes in ICD code version on 1999. This concern is also mentioned by van Asbeck et al., (2000).

The current study shows that males are at greater risk for SCI than females. This supports the general trends in SCI in Canada (Botterell et al., 1975; Canadian Paraplegic Association; Dryden et al., 2003; Krassioukov et al., 2003; Tator et al., 1993). However the ratio of SCI incidence between male to female is decreasing, indicating a rise in the incidence for females population

Fall related injuries are the major cause of SCI for seniors. This supports the previous findings (Dryden et al., 2003; Krassioukov et al., 2003; Pickett et al., 2006; Pickett et al., 2003). For falls-related SCI, the male rate is higher for falls from one level to another where as rates are almost equal in all types of falls for males and females.

Spinal fracture

There were 4362 cases of spinal fracture during study period, which gives mean annual incidence of 65.91 per hundred thousand in the population. This agrees closely with the rate reported in the province of Manitoba (Hu et al., 1996).

In our study population, the mean incidence rate of spinal fracture for age group 65-75 is 37.28, for age group 75-85 is 89.31 and rate for 85+ is 151.60 during 10 year of study period. This shows that the increase in number of cases is proportional to increasing age. Again this supports the previous research findings of Hu et al. (1996).

The female incidence rate of spinal fracture was higher throughout the study period. Females are at a higher risk for spinal fracture. Male incidence rates of spinal fracture due to falls suddenly goes up from 2000-01 to 2001-02 but this could be partly attributed to the increased numbers of missing data in registration due to the change from ICD9 to ICD10 (van Asbeck et al., 2000).

The annual incidence rate for spinal fracture due to falls is decreasing. The female incidence rate for falls is consistent but is 20% higher than male rates. Incidence rates for level of injury for spinal fracture shows that the injury with lumbar has the highest incidence rates for entire study period followed by dorsal. In our study, 52% of fracture is at lumbar level, 30% at dorsal and 12% at cervical level.

Falls are the major cause of fracture, almost 80% of incidence of spinal fracture occurred was due to falls followed by MVC (11%). This affirms to the Hu et al. (1996) study's outcome.

Utilization of health services

The study also examined the utilization of health services following SCI over seven-year period in the British Columbia. Utilization of health services was compared to that of the control group randomly selected from general population of the province and matched with age gender and region of residence. Comprehensive information of health services utilization was used to compare results.

Overall, 121 individuals with SCI and 605 matched controls were followed from the date of injury to seven years post injury. Control were randomly selected from the general population and matched for age, gender and place of residence. Following initial discharge, individuals with SCI had 1.72 times more hospital visits and 2.44 times more physician visits than the control group. A study conducted by Dryden et al. (2004) in the province of Alberta reported persons with SCI are 2.6 times more likely to experience re-hospitalization and 2.7 times more likely to have physician contact . Five major categories of hospitalization for SCI person are: injury, circulatory system diseases, nervous system diseases, digestive system diseases and respiratory diseases. With

exception of neoplasm, all other diagnostic categories had high hospitalization and high physician contacts for SCI group compared to control group. This current study documents that 81% of individuals with SCI were re-hospitalized at least once following the initial hospitalization, higher than reported in the previous studies (Dryden et al., 2004; Johnson et al., 1998) on the general population. Readmission rate and physician contact rates have declined over the period of follow-up. This is also reported in previous research in general population (Dryden et al., 2004; Ivie & DeVivo, 1994; Johnson et al., 1998). This shows that although seniors with SCI have a high hospitalization rate, it decreases in post injury years. Over the period of seven years, the major secondary complications after SCI were urinary tract infection, pneumonia, arrhythmia, depression, and cardiovascular diseases. This is also reported by the previous study (Krassioukov et al., 2003).

Spinal fracture is a risk factor for SCI, but there are no detail studies on this assertion. The incidence rate of spinal fracture is eight times higher than SCI incidence and it is also in decreasing trend. Spinal fracture is more common in females as compared to SCI. The discussion by Kannus (2006), Alaranta, Luoto, & Konttinen (2002) and Ling et al. (2000) suggested that osteoporosis, ankyloting spondylitis and spondylosis could be contributing factors for spinal fracture. Preventing these factors is the key to preventing spinal fracture, which will eventually prevent the SCI incidence. I recommend examination of the incidence of spinal cord injury followed by spinal fracture.

SCI and spinal fracture shows variation by health authorities. Further analysis of data set might give us further detail around geographical incidences, which eventually might contribute to develop preventive strategies.

The study shows that there is a need of continue follow-up care for seniors with SCI. Comprehensive treatment package is essential for further program and prevention planning. There is a need for gathering complete information of the injured person in order to plan a program of treatment. The Rick Hansen Spinal Cord Injury Registry (RHSCIR) is a Canadian initiative taken by the Rick Hansen Man in Motion Foundation (RHMIMF) at Vancouver General Hospital had in 2004. The foundation's vision is "A world in which people with spinal cord injury (SCI) can return to full physical function".

The RHSCIR further mentioned on its mission statement "The RHSCIR will be used as a tool to collect and store comprehensive, nationwide data for the purpose of improving care and clinical outcomes. It will promote encourage, and support the pursuit of excellence in SCI health care management" (Rick Hansen Spinal Cord Injury Registry). This is a great resource for researchers, policy makers and health care providers for planning care management. Further study by using this registry is recommended to analyze the complete picture of the injury.

CHAPTER SIX

Limitations

The limitations of this study are similar to those mentioned by Dryden et al. (2003, 2004). First, as administrative data rely on chart reviews and patient interviews, these datasets are unlikely to capture all individuals of SCI due to coding errors and incomplete entry. Second, ascertainment of pre-hospital deaths is likely incomplete. Many patients, who died at the scene from multiple injuries, may have possessed undetected SCI. It is impossible to estimate those numbers. Third, the data on level and extent of injury reflects discharge diagnosis and does not reflect neurological outcome that may have occurred following the discharge. Fourth, the data do not provide any information on quality of life and other health services. Hence, the estimate of health services will be underestimated. Finally, data are not available on health care services provided outside of the province.

Strengths

Besides all above mentioned limitation this study has several strengths. First, study utilizes the strength of longitudinal nature of administrative dataset to capture information of patients within this time-frame. This study has provided the most comprehensive and current examination of SCI in seniors in BC. Second, it is matched with other administrative dataset to see entire picture of health services received. Third, the study examined the entire population of seniors in the province of British Columbia. This minimizes any threat of external validity, selection biases and measurement biases. Finally, this is a population based study so it can be generalized to areas with similar population.

Conclusion

This study has provided a current and accurate measure of the incidence and aetiology of SCI and spinal fracture in seniors in British Columbia. The study found that falls are a major cause of injury and fracture. The incidence of spinal fracture is higher in females; whereas the incidence of spinal cord injury was higher for males. There were no significant temporal trends found in the incidence of SCI or non-SCI spinal fracture.

SCI places a heavy burden on the health care system in the first seven years following the injury. Persons with SCI have higher rates of contact with health care system compared to general population, including hospitalization, long term care, physician contacts. Persons with SCI are more vulnerable to secondary complication which also increases the utilization of health services. Besides these SCI people are more susceptible toward other health care problems as well.

It can be concluded that SCI and spinal fractures among the elderly are caused mainly through falls. The incidence for spinal fracture in fall accidents increases with age due to the increase numbers of falls among elderly population. People aged 65+ years constitute the fastest growing segment of the BC population. An effective multifaceted intervention strategy is necessary to reduce the falls in seniors' population. This includes combination of education, exercise medication assessment, risk factor reduction, and environmental modifications. Successful fall prevention education for elderly population may mitigate the prevalence to SCI in this population. The large percentage of elderly people with SCI has implications on the need to consider specific aging-related and geriatric needs in the rehabilitation of these people. There is need for prevention related research and intervention.

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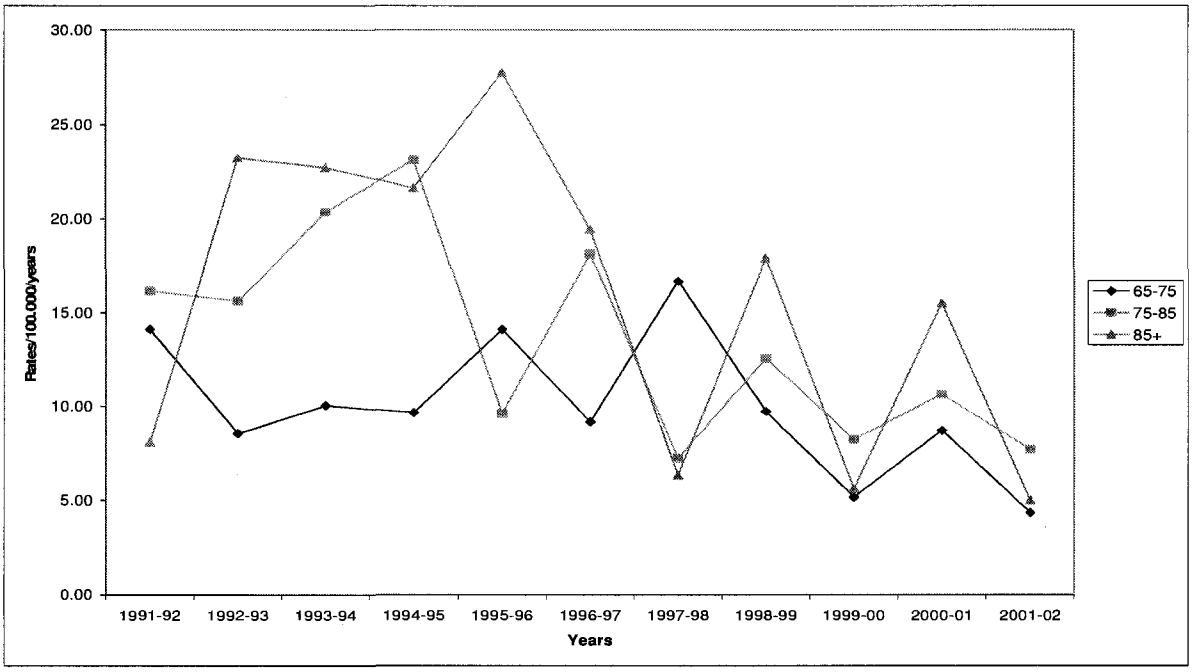
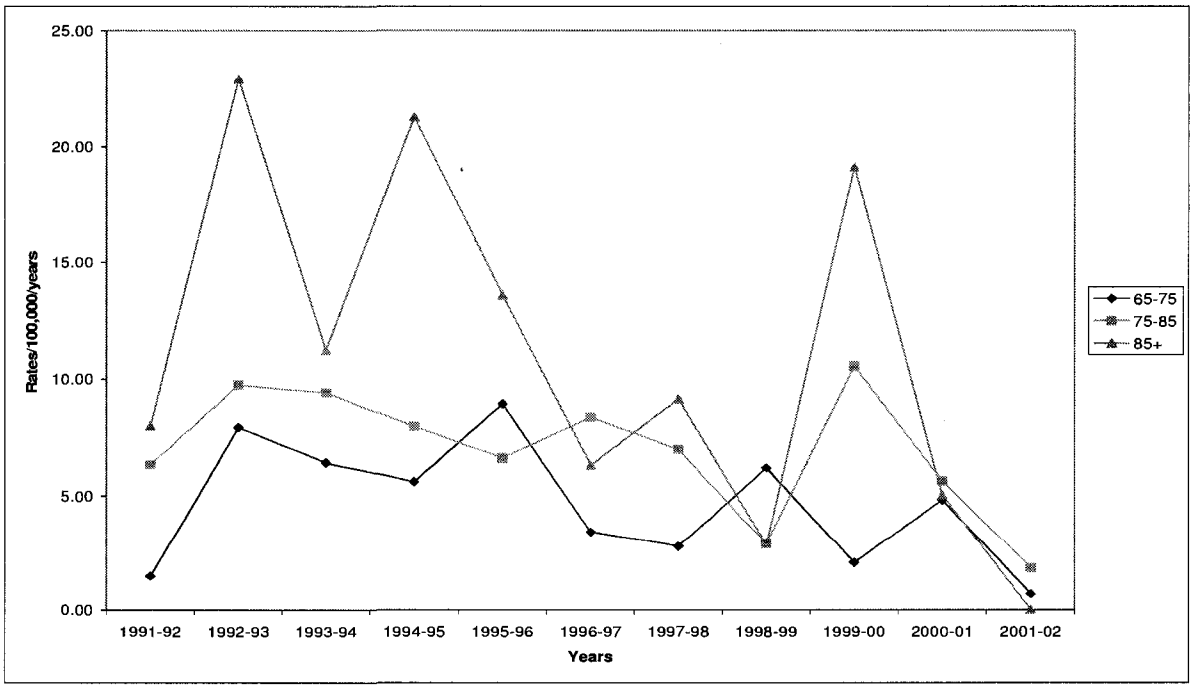
Appendix A

Annual male age specific incidence rates for SCI

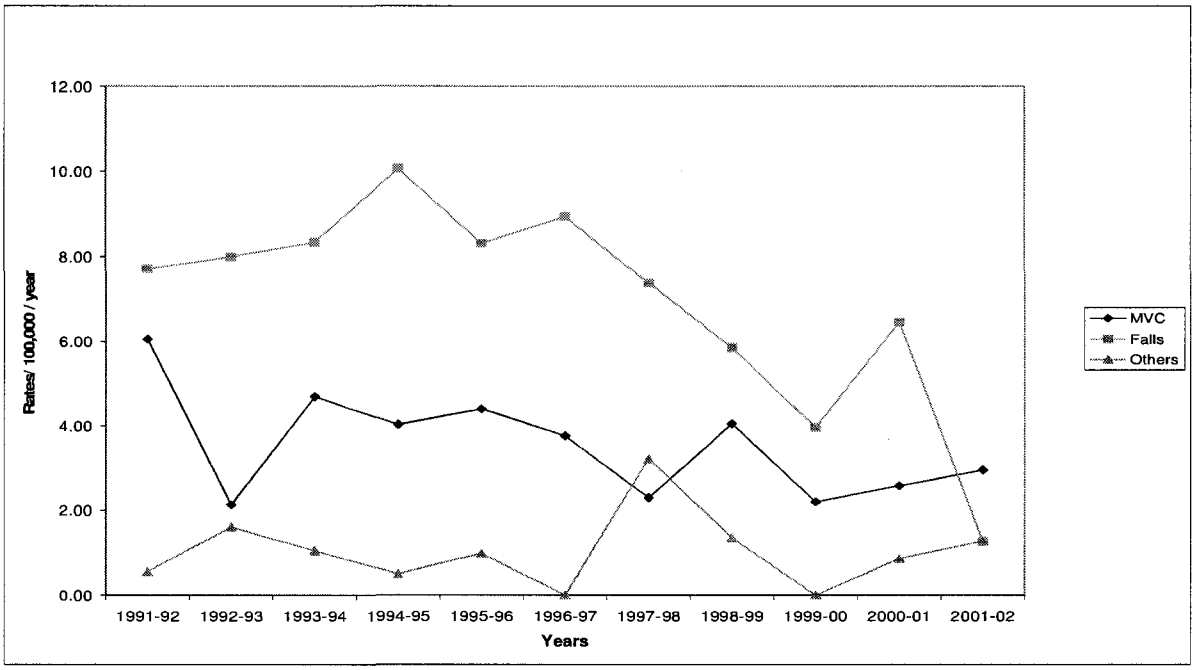


Annual female age specific incidence rates for SCI

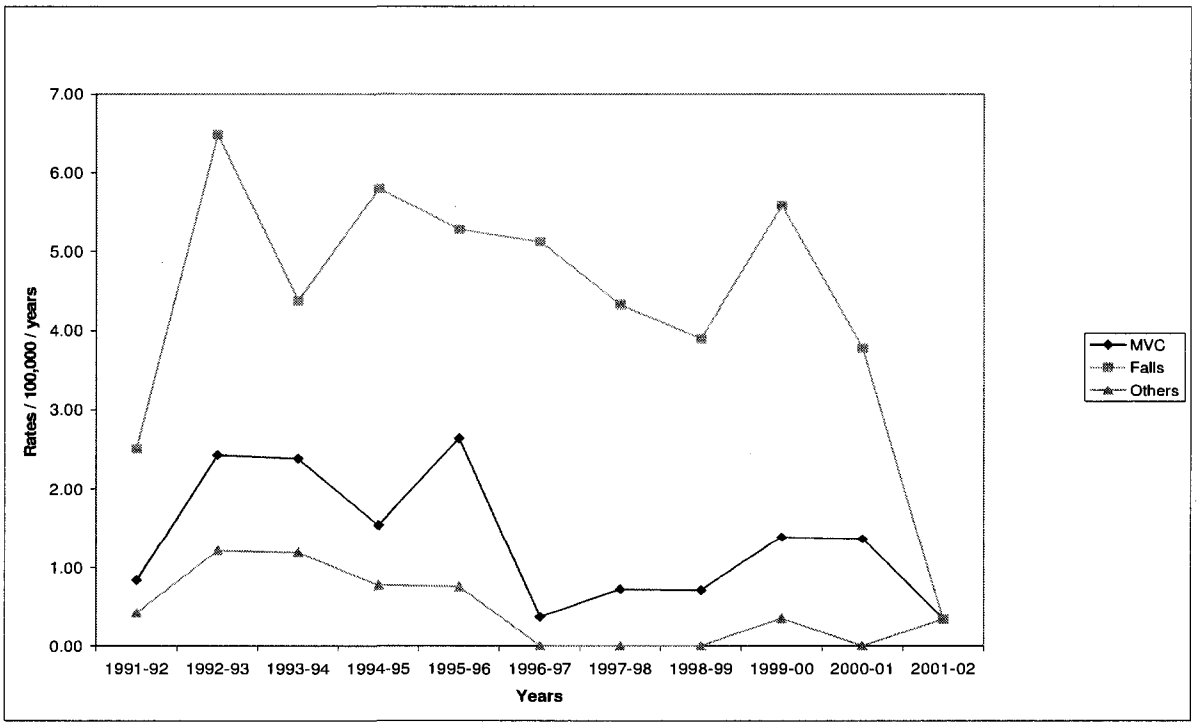


Appendix B

Male annual incidence rates for etiology of SCI

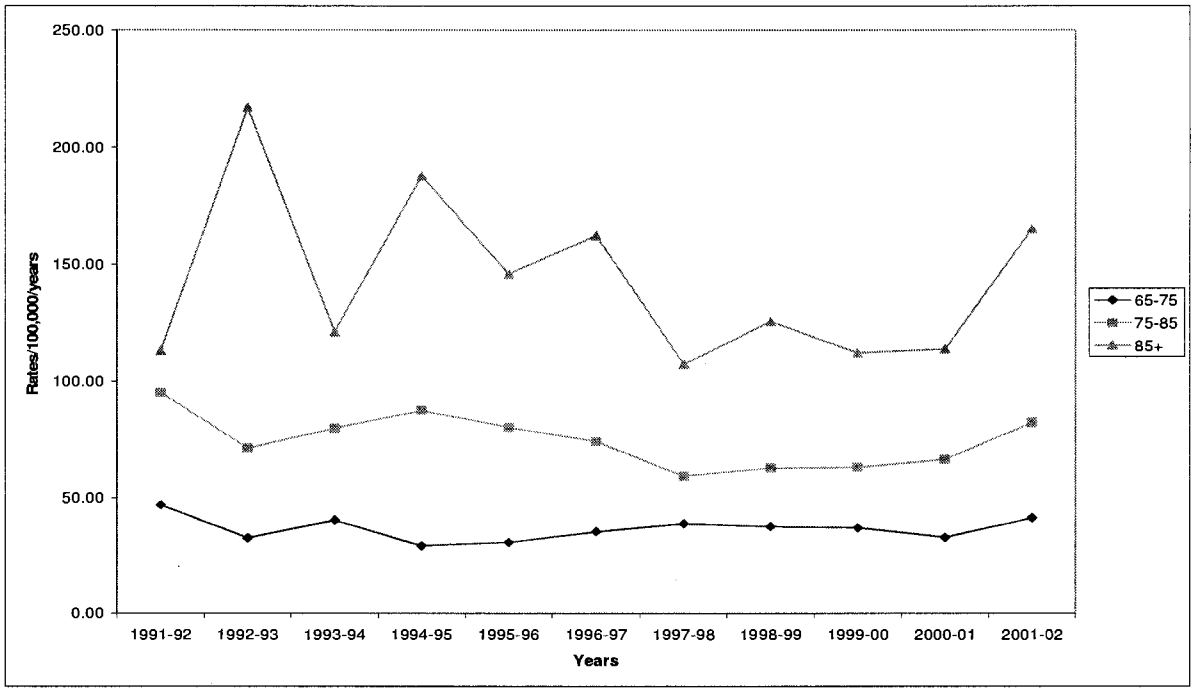


Female annual incidence rates for etiology of SCI

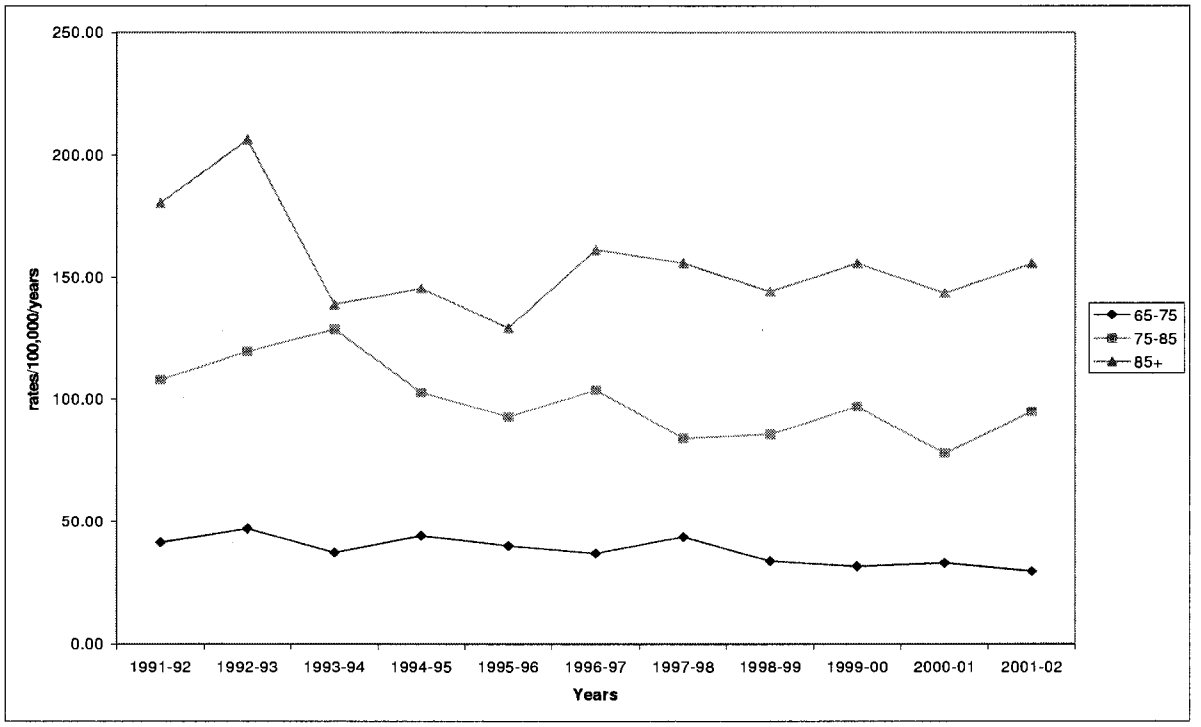


Appendix C

Annual male age-specific incidence rates for spinal fracture

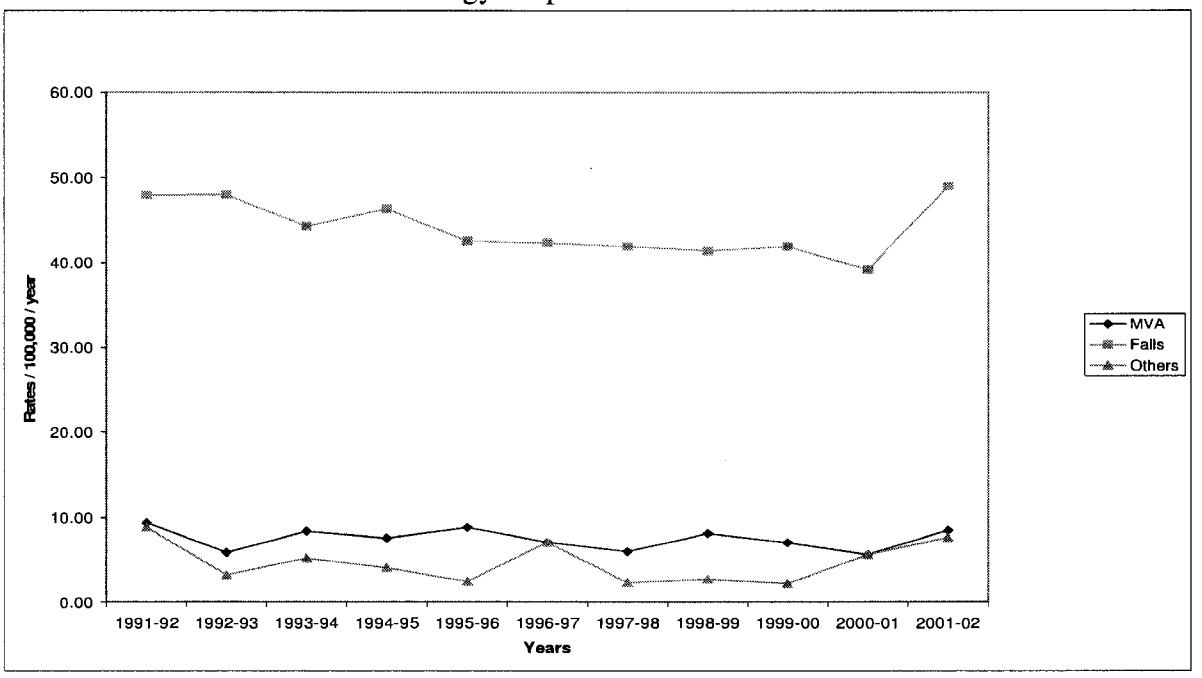


Annual female age-gender specific incidence rates for spinal fracture



Appendix D

Male annual incidence rates for etiology of spinal fracture



Female annual incidence rates for etiology of spinal fracture